There is little doubt that the construction industry has experienced exponential change and development in recent years. The 16th Built Environment Conference will examine five of these cutting-edge concepts to determine their state of the art in the construction sector both in practice and academic research. This conference therefore seeks responses to questions related to current conversations, debates and empirical research on:

**DECONSTRUCTION**
The dismantling or ‘unbuilding’ of buildings to maximise reusing and preserving the demolished fragments and involves taking a building apart piece by piece, essentially reversing the order of the construction.

**DIGITIZATION**
The conversion and transformation of construction business processes to use digital technologies and embrace the ability of digital technology to collect data, establish trends and make better business decisions.

**DISRUPTION**
Displacement of well established construction technologies, techniques or products to disruptively affect the normal operation or function of the construction industry while potentially creating a new industry or market. Artificial intelligence, virtual/augmented reality, internet of things, blockchain technology, and e-commerce are some of the disruptive technologies that are significantly influencing the future of the construction industry.

**DISASTER**
An occurrence that disrupts the normal conditions of existence and operation causing a level of suffering and challenge that exceeds the capacity of adjustment of the affected community and the construction industry.

**DEVELOPMENT**
In the context of construction refers to an industry that possesses the vision, leadership and capacity to bring about a positive transformation of itself within a condensed period of time.

Selected papers will be published as book chapters and indexed in Scopus. It is intended that these papers will contribute significantly to the existing body of knowledge relative to the science and practice of construction not only in South Africa but everywhere where the products of construction are produced even in these new challenging times of fear and uncertainty.

The conference invites papers within the context of its theme that address, inter alia, in both public and private sectors:
- Current trends and developments
- Innovation
- Opportunities and challenges
- Policies and procedures
- Legislation and regulations
- Practices
- Case studies

Papers will be reviewed according to:
- Relevance to the conference theme
- Objectives and outcomes of the conference
- Originality of the subject matter
- Rigor and robustness of empirical research
- Research design and methods


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AIMS AND SCOPE

The Journal of Construction (JOC) is the official journal of the Association of Schools of Construction of Southern Africa. ASOCSA has committed itself to foster excellence in construction communication, scholarship, research, education and practice and the Journal provides this medium to achieve this commitment. There are four issues of refereed Journal of Constructions per year serving all stakeholders and participants in the Construction and Engineering sectors.

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

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

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

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ABSTRACT

PURPOSE

The challenge of managing solid waste has become a global issue, and it is of major concern, particularly in emerging nations, as it escalates environmental drawbacks. The management of municipal waste is challenging because of the dearth of suitable infrastructure and facilities to handle and dispose of the increasing daily waste generation from urban centres. In addition, municipalities struggle to deliver efficient services because of dwindling Fiscus and ineffective regulations. This paper sets out to examine the status of Municipal solid waste management in South Africa from a literature viewpoint.

DESIGN / METHODOLOGY / APPROACH

The study’s methodology included a review of literature and materials from GoogleScholar® and various online portals and government agencies, such as the Department of Environmental Affairs and others expressly or impliedly involved in waste management. The evaluation was motivated by the global challenge of waste and hence the need to highlight the status of municipal waste management in South Africa.

FINDINGS

With the continuous population growth, which is expected to stimulate more waste generation, municipal waste is still disposed of unsegregated at the source and packed into one bin in most municipalities, thereby complicating the management process. Also, there is no legislation for beneficial waste disposal and treatment while priority is not given to waste management by civic organisations and bodies.

WHAT IS ORIGINAL / VALUE

While enormous effort is currently being put into waste management practices by different stakeholders, this study recommends an enhancement of the waste management collection system, encouragement of waste separation at the source towards recycling, freecycling, upcycling and circularity, waste disposal, public/private participation partnership in the waste management sector.

Keywords: Solid waste; Sustainable; Waste management; Legislation; South Africa.
INTRODUCTION

[1] Indicated that urbanisation impacts directly waste generation, and its wrong treatment results in environmental degradation and further health hazards. Therefore, the population directly influences the volume of solid waste generation. Furthermore, industrialisation and urbanisation, which have induced human habits and attitudes to life, have occasioned unrestrained natural resource exploitation and a further generation of complex waste, some of which cannot be degraded naturally [2]. Apart from these, some of the waste may be injurious to humans [3].

South Africa, the fastest-growing industrialised country in Africa with a population of 57 million, is a land of diversity culturally, socially, physically, climatically, geographically, ecologically and language-wise. [4] reported that the country has an annual population growth rate of 1.4% and an urban growth rate of 2.09%, as reported by the [5], and it is projected that as much as eight in ten people will live in urban areas by 2050 [6].

The percentage of the urban population has increased from 47% in 1960 to 65% in 2016, as shown in Figure 1.

GLOBAL STATE OF SOLID WASTE MANAGEMENT

The increase in urbanisation brings about a significant increase in waste generation [11], and it is reported that 1.3 billion tons are generated globally annually, with an expectation of annual growth to roughly 2.2 billion tons by 2025 [12]. Of this volume, approximately 62 million tons (MT) per annum is generated in sub-Saharan Africa; approximately 270 MT per annum in Eastern Asia and the Pacific Region; approximately 93 MT per annum in Eastern and Central Asia; approximately 160 MT per annum in the Caribbean and Latin America; approximately 63 MT per annum in North Africa and the Middle East; approximately 572 MT per annum by the OECD with 37-member states generate and approximately 70 MT per annum in South Asia [12].

In the year 2000, the U.S. Environmental Protection Agency (US EPA) revealed that recycling and reducing waste reduces the impact of climate change, therefore establishing a vital link between global climate change and municipal solid waste management [13].

The prevention, recovery, incineration and landfilling, also referred to as the philosophy of Waste Management Hierarchy, has been admitted by industrialised nations as the framework for municipal waste management [14]. Figure 2 shows the data collected and documented on waste generation and disposal in the United States of America from 1960 to 2017, and it shows the total MSW and per capita waste generation for the year.

The rate of waste products in the U.K. declined to 221MT in 2016 from 288.6 MT in 2008, and mineral waste with 81.1 MT had the largest share [15].

Municipal authorities in Asia are estimated to spend between 50–70% of their income on waste management, while if they neglect, it will return with a cost of 5% on average of the GDP [16]. Also, urbanisation induced population resulting in rapid economic growth significantly increases the consumption rates in Asian developing cities, and these have contributed to the increase in the municipal solid waste generation as well as changes in waste composition [17].

However, in particular, a major setback while studying sub-Saharan Africa is the dearth of data and the irregularity in existing data solid waste management practices. The data on solid waste generation is usually gathered using surveys that cover certain cities and are limited to a very short period [19]. Figure 3 presents municipal solid waste generation data in selected African states.

There is a challenge being faced by South Africa because its available infrastructure is not on par with its growing urban population. The management of solid waste is one service where such a gap exists in South Africa, and it is evident that efficient solid waste management systems to care for the increasing waste volume are non-existent [8]. Although the municipalities incur high costs on the current waste management systems, they are inefficient and could be a latent threat to the quality of the environment and public health [9]. Poor waste management deprecates public health, triggers environmental pollution, accelerates climate change, and significantly influences citizens’ quality of life. The interests of the municipalities are generally in the collection and transportation of solid waste from the cities and with minor consideration for its proper disposal [10].

Despite the passing of the Integrated Waste Management Laws, open burning and dumping, landfill fires, and human exposure to waste are generic at many of the waste disposal sites, and this results in hazardous risks, such as impairment to natural aesthetics and pollution, health hazards, odour nuisance and feeding of rodents. This paper aims to highlight the existing global municipal solid waste management system and hone in on the South African system to underscore its status towards identifying its challenges and recommending solutions.

Figure 1. Rural and urban population comparison, 1960 to 2016

Figure 2: Generation rate municipal solid waste of the United States, 1960 to 2017
Although numerous policies have been positioned to tackle waste and pollution in Sub-Saharan Africa, it is unclear of the translation of these policies into action and the progress they made towards achieving the aims and obligations [21] of these policies. Moreover, the failure of many African authorities towards enforcing environmental and waste legislation has given rise to an impunity culture, thereby weakening the effectiveness of waste management [22]. It is, however, clear that industry stakeholders are unable to keep up with the growing waste streams and the timely advancement of strategies and policies to effectively manage them [23].

The most that African countries have achieved is a ban on problematic products, especially single-use plastics. [24] reports that 29 African countries have implemented local or national regulations against plastics (Figure 4).

The general direction of waste management is governed by sustainability, which forms the basis for the hierarchy of waste management decisions in E.U. policy. However, in many African nations, the legislations are made principally to allocate responsibilities to the municipality with no attendant penalties for non-compliance [26]. The UN SDG outlines that the strategies for minimising waste can be established on the belief of the society and governments that they can modify their functional status quo towards achieving future sustainability [27]. However, [12] reports that many countries do not collect data on waste disposal and where it is collected; the procedure for such and the characterisations utilised for the different categories is often either inconsistent or unknown. Meanwhile, the global disposal of municipal solid waste as of 2012 is presented in Figure 5.

Different systems are implemented for waste handling and disposal globally; however, the major difference in the systems of the developing and developed countries is waste separation at the collection point [28], and this brings the ease of waste composting and recycling, which is recognised to be the most beneficial system of handling waste.

**METHODOLOGY**

Towards examining the status of solid waste management in South Africa from a literature viewpoint, published literature in related areas were selected and reviewed in line with the approach of [29]. [30] Detailed that systematic literature review with its great potential has been widely used in health science, which has informed its use in this study.

A keyword search was performed in Google Scholar, and the reason for this is that it is one of the most comprehensive and up-to-date widely used search engines for the analysis of interdisciplinary, peer-reviewed literature [31]. A list of key topic terms such as “waste”, “waste disposal”, “solid waste”, “municipal solid waste”, “waste management”, “solid waste management”, “municipal solid waste management”, and “South Africa” was developed and to cover contemporary times, the search focused on peer-reviewed literature published between 2003 and 2022 in order to cover a relatively comprehensive set of publications.

An initial 887 documents were retrieved, and their potential for inclusion in the final categorisations was evaluated based on the title and abstract. However, in some situations where titles and abstracts provided inadequate information, a full-text review was undertaken, and only publications mentioning municipal solid waste management were selected, leaving 287 articles. Our goal in this article was to highlight the current state of municipal solid waste management, and if there are duplicate results in the various search results, the categorisation was based on the principal issue discussed in these publications. Following a document screening process in which papers that did not suit the focus of our discussion were discarded, 75 articles were chosen for review in this study. It should be emphasised that the literature analysis done in this study was thorough but not exhaustive and that while Google Scholar covers a wide spectrum of academic literature, it does not cover every peer-reviewed publication, so significant publications may have been overlooked.
THE SOUTH AFRICAN STATE OF SOLID WASTE MANAGEMENT

(32) Indicates that South African cities’ waste management systems are inefficient and lack public participation. (33) Observed that despite the system of collecting, transporting and disposal of municipal solid waste by municipal authorities from the streets of Joe Slovo, open space dumping and littering in a most unhygienic manner is rife. In South Africa, municipal solid waste generated per capita in the township is 0.2 - 0.8kg per capita per day, suburban is 0.8 - 3kg per capita per day, and informal settlement < 0.2kg per capita per day (34). In simpler words, South Africans daily dispose of municipal solid waste that can fill an entire football field to a height of 10 metres, and each person generates up to 2.5 kilograms of waste per day, on average, depending on his or her level of income (35).

INSTITUTIONAL ASPECTS OF SOLID WASTE MANAGEMENT IN SOUTH AFRICA

The solid waste management structure is multi-faceted and complex, therefore the need for a distinctive institutional framework that will allocate responsibilities for the design and implementation of the various tasks are required. (33) Recommended that the government facilitate the system and establish institutions to effectively and efficiently handle solid waste management. The government sets up the institutional system of solid waste management in South Africa to enact laws and policies for protecting the environment (34), and the business of solid waste disposal, monitoring, and implementation is laid on the local municipalities (36). Table 1 summarises the functions of solid waste institutions in South Africa as provided by the National Waste Management Strategy. It is the statutory responsibility of the municipalities to provide and maintain the services and infrastructure within their jurisdiction, and as opined by (21), (38); the institutions involved in the management of solid waste must undergo SWOT analysis, which will allow stakeholders to determine the sectors that need to be consolidated. As (39) indicated, one vital step towards improving solid waste management is the recognition and upgrading of the profession of waste workers, while (40) and (41) recommended training and retraining motivation and incentives for waste management workers. South Africa continues to prioritise the waste management sector, with considerable attention being given to the sector by its government (42).

Table 1: Institution and their roles and responsibilities in solid waste management

<table>
<thead>
<tr>
<th>Level of government</th>
<th>Role and responsibility in SWM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local/Municipal government</td>
<td>i. providing and setting of local standards for waste removal, separation, disposal services and additional bins for separation at source; ii. working with stakeholders to extend recycling at the municipal level; iii. diverting organic waste from landfills and composting it; iv. designate a waste management officer to coordinate waste management matters; v. design an IWMP plan in line with the municipal integrated development plans (IDPs); vi. register transporters of waste above certain thresholds on a list of waste transporters.</td>
</tr>
<tr>
<td>Provincial government</td>
<td>i. regulate waste activities except for those assigned by law to the Minister. ii. promote and ensure the implementation of the NWMS and national norms and standards. iii. designate a provincial waste management officer to coordinate provincial waste management issues. iv. formulate a Provincial IWMP and an annual performance report on its implementation, both of which must be submitted to the Minister for approval. v. setting provincial norms and standards and establishing a provincial waste information system. vi. after consultation with DEA, providing a harmonised regulatory environment for national waste management and exercising discretionary powers where clear and compelling reasons exist.</td>
</tr>
<tr>
<td>National government</td>
<td>i. In particular, the Department of Environmental Affairs (DEA) is ultimately responsible for ensuring that the Waste Act is implemented and that the various provisions are harnessed most appropriately and effectively. The Waste Act specifies various mandatory and discretionary provisions that DEA must address. ii. In terms of mandatory provisions, DEA is responsible for establishing the National Waste Management Strategy, National Contaminated Land Register, National Waste Information System and setting national norms and standards. iii. Preparing and implementing a National Integrated Waste Management Plan.</td>
</tr>
</tbody>
</table>

GENERATION OF MUNICIPAL SOLID WASTE

(44) As shown in Table 2, established that waste generation per capita has a strong correlation with a country’s gross domestic product (GDP). The volume of waste generated by an individual per day in a country is the per capita waste generation, which generally increases with GDP growth. South African average per capita waste generation is 2.95kg/day (35). The population of an area is directly proportional to the waste generated, and as a confirmation, the City of Johannesburg is indicated to produce the largest volume of municipal waste of 1 492 000 tonnes per annum (45). Also, Table 3 shows that high income generates the highest kilogramme per capita per day.

