THE ROLE OF 'GREENING' AND AN ECOSYSTEM APPROACH TO ENHANCING CONSTRUCTION ERGONOMICS

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Ecological engineering principles are being incorporated into the design of buildings and developments through green infrastructure, sustainable designs, green roofs and walls, and water sensitive urban design principles. However, there is a need to go further than this to incorporate ecology as the standard approach in not just design, but all aspects of construction, buildings, spaces, and places to complement the sustainable sites initiative. The objective is to establish the use of ecosystems as the interface between technology and the environment through the implementation of the biophilic design concept and feng shui principles as part of the sustainable sites initiative in construction. An extensive literature survey and critical analysis of existing construction sites constitutes the methodology adopted for the exploratory phase of an extended study. The initial scope of the study is limited to an existing construction site with an established site management approach and procedures. The research originality and value arises from the establishment and integration of ecology and the use of ecosystems in construction ergonomics, and psycho-therapeutic stress management orientation and interventions in an endeavour to enhance the sustainable sites initiative in construction.

Keywords: biophilia, feng shui, ecology, ergonomic, construction performance.

INTRODUCTION

The special issue on the future of ergonomics: Ergonomics and Sustainability (2008 cited in Stanton and Stammers 2008; Ergonomics 2013) stated that there is a need for ergonomics to be practical beyond just stating the importance and relevance within this area. It should be directly and innovatively applied to strategies involving applications of the existing body of knowledge to the design of interventions and improvements that would bring the construction industry closer to a sustainable future (Hedge 2008; Stanton and Stammer 2008). Such design interventions would include the biophilic design concept and feng shui principle of workplace wellness interventions, which according to current research findings would generate the cost-effective 'biophilic construction site model (BCSM)' drawn from the theory of 'biophilia' (Obiozo 2012; Obiozo and Smallwood 2012; Smallwood and Obiozo 2013).

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Obiozo R and Smallwood R (2013) The role of 'greening' and an ecosystem approach to enhancing construction ergonomics *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference,* 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 959-968.

Petersen and Holness (2013) report that the Department of Environmental Affairs (DEA) and the South African National Biodiversity Institute (SANBI) are currently working on a project whose goal is to develop and package messages for other sectors of government concerning the relevance of biodiversity and ecosystem services to worker health and wellbeing initiatives. The project is geared towards socio-economic development and support of essential sectors of the economy of South Africa (Petersen and Holness 2013).

The risk of extreme climatic factors in the region presents a problem on account of the resultant increase in the human factor due to work stress, environmental stress and ergonomics of the workplace environment. The proposed intervention explores the substantial human and environmental benefits inherent in the use of ecosystem interventions and biodiversity. The goal is to maintain and harness the natural environmental assets of the workplace environment to the advantage of worker health, wellbeing and performance on the project (Comcare 2010).

The objective of the study advocates for the social organisational responsibility expressed in the practical intent of the organisational management towards sustainable development. This should be directed at an optimal exploration of the value of the natural attribute of the construction workplace environment in order to improve worker health and welfare (Zink 2005, cited in Stanton and Stammers 2008). Cognisance should be taken of the climatic factors and weather variations and how it affects the comfort and performance of the workers (Dul and Ceylan 2011). According to Matlock et al (2001) to improve the human experience the ecological economics of the natural vegetation and the need to preserve and conserve the ecosystem and biodiversity of the locality is also paramount.

The symbiosis and mutual benefit of this strategy would help to prevent the prognosis of the adverse effect of recognised threats to rangeland with regards to human activities such as construction work, mining, agriculture and other ill-advised acts of humankind that tend to disregard the environment and its resources (Matlock et al 2001). The importance of subverting these effects have been anticipated by the climate change models of the South African region presented in the findings of Petersen and Holness (2013).

ERGONOMICS, SUSTAINAIBILITY AND ECOSYSTEM-BASED ADAPTIONS

Ecological Engineering

Ecological engineering is concerned with the design, monitoring and construction of ecosystems (Matlock et al 2001), which shares similar goals to those of green ergonomics and sustainable sites initiative (Stanton and Stammers 2008; Hedge 2008). Mitsch and Jorgensen (2004) states that the design of sustainable ecosystems intends to integrate human society such as the construction workplace with its natural environment for the benefit of both the occupants and the workplace environment.

