CONTENTS

AIMS & SCOPE | 2

SUSTAINABILITY PRINCIPLES FOR CONSTRUCTION HEALTH AND SAFETY (H&S) MANAGEMENT
BENVIOLENT CHIGARA & JOHN SMALLWOOD | 5

AN INVESTIGATION INTO THE WATER ABSORPTION QUALITY OF CLAY BRICKS
BONGA KHUZWAYO1 RODERICK RANKINE1 MARK WALKER3 | 21

CONTRIBUTION OF CURRENT ACCIDENT INVESTIGATION PROCESSES TO CONSTRUCTION ACCIDENTS CAUSATION IN SOUTH AFRICA: A CASE STUDY APPROACH
TRINISHA LUTCHMIA & THEO C. HAUPT | 29

INSTRUCTIONS FOR AUTHORS | 38
AIMS AND SCOPE

The Journal Of Construction (JOC) is the official journal of the Association Of Schools Of Construction Southern Africa (ASOCSA). ASOCSA has committed itself to foster excellence in construction communication, scholarship, research, education and practice and the JOC provides the medium to achieve this commitment. JOC is at this stage a bi-annual refereed journal serving all stakeholders and participants in the building construction and civil engineering sectors.

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

Topics in JOC include sustainable construction, education themed by topic.

The Journal of Construction is committed to open access for academic work and is, therefore, an open access journal, which means that all articles are available on the internet to all users immediately from the date of publication. This allows for the reproduction of articles, free of charge, for non-commercial use only and with the appropriate citation information. All authors publishing in the Journal of Construction accept these as the terms of publication. Copyright of the content of all articles and reviews remains with the Journal of Construction and cannot be used in other publications.

Benefits of open access for authors, include:
- Free access for all users worldwide
- Authors retain copyright to their work
- Increased visibility and readership
- Rapid publication
- No spatial constraints

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

The Journal of Construction is committed to open access for academic work and is, therefore, an open access journal, which means that all articles are available on the internet to all users immediately from the date of publication. This allows for the reproduction of articles, free of charge, for non-commercial use only and with the appropriate citation information. All authors publishing in the Journal of Construction accept these as the terms of publication. Copyright of the content of all articles and reviews remains with the Journal of Construction and cannot be used in other publications.

Benefits of open access for authors, include:
- Free access for all users worldwide
- Authors retain copyright to their work
- Increased visibility and readership
- Rapid publication
- No spatial constraints
SUSTAINABILITY PRINCIPLES FOR CONSTRUCTION HEALTH AND SAFETY (H&S) MANAGEMENT

Benviolent Chigara and John Smallwood
Department of Construction Management, Nelson Mandela University, Port Elizabeth, South Africa
benviolent@gmail.com

ABSTRACT

PURPOSE
The persistent health and safety (H&S) problem in the construction sector requires that broader level interventions be introduced to improve outcomes. Although sustainability emerged as a potential strategy for improving H&S performance, the principles required to integrate sustainability thinking into H&S decision-making are missing. This study aims to establish the principles of sustainable construction H&S practice.

DESIGN
The data was collected through the distribution of 195 questionnaires to construction practitioners in Harare and Bulawayo, Zimbabwe, where after a response rate of 51.8% was achieved. The data was analysed using SPSS to compute descriptive statistics and perform exploratory factor analysis.

FINDINGS
The results indicate that seven principles, namely, responsible production, finance and procurement, prevention principle, social and environmental responsibility, social equity, governance, and a precautionary approach inform sustainable construction H&S practice.

VALUE ADDITION
The developed framework of sustainability principles and accompanying practices for H&S constitute an important contribution to the related body of knowledge. The framework can be used by construction practitioners to inform their occupational injury prevention programmes.

INTRODUCTION
The increasing attention to sustainability worldwide, calls for sustainable practices to be introduced in every sector. The construction industry, being a leading sector in the provision of infrastructure and creation of the built environment, has a major responsibility to ensure that its various practices are sustainable. However, the poor health, safety, and environmental (HSE) record in the construction industry suggests that the construction industry is far from being sustainable. Construction activities involve excessive resource consumption, land degradation, loss of habitats, and air and water pollution. The waste and environmental emissions generated from the construction process often exacerbate the construction H&S problem. Despite several interventions by the government and construction industry practitioners to improve H&S, construction incidents remain high. It is estimated that 2.34 million people die each year from work-related accidents or diseases, and approximately 60 000 fatal accidents are recorded per year on construction sites worldwide. The employees of the construction industry are six times more likely to be killed at work than employees in manufacturing. In Zimbabwe, the Millennium Towers accident, which resulted in 15 construction workers losing their lives, compromised the integrity of construction H&S management, and highlighted the need to improve H&S management in the sector. Along with 80% non-compliance with H&S provisions, the construction industry recorded an average incidence rate (IR) of 4.34 per 1 000 workers over a 5-years period from 2009-2012.

Keywords: construction, health and safety, principles, sustainability, principles.
The brief inventory of the H&S problem indicates that construction workers are exposed to conditions, which systematically diminish their capacity to meet their present and future work needs. Therefore, the need for a sustainable prevention strategy relative to H&S is both obvious and urgent. The sustainable prevention strategy calls for preventive actions relative to H&S to rely on integrated and holistic perspectives, which ensures such interventions have a long-lasting impact. To this end, sustainable development emerged as a potential improvement area and its potential to contribute to improved H&S outcomes has been raised for discussion. The sustainabil-

ity-based approach to H&S ensures that sustainability thinking is put at the forefront of H&S decision making, thereby elevating H&S issues to resonate with sustain-

ability. This is consistent with extant research indicating that sustainable development is the foundation upon which future construction business activities should be built.

SUSTAINABLE DEVELOPMENT IN THE CONSTRUCTION INDUSTRY

Sustainable development is defined as a development strategy to meet the needs of the present world population without causing adverse effects on the health and environment, and without depleting or endangering the global resource base, and hence without compromising the ability of future generations to meet their own needs. The overall goal of sustainable development is the long-term stability of the economy and environment, which can be achieved through integration of economic, environmental and social concerns throughout the decision-making process. This sustainable approach to H&S management combines both sustainable development and environmental preservation of infrastructure. In Zimbabwe, the construction industry contributed approximately 3.6% to gross domestic product (GDP) despite the country experiencing an economic recession. However, to reduce the impact of construction activities on the environment, the construction industry adopted the concept of sustainable construction. Sustainable construction is informed by seven principles, namely reduce resource consumption, reuse resources, use recyclable resources, protect nature, eliminate toxins, apply cycle costing, and focus on quality. The adoption of sustainable construction provided a unique window of opportunity to promote worker H&S as a fundamental dimension of true sustainable development. Regrettably, most sustainable construction agendas ignore social sustainability issues such as workplace. The Leadership in Energy and Environmental Design (LEED) rating system has only one component, namely indoor air quality, which has some focus on construction worker H&S. Against this background a new research agenda has emerged to explore the potential of sustainable development to contribute to improving H&S outcomes.

SUSTAINABILITY IN CONSTRUCTION HEALTH AND SAFETY

The concepts of sustainability and H&S are connected by their concern for resource conservation (both natural and human). The two concepts are connected by their concern for human well-being. Occupational H&S seeks to promote and preserve the highest degree of physical, mental and social wellbeing of the employees and workers in all occupations. With regards to sustainable development, human beings are at the centre of its concern as individuals entitled to a healthy and productive life in harmony with nature. In terms of H&S, sustainable development means the satisfaction of material needs through work and other production processes without causing danger to human health, the ecosystem, or health of the community either in the short term or the long term. Given the similarity of the objectives of sustainable development and occupa-
tional H&S, integrating the two concepts will intensify their power and foster their goal achievement. The objective of sustainable development in construction H&S management is to sustain a worker’s H&S for the duration of the current and future projects; a worker is involved in, and during the worker’s remaining lifetime after retirement, without any injuries. Sustainable H&S refers to the minimization of environmental, economic, and social sustainability concerns into construction H&S practice. The H&S risk management programmes should be extended to include the principles of sustainable development and, namely, intergenerational equity, prevention principle, and the precautionary principle. To optimise the benefits of sustainability practices in an organisation, it is important for construction practi-
tioners to understand the sustainability-based practices for construction H&S. The following section discusses environmental, social, and economic sustainability practices / attributes for H&S.