Table 2: Comparison of per capita of municipal solid waste generations per country’s income status

<table>
<thead>
<tr>
<th>Country income level</th>
<th>Per capita urban municipal solid waste generation (kg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1999</td>
</tr>
<tr>
<td>High-income countries</td>
<td>1.1-5.07</td>
</tr>
<tr>
<td>Middle-income countries</td>
<td>0.52-1.1</td>
</tr>
<tr>
<td>Low-income countries</td>
<td>0.45-0.9</td>
</tr>
</tbody>
</table>

Table 3: Comparison of per capita of municipal solid waste generations in South Africa per income status

<table>
<thead>
<tr>
<th>Region</th>
<th>Low Income</th>
<th>Middle income</th>
<th>High Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Africa</td>
<td>0.41</td>
<td>0.74</td>
<td>1.29</td>
</tr>
<tr>
<td></td>
<td>0.2-0.7</td>
<td>0.7-1.9</td>
<td>1.5-3.0</td>
</tr>
<tr>
<td>City of Johannesburg</td>
<td>0.38</td>
<td>0.66</td>
<td>0.99</td>
</tr>
<tr>
<td>Limpopo</td>
<td>0.32</td>
<td>0.4</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Among the nine South African provinces, Gauteng generates the highest volume of municipal solid waste at approximately 45%, Western Cape 20%, Mpumalanga 10%, KZN 9%, while the remaining 26% are shared by the other provinces (50), (51) (see Figure 6).

Figure 6: Waste generation of South African provinces

Source 45
COMPOSITION OF MUNICIPAL SOLID WASTE IN SOUTH AFRICA

The characterisation of solid waste in South Africa is documented by many authors, among which are [37] [52] [53] [54], but that of [54] is presented in Figure 7. The largest contribution to waste was 'other' at 35%, and it is a combination of biomass from paper and pulp industries as well as sugar mills and next to this is organic wastes at 16%, construction and demolition waste (13%), scrap metals (8%) and commercial and industrial waste (7%). General municipal waste only accounts for 4% of the total general waste, as organic, paper, plastic, glass, scrap metal, and tyre wastes were reported separately where possible (see Figure 7).

Efforts for house-to-house collections are made by the municipalities in most suburbs [58], [59], while the larger portion of recycled waste is collected by the recyclers, mostly after disposal by the municipality at the landfill sites [60], [61].

The extent of waste recyclables collected by the informal sector preceding the collection by the municipality is undocumented. [62] Reports that only 10% of waste collected is recycled, and such are accessed at transfer stations and dumps. Meanwhile, the handling of waste by the workers is carried out without adequate protective measures or precautions (see Figure 10), which can lead to them contacting and spreading communicable and non-communicable diseases, as observed by [63]. The system of community bin collection, which is handled by the municipality where available, is positioned either at awkward locations or the designs do not meet the required needs; hence, it overflows (see Figure 11). Besides, some of the waste transporting vehicles are also not designed properly for the task, and they sometimes become waste *dispersals* during their waste collection activities.

Although the municipalities are not resting on their lorries in waste collection services, some have engaged independent contractors to transport waste from communal stations to the disposal sites. In contrast, others have further engaged CBOs/FBOs/NGOs to administer segregation and collection from the source of generation to the point of collection [32], [64], [65], [52].

[32] reported a 17.8 % growth in the budget expenditure of the Metros’ for solid waste services between 2006/07 and 2009/10. Approximately $1.21 million US was spent between 2013-2016 for the collection, transportation and disposal of waste and of which only 30% were spent on disposal and the remainder on collection and transportation [66]. However, R1 billion is budgeted in 2021 to enhance accountability for the management of waste and specifically for the development of a Waste Economic Master Plan, fund the development of a new tyre waste industry plan, and review producer responsibility regulations [67].

With so many high budgetary provisions, little or no funds are being allocated for the scientific discarding of waste, as reported by [66]. Besides, even with the high allocation and outflow, the current service level in most urban centres could become a potential risk to the quality of the environment as well as the public health [28].

Several studies on the urban environment have disclosed that the efficiency of waste collection is a function of personnel availability and transportation [68], [69], [70]. [65] Indicated that the typical collection efficiency of municipal solid waste in South African cities and provinces is less than 60%. Furthermore, with the generation of roughly 95 MT of waste, according to [71], the waste collection vehicles require a transportation capacity of 266 million cubic metres, which may not be available with the combined capacity of the municipal vehicles and that of private contractors.

Despite the efforts of the various institutions and various municipalities towards well-equipped waste management practices in response to the National Environmental Management: Waste Amendment Act (NEMWA) 2014 (Act 26 of 2014), over 60% of municipal solid waste collected is still landfilled [48] and these impact the public health, deteriorate the quality of life and pollute the environment within a 2–3 km radius.

WASTE COLLECTION AND TRANSPORTATION ISSUES IN SOUTH AFRICA

Solid waste is collected at the household level in a plastic bin bag in most urban areas [32], [55], [56], while large complexes have storage bins [57] for solid waste like that Figure 8. The bins are for decomposable and non-decomposable waste, as no waste separation is done. In the townships, waste is mostly disposed of in open sites, as shown in Figure 9.

With many high budgetary provisions, little or no funds are being allocated for the scientific discarding of waste, as reported by [66]. Besides, even with the high allocation and outflow, the current service level in most urban centres could become a potential risk to the quality of the environment as well as the public health [28].
DISPOSAL METHODS AND FACILITIES AVAILABLE IN SOUTH AFRICA

The NEMWA came into force in 2014, but the research emanating from South African urban centres as indicated by (72) still puts the level of compliance for zero waste at very low. (73) Estimated that the methane emissions from South African landfills are between 0.2-0.4 Tg/year, aside from the immeasurable smoke emission from these sites and the individual informal incineration.

Also, a higher percentage of municipal solid waste is disposed of into unsanitary landfills or open land, as revealed in Figure 12.

In many municipalities/ urban centres, existing landfill sites are filling up, and there is no plan for a new acquisition. Landfills pollute the aquifer and ground asides from the pollution from greenhouse gas emissions and other organic aerosols (74). South Africa is reported to send approximately 95 million tonnes of waste to its 826 landfills, and less than 40% of the waste is recycled, according to analysts at Research & Markets (75). (71) Also added that only 6% out of an upward of 65 million tonnes of hazardous waste is produced is recycled.

Sanitary landfilling as a waste disposal method appears to continue to be a widely embraced practice in South Africa (36), (75), (76), (63), (77), (178). Reports that the scientific inclinations of such landfill sites are questionable, polluting the aquifer, atmosphere and soil. Also, waste workers carry on their duties mostly without adequate protective measures making them prone to various diseases (80). There are only three (3) composting sites in South Africa, with two (2) located in Cape Town, Western Cape Province (81) and one in the City of Johannesburg, Gauteng province (82).

CHALLENGES ASSOCIATED WITH MUNICIPAL SOLID WASTE MANAGEMENT IN SOUTH AFRICA

Presently, the management of solid waste by the municipalities is a challenge as it continues to litter roadways, low plains and vacant fields, open drains and sewer openings, among others, creating a serious public environmental and health nuisance apart from its unesthetic view. In addition, animals that feed on them consume both biodegradable and polyethylene waste risk a serious health hazard. Although waste management is a front burner for the South African government at all levels, they are still challenged by:

- All forms of municipal waste of whatever type is disposed of unsegregated at the source and packed into one bin, hence complicating the management process (74); (85); (84);
- Continuous population growth is expected to stimulate more waste generation, and hence the burden of waste management and other civic duties by the municipalities will continue to be a challenge (85); (86);
- Although there is a policy for integrated waste management (ISWM); however daily increase in and population, changing lifestyles, increase in income, and consumerism continues to grow the increased per capita waste generation at an unplanned rate (30); (65);
- There is no legislation for beneficial waste disposal and treatment in residential properties/neighborhoods from the planning stage; hence the landfills are getting filled, and there is difficulty in locating new ones (87); (88);
- Low priority is given to waste management by civic organisations and bodies; therefore, they do not prioritise it in their programmes and plans. These groups could do better as they usually are closer to the communities in their operations (89); (90);
- Involvement of social responsibility regarding waste management is very low, and citizens dispose of waste haphazardly in vacant lots, outside overflowing bins, and road kerbs, increasing collectors’ works (40); (91); (92). In addition, when such waste is cleared, new waste is dumped in a few days. Therefore, the situation is made worse by the low social education and public apathy towards this task.

Figure 12: Landfill site

WASTE DISPOSAL

Waste is expected to be disposed of only at designed landfills where it will not leach and contaminate the soil. Unharmful decomposable waste could be treated at the source by converting it into manure, while small quantity recyclables could be given directly to scavengers and or recyclers to recycle.

Also, new techniques and methods such as converting waste to bio-energy (e.g. use of biomethane gas for cooking and electricity) can be implemented in pilot programmes. Some hitherto landfill sites such as Walmer E and Chris Hani in Port Elizabeth (94) are reported to have methane gas deposits, which could be harnessed. Also, waste collection and transportation equipment should be upgraded.

PUBLIC/PRIVATE PARTICIPATION PARTNERSHIP

The government at all levels by legislation can introduce charges grounded on the ‘Polluters Pay Rule’ taxing citizens for waste management processes. However, faith-based organisations (FBOs), community-based organisations (CBOs), non-governmental organisations (NGOs) and other civic organisations can be encouraged towards taking this role and responsibility for holistic management, or they can transfer skills to the people themselves using the Public/Private Participation Programme (PPP) approach.

PROPOSED APPROACHES FOR THE ENHANCEMENT OF THE SOUTHERN AFRICAN MUNICIPAL SOLID WASTE MANAGEMENT SYSTEM

ENHANCEMENT OF THE WASTE MANAGEMENT COLLECTION SYSTEM

[93] underscored the significance and importance of the role of the informal system in municipal solid waste management in South Africa. Since the local government/municipalities have a vital responsibility as per the National Waste Management Strategy, they should consider the management and regulation of this sector, which will, aside from enhancing the efficiency of urban solid waste collection, provide job opportunities and better protection for the waste collectors. Furthermore, the collection of recyclable waste could be easily applied in South Africa by developing the existing collection by waste scavengers and waste buyers to offer a low-cost workforce that can embark on recycling practices rather than the municipal government expending a lot of resources on such.

ENCOURAGING SEPARATION AT THE SOURCE TOWARDS RECYCLING

The future holds a major challenge for waste recycling and minimisation if the current practices continue unabated. However, the proposed driving force to solve this, is the consideration of the separation of waste systematically from the source. Waste separation is a vital element of an effective and efficient waste management structure that could enhance energy minimisation and reduce labour inputs to any downstream.

Being a multi-dimensional subject which transcends technological solutions, and needs environmental, socio-economic, legal, cultural and institutional influences to function, the municipality should seek a path to find solutions to their diverse challenges. It is vital to seek reliable and dependable data that will help decision-makers be well informed to develop policies that will adapt to the desires of the citizens’ socio-economic state. Besides this the institutions of higher learning have a vital role in preparing experts and technicians in the waste management field. Furthermore, more investment must be made into the research and education geared towards the status of solid waste workers, citizens responsibilities and having cleaner cities.

PUBLIC/PRIVATE PARTICIPATION PARTNERSHIP

The government at all levels by legislation can introduce charges grounded on the ‘Polluters Pay Rule’ taxing citizens for waste management processes. However, faith-based organisations (FBOs), community-based organisations (CBOs), non-governmental organisations (NGOs) and other civic organisations can be encouraged towards taking this role and responsibility for holistic management, or they can transfer skills to the people themselves using the Public/Private Participation Programme (PPP) approach.
CONCLUSION

The encouragement of the cities towards waste separation and further marketing it to the informal network is a reliable option that will enhance the involvement of the citizens as well as the private sector through the NGO/FBO/CBOs and could improve waste efficiency. Waste littering should be prohibited in towns, cities, and other urban centres, and the masses are sensitised that they can reduce the health hazards induced by dangerous waste disposal methods. Waste bins must be suitably designed to waste littering should be proscribed in towns, cities, and other urban centres and the masses are sensitised that they can reduce the health hazards induced by dangerous waste disposal methods. Waste bins must be suitably designed to appropriately tasks, jurisdiction, authorities, and capacity to empower the various government levels and clarify the roles that they should play.

In conclusion, the study identified the lack of resources that borders on planning, data, funding, and infrastructure as the key challenge of managing waste in urban South Africa. In addition, the increased service demands coupled with lean resources in the municipalities are putting an enormous strain on the existing waste management systems.

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A STUDY OF THE KNOWLEDGE, PERCEPTIONS AND COMMITMENT OF MANAGEMENT PERSONNEL ON CONSTRUCTION SITES TOWARDS THE CONSTRUCTION REGULATIONS 2014

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ABSTRACT

PURPOSE

This study evaluates managers’ knowledge, perceptions, and commitment within construction firms in South Africa towards the Construction Regulations 2014. This study further aimed to identify the differences in responses between management personnel and construction workers within construction firms. The responses from the construction workers were mainly required for an objective assessment of the responses given by management.

DESIGN

An empirical research approach was adopted and the study employed a quantitative method of data collection analysed using IBM Statistical Package for Social Sciences (SPSS) version 25. Descriptive statistics were used to analyse the data and further interpreted using inferential statistics. Cronbach’s Alpha reliability test was used to determine the internal consistency of the constructs. Furthermore, Spearman’s correlation and independent t-test were conducted to determine the correlations and statistical significance of the constructs.

FINDINGS

The findings from management and construction workers revealed that there was a small correlation between management commitment and knowledge of health and safety (H&S) legislation, there was no statistical significance between the two constructs. Furthermore, management was not fully committed to applying all aspects of the construction regulations to improve construction workers wellbeing. The findings further indicate a need for more knowledge of H&S legislation and management commitment.

