Ergonomic Benefits of the Biophilic Construction Site Model and the Rock Garden Design

Speakers:
Obiozo, Rita (N) ¹; Smallwood, John (J) ²;

¹ Department of Construction Management, Nelson Mandela Metropolitan University, Port Elizabeth, South Africa
² Department of Construction Management, Nelson Mandela Metropolitan University, Port Elizabeth, South Africa

Abstract: The stark arid nature of construction sites presents a tiresome weary work environment that is burdensome and increases the work load on the workforce, resulting in sick construction site syndrome. There is an argument that suggests that the value of a systematic, ergonomic approach to designing the construction workplace could relieve the ambient condition on human comfort, performance, and H&S in construction. The validity of the argument is substantiated by findings in nature-psychophysiology and ecopsychology that promotes the biophilic design concept of the greening of the construction site as a relevant control measure.

The methodology includes an exploratory survey which involves a cross sectional analysis of case studies. The technique includes a comparative analysis of a construction site in Reading, UK, with a potential for greening and another construction site in the Northern Cape Region in South Africa. The findings validate the merit of the biophilic design concept, and the particular suggestion of the rock garden design as most adaptable to the greening of the construction site that fulfills the requirement for a sustainable sites initiative in construction.

Biophilia, construction, ergonomics, health and safety, performance

Introduction
The possibility exists in construction of creating a workplace that has a direct influence on human behavior and becomes motivational by elevating the moods and perceptions of the workforce. This would be more effective by the simultaneous reduction and elimination of the negative effects that exist in the construction workplace and the impact that construction has on the workplace environment as a subset of the global environment [6]. There is a need to create a relaxed atmosphere with a pleasant ambience within the construction site in the form of the biophilic construction site model (BCSM) as a construction management strategy that would counteract the psychosocial risk factors of the worksite and work processes [4]. The BCSM or the greening of the construction site is a derivation of the biophilic design concept which includes the application of the biophilic and feng shui interventions on the construction site [2, 5, 9, 10]. The biophilic design concept is derived from the theory of biophilia and the biophilia hypothesis and substantiated with a range of evidence from researchers across the scientific and built environment spectrum [7]. Biophilia is defined by Wilson [13] as the ‘innate affiliation of humankind to all organisms in nature’ and is as of yet missing on the construction site and would add value to the Construction Management body of Knowledge (CMBOK).
The objective of the study is to determine a desirable ambient condition for the construction site that enhances H&S, wellbeing and performance on construction sites by examining some of the ergonomics issues such as a construction site environment that is predominantly nature devoid. The methodology includes an exploratory survey of the greening of construction sites with and without the BCSM. The survey involves a comparative study of similar construction sites in the Northern Cape Province of South Africa and the findings where substantiated with another Case Study of a construction site in Reading, UK.

Findings indicate that regardless of the nature of the project and work processes, the presence of nature in the form of trees and green foliage plants could be included or introduced into the construction site premises and site offices and enhanced in subtle ways without compromising the functionality of the work processes. The recommendations includes the suggestion of the ‘informal dynamic rock garden’ which is found to be suitable to the nature of the construction site and its work process and a means impacting on sustainable sites initiative [4].

**BCSM and the healing of the ‘sick construction site’ syndrome**

Hedge [4] gives a concise description that aptly relates to the H&S, and ergonomic factor of the ‘sick construction site syndrome’, which indicates that a physical environment condition can exert dramatic influences on behavior that shapes humankind to seek certain places and avoid others. Given the scenario, derived from poor environmental ergonomics and a situation that compels a person to stay within such an environment as the construction workforce on the construction worksite; the effect will result in a socio-psycho-physiological breakdown that would compromise the individual’s ability to perform on an existential and cognitive level. The ultimate result is known to be psychotraumatic and contrary to workplace performance which eventually drives the appellation of the ‘sick construction site syndrome’ that compromises cost-effective project delivery. Research findings indicate that a ‘healing garden’ in the form of a socio-psychotherapeutic measure such as the BCSM is a necessary remedy in such a situation [4, 5, 12].