Environmental sustainability practices for construction H&S

Globally, it is estimated that 24% of the disease burden and 23% of all premature deaths can be attributed to environmental factors. The occupational health risks are directly related to physical, chemical and biological factors in the environment. The modified environmental factors cause 400,000 deaths annually from unintentional injuries. The generation of dust, hazardous materials, and unhealthy and unsafe practices such as concrete splitting, confined space work, waste and underuse of water and sanitation have adverse effect on the environment, and the H&S of construction workers and the community. The poor work environments contribute to diarrhea, lower respiratory infections, various forms of unintentional injuries and illnesses. The aforesaid indicate that the environment influences workers’ H&S and that the effectiveness of H&S management depends on the extent to which environmental practices are sustainable at the construction site. The ecological practices which are considered important for sustainable prevention in H&S include: minimising and adequately managing waste and hazardous substances; promoting ethical sourcing of materials/products; promoting better hygiene measures; protecting the environment from degradation; adopting a precautionary approach relative to H&S risks; considering the emergency management procedures; proactive response to climatic change risk, and hazard identifi-
cation and risk assessment (HIRA). The adoption of sustainable H&S practices considered to be important by previous studies relative to construction H&S.

Social sustainability practices for construction H&S

The protection of workers against illness, disease and injury arising out of employment is a fundamental element of social justice and constitutes a social and health dimension of the principle of sustainable development. Nevertheless, inadequate attention to social factors, namely, lack of quality H&S training, lack of quality supervision, and lack of safety culture is exacerbating the H&S problem in the industry. The social approach to sustainable prevention is anchored on the respect for human dignity and workers’ rights, integration of H&S in the design of buildings, engagement of H&S stakeholders, participation and empowerment through training, and corporate social responsibility (CSR). In addition, supervision and monitoring the implementation of H&S aspects, and enforcing the role of the H&S department in reducing work-related illnesses and absenteeism is a key to improve H&S management. On this note, the adoption of social sustainability practices is essential for sustainable H&S management. Social sustainability means that organisations provide equitable opportunities, encourage diversity, ensure the quality of life and provide democratic processes and accountable government structures.

Economic sustainability practices for construction H&S

From an economic perspective, H&S issues are considered as matters of economics since they stem from work, and work is an economic activity. Through the engagement of workers in the productive processes, organisations can achieve the triple bottom line objectives. A healthy and safe work environment facilitates undisturbed production, competitiveness, and sustainability of organisations. Economic sustainability practices for construction H&S are considered important for sustainable prevention, which future construction business activities should be based on sustainable principles of sustainable construction H&S practice. This is supported by available empirical evidence which shows that the total cost of accidents and injuries is much higher than the cost of accidents and injuries. The aforesaid indicate that the environment influences workers’ H&S and that the effectiveness of H&S management depends on the extent to which environmental practices are sustainable at the construction site. The ecological practices which are considered important for sustainable prevention in H&S include: minimising and adequately managing waste and hazardous substances; promoting ethical sourcing of materials/products; promoting better hygiene measures; protecting the environment from degradation; adopting a precautionary approach relative to H&S risks; considering the emergency management procedures; proactive response to climatic change risk, and hazard identifi-
cation and risk assessment (HIRA).
The respondents were asked to rate, using a five-point scale (where 1 = not important and 5 = very important), the relative importance of 29 sustainability-based practices. Close-ended questionnaires provide a greater degree of uniformity of responses and are easy to process. The selection of the study area was informed by research indicating that 80% of registered contractors and construction consultants in Zimbabwe are in Harare and Bulawayo. The data analysis was conducted with the help of the Statistical Package for the Social Sciences (SPSS) software (v.23) to compute descriptive and inferential statistics. To establish the principles of sustainability for construction H&S, exploratory factor analysis (EFA) was performed on the sustainability practices using SPSS.

### RESEARCH FINDINGS

The research findings will be discussed under the following sub-headings.

### SAMPLE STRATUM AND RESPONSE RATE

Table 2 indicates that 101 questionnaires were successfully completed, received, and included in the analysis of the data. This equates to an overall response rate of 51.8%.

<table>
<thead>
<tr>
<th>Respondent organisation</th>
<th>Distributed (No.)</th>
<th>Response No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contractors</td>
<td>58</td>
<td>44</td>
<td>43.6</td>
</tr>
<tr>
<td>Quantity surveyors</td>
<td>20</td>
<td>15</td>
<td>14.6</td>
</tr>
<tr>
<td>Government</td>
<td>20</td>
<td>15</td>
<td>14.6</td>
</tr>
<tr>
<td>Private sector clients</td>
<td>15</td>
<td>10</td>
<td>9.9</td>
</tr>
<tr>
<td>Architects</td>
<td>44</td>
<td>9</td>
<td>8.9</td>
</tr>
<tr>
<td>Engineers</td>
<td>38</td>
<td>8</td>
<td>7.9</td>
</tr>
<tr>
<td>Total</td>
<td>195</td>
<td>101</td>
<td>51.8</td>
</tr>
</tbody>
</table>

Table 2 indicates that the respondents were selected from a cross-section of construction practitioners in the private and public sectors. The respondents' educational qualifications range from National Certificate (2.0%), National Diploma (19.8%), Bachelors' Degree (50.5%), to Masters' Degree (25.5%). The respondents' work experience in the construction industry ranges from 2 years to 40 years with a mean of 12.0 years, and standard deviation of 8.66. The profile of respondents suggest that the study benefited from the perceptions of experienced and knowledgeable construction practitioners. This ensures quality responses and reliability of the research findings.

### THE IMPORTANCE OF SUSTAINABILITY PRACTICES IN CONSTRUCTION H&S

The respondents were asked to rate the importance of selected sustainability practices in reducing/or preventing occupational injuries in terms of percentage responses to a scale of 1 (not important) to 5 (very important), and mean score (MS) between 1.00 and 5.000, the midpoint being 3.00. The results are presented in Table 3.
TABLE 3: THE IMPORTANCE OF SUSTAINABLE PRACTICES IN CONSTRUCTION H&S

