AN INVESTIGATION INTO THE ERGONOMICS OF THE WESTERN CAPE CONSTRUCTION INDUSTRY

By

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A DISSERTATION PRESENTED TO THE HIGHER DEGREES COMMITEE OF CAPE PENINSULA UNIVERSITY OF TECHNOLOGY IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTERS OF TECHNOLOGY: CONSTRUCTION MANAGEMENT

CAPE PENINSULA UNIVERSITY OF TECHNOLOGY

2005

DECLARATION

With this statement I, William Samuels, affirm that the research work upon which this dissertation is based on, is my own (except where acknowledgements indicate otherwise), and that neither the entire research nor any part of it has been, is being or is to be submitted for other degree in this or any other education institution.

William Samuels November 2005

DEDICATION

I dedicate this work to my family, especially to my wife Patti, my sons and daughters-in-law Sean and Rochelle, Hylton and Edwina and my grandsons Troy and Liam.

ACKNOWLEDGEMENTS

My praise, gratefulness and thanks firstly go to God my Almighty Father for the blessings, wisdom, health and strength granted me, which enabled me to continue with this research. Thank you Father for hearing my prayers and granting me Thy grace and favour.

To Dr. Theo C. Haupt, my sincere gratitude to you for your continued guidance, patience and sacrifice and for supervising and guiding me through the research process. Thanks to you and your family for the time apportioned to me especially during difficult times. Your encouragement, assistance and professional leadership has greatly stimulated me and encouraged me throughout.

My gratitude is extended to Mr. André Rodriques, Head of Department of the Built Environment for his assistance, guidance and encouragement.

My appreciation goes to Dr. Winston Shakantu, who so willingly availed himself to be of assistance and to supervise and guide me along. Thank you for always being calm and for your encouragement.

My sincere appreciation and thanks to Mrs. Charlene May for her invaluable assistance, co-ordination, processing of the research data after hours and being such help all hours of the days and night. Thank you very, very much and also thank you to your family.

To my colleagues, Sarah, David, Ferdinand, Sinethemba, Trevor, Kolosa, Coleen, Desmond and Simphiwe, thanks for your support.

To Mrs. Taylia Green, Mark Quickfall and Dwain Birch thank you for your continued support and assistance.

To the staff of the Cape Peninsula University (CPUT) thank you all for your support.

Thank you to the National Research Foundation (NRF) and especially the persons who students never get to thank for financial support as well as for your kind assistance.

ABBREVIATIONS

CDC	Center for Disease Control (Atlanta, USA)
COP	Centre of Pressure
CPWR	Center to Protect Workers' Rights (University of Iowa, USA).
CSIR	Council for Scientific Industrial Research
CTD	Cumulative Trauma Disorders
CTS	Carpal Tunnel Disorder
HAVS	Hand-arm Vibration Syndrome
HSE	Health and Safety Executive
LBP	Lower back pain
MSD	Musculo-skeletal Disorders
MSI	Musculo-skeletal Injuries
NEPAD	New Partnership for Africa's Development
NIOSH	National Institute of Occupational Safety and Health
ORSHA	Oregon: Occupational Safety and Health Division
OHSA	Occupational Health and Safety Act No. 85 of 1993.
OHSAA	Occupation Health and Safety Amendment Act No. 181 of 1993.
OH&S	Occupational Health and Safety
PPE	Personal Protection Equipment
RSI	Repetitive Strain Injuries
RTW	Return To Work
SPSS	Statistical Package for Social Sciences

ULD	Upper Limb Disorders
USA	United States of America

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AN INVESTIGATION INTO THE ERGONOMICS OF THE WESTERN CAPE CONSTRUCTION INDUSTRY

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December 2005.

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Workers in the construction industry are often exposed to ergonomic challenges. Some of the most unfavourable ergonomic practices include bending and twisting of the body, lifting and handling of heavy materials and equipment, working above shoulder and head and below the knee levels. Despite provisions made in various legislations about compliance with the health and safety of the construction workforce, many employers still do not comply and are not changing the way construction activities are carried out. It was argued that some of the unfavourable ergonomic challenges such as repetitive and awkward work routines might lead to strains, sprains, musculo-skeletal disorders and

carpal tunnel syndrome and that these problems could contribute to absenteeism and reduced site productivity.

This study sought to establish the pervasiveness of ergonomic challenges and the extent to which the construction workforce are exposed to these challenges. Empirical studies using the philosophically positivistic paradigm and epistemologically objectivist method of on-site observation of construction workforce activity were conducted on purposively chosen samples of bricklayers, plasterers, painters and their helpers. The purpose remained to count and record body movements of the said workers over 30 minute intervals. Alongside the observations, interviews were conducted to establish what views and perceptions the workmen had with regard to the effect their daily work had on their bodies.

The results revealed that the extent and effect of unfavourable ergonomic exposures vary from trade to trade. For instance, bricklayers bent their bodies more than any other worker while plasterers did more work below the knee than their counterparts. In the same vein painters stretched their bodies and worked above their shoulders and heads more than their counterparts.

Further extrapolation of the data over the working life of the tradesmen and their helpers exposed the magnitude of the ergonomic exposures and the likely effects that these exposures would have on their bodies and health. For instance, the bricklayer and plasterer would have to bend and twist their bodies a record 5 million times in their 20-year working lives. The painter would be exposed to 3 million and 4 million times respectively of bending and twisting his/her body within the same 20-year period.

The main conclusion was that currently construction activity exposes the workforce to unprecedented unfavourable ergonomic practices. The recommendations were that management should take the health and safety of their workforce seriously and that the worker cohort should have direct intervention into the design and implementation of favourable ergonomic work practices at their workface.

CHAPTER 1

BACKGROUND INFORMATION

Introduction

This chapter introduces the concept of ergonomics and the effect that ergonomics has on construction workers. The word "Ergonomics" is a derivative of the Greek words *"ergon"*, meaning *work* and *"nomoi"*, meaning *natural laws* (Bridger, 1995). Ergonomics is therefore a study of human capabilities relating to work demands.

Ergonomics includes examination of human characteristics, capabilities, motivation, and limitations and desires necessary for the design of the living and working environment, increasing human efficiency and overall well-being (Kroemer, 2002). Ergonomics is scientifically informed by the biological sciences of anatomy and physiology. Ergonomics is concerned with the well-being of humans in the design of objects in the environment and their work systems (Barnhart, 1988). It involves everything to do with the activities of people. According to Smallwood (2003) ergonomics studies work, or the work system and includes the workers, their tools and workplace. The subject matter of ergonomics includes systems of work, sports and relaxation and health and safety.

Ergonomic activities include the measurement of human performance, focusing on the improvement of productivity and the protection of workers' health (Singleton, 1972). In the Occupational Health and Safety Act (No. 85 of 1993) and the Construction Regulations GNR 1010 of 18 July, 2003 ergonomics is extended to include the application of scientific information to the design of objects, systems and the environment for human use in order to optimize well-being and overall system performance.

The spectrum of ergonomics includes all aspects of a job including physical stresses and environmental factors. It is the science of designing the job to fit the worker. Ergonomics in reality tries to optimize the use of systems by adapting them to human capacities and uses (Grandjean, 1988).

History of Ergonomics

Some of the earliest ergonomic problems experienced by workers were recorded by Ramazzini (1633-1714) in 1713 (Wright, 1940). However, it was the groundbreaking work of Frederick Winslow Taylor (1909) that enabled industrial engineers and designers to improve productivity and achieve better quality that had the effect of increased wages and improved quality of life of the workers (Kroemer, 2004). Taylor (1909), highlighted the need to eliminate physical strain and damage to the human body while 'doing work the wrong way'. Taylor also identified the need to eliminate physical strain and bodily damage caused by doing the work the wrong way (Drucker, 1981).

Further work on ergonomics, was carried out in Britain by Murrell around 1949 (Bridger, 1995). Stringent wartime requirements stimulated the development of ergonomics as "a systematic, integrated and essential discipline" after World War II. Scientists analyzed the successes and failures of military objectives and realized that the needs of human beings had been overlooked in the design of equipment and machinery leading to less effectiveness.

Ergonomics has since developed into a science concerning human beings and how they function in the workplace and work related activities. Designers are now realizing and including the limitations of workers in their systems (Singleton, 1972).

Ergonomics in the Construction Industry

Construction is a physical process that is reliant on manual labour. The construction process by its very nature presents a challenge with regard to ergonomics (Smallwood, 2004). In the construction industry, a number of factors affecting ergonomics exist (Schneider and Susi, 1994). The ways in which construction activities are executed adversely affect the health of construction workers, and more so the older workers (Smallwood, 2003). The rate of sprains and strains in construction in the United States of America was found to be the second highest of all USA industries. Ergonomic problems here include musculo-skeletal disorders, upper limbs, back pain and health disorders. These disorders place a strain on the human body. Sprains and strains dominate work related injuries and illness in terms of the number of days taken off work. Back injuries occurring in the United States construction industry are the highest of all industries, and the highest in major and fatal injuries in any industry (HSC, 1999).

Excavating is recognized as the most hazardous construction activity in terms of ergonomics (Occupational Safety & Health Act, 2004). Also work that is executed above shoulder height or below knee height is detrimental to the human body. Moreover, materials used in construction may be heavy and inconveniently sized and / or shaped. In the German construction industry, the sizes and weights of masonry blocks have become increasingly problematic (Berg, 1999). Here, building blocks weigh up to 50 kg. Construction workers, especially masons complained that trouble with or ailments of the joints and spine emanate from the weight of heavy blocks. The association of the German construction BGs (Bau-BGs), responsible for safety and health in the construction industry together with the industrial accident injuries insurance for the construction industry, investigated the problems affecting the masonry sector. It was concluded that masonry work might constitute a health hazard where building blocks are of excessive weight. An agreement was reached that graded the size and weight into three categories namely: one-hand and two-hand building blocks and building blocks which may not be handled by hand, but by mechanical means.

Ergonomic problems include repetitive motions such as those of carpenters who continually hammer nails into wood and saw timber. Most construction workers are involved in climbing and descending as work progresses. The use of body force in execution of construction work is the norm for both tradesmen and general workers in handling of heavy materials. Most forms of construction work expose the workers to noise generated by use of construction materials, tools and mechanized equipment (Bridger, 1995; Singleton, 1972).

Bending and twisting of the bodies of workers while working is common practice as is reaching away from the body and reaching overhead. Much of construction work is done in awkward and cramped positions. Construction work often demands that workers remain working in the same positions for long periods, which over time is detrimental to the human body. Vibrating tools and equipment impact negatively on the state of health of workers. Construction workers sometimes work while suffering from injury which exacerbates and adds to the ergonomic problems experienced on construction sites (Zimmermann and Cook, 1999).

A number of trades or construction activities impact on construction ergonomics such as, plastering and laying of floor screeds, pipe-laying and pipe fitting, kerb-laying, paving, painting, waterproofing, joinery, ducting, floor-covering and floor and wall tiling, glazing, fencing, bricklaying and blocklaying, concreting, carpentry, ceiling and partitions, roofing, plumbing, drain laying, electrical installation, ironmongery, and structural steel work (Smallwood, 2003).

Table1 below details a report in which approximately 2,000 construction workers were interviewed to establish the incidence of workers working with injuries ('hurt') and problematic Job factors.

Table 1.1: Job factors that constitute a major ergonomic problem (Smallwood, 2003)

Job Factors	**Response (%)**
Bending or twisting the back	25.4
Staying in the same position for long periods	21,1
Working while hurt or injured	18.7
Handling heavy materials or equipment	17.2
Working in awkward /cramped positions	16.7
Reaching overhead or away from the body	14.9
Working in difficult environmental conditions (wet/humid, cold/hot)	13.2

Schneider and Susi (1994) identified the following ergonomic problems, according to activity and trade:

- Concreting that requires shoveling;

- Steel reinforcing that requires rapid repetitive twisting of the wrist and bending affecting the back; .
- Formwork necessitating workers bending, twisting and using body force;
- Structural steelwork that is manufactured and erected with awkward postural positioning, repetitive movements and the use of pneumatic tools and lifting of heavy elements;
- Masonry work that requires lifting and trunk twisting flexions;
- Roof construction that requires awkward postural positioning as well as handling of materials and work platforms of an unfavourable ergonomic nature;
- Building fabric (Manual work) that includes hand-arm vibration (bush-hammering) and handling of materials (e.g. Natural stone), bricks and structural elements;
- Plumbing, drainage and pipefitting that require reaching overhead and working in awkward postures:
- Electrical installation that necessitates bending of the wrist and working in cramped spaces;
- Floor-finishes requiring kneeling and bending; handling heavy materials and considerable hand wrist motion;
- Suspended ceiling installation that requires reaching overhead; and
- Painting and decorating involving reaching away from the body as well as reaching overhead.

It is argued that by arranging the environment to fit the person (worker) in it, ergonomics will reduce fatigue, visual disorders and musculo-skeletal disorders (MSD). Persistent musculo-skeletal troubles over prolonged periods result in chronic inflammation of muscles and tendons (Grandjean, 1988). Repetitive motions are all physical stressors emanating from continual use of manual tools such as vibrating jackhammers, excessive force such as lifting heavy equipment and working in awkward positions.

Cumulative Trauma Disorders (CTDs) or Repetitive Strain Injuries (RSIs) are mostly caused by repetitive motions, which if performed one at a time may normally not result in undue stress or physical damage. Cumulative Trauma Disorders are muscle, tendon and nerve disorders. Repeated movements of the body at work cause CTDs, especially when engaged in awkward postures, forces, contact stresses, vibrations and working in the cold. Moreover, when done repeatedly and for long periods, injuries may occur. Repetitive or cumulative injuries like tendonitis occur commonly in jobs where a great deal of repetition occurs (Schneider et al., 1999). Back injuries and several other conditions may result from repetitive motions.

Ergonomics involves the measurement of human performance. The ambient environment may have to be considered in relation to the worker. The affect of heat and cold will depend on the heat generated by workers themselves due to their work rate as well as the heat output of the machinery used for performing their tasks. In the working environment a well-designed job and a well-designed workspace with appropriate materials and tools and hours of work is critical and beneficial for the worker (Singleton, 1972).

Environmental Factors

Excessive noise around heavy machinery or equipment can cause permanent damage to hearing. Improper lighting in the work environment can cause damage to the eyes as well as eyestrain and headaches. The proceedings of the First International Ergonomics Symposium in Zadar, Yugoslavia, in 1985, revealed that the prevalence of postural related diseases and their relationship with working activities were becoming more and more evident (Hanson, 2001). Ogunlana and Chang (1998) concluded in the findings of an ergonomic study, conducted in Thailand that accidents affect productivity as a result of:

- Change in work assignment,
- Decrease in productivity,
- Change in the way tasks are done; and

- Motivation affects productivity, affects time spent on site and performance. A study in the United Kingdom (Price, 1992) showed that physical work, safety and working conditions ranked first among the needs that affect motivation of workers.

Purpose of the Research

Productivity, health, safety at work, quality of life at work, and participatory management are some of the well-known aspects of ergonomics (Kroemer, 2002). The three levels at which ergonomic knowledge can be used are:

- ***Tolerable conditions*** which do not present dangers to human life and health;
- ***Acceptable conditions*** (in accordance with current scientific knowledge and sociological, technological and organizational circumstances) to which the people involved can voluntarily agree; and
- ***Optimal conditions*** adapted to human characteristics, capabilities and desires to achieve physical, mental, and social well-being.

The purpose of the research is to identify the activities affecting the health and safety of construction workers that can be improved by applying ergonomic principles based on the three levels.

Statement of the Problem

Most construction activities require bending and twisting of the body, working in awkward positions, lifting and manually handling heavy and irregularly sized and shaped materials and components, working above shoulder height, and below knee level. This study will demonstrate that the construction industry is resistant to changing the way construction activities are carried out, ignoring the effects of repetitive and lengthy or sustained exposure to these activities that manifest themselves in chronic pain and ailments that result in increased absenteeism, loss of production and unsustainable employment.

Hypotheses.

Hypothesis 1

Construction activities require repetitive and lengthy periods of bending and twisting of the body, working in awkward positions, lifting and manually handling heavy and irregularly sized and shaped materials and components, and working above shoulder height and below knee level.

Hypothesis 2

Exposure to bending and twisting of the body, working in awkward positions, lifting and manually handling heavy and irregularly sized and shaped materials and components, and working above shoulder height and below knee level produces worker health problems.

Hypothesis 3

Health problems that affect construction workers manifest themselves in chronic pain and ailments.

Hypothesis 4

Ergonomic related health problems lead to increased absenteeism in the construction industry.

Hypothesis 5

Ergonomic related health problems lead to poor productivity on construction sites.

Hypothesis 6

Ergonomic related health problems lead to increased retrenchment of construction workers.

Hypothesis 7

Construction employers are resistant to changing the way construction activities are carried out.

Objectives.

The objectives of the study are:

- To establish the extent to which construction activities expose workers to ergonomic challenges and to identify the particular activities that present the most challenges.
- To conduct field observations of methods of work employed on site and identify ergonomic interventions that can be applied to improve the health and safety of workers.
- To establish to what extent the:
  - ✓ health of construction workers;
  - ✓ absenteeism;
  - ✓ productivity; and
  - ✓ retrenchments are affected by ergonomic related problems; and
- To establish whether and to what extent employers are resistant to changing the way construction activities are carried out.
- To establish the extent to which construction workers' well-being is affected by unfavourable ergonomic practices on construction sites and make recommendations based on the conclusions from the study.

Research Methodology

The Methodology to achieve the objectives of this research comprises of:

- A literature review of all available material relevant to the research topic, an empirical survey conducted by interviewing employees per questionnaire to assess what their perceptions were and what opinions they had about the effective functioning and ability to achieve objectives via an ergonomic design programme.
- Data gathering.
- Observations of and interviews with construction industry employees to establish whether objectives are achieved.
- Data analysis and interpretation.

Recommendations were made on how to address and improve on the practices that detrimentally affect the workers' health and safety and which negatively influence workers' quality of performance and production

Limitation

The research limitations were that:

- The research was confined to the Western Cape;
- The limited time period; and
- There was limited availability of construction stakeholder and co-operation, interviews, completion of questionnaires and observations on construction sites.

Structure of the Dissertation

This dissertation is structured as follows:

CHAPTER 1 Is an introduction of the concept of ergonomics and of the effect of ergonomics on the construction industry and on construction workers. It includes the historical background to ergonomics and the global overview of ergonomics in the construction environment. It concludes with the ethical statement applicable to this study.

CHAPTER 2 Reviews the literature on the application of ergonomics and the benefits workers and employers in the construction industry would enjoy as a result of the application of ergonomics.

CHAPTER 3 Presents the research design, methods and instruments.

CHAPTER 4 Presents the findings and analysis of the study.

CHAPTER 5 Interprets and discusses the data and presents the key findings. It also evaluates the hypotheses.

CHAPTER 6 Presents the conclusions of the study and recommendations formulated with reference to future study and research.

Ethical Statement

To comply with internationally accepted ethical standards no names of individuals or organizations were recorded on research instruments. In this way no individual or organization was linked to a particular completed research instrument, thus assuring anonymity. No compensation will be paid to any respondents for participating in the study. As with other studies there was compliance with quality assurance with respect to the following aspects:

- General conduct and competence of interviewers;
- Correctness and completeness of questionnaires used, especially where open-ended questions were used;
- Quality of data capturing by encoders; and
- Running of frequency distributions to check that all variables contain only values in the accepted range and variable labels.

Closing Remarks

This chapter presented the research problem addressed by the study. It briefly described the concept of ergonomics and sets out the objectives of the study the research methodology.

The following chapter will be the literature review

CHAPTER 2
LITERATURE REVIEW

Introduction

As the ergonomic approach to construction is often of an applied nature, it involves adaptation and / or design of the workplace or work environment to suit the capabilities and limitations of the workers. The ergonomic principle, therefore, is that tools, equipment, systems and tasks should be designed to suit the user or worker (Gibb et al., 1999).