Ecological systems (Ecosystems), Ergonomics and Sustainability

Zink, (2003 cited in Stanton and Stammers, 2008) in an invited plenary paper presented at the 15th Triennial Congress of the IEA, Seoul, 2003, argued for the benefits of considering occupational health and safety (OH&S) as a corporate social responsibility. This idea was a novel line of thinking at that time, whose potential was not fully addressed by researchers. According to Stanton and Stammers (2008), Zink

expounded a futuristic scope of corporate social responsibility as the driving force of sustainable development that is in consonance with economic growth and ecological balance. From this standpoint, the concept of sustainable development was presented as a key driver of change in organisational responsibility that regards the wellness and wellbeing of workers as a significant factor of worker health and welfare (Stanton and Stammers 2008).

However, Zink's recognition of opportunities for ergonomics from the sustainability movement has been shown by the number of citations given in research contributions reported in the special issue of ergonomics and sustainability (2008 cited in Stanton and Stammers 2008). The findings show human characteristics, behaviour and performance, and human interactions with technology as vital elements of these aspects. The range of data indicates that a natural synergy exists between these parameters and ergonomics regarding its objective of fully understanding and exploring the outcomes of human-system interactions (Stanton and Stammers 2008). Recent studies present the idea behind the concept of sustainability as an overreaching concern regarding the usage, conservation and preservation of the earth's natural and physical endowment. By all indications, these resources include the sustainability of organisations and the sustainable use of human resources (Stanton and Stammers 2008). In summary, Stanton and Stammers (2008) with significant evidence from the studies observed that a natural link clearly exists between ergonomics and these aspects of sustainable development.

The Biophilia Hypothesis

The initial thought pattern for biophilic design is drawn from the theory of biophilia proposed by Wilson (1984) and anticipated by Fromm (1973, cited in Jones 2002) as a concept that harnesses human attraction to certain habitats, activities and objects in their surroundings with substantial evidence from research findings that cut across all aspects of human spectrum; livelihood and professions. An integral of cognitive human need its application is yet to take its stand in green ergonomics and sustainable sites initiative with which it shares a natural synergy (Jones 2002; Rostykus 2011; EU-OSHA 2012; Dul and Ceylan 2011; Thatcher 2012; Ergonomics and Sustainability 2013). In Kellert and Wilson (1993), the biophilia hypothesis addresses the inherent and cognitive factors of humankind and its innate affiliation to all living organisms (plants, animals, the weather) as psycho-evolutionary and genetic, originating in the savannah regions of the world with its significant benefit of prospect and refuge. Prospect and refuge addresses the ability to look out expectantly from a secure environment like a tree shelter, a cluster of bushes or according to Kellert and Wilson (1993) and Heerwagen (2006) the Forest edge.

Greening Construction Sites – Biophilic Construction Site Model (BCSM)

The BCSM is a psychotherapeutic endeavour involving the implementation of rejuvenative and healthful wellness interventions with a landscape inspired perspective that involves the greening of construction sites regarding the establishment of domains of beneficial contact with nature onsite (Miyake 2003; Bird 2006). An eco-psychology study reviewed and endorsed by experts in Complementary and Alternative Medicine, Education and Psychology as well as Ergonomics investigates the proven benefits of human contact with nature that involves a unique tool enabling participants to purify and transform a primary contamination in mentality that leads to distorted thinking processes which blight human personal, social and environmental relationships (Jones 2002; Corbett and Milton 2011).

It is correlated and collaborates with the feng shui principle of wellness interventions on construction sites which involves the harnessing of the vital life force and energies inherent in an environment perceived to be either positive or negative (Diamond 2004). According to Gerstung and Mehlase (2000), Diamond (2004), and Bender (2007), feng shui involves the identification of the positive energies in-order to create a natural, harmonious, vibrant, balanced, and life giving environment. A study conducted by Smallwood (2003; 2006) explored the positive attributes and the viability of implementing feng shui principles on a construction site and determined that the need for such an intervention exists in construction. The intervention would lead to the orderly, beneficial and harmonious arrangement of facilities, and introduction of vibrant, pleasant energetic colours drawn from nature such as the choice of a sunny yellow colour for a shading device over a walkway, a healing leaf green shade-net or a painting of nature settings hung in site offices (Diamond 2004; Bender 2007; Miyake 2003).

