IMPACT: Journal of Research in Engineering & Technology (IMPACT: JRET)
ISSN(E): Applied; ISSN(P): Applied
Vol. 1, Issue 1, Jun 2015, 13-24

OPTIMIZING THE SYSTEM OF WORKPLACE ERGONOMICS FOR CONSTRUCTION WORKER'S HEALTH AND SAFETY

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ABSTRACT

Health and safety (H&S) issues exert a major effect on the competitiveness of construction industry. Construction workers experience a higher incidence rate of work related musculoskeletal disorders (WMDs) resulting in days away from work and affect the rate of productivity. Despite of technological and economic advancement the practice of construction is still affected by a high rate work related musculoskeletal disorders. The chance of being disabled by injury or serious illness is much greater than for workers in most other industrial sectors. Every construction worker is likely to be temporarily unfit to work at some time as a result of injury or health problems after working on a construction site. Work organisation and physical environment requires an appreciation and understanding of the role of planning and pre-planning of H&S to realise optimum ergonomics. This paper aims at optimising the operational system of workplace ergonomics among construction workers by emphasizing the impact of design and safe work practices associated through designing which is believed to be a source to preventing WMDs in the construction field. In order to address the ever growing impact of WMDs on construction workers, it is a vital necessity to review the operational perspectives relative to workers involvement and the impact of design on the workplace. A further benefit is the synergy between preserved environment, enhanced schedule, enhanced quality, and improved productivity. Reduced fatalities result in improved productivity and reduced cost. The paper indicates that efficient implementation of health and safety rule and policy is needed and analyses design as an ergonomic intervention to promote safe work practices in the construction field. Adopting the critical review of literature, the paper is relevant in promoting safe working place for construction workers in its emphasis on adherence to health and safety rule and policies during daily operation in ameliorating the impact on construction workers. The paper is a developmental discourse on the impact of design and construction management on construction ergonomics with an overview of promoting safe working construction site for construction workers.

KEYWORDS: Health and Safety, Construction Management, Work Related Musculoskeletal Disorders

INTRODUCTION

The construction industry faces many occupational injuries and fatality risks, making it both unique and challenging to study. Construction is always risky because of outdoor operations (Hsiao, H. and Simeonor P. 2001). Construction industry is a complex industry that employs a large man power. This sector is characterized by the mobility of workers; change of workplaces, tremendous diversity in regard to the importance and type of work performed in an extreme sensitivity to economic instability and large cyclical and seasonal variations in activity level. The industry faces a

disappropriate high incidence of injuries and illness that occur in construction sites around the world. As a significant employer of labour the large proportions of its activities and operations are labour intensive.

Practical rules on construction sites are like many other work organization as it involves site layout planning, design of workplaces, work time allocation and the time taken per each work task as well as the use of different techniques for job execution. The construction industry is characteristically unique for substance, form, size and purpose in which each building or facility may be described as custom made. Therefore the consideration is that the completed products of construction are not generally mobile in that they are permanently fixed in specific locations. These implies that components prefabricated and /or pre-assembled elsewhere remains site specific in its assemblage and where they are not unique, work operations that are similar and repetitive are executed in work environments that change from hour to hour due to changes in the environment such as weather conditions, locations, physical conditions and heights (Haupt,2001; Hallowell, 2008)

Despite sophisticated safety and health regulations in most countries, it is no secret that the industry is responsible for relatively high occupational injury rate. The complexity and instability inherent to this sector have repercussions on health and safety of construction workers. Construction workers experience a higher incidence rate of WMDs resulting in days away from work and affect the rate of productivity. Smallwood (2000) maintains that a healthy and safe environment and healthy people are required to produce a product or service at a profit. Construction tasks are physically very strenuous and the incidence of work related injuries and illness among construction workers are considerably higher than that in most other occupations. The tasks are often carried out in unfavourable postures with highly movements and thus generating a load believed to increase the risk of injury.