Historically, Leonardo Da Vinci in the 16th century, Giovanni Alfonso Borelli in the 17th century, Lavoisier Amar, Rubner and Johannson among others in the 19th century and the early 20th century contributed ideas, concepts, theories and practical data toward understanding of the effect of the work environment on the human body. Ergonomics interfaces with other applied disciplines and sciences. The foundations of ergonomics are the biological sciences, particularly anatomy and physiology (Kroemer, 2002). Kroemer (2002), also provides an overview of the seminal work by which Frederick Winslow Taylor (1909), defined and developed the concept of '*scientific management*'. The concept encapsulated the basic concepts of human factors and ergonomics used by industrial engineers and designers who are the major beneficiaries of ergonomic knowledge. Taylor (1909), defined three basic principles of scientific management as:

- Freeing the initiative of individual workers,
- Strengthening the work group; and
- Finding, training and developing individuals for the jobs they are best suited for (Drucker, 1981).

It is within the last principle that the application of ergonomics in the workplace is considered. For instance, in the work of Wright (1940), it was noted that the tonic movement of antagonist muscles, both extensors and flexors, caused severe exhaustion in carpenters and bricklayers. Further, it was found that workers employed in trades requiring standing for prolonged periods, experienced problems that for their comfort required changes in body position for example by walking and exercising the body in some way to increase blood circulation (Wright, 1940). Drucker (1981), quoting Taylor (1909), highlighted the need to eliminate physical strain and damage to the human body by not 'doing work the wrong way'. Taylor identified the concept of *ergonomics*, long before the word '*ergonomics*' was coined. As the "Society of Mechanical Engineers" could not publish his work on the basis that it was not scientific at the time, Taylor published his writings privately (Drucker, 1981).

The relationship between the worker, equipment, workplace and the work environment within an organization is of great interest to ergonomists and human factor experts. Ergonomists contend that work must be designed in a way that prevents and controls work related health problems. In this regard, equipment and task design should encompass the use of suitable equipment such as Personal Protective Equipment (PPE) (Gibb et al., 1999).

Construction is by its very nature dangerous. Construction activities pose health - problems to workers. The construction site brings together tradesmen such as carpenters, electricians, bricklayers, plasterers, plumbers, painters as well as unskilled construction workers employed in the respective trades (Schneider, 1999). The work is heavy and is often done in awkward working postures, which facilitates the development of cumulative trauma disorders (Keyserling, 2004). Drucker, (1981: 97-98), quoting Taylor (1909) pointed out that 'traditionally work creates injuries, fatigue, strain, dulls the faculties and wears out the body'.

Taylor was passionate about the need to study tasks, to organize and plan them and to provide the tools and the right information to enable workers to 'greatly increase the output of man without materially increasing his effort'.

Introduction to Musculo-Skeletal Disorders

The Workers are constantly at risk of injury from accidents in the construction work environment. A number of injuries such as sprains and strains, cumulative trauma disorders (CTD's), carpal tunnel syndrome (CTS) and tendonitis occur in the construction industry. Further, the prevalence of knee injuries is mostly among those trades where kneeling is required such as floor tiling, floor screeding and floor carpet laying.

Construction activities, therefore, pose threats to workers' health and well - being. The health problems present in the form of musculo-skeletal disorders, repetitive strain injuries, carpal tunnel syndrome and cumulative trauma disorders (Haupt et al., 2004).

Effects of Musculo-Skeletal Disorders

Musculo-skeletal Disorders (MSD) in the neck, shoulders and upper limbs as well as of the lower back, also referred to as repetitive strain injuries (RSIs), cause distress and disability (Baril et al., 1994). MSDs, impact negatively on worker's ability to perform tasks resulting in them being unable to maintain their quality of life (Stock et al., 1998).

In the United Kingdom, two million people suffered from ill-health (HSE, 1995). MSD involving 1,2 million people contributed toward 187 million working days being lost due to ill-health (CBI, 1997; Gibb et al, 1999). The impact on the economy is severe.

In the United States of America (USA), MSD due to poor training and ergonomic design are the leading source of compensation claims. RSIs include a number of upper limb disorders (ULD) such as tendonitis which involve inflammation of the muscle tendons and surrounding tissue; carpal tunnel syndrome (CTS) which is the increase in fluid pressure within the carpal tunnel of the wrist, and tennis elbow, which is tenderness and swelling in the forearm. The most common symptom associated with upper limb disorders is pain due to joint movement and soft tissue swelling. In the early stages of ULD, bruising or swelling may not be evident but will become more severe and may eventually render the worker unable to perform normal daily tasks (Hunting, 1994).

MSDs are difficult to diagnose and pain cannot easily be measured or objectively qualified. MSDs are the most common non-fatal injury in the construction industry and result mostly from overexertion or lifting materials that are too heavy, heavy work and vibration, frequent use of handheld tools, repetitive work and awkward work positions. Stress has been found to be associated with MSDs and lower back pain and diminished muscle strength. MSDs are reported to be the reason for eventual retirement through disabilities of 40% of older construction workers in South Africa. Medical history records consulted as part of a study of construction workers indicated that 15% of workers experienced MSD problems, 31% had back problems and 1% suffered slipped discs (Haupt et al., 2004).

In a review of MSDs among construction workers in Sweden, it was found that risk factors could contribute to injury rates (Schneider, 2001). The study identified that a clear relationship existed between heavy work and vibration, repetitive work and awkward postures. It further showed that lower back pain, age, poor physical fitness, and lack of sufficient leisure time and diminished muscle strength were contributory factors to the incidence of MSDs.

Deacon et al., (2005) reported that 40% of construction workers were retired due to MSDs. Lower back pain (LBP) is associated with exposure to lifting / forceful movement and whole body vibration exposure. Work related back pain is seldom caused by a single accident or incident at work resulting in injury. Low back pain is common among most trades. Bernardino Ramazzini (1633-1714) wrote in 1713 that workers such as carpenters experienced a gradual rise of afflictions due to the posture of the limbs or unnatural movements of the body while they worked. Those standing while doing their work engaged the antagonist muscles, both extensors and flexors. To enable the body to remain in a standing position is uncomfortable. This discomfort is eased by walking about or by exercising the body in some way. Deacon (2005) reported that the body posture changed when work was strenuous and while undertaking work standing in the same position. Incidence of lower back disorders such as aches, pain and discomfort is associated with turning, bending and handling of heavy materials. Ramazzini described carpentry as tiring work that greatly fatigued the worker (Wright, 1940).

A number of activities and body movements can result in disabling injuries. Force and posture of the hand, wrist and arm or pains in the upper limbs and lower back are all work related repetitive movements that could result in disabling injuries. In severe cases of injuries sustained during repetitive movements, loss of function, limited movement and loss of muscle power could occur (Gibb et al., 1999). Literature indicates that previous history of lower back pain is one of the best predictors of LBP (Ferguson et al., 2004).).

Impact of Restricted Workspaces

In the construction industry, a vast number of work activities are executed in positions that impose physical limitations on workers. A literature review of the physical limitations and musculo-skeletal complaints associated with work in unusual or restricted postures highlighted a number of restrictive positions and the resultant effects on workers (Gallagher, 2004). These restrictive positions included kneeling / squatting, stooping and lying in awkward positions (Gallagher, 2004). Workers' adaptations, limitations and trade-offs associated with working in awkward positions have been achieved. Ergonomic techniques used in design and adaptation of the work situation were not well received nor implemented where unusual postures were employed (Gallagher, 1991). The workplace factors that affect the way workers worked were:

- Working in the same position for long periods;
- Bending or twisting the back in an awkward way;
- Carrying, lifting or moving heavy materials or equipment; and
- Reaching or working above the head or away from the body.

Impact of Posture, Static Work and Handling Technique

Many workers adopt unusual or restricted postures while performing their daily tasks which reduced the performance capabilities and increased MSD complaints (Gallagher, 2004). Awkward work postures result from restrictions in the workspace. Lifting is the most common cause attributed to back pain and work related lower back pain. Unexpected loadings and sudden increases in loads could cause loss of balance and falls. The lifting of unexpectedly light loads or objects increased the risk of loss of balance. Centre of pressure (COP) displacements had been shown to increase in proportion to the release of a load of horizontal pulling and of symmetric lifting (Chow et al., 2004).

Hand held vibrating tools are commonly used in many trades in construction. Vibrating tools are likely to cause a variety of symptoms referred to as hand-arm vibration syndrome (HAVS) that may affect the nervous system or the muscular regions of the body. Research has shown that the symptoms could appear as digital vasospasm white finger', sensorineural disturbances, or as muscular weakness and fatigue (Gerhardsson et al., 2004).

Ergonomic Challenges

A number of construction activities expose workers to ergonomic challenges. Musculo-skeletal disorders result in 22.5 % of all construction accidents resulting in workdays lost in the USA (BLS, 1998). Substantial evidence exists that indicate that MSDs were a major cause of construction injuries requiring compensation to be paid (Schneider, 1997). Knee injuries were highest amongst plumbers, roofers, floor tilers and carpet layers, which are, trades executed by workers on their knees (Coble et al., 2000). Painters who, by the very nature of the execution of the trade, often worked with their hands and arms overhead and often in awkward positions (such as applications to ceilings and overhead structures requiring painting) need raised platforms to reach such work areas. High rates of elbow and shoulder pain symptoms are also attributed to awkward positions maintained while doing bricklaying (Cook et al., (1996).

A large volume of existing research identifies several types of musculo-skeletal injuries in most of the construction industry (Coble et al., 2000). The said research identified the construction injuries occurring in most trades including high levels of repetitive work such as nailing, working in awkward positions and forceful movement of heavy objects.

With reference to participatory ergonomic projects in Europe, workers were identified as essential participators in identifying high-risk tasks and potential solutions to such ergonomic problems. The interventions identified to reduce the risk of MSDs in construction could be classified as: new materials, new tools and equipment, improved work practices, improved work organization and planning, education and exercise and personal protection equipment (PPE) (Bronkhorst et al., 1997; van der Molen et al., 1997).

In an effort to reduce work-related MSD, ergonomic training programmes were initiated in construction, especially in Europe. Various ergonomic awareness modules were included in ergonomic training programmes. The educational modules included training for apprentices, toolbox talks on ergonomics, trade specific modules demonstrating how the different tasks or equipment could be modified to prevent musculo-skeletal injuries (MSIs) (van der Molen et al., 2004).

Building of housing units, offices, industrial complexes and institutional buildings engage bricklayers and bricklayer's assistants using bricks, blocks and mortar. Methods of work, materials used, tools, equipment and workplaces vary between workers, construction projects and countries, with resultant health and safety risks (van der Molen, 2005).

Observations revealed that Dutch bricklayers handle approximately 800 to 1100 bricks each per day and an average of 165 to 220 blocks each per day as well as mortar for the placing of the bricks and blocks. The bricklaying entails placing and adding mortar and placing of bricks and blocks in position to build walls. The most demanding physical work for bricklayers is repetitive lifting of bricks (single handed) and blocks (two-handed) accompanied by bending of the lower back for more than four hours of the work day which was found to increase the risk of lower back pain (van der Molen, 2005). The bricklayer's assistants are tasked with the physical work of manually transporting of bricks, blocks, mortar as well as the rest of the manual tasks involving lifting and carrying of building materials and pushing and / or pulling of wheelbarrows and the shoveling and placing of mortar where required. Sustained regular lower back complaints of Dutch bricklayers and bricklayer's assistants over a 12-month period are 45% (van der Molen, 2004).

Health Problems and Absenteeism

Work health promotion studies have quantified the relationship between good health and productivity (Karch, 2003). These studies attempted to assess the impact of worksite health promotion programmes on worker absenteeism, which is the number of sick days that an employee uses during a calendar year. The quantifiable outcome of the research efforts was a well designed and properly administered health promotion programme for the work environment securing healthier employees. It could be assumed that a company would experience some reduction in healthcare expenditures considering that to calculate the amount lost to sick leave for 1000 workers, (calculate Rate / Hour x Total Hours of Sick leave / annum) which in the USA amounts to $100 x 80000 = $8 million. Absence from work due to injuries or illnesses has a detrimental economic impact on business as absenteeism often necessitates the hiring of substitute labour incurring additional expense and cost of decreased productivity (Ho, 1997).

Health Problems and Poor Productivity

Many companies measure their productivity in terms of revenues or profits realised per employee. Measures related to productivity including absence, disability rates and safety incidents. The term 'presenteeism' describes being at work but not producing optimally. Research showed that employee productivity was affected by health conditions inclusive of back pain (Kirsten, 2003).

Deacon et al. (2004), found from their pilot study of methods employed by civil construction general workers, that the workers were receptive to change as they were in favour of improvements made and of increased work rate, as they were bored with the routine nature of the work.

Impact of Poor Health on Worker's Livelihood

The construction industry has a poor health record and it is widely agreed that adequate medical surveillance is not generally available. Because of the contractual nature of construction projects, the long term disabling nature of occupational illnesses impose severe financial burdens on families and the state. The construction companies are similarly negatively affected by workers compensation claims and higher insurance premiums than necessary (Gyi et al, 1997).

It is normally accepted by the ergonomics community that the ergonomics discipline can enhance productivity, quality and customer satisfaction. Despite it being widely accepted in the business community that productivity, quality and customer satisfaction are important business goals, ergonomics has not been accepted as a means to achieve the said goals to the benefit of the organization. Organizations where a need to obtain employees' commitment, reduce expenses and increase productivity exist, do, however, not use ergonomics as to tool to improve or rectify the situation.

Impact of Health Status on Retrenchments

Construction workers were rarely afforded the benefit of medical surveillance. Employers ignored the complaints of workers relating to MSDs and about their backs because of the incidence of fraudulent complaints of back problems being rejected by Compensation Commissioners (Haupt et al., 2004). There was generally a lack of occupational and non-occupational health care for construction workers in the Republic of South Africa (RSA).

Lack of Workplace Guidelines

The practice of ergonomics lacks objective guidelines for minimizing the risk of recurring lower back pain (LBP) and other health related problems. Guidelines or recommendations for the prevention of lower back injuries have over the last ten years been under revision by a number of stakeholders. A lifting guide based on epidemiological, biomechanical, physiological and psycho-physical evidence was developed by the National Institute of Occupational Safety and Health (NIOSH, 1981, Ferguson, 2004). Psychophysical studies by Snook and Cirell, (1991), wERE used as the basis for the development of recommendations for lifting, lowering, pushing, pulling and carrying. The control of tasks that require manual lifting is best achieved through the application of ergonomic design principles. Where the ergonomic principles are not easily achieved due to economic and technical problems, some organizations have been found to employ safe lifting techniques as a control measure (Johnson et al., 2005). In a study intended to address the need for safe behaviour through the exploration and development of a theoretical model explaining the emergence of safe behaviour (Johnson et al., 2005), established that safe-lifting behaviour is difficult to motivate.

The Role of Management in the Application of Ergonomics in Business

The manager's role in causing improvement is critical. Communication with management playing the pivotal role is important to achieve functional objectives.

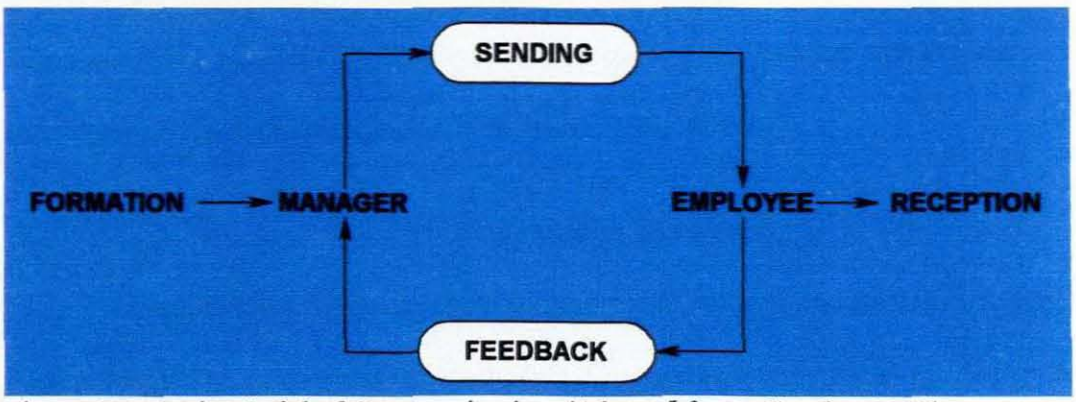

Figure 1.1: Basic Model of Communication *(Adapted from: Crosby, 1985)*

The manager helps the workers to develop a commitment to the goals of the work group through communication. Communication involves; the sharing of ideas, expressing requirements, accepting change and forcing thought (Fig 1). It allows the workforce to share ideas such as in 'toolbox talks' as well as formal forums to communicate workers input, to lay bare differences, to minimize misunderstandings and gather objective contributions to improve work and safety procedures (Crosby, 1985).

Companies admitted that they had concerns about workers health and well-being. Managers wanted to employ workers who are fit to do the job. Temporary workers and multi-employer companies, sub contractors and fear of job losses by workers did not produce a solution to the problem of costs due to occupational injuries and illnesses. Gyi et al., (1997) concluded that serious under-reporting of particularly minor injuries and near miss events undermines the validity of accident statistics, which is coupled with the failure to collate and undertake effective analysis of the data collected.

The manager remains responsible for checking that workers understand the prescribed requirements and technological innovation must be communicated to the workers (Crosby, 1985). Managers and management consultants need to equip themselves with the necessary knowledge about the existence and scope of the ergonomic discipline in the construction industry to enable them to incorporate ergonomics considerations in their management's decisions (Dul, 2003).

Problematic Job Factors

Poor ergonomics results in injury and disease to workers and negatively effect the cost, productivity, quality and work schedule. Ergonomic interventions will thus reduce fatalities and other injuries and improve health and safety, productivity and quality and thus reduce the cost of construction by completion of the work closer to the target set by the schedule (Smallwood, 1995).

Approximately 2,000 construction workers were consulted to determine where workers experienced hurt and the reasons why. The workers identified a number of job factors that were a major problem. Table 1.1, presents the major ergonomic problems as identified by the 2,000 workers interviewed by the University of Iowa (Center to Protect Workers Rights, 1995), and are listed in the sequence as prioritized by the said workers.

No identifiable studies that assess the degree of loading experienced by the spine of those already suffering from lower back disorders were obtainable. It could therefore not be established whether guidelines based on spine loadings are appropriate for workers returning to the workplace. While current guides denote 4.5kg as a safe practice, low risk for symmetric lifts in the shoulder, waist, knee and waist regions, the 4.5kg can present a medium risk of injury in the far-knee condition depending on the horizontal distance in question. Return to work or work restrictions; however, prescribe lifting on return to work to be no more than 4.5kg (Johnson et al, 2005).

In the case of floor tiling where kneeling is constantly necessary, it is not possible to avoid twisting the trunk. Workers simply do not take the time or the effort to reposition as the laying of floor tiles demand kneeling to best perform the task.

Return to Work

Research on the work environment in Canada revealed that 'return to work' (RTW) initiatives have been implemented to decrease the cost of lost time. Re-assignment to another job or to a modified work was instituted as a temporary measure (Krause et al., 1998). It was found that despite the benefits of RTW programmes in reducing cost and improving workspace morale, many workplaces appear unwilling or unable to implement and sustain successful RTW programmes (Soroki, 2001; Welsh, 1997; Brook et al., 2001; R. Baril et al., 2003).

The return-to-work guidelines that exist in the USA are vague and non-specific and do not address how the spine is loaded in a low back pain patient. Workers who return to work of after low back injuries, with no restrictions given relating to the weight (for example 5-10kg) risk factors such as lifting, and the posture of the body is not given the necessary attention. The restrictions are not instructive and the method of lifting of has to be taken into account Ferguson et al., (2004) leaving the ergonomic problems to remain.

Chapter Summary

This chapter provides an overview of available literature on ergonomics in construction. Highlighted are environmental problems and its physical limitations, ergonomics challenges and its effects on workers' health status and the role of management in the implementation of ergonomic practices in the workplace. These aspects of ergonomics in construction will be studied as described in the following chapter on the research methodology.

CHAPTER 3
METHODOLOGY

Introduction

This chapter presents the methodological argument for the conduct of this research. The chapter begins with an explanation of the meaning of methodology, followed by an analysis of the problem(s) to be addressed. The problem analysis then leads to a comparison of research paradigms and a subsequent statement of philosophical position taken for the research. The chapter concludes with an explanation of the sampling strategy adopted and method employed, and a description of the actual procedure employed.

Meaning of Research Methodology

The research deals fundamentally with the production and legitimisation of the various forms of knowledge associated with the practices of various subjects. Research methodology is a "combination of techniques used to enquire into a specific situation" (Easter-Smith et al., 2002: 31). In essence therefore, research methodology refers to the overall approach to the research process from the theoretical underpinning to the collection and analysis of data.