<table>
<thead>
<tr>
<th>Code</th>
<th>Sustainability practices / variables</th>
<th>Responses (%)</th>
<th>MS</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eco1</td>
<td>Responsible production and employment</td>
<td>4.1</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Eco2</td>
<td>Integrating H&amp;S into HIRAs</td>
<td>2.1</td>
<td>0.0</td>
<td>13</td>
</tr>
<tr>
<td>Eco3</td>
<td>Integrating H&amp;S into a firm’s business or management plan</td>
<td>1.0</td>
<td>1.0</td>
<td>3</td>
</tr>
<tr>
<td>Eco4</td>
<td>Integration of H&amp;S into procurement systems</td>
<td>2.1</td>
<td>1.0</td>
<td>19</td>
</tr>
<tr>
<td>Eco5</td>
<td>Assessing the impact of accidents and ill-health on project parameters</td>
<td>3.1</td>
<td>1.0</td>
<td>5</td>
</tr>
<tr>
<td>Eco6</td>
<td>LCA of H&amp;S investment</td>
<td>2.1</td>
<td>0.0</td>
<td>36</td>
</tr>
<tr>
<td>Eco7</td>
<td>Financial provision for H&amp;S</td>
<td>2.1</td>
<td>1.0</td>
<td>44</td>
</tr>
<tr>
<td>Eco8</td>
<td>Balancing cost efficiency with maintaining good H&amp;S</td>
<td>1.0</td>
<td>1.0</td>
<td>4</td>
</tr>
<tr>
<td>Env1</td>
<td>Environmental pollution, waste, toxic substances management</td>
<td>0.0</td>
<td>0.0</td>
<td>2</td>
</tr>
<tr>
<td>Env2</td>
<td>Protecting the environment</td>
<td>0.0</td>
<td>0.0</td>
<td>11</td>
</tr>
<tr>
<td>Env3</td>
<td>Site hygiene and welfare provisions</td>
<td>1.0</td>
<td>0.0</td>
<td>6</td>
</tr>
<tr>
<td>Env4</td>
<td>Social sustainability practices</td>
<td>1.0</td>
<td>1.0</td>
<td>5</td>
</tr>
<tr>
<td>Env5</td>
<td>Selection of low risk materials</td>
<td>1.0</td>
<td>4.1</td>
<td>7</td>
</tr>
<tr>
<td>Env6</td>
<td>Proactive response to risk of environmental thermal change</td>
<td>7.1</td>
<td>0.0</td>
<td>29</td>
</tr>
<tr>
<td>Env7</td>
<td>The polluter pays</td>
<td>6.2</td>
<td>3.1</td>
<td>28</td>
</tr>
<tr>
<td>Env8</td>
<td>Environmental information dissemination</td>
<td>2.1</td>
<td>2.1</td>
<td>27</td>
</tr>
<tr>
<td>Env9</td>
<td>Compliance with environmental policies</td>
<td>1.0</td>
<td>0.0</td>
<td>5</td>
</tr>
<tr>
<td>Env10</td>
<td>Site layout planning and management</td>
<td>2.0</td>
<td>1.0</td>
<td>18</td>
</tr>
<tr>
<td>Soc1</td>
<td>Respect for workers’ rights</td>
<td>0.0</td>
<td>0.0</td>
<td>10</td>
</tr>
<tr>
<td>Soc2</td>
<td>Site specific H&amp;S plan</td>
<td>0.0</td>
<td>0.0</td>
<td>11</td>
</tr>
<tr>
<td>Soc3</td>
<td>H&amp;S Policies</td>
<td>0.0</td>
<td>0.0</td>
<td>11</td>
</tr>
<tr>
<td>Soc4</td>
<td>Inclusive participation</td>
<td>0.0</td>
<td>0.0</td>
<td>11</td>
</tr>
<tr>
<td>Soc5</td>
<td>Training and knowledge transmission</td>
<td>0.0</td>
<td>0.0</td>
<td>11</td>
</tr>
<tr>
<td>Soc6</td>
<td>Supervision and monitoring</td>
<td>0.0</td>
<td>0.0</td>
<td>11</td>
</tr>
<tr>
<td>Soc7</td>
<td>Accident investigation, statistics and reporting</td>
<td>0.0</td>
<td>0.0</td>
<td>11</td>
</tr>
<tr>
<td>Soc8</td>
<td>Post injury RTW and disability management</td>
<td>2.0</td>
<td>3.0</td>
<td>21</td>
</tr>
</tbody>
</table>

It is notable that the MSs for all the practices are greater than the midpoint score of 3.00, which indicates that the respondents deem the practices to be very important as opposed to not important for reducing occupational fatalities, injuries, or disease. This confirms that all the practices / attributes are important and hence can be implemented by construction industry stakeholders as strategies for improving H&S performance.

IMPORTANCE OF SOCIAL SUSTAINABILITY IN CONSTRUCTION H&S

Given that 8 of the 11 variables have MSs > 4.20 ≤ 5.00, the results indicate that respondents deem the practices to be between more than important to very important in terms of reducing occupational fatalities, injuries, or disease. The results indicate that ‘respect for workers’ rights’, ‘information relative to H&S hazards’, ‘training and knowledge transmission’, ‘accident investigation, statistical and reporting’, and ‘H&S policies’ constitute the top five most important social sustainability practices for sustainable H&S management. This is consistent with the Constitution of Zimbabwe, which recognises the right to healthy and safe work as a fundamental worker’s right. In addition, training empowers workers to contribute meaningfully to H&S issues affecting them, and to work in a healthy and safe manner. During previous studies, the integration of H&S into design was identified as an important step to realise sustainability in H&S management. Two factors, namely ‘inclusive participation’ and ‘post injury RTW and disability management’ have MSs > 4.30 ≤ 5.00, which indicates that respondents deem the practices to be between a moderate to a more than important / more than important for reducing / preventing occupational fatalities, injuries, or disease. The social sustainability approach to H&S ensures that workers are not systematically hindered from participating in shaping construction H&S practice. In addition, compensation of injured workers, rehabilitation and RTW ensures that workers are protected from falling into an intergenerational poverty cycle.

IMPORTANCE OF ENVIRONMENTAL SUSTAINABILITY IN CONSTRUCTION H&S

The results presented in Table 3 indicate that ‘HIRAs’, HIRAs, ‘environmental pollution, waste, toxic substances management’, and ‘protecting the environment from degradation’ have MSs > 4.20 ≤ 5.00, which indicates that respondents deem the practices to be between more than important to very important / very important for H&S. Enforcing regulatory provisions and ensuring that stakeholders implement environmental protection into social development fosters greater human wellbeing and minimises H&S ramifications. The integration of HIRAs and selection of low risk materials in H&S management is consistent with the precautionary principle of sustainable development. The Grenfell Tower fire in West London, which resulted in 72 people losing their lives, reinforces the importance of integrating HIRAs and environmental concerns during the design of the buildings to safeguard the H&S construction workers and the occupants of completed buildings. The environmentally sustainable practices ranked 4th to 10th have MSs > 3.40 ≤ 4.20, which indicates that respondents deem the practices to be between a moderate to a more than important / more than important for reducing / preventing occupational fatalities, injuries, or disease. The social sustainability approach to H&S ensures that workers are not systematically hindered from participating in shaping construction H&S practice. In addition, compensation of injured workers, rehabilitation and RTW ensures that workers are protected from falling into an intergenerational poverty cycle.

Environmental information dissemination.

Eco2

The polluter pays

Eco3

Environmental information dissemination.
IMPORTANCE OF ECONOMIC SUSTAINABILITY IN CONSTRUCTION H&S

Table 3 shows the extent to which economic sustainability practices are important in construction H&S management. It is notable that all the MSs > 3.40 ≤ 4.20, which indicate that respondents deem the practices to be between important to more than important / more than important for reducing occupational fatalities, injuries, or disease. The results confirm extant literature wherein financial provisions for H&S are indicated that the resources required for H&S programmes are provided, and that stakeholders who do not systematically address H&S issues disqualified at the procurement stage. In addition, the availability of economic data has the potential to motivate stakeholders to invest in H&S and to consider the costs and benefits of H&S from a long-term rather than a short-term perspective. This is important because relying on short-term assessments often underestimate the real situation thereby misguided resource allocation for sustainable prevention.10

SUSTAINABILITY PRINCIPLES FOR CONSTRUCTION H&S PRACTICE

Further to the analysis of the MSs of individual practices, exploratory factor analysis (EFA) was employed to analyse the relationship among correlated sustainability practices and to group them into a limited, simple and interpretable cluster of principles / factors based on shared variance. Prior to conducting factor analysis, the data was checked for missing values and its appropriateness for factor analysis. Regarding the first assessment, one variable, that is, ‘Soc9’ (CSR) was removed from further analysis because of missing entries. The Bartlett’s Test of sphericity and the Kaiser-Meyer Olkin (KMO) measure of sampling adequacy (MSA) were used to evaluate the appropriateness of the data for conducting factor analysis. The results, presented in Table 4, indicate that the KMO coefficient is 0.839 (greater than the recommended threshold of 0.50) and the Bartlett’s test is statistically significant (p < .05) indicating that the sample data is suited for conducting factor analysis.