In construction industry, Hallowell (2008) and Haupt (2001) emphasized that the industry is characterized by fragmentation, multiplicity of operations, multiplicity of crews and industry culture which however contributes to unforeseen and unfamiliar hazards or unsafe behavior of workers'. The impacts of these characteristics in the industry have been identified to have resulted in poor health and safety performance of construction workers'.

Every worker is likely to be temporarily unfit to work at some time as a result of moderately serious injuries or health problems after working on a construction site (Smallwood,2004;Punnett and Wegman 2004; Rwamamara and Holzman 2007). Construction work typically requires the adopting of awkward postures, lifting of heavy materials, manual handling of heavy and irregular sized loads, frequent bending, bending and twisting of the body, working above shoulder height, working below knee level, staying in one position for a long period of time, climbing and descending and pushing and pulling of load. These are all done under difficult circumstances (Zimermann and cook 1999; Smallwood, 2004; Rwamamara et, al 2007; Punnett and Wegman, 2004).

Statistics provided by United states Labour statistics indicates that the rate of sprains and strains in construction namely I,8 per 100full time construction workers predominate in terms of the nature of injuries and illness resulting in days away from work and is the second highest of all industries (Smallwood et al., 2000). Based on the findings of ergonomics related research conducted among South African construction management and workers, Smallwood et al., (2000) conclude that the use of body force, reaching away from the body, reaching above the head, repetitive movement, bending or twisting of the back, climbing and descending were

Common and constitute work related job problems. The fact that construction is a project based industry is an important contextual issue when attempting to manage a dynamic changing work environment such as construction site, it should be borne in mind that an appropriate safety structure is needed to promote the operationalisation of the construction workers in a dynamic changing work environment.

However various safety management strategies and approaches have been implemented in construction to reduce injuries and unsafe behavior but enhancing organizational health and safety culture and workplace safety climate can have positive impacts on work environment and safety performance (Mohammed, 2003; Zhou et al., 2007; Oh and Sol, 2008). Safety through designing for operational system for construction workers is a fundamental principle of both ergonomics and occupational health and safety as it helps in reducing the onset of WMDs (Hecker et al., 2006; Moroszczyk,2007). Belle (2000) and Gibbons et al., (2000) concludes that the practice of ergonomics in the workplace is premised on designing the job and workplace to meet the capabilities and limitations of construction workers.

Impacts of Work Related Musculoskeletal Disorders (WMDs) on Construction Workers'

International commission on occupational health defines MSD as both disorders and diseases of musculoskeletal system that have a casual determinant that is work related. Budnick 2001 defines MSDs as injuries and disorders of the muscles, nerves, tendons, ligaments, cartilage and spinal discs which are directly and indirectly related to work or the work environment. Work related Musculoskeletal disorders (WMDs) are casually linked to physical loads resulting from occupational activities and believe to occur when mechanical workload is higher than physical capacity of human body. MSDs are difficult to diagnose as pain is hard to measure and quantify objectively and might be the reason that very few studies examine the prevalence of MSDs based on medical surveillance (Haupt et al., 2004).Construction workers rarely, if ever undergo any form of medical surveillance in their job. Sprains and strains are the most common nonfatal injury while overexertion or lifting too much at one time is the most common occurrence in the construction industry. In Sweden, Musculoskeletal injuries among construction workers were studied together with the risk factors that contributed to their injuries, Musculoskeletal symptoms were found to be much more prevalent among construction workers than office workers. There was a clear relationship between the demonstration of these symptoms to heavy work and vibration, exposures, frequent use of handled tools, repetitive work and awkward working positions. Furthermore, accurate data on the incidence of WMDs and its prevalence are difficult to obtain and official statistics are difficult to compare across countries. The disorder generates a destructive impacts on workers' life such as persistence of pain in work or leisure and even permanent disability. WMDs are not just one of the major occupational health problem worldwide, it is also recognize as an economic burden on the society directly and indirectly in cost. The direct costs are associated with workers' compensation, medical care and rehabilitation while the indirect costs include work quality, retaining costs and diminished morale (Rwamamara and Holzman 2007; Punnett and Wegman, 2004). Based upon a survey in the UK construction industry in 1995, out of 2million people who reported suffering from work related ill health, 1.2 million suffered (60% of the total) from MSDs.