VALUE

The paper bridges the gap between the literature pertaining to the knowledge of H&S legislation, perception of the workforce and the organisational commitment towards regulatory compliance in the South African construction industry.

Keywords: H&S, Legislation, Workers Wellbeing, Management Commitment
INTRODUCTION

The Occupational H&S Act (OH&S) 85 of 1993, "requires the employer to provide and maintain as far as is reasonably practicable a working environment that is safe and without risks to the health of workers and to take such steps as may be reasonably practicable to eliminate or mitigate the hazard or potential hazard." In response to the staggering rate of fatalities in the construction industry, the Construction Regulations 2003 under the OH&S Act 85 [1] assigned H&S responsibility to stakeholders: clients, designers and quantity surveyors [2]. The regulations were seen to have had an impact by increasing awareness in the industry [3]. However, Muri [4] argues that H&S requirements set out to protect workers are often overlooked by management. Furthermore, to achieve optimum H&S during all project stages, the regulations needed to be amended [3]. Therefore, developments in the field of construction H&S led to the revision of the Construction Regulations 2003 (CR 2003) [5] to the Construction Regulations 2014 (CR 2014) [6].

The promulgation of the CR 2014 instead of the CR 2003, places stringent H&S responsibilities on all project stakeholders [7]. Despite the enactment of the CR 2014, the CIDB contents that the South African construction industry has a rate of compliance with H&S requirements of less than 50% accompanied by unacceptably high rates of incidents as a result of poor workmanship, and a lack of proper supervision on site [8]. Some accidents are attributed to lack of commitment and awareness by clients and managers of the H&S requirements, poor leadership by H&S officers, perceptions and a poor attitude towards enforcement procedures by senior management, inadequate communication, and inadequate training [8].

Currently, there is little or no evidence suggesting the improvement of workers' quality of life and sustainability of the construction workforce. The primary focus of constructors is on compliance with the regulations to avoid fines and to avoid construction activities stopped as a result of non-compliance [9], [10], [11], [12], [13]. Other reasons for compliance have been attributed to profit maximisation and satisfying the requirements of the Department of Labour or the Department of Public Works [9], [10], [11], [12]. Improving construction workers' quality of life goes beyond just providing PPE, ticking checkboxes and securing projects [11], [12]. This study explores management's knowledge, perception and commitment of management towards the CR 2014 to improve construction workers' wellbeing. The study further compares the responses given by management to those reported by construction workers about management commitment and identifies the level of knowledge by both respondents. Responses from the construction workers were required to objectively assess the responses from management. The study makes an assumption that workers do not form part of decision making in the implementation of the regulations on site.

LITERATURE

There is a considerable amount of literature on construction accidents. In comparison to other industries, construction is believed to have one of the highest fatalities [14], [15], [16], [17], with the South African construction industry experiencing at least 1.5 to 2.5 fatalities and most deaths per week of all industries [7] and similarly, the US construction industry [14]. Construction accidents and fatalities emanate from ignorance regarding regulations and requirements, culture to complete projects as cheaply as possible, and inadequate commitment to enforcement by managers [13]. Furthermore, "where enforcement is necessary, it is often not pursued. Equally, when practised, the penalties are so small that enforcement is no longer an effective deterrent" [13:5]. Several studies have revealed that H&S knowledge positively influences organisational commitment and the perception of workers improving H&S culture and H&S awareness [18], [19], [20], [21].

Furthermore, some other factors have been attributed to the low-price bidding culture associated with the traditional tendering system, which does not encourage sufficient provision of H&S requirements and promotes low wages in the industry [4], [13]. Consequently, results in a lack of provision for PPE, lack of workers' insurance and the influx of informal workers for whom no tax or social security are paid [4]. Although procurement methods significantly improve workers' H&S, the most common procedure for awarding tenders in developing countries is through competitive tendering by the government [22], [23]. This procurement method encourages contractors to keep their prices low, compromising the quality of welfare facilities affecting labour as it is among the critical cost items [23]. Furthermore, "changes to the regulatory regime will help, but on their own will not be sufficient unless we can change the culture away from one of doing the minimum required for compliance, to one of taking ownership and responsibility for delivering a safe system throughout the life cycle of a building [24:2]." Therefore, it is inferred that H&S regulatory compliance is conceived as a derivative of safety knowledge and organisational commitment, which positively influence the employees' perception.

THE IMPACTS OF CONSTRUCTION REGULATIONS

Although the impacts of Construction Regulations are unquantifiable, they have positively affected the reduction of accidents. The Construction Regulations have had a desired upstream, midstream and downstream impact [25]. The intent of the Construction Regulations has helped create general awareness and requirements for H&S for all those involved in the construction work; however, various practical problems have been pointed out [26]. Despite the perceived contributions made by the Construction Regulations, there is still a need for further improvement of overall H&S [26]. Therefore, H&S should not be driven solely by legislation but must be seen as a value [27]. Management commitment is essential to the overall realisation of H&S compliance in the workplace [27].

Matete et al. [28] conducted a 5-point Likert scale ranking to determine contractors' perceptions of the construction regulations. Based on the findings, most respondents agreed that the CR should promote H&S compliance in the industry (mean=4.63). Although there was a high level of agreement for compliance, few industry role players were familiar with the CR 2014 (mean=2.93), and respondents seemed more familiar with the CR 2003 (mean=4.17) despite some respondents agreeing that the CR 2014 realised notable revisions and requirements (mean=3.77). However, it is unclear how more respondents realised significant modifications and requirements (mean=3.77) even though fewer were familiar with the CR 2014 (mean=2.93). The regulations are not improving H&S in all project phases and therefore, it should be mandatory for all construction companies to become fully compliant on the clients' database and 'not on paper only' [29]. Compliance with H&S legislation requires a combination of building site type and site managers' attitudes [29]. South Africa does not lack occupational H&S legislation. However, occupational H&S should not be driven solely by legislation but must be regarded more as a value [3], [30]. The construction industry requires more than just legislation to make it safer; it requires knowledge, commitment and change in perception towards safety [26].

METHODOLOGY

An extensive literature review included online databases, books, articles, reports and other studies. Furthermore, a quantitative study was employed and data were analysed using IBM Statistical Package for Social Sciences (SPSS) version 25. Descriptive statistics was adopted for the data analysis and further interpreted using inferential statistics. The total sample size for the study was 120 participants (80 managers and 40 construction workers) where a total of 80 contractors (civil and building) in the Kwa-Zulu Natal province were conveniently sampled based on proximity and familiarity. The response rate for the study was 78.3%. A total of 64 managers (as representatives of the companies) and 30 construction workers completed closed-ended questionnaires. Cronbach's Alpha reliability test help determine the internal consistency of the constructs used to identify the knowledge, perception and commitment of management towards the construction regulations 2014 to improve construction workers' wellbeing and the internal consistency of the various scales was deemed acceptable for interpretation. In addition, an Independent t-test was done to determine the statistical significance of the means between management and construction workers' responses with a further Spearman's correlation to identify the relationship between the constructs.

PROFILE OF THE RESPONDENTS

The median age for managers was 35 years ranging from 22 years minimum to 55 years maximum. The median years of experience were 6.5 years ranging from a minimum of 2 years to a maximum of 20 years. The median years of experience was suggested that managers were knowledgeable in most aspects of the construction industry. Most respondents were H&S Managers/Officers (29.7%) followed by Civil Engineers (23.4%) and Quantity Surveyors (21.9%). The respondents had either obtained a technical/vocational or university education.

Furthermore, 32.8% of the respondents had obtained their qualifications from technical/vocational schools, and the other respondents obtained their qualifications from universities, 67.2%. The median age of the construction workers was 33.5 years ranging from 26.0 years to 43.0 years and the median years of experience were 6.0 years with a minimum of 3.0 years and a maximum of 20 years. 62% of the workers (60%) were employed as artisans with different trades skills. Moreover, 33.3% of the construction workers had obtained junior high school certificates while 30.0% obtained their Matric/OLevel and 36.7% had technical/vocational training qualifications.
FINDINGS AND DISCUSSIONS

DATA INTERPRETATION

Table 1 presents the data interpretation range based on the 5-point Likert scales used in the study. The group interval coefficient value for the 5-point Likert scale was calculated as (5) /3 = 1.67. For further ease of interpretation, the mean values for the 5-point Likert scale were interpreted as; high, medium and low.

<table>
<thead>
<tr>
<th>Range</th>
<th>Knowledge Scale</th>
<th>Frequency Scale</th>
<th>Agreement Scale</th>
<th>Ease of interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.00 - 3.34</td>
<td>Excellent</td>
<td>Always</td>
<td>Strongly Agree</td>
<td>High (H)</td>
</tr>
<tr>
<td>3.33 – 1.68</td>
<td>Good</td>
<td>Often</td>
<td>Agree</td>
<td>Medium (M)</td>
</tr>
<tr>
<td>≤1.67</td>
<td>Average</td>
<td>Sometimes</td>
<td>Neutral/Unsure</td>
<td>Low (L)</td>
</tr>
<tr>
<td></td>
<td>Poor</td>
<td>Seldom</td>
<td>Disagree</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Strongly Disagree</td>
<td></td>
</tr>
</tbody>
</table>

RELIABILITY

The Cronbach’s Alpha coefficients between 0.70 ≤ α ≥ 0.80 were considered ‘acceptable’ while between 0.80 ≤ α ≥ 0.90 were considered ‘good’ and coefficients 0.9 ≤ α were ‘excellent’. Therefore, the internal consistency of the various scales was deemed acceptable for further interpretation:

Table 2 Summary of Reliability Statistics

<table>
<thead>
<tr>
<th>Construct</th>
<th>Management</th>
<th>Construction workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of construction H&amp;S legislation</td>
<td>Cronbach’s Alpha</td>
<td>Reliability</td>
</tr>
<tr>
<td></td>
<td>0.85</td>
<td>Good</td>
</tr>
<tr>
<td>Perception about the Construction Regulations onsite</td>
<td>0.75</td>
<td>Acceptable</td>
</tr>
<tr>
<td>Management commitment</td>
<td>0.81</td>
<td>Good</td>
</tr>
</tbody>
</table>

Reliability was acceptable across all the scales used, and further analysis of the results was conducted.

KNOWLEDGE OF CONSTRUCTION H&S LEGISLATION

Table 3 presents 5-knowledge based statements where respondents had to rate their knowledge of existing H&S legislation in the construction industry using a 5-point Likert scale where 1 = Poor, 2 = Fair, 3 = Average, 4 = Good and 5 = Excellent.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Management</th>
<th>Construction Workers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Knowledge of OH&amp;S Act 85 of 1993</td>
<td>3.77</td>
<td>1.16</td>
</tr>
<tr>
<td>Knowledge of Construction Regulations 2014</td>
<td>3.50</td>
<td>1.17</td>
</tr>
<tr>
<td>Knowledge of Construction Regulations 2003</td>
<td>3.38</td>
<td>1.21</td>
</tr>
<tr>
<td>Knowledge of COID Act 130 of 1993</td>
<td>3.27</td>
<td>1.17</td>
</tr>
<tr>
<td>Knowledge of the SA Constitution</td>
<td>3.05</td>
<td>1.10</td>
</tr>
</tbody>
</table>

MANAGEMENT:

The results in Table 3 indicated that the managers were most knowledgeable about the Occupational H&S Act 85 of 1993, Knowledge of the Construction Regulations 2014 and 2003 was ranked second and third, respectively. It is also evident that the respondents had high knowledge of the three legislations (means range between 3.77 and 3.38) and a medium knowledge of two legislations (means range between 3.27 and 3.05). Although management seemed knowledgeable about the relevant H&S legislation, it is expected that management must become more knowledgeable on the subject than what the findings suggested. Therefore, there is a need for managers to gain more knowledge of H&S legislation.

CONSTRUCTION WORKERS:

In Table 3, the construction workers’ knowledge of the Construction Regulations 2014 and knowledge of OH&S Act 85 of 1993 were ranked high and considered good (mean values were 3.48 and 3.35). However, knowledge was medium for the three statements COID Act 130 of 1993; the Construction Regulations 2003; and the SA Constitution (means range between 3.23 and 3.16). From the findings, it may be inferred that although construction workers were somewhat knowledgeable in some aspects of legislation, there is a need for more knowledge of construction H&S legislation.

Perception towards the Construction Regulations Onsite

In Table 4 The respondents were asked to indicate their level of agreement in relation to their perception towards the construction regulations using a 5-point Likert scale where 1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree and 5=Strongly Agree.

Table 4 Perception towards the Construction Regulations Onsite

<table>
<thead>
<tr>
<th>Statements</th>
<th>Management</th>
<th>Construction Workers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Lack of adequate H&amp;S provision negatively impact other project parameters</td>
<td>4.14</td>
<td>0.79</td>
</tr>
<tr>
<td>Infringement of the construction regulations poses a threat to workers wellbeing and sustainability in the construction industry</td>
<td>4.13</td>
<td>1.08</td>
</tr>
<tr>
<td>The application of amended Construction Regulations 2014 has a positive impact on the overall quality of construction labourers' H&amp;S of construction workers</td>
<td>4.05</td>
<td>.79</td>
</tr>
<tr>
<td>Construction Regulations 2003 has a positive impact on the overall health and wellbeing of construction labourers</td>
<td>3.92</td>
<td>1.01</td>
</tr>
<tr>
<td>Construction Regulations clearly define legal parameters on how to improve workplace H&amp;S for workers</td>
<td>3.89</td>
<td>.76</td>
</tr>
<tr>
<td>Contractors are fully committed to improving the H&amp;S of construction workers through Construction Regulations 2014</td>
<td>3.79</td>
<td>.86</td>
</tr>
<tr>
<td>Contractors are applying all aspects of Construction Regulations to improve the health and wellbeing of construction workers</td>
<td>3.73</td>
<td>.91</td>
</tr>
<tr>
<td>Contractors Regulation 2014 are perceived to have a positive impact on the reduction of construction workers fatalities</td>
<td>3.73</td>
<td>.88</td>
</tr>
<tr>
<td>Contractors register with COID because they care about labourers’ wellbeing</td>
<td>3.42</td>
<td>.92</td>
</tr>
<tr>
<td>The impacts of construction regulations 2014 have not been determined to date</td>
<td>3.16</td>
<td>.87</td>
</tr>
</tbody>
</table>

The application of amended Construction Regulations to improve the health and wellbeing of construction workers’ has a positive impact on the overall quality of construction labourers’ H&S of construction workers through Construction Regulations clearly define legal parameters on how to improve workplace H&S for workers. Construction Regulations 2003 has a positive impact on the overall health and wellbeing of construction labourers. The application of Construction Regulations 2014 has a positive impact on the overall quality of construction labourers’ H&S of construction workers. Infringement of the construction regulations poses a threat to workers wellbeing and sustainability in the construction industry. Lack of adequate H&S provision negatively impact other project parameters.
MANAGEMENT:

From Table 4, it is evident that most managers expressed high levels of agreement that lack of adequate H&S provisions negatively affected other project parameters (mean = 4.14). It could also be argued that respondents believed that H&S were not entirely significant. Managers also had high agreement levels that infringement of the regulations negatively affected workers’ wellbeing and sustainability (mean = 4.13). The mean value suggested that not all respondents agreed that compliance has had a positive impact on workers’ wellbeing and sustainability. Furthermore, there was a high level of agreement that the application of the Construction Regulations 2014 and 2003 has had a positive impact on workers’ wellbeing (mean = 4.05 and 3.92, respectively). The contractors were committed to improving workers’ wellbeing with the application of the Construction Regulations 2014 (mean = 3.79), noted by the high level of agreement. However, it could be argued that contractors were not fully committed to improving workers’ wellbeing by applying all aspects of the Construction Regulations as full commitment would have resulted in full agreement with the statement. The Construction Regulations were perceived to have had a positive impact (mean=3.73) on the reduction of accidents, however, the mean suggests contractors were not applying all aspects of the construction regulations based on their level knowledge of the legislation observed in Table 3.