TABLE 4 KMO AND BARTLETT’S TEST FOR H&S SUSTAINABILITY CONSTRUCTS

| Kaiser-Meyer-Olkin Measure of Sampling Adequacy | .839
| Bartlett’s Test of Sphericity | Approx. Chi-Square 1615.971 |
| DF | 378 |
| Sig. | .000 |

In order to extract the principles, the remaining 28 variables were subjected to principal component analysis. To facilitate easy interpretation of the principles / factors extracted, the principal component matrix was rotated using the Varimax with Kaiser Normalisation rotation method. The study retained in the analysis practices / attributes with factor loadings and communalities greater than 0.50. Practices which failed to load above this threshold, namely ‘Env9’ (compliance with environmental policies) and “Soc3” (H&S policies) were removed. Using the eigenvalues greater than 1.0 criterion, seven underlying principles, explained by 26 practices, and explaining 72.2% of the variability in the original variables were extracted. Table 5 presents a summary of the output of factor analysis. The Cronbach’s alpha coefficient for each principle is greater than critical value of 0.70, indicating internal consistency of the items in the scale.

TABLE 5: A FRAMEWORK OF SUSTAINABILITY PRINCIPLES AND PRACTICES FOR CONSTRUCTION H&S

<table>
<thead>
<tr>
<th>Principles and practices of sustainability in H&amp;S</th>
<th>Com</th>
<th>Principle / Factor loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Responsible production</td>
<td>.859</td>
<td>.781</td>
</tr>
<tr>
<td>Eco2 Optimum production targets</td>
<td>.797</td>
<td></td>
</tr>
<tr>
<td>Eco1 Responsible production and employment</td>
<td>.718</td>
<td></td>
</tr>
<tr>
<td>Eco4 LCA of H&amp;S interventions</td>
<td>.773</td>
<td></td>
</tr>
<tr>
<td>Eco3 Balancing cost efficiency and maintain good H&amp;S</td>
<td>.567</td>
<td></td>
</tr>
<tr>
<td>Env9 Selection of low risk materials</td>
<td>.598</td>
<td></td>
</tr>
<tr>
<td>2. Finance and procurement</td>
<td>.857</td>
<td>.870</td>
</tr>
<tr>
<td>Eco6 Financial provision for H&amp;S</td>
<td>.812</td>
<td></td>
</tr>
<tr>
<td>Eco7 Integration of H&amp;S in business plan of organisations</td>
<td>.789</td>
<td></td>
</tr>
<tr>
<td>Eco5 Integration of H&amp;S into procurement systems</td>
<td>.730</td>
<td></td>
</tr>
<tr>
<td>Eco8 Assessing the impact of accidents on project parameters</td>
<td>.642</td>
<td></td>
</tr>
<tr>
<td>3. The preventative action principle</td>
<td>.797</td>
<td>.776</td>
</tr>
<tr>
<td>Env5 Proactive response to environmental thermal change risks</td>
<td>.834</td>
<td></td>
</tr>
<tr>
<td>Env6 The Polluter pays</td>
<td>.754</td>
<td></td>
</tr>
<tr>
<td>Env3 Site hygiene and welfare provisions</td>
<td>.788</td>
<td></td>
</tr>
<tr>
<td>Env7 Environmental information dissemination</td>
<td>.646</td>
<td></td>
</tr>
<tr>
<td>4. Social and environmental responsibility (SER)</td>
<td>.769</td>
<td>.670</td>
</tr>
<tr>
<td>Soc7 Accident investigation, statistics and reporting</td>
<td>.784</td>
<td></td>
</tr>
<tr>
<td>Env1 Preserving and protecting the environment</td>
<td>.706</td>
<td></td>
</tr>
<tr>
<td>Env2 Environmental pollution / waste management</td>
<td>.690</td>
<td></td>
</tr>
<tr>
<td>Soc4 Inclusive participation</td>
<td>.607</td>
<td></td>
</tr>
<tr>
<td>Soc11 Prevention through design</td>
<td>.623</td>
<td></td>
</tr>
<tr>
<td>5. Social equity</td>
<td>.555</td>
<td></td>
</tr>
<tr>
<td>Soc1 Respect for workers’ rights</td>
<td>.595</td>
<td></td>
</tr>
<tr>
<td>Soc11 Prevention through design</td>
<td>.698</td>
<td></td>
</tr>
<tr>
<td>Soc8 Post injury RTW and disability management</td>
<td>.676</td>
<td></td>
</tr>
</tbody>
</table>
The extracted principles of sustainable construction H&S were named in accordance with the composition of observed practices / attributes that correlate highly with each principle.

**Principle 1: Responsible production.** The first principle of sustainable construction H&S explained 38.1% of the total variance, with four practices loading to it. The principle encompasses the promotion of healthy and safe production methods and processes that minimise waste, optimise the use of human resources during current and future projects, ensure that materials / products are not harmful to the H&S workers and occupants of buildings, and make H&S and the environment principal in production processes. This shift from the conventional end-of-pipe with a focus on hazard measurement and control, to incorporation of H&S in the design and redesign of the production processes has beneficial effects relative to H&S, the environmental benefits and cost\(^2\). In addition, it reduces the risk of antagonistic concerns between H&S, the environment, and productivity\(^1\). An LCA assessment of H&S interventions ensures that their business partners in the supply chain\(^1,2,9\). The focus of this principle is consistent with previous studies, which established that companies which integrate H&S in management and production achieve better results\(^10\).

**Principle 3: The prevention principle.** The third principle of sustainable construction H&S explained 7.18 % of the total variance with four items, namely ‘proactive response to environmental thermal change risks’, ‘the polluter pays’, ‘site hygiene and welfare provisions’, and ‘environmental information dissemination’ loading on this principle. The principle seeks to prevent, rather than react to the impact of modified environmental factors on workers’ H&S. To fulfil this principle, companies must demonstrate that there is a proactive strategy with regards to managing climate change risks\(^10\), promote better site hygiene measures\(^10\), complying with regulatory provisions, dissemination of environmental information. Unlike the precautionary principle, the preventative action principle is applied when the risk of harm is clear\(^10\). During a previous study, the prevention principle was identified as one of the principles framing sustainable prevention in construction H&S\(^9\).

**Principle 2: Finance and procurement.** The second principle explained 9.93 % of the total variance, and it encompasses four practices, namely ‘financial provision for H&S’, ‘integration of H&S in business plan of organisations’, ‘integration of H&S in procurement’, and ‘assessment of the impacts of accidents and ill-health on project parameters’. The principle encompasses the provision of optimum financial resources for H&S and the management of upstream and downstream activities to ensure that stakeholders are accountable for the practices of their business partners in the supply chain\(^1,2,9\). This principle encompasses the promotion of institutional capacity for the implementation of H&S programmes through assigning responsibility, capacity building and providing ongoing support in the decision-making process. Capacity building in the area of H&S is important to establish policies, programmes and interventions that respond efficiently to H&S needs\(^11\). The principle ensures that employers provide the leadership, supervision and plan of action needed to ensure that workers perform their work with due regard to their H&S.

**Principle 4: Social and environmental responsibility (SER).** The fourth principle explained 4.86 % of the total variance, and has four practices loading on it. The ‘integration of SER encompasses the integration of social and environmental concerns into H&S strategies, policies and procedures in order to minimise adverse impacts of construction activities on workers, the community and the environment. Through internalising pollution prevention in workplace H&S, the principle ensures that an organisation is both environmentally and socially responsible in model sustainability. This principle reinforces the importance of having an appropriate infrastructure to promote workers’ participation\(^10\) with regards to their H&S and to prevent rather than respond to contaminated areas. Worker participation is important to ensure that H&S policies embrace sufficient environmentally friendly programmes to ensure that workers are safe\(^11\).