Methodology is concerned with: why data should be collected; what data should be collected; where data should be collected from; when the data should be collected; how the data should be collected and how the data will be analysed. Like theories, methodologies cannot be true or false, or indeed 'right' or 'wrong'; they can only be more or less useful (Silverman, 1997).

Analysis of the Problem

The operations and processes associated with the execution of physical work in construction, ergonomically impact negatively on the well being of operatives and craftsmen, and the productivity of the employing companies.

To resolve the problem, it is necessary to understand the operations and processes associated with the execution of work on construction sites. The overall objective of the research was, to establish to what extent unfavourable ergonomic practices were prevalent on construction sites and what effect such practices have on the health and safety of the workers and to what extent productivity is affected. The results of the investigation would be used to establish to what extent ergonomic practices negatively influence workers' health and safety and productivity in the workplace.

Scope

The problem is specific to construction in the Western Cape. However, the solution to the problem should be as generalisable as possible to the RSA construction industry.

Nature of Description

A balance must be made between describing the problem qualitatively and quantitatively. This can be considered as balancing the description of 'why' a phenomenon happens against 'what' happens. Re-examining the objectives of the study makes it apparent that in the first instance there is a requirement to establish 'what' is happening as opposed to why it is happening. This points the research towards a methodological position incorporating primarily quantitative analysis.

Complexity

This dissertation seeks to establish the dynamics associated with ergonomics in the construction industry. The problem can be considered to be widespread throughout the RSA as construction methods are common throughout the industry. The problem can be described as being generic, quantitative and simple and given the nature of any particular research problem, will dictate its means of solution. The methodological framework and methods employed in the research were required therefore to reflect these features (Tookey, 1998). The next step was therefore to establish the most appropriate philosophical position for the research, prior to the selection of the appropriate method(s). To achieve this it was necessary to understand theoretical approaches to problems. Theoretical perspectives and approaches to knowledge creation are based on a number of sociological and related backgrounds (Chia, 2002).

Establishing the Philosophical Background of the Research

In order to establish the philosophical position of the research, it was necessary to examine the sociological, epistemological and ontological background for the research. This would place the research in an established philosophical background and therefore a relevant paradigm. The choice of paradigm has implications on both the research design and research methods. The paradigm is determined by the nature of the research being investigated (Easterby-Smith et al., 2002; Chia, 2002).

Sociological Background

Humans behave in a social manner and organise life in groups. Sociology is the study of human social organizations. Sociological backgrounds influence people's philosophies. Philosophy is primarily concerned with rigorously establishing, regulating and improving the methods of knowledge creation in all fields of intellectual endeavours including the field of management research (Chia, 2002). Philosophical thinking revolves around four pillars of, metaphysics, logic, epistemology and ethics (Chia, 2002).

Metaphysics concerns questions of being and knowing. In metaphysical enquiries, therefore questions of ontology, that is, the nature of reality are central (Neuman, 2000). Logic deals with methods of reasoning that are employed in apprehending reality in order to extract from it certain useful universal generalisations about how things work (Neuman 2000). The study of logic enables establishment of how certain knowledge claims are arrived at and legitimized and hence the validity and reliability of such knowledge claims (Neuman, 2000; Easterby-Smith et al., 2002; Chia, 2002). Epistemological claims are founded on certain metaphysical assumptions and the use of particular methods of reasoning. Ethics deals with moral evaluation and judgement of issues facing researchers in everyday life (Neuman, 2000; Easterby-Smith et al., 2002; Chia, 2002).

Philosophical attitudes are often inherited from people's cultural settings, that is, sociological background. Research orientations are inextricably linked to philosophical preferences, which are in turn influenced though not necessarily determined by embedded collective histories and cultural traditions (sociological backgrounds) within which individual identities have emerged. Interpretation and selective abstraction are inevitable facts of the process of knowledge creation (Babbie, 2004). Academic research must, however, avoid this since the nature and type of problem should be allowed to define the method of solution required.

When conducting management research, it must not be assumed that the researcher and practitioner hold similar attitudes and definitions of what constitutes knowledge since there is an implicit set of philosophical assumptions that justifies different individual orientations (Babbie, 2004; Holt, 1998). These differences in priorities imply that the process of creating and legitimising knowledge has significant epistemological shortcomings and complexities the researcher must be fully aware of (Neuman, 2000; Easterby-Smith et al., 2002; Chia, 2002).

Epistemological Background

Epistemology is the study of knowing, that is to say, how we know what we know. Epistemology uses a general set of assumptions about the best ways of inquiring into the nature of the world. Epistemological investigation attempts to reflect on the methods and standards through which reliable and verifiable knowledge is produced. Epistemology is therefore a study of the verification of knowledge (Babbie, 2004; Neuman, 2000; Easterby-Smith et al., 2002; Chia, 2002).

People construct social reality from interactions and sense impressions. Parts of social reality are identified, labeled and causally linked to other parts of people's experiences in order to form a coherent system of explanation. Through a process of differentiating, naming, classifying and relating, modern knowledge is systematically constructed. Knowledge is therefore, created through the process of selective abstraction, identification and recombination (Chia, 2002). This implies that researchers must be cautious about their findings and limitations of any truth-claims made. The validity of such claims is dependent upon a deeply embedded set of metaphysical assumptions underpinning Western thought (Babbie, 2004; Neuman, 2000; Chia, 2002). These form the ontological background.

Ontological Background

Ontology is the study of "being". Ontology can be defined as a formal explicit specification of a shared conceptualisation (Gruber, 1993; Borst, 1997). Conceptualisation refers to an abstract model of some phenomenon in the world by having identified the relevant concepts of that phenomenon.

According to Chia (2002), there are two opposing ontological backgrounds in which sociologists and other researchers can base their methodology. These are Parmenidean and Heraclitean ontologies. The Heraclitean ontology emphasizes the primacy of a fluxing, changeable and emergent world while the Parmenidean, ontology insists upon the permanent and unchangeable nature of reality. The opposition between a Heraclitean ontology of becoming and Parmenidean ontology of being provides researchers with the key for understanding of the contemporary debates in the philosophy of the social sciences and their implications for management research (Chia, 2002).

Research Paradigms

Philosophies of science are ultimately concerned with the question of how scientists should carry out research given the understanding of the nature of knowledge. Ontological assumptions affect epistemological assumptions, which in turn affect methodological assumptions. It is therefore not wise to pick a methodology arbitrarily since each methodology brings with it epistemological and ontological assumptions (Easterby-Smith et al., 2002; Chia, 2002).

A paradigm is a shared and common framework for understanding and tackling problems. The evidence versus theory relationship is framed by the paradigm in which the research is carried out (Kuhn, 1970, 1979). Essentially researchers need to understand methodological paradigms as a vehicle to underpin, support and justify a chosen approach to research.

Positivist Paradigm

Positivism is a philosophical position held within the natural and social sciences that combines logic and rationality with empirical observation. In its most basic form, positivism assumes that the researcher is a neutral spectator of the object of enquiry. In positivism, reality is assumed to exist independent of the perceptions, beliefs and biases of the researcher (Neuman, 2000; Oliver, 2004). Research therefore consists of undistorted recording of observations obtained through meticulous investigation and use of precise terminologies and classifications in the reporting process.

The researcher should focus on facts and look for causality in order to be able to identify underlying 'laws' by which the world, and specifically the system under observation, is governed. It thus follows that positivism has at its heart the notion that the 'world' in which research is undertaken is completely external, and that the observer is totally independent of the system being observed (Chia, 2002; Fellows and Liu, 2003). The essential sequence of positivistic scientific inquiry revolves around four main stages: Observation stage, hypothetical construct stage, testing stage and the analysis stage.

Observation Stage

A phenomenon is observed in its natural state in order to establish the dynamic of the process. Observation is critical to the establishment of the dependent and independent variables of the process (Easterby-Smith, 2002). Once the observation stage is fully completed, the researcher should be able to deduce the nature and scope of the problem under observation and begin to build a theory to explain its occurrence.

Hypothetical Construct Stage

A hypothesis is a tentative explanation for an observation, phenomenon, or scientific problem that is used as a basis for further investigation. The classic positivistic approach is the formulation of a hypothesis from observed facts, and research that is geared towards either the 'proof' or 'disproof' of the original research hypothesis. Frequently multiple hypotheses are presented by matching the knowledge claims of broadening the scope and applicability of the analysis. Thus hypothesis testing essentially seeks to validate knowledge by matching the knowledge claims of the researcher with the phenomena in reality. Consequently theories are proposed as universal hypotheses to be tested empirically (Babbie, 2004; Neuman, 2000).

Testing Stage

Once a hypothetical construct is in place, the researcher must design and experimentation or sampling strategy that permits the researcher to identify precise relationships between variables. These variables are studied intensively in controlled conditions (Galliers, 1991). The strategy is closely allied with quantitative research and usually involves statistical testing and developing relationships between variables.

Control of all relevant variables in the experimental design can be difficult, particularly when investigating social phenomena. The consequence of poor control is poor validity and reliability. This in turn produces a lack of generalisability.

Analysis Stage

Typically research generates large amounts of data. This is essential from a positivistic perspective (Marshall and Rossman, 1995). Positivistic research aims to define and describe underlying laws and principles governing observed phenomena. Within a positivistic analytical context, data integrity and density, allied to statistical significance, becomes the cornerstone of effective research.

Once all the relevant data has been analysed, a positivistic researcher should be in a position to support or reject their hypotheses. If a hypothesis is supported, then the researcher has to assess whether it is sufficiently exacting to fully describe the phenomenon. Phenomena should be isolated and experimental observations should be repeatable (Easterby-Smith et al., 2002). Once a hypothesis has been initially supported, further testing should take place in order to demonstrate its repeatability and consequent validity (Hirshheim, 1985; Alavi and Carlsonm,1992). The process is repeated until the phenomenon has been fully described and a general "law" has been established.

Phenomenological Paradigm

Phenomenology is the study of phenomena in their natural environment. A phenomenon is a fact or occurrence that appears or is perceived by an observer. Phenomena where the cause is in question therefore drive research. The phenomenological paradigm is concerned with understanding phenomena within their own frames of reference. In other words, phenomenologists treat each occurrence as a separate entity that should be described in isolation from the world around it (Marshall and Rossman, 1995).

It is the contention of phenomenologists, that social and management science is socially constructed and therefore subjective and it is not possible for the observer / researcher to remain objective (Easterby-Smith et al., 2002; Marshall and Rossman, 1995). The approach used by psychologists, seeks to explain the structure and essence of the experiences of a group of people (Banning, 1995). A phenomenologist is concerned with understanding certain group behaviours from that group's point of view.

Research Philosophical Position

Many social science researchers have over the years argued in favour of positivism because it is characteristically objective and can deliver generalisable results (Rooke, 1997; Harris, 1998). There is, however, an argument for the use of more phenomenological approaches that attempt to describe the totality of the situation, or indeed a mix of approaches, that may produce better results (Leonard, Raftery and McGeorge, 1997).

Positivism has empirical knowledge and vast statistical and experimental data. Phenomenology is new and has rather bizarre ideas of how things may change as you look at them and can be more than one thing at once. Debate is healthy in these fields, and yet from the utilitarian view of the construction manager, it seems that both the positivist and the phenomenological approach have merits, depending on the situation. In the particular field of research that is the contention in this dissertation, that is, to establish the extent to which construction activities expose workers to ergonomic challenges and which particular activities present the most challenges, is especially true.

Epistemologically, the problem being addressed by this research is an objective problem in need of observation and measurement. Therefore the research must be objectivist rather than interpretivist. In other words this output requires a representational view of generic approach to ergonomics as part of Health and Safety practice in the construction environment.

The research strategy designed must reflect the fundamentally positivistic underpinnings. Section 3.7, examines the most pertinent research methods now that the philosophical standpoint for the research has been fully established. Section 3. 8, establishes the research design.

Selection of Research Method

Research methods are individual techniques for data collection and analysis (Easterby-Smith et al., 2002). There are several ways in which research methods can be classified. A common method is to make the distinction between quantitative and qualitative research methods (Myers, 1997). The research method adopted for this research, must be able to generate data that is objective, quantitative, and fully descriptive of ergonomic practices on construction sites.

The principal characteristic of academic inquiry is the use of nationally grounded, validated research methods (Holt, 1998). There is a wide variety of research methods available to the researcher. Each research method has its strengths and weaknesses. Certain methods are more appropriate to investigate particular concepts than others. The research method chosen to address a problem should depend on the research subject and nature of the specific problem.

Generally the method evolves from, and is determined by the research question (Babbie, 2004). In order to select the most appropriate research method, it is necessary to eliminate as far as possible those research methods that are not appropriate. Table 3.1

demonstrates a distribution of research methods according to the nature of the research problem being addressed.

Table 3.1: Framework for research methods *(Adapted from Meredith, 1989)*

Approach to Knowledge Generation	**Direct Observation of Object Reality**	**People's Perception of Object Reality**
Logical Positivist / Empiricist	(A) Field Studies / Observations Field Experiments	(B) Structured Interviewing Survey Research / Questionnaires
Interpretive	(C) Action Research Case Studies	(D) Historical Analysis Delphi / Expert Panel Intensive Interviewing Introspective Reflection

The logic of the preceding sections now allows the elimination of inappropriate research methods without having to investigate their validity further. Section 3.6 states the philosophical position and underpinnings of this research as positivistic. The research method needs therefore to be objectivist, representational, generalisable and quantitative. Relating these requirements to Table 3.1, it can be seen that interpretative methods are not appropriate. Therefore those methods listed in (C) and (D) of Table 3.1 are inappropriate. All of these methods require a degree of interpretism detrimental to the objectivity of the study.

Furthermore, the literature examined in Chapters 1 and 2 demonstrates that the problem of ergonomics in construction is not given the necessary attention by those within the industry in the Western Cape. Eliminating the methods that appear in quadrants (C) and (D), leaves a relatively limited set of methods that are pertinent to the situation of this research. Specifically the observational methods or the field study would appear the most appropriate to this study. The 'site' became a crucial component of the understanding of the dynamic. To perform a valid field experiment, site observations would have to be done during working hours and would not be possible without the co-operation of the site management. Therefore, by a process of elimination it was established that the most appropriate method of research in the context of this research would be by a Field Study (Observations).

Because it was not possible to establish the perception of workers towards their experiences, an additional method was required. It was required as this complements the Observations / Field Study method established above. Thus by a similar process of elimination structured interviews (by questionnaires) (B) were established as the appropriate method. The research can thus correlate the findings from observations with the findings from the questionnaires.

Designing the Research Plan

The research plan gives direction and enables researchers to conduct systematic research. Research strategies clarify the types of information the researcher needs to find. The research detailed in this thesis can now be seen to be focusing on the conduct of a field study in order to collect and record objective data for further analysis. Therefore it was pertinent to establish specific components of the research plan. An appropriate research instrument had to be designed for the analysis of the ergonomics practices in the construction industry in the Western Cape. In addition a robust sampling strategy had to be established.

Development of the Research Instrument

As has been stated in section 3.3, the problem being addressed by this research is that most construction activities require bending and twisting of the body; working in awkward positions; lifting and manually handling heavy and irregularly shaped materials and components; and working above shoulder height and below knee level occurring on construction sites. The objectives were to establish to what extent ergonomic related problems affect the health of construction workers, absenteeism, productivity and retrenchments and to what extent employers are prepared to consider the integration of ergonomic principles along with health and safety procedures in their management culture to benefit both the businesses and the workforce. The instruments developed therefore needed to be robust enough to measure this wide range of objectives.

Research Instruments

Since the problem was analyzed to be simple rather than complex a simple observation tool to record observations of the activities of construction workers, in the form of a schedule, was preferred (See Appendix 2). The observation tool is designed to assist in counting the various activities and body movements against the elapsed time (*per 30 minutes*) and to record such body movements and working activities during the elapsed time.

Descriptive and analytical surveys can be used to gather opinions of the affected population (Fellows and Liu, 2003), as well as the facts and views on what happens on construction sites, as expressed by the worker cohort. The second tool used to obtain information about the well-being and experiences of construction workers was a questionnaire. The descriptive survey deals with counting of the respondents' opinions reflecting on working conditions and how it affects their bodies. The counting would be analysed later to compare or illustrate trends and the reality (Naoum, 2003).

Sampling

The nature of the research method employed, in conjunction with the population being studied, dictated the sampling strategy used. According to Babbie (2004) and Neuman (2000), the purpose of the study has a significant impact on the nature of the sample selected. In this study the population under scrutiny was defined as construction workers in the Western Cape. Given the fact that the field study is the research method chosen, a sampling strategy particularly appropriate to field study, and to the population, needed to be selected. This sampling strategy had to be balanced with the objectives of the study and the requirements for data collection.

The previous section addressed the objectives of the study in relation to the types of data required. Considering the depth of data needed for analysis, the research instrument designed required the researcher to attend and observe construction activities on site.

The sampling strategy adopted by this study was the purposive *(or judgemental)* sampling (Babbie, 2004; Neuman, 2000; Easterby-Smith, 2002). This is a non-probabilistic sampling technique that takes the samples of the population chosen for observation as being representative of the wider phenomenon being studied. Purposive sampling is appropriate in the context of this study, since the study utilizes the field study research. Babbie (2004), notes that purposive sampling is useful when it is not possible to enumerate the total population under study. There is a huge range of construction projects of varying sizes under construction in the Western Cape and since all types and sizes cannot be sampled, purposive sampling was considered the most appropriate method.

Research Limitations

A research project can be subject to potential pitfalls and problems. The intent is to address some of the likely pitfalls and problems in the circumstances reflected in this research effort.

Ethical Considerations

Integrity is fundamental to the work of scientists, scholars and professionals. It is important that throughout a research project language and materials that are oppressive or discriminatory to any group of people are avoided. There are limited ethical constraints for this research. The management and all workers of the co-operating sites that form the basis of this study, provided consent. No sites are identified in the research dissertation and there is no requirement to name individuals or groups of people who participated by responding to questionnaires or being observed while working. All participants assessed in the study were aware of their participation as groups with no individual identities.

Reliability

Reliability refers to the ability of the instrument used to produce the same answer in the same circumstances time after time. Reliability is concerned with the findings of the research and the credibility of such findings. The issue regarding reliability is, whether the evidence and conclusions stand up to the closest scrutiny. Research findings that can be repeated are reliable. Reliability means dependability or consistency, which suggests that the same thing is repeated or recurs under identical or similar conditions (Welman and Kruger, 2001). It was intended in this research to limit the range and scope of the study such that the findings would be repeatable within the context of the construction projects surveyed.

Observer Bias

Observer bias refers to consistent distortion, conscious or unconscious, in the perception or reporting of the measurement by the observer. The research instrument was designed to be as objective as possible requiring minimum input from both the researcher and the site personnel under observation. The research instrument is included in this dissertation in Appendix 5. The recording of data was as objective as possible, therefore minimizing observer bias.

Validity

Validity suggests truthfulness and refers to the way a researcher conceptualizes the idea in a conceptual definition and a measure. It refers to the way an idea fits into actual reality and to what extent the research findings accurately reflects what is really happening in the given situation. A test or effect is valid if it demonstrates or measures what the researcher thinks or claims that it does. Faulty research procedures, poor examples and inaccurate or misleading measurement can undermine validity.

Validity can be defined as the degree to which a test measures what it is supposed to measure (Wiersma, 2000). According to Leedy (1997), validity is concerned with the soundness and effectiveness of the measuring instrument. Validity is therefore the degree to which the researchers are able to prove cause and effect. The research instrument has been designed so as to obtain all the necessary information required to complete the study and for anyone wishing to use it later to be able to obtain as close as possible, similar information.

Methodological Assumptions

The purposive sample is effective in achieving a representative sample of the bricklayers, plasterers, painters and their helpers on construction projects in the Western Cape.

Closing Remarks

This chapter has discussed the methodology adopted for the conduct of this research study and has given the justification for the choice of the research instrument. The philosophical construct and position and the research design and consequent validity were highlighted. The next chapter presents and analyses the data collected from sites.

CHAPTER 4
DATA PRESENTATION AND ANALYSIS

Introduction

This chapter presents the results of observations of construction workers on sites and from questionnaires completed by construction workers on sites in the Western Cape. Results of face-to-face interviews conducted with construction workers are also presented. The trades observed included bricklaying, plastering, floor-screeding and painting. Both artisans and general workers were observed. The questionnaires and interviews were designed to establish the extent that ergonomic considerations were applied as part of health and safety practices on construction sites. The project involved included building and renovating of houses, offices and industrial complexes.