CONSTRUCTION WORKERS:

The majority of the construction workers had high levels of agreement that lack of adequate H&S negatively affected other project parameters (mean = 4.00). They further conveyed a high level of agreement that the regulations clearly defined legal parameters on how to improve H&S, and how infringement of the regulations has detrimental effects on wellbeing (mean=3.90 and 3.87). Furthermore, the workers had high levels of agreement that contractors were fully committed to improving their wellbeing and also registered with COID because they cared about their wellbeing (mean = 3.77 and 3.57). The construction workers gave a medium level of agreement on whether the regulations have had any positive impact on accident reduction; and whether contractors applied all aspects of the construction regulations to improve their wellbeing (means were 2.80 and 2.60). It was evident from the findings that contractors were not fully committed to improving construction workers’ wellbeing on site. Both management and construction workers similarly conceded that the lack of adequate H&S provisions had a negative impact on other project parameters. The respondents had further agreed that the regulations set clear legal parameters on improving workers’ H&S and that contractors were fully committed to improving workers’ wellbeing. However, the responses from both management and construction workers did not suggest that contractors were fully committed to improving the H&S of construction workers through the application of the construction regulations 2014. Ensuring full commitment would have been reflected by an excellent response and not merely a good response as indicated by the mean value. The respondents shared the same views on DoL’s involvement in ensuring full compliance with the regulations; contractors’ commitment to improving workers’ wellbeing; registration with COID, and also that the construction regulations established a general awareness on safety.

MANAGEMENT COMMITMENT

The respondents were requested to indicate their level of agreement on management commitment and attitudes towards the Construction Regulations 2014, based on a 5-point Likert scale where 1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree and 5=Strongly Agree. Under Table 4, the participants were presented with 11-statements on management commitment to H&S legislation and their attitudes towards the Construction Regulations 2014.

Table 5 Management Commitment

<table>
<thead>
<tr>
<th>Statements</th>
<th>Management</th>
<th>Construction Workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) workers possess medical certificates of fitness</td>
<td>Mean: 4.36</td>
<td>Mean: 3.98</td>
</tr>
<tr>
<td>The firm employs trained H&amp;S staff on site</td>
<td>SD: 1.10</td>
<td>SD: 0.86</td>
</tr>
<tr>
<td>H&amp;S inspections are done regularly and at least daily</td>
<td>Intr: H</td>
<td>Intr: H</td>
</tr>
<tr>
<td>The head office management ensures compliance with CR 2014 for wellbeing</td>
<td>Rank: 1</td>
<td>Rank: 1</td>
</tr>
<tr>
<td>The head office management are intolerant of poor construction H&amp;S</td>
<td>Mean: 3.91</td>
<td>Mean: 3.86</td>
</tr>
<tr>
<td>The head office management insists on the elimination of hazards by complying with CR</td>
<td>Mean: 3.86</td>
<td>Mean: 4.00</td>
</tr>
<tr>
<td>The construction workers’ wellbeing is important to the head office management</td>
<td>Mean: 3.72</td>
<td>Mean: 3.00</td>
</tr>
<tr>
<td>The firm penalizes workers for poor H&amp;S practices on site</td>
<td>Mean: 3.55</td>
<td>Mean: 3.80</td>
</tr>
<tr>
<td>Management consults with the H&amp;S committee, representative union or representative group of employees, on the monitoring and reviewing of the risk assessments of a specific site</td>
<td>Mean: 3.45</td>
<td>Mean: 3.33</td>
</tr>
</tbody>
</table>

**MANAGEMENT:**

Table 5 indicates a high level of agreement that all workers had medical certificates of fitness; firms employed competent H&S staff as stipulated in the construction regulations, and firms conducted H&S inspections at least once daily (means ranged from 4.36 to 4.13). Although workers possessed medical certificates, there was a reduction in the mean value for the validity of medical certificates even though the response rate was still high (mean=3.98). There was also a high level of agreement that head office ensures commitment with the regulations; were intolerant of poor H&S practices, and insisted on hazard elimination (means range between 3.92 to 3.86).

Although there was a high level of agreement that construction workers’ wellbeing was important to management, the statement was not the highest ranking as would have been expected (mean=3.72). This is suggestive that management merely complies because it is a requirement by law but does not fully commit to H&S practices such as promoting workers’ wellbeing. It was also found that workers were penalised for poor H&S practices (mean = 3.55). Although still high ranking, there was a lower level of agreement concerning the consultation of H&S committees; representative unions or representative group of employees, on the monitoring and reviewing of the site-specific risk assessments (mean=3.45). There was a medium level of response for construction workers being rewarded for good H&S practices on site (mean=2.72) over and above the finding that they were penalised for poor H&S practices. There is a need for more management commitment to improve workers’ wellbeing.

**CONSTRUCTION WORKERS:**

The data in Table 5 suggested that the construction workers had a high level of agreement that firms employed trained H&S staff and had medical certificates of fitness (means range between 4.47 and 4.23). There was also a high level of agreement that head office medical ensured compliance with the regulations; insisted on hazards elimination and further agreed that they were penalised for poor H&S practices (means ranged between 4.13 and 3.80). Furthermore, there was a high level of agreement about daily H&S inspections, even though inspections were not carried out sufficiently (mean=3.47). Workers had valid medical certificates and head office management was intolerant of poor H&S (both means were 3.40), as indicated by the high agreement level though still far less than satisfactory. There, however, was a medium response whether management consulted with the H&S committees; representative unions or representative group of employees, on the monitoring and reviewing of the site-specific risk assessments (mean=3.33).
Workers also gave a medium response whether management cared for their wellbeing (mean=3.00) and disagreed that they were rewarded for good H&S practices on site (mean=2.57). From these findings, it is suggestive that construction workers’ H&S are still not prioritised.

It could be argued from the findings in Table 5 that construction workers, who are physically on-site, did not view inspections as sufficient enough. Further similarities indicated that workers possessed medical certificates of fitness, although they were not all valid. Also, construction workers’ level of agreement was very low compared to that of management. There seemed to be a lack of consensus between what the managers reported and what the workers reported, which further suggested a lack of commitment by management. Workers were not consulted in reviewing site-specific risk assessments and of significance was the fact that workers were almost unsure whether head ofﬁce management cared about their wellbeing.

Furthermore, an independent t-test was conducted (Table 7) to determine the statistical signiﬁcance of the composite means among management was high for all constructs. The composite mean for construction workers was high for Knowledge of Legislation, Perception towards the Construction Regulations Onsite and Management Commitment. The interpretation of the strength of association was determined as follows: Small Correlation = 0.1<r>0.3: Medium/moderate Correlation = 0.3<r>0.5: Large/strong correlation r>0.5.

**MANAGEMENT COMMITMENT:**

In comparison, the high composite means suggest that there is no statistically signiﬁcant difference between the means for management (mean=3.62, SD=0.62) and construction workers (mean=3.81, SD=0.80); t (46) = 1.170, p=.248. The findings suggest that both respondents share similar views regarding management commitment to improving workers’ wellbeing. However, based on the lower mean values, it is evident that full commitment is still not engendered.

**PERCEPTION:**

Although management expresses a high level of agreement that contractors apply all aspects of the construction regulations to improve workers’ wellbeing, the construction workers express a lower medium level of agreement (mean=3.78, SD=0.43 and mean=3.33, SD=0.67, respectively). There is a statistically signiﬁcant difference between the two groups means, t (40.72) = 3.269, p<0.002; suggesting that management and workers do not statistically share the same views on the level of compliance with legislation onsite. However, the construction regulations are perceived to have had a positive impact on increasing awareness, although both parties highly agree that their impact on accident reduction are yet to be realised. This ﬁnding is in line with the literature ﬁndings that, “Although it cannot be quantiﬁed, it can be inferred that the Construction Regulations have had a positive impact on reducing H&S accidents” [6:11]. Furthermore, [12] regulations and legislation are key in directing and controlling activity; improving the responsibility of business owners and H&S [12]. The less than excellent mean values suggests that the impact of the Construction Regulations 2014 has not been fully realised. It may be inferred that the low level of compliance negatively affects the impact of the construction regulations and workers’ wellbeing.

**KNOWLEDGE OF LEGISLATION:**

Comparatively, there is a high level of agreement for managers’ knowledge (mean=3.39, SD=0.91), while the construction workers have a medium knowledge (mean=3.26, SD=0.90) about the relevant construction H&S legislation. There is no statistically signiﬁcant difference between the means, t(92) = .651, p=.516; suggesting that both managers and workers have the same level of knowledge of construction H&S legislation. From Table 4, of signiﬁcance is the fact that knowledge of legislation ranked the lowest for both management and construction workers. Ideally, both respondents are expected to be very knowledgeable (especially management) about legislation and not merely high or medium knowledge. It may be inferred that both management and construction workers’ possess knowledge about the relevant H&S legislation even though this knowledge is less than satisfactory; therefore, there is a need for more education and training. A study conducted by Matete, Emuze & Smallwood [16] about the Construction Regulations reported similar ﬁndings.

**SPEARMAN’S CORRELATION**

Spearman’s rank-order correlation (rho/rs) was used to measure the strength and direction of association/relationship between the constructions: Knowledge of Legislation, Perception and Management Commitment. The interpretation of the strength of association was determined as follows: Small Correlation = 0.1<r>0.3: Medium/moderate Correlation = 0.3<r>0.5: Large/strong correlation r>0.5.
ACKNOWLEDGEMENTS

The authors much acknowledge the support of the National Research Fund (NRF).

REFERENCES


ABSTRACT

PURPOSE

Masonry construction in South Africa is jeopardized by several factors, such as the use of poor-quality materials, sub-standard building and design practices, and poor-quality building workmanship. Among these, the most common deficiency is poorly prepared and sub-standard mortar paste. This paper investigates in situ practices that commonly contribute to poor-quality mortar.

DESIGN/METHODOLOGY/APPROACH

This paper reports on a qualitative study conducted in South Africa aiming to identify deficiencies that result in poor quality of fresh and hardened mortar. Data was collected from nine (9) purposefully selected construction sites. A mortar preparation checklist was used to assess the quality of the mortar as it was being prepared.

FINDINGS

While the results were obtained at KwaZulu Natal construction sites and cannot be assumed to be common practice in South Africa, the study nevertheless indicated a lack of enforcement of standards which can contribute to poor quality of mortar.

VALUE

The study identifies some common sub-standard practices that contribute to poor quality mortar. The deficiencies can be avoided by complying with and enforcing the mortar preparation standards.

Keywords: Sand cement mortar, Masonry, Masonry construction standards, Mortar constituents
BACKGROUND AND INTRODUCTION

Numerous factors jeopardize masonry construction in South Africa, including the use of substandard materials, substandard building design and practices, and substandard building workmanship. Among these deficiencies, the most prevalent is improperly prepared and substandard mortar paste. This article examined in situ practices that frequently result in poor-quality mortar.

Mortar is a workable paste that binds together the individual masonry units\(^1\). It provides protection against the infiltration of air and water through the joints. Mortar ingredients, which include sand, cement, and water, play unique roles in the functions of mortar. The primary function of sand in mortar is to increase the volume of mortar for economic reasons. The sand needs to be included as an accurate quantity (mass/volume) to produce cheap mortar without compromising the strength of mortar. Contamination of sand with other constituents (such as plant material, oils, etc) at source such as river bank and/or storage facility affects the quality of mortar. In South Africa, sand can be mined directly from the river beds and sold without being evaluated and graded for its suitability for the intended purpose. It may therefore be nonconforming with various South African National Standards.

SANS 1090 recommends careful considerations during the proportioning of mortar mixes, to achieve all the desired properties of both fresh and hardened mortar. Inspection and test methods\(^2\) exist for assessing certain parameters applicable to sand, namely, grading and fineness modulus; dust content, methylene blue adsorption, clay content, organic impurities, soluble deleterious impurities and drying shrinkage of a mix. The client needs to specify the quality of fine aggregate they want according to class of sand (i.e. natural or manufactured) and the intended purpose. If large batches are required, there needs to be an agreement between the supplier and the client prescribing the grading method and the acceptable parameters for the fineness modulus. Verification is required on delivery, in the form of a document, which will state the type and class of fine aggregate\(^3\).

The cement is a water-based binder which holds fine aggregates together. Various types of cements, including cements used for masonry, are used in South Africa. Cements are made according to compulsory standards, which makes it illegal to supply cement that does not meet the requirements of the relevant national standard. South African cements may therefore be assumed to be conforming to the relevant standard specifications on leaving accredited factory. The quality of cement may, however, deteriorate if it is exposed to water either in liquid or vapour form while being stored. Cements should therefore be handled and stored in a way that ensures that there is no water or air is minimised, and the length of time between cement manufacture and cement use should be kept as short as possible\(^4\).