**Research Methodology**

The exploratory greening construction site survey involves the triangulation method of analysis of three construction sites in progress which includes: CWS-1 and CWS-2 located in the Northern Cape Region of South Africa, with and without the BCSM respectively; an onsite visit that lasted for a duration of nearly two months with a questionnaire survey involving both workers and managements, management reports, photo elicitations, observations and interviews. However, the survey at CWS-3 located in Reading, UK, included only photo-elicitations and personal observations with no interviews, and was conducted as a comparative study due to the similarity of the background and context. The similarity of the location of the construction sites include the extreme summer heat and temperatures experienced on all construction sites during the period of survey and observation. The remarkable associative factor which forms the basis for the comparative analysis of the study involves the different ways the three construction sites adapted to the psychotraumatic / psychosocial risk factors relative to the heat stress experienced during the
work processes. This factor is significant with respect to the relevance accorded to the BCSM single element of study which includes the existing trees common to each construction site.

Case Study 1: CWS-1; With the BCSM

The key biophilic design features of the BCSM element of study

The Bashewa Construction management at CWS-1 enhanced the existing tree on the construction site by moving the site office containers in such a way as to create two outdoor shelters between the three Carmel Thorn / Acacia Erioloba trees enhanced with shade nets. The shelters were furnished with chairs and tables, and live chameleons harvested from the site premises were placed on the trees for the worker to feed during their lunch break hour as an aspect of attention restorative therapy (ART) according to van den Berg et al. [12] as shown in Photos 1, 2 and 3.

![Photos 1, 2 and 3. The first outdoor shelter enhanced with shade net with site meeting in progress; and a live chameleon hanging from the Acacia Erioloba locally known as Carmel Thorn tree; and the second outdoor shelter showing the general workers relaxing during the lunch break (Courtesy: Bashewa Construction Management).](image)

Analysis from the questionnaire survey

This study entailed the use of a Likert type scale ranging from 1-5 for the self-administered questionnaire; in terms of percentage responses to a scale of 1 (strongly disagree) and 5 (strongly agree), and a MS between 1.00 and 5.00. Descriptive statistics in the form of frequencies and a measure of central tendency, were computed from the data gathered which included 25 in the analysis of the data. The computing of a MS enabled the results to be ranked (R) in importance to one another as shown in Tables 1 and 2.

<table>
<thead>
<tr>
<th>Functional values</th>
<th>Unsure</th>
<th>Strongly disagree</th>
<th>Strongly agree</th>
<th>MS</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased work effectiveness</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>28.0</td>
<td>1</td>
</tr>
<tr>
<td>Improved comfort</td>
<td>8.0</td>
<td>8.0</td>
<td>64.0</td>
<td>4.0</td>
<td>1</td>
</tr>
<tr>
<td>Greatly reduced turnover</td>
<td>8.0</td>
<td>8.0</td>
<td>36.0</td>
<td>0.0</td>
<td>1</td>
</tr>
<tr>
<td>Rapid payback investment</td>
<td>8.0</td>
<td>8.0</td>
<td>32.0</td>
<td>0.0</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 1 indicates the respondents’ degree of concurrence with respect to the cost effectiveness of the psychotherapeutic value of the BCSM element of study. It is notable that three (60%) of the functional values have MSs > 3.00, which indicates that in general there is agreement as opposed to disagreement – ‘increased work effectiveness’, ‘improved comfort’, and ‘greatly reduced turnover’. However, two (40%) functional values have MSs ≤ 3.00 i.e.
disagreement as opposed to agreement. However, the MSs are both 2.96, which is virtually on the cut point, namely 3.00 – ‘rapid payback in investment’, and ‘absenteeism cut in half’. In terms of the various ranges only 20% of the functional values, namely first ranked ‘increased work effectiveness’ has an MS $\geq 3.40 \leq 4.20$, which indicates that the agreement is between neutral and agree / agree. Thereafter, the rest of the functional values (80%), namely those ranked second to fourth have MSs $> 2.60 \leq 3.40$, which indicates that the agreement is between disagree to neutral / neutral. Included in this range are ‘improved comfort’, ‘greatly reduced turnover’, ‘rapid payback investment’, and ‘absenteeism cut in half’.