Processing of the Data

Research data were obtained using methods outlined above; in particular purposive sampling using observations and questionnaires. The Statistical Package for Social Sciences (SPSS) computer software programme was used to analyse the data. The SPSS package calculated the measures of central tendency of the respective activities / trades being investigated. This produced the required statistics including the mode, mean and median as well as the standard deviation (Blaikie, 2004). Frequency tables were used to reflect the frequency of the activities and the percentages derived from the data.

Bricklaying: Artisans

Behavioural observations of construction workers inclusive of unfavourable ergonomic practices were recorded while bricklaying was in progress on site. The nature of the bricklaying trade and the way brickwork is done, dictated that bricklayers go through a routine that revealed the ergonomics of the trade. A sample of 20 bricklayers was observed, and their body movements were counted and recorded over periods of 30 minutes.

To prepare for bricklaying, stock bricks and mortar were placed at ground floor level or on scaffold boards. To pick up the bricks, blocks or mortar, the bricklayers had to bend down to scoop up the mortar, straighten up and twist the body to lay the mortar bed. It was observed that bricklayers seldom moved their feet, preferring rather to twist their bodies to lay the mortar bed or the bricks. The next move was to return to the bending position to pick up the bricks, scoop mortar, apply mortar to the bricks and straighten up, twisting the body again to lay the bricks.

The bricklaying at the floor level often involved the bricklayers kneeling when placing the bricks. Laying of the damp-proof course also necessitated the bricklayer kneeling. In striking off the excess mortar from the opposite side of the wall being built, the bricklayer had to reach away from the body.

The second stage of the bricklaying process normally commenced after the scaffold had been erected and bricks and mortar had been placed in the position from which it would be used. Bricks, blocks and mortar were again placed on scaffold board level, essentially placing the material at the feet of the bricklayer as mentioned earlier and then following the routine described earlier. Window- and doorframes were built in as the brickwork proceeded. At the head of the window level, the concrete lintols were fitted into position.

Bricklaying: Research Process

Bricklaying: Site Observation of Artisans

A team of graduate research assistants collected data and recorded behavioural observations of the ergonomic aspects of activities on construction sites. The research assistants made observations while standing with the workers. All activities that had a potential ergonomic effect were recorded by counting the particular individual body movements of workers over periods of 30 minutes, and were recorded on an observation schedule. These movements included bending of the body, twisting of the body, manually lifting heavy materials and objects, working below knee level, working above the shoulders and reaching overhead, reaching away from the body, standing in one position to perform duties, kneeling while working and also whether hard hats and gloves were worn, and safety harnesses used. The observations were, counted, recorded and encoded for later statistical processing using the SPSS package.

Bricklaying artisans (bricklayers) were observed to bend their bodies a median 68 number of times per 30 minutes while laying bricks. Of the bricklayers observed, 100% engaged in bending of their bodies while brickwork was done. The artisans also twisted their bodies at a median 68 times per 30 minutes while lifting, and manually handling heavy materials occurred 60 times per 30 minutes (Table 4.1; Figure 4.1).

Table 4.1: Bricklaying Artisans Movements

Movement / Activity	Min	Max	Median	Range
Bending of the body	34.00	130.00	68.00	96.00
Twisting of the body	19.00	146.00	68.00	127.00
Manually lifting heavy materials / objects	14.00	106.00	60.00	92.00
Working below knee level	4.00	104.00	45.00	100.00
Working above shoulder level / overhead	2.00	76.00	14.00	74.00
Kneeling while working	2.00	50.00	12.00	48.00

Working below knee level occurred an average of 45 times per 30 minutes while kneeling, while working occurred 12 times per 30 minutes. Working above shoulder height and reaching overhead occurred 14 times per 30 minutes. Reaching away from the body occurred 36 times over the 30-minute period of observation.

Figure 4.1: Bricklaying artisan bending to scoop mortar placed at his feet on the scaffold.

The bricklayer in Figure 4.1 can be seen to have held onto the wall under construction to stabilize himself on the scaffold. The scaffold board was ± 900mm wide and was loaded with 390 mm long blocks and a mortar tray. Because of all this congestion the work platform was awkward to move on. As a result, the bricklayers further twist their bodies as they built the walls. In Figure 4.1 it can be seen that there is a gap between the scaffold board and the outer edge of the tubular frame of the scaffold with no protection rail. Both of the workers visible were not wearing any personal protection equipment (PPE).

Both bricklayers (Table 4.1) and bricklaying general workers bent their bodies while working. The bricklayers bent to scoop up mortar placed at their feet on the ground or floor or on scaffold on which they were working from. Every scoop of the trowel required the bricklayer to bend down, straighten up and turn to lay the brick / block. The twisting of the body followed every bending movement that the bricklayer made in the process of laying the bricks.

In cases where non-standard sized bricks or off cuts of bricks were needed to fill gaps, the bricklayers had to split the standard size brick or block by using either bolsters or trowels while holding the brick in one hand. It was observed that splitting of bricks with trowels is common practice in all cases where common bricks were used. In the instances where face bricks were used, mechanical means were used to cut the bricks to the required size. The practice of manually cutting bricks required further bending and twisting of the body and strained the wrists and palms of the hands.

Apart from handling bricks, bricklayers also had to position door- and window frames as well as sub-frames to form openings and place lintols over openings. The lintols were often heavy and had to be lifted by hand and the bricklaying general workers had to assist the bricklayer to place these lintols. This type of exercise required lifting and placing of the heavy elements above shoulder height. Despite the rigours of these manual work activities, 80% of bricklayers observed did not use gloves (Table 4.2) even though heavy and awkward sized materials were handled in all of the cases observed.

All bricklayers performed work above shoulder height. This was necessitated by the way brickwork stages are programmed on site. A scaffold was used when the first lift of brickwork above floor level was complete. The second lift of brickwork is above the scaffold and thereafter the bricklayers reached above their shoulders as well as away from the body to perform such brickwork in awkward positions.

Figure 4.2: Bricklayer working above shoulder height.

95% of the bricklayers observed wore safety boots. Although they were supplied with hard hats and gloves, 10% of the bricklayers did not wear hard hats and 80% did not wear gloves while handling rough materials and cement mortar. This may reflect the culture of workers not caring for their own health and safety and the culture of the organization and that of the management despite the Occupational Health and Safety Amendment Act, No. 181 of 1993.

Table 4.2: Bricklaying Artisans: PPE

Bricklayers	**Yes**	**No**	**Number/ Percent**	
Hard Hats	(90%)	(10%)	20	(100%)
Gloves	(20%)	(80%)	20	(100%)
Safety Boots	(95%)	(5%)	20	(100%)

Bricklaying: Observations / Findings

Observations revealed that brickwork above the window head height often necessitated bricklayers reaching above shoulder height. Lifting of heavy concrete lintols and other building materials such as door and window frames and the repetitive handling of bricks and especially cement building blocks placed heavy ergonomic challenges on the bodies of bricklayers. When the brickwork was below a reinforced concrete first floor slab, it was awkward to lay bricks in position in the restricted spaces. This forced bricklayers to remove their hard hats to be able to conduct work in such restricted spaces.

Bricklaying: General Workers

The bricklaying general worker's function entails assisting the bricklaying artisans. General workers are subjected to strenuous unfavourable ergonomic practices on construction sites. The general worker has to prepare the site by delivering the materials to the point where work is to be done. Bricks (or Blocks), mortar and other building materials have to be placed in close proximity to where they would be required for use by the bricklayer.

Bricklaying General Workers: Site Observations

The team of research assistants conducted the behavioural observations of the unfavourable ergonomic practices in the activities of bricklaying general workers on site. The research assistants made the observations while on site.

All actions and activities with potential ergonomic effects were recorded by counting the particular identifiable body movements. These movements included bending of the body, twisting of the body, lifting manually heavy materials and objects, working below the knee level, working above the shoulders and reaching overhead, reaching away from the body, standing in one position to perform duties, and kneeling while working. They also included whether hard hats were worn, gloves used and safety harnesses were used. The observations were carefully counted, recorded and encoded for later statistical processing using the SPSS package.

A sample of fourteen bricklaying general workers was observed, and their body movements were counted and recorded over a period of 30 minutes per activity. These were coded for processing using SPSS software.

Observations revealed that, one general worker would toss bricks to the other who caught the bricks and placed them where the bricklayer required them stacked. This exercise required that the general workers bend, pick up a brick or two simultaneously, straighten up, twist the body while tossing the brick(s) to the second general worker who caught the brick(s), twisted their / his body and bend to place the brick on a stack on the floor or on the scaffold after which they would straighten up, twist the body to face the next bricks to be tossed up to them.

Bending and twisting as and when they scooped mortar and tossed it to the pile on the scaffold above, where it was required, further affected the body of the bricklaying general worker. These actions required bending and twisting of the body, working below the knee level and above the shoulders and reaching away from the body (Table 4.3). These movements were aggravated by work done in awkward and confined spaces and in large complexes.

Part of the general workers' work involved assisting the bricklayer to lift and fit concrete lintols into position. This process required that the general worker reach away from the body and work above the shoulders and overhead. Such continuous strenuous activities also placed cumulative strain on the body. The bricklaying general workers' movements included bending and twisting of the body, lifting and manually handling heavy materials and objects, and working away from the body.

Bricklaying general workers were observed bending their bodies a median 52 number of times per 30 minutes while assisting and providing supplies for artisans. The bricklaying general workers had to bend their bodies during other routines. These included the mixing, shoveling and placing of mortar at ground or first floor level or on the scaffold where the artisan needed it. The mixing and shoveling of mortar necessitated that the general worker bend down, scoop up and toss shovels full of mortar to the scaffold above. All of the general workers observed (100%) engaged in bending of their bodies in the course of their duties. Twisting of the bodies of bricklaying general workers occurred a median 64 times per 30 minutes while the lifting and handling of heavy objects and materials occurred 37.5 times every 30 minutes (Table 4.3).

The placing of mortar and the provisioning of bricks and other materials subjected the bodies of the workers to bending and twisting of the body, lifting, working above shoulder height and reaching overhead (Table 4.3). Tossing of bricks to a second person, at a level above also placed heavy demands on the bodies of general workers.

Table 4.3: Bricklaying General Workers Movements

Movement / Activity	**Median**	**Min**	**Max**	**Range**
Bending of the body	52.00	10.00	114.00	104.00
Twisting of the body	64.00	23.00	152.00	129.00
Manually lifting heavy materials / objects	37.50	10.00	114.00	104.00
Working below knee level	28.00	8.00	120.00	102.00
Working above shoulder level / overhead	55.00	10.00	120.00	110.00
Kneeling while working	28.00	2.00	44.00	42.00
Reaching away from the body	20.00	4.00	104.00	100.00

Bricklaying general workers bent their bodies a median 52 times per 30 minutes and twisted their bodies 64 times per 30 minutes. Lifting and handling of heavy and awkwardly shaped materials occurred 37.5 times per 30 minutes (Table 4.3). Working below the knee occurred 28 times per 30 minutes and kneeling while working occurred 28.00 times per 30 minutes.

General workers worked above shoulder height and reached overhead 55 times in 30 minutes. They worked below knee level 28 times in 30 minutes and kneeled while doing work 28 times in 30 minutes. They reached away from the body 20 times in 30 minutes (Table 4.3). Only 42.9% of bricklaying general workers wore gloves (Table 4.4). All bricklaying general workers wore safety boots and 85.7% wore hard hats.

Table 4.4: Bricklaying General Workers: PPE

Bricklayers	**Yes**		**No**		**Number / Percent**	
Hard Hats	12	(85.7%)	3	(14.3%)	14	(100%)
Gloves	6	(42.9%)	8	(57.1%)	14	(100%)
Safety Boots	14	(100%)	Nil	(0%)	14	(100%)

Brickwork was normally done in a standing position. The bricklayer finished one section of the wall before moving to the next. The general workers, however, had to walk around to collect and place the required materials wherever they were required and thus did not necessarily remain in the same position while performing their duties. After the brick walls had been erected, the scaffolds were usually left in position for the plastering stages.

Plastering: Artisans

Plastering is a labour intensive trade that requires skilled tradesmen. Plastering was normally commenced at the upper level and continued downwards. This practice was preferred as the scaffolds were usually in place after the brickwork was completed.

Plastering general workers mixed the cement mortar and shoveled it to the required level. The batches of mortar were tossed up to the plasterer who caught the mortar on the mortarboard and turned the body ± 90° to apply the mortar to the wall surface. This exercise occurred at ground or floor level as well as on scaffolds. Where tower cranes or hoists were used, the mortar was hoisted up to the required level and then conveyed by wheelbarrows.

The catching of mortar on mortarboards placed continuous strain on the wrists of plasterers. It is common practice in the industry that assistants toss workable portions of mortar to be caught on the mortarboard by the plasterers. The reason given by the workers for this practice is that it accelerates the plastering process. Plaster was pasted onto the rough brick / block wall surface until a large enough area was covered. Then the covered portion / section was screeded using a straight edge. To obtain a smooth texture, steel floats were used (Figure 4.4).

The second phase of the plastering process involved the 'dragging' of a 'straight edge' to smoothen the wall surface. This process required both bending and twisting of the body. Plastering was therefore demanding on the human body as the plasterers were kept in constant motion as they stroke off excess mortar during the finishing process. Whilst all this movement occurred the plasterer also had to reach above shoulder level and at times had to kneel to finish the lower parts of walls requiring work below the knee. Plastering of the lower level of the wall commenced as soon as the scaffold was removed.

Because plastering is a wet trade the surface was largely damp. When asked if the process did involve getting wet on their knees, the plasterers responded by saying that they accepted the practice as an occupational hazard. However, they used knee guards / pads to ease the pain and provide protection. Plastering required reaching away from and twisting of the body.

Plastering: Observations

Research assistants observed sixteen plasterers in 30-minute intervals in the process of plastering brick walls. The observations focused on the ergonomic activities affecting the bodies of the workers. The activities involved bending and twisting of the body (Figure 4.4), lifting and manually handling of materials and objects, working above shoulder height and reaching overhead (Figure 4.3), working below knee level, reaching away from the body and working when kneeling. Assistants also observed incidents of use of personal protection equipment to improve construction health and safety.

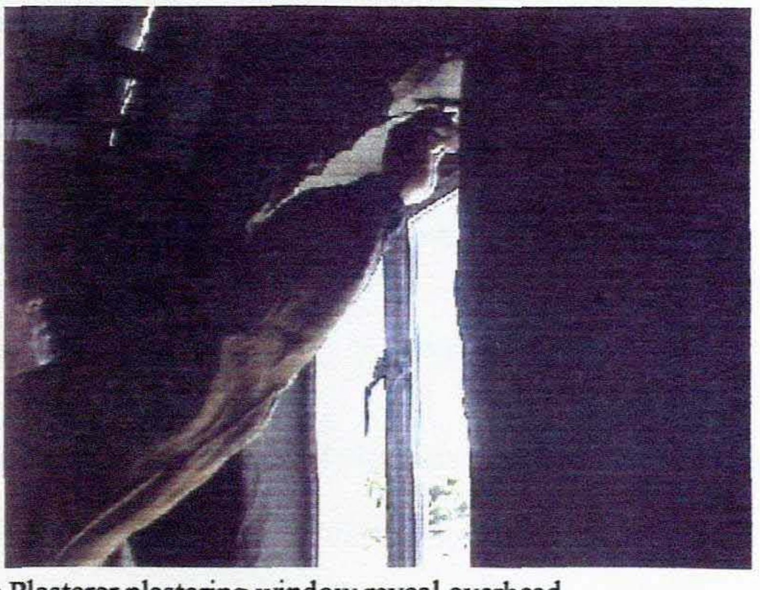

Figure 4.3: Plasterer plastering window reveal overhead

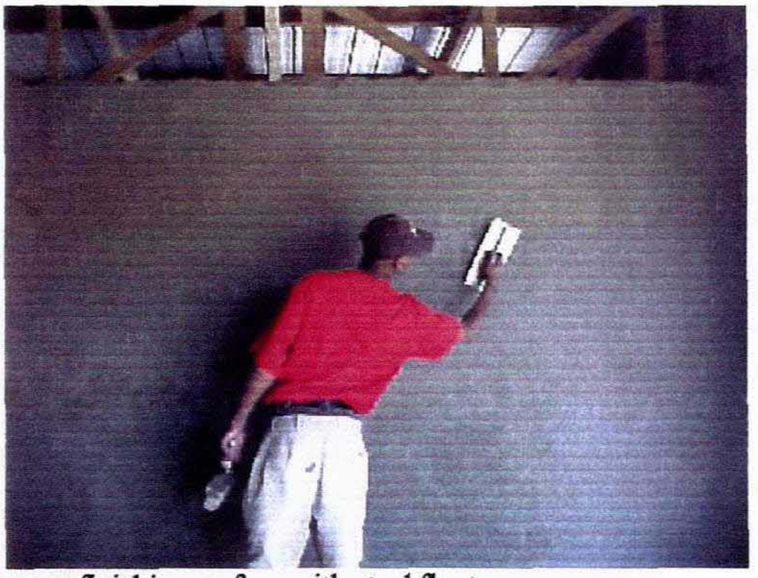

Figure 4.4: Plasterer finishing surface with steel float

Table 4.5: Plastering Artisan: Body Movements / Activities

Body Movement / Activity	Median	Min	Max	Range
Bending of the body	57.0000	40.00	92,00	52.00
Twisting of the body	69.0000	14.00	120.00	106.00
Manually lifting heavy materials / objects	37.0000	21.00	80.00	59.00
Working below knee level	16.0000	1.00	50.00	49.00
Working above shoulder level / overhead	40,0000	1.00	8.00	7.00
Reaching away from the body	32.0000	2.00	60.00	58.00

The observations showed that plasterers subjected their bodies to bending and twisting 57 times in 30 minutes. Plasterers also twisted their bodies 69 times in 30 minutes and lifted and manually handled heavy objects a median 37 counts in 30 minutes.

Plasterers worked above shoulder height and reached overhead a median 40 count in 30 minutes.

Plastering below knee level occurred 16 times in 30 minutes and kneeling while working occurred 42 times in 30 minutes. Reaching away from the body occurred 32 times in 30 minutes (Table 4.5).

Table 4.6: Plastering Artisan: PPE

Plastering Artisan	Yes		No		Number/ Percent	
Hard hats	16	(100%)	Nil	(0%)	16	(100%)
Gloves	10	(62.5%)	6	(37.5%)	16	(100%)
Safety boots	16	(100%)	Nil	(0%)	16	(100%)
Safety harness	16	(100%)	Nil	(0%)	16	(100%)

All plasterers were issued with gloves but only 62.5% of them used them during their work process (Table 4.6). All plasterers wore hard hats, harnesses and safety boots.

In order for plasterers to execute their work effectively, the plastering general workers assisted them. Every aspect of the functioning of the plasterers required input from the plastering general workers.

Plastering: General Workers

Plastering general workers performed a number of physical activities to support the plasterers. These included placing materials and tools at hand for plasterers to do the plastering and floor screeding. The general workers were exposed to ergonomically unfavourable activities such as bending of the body, twisting of the body, lifting / manual handling of heavy materials / objects that affect their bodies (Table 4.7).

Research assistants observed fourteen plastering general workers conducting work on site. These workers twisted their bodies a total of 66 times in 30 minutes.

Table 4.7: Plastering General Worker: Body Movements / Activities

Body Movement / Activity	Median	Min	Max	Range
Bending of the body	55.50	32.00	126.00	94.00
Twisting of the body	66.00	24.00	126.00	102.00
Manually lifting heavy materials / objects	46.00	19.00	126.00	107.00
Working below knee level	36.00	1.00	76.00	75.00
Working above shoulder level / overhead	36.00	28.00	60.00	32.00
Reaching away from the body	32.00	2.00	56.00	54.00

The data collected further revealed that general workers did work above shoulder height and overhead a median 36 times in 30 minutes. Working below the knee level occurred 36 times in 30 minutes (Table 4.7).

General workers, when placing mortar where the plasterer requires it, had to shovel it into position. When the plastering was done in an elevated position, the general worker shoveled the mortar and tossed small batches from below to be caught above by the plasterers using mortarboards. These motions subjected the general workers bodies to bending and twisting and straining movements to their wrists and palms. Shoveling necessitated work below knee level while the tossing of mortar resulted in reaching away from the body.

