ERGONOMICS IN BUILDING CONSTRUCTION

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A project report submitted in partial fulfillment of the
requirements for the award of the degree of
Master of Science (Construction Management)

Faculty of Civil Engineering
Universiti Teknologi Malaysia

AUGUST 2012

This dissertation is dedicated to my beloved, supporting and caring husband, Shahab, who has supported me all the way since the beginning of this research. Thank you for your unconditional love, support, and care. This dissertation is also dedicated to my family, who has been a great source of motivation and inspiration for me.

ACKNOWLEDGEMENT

All praises to God for the strengths and blessing in completing this dissertation.

Foremost, I would like to express my sincere appreciation to my supervisor Associate Professor Aziruddin Ressang for the continuous support of my research, for his patience, motivation, enthusiasm, and immense knowledge. His invaluable advice and guidance helped me in all the time of research and writing of this dissertation. Without his continued support, this thesis would not have been the same as presented here.

My Special gratitude also goes to my beloved husband, His invaluable help of constructive comments and suggestions have contributed to the success of this research. Thank you for the encouragements and supports, for being my inspiration, for your understanding and most importantly for your endless love.

Last but not least, my deepest gratitude goes to my family for their kind cooperation in assisting and helping me in my research. I am grateful for their constant support and help.

ABSTRACT

Protecting the safety and health of construction workers is challenging due to diversity and dynamic features of construction industry. Construction industry in recent years has shown interest in Ergonomics science. Some construction activities may lead to Cumulative Trauma Disorders (CTDs) due to lack of knowledge about Ergonomic Risk Factors (ERFs), illnesses and injuries related to construction activities. This research was aimed at studying Ergonomic Risk Factors (ERFs) in building construction sites so as to recommend suggestions which mitigate the current scenario of Ergonomic injuries. To achieve the aim of this research Ergonomic Risk Factors (ERFs) were studied. Data collected through questionnaires were analyzed using SPSS software, Ms excel, Mean value index and Risk assessment process. The reliability of data was assessed by calculating Cronbach's alpha (α); Mean value index and Risk assessment process were used to determine the risk level of ERFs; Relative Importance Index (RII) method was used in order to rank factors affecting Ergonomics injuries in order of importance. The results indicated that the most critical ERFs were extreme hot temperature, leaning forward/side, twisting the back, organizational factors (i.e. management style, policies, participation in decision making) and personality characteristics (i.e. stubbornness, inconsiderateness, ignorance). According to the results the most important factors by which Ergonomics injuries are affected, were training, management and organization communication, Job Hazard Analysis (JHA) and work practices. Based on the analysis and findings, suggestions were recommended to enhance the workers' safety and health in construction sites. Finally the application of Cognitive Work Analysis (CWA) in construction Ergonomics domain was investigated as a part of this research according to findings and analysis.

ABSTRAK

Oleh kerana keragaman dan dinamis nya sektor pembinaan, melindungi keselamatan dan kesehatan pekerja binaan adalah sangat mencabar. Setengah aktiviti pembinaan boleh menyebabkan gangguan trauma yang kumulatif. Ini di sebabkan kurangnya kesadaran tentang faktor risiko ergonomis. Penelitian ini bertujuan untuk mempelajari faktor risiko ergonomis (ERFs) didalam pembinaan bagi mencadangkan cara mengurangkan kecederaan ergonomis. Untuk mencapai tujuan ini, faktor risiko ergonomis di kaji. Data yang di perolehi di analisa menggunakan peranti SPSS, indeks kepentingan relatif (RII) dan Indeks purata. Keandalan data dinilai menggunakan Cronbach's alfa (α); Nilai indeks dan penilaian risiko yang digunakan untuk menentukan tingkat risiko factor ergonomis, cara ini digunakan dalam urutan peringkat faktor-faktor yang mempengaruhi kecederaan ergonomis menurut urutan pentingnya. Hasil analisa menunjukkan bahwa faktor risiko ergonomis yang paling penting ialah suhu panas yang melampau, bersandar ke depan/sisi, memutar kembali, organisasi faktor (yaitu gaya pentadbiran, cara mengambil keputusan dan karakteristik kepribadian yaitu keras kepala, tidak bertimbang rasa dan ketidaktahuan. Menurut hasil penelitian faktor yang mempengaruhi kecederaan ergonomis ialah latihan, komunikasi, dan cara bekerja. Berdasarkan analisis dan temuan, saran yang di cadangkan untuk meningkatkan keselamatan dan kesehatan pekerja binaan adalah latihan dan pentadbiraan yang mantap. Akhirnya aplikasi dari Kognitif Pekerjaan Analisis (CWA) dalam konstruksi ergonomi domain dikaji sebagai bagian dari penyelidikan ini .