Loewenson (1999) concludes from research findings that injuries on workers range from 0.35 to 49.4 injuries per 1000 workers in the southern African Development Community and fatalities range from o.85to 2.16 per 100 000 workers. The international Labour Organisation (ILO) estimates that some 6000 worker die each day worldwide and 337million people are victims of work related accidents and illness arising from occupational injuries (MLPC, 2008). According to

Rose and Örtengren (2000), in a study to estimate the work environment economic impact on construction industries, estimated that 6% of the work-environment related injury costs for medium construction firms and 94% remaining are made up by costs related to productivity loss due to construction worker injury.

In the working population of Netherlands, according to Hilderbrandt (2001), it is estimated that approximately 30% of MSDs per year are work related in which its prevalence rates do vary with level of exposure. In the Swedish construction Rwamamara (2007) ascertains that the research studies show that 71.2% of occupational diseases in the industry are MSDs and maintains that occupational injuries such as MSDs are unquestionably wasteful and non- value adding events in construction production. However, the risk factors which can cause or have an association with WMDs include repetitive motion, forceful exertions of the hands, frequent or heavy lifting, pushing, pulling or the carrying of heavy objects, and prolonged awkward postures. These are considered to be the primary risk factors for WMD complaints, while contact pressure, vibration, temperature and combination effects are considered as secondary factors thereby emphasising the strong evidence that WMDs are associated with lifting, high exertion, and awkward postures.

(Marras et al., 2000; Gambatese et al., 2005). Hecker et al. (2006) emphasise that a fairly large percentage of construction accidents could have been eliminated, reduced or avoided by making better choices in the design and planning stages of a project. Paying attention to health and safety issues of construction workers in the design phase could have a significant impact in reducing the risk of injury during construction. The table 1 below summarizes the factors related to work-related musculoskeletal disorders enumerating the identified risk factor, its consequences, direct and indirect impact on the health of construction workers.

Table 1: Factors Related to Work-Related Musculoskeletal Disorders Affecting the Health of Construction Workers

Factor / Action	Possible Result or Consequence	Action / Causes	Direct Impact	Indirect Impact
Forced exertion	Acute overloading of body tissues	Lifting, carrying, pushing, pulling heavy objects	Restricted activity days	Low productivity
Handling heavy loads over long periods of time	Degenerative health disorders	Manual handling of materials	Sprain and strain on the back	Loss of income to workers, absenteeism
Working in unfavourable/awkward postures	Pains and strain	Working heavily bent, or twisted trunk, or hands and arms above shoulders	Non-coordination of body system	Non-achievement of quality
Working in the same position	Long muscular activity and overload body tissue	Working overhead, working in a confined space	Sprain and repetitive strain injuries.	Early retirement
Repetitive manipulation of the body	Unspecific complaints in the upper extremities	Repeated activation or muscles without relaxation	Ill health	Fatigue Absenteeism

Dynamic Work Environment of the Construction Industry

Work environment is an aspect that has a psychological and psychosocial impact on the health of a construction workers' There is a clear evidence of the relationship between work environment and the health and safety of the workers' (Hilderbrandt 2001). Gibb et al., (2004) contend that a vast number of studies show an association between the work environment and health of construction workers'. The work environmental factors and individual construction worker are intervening variables resulting in occupational illness and injury as construction worker operates in a constant changing environment and precipitate to a condition that lead to a negative health outcomes.