The data reveals that plastering general workers bent their bodies 55.5 times in 30 minutes and twisted their bodies 66 times in 30 minutes. The same workers lifted and manually handled heavy materials 46 times in 30 minutes. Plastering general workers also worked below knee level was found to effect plastering general workers 36 times in 30 minutes. They reached away from the body 32 times in 30 minutes (Table 4.7).

Table 4.8: Plastering General Workers: PPE

Plastering General Workers	**Yes**		**No**		**Number / Percent**	
Hard Hats	13	(92.9%)	1	(7.1%)	14	(100 %)
Gloves	9	(64.3%)	5	(35.7%)	14	(100%)
Safety Boots	14	(100%)	NIL	(0%)	14	(100%)

The majority of workers observed wore hard hats (92.9%). All workers observed wore safety boots. Gloves were worn by 64% of the workers observed.

Plastering workers were observed working in parts of the construction environment free of other trade activities and in such cases some of the personal protective equipment was not used.

Painting: Artisans

The research assistants also observed painting activity on site. It was noted that painting activities required painters to move continually while undertaking their work.

Painting was done while standing at ground or floor level as well as in elevated positions. In the standing position, the painters' bodies were subjected to various unfavourable movements. Because painting was done with brushes, the trade affects the palms of the hand and the wrist over time. The application of paint by roller on larger areas allowed easier movement of the hand, wrist and the arm. All awkward corners and niches had to be painted with brushes, as there was need for accuracy.

The next stage that the painters engaged in was the use of ladders or elevated platforms to reach the elevated surfaces of the facade. Ladders remain the most commonly used aid for reaching upper portions of walls. Painting involved unfavourable ergonomic practices of bending and twisting of the body, working below knee level, working in awkward positions, working above shoulder height, reaching overhead and reaching away from the body. Sanding and scraping of surfaces in preparation for the application of paint to such surfaces had a similar impact on the painter as the painters were forced into the same awkward positions.

Observation of Painting Artisans

The team of research assistants collected data and recorded the behavioural observations of the ergonomic aspects of the activities of painting artisans on construction sites. Activities that could have an ergonomic effect on the workers were recorded by counting the particular body movements of the workers over periods of 30 minutes. A sample of seven painters was observed and their body movements were counted and recorded over 30 minutes intervals. At various stages of the painting process, the ergonomic practices were observed, and recorded for later statistical processing using the SPSS package (Tables 4.9).

Table 4.9: Painting Artisans Movements

Movement / Activities	Median	Min	Max	Range
Bending of the body	42.00	20.00	108.00	88.00
Twisting of the body	52.00	20.00	138.00	118.00
Manually lifting heavy materials and objects	60.00	14.00	102.00	88.00
Working below knee level	38.00	6.00	124.00	118.00
Working above shoulders and reaching overhead	43.00	10.00	108.00	74. 00
Kneeling while working	38.00	1.00	124.00	79.00
Reaching away from the body	40.00	1.00	86.00	85.00

Working above shoulder height and reaching overhead formed part of the activities / body movements of painters. Where rollers are used for painting, it was observed that painters increasingly used extension handles that helped to minimize the overhead reach. Where brushes were used especially in awkward positions such as corners, cornices, soffits or ceilings, it was necessary for painters to work overhead. From discussions with painters, it was evident that painters welcomed the extended handles.

The painting artisans (painters) were observed bending their bodies a median 42 times in 30 minutes. Twisting of the body was observed, occurring a median 52 times in 30 minutes. Lifting and manually handling of materials and equipment occurred a median

60 counts in 30 minutes. Working below the knee was observed a median 38 counts per 30 minutes. Reaching away from the body occurred a median 40 counts in 30 minutes (Table 4.9).

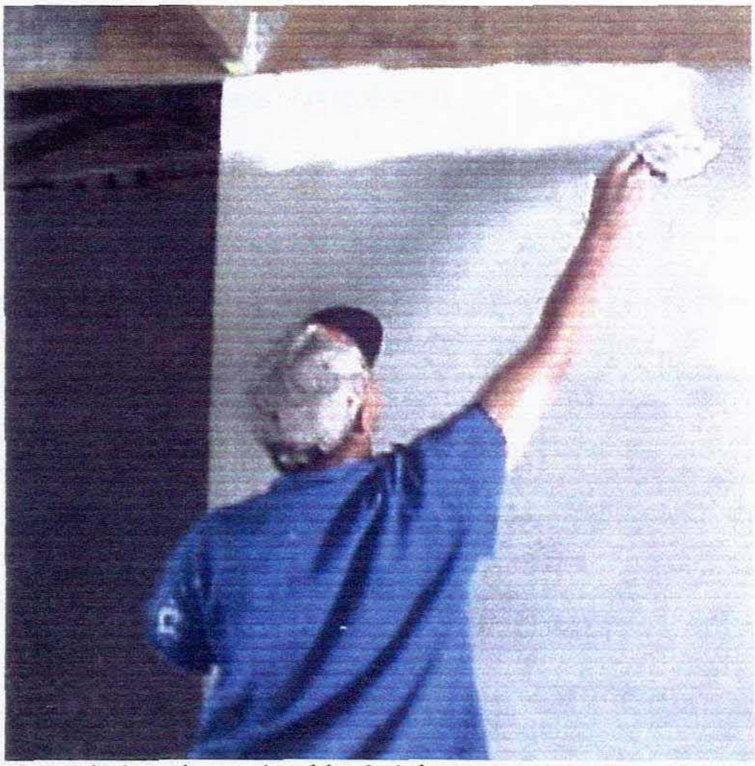

Figure 4.5: Painter painting above shoulder height

Reaching above shoulder height and overhead occurred a median 10 counts in 30 minutes. Working above the shoulder and reaching overhead was not done in isolation but in conjunction with other movements and activities such as standing on ladders and other typical movements made during the painting process.

Painting is done standing at ground or floor level and in elevated positions. The use of ladders allowed painters to climb higher up and thus, reduce the amount of working above shoulders and overhead.

Painting: General Workers

Painters need assistance from painting general workers in order to achieve optimum production levels. Research assistants recorded the behavioural observations of painting general workers, inclusive of the unfavourable ergonomic practices, movements and activities while the work process was underway.

Painting general workers assisted painters, position ladders and platforms that had to be erected. Painting general workers are affected by ergonomic practices of bending and twisting of the body, working below the knee level, working in awkward positions, working above shoulder height, reaching overhead and reaching away from the body. Sanding and scraping of surfaces in preparation for the application of paint to such surfaces had a similar impact on the painting general worker, since both were forced into the same awkward positions as demanded by the painting process.

Observation of Painting General Workers

The team of research assistants collected data and recorded the behavioural observations of the ergonomic aspects of the activities of painting general workers on construction sites. Activities that could have an ergonomic effect on the workers were recorded by counting the particular body movements of the workers over periods of 30 minutes. A sample of three painting general workers was observed and their body movements were counted and recorded over a period of 30 minutes per activity. At various stages of the painting process, the ergonomic practices were observed, and recorded for later statistical processing using the SPSS package (Tables 4.10).

Table 4.10: Painting General Workers - Numbers of Body Movements

Body Movement / Activities	Median	Min	Max	Range
Bending of the body	50.00	40.00	60.00	20.00
Twisting of the body	50.00	40.00	60.00	20.00
Manually lifting heavy materials and objects	10.00	10.00	20.00	10.00
Working below knee level	20.00	20.00	20.00	0.00
Working above the shoulders and reaching overhead	35.00	30.00	40.00	10.00
Reaching away from the body	10.00	2.00	10.00	8.00

The workers bent their bodies an average of 50 times in 30 minutes.

They twisted their bodies frequently working from ladders. The twisting of the bodies occurred 50 times in 30 minutes. Painting general workers also lifted materials and reached overhead a median of 10 times in 30 minutes (Table 4.10).

The nature of the trade of painting is such that some of the work below the knees forces the painters to bend their bodies and occurs below the knee and thereby necessitating some kneeling to conduct some work. Work below the knees occurred 20 times in 30 minutes during the observation period.

Working above the shoulder height and reaching overhead formed a substantial part of the activities / body movements of general workers. Painting general workers reached above shoulder height and overhead an average of 35 times in 30 minutes (Table 4.10). They used ladders to access areas high up and thus, reduce the amount of work done above the shoulders and overhead. The workers reached away from the body frequently during painting. Work while reaching away from the body occurred 10 times in 30 minutes (Table 4.10).

Interviews

Introduction

The second research process used a questionnaire that was used to record interviews with construction workers to obtain responses from both the workers' cohort and the employers. The data obtained from the interviewees and the responses to the questionnaires were required to ascertain the effect of the unfavourable ergonomic practices in the construction industry in general and the effect on the workers in particular. It was anticipated that the responses by the workers, to the questionnaire, would reflect on the various ergonomic practices and interventions put in place to enhance the overall health and safety performance of the construction firms.

Some of the questions sought to obtain data on health conditions in the construction industry including backache, sore muscles and joints, hand and palm pains, shoulder pains, knee pains, skin problems, breathing problems, lung infections (coughing), headaches and eyesight problems (vision). The responses were captured and encoded using the Statistical Package for Social Sciences (SPSS).

Analysis of Responses

40% of the respondents had attended an induction session dealing with occupational health and safety (OH&S) on construction sites. 52% of the respondents had not received OH&S induction, on construction sites. The balance was not sure as to whether they had undergone some induction process.

Site Environment Occupational Health and Safety

As regards whether the construction site environment is unsafe, 47.3% thought it was not, while 27.3% were not sure whether construction sites present a health risk to workers. The balance regarded the construction site environment as safe.

Occupational Health: Bending the Body

It is evident from the data and the overall occurrence of 91.9%, that the majority of construction workers bend their bodies during the work process. 46.4% of the respondents are heavily subjected to bending at work while 30.4% of the respondents moderately bend their bodies while working and 10.7% of the workers seldom bend their bodies while at work. The work of the remaining 8.9% of the workers is of such a nature that they do not bend their bodies in the course of their duties (Table 4.9; 4.10).

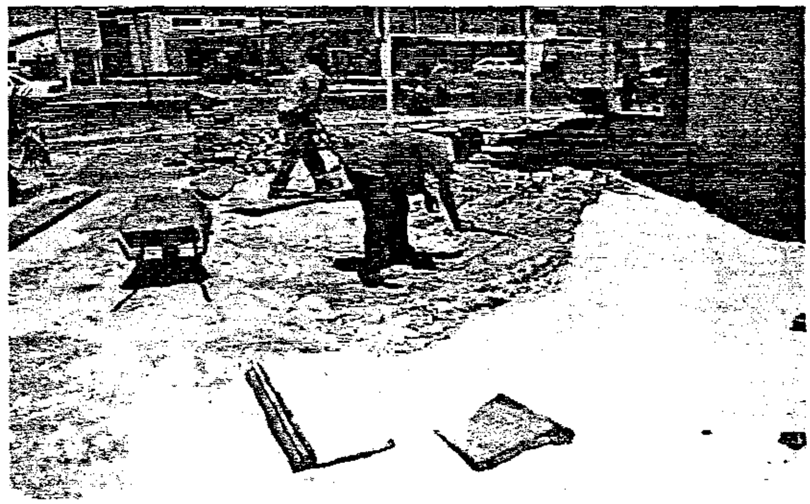

Figure 4.6: All facets of construction require bending of the body

Table 4.11: Frequency of Bending the Body

Bending of the body	Frequency	Percent
Never	5	8.9
Seldom	2	3.6
Sometimes	6	10.7
Often	17	30.4
Always	26	46.4
TOTAL	56	100.0

Occupational Health: Lifting and Manual Handling of Materials

91.1% of the workers lifted and manually handled materials. Of the respondents interviewed, 44.6% were very frequently subjected to manually lifting and handling materials and equipment while at work. A further 26.8% of the respondents were moderately subjected to lifting of materials. 14.3% of the respondents sparingly lifted materials while 5.4% seldom lifted materials. 8.9% of the respondents stated that they hardly / did not lift any thing on building sites.

Occupational Health and Toolbox Talks

Occupational health toolbox talks address health aspects of construction activities. 49% of respondents did not gain exposure to OH&S measures through toolbox talks while 5.9% were unsure whether they have been exposed to toolbox talks. 54.9% of the workers were not effectively prepared by toolbox talks to face the challenges of OH&S on construction sites. The remaining 45.1% of the workers who responded were aware of what toolbox talks are or had been afforded the opportunity to learn from such instruction in OH&S on sites. 50% of the respondents had undertaken OH&S training designed to prevent injury to workers while working on construction sites. 44.2% did not benefit from such OH&S training while the remaining 5.8% were unsure as to whether they had received such training.

Reaching Away from the Body

92.5% of the workers performed work that required reaching away from their bodies. Those who frequently reached away from the body accounted for 22.6% of the workers. 17% of the respondents regularly reached away from the body, while 32.9% sparingly reached away from their bodies. 20.8% seldom reached away from the body and the balance did not reach away from the body during work. 23.6% of the respondents reached overhead. Of those workers who did, 14.5% frequently reach overhead while 16.4% of respondents sparingly reached overhead and 27.3% seldom reached overhead. The balance 18.2% did not need to reach overhead in the execution of their duties. Of all the respondents, 81.8% were reaching overhead in the course of their duties.

Working below Knee Level

It was observed that 78.2% of the workers worked below knee level. 25.5% of the respondents claimed that they frequently worked below the knee. 23.6% moderately worked below the knee while 21.8% sparingly worked below the knee. 7.3% did hardly any work below the knee, and 21.8% did not need to work below the knee.

Standing While Working

The majority of workers in the construction industry stand while doing their work while 67.9% frequently stand while doing their work and 17.9% often worked while standing. 8.9% sparingly stand while working while 1.8% seldom stands while working. In essence, 96.4% perform their work while standing. The balance does not have to stand to perform their duties.

Twisting the Body

Twisting of the body is a common occurrence in the construction industry where 39.3% of workers do twist their bodies while working and 14.3% often twist their bodies while at work. 17.9% seldom twist their bodies while 14.3% do not have to twist their bodies.

Work in Awkward Positions

Some construction work subjects workers to work in awkward positions. 23.6% of the workforce very frequently works in awkward positions. 30.9% seldom work in awkward working conditions while the remaining 12.7% are not required to work in awkward positions.

Workers' Response

The extent to which construction workers health is affected by ergonomic related problems can be seen in the data collected in this research.

From the responses it emerged that:

- 50% of workers believe that construction work has not affected their physical health. Of the remaining 50%, 48.3% suggested that construction activity did cause health problems while 1.7% were unsure as to whether construction activities contribute to health problems.

- Backache appeared to be the highest of all ailments suffered by construction workers. The prevalence of backache was in 71.9% of the workers. 28.1% of the workers felt that construction activities did not affect their physical well-being.

- Sore muscles and joints were identified by 64.5% of the workers as resulting from construction activities. 32.3% of workers did not feel that construction affect the physical health of the workers.

- Hand and palm pains could originate from a number of activities; including the use of tools and not wearing protective gear such as gloves, provided on sites. Pain of the hand and palm had affected 36.7% of the workers while 20% were unsure whether they were affected. 43% of the workers did not experience any health problems as a result of construction activities. The various construction activities involving tools such as trowels chisels and heavy power tools, physically affects all the workers engaged in such construction work.

- 27.6% of workers experienced wrist pain resulting from performance of construction work. 55.2% of the workers did not belief that construction activities played a role in the development of wrist pains.

- Shoulder pain ranked high (53.3%) among workers who felt that these resulted from construction activities. 3.3% were unsure whether construction activities caused shoulder pain while 43.3% of the workers did not associate shoulder pain with construction activities.

- 33.3% of the workers associated knee pain with construction activities. However, 53.3% of the workers did not link knee problems with construction. 13.3% of the workers were not sure whether working on knees had any effect on their knees.

Closing Remarks

Through observations and the responses to the questionnaires used in the interviews, it was reasonably confirmed that unfavourable ergonomic practices affecting the health and well-being of construction workers are prevalent in the construction industry as described in this chapter. The data will be interpreted in the following chapter.

CHAPTER FIVE

DATA INTERPRETATION

Introduction

Ergonomics is commonly believed to contribute to the social goals of an organization by the protection of the health of workers and the achievement of economic goals in terms of productivity and quality (Koningsveld et al., 2003). Workers in the construction industry are subjected to immense pressure and undertake heavy physical activities, workloads and work stress (van der Molen, 2005).

Bricklaying: Artisans

The following paragraphs provide an illustration of the pressures and workloads of construction work. Of all the trades, bricklaying imposes more bending and twisting of the body. Taking the practical lifespan of bricklayers to be 20 years, and holding other things constant, it can be extrapolated that bricklayers subject their bodies to 5,146,240 counts of bending and twisting of the body during their practical working life (Table 5.1).

In the same vein, lifting and manual handling of heavy materials and overhead work can be extrapolated to 4,540,800 incidences in the working life of a bricklayer (Table 5.1). The commonly used stock brick measuring 222mm x 106mm x 73mm, has a mass of ± 3,5kg. Bricklayers in The Netherlands, lays approximately 800 to 1000 bricks per day (van der Molen, 2005). In South Africa, the construction industry estimate, established by rule of thumb, is 550 bricks per day. It can thus be extrapolated that a bricklayer lifts 1,925kg per day, which translates to 9,240,000kg (9,240 ton) over a 20-year working life (Table 5.2). Being the third highest count of physical activity affecting the bricklayers' bodies, it can be assumed that lifting of bricks will have similar negative effects on a tradesman's body over their working life time.

Table 5.1: Bricklaying Artisans: Numbers of Body Movements

Activity / Body Movement	**Median Value**	**Period**					
		/ hr	**/ day**	**/ week**	**/ month**	**/ year[3]**	**/ life++**
		***2**	***8**	***5**	***4.3**	***11**	***20**
Bending of the body	68	136	1,088	5,440	23,392	257,312	5,146,240
Twisting of the body	68	136	1,088	5,440	23,392	257,312	5,146,240
Manually lifting heavy materials / overhead	60	120	960	4800	20640	227,040	4,540,800
Working below knee level	45	90	720	3,600	15,480	170,280	3,405,600
Working above shoulder / overhead	14	28	224	1,120	4,816	52,976	1,059,520
Kneeling while working	12	24	192	960	4,128	45,408	908,160

++ 20 Years assumed to be a working life.

[3] *One year (11 Months work +1 Month annual leave).*

Working below knee level, which by its nature infers that work is executed while the body is in a bent position has a significant effect on the lower torso, the legs in particular. When the data collected is extrapolated over the working lifespan of a bricklayer, they work on average 3,715,200 times below the knees. This ergonomic activity can also be assumed to have a negative effect the artisan's body at the end of the working life.

Table 5.2: Bricklaying Artisans: Lifting of Bricks

Bricklayer	Handling / lifting bricks			
	@ 550 Bricks per Artisan per Day	Per Week	Per Year	/ Life[1]
	*3.5	*5	*48	*20
Mass / kg	1,925kg	9,625kg	462,000kg	9,240,000kg

[1] 20 years work lifespan

Working above shoulder height and overhead can be calculated to occur on average 1,155,840 times during the working life of a bricklayer. The physical strain on the body repeated over prolonged periods can be presumed to have a negative effect on the artisan's body at the end of their working life.

Kneeling while working is frequently necessary to do work at floor level and in awkward spaces where the floor to ceiling height is limited. The incidence of kneeling in brickwork escalated to reflect the repetition over a twenty-year work period can be estimated to be 990,720 times. The cumulative effect of kneeling and other activities the bricklayers' bodies are subjected to, must be detrimental to the workers. The enormity of these effects on the workers' bodies if viewed in isolation will not initially be evident and may be overlooked.

Bricklaying: General Workers

The incidence of bending and twisting of the body of bricklaying general workers was found to be high (Table 5.3). Considering the nature of the tasks that bricklaying general workers perform and their practical working lifespan of the workers of 20 years, it can be extrapolated that bricklaying general workers subject their bodies to 3,935,360 counts of bending and 4,843,520 counts of twisting of the body during their practical working life (Table 5.3).