Both SANS 50197-1/EN 197-1 and SANS 50413-1 are referenced in the Compulsory Specification for Cement, as published by Government Notice No. R. 544 (Government Gazette No. 30023) of 6 July 2007 (page 4). The standard requires that all cement packaging should be marked in accordance with the requirements of Annexure B\(^5\) of the standard. A legally binding standard in the South African construction industry applicable to suppliers of cement stipulates that it is a criminal offence to sell cement that is not SABS approved.

South Africa has several test procedures in place, published by the South Africa Bureau of Standards (SABS). SABS has the function of testing and certifying products and services to ensure they comply with standards. Furthermore, SABS develops and enforces compulsory technical specifications, which are based on national standards. The standards that are used throughout the masonry construction industry comprise of technical specifications (standard methods) and the Act passed by the National Parliament (National Building Regulations and Building Standards Act No. 103 of 1977) has the power to declare certain standards as compulsory. This implies that materials, products and designs not complying with the Act would not be allowed. Additionally, the Act includes reference to the various standards that make up the only compulsory standard in the South African construction industry is that for cement\(^6\). The lack of obligatory technical assessments or standardisation of all building materials allows for substandard materials, products and designs to exist.

Water in mortar controls both fresh and hardened properties. Fresh properties of mortar influence hardened properties, that is, the stiffer the fresh mortar is, the more difficult it will be to paste and manoeuvre it around mortar. This results in poor-quality mortar joints. Water is sourced from different sources, including municipal supplies, boreholes, rivers and harvested rainwater. SANS 2001-CM1 requires that water used to mix mortar shall be fit for drinking\(^7\). SANS 241-1 refers to qualities of drinking water in terms of physical, chemical and microbiological characteristics that water considered fit for drinking must have undergone careful consideration of the aforementioned characteristics\(^8\). Guidelines issued by the Department of Water Affairs & Forestry\(^9\), also supports both the later published SANS 241-1 and World Health Organization Guidelines, with respect to water used for domestic purposes, thus impacting on that used to mix mortar. Testing and assessing of water includes the evaluation of various elements such as: iron, suspended solids, etc. Other tests are, electrical conductivity, oxygen absorption, chemical oxygen demand, and pre-treatment for metal analysis. Careful selection of materials and quantities includes using the correct amount of water for a mix to promote a strong enough bond and desired durability.

LITERATURE

There are statutory bodies, such as the National Home Builders Registration Council (NHBRC), which set out technical requirements with respect to design and construction rules. Adhering to them enables a home builder to comply with NHBRC standards. NHBRC sends out inspectors that have the primary function of ensuring compliance with building standards\(^10\). Engineers plan and build complex structures to fulfil functional objectives and specifications while taking into account the constraints imposed by practicality, regulation, safety and expense\(^11\). Some masonry failures are attributed to negligence, ignorance, or mere oversight. The failures include those applicable to cladding and/or walls which are assembled by mortar\(^12\).

Building materials need to be assessed for suitability of intended purpose, then purchased, sometimes stored prior to use, gauged according to specification, mixed, placed and finished. Ingredients need to be gauged by either volume or batching. Volume batching is generally used on small jobs as it simply requires containers for measuring but presents uncertainties associated with bulking. The method has inherent inaccuracy when measuring granular material in terms of volume since the volume of dried compacted sand weighs much more than the volume of moist sand in a loose condition. The effect of bulking is not often considered for moist fine aggregates. If a wheelbarrow is used to gauge materials, it should be wheelbarrows used for civil engineering purposes\(^13\). The pan capacity has an impact as it is gauged against an accurate packed/weighted pocket of cement. Weigh batching is not so popular in small jobs, although it offers accuracy, flexibility and simplicity, as it requires measuring using costly measuring equipment. The benefits of it being more accurate and leading to more uniform proportioning.

Well-mixed mortar will be homogeneous and uniform in colour\(^14\). Although hand mixing is a common practice for small-scale inconsequential mortar works, it is indeed used on important masonry construction works because a mosaic must mix mortar that will be used and finished within two hours\(^15\). As much as the method may be popular, it is commonly understood that hand mixing cannot always be thorough and efficient\(^16\).

Often, this newly made mix needs to be retempered. Retempering is the process of adding water to mortar after it has started to stiffen to lessen it up and restore lost workability. This is aggravated by scheduled construction breaks, such as tea and lunch times. Other causes for retempering are repositioning/resetting of working scaffolding, cutting of masonry to fit the requirements for the wall(s) being constructed, and other unforeseen causes. Retempering usually has an effect on the compressive strength and workability of mortar\(^17\). The compressive strength of retempered mortar is reduced in proportion to the age of retempering\(^18\). Materials should use time constraints to determine the acceptability of mortar rather than attempting to guess whether mortar is unworkable due to water evaporation or cement hydration\(^19\).

Poor workmanship is a key factor in the causes of building defects or failures, and it affects many residential houses\(^20\). Poor workmanship is closely linked to: the lack of effective and efficient communication, inadequate or lack of understanding of given information/details, failure to verify given instructions/information, inadequate monitoring and supervision of work undertaken, incompetent technical skills and expertise, and inadequate or total lack of feedback resulting in recurring errors. Furthermore, lack of experience and competency of labourers is the most significant contribution to poor workmanship\(^21\). On analysis, correlation test results indicated that this can be mitigated by providing adequate training and education to labourers such as masons, in the case of South Africa. The poor quality of workmanship in construction of masonry structures generally results in inferior mortar walling and mortar joints that occasionally necessitate investigation to decide whether or not the structure is sound\(^22\).

SANS 2001-CM1 on Masonry Walling\(^23\) requires that for Category-1 construction, compressive strength tests for construction control purposes are carried out in accordance with the procedure laid down in Clause 6.1 with regards to preliminary laboratory mortar testing. This recommendation would enable material problems to be identified early while there is still time to rectify them. In addition, regular testing of the mortar used on site is carried out in accordance with the procedure laid down in Clause 6.2 (page 41-42) and SANS 6292\(^24\), with respect to works mortar tests. This involves three test cubes being prepared for every 150 m\(^2\) of wall in which a single grade of mortar is used, or for every storey of the building, whichever gives the greater frequency of testing (SANS 2001-CM1:55). Category-II construction\(^25\) is assumed where the requirements for Category-I construction control are not complied with.

Cemex Mortars\(^26\) presents four types of mortar testing aimed at production control, performance, compliance and forensic investigations. The latter involves investigating problems in order to resolve disputes by conducting chemical analysis of hardened mortar for cement or air content.
The most common method used in South Africa for testing the strength of hardened mortar is by determining the cement-content, which involves extracting samples by coring through mortar joints of existing masonry walls, using any method of extracting hardened mortar through joints. Samples are crushed to a fine powder, followed by chemical analysis of insoluble residue to determine quantities of soluble silica and lime content. Control samples are often required. However, if these are not available, it is simply a matter of analysing these for the same limits when the cement content can be determined by simple proportion. If control samples are not accessible, then sensible assumptions regarding their composition must be made. Cement content can be assessed within plus or minus 15 % or better.

Poor quality often results in defects and/or failures, whereas good quality assumes no defects and/or failures. However, a clear separation between what constitutes good and poor quality needs to be established. Good quality comes at a cost because there are essential requirements for achieving quality mortar. Quality should be measured and managed as it determines fitness for purpose, or conformance to or meeting requirements. The latter could be managed, whereas the former is achieved through conformance to or meeting requirements. Requirements can be defined, communicated and measured for conformance. Mortar quality is a measure of the fitness of mortar to fulfil the intended purpose defined in the specifications. Therefore the outcome of measurement can either be satisfactory or unsatisfactory. The requirements for mortar are generally communicated through standards, codes of practice and construction drawings.

The Construction Industry Development Board raised some concerns, involving non-compliance with national standards. The following are described:

- Poorly specified building projects, artisans and foremen in the field of work that they are unqualified for/or they do not possess the skills necessary for the work;
- Failure of small-scale manufacturers to comply with the requirements of a specification, thus compliance with SABS standards cannot be appealed.
- Small scale entrepreneurs' perception that many of the current specifications are a barrier to entry and exclude their participation in particular markets.
- As a result of these, some clients are not demanding that materials comply with SANS standards, leading to a persistence in poor materials being used.
- And lastly, the incapable or incompetent building inspectors who are incapable of properly conducting compliance assessments.

To support the truth or value of the above, the ingredients for producing mortar must be assessed for deficiencies, as well as associated sub-standard practices.

**METHOD**

**OBJECTIVE**

The objective of the study was to determine common and/or correlating deficiencies in the production of mortar.

**DATA COLLECTION METHOD**

The data was collected from nine (9) construction sites. The permission was granted by the appointed consulting engineer to use the technician running the projects to make observations and record findings in line with the checklists provided. The author’s trained technicians in advance and supervised them continuously throughout data collection to ensure that site observations and data collection were conducted and collected (respectively) in a consistent and accurate manner. Mortar mixes were frequently done at different times and locations, as well as concurrently at multiple locations. As a result, where it was unavoidable, the technician’s sole responsibility was to collect data. Site visits were aligned to the construction schedule, and no mortar used in the construction of masonry elements or components was evaluated more than once. Allowance was made for data collection to be spread out to facilitate greater participation from skilled/unskilled labour.

**LIMITATION OF THE STUDY**

The paper presents an indication of what could be happening in the South African masonry construction industry with respect to production quality of mortar. The results reported in this paper do not represent an exhaustive study of practices in the South African construction industry. The authors wanted to get an indication of what could be occurring at other construction sites. Another limitation is the fact that the study was only conducted a few KwaZulu Natal projects.

**MORTAR PREPARATION CHECKLIST**

Table I presents properties that were investigated during the structured field study. Observations were conducted in natural settings. The foreman/supervisor was requested to inform the author every time they were going to lay bricks so the evaluator could observe site practices. Table I is adapted from Structural Concrete Masonry: A Design Guide showing only activities relevant to this study.

<table>
<thead>
<tr>
<th>Item</th>
<th>Property to be checked</th>
<th>Test method requiring technical knowledge</th>
<th>Non-sophisticated testing method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortar Sand</td>
<td>Contamination</td>
<td>Visual check on type and cleanliness</td>
<td></td>
</tr>
<tr>
<td>Grading</td>
<td></td>
<td>SANS 1090 and SANS 201</td>
<td></td>
</tr>
<tr>
<td>Cement</td>
<td>General quality</td>
<td>Look for the SABS mark</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contamination by moisture</td>
<td>Visual examination for lumps in cement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Age at time of use</td>
<td>Check site records</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>Purity</td>
<td>SANS 51008 and SANS 163-1</td>
<td>Smell the water. Check for cloudiness, particles and the colour.</td>
</tr>
<tr>
<td></td>
<td>Mix proportions</td>
<td>Accuracy of volume and/or mass batching method or equipment during batching</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mixing time and conditions of mixing equipment</td>
<td>Uniform distribution of ingredients by visual examination</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Consistency</td>
<td>Visual check</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Retempering</td>
<td>Measurement of time interval between addition of water and use of mortar</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Colour</td>
<td>Visual examination</td>
<td></td>
</tr>
</tbody>
</table>

All ingredients for making mortar and fresh mortar were assessed for the following properties: contamination of sand, general quality of cement, contamination of cement by moisture, age of cement at the time of use, purity of water, mix proportions of ingredients, mixing time and conditions of mixing equipment, consistency of the mix, retempering of mortar, and colour of mortar. 14 evaluations were made on each site shown in Table II. The Likert scale was used to measure the attitude of the assessor by evaluating the extent to which they agreed or disagreed to a particular statement that measured whether a particular aspect complied with the code.

The data collection process was spread out by limiting each site visit to one or two per week. The projects selected had at least three independent teams responsible for executing specific portions of the building. The projects used masonry subcontractors for mixing and laying masonry units. This allowed an opportunity to investigate how at least of three subcontractor team members prepare sand cement mortar. In conclusion, although nine sites (n = 9) were investigated, strictly speaking, in view of the actual number of teams engaged in mixing mortar was at least twenty-seven (n = 27).
RESULTS AND DISCUSSION

STATEMENT OF FINDINGS, INTERPRETATION AND DISCUSSION OF THE DATA

The questionnaire was the primary tool that was used to capture data and was used on nine (9) construction sites, fourteen times (14). The data collected from the responses was analysed with SPSS version 25.0. The results present the descriptive statistics in the form of graphs, cross tabulations and other figures, for the quantitative data that was collected. Inferential techniques include the use of correlations and chi square test values, which are interpreted using the p-values. In total, 126 questionnaires were despatched and 126 were returned, which gave a 100% response rate. The research instrument consisted of 10 items, with a level of measurement at a nominal or an ordinal level. One item in Table 1, grading of sand was not investigated as the data could not be obtained without violating the characteristics of ethnographic research.

RELIABILITY STATISTICS

The two most important aspects of precise operation (in this case evaluation of mortar preparation and application) are reliability and validity. Reliability was computed by taking several measurements on the same subjects, and a reliability coefficient of 0.50 or higher is considered as “acceptable” for a newly developed construct. It is acknowledged that the number of accurate readings is limited, and a rigorous statistical analysis, for that reason, cannot be carried out. The analysis presented is what would have been done on a more extensive dataset.

Although, Cronbach’s alpha score for all the items that constituted the questionnaire yielded 0.444. Values greater than 0.4 are considered acceptable[1]. A KMO value greater than 0.5 and a significance level for the Bartlett’s test less than 0.05 indicate that the data are highly correlated. The reliability scores for all sections approximate the recommended Cronbach’s alpha value of 0.500 for a newly developed construct. This indicates a degree of acceptable, consistent scoring for this section of the research.

The matrix table was preceded by a summarised table that reflects the results of KMO and Bartlett’s Test. The requirement is that Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy should be greater than 0.50 and Bartlett’s Test of Sphericity should be less than 0.05. In all instances, the conditions were satisfied which allowed for the factor analysis procedure. Factor analysis was done only for the Likert scale items, certain components divided into finer components. This is explained below in the rotated component matrix.