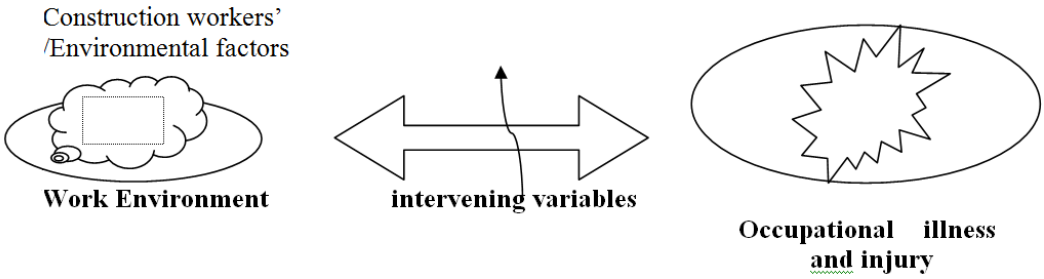

Figure 1: Intervening Variables of Work Environment

Smallwood (2000a) submitted that construction sites are dangerous and some trades are very risky due to the nature of the related activities: demolition; structural steel erection, and painting and decorating. Schedule pressures exacerbate the situation. These activities are prone to health and safety works because of the physical environment of works, nature of the construction work operations, construction methods, construction materials, heavy equipment used and physical properties of the project itself. The industry is highly dynamic with high level of uncertainty. This implies that the characteristics of the industry collectively provide a challenge in terms of construction health and safety as opposed to an excuse for lower standards in manufacturing industry (Smallwood, 2000; Hallowell, 2008). Based on the findings of ergonomics related research conducted among South African Construction management and workers, Smallwood et al.(2000a) conclude that the use of body force, reaching away from the body, reaching above the head, repetitive movements, bending or twisting the back, climbing and descending, were common and constitute work related job problems.

The table below emphasise the several factors that may contribute to high injury / fatality in construction compared with manufacturing industry. Thus, the characteristics of work conditions in construction industry are supported by various authors; Smallwood, (2000), Haupt (2001) Yi and Langford (2006) and Hallowell (2008).

Table 2: Typical Work Condition (Hallowell, 2008)

Work Condition	Construction	Manufacturing
Shelter	often little or none	Work occur inside
Repetition	Low	High
Repetitive movements	High	Low
Task predictability	Low	High
Task standardization	Low	High
Work hours	Various	Controlled shifts

Issues of Health and Safety in Construction Workplace

Health is defined as "The degree of physiological and psychological well being of an individual." and safety as both "The state of being safe: freedom from injury or danger." and "The quality of insuring against hurt, injury, danger or risk."These definitions clearly indicate that H&S have both an occupational and a non – occupational dimension. Within the occupational context, healthy is defined as " free from illness or injury attributable to occupational causes" and safe as "free from any hazard". Occupational health includes occupational hygiene, occupational medicine, and biological monitoring (Haupt 2001; Republic of South Africa, 1993). "Injury refers to damage to tissue resulting from acute exposure to physical and chemical agents", whereas disease is defined as "a departure from a state of health usually recognised by a sequence of signs and symptoms, or a process, which disturbs the structure or functions of the body".

Smallwood (2000b) reports that many authors maintain that the poor H&S culture of the industry is a major cause. H&S in construction is based on the premise that the hazards exist because they are designed into the permanent features of a project. These features impact on the H&S of those who build it (Gambatese *et al.*, 2005; Rwamamara 2007). Improving the H&S of the construction site work environment has repeatedly shown to save lives, time and money. A study performed interalia, by the Naval Surface weapon center in silver spring, Maryland confirmed that virtually every incident among the construction workers' resulted from poor upstream management and could have been prevented through proper health and safety management (Hallowell, 2008). H&S management ensures that productive work in construction is designed and performed with workers' H&S in mind. This involves ensuring the manager to evaluates the H&S risk and that the planned work is resourced so as to prevent occupational injuries or illness that will be detrimental to construction workers. The HSE guide book outlines five key elements for successful H&S management, which includes policy, organizing, planning and implementation, measuring performance and reviewing the performance, to mitigate occupational injuries or illness.