Table 5.3: Numbers of Body Movements

Activity / Body Movement	Median Value	Period					
		/ hr	/ day	/ week	/ month	/ year[3]	/ life++
		*2	*8	*5	*4.3	*11	*20
Bending of the body	52	104	832	4.160	17,888	196,768	3,935.360
Twisting of the body	64	128	1.024	5.120	22,016	242,176	4,843,520
Manually lifting heavy materials / overhead	37.5	75	600	3,000	12,900	141,900	2,838,000
Working below knee level	28	56	448	2240	9,632	105,952	2,119,040
Working above shoulder / Overhead	55	110	880	4,400	18,920	208,120	4,162,400
Kneeling while working	28	56	448	2240	9,632	105,952	2,119,040

++ 20 Years assumed to be a working life.
[3] One year (11 Months work +1 Month annual leave).

Working above shoulder level and reaching overhead was observed to be 55 counts per 30 minutes, which can be extrapolated to 4,162,400 over the working lifespan of the bricklaying general workers.

In line with bricklayers, bricklaying general workers handle approximately 550 bricks per day. It can thus also be extrapolated that a bricklaying general worker lifts 1.925 kg of bricks per day, which translates to 9,240,000kg (15.24 tons) over a 20-year practical working lifespan (Refer Table 5.4).

Table 5.4.1: Lifting of Bricks

Bricklaying General Worker	Handling / lifting bricks			
	@ 550 BricksPer Day	Per Week	Per Year	/ Life[1]
	*3.5	*5	*48	*20
Mass / kg	1,925	9,625	462,000	9,240,000

[1] 20 years work lifespan

In some instances it is required of one general worker to assist two artisans in the daily routine. In the event where the 2:1 ratio of two artisans to one general worker occurs, the amount of lifting required of the general workers is therefore doubled. Being the third highest count of physical activity affecting the general workers' body, it can be assumed that lifting of bricks has an adverse effect on the bodies of general workers over time. Working below knee level, which forces the workers to bend while executing work, which will have a detrimental long-term effect on the lower torso and especially on the legs. The data collected, when extrapolated, reveals that the general worker would on average have executed this ergonomic practice of working below knee level 2,119,040 times over the practical working lifespan.

Working above shoulder height and overhead frequently occurs amongst the tasks of the general worker. The occurrence of work above shoulder and overhead activities can be extrapolated to be 4,162, 400 times collectively over the duration of the working lifespan of general workers (Table: 5.3).

Kneeling while working is frequently necessary to do work at floor level. The incidence of kneeling by general workers, escalated to reflect the repetition over the working lifespan would be 2,119,040 times. The cumulative effect of this activity would be equally detrimental to the workers' bodies.

Table 5.4.2: Bricklaying General Workers Use of Gloves

Bricklaying General Workers	Gloves		
	Frequency	Valid Percent	Cumulative Percent
Yes	6	42.9	42.9
No	8	57.1	100.0
Total	14	100.0	

Observations revealed that only 42.9% of bricklaying general workers wore gloves, despite the rough work and handling cementatious materials (Table 5.4).

Table 5.5: Plastering Artisans – Number of Body Movements

Activity / Body Movement	Median Value	Period					
		/ hr	/ day	/ week	/ month	/ year[3]	/ life++
		*2	*8	*5	*4.3	*11	*20
Bending of the body	57	114	912	4,560	19,608	215,688	4,313,760
Twisting of the body	69	138	1,104	5,520	23,736	261,096	5,221,920
Manually lifting heavy materials / overhead	37	74	592	2,960	12,728	140,008	2,800,160
Working below knee level	16	32	256	1,280	5,504	60,544	1,210,880
Working above shoulder / overhead	40	80	640	3,200	13,760	151,360	3,027,200
Kneeling while working	42	84	672	3,360	14,448	158.928	3,178,560
Reaching away from body	32	64	512	2,560	11,008	121,088	2,421,760

++ 20 Years assumed to be a working life.

[3] One year (11 Months work +1 Month annual leave).

Plastering: Artisans

Plastering work continuously exposes the workers to bending and twisting of their bodies (Table 5.5). Considering the body movements connected to this activity, and the effect that bending has on the plasterers' bodies over their working lifespan, it can be extrapolated that plasterers bend their bodies 4,313,760 times over their working lifespan. Twisting of the bodies occurs 5,221,920 times if extrapolated over the working lifespan. Lifting and manual handling of materials and the lifting of mortar and the application thereof overhead would have a negative cumulative effect on the body of the tradesman over the working lifespan of the plasterer. Lifting, over the lifespan of the plasterer would occur 2,800.160 times while working above the shoulder can be extrapolated to be 3,027,200 times.

As plastering work is done higher up, as well as below the knee level, the effect will be considerable on the long term. Working below the knee translated to a lifespan, total of 1,210,880 times. Kneeling while working such as laying of screeds and plastering at the lower levels of walls can be extrapolated to 3,178,560 times in the working life of plasterers (Table 5.5).

Reaching away from the body occurs frequently in the plastering process. Reaching away from the body occurs when trying to apply mortar or stretching to widen the area covered while remaining in one area. This activity occurs frequently during floor screeding, and also in striking the mortar to the desired wall texture. Such activities over the practical working lifespan of the plasterer would occur 2,421,760 times.

The cumulative effect of the movements and activities of plasterers may initially not be evident but can be estimated to be detrimental.

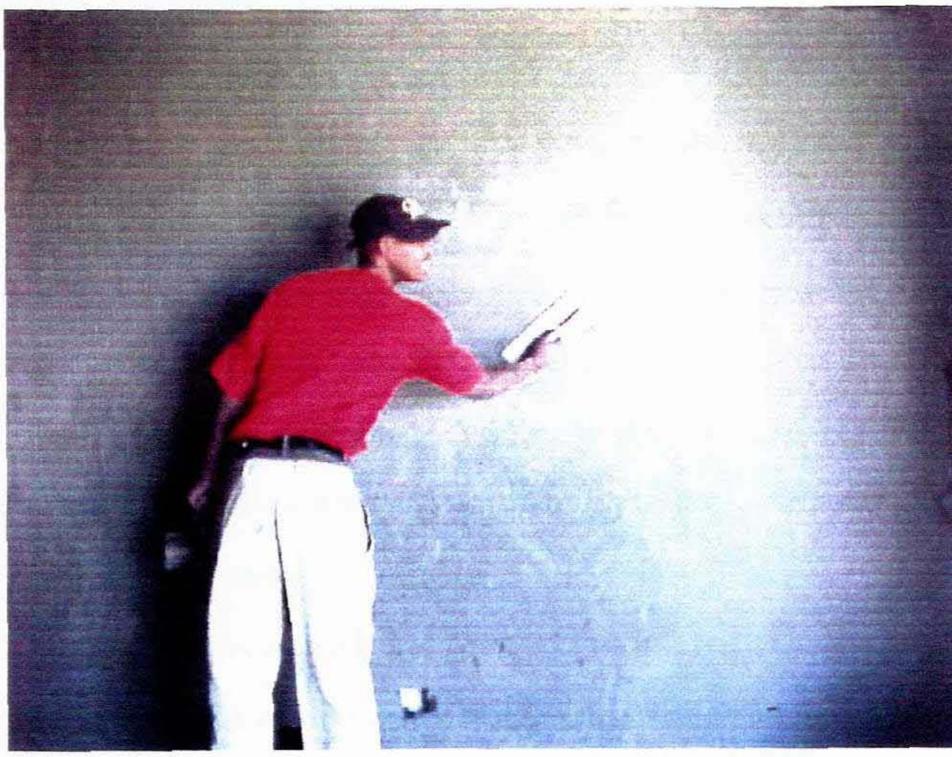

Figure 5.1: Plasterer: Reaching away from normal stance, bending, stretching and straining the wrists

Plastering: General Workers

Table 5.6: Plastering General Workers: Numbers of Body Movements

Activity / Body Movement	Median Value	Period					
		/ hr	/ day	/ week	/ month	/ year[3]	/ life++
		*2	*8	*5	*4.3	*11	*20
Bending of the body	55.5	111	888	4,440	19,092	210,012	4,200,240
Twisting of the body	66	132	1,056	5,280	22,704	249,744	4,994,880
Manually lifting heavy materials / overhead	46	92	736	3,680	15,824	174.064	3,481,280
Working below knee level	36	72	576	2,880	12,384	136.224	2,724,480
Working above shoulder / Overhead	36	72	576	2,880	12,384	136,224	2,724,480

++ 20 Years assumed to be a working life.

[3] One year (11 Months work +1 Month annual leave).

The cumulative effect of the repetitive activities on plastering general workers may also not initially be evident. Working above the shoulder and reaching overhead is common due to the nature of the trade. The eventual effect when extrapolated over the practical working lifespan of the worker can be substantial. Bending of the body was recorded to occur 55.5 times in 30 minutes (Table 5.6). Extrapolated over a 20 years working lifespan, gives a total of 4,200,240 times of bending of the body. Twisting of the body would occur 4,994,880 times over the working lifespan of a plastering general worker. Manually lifting heavy materials overhead would accumulate to a 3,481,280 times within the same period. Working below knee level and working above shoulder height and overhead, both amounts of 2,724,480 counts occurring (Table 5.6) over a working lifespan of 20 years.

The number of incidences extrapolated from the data is significant and reflect the enormous cumulative effect of the repetitive movements that the bodies of the plasterers subjected to over the working lifespan.

Painting: Artisans

Table 5.7: Painting Artisans: Numbers of Body Movements

Activity / Body Movement	Median Value	Period					
		/ hr	/ day	/ week	/ month	/ year[3]	/ life++
		*2	*8	*5	*4.3	*11	*20
Bending of the body	42	84	672	3,360	14,448	158,928	3,178,560
Twisting of the body	52	104	832	4,160	17,888	196,768	3,935,360
Lifting manually handling materials / overhead	60	120	960	4800	20640	227,040	4,540,800
Working below knee level	38	76	608	3,040	13,072	143,792	2,875,840
Working above shoulder / overhead	43	86	688	3,440	14,792	162,712	3,254,240
Kneeling while working	38	76	608	3,040	13,072	143,792	2,875,840
Reaching away from the body	40	80	640	3,200	13,760	151,360	3,027,200

++ 20 Years assumed to be a working life.

[3] One year (11 Months work +1 Month annual leave).

By the very nature of the painting process, the body of the painter will presumably over the duration of his practical working life be subjected to unfavorable ergonomic practices. Bending of the body occurred on average 42 times per 30 minutes. The body of the painter will presumably over the duration of his practical working life, be subjected to 3,178,560 times bending (Table 5.7).

Twisting of the body was occurring at 52 times per 30 minutes, can be extrapolated to 3,935,560 times during their working life. Manual lifting of materials and reaching overhead would occur 4,540,800 times during their working life. Meanwhile working below knee level and kneeling would occur 2,875,840 times over the working lifespan. Reaching away from the body would occur 3,027,200 times (Table 5.7) during the same period.

Painting: General Workers

Bending of the body was observed to occur on average 50 times in 30 minutes. By the very nature of the painting process, the body of the painting general workers will presumably over the duration of his practical working life, assumed to be 20 years, be subjected to 3,784,000 counts of bending of the body (Table 5.8).

Twisting of the body would occur 3,784,000 times over the same period. The manually lifting materials and reaching overhead would occur 756,800 times and working below the knee level and kneeling while working would extrapolate to 1,513,600 times over the working lifespan. Reaching away from the body would occur 756,800 times.

Table 5.8: Painting General Workers: Numbers of Body Movements

Activity / Body Movement	Median Value	Period					
		/ hr	/ day	/ week	/ month	/ year[3]	/ life++
		*2	*8	*5	*4.3	*11	*20
Bending of the body	50	100	800	4,000	17,200	189,200	3,784,000
Twisting of the body	50	100	800	4,000	17,200	189,200	3,784,000
Manually lifting / handling materials / overhead	10	20	160	800	3,440	37,840	756,800
Working below knee level	20	40	320	1,600	6,880	75,680	1,513,600
Working above shoulder / overhead	35	70	560	2,800	12,040	132,440	2,648,800
Reaching away from the body	10	20	160	800	3,440	37,840	756,800

++ 20 Years assumed to be a working life.

[3] One year (11 Months work +1 Month annual leave).

The enormity of these effects on the workers' bodies if considered in isolation may not be evident and may be overlooked to the detriment of the workers in later life. However, it may well be that these effects may be counteracted by a healthy lifestyle, intake of nutritious foods and exercise. The health outcomes apart from OH&S practices depend entirely on the personal circumstances of the individual.

Interpretation of the Comparative Data

Bending of the Body

The histogram (Figure 5.2) displays a comparison of the respective trades and average number of counts of bending of the bodies of workers as observed and recorded over a 30-minute period.

Bricklayers suffer as a result of the bending – they suffer more than other workers. The plasterers seem to suffer effect of bending the second most followed closely by plastering general workers, bricklaying general workers and the painting general workers respectively. The painters appear to be the least affected.

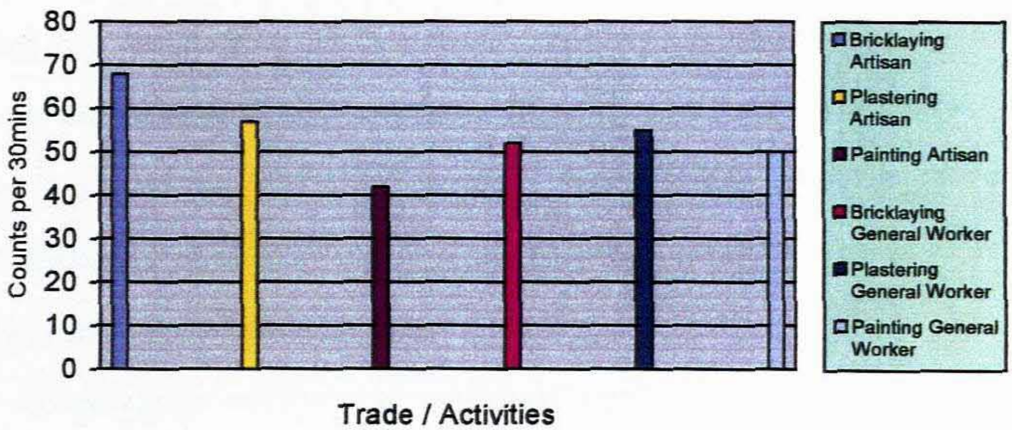

Figure 5.2: Bending of the Body

Bricklaying artisans (bricklayers) bent their bodies an average 68 counts in 30 minutes while laying bricks. It appears from the histogram in Figure 5.1 that the natural method laying bricks subjects the artisan to more bending than their plastering or painting counterparts. This is because bricklaying entails scooping of mortar (you are required to lay bricks with 10mm joints), which in most cases is placed at the feet level of the artisan.

The counts also reflect the ergonomic challenges involved in the physical execution of the bricklaying, plastering and painting processes respectively. Bricklaying involves working with heavier materials and building components compared to the activities involved in plastering and painting. The effect of handling heavier materials such as blocks and bricks are more detrimental on bodies of bricklayers compared with cement-mortar and paint products used by plasterers and painters. It can, however, be noted from the data that the high incidence of unfavourable ergonomic activity of bending of the body is prevalent and persists in all of the three trades of bricklaying,.plastering and painting observed.

With regard to the general workers in bricklaying, plastering and painting it can be observed from the data that while the general worker acts in a supportive role, the counts reflect similarly high numbers of occurrence of bending of the bodies as that of the artisans. The bricklaying general workers suffered 52 counts of bending of the body over the 30 minutes period while the plastering general workers bended their bodies 55 times and their painting counterparts, 50 times.

Ultimately, the repetitive body movements over long periods can be assumed to have a detrimental effect on the physical health of the workers.

Twisting of the Body

The histogram in Figure 5.3 shows how much the six groups of workers twisted their bodies while at work. The repetitive nature of the said movements should be detrimental to the health of the tradesmen. The highest of all counts recorded in respect of twisting of the body was by bricklaying artisans and the plastering artisans. The painting artisans recorded the least counts of twisting of the body.

The histogram (Figure 5.3) further reflects that the bricklaying general workers, plastering general workers and painting general workers are subjected to similar demands on their bodies to that of artisan workers. Plastering general workers are subjected to 66 counts per 30 minutes and bricklaying general workers to 64 counts per 30 minutes while painting general workers were subjected to 50 counts of twisting per 30 minutes.

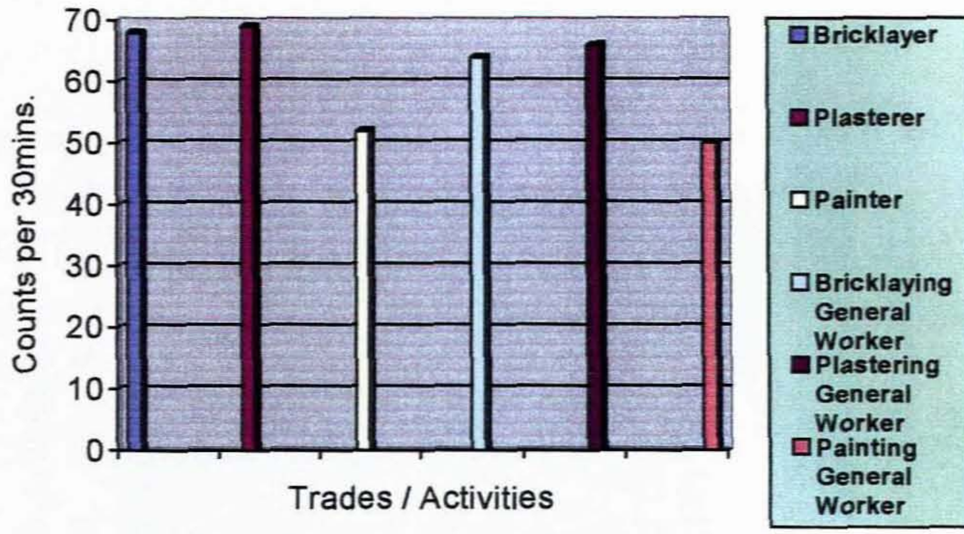

Figure 5.2: Twisting of the Body

Lifting/ Manually Handling Heavy Materials/ Objectis

Most construction activity requires lifting and manual handling of heavy materials and objects. Figure 5.4 presents findings in this respect over 30 minutes intervals. In this period of time the bricklayers and the plasterers recorded 60 counts; the highest amounts of lifting and manual handling of objects. The most demanding task of the bricklaying general worker is the manual cartage of bricks / blocks, and mortar using wheelbarrows which in turn also involve pushing / pulling.

Plastering general workers (46 counts in 30 minutes) were subjected to similar activities as bricklaying general workers (37.5counts in 30 minutes) except that they mostly had to basically cart mortar and place it in position for use by the plasterer. Painting general workers usually had to lift and carry ladders and containers of paint materials, around the site. This had less effect on their bodies compared with bricklaying general workers and plastering general workers.

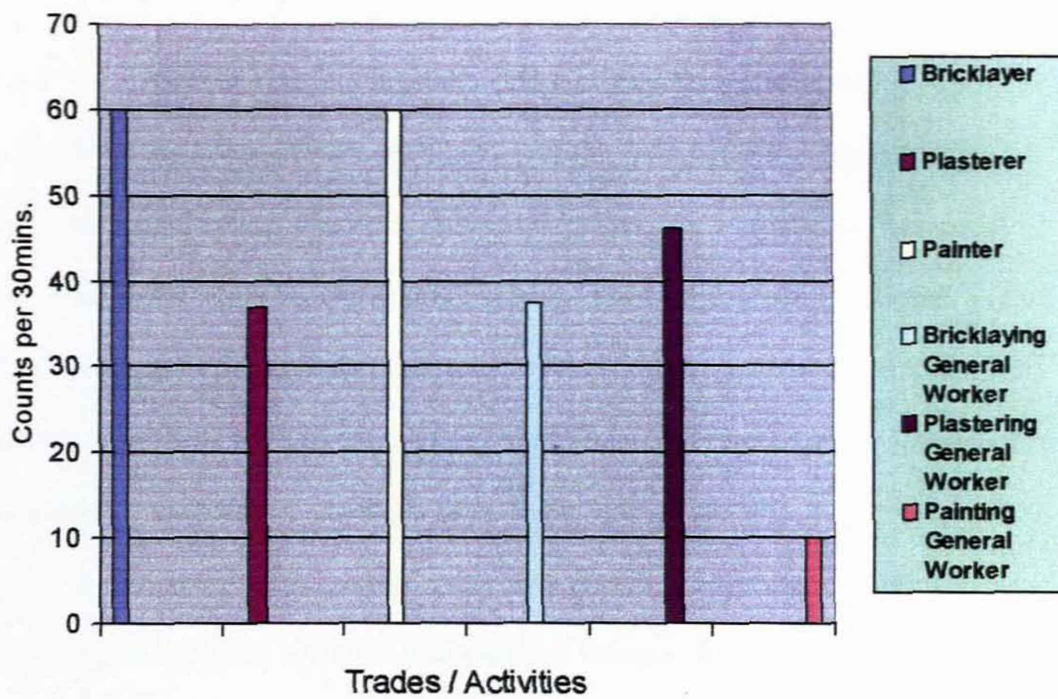

Figure 5.4: Lifting/ Manually Handling Heavy Materials/ Objects

The movement of painters, especially as regards the lifting and moving of ladders and paint containers appeared to be light work when compared with the execution of most of the other building trades. However, the repetitive nature and frequency of movements appeared to have an effect on the bodies of the painters. During interviews, it became apparent from the responses of the painters that the back pain was a problem that afflicted workers who frequently climb up and down the ladders and stretch and reach away from the body.