---

**Table II. Nine (9) sites where field studies observations were conducted by Technicians**

<table>
<thead>
<tr>
<th>Site name</th>
<th>Site description and project construction cost in million (M)</th>
<th>Number of evaluations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Construction of a new double story school (35 M)</td>
<td>14</td>
</tr>
<tr>
<td>2</td>
<td>Construction of classrooms and hostels (20 M)</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>Construction of a new double story school (16 M)</td>
<td>14</td>
</tr>
<tr>
<td>4</td>
<td>Construction of 6 Flats in a Township (3 M)</td>
<td>14</td>
</tr>
<tr>
<td>5</td>
<td>Construction of a double garage (0.15 M)</td>
<td>14</td>
</tr>
<tr>
<td>6</td>
<td>Construction of a double garage and a granny flat (0.2 M)</td>
<td>14</td>
</tr>
<tr>
<td>7</td>
<td>Construction of rental units (0.5 M)</td>
<td>14</td>
</tr>
<tr>
<td>8</td>
<td>Construction of a concrete infill retaining walls (0.1 M)</td>
<td>14</td>
</tr>
<tr>
<td>9</td>
<td>Construction of multi-storey offices (200 M)</td>
<td>14</td>
</tr>
</tbody>
</table>

---

**Table III. KMO and Bartlett’s Test**

<table>
<thead>
<tr>
<th>Component</th>
<th>Number of items</th>
<th>KMO</th>
<th>Bartlett’s Test of Sphericity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contamination of sand</td>
<td>4</td>
<td>0.542</td>
<td>0.091</td>
</tr>
<tr>
<td>Contamination of cement by moisture</td>
<td>4</td>
<td>0.194</td>
<td>0.646</td>
</tr>
<tr>
<td>Age of cement at the time of use</td>
<td>4</td>
<td>0.110</td>
<td>0.771</td>
</tr>
<tr>
<td>Purity of water</td>
<td>4</td>
<td>0.127</td>
<td>0.169</td>
</tr>
<tr>
<td>Mix proportions of ingredients</td>
<td>4</td>
<td>0.559</td>
<td>0.196</td>
</tr>
<tr>
<td>Mixing time and conditions of mixing equipment</td>
<td>4</td>
<td>0.082</td>
<td>0.035</td>
</tr>
<tr>
<td>Consistency of the mix</td>
<td>4</td>
<td>0.338</td>
<td>0.087</td>
</tr>
<tr>
<td>Retempering of mortar</td>
<td>4</td>
<td>0.032</td>
<td>0.144</td>
</tr>
<tr>
<td>Colour of mortar</td>
<td>4</td>
<td>0.783</td>
<td>0.068</td>
</tr>
</tbody>
</table>

**Table IV. Rotated Component Matrix**

<table>
<thead>
<tr>
<th>Component</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contamination of sand</td>
<td>0.542</td>
<td>-0.076</td>
<td>0.091</td>
<td>0.291</td>
</tr>
<tr>
<td>Contamination of cement by moisture</td>
<td>0.194</td>
<td>0.151</td>
<td>0.646</td>
<td>-0.097</td>
</tr>
<tr>
<td>Age of cement at the time of use</td>
<td>0.110</td>
<td>0.065</td>
<td>0.771</td>
<td>0.059</td>
</tr>
<tr>
<td>Purity of water</td>
<td>0.127</td>
<td>0.680</td>
<td>0.169</td>
<td>0.079</td>
</tr>
<tr>
<td>Mix proportions of ingredients</td>
<td>0.559</td>
<td>0.447</td>
<td>0.296</td>
<td>-0.043</td>
</tr>
<tr>
<td>Mixing time and conditions of mixing equipment</td>
<td>0.082</td>
<td>0.246</td>
<td>-0.355</td>
<td>0.575</td>
</tr>
<tr>
<td>Consistency of the mix</td>
<td>0.338</td>
<td>0.722</td>
<td>0.087</td>
<td>-0.080</td>
</tr>
<tr>
<td>Retempering of mortar</td>
<td>0.032</td>
<td>-0.129</td>
<td>0.144</td>
<td>0.848</td>
</tr>
<tr>
<td>Colour of mortar</td>
<td>0.783</td>
<td>-0.071</td>
<td>0.068</td>
<td>-0.063</td>
</tr>
</tbody>
</table>

**Extraction Method:** Principal Component Analysis.

**Rotation Method:** Varimax with Kaiser Normalization.

---

With reference to the Table IV:

- The principle component analysis was used as the extraction method, and the rotation method was Varimax with Kaiser Normalization. This is an orthogonal rotation method that minimizes the number of variables that have high loadings on each factor. It simplifies the interpretation of the factors.
- Factor analysis/loading show inter-correlations between variables.
- Items of questions that loaded similarly imply measurement along a similar factor. An examination of the content of items should be less than 0.05. This indicates a degree of acceptable, consistent scoring for this section of the research.
- All of the conditions are satisfied for factor analysis. That is, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy value should be greater than 0.500 and the Bartlett’s Test of Sphericity sig. value should be less than 0.05.

---
The contamination of sand, the proportions of ingredients in the mix, and the colour of mortar are all related as suggested by the study's findings. Early in the study, a review of the literature established a foundation of knowledge regarding the importance of ensuring that: (1) sand is not contaminated prior to receiving or being delivered; (2) ingredient proportions are carefully calculated and gauged; and (3) colour of mixed mortar is consistent\[1\]. Construction site practices failed to ensure that aggregates are inspected for cleanliness, size, colour, and contamination and also that aggregates are transported, handled, and stored in a manner that minimizes fines loss; foreign material contamination; and prior to use, all necessary equipment is cleaned\[2\]. The article identified that these in situ practices frequently result in poor-quality mortar. This is in addition to risk factors such as the use of substandard materials, substandard construction and design practices, and substandard building workmanship.

When superior materials, superior building designs, and superior building workmanship are used in construction, mortar is made with cements and mix proportions that impart inherent durability. When considering concrete's durability, the constituents and proportions of the mortar mix are guided by the desire to minimize the concrete's permeability and maximize its chemical resistance to aggressive agents in the surrounding environment. Various input parameters, such as mix proportions are critical since they are used to estimate the service life and life-cycle costs of reinforced concrete structures\[3\]. It is commonly accepted that the best indicator of thorough mixing is the consistency of the colour and texture of mortar and it should therefore be mixed until the consistency, colour, and texture are uniform\[3\]. Ingredients (cement and sand) are not always combined to a uniform colour on a non-absorbent surface.

The purity of water and consistency of the mix are all related as suggested by the study's findings. Purity of water is a concern because, despite the fact that municipal water is used, the containers are not always cleaned after being used for other purposes. Visual inspection is critical, including smelling the water and checking for cloudiness, particles, and colour. SANS 2001-CM1 recommends that the water used to mix mortar be of a similar quality to that used for human consumption\[3\]. The study found that water becomes contaminated several times prior to use at storage points (water containers or buckets), which are located between the municipal connection point and the point of use. There is a quality control system in place to ensure the water used in construction is of high quality if municipal water is being used. However, there are construction sites that lack municipal water, and it is the client's or owner's, or contractor's responsibility to ensure that they meet and exceed the municipal standard. All sites in this study used municipal water. SANS 241-1 defines drinking water quality in terms of microbiological, physical, aesthetic, and chemical determinants and specifies that water deemed suitable for drinking must take these values into account\[4\].

The contamination of cement by moisture and age of cement at the time of use are all related as suggested by the study's findings. Certain contractors, constructors, and builders appear not to understand that cement has a short shelf life due to its hygroscopic nature, which means it absorbs moisture. Through a process called hydration, water causes the mortar to harden. The chemical reaction in which the major constituents of cement form chemical bonds with water molecules, result in the formation of hydrates or hydration products. This property of cement necessitates that it be used prior to its 'best before' date to ensure a long-lasting structure. Cement has a three-month shelf life\[5\]. Cement also decays due to pathological factors such as the atmospheric environment and operating conditions. Cement deteriorates rapidly during the monsoon. However, cement begins to degrade after approximately three months. It is recommended that cement be used within three months of its packaging. If cement is required after three months of manufacture and packaging, it should always be tested using a variety of different cement tests.

The study's findings indicate that the mixing time and conditions of mixing equipment and retempering of mortar are all related and suggestive. Mortar began to lose some of its properties as the time interval between mixing and use increases. Weather conditions can have an effect on how mortar reacts and how manageable it is. Summer's heat and winds during the project's construction accelerate the drying process. Retempering, the process of adding water to mortar to restore its workability, becomes necessary to maintain the proper condition of the mortar for laying masonry. Masons retempered mortar on the mortar board. This was done typically by dribbling water into the mortar pile and then reworking it with a towel or shovel. This replenished the water lost through evaporation. It maintained the mortar's plasticity, allowing units to be laid and positioned within it. Additions of water to mortar are permitted only if time constraints have not been exceeded (beginning from the initial introduction of water). When water and cement come into contact, a delay occurs before hydration, or the chemical reaction between the cement and water, begins. The situation is exacerbated by the fact that masons do not use time constraints to determine whether mortar is workable due to water evaporation or cement hydration\[6\]. A general recommendation is to limit the useful life of a mortar to two hours after water is introduced, but this can be reduced in hot or dry weather. Mortar that has seen better days should be discarded. Of course, good practice also includes adjusting the mortar quantities to match the mason's pace and preventing the mortar from evaporating moisture. This may entail covering the mortar on the board, working during cooler hours of the day, or storing the mortar in a covered tub.

<table>
<thead>
<tr>
<th>Description</th>
<th>Never use</th>
<th>Unsuitable to use</th>
<th>Unsure</th>
<th>Suitable to use</th>
<th>Good to use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour of mortar</td>
<td>6.3</td>
<td>18.3</td>
<td>10.3</td>
<td>34.9</td>
<td>30.2</td>
</tr>
<tr>
<td>Retempering of mortar</td>
<td>25.4</td>
<td>21.4</td>
<td>8.7</td>
<td>16.7</td>
<td>27.8</td>
</tr>
<tr>
<td>Consistency of the mix</td>
<td>0.0</td>
<td>4.0</td>
<td>15.9</td>
<td>34.9</td>
<td>45.2</td>
</tr>
<tr>
<td>Mixing time and conditions of mixing equipment</td>
<td>24.6</td>
<td>16.7</td>
<td>3.2</td>
<td>19.8</td>
<td>35.7</td>
</tr>
<tr>
<td>Mix proportions of ingredients</td>
<td>0.0</td>
<td>0.8</td>
<td>26.2</td>
<td>41.3</td>
<td>31.7</td>
</tr>
<tr>
<td>Purity of water</td>
<td>0.0</td>
<td>3.2</td>
<td>16.7</td>
<td>31.0</td>
<td>49.2</td>
</tr>
<tr>
<td>Age of cement at the time of use</td>
<td>0.8</td>
<td>1.6</td>
<td>1.6</td>
<td>7.1</td>
<td>88.9</td>
</tr>
<tr>
<td>Contamination of cement by moisture</td>
<td>0.8</td>
<td>3.2</td>
<td>2.4</td>
<td>12.7</td>
<td>81.0</td>
</tr>
<tr>
<td>General quality of cement</td>
<td>4.8</td>
<td>8.7</td>
<td>4.0</td>
<td>19.0</td>
<td>63.5</td>
</tr>
<tr>
<td>Contamination of sand</td>
<td>9.5</td>
<td>7.9</td>
<td>4.8</td>
<td>48.4</td>
<td>29.4</td>
</tr>
</tbody>
</table>

Figure I. Mean values.

Some statements show (significantly) higher levels of “Good to use” / “Suitable to use” whilst other levels of good/suitable use are lower (but still greater than levels of unsuitable use). Figure 1 represents the results by mean values.

<table>
<thead>
<tr>
<th>Table V. Scoring patterns</th>
<th>Colour of mortar</th>
<th>Retempering of mortar</th>
<th>Consistency of the mix</th>
<th>Mixing time and conditions of mixing equipment</th>
<th>Mix proportions of ingredients</th>
<th>Purity of water</th>
<th>Age of cement at the time of use</th>
<th>Contamination of cement by moisture</th>
<th>General quality of cement</th>
<th>Contamination of sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never use</td>
<td>6.3</td>
<td>25.4</td>
<td>0.0</td>
<td>24.6</td>
<td>0.0</td>
<td>0.0</td>
<td>0.8</td>
<td>0.8</td>
<td>4.8</td>
<td>9.5</td>
</tr>
<tr>
<td>Unsuitable to use</td>
<td>18.3</td>
<td>21.4</td>
<td>4.0</td>
<td>16.7</td>
<td>0.8</td>
<td>3.2</td>
<td>1.6</td>
<td>3.2</td>
<td>8.7</td>
<td>7.9</td>
</tr>
<tr>
<td>Unsure</td>
<td>10.3</td>
<td>8.7</td>
<td>15.9</td>
<td>3.2</td>
<td>26.2</td>
<td>16.7</td>
<td>1.6</td>
<td>2.4</td>
<td>41.3</td>
<td>4.8</td>
</tr>
<tr>
<td>Suitable to use</td>
<td>34.9</td>
<td>16.7</td>
<td>34.9</td>
<td>19.8</td>
<td>41.3</td>
<td>31.0</td>
<td>7.1</td>
<td>12.7</td>
<td>49.2</td>
<td>31.7</td>
</tr>
<tr>
<td>Good to use</td>
<td>30.2</td>
<td>27.8</td>
<td>45.2</td>
<td>35.7</td>
<td>31.7</td>
<td>49.2</td>
<td>88.9</td>
<td>81.0</td>
<td>63.5</td>
<td>29.4</td>
</tr>
</tbody>
</table>

Some statements show (significantly) higher levels of “Good to use” / “Suitable to use” whilst other levels of good/suitable use are lower (but still greater than levels of unsuitable use). Figure 1 represents the results by mean values.

**DEMOGRAPHIC DATA**

There were 14 respondents from each of the 9 sites.

**SECTION ANALYSIS**

The section that follows, analysed the scoring patterns of the respondents per variable per section. The results were first presented using summarised percentages for the variables that constitute each section, and further analysed according to the importance of the statements. Table V summarises the scoring patterns.
The objective of this paper was to look at in situ practices that may result in substandard mortar. This is in addition to a number of other factors threatening masonry construction in South Africa, particularly in KwaZulu Natal, where the study was conducted. Substandard building materials, building and design practices, and construction quality are all current concerns. The Construction Industry Development Board had expressed concerns about non-compliance with National Standards, which led to this study. Among many concerns are poorly specified building projects, artisans and foremen that are inadequately qualified or unqualified or they do not possess the skills necessary for the work.