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ABBREVIATIONS	FULLNAME
OSHA	Occupational Safety and Health Administration
IDCs	Industrial Developing Countries
NIOSH	National Institute of Occupational Safety and Health
IEA	International Ergonomics Association
SOCSO	Social Security Organization
WRMDs	Work-related musculoskeletal disorders
CTDs	Cumulative Trauma Disorders
BLS	Bureau of Labor Statistics
MSDs	Musculoskeletal Disorders
HSE	Health and Safety Executive
WRMSDs	Work Related Musculoskeletal Disorders
ERFs	Ergonomics Risk Factors
CWA	Cognitive Work Analysis
SHOs	Safety and Health Officers
SPSS	Statistical Package for Social Science
EPA	European Productivity Agency
CTS	Carpal Tunnel Syndrome
UV	Ultra Violet
WBV	Whole Body Vibration
RSIs	Repetitive Strain Injuries

RMIs	Repetitive Motion Injuries
ILO	International Labor Office
OCDs	Occupational Cervicobrachial Disorders
UEMSDs	Upper-Extremity Musculoskeletal Disorders
HAVS	Hand-Arm Vibration Syndrome
LBP	Low back pain
LWB	Lightweight block
AAC	Autoclaved Aerated Concrete
PPE	Personal protective equipments
HAV	Hand arm Vibration
RII	Relative Importance Index
RBTs	Risk-based technologies
DOSH	Department of Safety and Health
ACS	Automatic Climbing System
SCC	Self Compacting Concrete
WDA	Work Domain Analysis
ConTA	Control Task Analysis
SA	Strategies Analysis
SOCA	Social Organization and Cooperation Analysis
WCA	Worker Competencies Analysis
AH	Abstraction Hierarchy
SBB	Skill-Based Behavior
RBB	Rule-Based Behavior
KBB	Knowledge-based behavior

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CHAPTER 1

INTRODUCTION

1.1 Background of research

Professional equipments that are used in building construction nowadays are the consequences of hard human efforts during centuries. Despite the existence of professional instruments, use of body in building and construction is inevitable, therefore the methods of using body for executing tasks are of great importance. Unfortunately poor working methods in building construction cause losses in the terms of physical and mental injuries and economics losses (Reese & Eidson, 2006).

The science that cares about the way of doing the human's work in workplace is required. The elements of this science are human behavior, abilities, situation, condition of work and environment. Maximizing the comfort, safety and health of workers, productivity and efficiency are the goals of application of this science (OSHA, 2000). Ergonomics tries to provide the best fit between the workers and their jobs; it is derived from two Greek words "ERGON" that means "work" and "NOMOS" which mean principles or laws, therefore literally Ergonomics means the laws of work (Sanders, 2004).

Based on Bridger (2003) a Polish natural scientist Jastrzebowski introduced the Ergonomics into literature in 1857 and years later in 1949 Murrell reinvented and established the Ergonomics formally. Industrial Developing Countries (IDCs) started to study and research on Ergonomics during the early 1960s. However there are some reports about Ergonomics earlier, for example it is reported by Sen (1984), one of the founders of Ergonomics in India, Ergonomics work at a cotton textile mill in West Bengal as early as 1953 (Mustafa et.al., 2009). History of Ergonomics in Malaysia goes back to the establishment of the Ergonomics division in the National Institute of Occupational Safety and Health (NIOSH) on 1st December 1992 (Mustafa et. al., 2009).