In comparison to other trades, the lifting and moving of ladders and lifting of containers of paint appeared light. The repetitive nature and frequency of movements did appear to have an effect on the bodies of the painting general workers. During interviews, it became apparent from the responses of the workers that back pain was rife among workers who frequently climbed up and down ladders and stretched and reached away from their bodies.

Working Above Shoulder Height / Reaching Overhead

Working above shoulder height and reaching overhead is prevalent in the activities of bricklaying, plastering and painting. The data presented in Figure.5.5 shows the effect of the activities on bricklayers, plasterers and painters as well as on bricklaying, plastering and painting general workers. The nature of construction work and the way in which the trades are executed, requires that workmen work above their shoulders or reach overhead several times in the observation period.

In this instance, bricklayers average 43 counts in 30 minutes for bricklaying excluding the ancilliary activities of lifting and fitting of lintols, doorframes and windowframes to be built into the walls under construction which involve working above shoulder height. The variety of activities that bricklaying general workers engaged in accounted for an average of 55 counts in 30 minutes of working above shoulder height. paintersThe data reflecting painters working above shoulder height reflects 10 counts in 30 minutes which appears low in comparison with the other trades. Painters did, however, have the benefit of repositioning by using ladders. The effect of painting in awkward positions such as painting of eaves and soffits of beams etc., however, is of a repetitive nature and had the effect of straining of the body (Figure 5.5).

Large soffits and ceilings being painted is not included, as such areas are largely done with rollers with extended handles which ease the action of working above the shoulder. Painting corners and brushing overhead is still done by hand requiring sustained effort. The cumulative effect of working above the shoulders therefore remains potentially detrimental to the bodies of the workers.

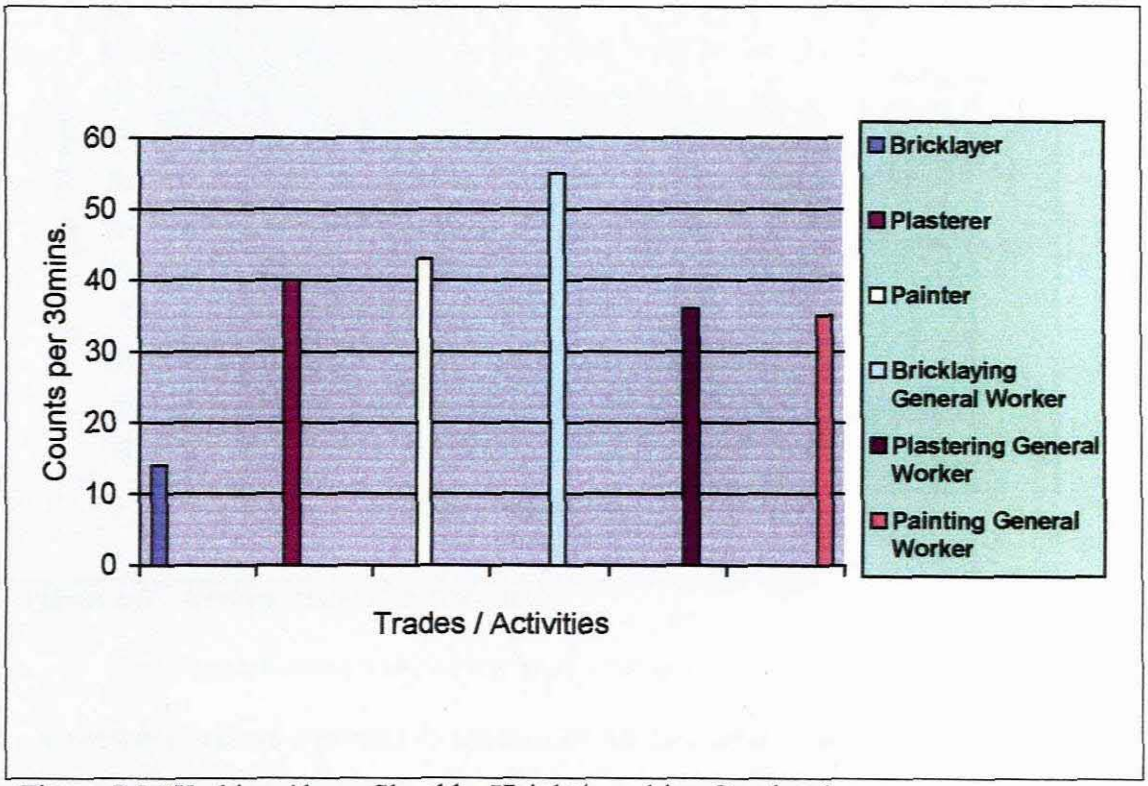

Figure 5.5: Working Above Shoulder Height/ reaching Overhead

The histogram (Figure. 5.5) reflects the number of times that the workers did work above shoulder height or reached overhead. The chart shows that no comparable practice exists and that activities affected the respective workers differently depending on the work that had to be done.

Painters seem to be subjected to more work requiring reaching above shoulder height and reaching overhead. The cumulative effect of working above the shoulders therefore should be detrimental to the bodies of the workers.

Working Below Knee Level

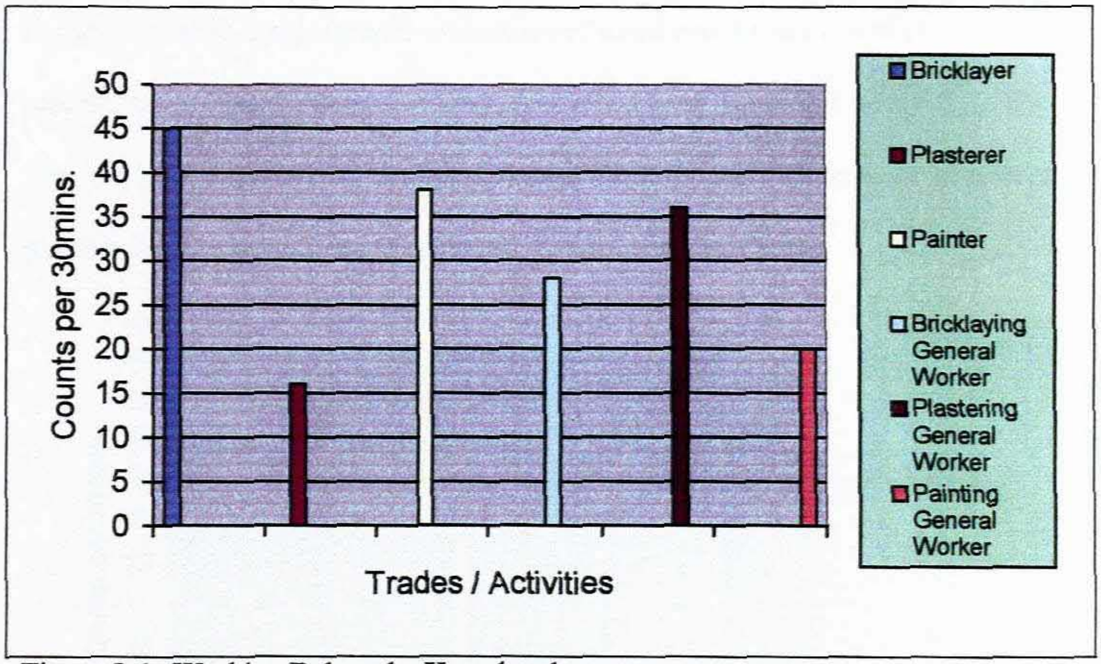

Figure 5.6: Working Below the Knee level

Statistics reflecting work below knee level is shown in Figure. 5.5. Here it is shown that bricklayers worked 45 times in 30 minutes below knee level. In the same vein, plasterers only worked below the knee, 16 times in a 30 minutes period. Moreover screeding work subjects the plasterer to kneeling. Kneeling occurred 42 times in 30 minutes. This places an enormous strain on the body of the plasterer as kneeling involves bending and twisting of the body at the time of the screeding process as well as placing strain on the knees. Painters required 38 counts in 30 minutes of work below the knees. Painting and plastering general workers were observed having done 28 times in 30 minutes and 20 counts in 30 minutes respectively.

While individual counts differ substantially, the effect of the activities over the long term is similarly detrimental.

Reaching Away from the Body

Figure 5.7 shows the comparative numbers of times that the various observed workers reached away from the body. Bricklayers reached away from their bodies a record 36 times in 30 minutes. Plasterers reached away from the body 32 times in 30 minutes while painters reached away from their bodies 40 times in 30 minutes.

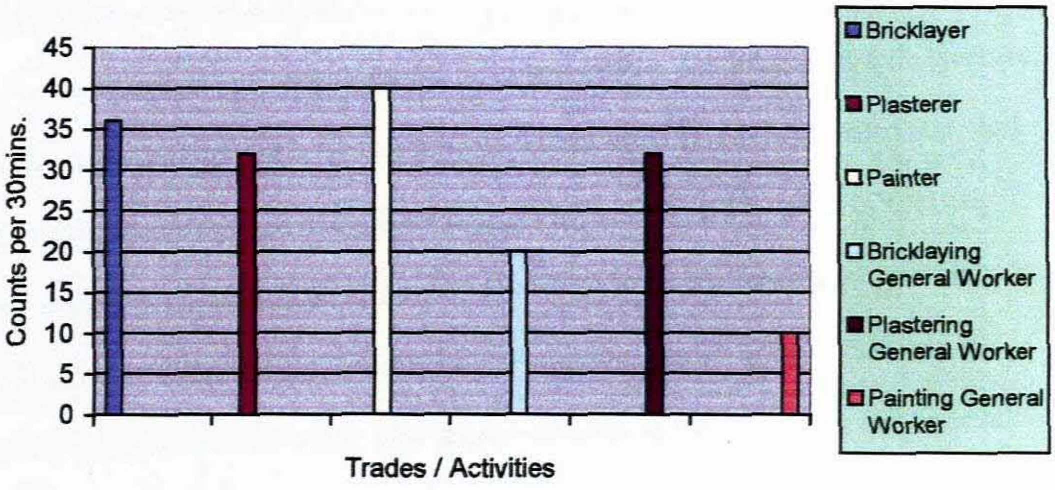

Figure 5.7: Reaching Away from the Body

The bricklaying general workers reached away from the body 20 times in 30 minutes while the plastering general workers did so 32 incidence in 30 minutes. The painting general workers' activities present fewer demands on the body and thus only reached away from the body 10 times in 30 minutes.

All observed construction workers reached away from their bodies. The chart (Figure. 5.7) displays the situation described. In comparison to other trades, the painter was required to reach away from the body much more than other counterparts did.

Testing of the hypotheses

Hypothesis 1

Construction activities require repetitive and lengthy periods of bending and twisting of the body, working in awkward positions, lifting and manually handling heavy and irregularly sized and shaped materials and components, and working above shoulder height and below the knee level.

The literature has been reviewed and observations and interviews with workers regarding construction site activities were conducted. The statistics revealed that workers in all trades were subjected to different degrees to bending and twisting of the body, lifting manually / heavy materials / objects, working below the knee level, working above shoulder level / overhead and kneeling while working. For example, in the case of bricklayer artisans several of the movements recurred on average about twice per minute

The hypothesis that construction activities require repetitive and lengthy periods of bending and twisting of the body cannot be rejected.

Hypothesis 2:

Exposure to bending and twisting of the body, working in awkward positions, lifting and manually handling heavy and irregularly sized and shaped materials and components, and working above shoulder height and below level knee level results in worker health problems.

The study revealed that workers' health continued to be affected by ergonomic activities on construction sites. Workers attributed many of their health problems to site activities. Osten (1996) refers to an epidemiological study that found a significant relationship between awkward postures and higher rates of back and shoulder pain. A number of other postures such as kneeling, squatting, lying and bending (stooping), were commonly taken up by construction workers during the execution of their work routines.

The hypothesis that unfavourable ergonomic practices on construction sites produce worker health problems thus cannot be rejected.

Hypothesis 3

Health problems that affect construction workers manifest themselves in chronic pain and ailments.

The study revealed that workers suffered a number of chronic pain and ailments believed to be resulting from work activities. These health problems included backache (71.9%), sore muscles and joints (64.5%), shoulder pains (53.3%), hand and palm pains (36.7%), knee pains (33.3%) and wrist pains (33.3%). The data suggests that the health problems that affect the workers result in chronic pain and ailments.

The hypothesis that health problems that affect construction workers suffer manifest themselves in chronic pain and ailments cannot be rejected.

Hypothesis 4

Ergonomic related health problems lead to increased absenteeism in the construction industry.

The study revealed that the workers suffered backache, sore muscles and joints, shoulder pains, hand, palm and knee pains in descending order of prevalence. These ergonomic related health problems are of the nature that they result in absenteeism.

The hypothesis that ergonomic related health problems lead to increased absenteeism in the construction industry cannot be rejected.

Hypothesis 5

Ergonomic related health problems lead to poor productivity on construction sites.

The extent to which the ergonomic related health problems lead to poor productivity could not be measured or established due to lack of participation by employers. The respondents (seven employers interviewed) expressed a commitment to the OH&S process and ergonomic practices but no records were made available to reflect the magnitude of the health problems and their effect on productivity. However, the literature revealed that employee productivity was affected by health conditions inclusive of back pain (Kirsten, 2003). Work health promotion studies revealed that absence from work due to injuries or illnesses had a detrimental economic impact on business, incurring additional cost of decreased productivity (Karch, 2003; Smallwood, 1995).

The findings are statistically inconclusive, however, the literature suggests that health problems lead to poor productivity on site. The hypothesis therefore cannot be rejected.

Hypothesis 6

Ergonomic related health problems lead to increased retrenchments of construction workers.

The extent to which the ergonomic related health problems lead to increased retrenchments and redundancies could not be measured or established due to lack of participation by employers. The seven employers, who availed themselves to be interviewed, did not provide any information regarding retrenchments and redundancies in their enterprises.

Since the findings are statistically inconclusive, the hypothesis could not be proven and is therefore rejected.

Hypothesis 7

Construction employers are resistant to changing the way construction activities are carried out.

The study was not able to establish to what extent employers are prepared to consider the integration of ergonomic principles along with H&S procedures in the management culture in the management culture to benefit the business as well as the workers. All construction sites visited, however, displayed an awareness of H&S and observed the use of PPE to some extent.

Observations revealed that workers were subjected to unfavourable ergonomic practices, which affected the workers' health.

It could, however, not be conclusively established whether or to what extent employers are resistant to changing the way construction activities are carried out.

The hypothesis could not be proven and is therefore rejected.

Closing Remarks

Chapter five interpreted the data as recorded and analyzed. An extrapolation of the data was done to reflect the impact on the workers' bodies of the work processes over their working life span.

Construction industry employers face the challenge to identify the need and consider the integration of ergonomic principles along with OH&S procedures in their management culture to benefit the interests of the business as well as the workers.

The next chapter presents the conclusions and recommendations of this study.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

Introduction

The research was conducted to determine what effect ergonomics has on the construction industry in general and on the construction workers in particular. The research sought to establish the extent to which construction activities expose workers to ergonomic challenges and which particular activities present the most challenges. The research was conducted to establish to what extent construction employers are prepared to consider the integration of ergonomic principles with these H&S procedures in their management culture to benefit the business as well as the workers.

The literature review established that a number of unfavourable ergonomic practices are prevalent in many parts of the world. The literature reflected on the historical background of the study of ergonomics as well as the effect of occupational health problems on construction workers. The economic effect resulting from insufficient ergonomic consideration in the management of construction projects as well as the socio-economic consequence thereof were outlined.

The method employed in conducting the research encompassed a logical positivist and empiricist approach. Field observations as well as interviews were conducted among construction workers on various construction sites. The relevant data was collected, recorded and encoded for later processing using the SPSS software.

Chapter four presented the results of the research while chapter five presented an interpretation of the data as recorded and analyzed.

The operational definition of construction ergonomics can in view of the findings be defined as follows:

"Construction Ergonomics studies the relationship between workers, and their work environment and optimizes the use of work systems adapted to worker capabilities and characteristics to increase their efficiency, overall health and well-being, system performance and improved productivity".

This chapter provides an overview of and summarises the findings and conclusions and then makes recommendations

Summary

Background investigations of this research revealed that construction activities expose workers to ergonomic challenges that affect the health of workers and result in absenteeism, reduced productivity retrenchments and redundancy. The lack of social and economic sustainability has a detrimental effect on the workers and their dependants.

The research aimed to establish the extent to which construction workers' well-being is affected by unfavourable ergonomic practices on construction sites and to make recommendations based on the conclusions from the study.

Conclusions

The conclusions from the of the research are that compared to previous studies, workers observed in this study were inclined to choose not to take time or make an effort to re-position, but would opt for the faster movement of the twisting of the torso motion. Kroemer (2002), refer to this behaviour as:

"***Acceptable conditions*** (in accordance with current scientific knowledge and sociological, technological and organizational circumstances) to which the people involved can voluntarily agree."

Awkward work postures resulted from restrictions in the workspace including where badly designed scaffold systems were in use. Insufficient workspace (Figure 4.1) on the scaffolds limited movement and application of ergonomically sound working techniques, which might reduce the incidence of MSD occurring.

The most frequently used working posture was standing. A number of other work postures, such as, kneeling, squatting, lying and bending (stooping), are commonly used by construction workers during the execution of their work routines. This is in line with an epidemiological study (Osten, 1996), which determine there to be a significant relationship between awkward postures and higher rates of back and shoulder pain.

The phenomena observed reflect inter alia, poor site management.

Absenteeism

Failure to put ergonomic practices in place may result in increased absenteeism due to injuries and other health problems. Absenteeism reduces staff levels and introduces skills shortages, which in turn result in poor production levels being realized. The study revealed that a large number of construction workers suffer from backache, a result of unfavourable construction activities and insufficient implementation of health and safety and ergonomic procedures.

This very nature of the construction industry, may result in the retrenchment of workers who are frequently absent because they are not able to perform physical work.

Redundancy

The poor image of the construction industry has the effect that the older worker cohort that has left the industry has not been replaced by a sufficient number of younger entrants willing to join the industry (Smallwood et al., 2004). This study was unable to secure records reflecting the statistics regarding numbers of workers leaving the construction industry as a result of MSD's, occupational and non-occupational diseases because such data does not presently exist or is not made available at this stage. The nature of the construction employment environment has not improved in many years.

Workers forced to leave construction projects as a result of workplace injuries or occupational diseases often do not return to such sites because of the short duration of contracts. This problem is in practice tantamount to termination of employment. The employment practices in terms of which construction workers are employed (if and when required), namely for the duration of a construction contract, remain and are essentially a practice that result in inevitable redundancy of workers when they are no longer required. In other words, there is no automatic progression of workers on one contract or project to the next contract when their original contract or project is complete.

Effect of Health problems

Construction is a physical process that presents various ergonomics related problems. The problems include bending and twisting of the body, reaching away from the body and reaching overhead, working in awkward positions, lifting and manually handling heavy and irregularly sized and shaped materials and components, working below knee level and working while kneeling. The findings revealed that unfavourable and repetitive ergonomic practices are common in the construction industry.

The interviews with construction workers revealed that large numbers of construction workers experienced debilitating effects of ergonomic activities on their physical health, such as backache, sore muscles and joints. Hand and palm pains, wrist pains, shoulder pains, knee pains and to a lesser extent skin problems, lung infections (coughing) and headaches.