The study identifies four trends, including 1) sand contamination, which affects the colour of mortar and ingredient mix proportions, which also affect the colour of mortar. 2) The purity of the water has an effect on the mortar's consistency and 3) moisture contamination of cement and the cement's age at the time of use. The expected result of storing cement for a longer period of time increases the amount of time cement is exposed to a humid environment. Clearly, this effect is anticipated to be significant in KwaZulu Natal, because the ambient air humidity in this province is higher than in many other parts of landlocked provinces. 4) Mixing time and equipment conditions affect retempering of mortar. This means that mixing mortar too soon before use increases the likelihood that it will require to be retempered. Additionally, if the mixing equipment is in poor condition due to leakage or inability to contain water, the likelihood of the mortar needing to be retempered increases.

Although there was one negative value which implied an inverse relationship, that is, the variables have an opposite effect on each other, it did not make logical sense, for example, the shorter the mixing time and conditions of mixing equipment, the better the general quality of cement.

CONCLUSION AND RECOMMENDATION

The construction industry still has a great deal of work to do. The only mandatory standard in the South African construction industry to date is that for cement. Due to the absence of mandatory technical evaluations or standardisation of all building materials, substandard materials, products, and designs exist. Excellent quality comes at a cost, as there are certain requirements for producing high-quality mortar. Quality should be measured and managed because it is what determines fitness for purpose, conformance to, and compliance with requirements.

The statutory bodies and the South African government should conduct thorough investigations into ongoing deficiencies and take necessary and appropriate measures to mitigate and/or rectify them by providing and promoting education and awareness about masonry construction materials and National Standards. Furthermore, the National Standards should be enforced.

ACKNOWLEDGEMENTS

We thank the appointed consulting engineer who allowed the first author to use technicians running the projects to make observations and record findings. It allowed him an opportunity to learn more about the activities that happen on a construction site, as well as identifying deficiencies that would otherwise be impossible to identify if the labours were not made aware of these.

Other critical issues identified by the study that require immediate attention include the use of contaminated sand in mortar mixing. Additionally, the mixing time was not scheduled effectively and efficiently in light of the environmental effects (rain or high temperatures). Equipment for mixing is not always in good condition. The procedure for retempering mortar does not adhere to recommended National Standards. The ingredients for mortar are not always thoroughly mixed before water is added, and the mix is not always thoroughly mixed after water is added, resulting in a non-homogeneous and non-uniform colour. Contaminated sand results in a mortar that is heterogeneous. This is to be expected in KwaZulu Natal and the majority of South Africa, as sand can be extracted directly from river beds and sold without being evaluated and graded for suitability for the intended purpose. If sand does not conform to South African National Standards, then mortar will not conform, resulting in masonry structural elements that do not conform to South African National Standards.

The following relationships were identified:

- “Mixing time and mixing equipment conditions” and “mortar retempering.” The longer the time interval between mixing and using mortar, the more likely it will require to be retempered, and vice versa.
- “Sand contamination” and “mortar colour.” The more contaminated the sand, the more likely it will exhibit inconsistency in colour, and vice versa. Contamination can occur as a result of the presence of other materials and/or substances.
- “Moisture contamination of cement” and “cement age at time of use.” The longer cement remains in storage, the more likely it will become contaminated by water, and vice versa.
- The “proportions of ingredients in the mix” and the “colour of the mortar.” The more inconsistent the proportions of the mix, the more likely the mortar will vary in colour (between batches), and vice versa. A lack of cement equates to a lack of strength.
- “Ingredient proportions for mixing” and “mixing equipment conditions.” The dirtier the mixing equipment becomes from prior mixes, such as cement clots, the more likely the proportions of materials in the mix will be affected.

CORRELATIONS

Bivariate correlation was also performed on the (ordinal) data. Positive values indicate a directly proportional relationship between the variables, and a negative value indicate an inverse relationship. All significant relationships are indicated below:

- The correlation value between “mixing time and conditions of mixing equipment” and “retempering of mortar” is 0.255. This is a directly related proportionality. The longer time between mixing mortar and using it, the more likely it that it will need to be retempered, and vice versa.
- The correlation value between “contamination of sand” and “colour of mortar” is 0.198. This is a directly related proportionality. The more contaminated the sand is, the more likely it is that it will have inconsistent colour, and vice versa. Contamination can come from other materials and/or substances.
- The correlation value between “contamination of cement by moisture” and “age of cement at the time of use” is 0.269. This is a directly related proportionality. The longer cement is not in use, the more likely it is that it will be contaminated by water, and vice versa. Water relates to moisture.
- The correlation value between “mix proportions of ingredients” and “colour of mortar” is 0.186. This is a directly related proportionality. The more inconsistent the mix proportions, the more likely you get varying colour of mortar (between batches), and vice versa (less cement implies low strength).
- The correlation value between “mix proportions of ingredients” and “conditions of mixing equipment” is 0.188. This is a directly related proportionality. The dirtier the mixing equipment becomes, such as cement clots from prior mixes, the more likely the proportions of materials in the mix may be affected.

A p-value was generated from the test statistic. A significant result is indicated with “p < 0.05”, and they are:

- Contamination of sand and the construction site. That is, the site at which the respondent was based did play a role in terms of how contamination of sand was rated. Similarly for the following:
  - General quality of cement.
  - Contamination of cement by moisture.
  - Mix proportions of ingredients.
  - Mixing time and conditions of mixing equipment.

A second Chi square test was performed to determine whether there was a statistically significant relationship between the variables (rows vs columns). The null hypothesis states that there is no association between the two. The alternate hypothesis determined that there is an association.

CROSS TABULATIONS

A p-value was generated from the test statistic. A significant result is indicated with “p < 0.05”, and they are:

- “Mixing time and mixing equipment conditions” and “mortar retempering.” The longer the time interval between mixing and using mortar, the more likely it will require to be retempered, and vice versa.
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27. Shiny, R.B.a.u.R.a. Radiant – Business analytics using R and Shiny. 2022; Available from: https://radiant-rstats.github.io/docs/multivariate/pre_factor.html#:~,:text=A%20KMO%20value%20over%200.5,above %200.4%20are%20considered%20appropriate
ABSTRACT

PURPOSE
This study evaluated the stakeholder participation in South African green building and specifically the findings of market dominance found in an exploratory 2017 study. The 2017 study described stakeholders’ participation trends in new South African office buildings certified by the Green Building Council of South Africa (GBCSA) from 2009-2015. The new study included data covering the period 2016-2018.

DESIGN
The case study data of projects were secured from the GBCSA and analysed statistically to describe participation trends and market share of stakeholders.

FINDINGS
GBCSA data confirmed 156 new office buildings with green building certification (2009 – 2018) involving 75 owners and 63 architect firms but only 27 green consulting firms and 34 main contractors. The combined market shares of the top three firms differed significantly from owners (19.9%) to main contractors (50.3%) and green consultants (57.7%). The public sector participation is lagging, with only 20 certified buildings.

VALUE
This finding confirmed the dominant green building status of the leading firms amongst main contractors and green consultants, which may have positive and negative implications for South African green building prosperity. The growth in the number of participating stakeholders across disciplines has stabilised. However, a renewed focus on the public sector can improve these trends and increase the acceptance of green building in the industry.

Keywords: Green buildings, Participation Trends, Market Share, Stakeholders, South Africa.
INTRODUCTION
Global occurrences of food and water shortage, rising sea levels, and increasing incidents of severe weather events all confirm that climate change is a reality in the twenty-first century. According to The Economist, the realisation of the earth's inability to sustain the current rate of natural resource exploitation leads to the consideration of green building principles.

The construction industry contributes extensively to the problem. The built environment accounted for 12% of freshwater consumption, 40% of the worldwide impact of the end-use energy consumption, 40% of total waste generation, and 33.3% of greenhouse gas emissions worldwide. The problem is also prevalent in South Africa. Green building practices can help to address this problem through energy saving, land saving, stormwater runoff reduction, natural material conservation, and pollution reduction. For South Africa to benefit from the positive outcomes offered by green building developments, the committed and full participation of important industry stakeholders will be required.

A study by Olanipekun et al. indicated that internal incentives convincing stakeholders to pursue green building through their own volition might be a very efficient way to broaden stakeholder participation. Building owners were found to be more stimulated by non-financial incentives. Some et al. agreed that strong stakeholder participation is a very important attribute of an efficient and growing green industry. There is, therefore, a need for efficient stakeholder participation in green building construction and upgrades in South Africa.

A 2017 exploratory study on stakeholder participation in South African Green Star awarded office buildings confirmed indications of dominance amongst the participating main contractors and sustainability consultants. The combined market share percentage of the three largest participants amongst main contractors was 53% and 61% for sustainability consultants.

Many international studies from different economic industries have cautioned against market dominance by a few major stakeholders by indicating the potential challenges often linked to market dominance. While vibrant stakeholder firms with a growing market share and positively supporting their industry, such as the green building industry, may be of great value to the industry, some caution is merited. Some of the negative consequences mentioned by these studies on market dominance include anti-competitive behaviour, declining value for money offered to clients and lack of new or differentiated product development.

Many authorities in the USA are opposed to a market share of more than 20% when considering issues of collaboration between firms. Some of the negative consequences mentioned by these studies on market dominance include anti-competitive behaviour, declining value for money offered to clients and lack of new or differentiated product development. DePamphilis indicated an acceptable margin for market share by confirming that regulatory authorities in the USA are opposed to a market share of more than 20% when considering issues of collaboration between firms.

Indications of skewed or dominant participation in South African green building may therefore hold the potential of negatively affecting the future growth of the local green building industry. A primary objective of the study was to consider the previous indications of market dominance and the extent to which such market dominance has increased or abated. The study also aimed to describe the general levels of participation in green building and to what extent the levels of participation between different stakeholder disciplines may differ.

LITERATURE REVIEW
CLIMATE AND CLIMATE CHANGE
Climate change can be defined as the variation in either mean climate or a change in climate variability over a long period of time. Climate change and rising temperatures are unavoidable realities in the twenty-first century. NASA projected that the rise in temperatures would continue into the foreseeable future. Ozone radiation from the sun, oceanic changes, volcanic eruptions, human activities and construction activities contribute to global warming. Global warming stresses the natural ecosystem through severe temperature increases, water shortages, droughts, intense storms and other natural disasters.

The IPCC reported that between 1970 and 2004, global greenhouse gas emissions due to human activities increased by as much as 70%. The built environment's share of pollution is estimated to be between 30% - 40% of solid waste, 30% - 40% global greenhouse gas (GHG) emissions and roughly 20% water effluents. The growth rate of global greenhouse gas emissions from the built environment is estimated at 2.5% per year for commercial buildings and 1.7% per year for residential buildings.

Hwang and Tan attributed the environmental imbalance between environmental inputs and outputs to global warming, pollution, and acid rain that damage the natural environment. The WWF maintained that global warming results from greenhouse gas emissions from buildings due to the usage of fossil-fuel-based energy sources such as coal.

STAKEHOLDER PARTICIPATION
Built environment stakeholders may have different reasons for undertaking green building projects. Architects may, for example, focus on the conservation of resources; engineers are concerned about structural designs and energy efficiency aspects, while property owners are anxious about penalties due to greenhouse gas emissions. Nelson highlighted the role of governments to formulate regulations and policies supporting green building.

Cost efficiency in green building is another important motivation to ensure the correct stakeholder team composition. Macaluso and Walker stated that an experienced Quantity Surveyor must be appointed at the earliest possible stage to ensure cost efficiency in green building developments. The size of firms may also impact their green building involvement. McGraw-Hill Construction reported that large and small firms show more commitment and record higher levels of participation in building green than medium-sized firms.

GREEN BUILDINGS
According to the GBCSA, green building involves energy and resource-efficient construction and operating methods exercised with environmental responsibility. The WBCSD defines green buildings in terms of their efficiency on the utilisation of energy, water and other materials while at the same time reducing the impact of the building on people's health and environment using enhanced design, construction, operation, maintenance and removal.

BENEFITS OF GREEN BUILDINGS
Green buildings can potentially offer many benefits and rewards when compared to conventional buildings.

Energy savings.
Zuo and Zhao claimed that green buildings use about 30% less energy than conventional buildings. Dodge Data & Analytics claimed that in 2018 green technologies reduced energy consumption in buildings by 66%.

Environmental benefits.
Green building strives to protect biodiversity, preserve natural resources, decrease water wastage and enhance air quality. The WBCSD argued that green commercial buildings could lower air pollutants and greenhouse gas emissions, reduce volumes of waste, and significantly reduce the use of natural resources.

Productivity and health.
According to the USGBC, most conventional commercial buildings in the USA offer poor indoor environmental quality, costing companies billions of dollars annually from lost productivity, medical claims and ultimately poor performance. Green buildings significantly reduced illness symptoms, absenteeism and increased productivity compared to conventional buildings.

Financial benefits.
Green buildings offer lower energy use and reduce the cost of waste, water, environmental and emissions, operations and maintenance while increasing productivity and health. In addition, the WBCSD also identified the benefits of higher property value, higher occupancy levels, job creation, marketability, higher return on investment, insurance discounts and reduced liability and risk as some of the financial benefits associated with green building. Smith and DuToit agreed with many of these benefits in their study.

The Morgan Stanley Capital International (MSCI) reported that according to the IPD's Annual South African Green Property Index, the group of Green Star certified Prime and A-grade office buildings in 2017 outperformed the non-green Prime and A-grade office buildings by 45% in total returns (11.6% vs 8.0%). Vacancy rates of Green Star certified Prime and A-grade office buildings were 49.5% lower (5.0% vs 10.1%).
BARRIERS TO GREEN BUILDINGS.

South Africa remains the leading African country in adopting the green building concept[8]. However, there are still potential barriers to the green building sector’s growth.

Cost. Yudelson[10] argues that green building projects are often more expensive when compared to conventional buildings. However, a recent study on South African green building costs and trends found an average green building cost premium of only 3.9% for Green Star SA certified office buildings[16]. To curtail the green building cost premium requires sustainability to be part of conceptual design at an early stage[20].

Attitude and Market. Hakkikinen and Belfort[23] argued that property owner buy-in on the green building concept is often difficult to achieve. Hwang and Ng[22] found resistance to change to be a challenge for green building.