According to Grandjean (1980) Ergonomics is a study of man's behavior in relation to his work. The object of this research is man at work in relation to his spatial environment. The most important principle of Ergonomics is fitting the task to the human. Ergonomics is interdisciplinary; it bases its theories on physiology, psychology, anthropometry, and various aspects of engineering (Stanton, 2005). Definition of Ergonomics in Occupational Safety and Health Administration (OSHA 2000) is the science of "designing the job to fit the worker, instead of forcing the worker to fit the job" (OSHA 2000).

History and future of Ergonomics in building and construction was discussed at the First International Symposium of Ergonomics in Building and Construction by Koningsveld and van der Molen which was part of the 13th triennial congress of the IEA in Tampere in 1997. The results of the first international symposium of Ergonomics in building and construction can be interpreted as that the methods of work, condition and organization of work need to be changed fundamentally to provide a secure and healthy future for companies and labor force in construction industry (Karwowski, 2006). To obtain the safe future, Ergonomics can help to improve process of construction, therefore the awareness of Ergonomics knowledge and principles is essential to enhance the styles of work and create the safe workplace for personnel.

1.2 Problem statement

Protection of safety and health of construction workers may be challenging because of diversity, changeability and dynamic features of building and construction industry. Complexity of the projects and extensive scope of the works in construction industry make the workers to be exposed to injuries, illnesses, disabilities or even deaths. Construction industry has a very long history in improvement of methods and equipments during the years of its life. Despite the efforts done in occupational safety and health, construction industry has high rates in injuries and illnesses (SOCSO, 2010). Tasks associated with the building construction such as roofing, masonry, tile setting, plastering, concrete construction were classified among the top ten across other industries in initiated project by Washington state for the period 1990 to 1998. Twelve high-risk industries were recognized by the Standard Industrial Classification based on their prevention index, which is a combination of musculoskeletal injury incident rate and total number of injuries (Spielholz, 2006).

Several million workers each year are affected from Work-related musculoskeletal disorders (WRMDs) with total costs exceeding $100 billion every year. The upper-extremity Cumulative Trauma Disorders (CTDs) in the United States include 11% of all occupational injuries and contribute to work-related disability in a wide range (Dorf, 2005). It was reported by US Bureau of Labor Statistics (BLS) that almost 10 percent of all musculoskeletal disorders (MSDs) cases in 2004 occurred in construction. Construction industry is one of the seven occupations with the highest incident rate. Reporting of 9% of the 4.3 million incidents in private industry in 2004, a total of 401,000 non-fatal injuries and illnesses were incurred by construction workers; among them overexertion was the most common event (about 20% of all cases) for days away from work in private construction in 2004 (BLS, 2004). Injuries due to overexertion during work activities in construction (e.g., low back pain, cervicobrachial disorders, and upper extremity cumulative trauma injuries) accounted for 24% of all construction injuries (Everett**,** 1999).

Occupational safety and health statistics in construction industry are worse than other industry. According to Accident (1998) 6% of the laborers work in construction industry but 10% of occupational injuries and 21% of all occupational fatalities happens in this field (Everett**,** 1999). According to BLS in term of time way from work and loss of time, laborers in construction industry were placed fourth among other occupational groups in year 2000 because of musculoskeletal injuries. Average time way from work was 10 days for construction industries, while it was 7 days for other industries (BLS, 2000). Musculoskeletal injuries in construction work are among the most significant risk zones for Construction workers (Hess et. al., 2004). More than 55% of construction injuries reported in 2003 is related to Musculoskeletal Disorders (MSDs) based on the statistics of BLS (Sobeih et al, 2009).

Figure 1.1 shows that construction is among industries that have statistically significantly higher rates of work-related illness and reportable non-fatal injury (HSE Statistics, 2010/11).