**Principle 5: Social equity.** The fifth principle of sustainable construction H&S explained 4.64 % of the total variance and three practices loaded on this principle. The principle encompasses putting workers at the centre of organisational and project policies to ensure a non-declining quality of life for workers at the current and future projects the worker is involved. By promoting compensation, rehabilitation, and RTW for the injured workers, the principle seeks to protect workers from falling into an intergenerational cycle of poverty. In addition, respect for workers’ rights to healthy and safe work, and the ‘integration of H&S in the design of buildings’\(^12\) are important interventions which ensure that workers are protected from unfair labour practices and H&S risks arising from the design of buildings.

**Principle 6: Governance.** The sixth principle of sustainability in construction H&S explained 3.80 % of the total variance and three practices loaded to it. This principle encompasses the provision of institutional capacity for the implementation of H&S programmes through assigning responsibility, capacity building and providing ongoing support in the decision-making process. Capacity building in the area of H&S is important to establish policies, programmes and interventions that respond efficiently to H&S needs\(^11\). The principle ensures that employers provide the leadership, supervision and plan of action needed to ensure that workers perform their work with due regard to their H&S.

**Principle 7: Precautionary approach.** The seventh principle of sustainability in construction H&S explained 3.72 % of the total variance and three items loaded on this principle, namely HIRAs, site layout planning and management, and information with regards to H&S risks. The principle encompasses the need to take appropriate action, when an activity raises threat of harm to human health or the environment, notwithstanding scientific uncertainty about the nature and extent of the risk\(^10\). While not intended to eliminate risk, the precautionary principle ensures that the associated benefits of a decision outweigh the risk\(^11\).
recognised principles of the sustainable development agenda suggesting that the principles may have a universal application. By internalising the principles into H&S practice, an integrated, holistic and sustainable approach is adopted to reduce construction incidents and improve the quality of life for construction workers. However, the transition to sustainable practice requires the review of regulatory, policy and institutional frameworks to allow scope to incorporate the principles in H&S decision making throughout the construction supply chain. Since the study was limited to the perceptions of respondents from two cities in Zimbabwe, the generalisability of the results to other regions and countries may be limited. Future research may be conducted to validate the framework and develop a universal model of sustainable construction H&S.

ACKNOWLEDGEMENTS

The researchers are grateful to all construction practitioners who participated in the survey through completing the questionnaires, and to the anonymous reviewers for their invaluable suggestions to improve the quality of this research paper.

REFERENCES


[53] Centre for Safety and Health Sustainability (CSHS), (2016) CSHS best practice guide for occupational health and safety in sustainability reports. CSHS.


AN INVESTIGATION INTO THE WATER ABSORPTION QUALITY OF CLAY BRICKS

Bonga Khuzwayo 1 Roderick Rankine 2 Mark Walker 3

1 Department of Civil Engineering and Geomatics, Durban University of Technology, South Africa
2 Rod Rankine Engineering Solutions CC, South Africa
3 Department of Mechanical Engineering, Durban University of Technology, South Africa
1 bongak@dut.ac.za; 2 rod.rankine@telkomsa.net, 3 walker@dut.ac.za

ABSTRACT

Purpose of the paper

Masonry walling, using clay units in South Africa (SA), needs to comply with various standards, inclusive of SANS10145-1 and SANS227. The compressive strength and water absorption of clay units are physical properties that some manufacturers and suppliers of masonry units make available to the public, as they are often specified/required by designers. The majority of building merchants sell clay bricks with no claims regarding properties, performance or compliance with stipulated standards. Inconsistency in testing methods and lack of standard enforcement by statutory bodies for all stakeholders presents difficulties for the designers in ensuring that their designs meet the intended level of performance, with respect to the flexural strength, which is affected partly by the water absorption capacity of clay bricks.

Design/methodology/approach

Hence, the study hypothesized that designers and clients need to obtain an independent confirmation of the water absorption capacity of clay bricks to ensure the expected level of performance and durability of masonry walling. A total of 370 clay brick samples, purchased from emerging and established entrepreneurs/manufacturers across SA, were tested for their water absorption capacity.

Findings

Only 45.9% of clay bricks were determined to have the water absorption capacity outside of the recommended parameter of 12 to 20% when used for structural purposes.

Value

The designs that specified clay units with water absorption less than seven% run a risk of compromising the level of intended performance. A plane of failure, parallel to bed joint will be assumed, which will not be achieved in a real masonry walling as the clay bricks are not available from the merchants across all provinces in SA.

Keywords: clay units; water absorption

BACKGROUND AND INTRODUCTION

The design of masonry structural elements, such as walls, requires some informed design assumptions with respect to the material’s physical and mechanical properties. The designer provides specification/s necessary to achieve the intended product. A free standing boundary wall and its level of performance for example, could resist wind pressure that will cause it to bend. Usually, the compressive strength is the physical property that most designers specify. However, when designing walls made from clay units, bending about the plane of failure parallel and/or perpendicular joints, the specification for the water absorption becomes critical as the bond mechanism between clay bricks and mortar yields to different flexural strengths for various types of mortar class [1]. Various types of clay units comprising units that conform and do not conform to South African National Standard 227 [2], produced by manufacturers who either do or do not carry the South African Berea of Standard marks, are available/or exist in South Africa. Manufacturers who do not comply can easily compromise on the quality of materials and production procedures [3], thereby affording a cheaper price. Similarly, there is a vast amount of masonry walling that disregard South African National Standard 10145 [4], which deals with design and construction of concrete masonry.
There are various factors contributing to their performance. In situ testing and sample extraction yielded masonry characteristics. The construction industry attracts a growing number of individuals who are producing designs. They also provide specification/s for the materials, substandard designs, inadequate specifications and unprofessional individuals. There exists an increasingly growing number of individuals who are producing construction materials such as clay bricks. Invariably, problems arise when these individuals do not possess the prerequisite knowledge and skills which, more often than not, results in the production of substandard and/or poor-quality clay units.

Designers are expected to make rigorous assumptions to produce designs. They also provide specifications necessary to achieve the level of intended performance. Numerous methods are considered in informing the requirements of the materials they offer. Not all products contain or even include technical specification. Availability of substandard and/or poor-quality clay bricks from the merchants presents an inadvertent opportunity to be used with adverse effects. Utilising clay bricks to build structural walls, identified earlier in this paper, clearly poses risks associated with the quality of materials, substandard designs, inadequate specifications and unreliable workmanship. Clay units, being elements manufactured off site, ought to reflect higher standards. In addition, the factory production environment affords quality control and testing measures superior to that achievable at the construction site.

Essentially, three (3) types of mortar are used in masonry, namely; classes I, II and III. Class III mortar has long been suspended for structural use due to very low strength [10]. Mortar class is identified by the compressive strength required at 28 days. Based on works test, the strengths are 10 MPa, 5 MPa and 1.5 MPa for class I, II and III, respectively. In a laboratory, there is a difference in the performance of real structures. Microstructural features of the materials play an important role in the deterioration of old masonry structures, owing to salt crystallization, frost damage, etc. Whilst the impact of water saturation has been investigated for clay-bearing rocks, ceramics and concrete, its consequences on the mechanical behaviour of brick masonry still requires in-depth clarification. For this reason, in the present paper, the compressive strength and Young’s modulus of fired clay bricks, cement-based and time-based mortars, along with masonry triplets, are investigated in wet and dry conditions. The sequential effects are elucidated in the light of the materials’ microstructural features, i.e., total void amount and pores size distribution [11].

The literature review reveals the importance of mechanical and corrosion effects that physical properties of clay bricks have on the design performance with respect to the mortar with which it bonds.