Case Study – BHP Billiton Central Block Construction Project at Wessel's Mine, Hotazel, Northern Cape Province of RSA.

The case studies involved three temporary construction sites comprising five construction companies and one permanent construction site of BHP Billiton Wessel's Manganese Mine at Hotazel Central block project site, Northern Cape Province of the Republic of South Africa. The central block project includes the contract for the construction of a ventilation shaft, electrical sub-station and motor control buildings for the surface and underground mines. Murray and Roberts (M&R) Cementation is contracted to build the ventilation shaft with a four year contract with Synntech Project Management Company. Bashewa Construction has a nine months contract for the installation of the electrical sub-station to power the ventilation fans for the shaft with Olivier Construction on the civil works for the construction of the motor control building. Gear, Mine and Steel Construction was not working on site at the time of the survey.

The research method involved a field survey and exploratory case study on construction sites to determine the effect of greening of construction sites on workers and managements' health, wellbeing, and performance. The data collection technique included a focus group study, oral and written interviews of workers and management observations, questionnaire survey, and photo elicitations.

Description of location – extreme climatic conditions

The construction sites are located at Hotazel near Kuruman in the arid interior of the semi desert region of the Northern Cape Province of the RSA. The 2013 meteorological and geological data from the BHP Billiton Environment office indicates that the region experiences extreme temperatures in the winter and summer. The geological features include a manganese core and a depth of sand more than 21km from the surface. The summer afternoons are extremely hot, dry and stuffy. The environment is dusty with very little rainfall or precipitation. It has sparse vegetation and is located in a lonely desolate area about a full hour's drive from the nearest town, Kuruman, at the border between RSA and Botswana. The workers find the stress of commuting to work with the climatic extremities very challenging increasing the job stress factor, which corroborates with findings from (Lingard and Francis 2004; HSE 2007; CIOB 2007; EU-OSHA 2012).

Key Biophilic design element – Greening of Construction Site Survey

The greening of the construction site was largely restricted to the temporary construction site office premises of the construction companies; the main entrance locations, the general parking lot and central block office premises of the permanent site of BHP Billiton (Photos 5 and 6), and the premises of M&R Cementation temporary staff residences. All four construction firms identified with the green effort according to the peculiarities of each site. Details of key biophilic elements of greening on each site and mode of application are given below:

a. M&R Cementation began with a totally nature devoid environment and all trees and plants where imported to the site. There was a considerable modification of the existing site. An existing valley and dump yard on the site was refilled with soil originally scraped from the construction site to bring it to the same level with the rest of the site. Total staff strength of M&R Cementation is 204; with 59 at the Vent Shaft construction.

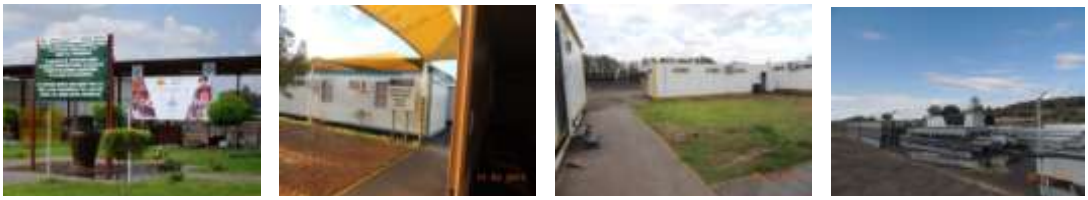
   The key biophilic element of greening included a rose garden courtyard fondly referred to as 'an oasis in the desert' developed at the entrance location. It featured a large giant water jug fountain, trees and various colours of rose bushes. Soft grass was planted on the entire site office premises. Yellow sun shading devices were used on covered walkways to enhance the rays of the sun with rose bushes planted alongside the walkways and within the courtyards. The planting of grass by the workers in the courtyard extension of their changing room, and the effort to maintain it green with waste water from their shower drains, overcame the lack of water on the site at the time of the survey, and indicates appreciation and support for management's green efforts (Photos 1, 2 and 3).
b. Bashewa construction protected the existing Carmel Thorn (Acacia Erioloba) trees on the site and enhanced it with shade nets to create two outdoor shelters that are used for site meetings, lunch breaks, and community gatherings as a place of rest, refuge and shelter from the elements. The shelter was also furnished with chairs and tables (Photo 7).