Table 2 indicates the respondents’ degree of concurrence with respect to the ‘socio-psycho-physiological value’ of the implementation of the BCSM relative to the ‘psychological wellbeing attribute’.

<table>
<thead>
<tr>
<th>Psychological wellbeing attribute (Psychological factor)</th>
<th>Unsure</th>
<th>Strongly disagree</th>
<th>Strongly agree</th>
<th>MS</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved comfort and wellbeing’</td>
<td>0.0</td>
<td>0.0</td>
<td>4.0</td>
<td>0.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Improved psychosocial value</td>
<td>0.0</td>
<td>0.0</td>
<td>4.0</td>
<td>4.0</td>
<td>72.0</td>
</tr>
<tr>
<td>Organisational respect for workers</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>4.0</td>
<td>68.0</td>
</tr>
<tr>
<td>Spiritual upliftment of the workplace</td>
<td>0.0</td>
<td>0.0</td>
<td>4.0</td>
<td>4.0</td>
<td>36.0</td>
</tr>
<tr>
<td>Satisfaction with workplace aesthetics</td>
<td>0.0</td>
<td>0.0</td>
<td>4.0</td>
<td>12.0</td>
<td>64.0</td>
</tr>
</tbody>
</table>

Source: Field Survey.

Five (100%) of the psychological values has a MS $> 3.00$, which indicates that generally there is agreement as opposed to disagreement in terms of the impact of the implementation of the BCSM on ‘improved socio-psycho-physiological wellbeing’. In terms of the various ranges 100% of the psychological values has a MS $\geq 3.40 \leq 4.20$, which indicates that the agreement is between neutral and agree / agree. In terms of ranking ‘improved comfort and wellbeing’ is ranked first; ‘enhanced psychosocial value’ is ranked second; ‘organizational respect for workers’ and ‘spiritual upliftment of the workplace’ are ranked third; and ‘workplace aesthetic appeal / satisfaction’ is fourth ranking.

**Result and deductions from findings**

In corroboration with literature findings, management reports, the interviews and observations with the workforce, the findings indicate the following:

1. The findings in Table 1 indicate that the BCSM single element of study was effective in achieving ‘increased work effectiveness’ (MS = 3.76). The MSs of the functional values in Table 1 are also indicative of the fact that the psychotherapeutic measure of the BCSM element of study has contributed between a moderate to a major extent to generally improved cost effectiveness and successful delivery of the project.
2. In Table 2 the BCSM single element of study was effective to a significant extent to enhanced socio-psychophysiological wellbeing of the workers as shown in Table 2. The findings indicate that to a general extent the workforce agreed by a 100% that there the psychological wellbeing factors translate into improved psychosocial / psychophysiological value of the BCSM with improved comfort and wellbeing ranked
first (MS=3.88). These values significantly establishes the presence of a nourishing non-toxic environment with the introduction of the BCSM element of study that includes: Social / emotional / ecological intelligence; indicative of the healing of the ‘sick construction site syndrome’ according to literature findings [1, 3, 7].

Comparative Analysis: without the BCSM

Case Study 2; CWS - 2

The CSW-2 involves a field survey of Landfills construction site at Finsch mine in the Northern Cape region of RSA without the BCSM. The construction workers carried out the scheduled tasks under the excessive heat of the summer season without the benefit of an outdoor shelter for lunch break retreat. Unlike CWS-1 the shade net was provided only for the parking lot as shown in Photo 4, 5 and 6.

Photos 4, 5 & 6: Construction workers sheltering under the one existing tree on the site office premises; View from the shade net covering the parking lot next to the tree; the parking lot (Source: Field Survey).

Derivations from Findings: CWS-3 and Suggestions for BCSM adaptation

The CWS-3 involves a field survey of a construction site in Reading, UK, near the Reading Town Hall. The construction workers carried out the scheduled tasks under the balmy heat of the English Summer season as shown in Photos 7, 8 and 9. The suggested solutions for ‘informal dynamic rock garden’ adaptation to the BCSM as derived from the research findings is as shown in Photos 7, 8 and 9.