**METHOD**

Clause 6.9 of South African National Standard 227 requires (three) 3 apparatuses to conduct the test, namely; a forced-draught drying kiln capable of maintaining a temperature of at least 105°C; a lidded heating tank with a grid at the bottom to allow circulation of water all around the units; and a balance able to measure the mass of units to an accuracy of 0.1% [11]. This procedure stipulates the drying of units in a kiln at a temperature of at least 105°C until a constant mass (m) is achieved. The specimens are then immersed in clean water for 24-hours (commonly known as the immersion test), maintaining a room temperature between 22-25°C. On completion, the specimens are removed; excess water is wiped off using a damp cloth and mass (m) is measured immediately. After the 24-hour immersion test, the specimens are placed on a grid inside a tank. The water temperature is raised to boiling point over a period of one (1) hour and maintained at 105°C for 24-hours (commonly known as the five (5) hour boiling test). The tank is then switched off and the water in the tank with specimens is allowed to cool naturally between the period of 16-19 hours. The specimens are removed, wiped with a damp cloth and mass (m) is measured. The water absorption capacity is calculated in accordance with clause 6.9.4.
The South African National Standard 10164-1 presents two methods, namely: the five (5) hour boiling and the vacuum test (the latter method is not the focus of this paper). However, the two methods give acceptable concurring results for the majority of clay units. Clause 6.5 advises that the specimens are dried in a ventilated kiln at a temperature of 110-115ºC. When the specimens are cooled, they are weighed to an accuracy of 0.1%. After recording mass \( m_1 \), the specimens are placed on a grid inside a tank. The water temperature is raised to boiling over a period of one (1) hour and maintained at boiling point for five (5) hours (commonly known as the five (5) hour boiling test). The tank is switched off and the water in the tank with specimens is allowed to cool naturally between the period of 16-19 hours. The specimens are then removed; excess water is wiped off with a damp cloth, and mass \( m_2 \) is measured within two minutes after removing them from water. It is imperative to note that this standard does not expect the specimens to be immersed in water for 24 hours prior to boiling.

### Procurings clay units from the manufacturers and/or suppliers

The clay specimens were purchased from the manufacturers and suppliers across SA but predominantly in Durban (KwaZulu Natal). Some specimens were obtained from Cape Town and Pretoria. Manufacturers and suppliers were identified through an internet search and by physically visiting industrial hubs with crowded hardware stores. Upon identifying suitable specimens, 10 specimens of each type were purchased, provided that the first author had not purchased the same from another supplier. Identical specimens were purchased if they came from a different quarry and/or had a different colour as compared to the specimens already procured. A receipt (proof of payment) was obtained for every specimen purchased. A total of 37 different types of specimens (see figure 1 below) were attained, ranging from emerging to established entrepreneurs/manufacturers/suppliers. During interaction with salespersons, the first author enquired about the compressive strength and water absorption of the clay bricks they offer for sale.

### Choosing the testing method: SANS227 or SANS10164-1

A pilot study was conducted on common clay bricks to determine the outcome of each method. Ten (10) number of three (3) types of units were purchased to determine water absorption by using both test methods. The results revealed that the method stipulated by SANS227 provides larger water absorption values as compared to the method presented by SANS10164-1. Furthermore, since SANS10164-1 presented two methods, the five (5) hour boiling and the vacuum test, giving similar results, it became more plausible to proceed with 24 hour immersion followed by five (5) hour boiling. There were 370 units tested in accordance with Clause 6.9 of SANS 227.
The 24-hour immersion test revealed that 51% of clay units have water absorption capability between seven% and but not including 12%. The balance (49%) had water absorption, included and in excess of 12%. After five-hour boiling, 75.6% of clay units were determined to have water absorption equal or greater than 12%. The balance (24.3%) had water absorption between seven% and but not including, 12%. Water absorption gained after boiling ranged between one% and nine% giving an average of four%. Figure 4 also reveals 21.6% of the bricks above the upper limit of 20% and 24.3% of the bricks below the minimum limit of 12%, were recommended for structural use.

**Figure 4: Water absorption for 37 types of specimen around SA.**

Samples procured from across South Africa were tested for the water absorption capacity to highlight the point that designers and clients need to obtain an independent confirmation of the water absorption capacity of clay bricks to ensure the recommended level of performance and durability of masonry walling. The designs that specified clay units with water absorption less than seven% run a risk of compromising the level of intended performance because a plane of failure parallel to bed joint will be assumed, which will not be achieved in a real masonry walling, as the clay bricks will not be available from the merchants across all provinces in SA.

**CONCLUSION**

The differences in the testing methods given by SANS227 and SANS10164-1 emphasized the need for the South African Bureau of Standards to adopt one method in order to enable a common testing method to measure the water absorption of clay bricks.

The designs that specify clay units with water absorption less than seven% run a risk of compromising the level of intended performance because a plane of failure parallel to bed joint will be assumed which will not be achieved in a real masonry walling as these clay bricks are not available from the merchants.

With reference to the clay bricks, 24.3% were determined to be below the lower recommend limit and 21.6% were determined to be of the recommended upper limit suitable to be used for structural purposes.

**REFERENCES**

CONTRIBUTION OF CURRENT ACCIDENT INVESTIGATION PROCESSES TO CONSTRUCTION ACCIDENTS CAUSATION IN SOUTH AFRICA: A CASE STUDY APPROACH

Trinisha Lutchmia
Engen Petroleum
tlutchmiah@gmail.com

Theo C. Haupt
Faculty of Engineering
Mangosuthu University of Technology
Durban, South Africa
Pinnacle.haupt@gmail.com

ABSTRACT

Purpose: This paper is part of a preliminary study which analyzes the causes identified in accident investigation reports in order to determine whether the causes identified are indeed the root causes or direct causes. The effectiveness of the subsequent preventative and remedial measures and the prevention of the recurrence of the same accidents are also identified.

Design/methodology: Using a qualitative research approach, a combination of exploratory and collective case studies were done on construction accident causation where a sample of 30 accidents drawn from actual investigation records of a large construction company were examined to determine their recorded causes. These were compared against various established causation theories to determine whether the correct root causes had been identified, the subsequent remedial actions were responsive to these causes, and whether the same accident was likely to recur or not.

Findings: The findings indicate that accident investigation processes are ineffective as they primarily focus on the direct or trigger causes of an accident and not the underlying root causes. This leads to the incorrect remedial action taken, ultimately resulting in the accident recurring. Therefore, if accident investigation processes are improved to focus on the underlying root causes of accidents, the recurrence of the same construction accidents will reduce.

Keywords: Accident causation, Construction Accidents, Health and Safety, South Africa

INTRODUCTION

Many accidents involving loss of life and limb have occurred on construction sites across South Africa. Consequently, these accidents have created negative impressions of the industry and sector [1]. The examination of the causation of accidents is necessary considering the potential consequences of high casualty tolls, environmental damage, economic losses and ethical/moral considerations [2]. It is well-known that construction represents a challenging regime in which to manage health and safety exacerbated by the enormous diversity in terms of the size and range of its activities [3]. Poor health and safety (H&S) not only negatively affects workers’ lives which is always top priority, it also negatively affects project costs, quality, schedule and results in increased insurance premiums, medical costs and reduced productivity [4]. Additionally, construction activities occur in hazardous working environments with direct exposure to many hazards that are not necessarily present in other industries or working environments. Benefits of improved H&S include increased efficiency, enhanced competitiveness, increased profitability, reduced delays, fewer disputes and reduced conflict [5].
Health and safety improvements in the workplace are developed and shaped because of the knowledge gained and assumptions made from accidents that have occurred. Understanding what causes accidents is important as it helps distinguish between factors that require attention and remedial action and factors that are unimportant and can be ignored. There are several theories that exist created by scholars in attempts to provide understanding of the causation of accidents on construction sites. Despite these theories, accidents have continued unabated. Typically, these theories have focused on the construction worker as being the primary cause of accidents – a basic tenet of the behavioural safety approach originally promoted by B.F. Skinner and espoused by, for example Krause, Hildley and Reynolds.