   Key biophilic design features: There was no planting or importation of new trees to the site; rather the existing trees were enhanced with shade nets and live Chameleons placed in it; which was a joy to feed by management and workers. It was a beautiful sight, appealed to the senses and had a healing presence. The sounds of the birds chirping in the trees provided a pleasant backdrop to the lunch break retreat when the workers were resting in the shelter after stressful site work. The total staff strength of Bashewa Construction is 10 and details are shown in Photos 7 and 8.
c. Olivier Construction's site offices were located on the same premises and also benefited from the efforts of Bashewa's construction management. Their workers shared the outdoor shelters. This helped to improve communication and interaction between employees of the two firms. Their total staff strength was originally 40, but was reduced to 18 at the time of the survey since the project is near conclusion (Photos 7 and 8).
d. Synntech Project Management Company had a staff strength of 10 and shared the construction site and premises of M&R with office extensions and gardens created to accommodate them (Photo 2).

A fifth construction company, Gear Mines and Steel had a contrasting construction site environment from the rest with a distinctly nature devoid, arid, and stark environment. The site offices were right in the middle of this hot setting with no effort at all at greening (Photo 4). Everyone passing by this site enroute to Bashewa Construction site or the Vent shaft could visibly feel the 'physical and psychological heat' emanating from the site and environment and usually passed a comment to that effect. All spontaneously testified to and disassociate from the construction site with repugnance. The total staff strength is unknown since the employees were not on site at the time of the survey.

Comparative analysis of study – the lack of biophilic design feature (Green element): Gear Mine and Steel Construction Company maintained the currently 'questionable' existing pattern of construction companies that have no form of nature on the construction site (Photo 4). It presents an unwelcome association to the other two green construction sites of M&R Cementation and Bashewa Construction.

Photos of all four construction sites are as shown below.



Photos 1, 2, 3 and 4: M&R Rose garden courtyard with giant water jug fountain; Sunny coloured shade over walkway leading from M&R to Synntech Project Management Offices; contrastingly green grass at M&R workers changing room extension courtyard; the contrasting site of Gear Mine and Steel Construction devoid of beneficial natural green element (source: Field Survey).

Photos 5, 6, 7 and 8: BHP Billiton central block office courtyard; Parking lot at BHP Billiton; Outdoor shelter at Bashewa and Olivier Construction site offices premises; and live chameleon on the Carmel Thorn tree at Bashewa Construction site (source: Field Survey).

Results and Analysis of findings

Organisational effectiveness in construction has necessarily metamorphosed into BCSM or the 'Greening of Construction Sites' as an effective tool for cost effective construction risk management and productivity improvement (Miyake 2003; Taylor 2007; Sass 2012; Obiozo, 2012; Obiozo and Smallwood 2012; Smallwood and Obiozo 2013). Of particular importance is that all three firms individually evolved the biophilic design and correlated feng shui principles of wellness intervention on their construction sites without any prior knowledge or information regarding the concepts.

BHP Billiton also encouraged and motivated the greening effort with the yearly tree planting exercise at their Wessel's Mine Hotazel Manganese construction sites as part

of their environmental protection activity. In fact, the trees at M&R were obtained from the consignment of BHP Billiton freely distributed trees to their contractors. M&R Cementation, however, not only planted and maintained the trees on their site, but also nurtured and fed them with manure and fertiliser so that they survived the harsh weather conditions onsite, unlike so many others planted within the same environment at the same period. The HSE director of M&R Cementation and Bashewa Construction Management in their reports testified to having implemented the green elements on their construction sites from a gut feeling derived from their pleasant experience of landscaped gardens in social and private settings.