Photo 7, 8, 9: Construction site in Reading, UK showing an existing tree and a dumpyard that could be adapted according to the BCSM recommendation to improve the psychosocial value; and workers performing some of their work tasks under the tree (Source: Field Survey).
Photo 10, 11, and 12: Various adaptation of the informal dynamic ‘rock garden’ design recommendation suitable for the creation of an intelligent construction site with psychotherapeutic value on CWS-2 to enhance its potential for the BCSM (Source: [9]).

**Personal Observation**

The obvious lack of enhancement of the BCSM / Greening potential of the construction site; Photos 7, 8, and 9; reduced the psychosocial value of the construction site and interface with the social setting in the midst of Reading’s central business district (CBD). This could have resulted in added stress on worker performance, visible in the fact that the workers were observed to have taken refuge under the trees to perform some of their work activities; Photo 9. The lack of enhancement of the tree shade as in CWS-1 could have resulted in the fact that unlike at CWS-1 workers were not observed to have been onsite during the lunch break hours. According to research findings absence from site could delay workers’ resumption of work after lunch break, and consequent loss in working time [6, 9, 10].

**Suggested biophilic design concept for CWS-3: the ‘informal dynamic rock garden’**

According to research findings, the suggested biophilic design concept for the greening of CWS-2 includes the adaptation of its potential to the BCSM recommendation of ‘informal dynamic rock garden design’ for construction sites as shown in Photo 10, 11 and 12. Photo 10 depicts the adaptation of the dump-yard in Photo 7 with a pleasant combination of rocks and vegetation to enhance the psychosocial value. The tree shade in Photo 7, 8 and 9 could be adapted as an outdoor shelter as represented in Photos 11 and 12, with the inclusion of plants and a rock seat as an ‘H&S rest cure and refuge zone’ during the lunch break which would enhance the ergonomic status, emotional intelligence and ecological intelligence of the construction site according to research findings [1, 8]. The suitability of the ‘informal dynamic rock garden design’ for the adaptation of the construction site to the BCSM is determined in the exploratory research survey which formed part of an extended PhD study.

**Analysis and Discussion from Findings**

A common factor to all construction sites; CWS-1, CWS-2 and CWS-3; is the vital importance of the presence of trees onsite exhibited by the different manner of the worker / management response to the psychosocial risk factors present on the construction site. The management of CWS-1 and CWS-2 had no knowledge of the biophilic design concept or the biophilia theory; no interview was conducted at CWS-3. At CWS-2 and CWS-3; management had neither regard for nature in the presence of trees onsite nor ergonomic benefit accrued thereof. At CWS-1; management responded to the basic existential needs of the workers / project addressing environmental ergonomics relative to worker wellbeing, H&S, and performance. The recognition accorded to the attributes of the existing trees on the three construction sites is significant to the study advocating the ‘realism of the psychosocial recuperative value’ of the BCSM and ‘dynamic rock garden concept’ as relevant to CMBOK and sustainable sites initiative [9, 10].

**Conclusion and Recommendations**
The research findings conclusively inform the relevance of the BCSM single element of study in enhancing the socio-psychotherapeutic value of the construction site, cost effective performance and project delivery. The presence of nature in the form of plants and tree shades according to the biophilia hypothesis is deemed relevant to sustainable sites initiative in construction [7]. Informal dynamic rock garden design is indicated as a suitable healing garden associated with the BCSM strategy, adaptable to the nature of the project and complexity of the construction site. Therefore, further research is recommends towards the incorporation of dynamic rock gardens in the pre-bid, contract, and during work processes not only as part of external works at the conclusion of the project for the benefit of the end users. As a relevant aspect of CMBOK this should form a core part of the organisational management structure and planning of the construction worksite particularly the inclusion of plants within the site office, worksite premises and welfare facilities and training of construction management practitioners [9, 10].

References