In discussing accident prevention, it is important to clarify the terms “accident” and “incident.” The term “accident” implies that the event was not expected, foreseen or intended. An “incident” is defined as a minor happening, an event or an occurrence, whether predictable or not, that takes place because of something else.

The same types of accidents occur repetitively in the construction industry around the world. Many of the construction hazards are well known. Despite extensive research on many of these hazards they seem to continue to occur with the same incidence of death, injury and illness. Statistically, it is generally understood where deaths, injuries and illnesses are most likely to occur in the construction industry. Despite this understanding the industry has been more than lethargic to learn from its mistakes and introduce interventions to prevent these negative and unfortunate outcomes.

Accident Causation Theories

There are a vast number of theories about the causes of accidents on construction sites that are typically regarded as dangerous and hazardous working environments. Some of the better known older theories include, for example, the following:

- Accident Proneness Theory
- Goals-Freedom-Alertness Theory
- Adjustment Stress Theory
- Chain of events (Domino theory)
- Distractions Theory
- Human Error Theories; and
- Model of Causal Influences in Construction Accidents.

Accidents are preventable and should be regarded as failures of management and the system of management. Very few if any of the theories comprehensively addresses these issues. Further, in line with the more recent accident theories, the aim of organisations should be to shift the emphasis from errors on the part of the individual to the management and organisational errors that cause poor health and safety performance.

LITERATURE REVIEW

In discussing accident prevention, it is important to clarify the terms “accident” and “incident.” The term “accident” implies that the event was not expected, foreseen or intended resulting from negligence that results in injury, loss or damage. An “incident” is defined as a minor happening, an event or an occurrence, whether predictable or not, that takes place because of something else.

The same types of accidents occur repetitively in the construction industry around the world. Many of the construction hazards are well known. Despite extensive research on many of these hazards they seem to continue to occur with the same incidence of death, injury and illness. Statistically, it is generally understood where deaths, injuries and illnesses are most likely to occur in the construction industry. Despite this understanding the industry has been more than lethargic to learn from its mistakes and introduce interventions to prevent these negative and unfortunate outcomes.

Table 1: Summary of accident causation theories

<table>
<thead>
<tr>
<th>Theory/Model</th>
<th>Focus of accident causation and target of corrective action</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accident Proneness Theory</td>
<td>On Worker</td>
<td>A</td>
</tr>
<tr>
<td>Goals-Freedom-Alertness Theory</td>
<td>On Worker</td>
<td>B</td>
</tr>
<tr>
<td>Adjustment Stress Theory</td>
<td>On Worker</td>
<td>C</td>
</tr>
<tr>
<td>Distractions Theory</td>
<td>On Worker</td>
<td>D</td>
</tr>
<tr>
<td>Chain of events - (Domino theory) – Heinrich’s Theory</td>
<td>Social &amp; Family Background</td>
<td>E1</td>
</tr>
<tr>
<td>Chain of events - (Domino theory) – Heinrich’s Theory</td>
<td>Personal Factors (greed, stupidity, recklessness could be in a person’s nature or learned, etc.)</td>
<td>E2</td>
</tr>
<tr>
<td>Chain of events - (Domino theory) – Heinrich’s Theory</td>
<td>Unsafe Acts (on the worker); Unsafe Conditions (mechanical or physical hazards)</td>
<td>E3</td>
</tr>
<tr>
<td>Chain of events - (Domino theory) – Heinrich’s Theory</td>
<td>Immediate Causes: Unsafe Acts (on the worker); Conditions (mechanical or physical hazards); or Errors</td>
<td>F1</td>
</tr>
<tr>
<td>Chain of events - (Domino theory) – Heinrich’s Theory</td>
<td>Basic (contributing) Causes: Personal Factors (fatigue, lack of motivation, insufficient safety knowledge), or Job Factors (unrealistic work schedules, inadequate resources, etc.)</td>
<td>F2</td>
</tr>
<tr>
<td>Chain of events - (Domino theory) – Heinrich’s Theory</td>
<td>Lack of Control by Management Root causes</td>
<td>F3</td>
</tr>
<tr>
<td>Multiple Causation Model</td>
<td>Management System (Root Causes): Management Policies, Procedures, Supervision, Effectiveness, Training, etc.</td>
<td>G</td>
</tr>
<tr>
<td>Reason’s Framework for Accident Causation</td>
<td>Active Failures: On Worker</td>
<td>H1</td>
</tr>
<tr>
<td>Reason’s Framework for Accident Causation</td>
<td>Latent Failures: Head Office and Site Management Levels</td>
<td>H2</td>
</tr>
<tr>
<td>Constraint-Response Theory</td>
<td>Proximal Factors: Site Management and on Injured Worker Levels</td>
<td>I1</td>
</tr>
<tr>
<td>Constraint-Response Theory</td>
<td>Distal Factors: Management Level and Includes Project Conception Restraints, Project Design and Project Management Constraints,</td>
<td>I2</td>
</tr>
<tr>
<td>Human Error Theories</td>
<td>Behaviour Based Models: On Worker</td>
<td>J1</td>
</tr>
<tr>
<td>Human Error Theories</td>
<td>Human Factor Models: On Worker; and Design of Tasks, Tools, and Workplaces</td>
<td>J2</td>
</tr>
<tr>
<td>Hierarchy of Causal Influences in Construction Accidents Model</td>
<td>Immediate Accident Circumstances:</td>
<td>J3</td>
</tr>
<tr>
<td>Hierarchy of Causal Influences in Construction Accidents Model</td>
<td>Work Team: Actions, Behaviour, Capabilities and Communication</td>
<td>K1</td>
</tr>
<tr>
<td>Hierarchy of Causal Influences in Construction Accidents Model</td>
<td>The Workplace: Layout/Space, Lighting/Noise, Hot/Cold/ Wet, Local Hazards</td>
<td>K2</td>
</tr>
<tr>
<td>Hierarchy of Causal Influences in Construction Accidents Model</td>
<td>Materials and Equipment: Suitability, Usability, Condition</td>
<td>K3</td>
</tr>
<tr>
<td>Shaping Factors:</td>
<td>Work Team: Attitudes, Motivations, Knowledge, Skills, Supervision, Health and Fatigue</td>
<td>K4</td>
</tr>
<tr>
<td>Shaping Factors:</td>
<td>The Workplace: Site Constraints, Work Scheduling and Housekeeping</td>
<td>K5</td>
</tr>
<tr>
<td>Shaping Factors:</td>
<td>Materials and Equipment: Design, Specification and Supply/ Availability</td>
<td>K6</td>
</tr>
</tbody>
</table>
Theory/Model | Focus of accident causation and target of corrective action | Ref
---|---|---
Environmental Level - Social, Political and Market Context: Political Influence, Regulatory Influence, Market Influence, Societal Influence | L4

METHODOLOGY
This study employs a qualitative research approach. A combination of exploratory and collective case study was done on construction accident causation where a sample of accidents drawn from actual investigation records of a large construction company was examined to determine their recorded causes. These were compared against the various causation theories to determine whether the correct root causes and remedial action had been identified and whether the same accident was likely to recur or not. The research design is based on quota sampling as a sample of any 30 lost time accidents reports were acquired from the participating large construction company for selection and analysis for this study.

This paper is based on only part of the final study. It excludes a survey that was done of a small sample of contractors and health and safety officers to determine whether the results of the case studies were aligned with what these parties actually experienced on their construction projects and sites.

FINDINGS
A sample of 30 accident investigation reports were analysed by categorising every accident cause identified in these reports according to the relevant accident causation theories previously highlighted as shown in Table 1 to determine which theories were most prevalent or appeared most commonly in the reports. The frequency of each accident causation theory was analysed to determine whether the identified causes of the accidents listed in the reports were focused on the actions and failures of workers or management and whether the remedial actions taken were correct and would enhance the prevention of the same accident from reoccurring according to the theories they were classified under.