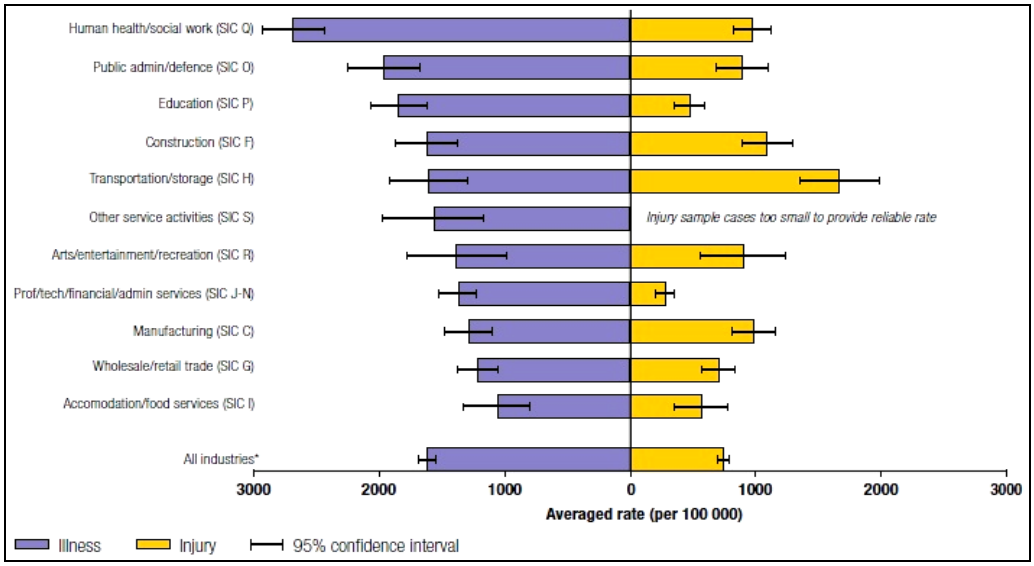

Figure 1.1 - Estimated rates of new cases of self-reported work-related illness and reportable non-fatal injury, by industry, for people working in the last 12 months, average 2008/09-2010/11 - Source: Labour Force Survey, HSE.

Figure 1.2 shows that MSDs and stress, depression or anxiety have higher incident rate than other illnesses (HSE Statistics, 2010/11).

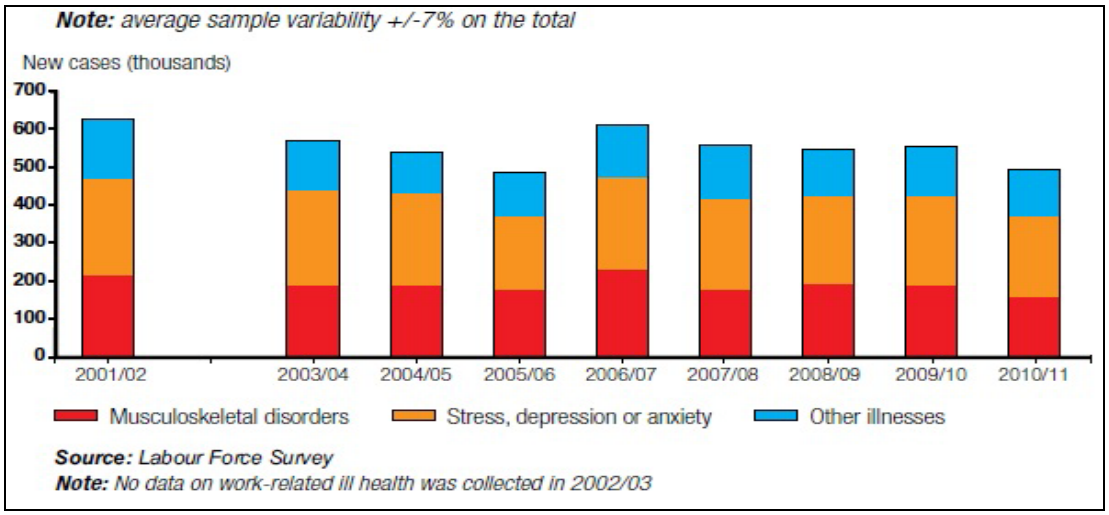

Figure 1.2 - New cases of self-reported work-related illness among people who worked in the last 12 months, HSE.

The Malaysian industry, as a developing industrial nation, experienced quick development from 2005 to 2010 under the 9th and 10th Malaysian plan. The job content is affected by introductions of new technologies, quickly changing marketing and strategies of production. This changing of job content leads to the prevalence of WRMSDs (Hashim & Taha, 2012). Figure 1.3 shows that diseases caused by physical agents such as noise, vibration and hot temperature and occupational Musculoskeletal Disorders (MSDs), which constitute more than 30% of all occupational diseases, originate from Ergonomics risk factors (ERFs).