It is interesting to note and of particular importance to this research, that the greening of the M&R construction site is the effort and responsibility of the HSE department of the organisation. It is an HSE strategy they highly advocate to and strongly believe in, and many times the HSE Manager would stake personal monies to sustain the green project. According to an M&R HSE Management Survey Report it is an all staff intensive exercise and therefore comes highly recommended from both management and employees to all construction managers by reason of health, safety, environment, performance, and productivity. The 'greening' is always a pleasant surprise and a welcome sight encountered by staff and visitors to the construction sites. The comment of a visitor to the site confirms this: "It is commendable and should be encouraged". The Bashewa Construction Manager also commented that the inspiration to 'green' their construction site was an encouragement from the M&R construction site, especially the beneficial encounter with the rose garden courtyard with giant water jug fountain at the entrance courtyard.

The use of sunny yellow shading devices for the walkways in the M&R site office area enhanced the rays of the sun, creating energising sunny shades; the vibrant dynamic colours of natural blooms of rose flowers added to the pleasant scent is collectively associated with the positive vital life giving energy inherent in the particular construction workplace environment. The vibrant dynamism of the ever changing colours of the live chameleon is appealing and energising and constitutes a welcome diversion from workplace stress and balances the diversity of the ecosystem of the natural workplace environment. Some of the live chameleons were picked from the construction workplace environs which constitute their natural habitat. These factors harmonise and synchronise with the key elements involved in feng shui and the biophilic design concept (Kellert and Wilson 1993; Gerstung and Mehlase 2000; Bender 2007; Heerwagen 2006). It is apparent that these principles are in harmony with ecosystem adaptation and ecological engineering according to (Matlock et al 2001; Mitsch and Jorgensen 2004). Employee responses confirm it as a beneficial healthy pleasant workplace strategy that promotes worker wellbeing, health, and performance (Stanton and Stammers 2008; Hedge 2008).

Discussion from Findings

The sense of responsibility of the management towards sustaining the physical, economic and social aspects of the workplace environment would fall in the category of ecological engineering geared toward the preservation and conservation of the ecosystem and biodiversity of the workplace of which the human factor is an integral (Matlock et al 2001; Mitsch and Jorgensen 2004). According to Petersen and Holness's (2013) climate change model, the real threat of range shift from climate change necessitates the maintenance of the biodiversity of the particular locality and region in which the worksite is located. This effort has been applied to the advantage

of the employees and the organisation. For instance, the existing trees at Bashewa construction site office premises were retained and maintained not cut down as is usually the case. At the M&R construction site, more trees, rose bushes and grass were planted as dust cover to hold the soil in place against erosion and weathering due to construction and climatic factors.
The waste water from the construction work and the shower drain of the M&R Construction workers was redirected for hydration, watering of plants and keeping the environment cool and pleasant in-order to create a beneficial micro climate that is conducive to work in all seasons.

CONCLUSIONS

The beneficial application of ecological engineering in the construction workplace has been established by evidence from the research study. It has also presented an identifiable and verifiable data that explores the reality of the proposition contained in the special issue publication on the future of ergonomics: Ergonomics and Sustainability (2008 cited in Stanton and Stammers 2008; Ergonomics 2013). It has established organisational social responsibility as an effective tool towards enhancement of worker health, welfare and performance as proposed and anticipated by Zink (2005, cited in Stanton and Stammers 2008).

The research has also demonstrated the benefit of investing in people and the practicality of ecological engineering in the sustainable development of the construction workplace and mitigation of the psychosocial risk factor of the workplace environment according to the complexity of each project (Heerwagen 2006; CIOB 2007; HSE 2007; EU-OSH 2012). It also serves as an innovative strategy in ergonomics and human factor towards enhanced employee assistance programme (EAP), worker performance and productivity that is nature derived. There is a call for further research and exploration of the various applicable methods of greening the construction workplace to enhance ergonomics and sustainable development, worker health, performance and wellbeing by employing the ecosystem-based adaptation method (Stanton and Stammers 2008; Petersen and Holness, 2013).

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