Bending and twisting of the body continually affected the workers' bodies; in particular the lower back and legs. Lifting and manual handling of heavy and irregularly sized and shaped materials and construction components also contribute to health related problems. All workers to some extent reached away from the body while working. Reaching away from the body could have a far-reaching impact on the workers over time. Other prevalent ergonomic problems observed are the performance of work above shoulder height and below the knees.

When asked what their view on their work conditions were, the respondents suggested that as employment in the construction industry was of a temporary nature, they may well not experience the physical problems resulting from continued employment in the industry. Because their present employment contract may end with completion of the current job there might not be any danger of long term health problems resulting from continued employment in the unfavourable ergonomic conditions currently experienced.

It became apparent from the interviews with workers that workers' view the work situation in the construction industry as being employment of a temporary nature.

Workers expressed the view that they suffer the consequences of not having a stable and secure work situation, the exception being when the construction industry enjoys a "boom".

Recommendations for Construction Industry Managers and Workforce

- Based on the findings of the research the following recommendations are made:
- A clearly expressed commitment from management is necessary to encourage workers to engage and realize the benefits of favourable ergonomic practices. The worker cohort should be afforded direct participation in the design and final implementation of sound ergonomic practices in the construction work environment.
- Tables 5.1, 5.2, 5.3, 5.4.1, 5.4.2, 5.5, 5.6, 5.7, 5.8 (pages 75, 76, 77, 78, 79, 79, 81, 82, 84 respectively), illustrate the volume of activities derived from the findings, and the potential impact the activities can have on the workers' bodies. All individuals involved in construction have a vested interest in the health, safety and welfare of the workers cohort in the construction environment and should therefore be committed, to identification and practice of sound principles that can benefit of all workers.
- Ergonomic principles should be initiated and properly followed to eliminate physical risk factors faced by workers.
- Work place activity should be designed in such a way that they eliminate or reduce as far as possible motions that reinforce fatigue of muscles.
- Special care should be taken in the design of jobs where awkward positions are used in order to improve worker productivity. Mechanical aids could be used to

reduce the risks that workers are exposed to in restricted workspaces. Mechanical assistance should be provided where it is available or obtainable, to reduce the chance of continuous risk of MSDs on the workers' bodies. Telescopic and articulated lifts and trucks can deliver bricks / blocks, sand and many other building components and materials to upper levels of projects and reduce the physical strain on workers' bodies. This would not only increase retention but productivity too. In addition, mechanization, mechanical tools and devices could greatly ease the bending of the body and assumption of awkward positions at work.

- To avoid back injury, flexion of the body should be limited and care should be exercised when flexion cannot be avoided. To achieve this stepped work platforms with chest level position of immediate required materials could be introduced.
- Special care has to be taken in the design of jobs where awkward positions are used in order to improve productivity. Mechanical aids could be used to reduce the risks that workers were exposed to in restricted workspaces.
- Care should also be exercised where lifting is required in the kneeling and sitting position. Ideally, lifting should be done at the level between the shoulder and the hip. This can be achieved by placing the object to be lifted initially on a raised platform. Johnson (2005) suggests that managers must clearly demonstrate commitment to the importance of safe lifting, and be mindful that injuries result in lost time. Gradations of weights of materials could also be introduced so that heavier material lifting could receive mechanical aids.
- The use of PPE is essential and should be monitored and enforced to ensure that workers in all trades, benefit and are protected. Management should insist on safe

work practices and in planning of work programmes and processes, must incorporate ergonomic principles within the proposed work scheme.

Recommendations for Future Research

In view of the inconclusive findings in respect of hypotheses 5, 6 and 7, the challenge to the management of employers and employer organisations in the construction industry is to have a database of incidences of work related injuries. This information would provide valuable insight into the H&S of the construction workforce. It would also be indicative of whether and to what extent the need to improve ergonomics in the construction industry is.

Resistance to changing the way construction activities are carried out is counter-productive. Ongoing injuries are detrimental to the well-being of construction workers as well as to productivity on site. It is thus essential and inevitable that change be implemented.

Further research with input from a broad section of the construction employers as well as employee organisations may be valuable to the industry in general and to participants in particular.

LIST OF APPENDICES

APPENDIX A: LETTER OF INTRODUCTION

CAPE PENINSULA UNIVERSITY OF TECHNOLOGY

Cape Town Campus
P O Box 652
CAPE TOWN 8000

OFFICE OF THE RESEARCH COORDINATOR: FACULTY OF ENGINEERING

Bellville Campus
P O Box 1906
BELLVILLE 7535

2005-06-18

To Whom It May Concern:
Dear Sirs

CONSTRUCTION ERGONOMICS QUESTIONNAIRE

William Samuels is currently reading for a M.Tech degree in Construction Management at the Cape Peninsula University of Technology and is investigating the effects of various ergonomic practices and interventions on the overall health and safety performance of construction firms.

His study forms part of a major research project being under taken by the South African Built Environment Research Centre (SABERC) to improve the H&S culture and performance of the South African construction industry.

Your participation in this study is pivotal to its success. The attached questionnaire will take about 10-15 minutes to complete.

Your confidentiality and anonymity is assured.

The results of this survey will be summarized in a report and sent to you upon request.

Should you have any questions about the study you may contact Dr Theo Haupt or William Samuels on the numbers provided.

Yours faithfully,

Dr. Theo Haupt

Research Co - Ordinator

Phone 021 9596637

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APPENDIX B: OBSERVATION NOTING SHEET

OBSERVATIONS OF ERGONOMICS IN THE CONSTRUCTION INDUSTRY IN THE WESTERN CAPE

The observations deals with the ergonomic aspects of activities on construction sites and aims to find out to what extend ergonomic consideration are applied on construction sites as part of health and safety practice. It forms part of a major study by the Southern African Built Environment Research Center (SABERC).

TRADES: **Bricklaying; Plastering; Floor Screeding; Tiling;**

Painting; Paving Bricks / blocks; Kerb Laying;

(Circle the Trade dealt with on this page)

Category of Employment:		
Artisan	Operator	General worker

(Circle the Category of Employment being observe

	Activity	**Observation Period**
		(No. of times per 30mins.)
1.	Bending of the body.	
2.	Twisting of the body.	
4.	Lifting / manually handling heavy materials / objects.	
5	Working above shoulder height / Reaching overhead	
6.	Working below knee level	
7.	Working in one position. If so, specify	
8.	Reaching away from the body.	
9.	Standing in one position	
10.	Kneeling	

11.	**Does the worker wear Personal Protective Equipment (PPE)?**		**Yes**	**No**
		Describe the Activity / working conditions		
11.1	Hard hat			
11.2	Gloves			
11.3	Safety harness			
11.4	Goggles			
11.5	Safety boots			
	If not, is it required for safety?			
	Comments:			

12.	**Repetitive work**	**Yes**	**No**
12.1.	Which task or jobs use the same motion dozens of times per hour? (e.g. bending, twisting of the body, lifting, nailing, hammer-drilling etc.) Specify observation		
.1.1			
.1.2			
.1.3			
12.2.	Can the number of repetitions be reduced by rotation or by breaks?		
	If so, Describe the prevailing conditions observed		
.2.1			
.2.2			
.2.3			

13.	**Awkward Positions**	**Yes**	**No**
13.1.	Work in awkward positions.		
	If so, Identify positions and time spent		
13.1.1			
.1.2			
.1.3			
13.2.	Is sufficient space available where **bending of the body** occurs?		
.2.1			
.2.2			
.2.3			
13.3.	Is sufficient space available where **twisting of the body** occurred?		
.3.1			
.3.2			
.3.3			

APPENDIX C: QUESTIONNAIRE

QUESTIONNAIRE ON ERGONOMICS IN THE CONSTRUCTION INDUSTRY IN THE WESTERN CAPE

This questionnaire deals with the ergonomic aspects of activities on construction sites and aims to find out to what extent ergonomic consideration are applied on construction sites as part of health and safety practice. It forms part of a major study by the Southern African Built Environment Research Centre.

1.	**How old are you?**	
	Years	Months

2.	**How long have you worked:**		
		years	months
2.1	In Construction?		
2.2	For Current Employer?		
2.3	In other Industry? Specify		

3.	**What type of construction work have you done, are you currently doing, and for how long have you done each?**		
	Type of work	Duration	
		Years	Months
3.1			
3.2			
3.3			
3.4			

4.	**Have construction activities affected your physical health?**	
Yes	No	Unsure

4.1	**If 'Yes', in which ways?**			
Manifestation		Yes	No	Unsure
4.1.1	Backache			
4.1.2	Sore muscles and joints			
4.1.3	Hand and palm pains			

4.1.4	Wrist pains			
4.1.5	Shoulder pains			
4.1.6	Knee pains			
4.1.7	Skin problems			
4.1.8	Breathing problems			
4.1.9	Lung infections (coughing)			
4.1.10	Headaches			
4.1.11	Eyesight problems (vision)			

5.	**Have ever been absent from work as a result of the following afflictions?**			
Manifestation		Yes	No	Unsure
5.1	Backache			
5.2	Sore muscles and joints			
5.3	Hand and Palm pains			
5.4	Wrist pains			
5.5	Shoulder pains			
5.6	Knee pains			
5.7	Skin problems			
5.8	Breathing problems			
5.9	Lung infections (coughing)			
5.10	Headaches			
5.11	Eyesight problems (vision)			

6.	How frequent were you absent from work as a result of the following afflictions? Where 1 = Never, 2 = Seldom, **3 = Sometimes, 4 = Often, 5 = Always**					
Manifestation		1	2	3	4	5
6.1	Backache					
6.2	Sore muscles and joints					
6.3	Hand and palm pains					
6.4	Wrist pains					
6.5	Shoulder pains					
6.6	Knee pains					
6.7	Skin problems					
6.8	Breathing problems					
6.9	Lung infections (coughing)					
6.10	Headaches					
6.11	Eyesight problems (vision)					

7.	**Which of the following have you experienced? If 'yes', Please state the number of times experienced**	Yes	Number	No	Unsure
7.1	Disabling injury				
7.2	Medical aid injury				
7.3	First aid injury				
7.4	Occupational disease				

		Yes	Number of times	No
8.1	**Do you have a regular / personal doctor?**			
			//////////////////////	

		Yes	Number of times	No
9.1	**Have you seen a doctor in the past 6 months?**			

10.	**Have you ever experienced any of the following, and if so, how many times?**				
Intervention		Yes		No	Un sure
		Number of times	Cannot remember		
10.1.1	Pre-employment medical examination (Entry)				
10.1.2	In-employment medical examination				
	Post-employment (Exist)				
10.2	OH 'toolbox talks' addressing health aspects of construction activities				
10.3	Induction which addressed OH aspects of construction activities				
10.4	OH training designed to prevent injury while working in construction				

11.	**Could the construction process be improved?**	
Yes	No	Unsure

11.1 If 'Yes', explain or give examples

____

____

____

12.	**Do you regard the construction site environment as healthy?**	
Yes	No	Unsure

13	In the execution of your work, how frequently do you do the following where 1 = Never, 2 = Seldom, 3 = Sometimes, 4 = Often, 5 = Always	1	2	3	4	5
13.1	Bending					
3.2	Lifting					
13.3	Reaching away from the body					
13.4	Reaching above your head					
13.5	Work below knee level					
13.6	Standing					
13.7	Twisting the body					
13.8	Work in awkward positions					

APPENDIX D: QUESTIONNAIRE CONSENT FORM

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QUESTIONNAIRE

ERGONOMICS IN THE CONSTRUCTION INDUSTRY IN THE WESTERN CAPE

CONSENT FORM

Dear Researcher,

I have had the aims of the research explained to me, and I agree to voluntarily participate in the research study entitled ' **Ergonomics in the Construction Industry in the Western Cape'**. I understand that all findings will be kept completely confidential, and I may withdraw from this study at any time.

Construction Worker's signature: ______________________________

Date: ______________________________

Researcher's signature: ______________________________

APPENDIX E: ERGONOMICS STATISTICS TABLES

Table 3: Frequency Table): Bending the Body

Trade: **BRICKLAYING ARTISAN**			Activity: Bending of the Body	
		Frequency	Valid Percent	Cumulative Percent
Valid	34.00	1	5.0	5.0
	40.00	1	5.0	10.0
	52.00	2	10.0	20.0
	54.00	1	5.0	25.0
	60.00	1	5.0	30.0
	62.00	1	5.0	35.0
	64.00	1	5.0	40.0
	66.00	1	5.0	45.0
	68.00	2	10.0	55.0
	70.00	1	5.0	60.0
	82.00	1	5.0	65.0
	86.00	1	5.0	70.0
	88.00	1	5.0	75.0
	92.00	1	5.0	80.0
	96.00	1	5.0	85.0
	102.00	1	5.0	90.0
	130.00	2	10.0	100.0
	Total	20	100.0	

Table 4.1: Bricklaying Artisans Body Movements

BRICK LAYERS	Trade (Bricklaying)	Category of employment (Artisan)	Bending of the Body	Twisting of the Body	Lifting / manually handling heavy materials / objects
Valid	20	20	20	19	17
Missing	0	0	0	1	3
Mean	1.0000	1.0000	74.8000	70.6842	60.4706
Median	1.0000	1.0000	68.0000	68.0000	60.0000
Mode	1.00	1.00	52[a]	36.00[a]	14.00[a]
Standard Deviation	.00000	.00000	26.12843	36.27067	24.73693
Minimum	1.00	1.00	34.00	19.00	14.00
Maximum	1.00	1.00	130.00	146.00	106.00

Table 6.: Frequency Table: Lifting/ Maually Heavy Material/ Objects

Trade: **BRICKLAYING GENERAL WORKERS**		Activity: Lifting / Manually handling heavy Materials/ Objects	
	Frequency	Valid Percent	Cumulative Percent
Valid 10.00	1	7.1	7.1
11.00	2	14.3	21.4
12.00	1	7.1	28.6
24.00	1	7.1	35.7
34.00	1	7.1	42.9
35.00	1	7.1	50.0
40.00	1	7.1	57.1
56.00	1	7.1	64.3
78.00	1	7.1	71.4
86.00	1	7.1	78.6
90.00	1	7.1	85.7
104.00	1	7.1	92.9
114.00	1	7.1	100
Total	14	100.0	

Table 7.1: Frequency Statistics Bricklaying – General Workers

BRICKLAYING GENERAL WORKERS	Trade (Bricklaying)	Category of employ-ment (General worker)	Bending of the Body	Twisting of the Body	Lifting / manually handling heavy materials / objects
Valid	14	14	14	11	14
Missing	0	0	0	3	3
Mean	1.0000	3.0000	60.2857	76.7273	50.3571
Median	1.0000	3.0000	52.0000	64.0000	37.500
Mode	1.00	3.00	40.00	23.00[a]	11.00
Stand. Deviation	.00000	.00000	34.56194	44.16354	37.28189
Minimum					
Maximum	1.00	3.00	10.00	23.00	10.00
	1.00	3.00	114.00	152.00	114.00

Table 7. 2: Bricklaying General Worker

BRICK-LAYING GENERAL WORKER	Trade	Category of Employ-ment	Lifting/ manually handling heavy materials/objects	Working above shoulder / Reaching overhead	Reaching away from the Body
Valid	14	14	14	8	11
Missing	0	0	0	6	3
Mean	1.0000	3.0000	50.3571	61.7500	34.6364
Median	1.0000	3.0000	37.5000	55.0000	20.0000
Mode	1.00	3.00	11.00	10.00[a]	4.00[a]
Std Deviation	.00000	.00000	37.28189	42.35142	31.24187
Minimum	1.00	3.00	10.00	10.00	4.00
Maximum	1.00	3.00	114.00	120.00	104.00

Table 9. 1: Plastering Artisan - Statistics

PLASTERER	Trade	Category of Employment	Bending of the Body	Twisting of the Body	Lifting / manually handling heavy materials / objects
Valid	16	16	16	16	10
Missing	0	0	0	0	6
Mean	2.0000	1.0000	61.4375	69.2500	43.0000
Median	2.0000	1.0000	57.0000	69.0000	37.0000
Mode	2.0	1.0	42.00[a]	50.00[a]	26.00[a]
Std Deviation	.00000	.00000	17.34347	28.37722	20.88061
Minimum	2.0	1.0	40.00	14.00	21.00
Maximum	2.0	1.0	92.00	120.00	80.00

Table 9. 2: Plastering Artisan - Statistics

PLASTERER	Trade	Category of Employ-Ment	Working above shoulder height / Reaching overhead	Working below knee level	Reaching away from the Body	Kneeling
Valid	16	16	15	7	13	1
Missing	0	0	1	9	3	15
Mean	2.0000	1.0000	41.4000	21.5714	29.4615	42.0000
Median	2.0000	1.0000	40.0000	16.0000	32.0000	42.0000
Mode	2.0	1.0	28.00	16.00	32.00	42.00
Std Deviation	.00000	.00000	22.78408	17.41510	18.25110	
Minimum	2.0	1.0	8.00	1.00	2.00	42.00
Maximum	2.0	1.0	90.00	50.00	60.00	42.00

Table 10: Plastering Artisan - Statistics

PLASTERERS Use of gloves		Frequency	Valid Percent	Cumulative Percent
Valid	Yes	10	62.5	62.5
	No	6	37.5	100.0
	Total	16	100.0	

Table 12.2: Plastering General Workers Statistics

PLASTERING GENERAL WORKERS	Trade	Category of Employment	Working above shoulder height/ Reaching overhead	Working below knee level	Reaching away from the Body
Valid	14	14	9	11	13
Missing	0	0	5	3	1
Mean	2.0000	3.0000	38.4444	34.1818	27.3846
Median	2.0000	3.0000	36.0000	36.0000	32.0000
Mode	2.00	3.00	40.00	36.00	32.00
Std Deviation	.00000	.00000	9.22105	21.52124	17.39990
Minimum	2.00	3.00	28.00	1.00	2.00
Maximum	2.00	3.00	60.00	76.00	56.00

Table 11: Frequency Table: Twisting of the Body

Trade: PLASTERING GENERAL WORKERS			Activity: TWISTING OF THE BODY	
		Frequency	Valid Percent	Cumulative Percent
Valid	24.00	1	7.7	7.7
	32.00	2	7.7	15.4
	44.00	1	7.7	23.1
	58.00	1	7.7	30.8
	62.00	1	7.7	38.5
	63.00	1	7.7	46.2
	66.00	1	7.7	53.8
	67.00	1	7.7	61.5
	84.00	1	7.7	69.2
	86.00	1	7.7	76.9
	100.00	1	7.7	84.6
	110.00	1	7.7	92.3
	126.00	1	7.7	100.0
	Total	13	100.0	
Missing	9999.00	1		
Total		14		

Table 12.1: Plastering General Workers - Statistics

PLASTERING GENERAL WORKERS	Trade	Category of Employ-ment	Bending of the Body	Twisting of the Body	Lifting / manually handling heavy materials / objects
Valid	14	14	14	13	14
Missing	0	0	0	1	0
Mean	2.0000	3.0000	65.7143	72.6154	54.6429
Median	2.0000	3.0000	55.5000	66.0000	46.0000
Mode	2.00	3.00	52.00	24.00[a]	46.00
Std Deviation	.00000	.00000	30.50455	31.23176	33.17461
Minimum	2.00	3.00	32.00	24.00	19.00
Maximum	2.00	3.00	126.00	126	126.00

Table 14: Frequency Table, Bending of the Body

Trade: PAINTING ARTISAN			Activity: BENDING OF THE BODY	
		Frequency	Valid Percent	Cumulative Percent
Valid	20.00	2	28.6	28.6
	38.00	1	14.3	42.9
	42.00	1	14.3	57.1
	60.00	1	14.3	71.4
	102.00	1	14.3	85.7
	108.00	1	14.3	100.0
	Total	7	100.0	

Table 15: Painting Artisans - Statistics

PAINTERS	Trade	Category of Employment	Bending of the Body	Twisting of the Body	Reaching away from the Body
Valid	7	7	7	7	7
Missing	0	0	0	0	0
Mean	5.0000	1.0000	55.7143	62.5714	33.2857
Median	5.0000	1.0000	42.0000	52.0000	40.0000
Mode	5.00	1.00	20.00	20.00[a]	1.00[a]
Std Deviation	.00000	.00000	36.39466	47.50739	30.25841
Minimum	5.00	1.00	20.00	20.00	1.00
Maximum	5.00	1.00	108.00	138.00	10.00

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