In managing H&S in workplace, there is need for a clearly defined policy, well defined plans, incorporating objectives, strong management commitment, the provision of sufficient resources, systematic training programmes, effective monitoring and reporting of performance and making improvements (Lingard and Rowlinson, 2005). According to HSE (2000), defining a corporate H&S policy is the first step in occupational H&S management process.In view of this, events causing injuries and illness may also damage property and interrupt production. Therefore, identifying hazards and assessing risks, putting precautions in place protects workers' and safeguard production.

The H&S policy should influence the selection of people equipment and materials, the way work is done and how goods and services are provided. A writing statement on the arrangements for implementing and monitoring policy shows that hazards' have been identified and risks assessed, eliminated and controlled. The effectiveness of the policy is dependent on creating an organisation in which roles, responsibilities and relationships support the systematic planning and control of H&S.

Furthermore, the various construction project stakeholders must be committed to the effectiveness of the policy. Rwamamara (2007) submitted that a positive H&S culture constituting the following five 'C's are essential aspects for H&S management in workplace:

- Commitment in being clear about your intent to achieve excellence in H&S.
- **Competence:** Ensuring that the workforce is competent to fulfill their H&S responsibilities, the training needs of different groups of employees (different trades' men).
- **Control:** Monitoring staff knowledge and awareness.
- **Consultation:** Involving the workers in the reviewing of problems and procedures and
- **Communication:** Occupational H & S information needs to flow effectively within the organization and people outside it.

Operational Perspectives for Construction Workers

Health and safety management systems are rule and procedures based. The systems are based on the premised that health and safety are both management responsibility and a line function.

The top management formulates policy and its actual success depends on the ability of site management and supervisory personnel to ensure that rules and policies are adhered to during daily operations. This perspective is concern with efficient implementation of H&S rules and policies on construction site. It encompasses the ability to address specific project objectives in relation to H&S, appraisal of physical work environment and workers' constructive involvement. This include higher degree of compliance, high level of work force proactiveness, more efficient site layout planning, efficient communication / feedback Systems, safer workplaces and better workers' / supervisors' relationships. In considering these goals, measures would likely relate to elements such as process improvement, frequency of suggestions to improve H&S of construction workers', H&S meetings, plan reviews, extent of accident / incident analysis tasks and ratio of recommended / completed remedial actions, degree of employee empowerment and constructive involvement (Mohamed,2003;Schneider, 2001). Site operatives are required to plan and organize their operations, ensure that the workers are trained and competent and know the special risks of their trade and raise problems with their site supervisor or safety representative (HSE 2009).

In the operationalisation of construction work, job demand is a perceived work characteristic refers to construction workers' perception of the demand that are imposed upon them by the work and the work environment. However these job demands are considered detrimental to the health of the construction worker as it includes the pressure of accomplishing the workload and intense concentration. Therefore high job demands combined with too low levels of decision latitude results in negative health outcomes. Furthermore construction site is one of the primary resources available to the contractor. Site layout planning and facilities is to produce a working environment that will minimise risk and maximize efficiency. Aspects of the site layout planning that need to be addressed include; access and traffic routes; material storage handling; site offices and amenities; construction plant; fabrication workshops; services and facilities; and the site enclosure. Mohamed (2003) amplifies that tidy and well planned (layout) sites are more likely to provide a high level of safety for the workforce as injuries and illness are lurk in the work environment.

Design as an Intervention

Design is a problem solving process with the ability of the designers to adapt the construction work environment to meet construction workers' H&S needs in the design of permanent features of a project. Design occurs upstream of

construction and has the potential to reduce H&S risk as it impacts on construction ergonomics both directly and indirectly (Smallwood, 2000b; Gambatese *et al.*, 2005). Directly through: conceptual design; selection of type of structural frame and walling; detailed design, and specification of finishes and materials. Indirectly: through completeness of design, particularly services; site coverage; access to site; compatibility of the design to mechanization, and the nature of the required work processes and the facilitating of pre-planning. However, the explicit consideration of construction health and safety issues by the designers of facilities may serve as a preventive filter for construction safety incidents.