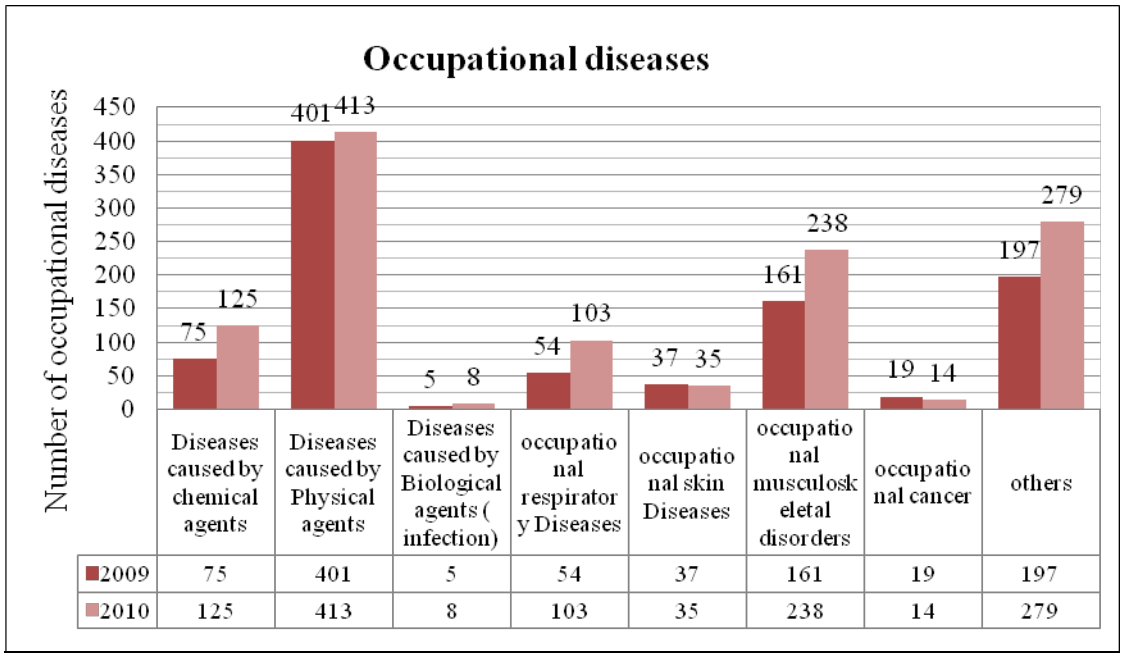

Figure 1.3 - Number of occupational diseases, Social Security Organization (SOCSO 2009-2010)

1.3 Aim and objectives of the research

The aim of this research is to study Ergonomics risk factors (ERFs) in building construction and to propose suggestions to mitigate Ergonomics injuries. To achieve the aim of this research the following objectives have been identified:

i. To identify the Ergonomics Risk Factors (ERFs) in building construction
ii. To evaluate the risk of Ergonomics Risk Factors (ERFs)
iii. To study factors affecting Ergonomics injuries in building construction
iv. To propose suggestions to reduce Ergonomics injuries
v. To investigate the application of Cognitive Work Analysis (CWA) in Ergonomics in construction domain

1.4 Scope of the research

This study investigated the construction industry in Malaysia, and the main scope was building construction in Johor Bahru. Project managers, Dosh officer, safety and health officers (SHOs), site managers and academicians involved in construction industry were respondents of this research for collecting data. Questionnaires and interviews with respondent conducted to ensure the accuracy of collected data.

1.5 Methodology in brief

The methodology that was used in this research was comprised of the following five phases (Figure 1.4).