The causes of the 30 construction accidents as stated in the respective accident investigation reports were classified into three categories namely: Direct Causes, Contributory Causes and Root Causes. If the causes identified in the reports were in reality the root causes and not direct or contributory causes, then the underlying causative issues would have been identified in the investigation and the resultant remedial action recommended would most likely prevent the reoccurrence of the accident. If direct or contributory causes were only identified in the report, then arguably the recommended remedial action taken to be taken would not be effective and appropriate resulting the the likely recurrence of the accident.
This finding suggests that the reported root causes of the 30 construction accidents rarely if ever related to the
tolerance or failures of management, management system or the organisation.

These findings therefore suggest that accident investigation processes are flawed because of their focus as they
predominantly blamed the causes of construction accidents on the negligence of workers. As much as worker
negligence contributes to the cause of the accident there are other underlying causes such as the lack of training,
supervision, health and safety awareness and culture within the organisation, management failing to rotate teams
on strenuous tasks and much more. These are typically management functions and responsibilities. If these
particular underlying root causes are not addressed the accident will most likely continue to reoccur.

CONCLUSION

The findings indicate that the causes of construction accidents identified using current accident investigation processes are
predominantly related to the negligence and failures of workers and rarely identify the negligence of management, failure
of the management system or the organisation as the underlying root cause. Accident investigation processes were found to
be deficient as they primarily focused on the downstream direct or trigger cause or agent of the accident and not the
underlying upstream root cause. This approach inevitably leads to the incorrect remedial action being recommended and
taken ultimately resulting in the accident reoccurring despite the emphasis placed on H&S within the organisation.

Given that the intent of any accident investigation should be to prevent the recurrence of the same type of accident, all
root causes need to be investigated. Clearly the present system of accident investigation and recordkeeping focuses on the
downstream event, the last domino in the chain of events or the trigger event. Arguably, by only addressing the final trigger
event the accidents will not be prevented from reoccurring.

Based on the findings, the behavioural health and safety interventions or the remedial action taken based on the direct
or contributory causes, as part of a health, safety and environmental management system, would not necessarily prevent
accidents. Rather they might reduce accidents but not prevent them.

The findings of this study cannot necessarily be generalized to the entire construction industry given that it used cases within
a single large organization. However, it gives insight into the possibility that other construction companies might be doing the
same thing, namely making the same misjudgements which result from ineffective accident investigation processes and the
subsequent reoccurrence of accidents. It is therefore recommended that a more indepth study is done with a larger sample
size of different construction companies in South Africa. Considering that the ultimate goal for any construction stakeholder is
to strive for zero accidents, any approach which does not prevent accidents is seriously flawed and needs to change.
REFERENCES


[7] Swuste, P. (2008), You will only see it, if you understand it” or occupational risk prevention from a management perspective, Human Factors and Ergonomics in Manufacturing, 18: 438-453.


INSTRUCTIONS FOR AUTHORS

1. Submission of manuscripts

Authors should submit their papers electronically to The Editor at joc@asocsa.org.

Provided that the paper is attached as a separate file using the recommended MS Word software format. All electronic submissions containing viruses will be deleted without opening them.

Manuscripts must be submitted in English and must be original, unpublished work not under consideration for publication elsewhere. It will be assumed that authors will keep a copy of their manuscript. Manuscripts are not returned to the author(s).

Manuscripts are blind peer reviewed by acknowledged experts. Revisions may be required before a decision is made to accept or reject the paper. If an author is uncertain whether a paper is suitable for publication in JOC, it is acceptable to submit a synopsis first.

2. Elective communication

The paper should be written and arranged in a style that is succinct and easily followed. An informative but short title, a concise abstract and keywords and a well-written introduction will help achieve this. Simple language, short sentences and a good use of headings all help to communicate information more effectively. Discursive treatments of the subject matter are discouraged. Figures should be used to aid the clarity of the paper. The reader should be carefully guided through the paper.

3. Publication Fees

The Journal of Construction is an Open Access Journal, and all accepted articles carry a publication fee of Ten Thousand Rands (R 10,000).

4. Preparation of the manuscript

Length: Although there is no length limitation, papers should preferably be between 3,000 and 6,000 words in length (8 to 12 pages). Longer papers will only be accepted in exceptional cases and might be subject to serialisation at the discretion of the editor.

Layout: The manuscript must be in English, typed and 1.5 line-spaced 10-pt Arial font on one side of A4 paper only, with a 3cm margin on the left-hand side. All other margins are to be 2cm. All text should be linked to the left and right margins i.e. paragraphs should not be indented and text should be justified. One-line spacing should be left between paragraphs and double line spacing before a new heading. Leave one line space between a heading and the following paragraphs. All headings should be in 12pt bold capitals. Paragraphs and sub-paragraphs should not be numbered. The pages should be numbered consecutively. There should be no loose addenda or notes or other explanatory material. The manuscript should be arranged under headings and sub-headings.

Title page (page 1): The first page of the manuscript must contain a concise and informative title, a secondary running title of not more than 75 characters and spaces, the name(s), the affiliation(s) and address(es) of the author(s) and the name, address, telephone, fax and email of the author who will be responsible for correspondence and corrections. The title should be in 12pt bold capitals, the name(s) of the author(s) in 10pt bold upper and lower case and the affiliation(s) and address(es) in 10pt upper and lower case with a single line space between each.

Abstract and keywords (page 2): To produce a structured abstract, complete the following fields about the paper. There are four fields which are obligatory (Purpose, Design, Findings and Value); the other two (Research limitations/implications and Practical implications) may be omitted if they are not applicable to the paper. Abstracts should contain no more than 150 words.

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

Purpose of this paper

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

Design/methodology/approach

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

Findings

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

Research limitations/implications (if applicable)

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

Practical implications (if applicable)

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

What is original/value of paper?

What is new in the paper? State the value of the paper and to whom.

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

Introduction (page 3): The introduction should clearly state the purpose (aims and objectives) of the paper. It should include key references to appropriate work, but is NOT the place for a comprehensive historical or literature review.

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

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

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

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

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

Drawings and diagrams must not exceed 140mm in width and all dimensions must be in mm. Annotation must be in upper and lower case lettering, the capital of which should be 3 mm high.

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

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

The table identification should be in bold. Identify all statistical methods and sources of data.

Tables should only have horizontal lines, the heading and bottom lines being in bold.

All words should be in upper and lower case lettering. The headings should be aligned to the left of their columns, 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.
Symbols, abbreviations and conventions: Symbols, abbreviations and conventions in papers must follow the recommended SI units. Where non-standard abbreviations are used, the word(s) to be abbreviated should be written out in full on the first mention in the text, followed by the abbreviation in parentheses.

References: The numbered 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.

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

Copyright: Submission of a paper to JOC is taken to imply that it represents original, unpublished work, not under consideration for publication elsewhere.

The Journal of Construction is committed to open access for academic work and is, therefore, an open access journal, which means that all articles are available on the internet to all users immediately from the date of publication. This allows for the reproduction of articles, free of charge, for noncommercial use only and with the appropriate citation information. All authors publishing in the Journal of Construction accept these as the terms of publication.

Permission to publish illustrations must be obtained by the author before submission and any acknowledgements should be included in the figure captions. Should the author wish to have the paper published elsewhere, such as in an anthology, the author must write and seek consent from the Publisher which will normally be given provided acknowledgement of the original source is provided.

Copyright of the content of all articles and reviews remains with the designated author of the article or review. Copyright of the layout and design of Journal of Construction articles and reviews remains with the Journal of Construction and cannot be used in other publications.

Benefits of open access for authors, include:

- Free access for all users worldwide
- Authors retain copyright to their work
- Increased visibility and readership
- Rapid publication
- No spatial constraints

### Table 1 Components of expenditure

<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>

Source1