In research conducted, *inter alia*, by the UK research project, to identify where safety is compromised in construction, the researcher conclude that half of these incidents could be prevented by design alteration while Smallwood (2 000) emphasised that there is link between design, healthy and safe construction and maintenance. However, during a study conducted in South Africa among general contractors (GCs) to determine their perceptions regarding the influence of design on construction and needs related thereto. It is noted that design and method of fixing negatively affect H&S of construction and amplify the need for the consideration of H&S throughout all phases of a project by the designers.

Therefore, inadequate design affects the H&S performance of construction workers'. The risk factors and ergonomic interventions in construction indicate that designers could make a difference directly in the reduction of WMDs in the area of materials, equipment, workers anthropometry and access, workplace organisation, the size and weight of materials, prefabricated buildings, layout planning and processes used during construction (Zimmerman and Cook, 1999; Vedder and Carey, 2005; Smallwood, 2000). However, explicit consideration of construction health and safety issues by the designers of facilities may serve as a preventative filter for construction incidents (Hallowell 2008; Gambatese 2005). Designers also influence indirectly through choice of procurement system, effectiveness of design coordination and the use or non – use of prequalification of contractors, selection of contractors and project duration (Smallwood, 2000b). In a study conducted interalia, among the architectural technologist in South Africa, it is noted that design contributes to the onset of WMDs and that certain procurement systems, such as design – build engender ergonomics and contributes to the onset of WMDs as it involves purchasing of equipments, materials, supplies, labour and services required for construction and implementation during all phases of construction project. Therefore with the knowledge of limitations of construction worker, the design principle may be employed during the planning and construction of the workspace, equipment or job task as a means of primary intervention (Rwamamara, 2007; Samuels, 2005; E-Facts, 2007).

To reduce the injury and health risks to workers, tasks and tools should be designed accordingly (Vedder and Carrey, 2005). The design for health means, the elimination or reduction of exposure of the worker to physical agents that cause WMDs. The design process could emulate the Construction Design and Management (CDM) Regulations in the UK and EU construction industry, which clearly define the designer's duties in respect of reducing H&S risks during construction to avoid hazards, combat risks and provide information. According to the CDM Regulations in the UK, the best form of protection against a hazard is to eliminate the hazard at the source. Therefore a comprehensive method statement for all elements of construction work during the design process is needed to enhance safety and productivity (Rwamamara, 2007; Toole, 2002).

To evaluate the implication of design on WMDs in the operation of construction, the design process needs a multi-disciplinary team involving all the stakeholders involved in the design, construction and the use of the facility so as to develop a conceptual model to improve WMDs in the construction workplace.

CONCLUSIONS AND RECOMMENDATIONS

Construction workers employed must be trained, competent and fit to do job safely and without their own or others health and safety at risk. Healthy environment builds on these strengths and motivates to develop a continuous learning and sharing work environment that rewards productivity, problem-solving initiative, responsibility, and team work. A holistic approach requires the integrated development of work organisation and physical environment, work organization and physical environment requires an appreciation and understanding of the role of planning and pre-planning of H&S to realise optimum ergonomics. The risk factors and ergonomic interventions in construction indicate that designers could make a difference directly in the reduction of WMDs in the area of materials, equipment, workers anthropometry and access, workplace organisation, the size and weight of materials, prefabricated buildings, layout planning and processes used during construction (Zimmerman and Cook, 1999; Vedder and Carey, 2005; Smallwood, 2000b: Gibb et al.,2004).An effective H&S policy is needed in the construction industry monitored and implemented by the stakeholders so as to achieve the positive H&S culture in the workers daily operations.

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