Information, Knowledge and Awareness. Hwang and Ng[22] and Rodriguez-Nikli, Kelley, Xiao, Hammer and Tit[35] attributed the lack of reliable and credible research data and inadequate information on green building as the most critical barriers for stakeholders to accept and adopt green building practices. Subsequently, lack of information hinders awareness of green buildings and their associated products.

Management and Government support. Any new product developed for the market needs leadership support to gain adoption and market acceptance. Therefore, Qi, Shen, Zeng, and Jorge argued that management support is significant in adopting green technologies and practices[35]. Oluibunni, Xia and Skitmore[39] stated that governments need to promote the adoption of green technologies and should formulate financial and non-financial incentives and regulations to promote green buildings.

Scepticism. The GBCSA[42] reports scepticism on global warming and climate change as one of the significant barriers that can have a remarkable negative effect on the acceptance and adoption of green technologies and practices as well as the growth of the green building industry

False green claims. According to Hwang and Tan[35], the under-performance of green products leads to mistrust from clients and the public and tarnish the green concept and hinders the development of the green building industry.

SOUTHERN GREEN BUILDING PARTICIPATION.

A 2017 study of 106 new South African office buildings awarded a Green Star certification from the GBCSA confirmed widely varying participation trends amongst stakeholders[8]. As many as 69 architectural firms participated in these buildings, but only 28 main contractors and 23 sustainability consultants were involved. The major stakeholders’ market dominance or lack thereof in each discipline confirmed the skewed nature of stakeholder participation in the South African green building industry. The study found that the combined market share percentage of the three largest participants per discipline was a modest 25% for architects but a dominating 53% for main contractors and 61% for sustainability consultants.

Such skewed participation in green building may hold the potential of negatively affecting the future growth of the South African green building industry. An industry where a dominant portion of the overall participation by stakeholders rests with only two or three role players will lead to such an industry vulnerable to the possible misfortune of the untoward actions of such dominant stakeholders. The potentially threatening market dominance level may be as low as 20%. This was confirmed by DePamphilis[11], who highlighted that regulatory authorities in the USA are opposed to a market share of more than 20% when considering collaboration between firms.

Different international studies have found that the market dominance of an industry by a few major stakeholders hold many potential challenges or threats. The negative effects of market dominance may include anti-competitive behaviour, declining value for money offered to clients and lack of new or differentiated product development. The negative effect of market dominance may, however, be softened by the lack of high entry barriers[11][8][16].

This study set the objectives to continue the work done in the above mentioned 2017 study. The study investigated if the indications of market dominance had changed if participation in the local green building industry was less skewed and a broadening of participation in green building was apparent amongst stakeholder disciplines.
The number of firms participating in green building projects per discipline grew over time (see Figure 1). The number of firms in all the stakeholder disciplines with experience of only one green building roughly equalled the number of firms with experience in multiple green buildings. The percentages varied between 44.4% and 55.6%.

Figure 2 details the cumulative number of projects certified by the GBCSA until 2018. The commercial real estate sector produced the large majority of 115 green buildings (72.3%). The financial services sector with 27 buildings was another well-represented sector. Even though the public sector with 20 buildings was third on the sector list, the large number of public sector office buildings confirm that this sector is very much underperforming in their participation in green building.

Table 1: Dispersion of participation in Green Building projects per discipline

<table>
<thead>
<tr>
<th></th>
<th>Owners</th>
<th>Architects</th>
<th>Quantity Surveyors</th>
<th>Green Consultants</th>
<th>Main Contractor</th>
<th>Structural Engineer</th>
<th>Electrical Engineer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of firms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>with green building</td>
<td>75</td>
<td>63</td>
<td>55</td>
<td>27</td>
<td>34</td>
<td>42</td>
<td>48</td>
</tr>
<tr>
<td>projects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Split between firms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>with one vs multiple</td>
<td>37 / 38</td>
<td>34 / 29</td>
<td>29 / 26</td>
<td>15 / 12</td>
<td>16 / 18</td>
<td>21 / 21</td>
<td>23 / 25</td>
</tr>
<tr>
<td>Firms with one</td>
<td>49.3%</td>
<td>54.0%</td>
<td>52.7%</td>
<td>55.6%</td>
<td>47.1%</td>
<td>50.0%</td>
<td>47.9%</td>
</tr>
<tr>
<td>project (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firms with multiple</td>
<td>50.7%</td>
<td>46.0%</td>
<td>47.3%</td>
<td>44.4%</td>
<td>52.9%</td>
<td>50.0%</td>
<td>52.1%</td>
</tr>
<tr>
<td>projects (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source (from the data)

The number of firms participating in green building projects per discipline grew over time (see Figure 1). The number of firms in all the stakeholder disciplines with experience of only one green building roughly equalled the number of firms with experience in multiple green buildings. The percentages varied between 44.4% and 55.6%.

Table 2 confirmed that firms with multiple green buildings experience dominated the industry in all stakeholder disciplines. The combined market share of these firms varied from a minimum share of 85.9% for electrical engineering firms to a maximum of 90.8% for green building consultants. The three firms with the largest market share in each discipline varied significantly. The smallest combined market share of the three firms in each discipline with the largest share was owners (19.9%) and architects (29.3%), indicating that these disciplines do not have dominating firms. At the other end of the spectrum, the data indicated that main contractors (50.3%) and green building consultants (57.7%) have a few dominant stakeholders. Therefore, the status quo described in the 2017 study has remained largely unchanged.

Table 2: Market share of participants in Green Building per discipline

<table>
<thead>
<tr>
<th></th>
<th>Owners</th>
<th>Architects</th>
<th>Quantity Surveyors</th>
<th>Green Consultants</th>
<th>Main Contractor</th>
<th>Structural Engineer</th>
<th>Electrical Engineer</th>
</tr>
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<tbody>
<tr>
<td>Market share single project (%)</td>
<td>21.6%</td>
<td>18.8%</td>
<td>16.7%</td>
<td>9.2%</td>
<td>9.8%</td>
<td>13.0%</td>
<td>14.1%</td>
</tr>
<tr>
<td>Market share (%) of firms with multiple projects</td>
<td>78.4%</td>
<td>81.2%</td>
<td>83.3%</td>
<td>90.8%</td>
<td>90.2%</td>
<td>87.0%</td>
<td>85.9%</td>
</tr>
<tr>
<td>Projects held by top 3 firms</td>
<td>34</td>
<td>53</td>
<td>46</td>
<td>94</td>
<td>82</td>
<td>67</td>
<td>52</td>
</tr>
<tr>
<td>Market share of top 3 firms</td>
<td>19.9%</td>
<td>29.3%</td>
<td>26.4%</td>
<td>57.7%</td>
<td>50.3%</td>
<td>41.4%</td>
<td>31.9%</td>
</tr>
<tr>
<td>Projects the largest firm</td>
<td>16</td>
<td>25</td>
<td>20</td>
<td>45</td>
<td>48</td>
<td>24</td>
<td>25</td>
</tr>
<tr>
<td>Market share of top firm</td>
<td>9.4%</td>
<td>13.8%</td>
<td>11.5%</td>
<td>27.6%</td>
<td>29.4%</td>
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<td>15.3%</td>
</tr>
</tbody>
</table>

Source (from the data)

The number of firms participating in green building projects per discipline grew over time (see Figure 1). The number of firms in all the stakeholder disciplines with experience of only one green building roughly equalled the number of firms with experience in multiple green buildings. The percentages varied between 44.4% and 55.6%.

Figure 1: Cumulative number of firms participating in green buildings

Figure 2: Cumulative projects by sector

INDICATIONS OF MARKET DOMINANCE

Table 2 confirmed that firms with multiple green buildings experience dominated the industry in all stakeholder disciplines. The combined market share of these firms varied from a minimum share of 85.9% for electrical engineering firms to a maximum of 90.8% for green building consultants. The three firms with the largest market share in each discipline varied significantly. The smallest combined market share of the three firms in each discipline with the largest share was owners (19.9%) and architects (29.3%), indicating that these disciplines do not have dominating firms. At the other end of the spectrum, the data indicated that main contractors (50.3%) and green building consultants (57.7%) have a few dominant stakeholders. Therefore, the status quo described in the 2017 study has remained largely unchanged.

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<td>15.3%</td>
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Source (from the data)
This finding was confirmed by the firm with the largest market share in each discipline. Amongst owners, the largest market share was 9.4%, a significant but not dominant share. However, the data on green building consultants (27.6%) and main contractors (29.4%) confirmed evidence of very successful and strong firms operating in the green building industry.

INDIVIDUAL STAKEHOLDER DISCIPLINES

Owners.
Figure 3 indicated the steadily inclining accumulative number of green building owners. As the number of green building owners increases, the annual percentage growth of new owners entering the green building industry between 2009 and 2018 can be expected to decline. Over the last three years, the increase has stabilised at between 10% and 20% per annum. A total of 45 owners (60%) are from the commercial real estate sector, with 15 owners (20%) from the financial services sector and with 9 public sector owners (12%). Of the 75 owners, 37 (49.3%) companies owned only a single green building.

Figure 3: Owners Participation over time

Architects.
Figure 4 details the cumulative number of architect firms active in green building and the annual number of new architect entrants into the industry. The annual new entrant number for architects increased steadily from 2009 to reach a maximum of 13 firms in 2013 and 2014 but has since declined to not more than 5 firms per year.

Figure 4: Architects Participation over time

Quantity surveyors.
Figure 5 details the cumulative number of quantity surveying firms active in green building and the annual number of new quantity surveying entrants into the industry. This annual new entrant number for quantity surveying increased steadily from 2009 to reach a maximum of 11 firms in 2013 but has since declined to not more than 6 firms per year.

Figure 5: Quantity surveyors Participation over time

Electrical engineers.
Figure 6 details the cumulative number of electrical engineering firms active in green building and the annual number of new electrical engineering entrants into the industry. This annual new entrant number for electrical engineering increased steadily from 2009 to reach a maximum of 8 firms in 2013, has since declined to only one firm in 2017 but then increased sharply by 9 firms in 2018.

Figure 6: Electrical engineers Participation over time
Structural engineers.
Figure 7 details the cumulative number of structural engineering firms active in green building and the annual number of new structural engineering entrants into the industry. This annual new entrant number for structural engineering increased irregularly from 2009 to reach a maximum of 8 firms in 2015, has since declined to only one firm in 2017 but then increased by 5 firms in 2018.

Green consultants.
Figure 9 details the cumulative number of green consultants active in green building and the annual number of new green consultant entrants into the industry. This annual new entrant number for green consultants increased steadily from 2009 to reach a maximum of 9 firms in 2013 but has since declined to 1 or 2 firms per annum.

Main contractors.
Figure 8 details the cumulative number of main contractors active in green building and the annual number of new main contractor entrants into the industry. This annual new entrant number for main contractors increased steadily from 2009 to a maximum of 6 firms in 2013 but has since declined to 3 or 4 firms per annum.

CONCLUSION AND RECOMMENDATIONS
The study confirmed that the skewed nature of stakeholder participation identified in 2017 has changed very little since then. In the stakeholder disciplines of green building consultants and main contractors, the trend of two or three strongly established role players with dominating market shares is still very much apparent. In light of the many studies that cautioned against market dominance, the GBCSA and the green building industry should note this finding and consider if corrective measures need to be considered.

The study also indicated a widely distributed acceptance of the green building practice amongst South African stakeholder firms. The study found a wider spread of participation in green building amongst architects than in the other six disciplines included in the study from 2016 to 2018. Many architect firms indicated a willingness to accept the risk and new challenges of green building. Many architectural firms, however, lacked continued experience in green building. More architect firms participated in only one green building project compared to the other disciplines. In contrast, the green building consultant firms and the main contractors were the two disciplines with the lowest number of participating firms and the firms that achieved the highest market share for participating in green buildings.

The fact that since 2013 the number of firms participating in green building has declined and stabilised at relatively small numbers across all disciplines are cause for concern. The low participation of building owners from the public sector in green building is another cause for concern. However, this finding may also hold the promise of an opportunity. The GBCSA should consider increasing its communication and educational efforts focused on the public sector. Sustained strategies to target the public sector may well result in changing opinions and priorities of public sector officials and institutions in favour of green building. Positive results that may emanate from the above are an increase in the number of public sector office buildings applying for Green Star certification. Secondly, the rolling out of a range of incentives from the government to stimulate green building participation across all stakeholders disciplines.

ACKNOWLEDGEMENTS
This study would not have been possible without the kind and generous support of the GBCSA.
REFERENCES


What are the reasons for writing the paper or the aims of the research?

Purpose of the Paper

The abstract should reflect only what appears in the original paper. Provide no more than 5 keywords.

impact if they are not applicable to the paper. Abstracts should contain no more than 150 words. Write concisely and clearly.

(Purpose, Design, Findings and Value); the other two (Research limitations/implications and practical implications) may be

The first page of the manuscript must contain a concise and informative title, the name(s), the affiliation(s) and the address(es)

illustrations

Illustrations should be submitted in a form ready for reproduction, preferably as high-resolution jpg files. Diagrams and drawings

Discussion:

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

Conclusions:

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

Illustrations:

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

Illustrations should be submitted in a form ready for reproduction, preferably as high-resolution jpg files. Diagrams and drawings
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reputable computer software drawing package.

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lower-case lettering, the capital of which must be 3mm high.

Figures will normally be reduced in size on reproduction and authors should draw this with this in mind. With a reduction of 2:1
in mind the authors should use the lines not less than 0.25mm thick and upper- and lower-case lettering, the capitals of which
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Tables must be located close to the first reference to them in the text and must be referred to as Table 1, Table 2, etc. and be numbered in the order in which they are referred to in the text. The table identification and accompanying informative description on and any reference should be one line space immediately above the table and linked to the left margin. The table identification should be in bold. Identify all statistical methods and sources of data.

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

<table>
<thead>
<tr>
<th>Component</th>
<th>Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleaning works</td>
<td>40.9</td>
</tr>
<tr>
<td>Mechanical Services</td>
<td>37.7</td>
</tr>
<tr>
<td>Building Works</td>
<td>13.6</td>
</tr>
<tr>
<td>Civil Works</td>
<td>7.8</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 1 Components of expenditure

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

References:
The numbered superscript reference system must be used. References in the text should be numbered consecutively (1), etc.
References should be collected at the end of the paper as they appeared in the manuscript. The style should follow the examples below:


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

End Notes:
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