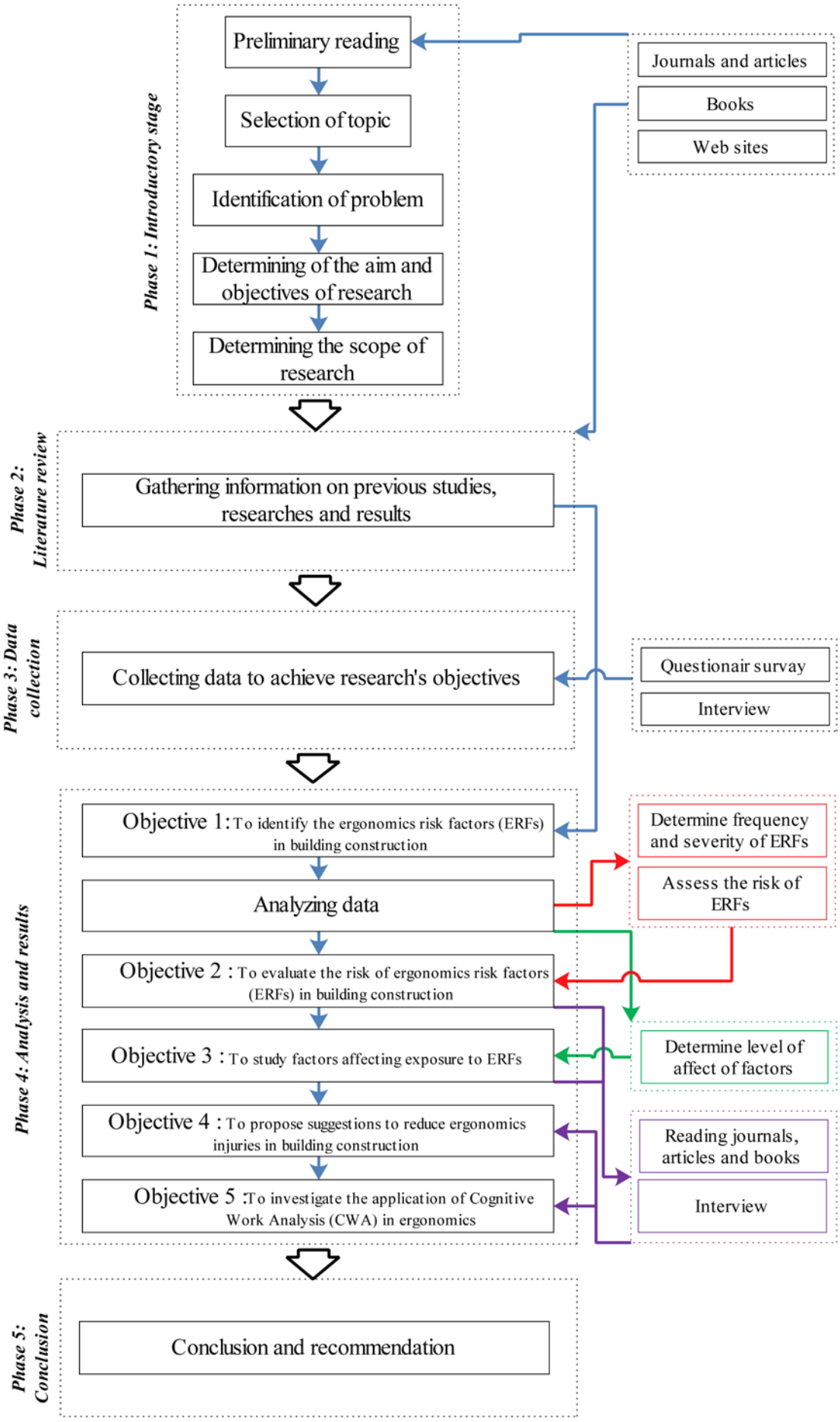

Figure 1.4 - Research Methodology

1.5.1 Phase 1: Introductory stage

In this phase articles and journals were studied to decide the area of research. The topic of the research was selected after the area was decided. The aim, objectives and scope of the research was determined in this phase as well.

1.5.2 Phase 2: Literature review

In second phase of this research, previous literatures, studies and researches related to the topic, in journals articles, Books and websites were reviewed.

1.5.3 Phase 3: data collection

In addition to collected information in second phase, in third phase objectives of the research were studied through distribution of questionnaires and interviews.

1.5.4 Phase 4: Analysis of data and results

Analysis of collected data through interviews and questionnaires was performed using Statistical Package for Social Science 18.0 (SPSS) software and Microsoft excel.

1.5.5 Phase 5: Conclusion and recommendation

Conclusions and recommendations were based on the results and achievements of research's objectives.

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