

SAFETY CONSIDERATIONS DURING THE DESIGN PROCESS IN
CONSTRUCTION INDUSTRY

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To my beloved wife

Thank you for your unconditional love, support, and care...

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In the name of God, the Compassionate, the Merciful

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ABSTRACT

Construction industry plays an important role in improvement of any country's economy. Despite the contributions to economy, there are many accidents and fatalities happening in construction industry. The intention of this research is to address workers' safety in the design stage prior to commencement of construction activities. To achieve the aim of this research construction site hazards are identified through previous literatures, interview and distributing questionnaires among safety officers, safety supervisors and project managers. The seriousness of construction hazards and level of effect of design factors on construction hazards are determined. Data collected through questionnaires have been analyzed using *SPSS* software and MS Excel. The reliability of data was assessed by Cronbach's alpha (α) value; frequency rate, Mean value and Relative Importance Index (RII) are used for analyzing data. The results indicate that serious construction site hazards originate from process of work, manual handling of operations and equipment; however these hazards can be extremely affected through factors in the design stage such as training and educating designers on construction safety and choice of construction methods and materials.

ABSTRAK

Industri pembinaan memainkan peranan yang penting dalam peningkatan ekonomi mana-mana negara. Selain daripada sumbangan terhadap ekonomi, terdapat begitu banyak kemalangan dan kematian yang berlaku dalam industri pembinaan. Tujuan kajian ini adalah untuk menangani masalah keselamatan pekerja di peringkat reka bentuk sebelum aktiviti pembinaan dijalankan. Bagi mencapai matlamat ini, bahaya mengenai tapak pembinaan perlu dikenal pasti melalui kajian literatur, temu bual dan mengedarkan borang soal selidik di kalangan pegawai keselamatan, penyelia keselamatan dan pengurus projek. Tahap keseriusan bahaya pembinaan dan tahap kesan faktor reka bentuk mengenai bahaya pembinaan ditentukan. Data yang dikumpul melalui soal selidik telah dianalisis menggunakan perisian SPSS dan MS Excel. Kebolehtentuan data dinilai oleh nilai alpha Cronbach (α), kadar kekerapan, nilai min dan Indeks Kepentingan Relatif (RII) digunakan dalam data analisis. Hasil keputusan menunjukkan bahawa bahaya tapak pembinaan itu berpunca daripada proses pengendalian kerja dan manual operasi dan peralatan. Namun bahaya ini boleh menjadi lebih kritikal melalui faktor-faktor di peringkat reka bentuk seperti latihan dan pendidikan kepada pereka mengenai keselamatan pembinaan dan pemilihan kaedah pembinaan dan bahan binaan.

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LIST OF ABBREVIATIONS

ABBREVIATIONS	FULLNAME
ACGIH	American Conference of Governmental Industrial Hygienists
ARCTM	Accident Root Causes Tracing Model
BBS	Behavior-based safety
BLS	Bureau of Labor Statistics
CDM	Construction (design and management)
CHAIR	Construction Hazard Assessment Implication Review
CHPtD	Construction Hazard Prevention through Design
COSHH	Control of Substances Hazardous to Health Regulations 1988
CTS	Carpal Tunnel Syndrome
DOSH	Department of Occupational Safety and Health
ERFs	Ergonomics Risk Factors
HSE	Health and safety executive
IAQ	Indoor Air Quality
ILO	International Labor Organization
ISTD	Institute for Safety Through Design
MSDs	Musculoskeletal Disorders
NIOSH	National Institute of Occupational Safety and Health
NORA	National Occupational Research Agenda
NSC	National Safety Council
OSH	Occupational Safety and Health
OSHA	Occupational Safety and Health Association
PPE	Personal Protective Equipment
PtD	Prevention through Design
RIDDOR	Reporting of Injuries, Diseases and Dangerous

	Occurrences Regulations 1995
RII	Relative Importance Index
SIC	Standard Industrial Classification
SOCSSO	Social Security Organization
SPSS	Statistical package for social science
USDOL	United States Department of Labor
UV	Ultra violet

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CHAPTER 1

INTRODUCTION

1.1 Background of research

Construction industry plays an important role in improvement of any country's economical growth. Despite the contributions to economical growth, construction industry has always been blamed for the high rate of accidents and fatalities; this matter has placed the construction industry among the industries with unreasonable rate of accidents, disabilities and fatalities. [Abdul Rahim Abdul Hamid et al., 2003]

According to report by NSC (National Safety Council) in 1996, 1000 construction workers died at work and 350,000 suffered disabilities. Although Construction workers constitute only 5% of the United States' workforce, an out of proportion rate of 20% of all occupational fatalities and 9% of all disabling occupational injuries relate to construction industry. [Tariq S. Abdelhamid et al., 2000]

In year 2002, US construction industry accounted for 1121 total fatalities, or 20% of all work-related fatalities in the United States [BLS (2003), USDOL 03-488]. The world rate of occupational injury, illness, and fatalities is still alarming. Nationally, more than 55,000 people die from occupational hazards annually, 294,000 illnesses and 3.8million are getting injured. The accidents' annual direct and indirect costs have been appraised to be from \$128 billion to \$155 billion [Paul A. Schulte et al., 2008].

Boundaries separating design and construction phases are sometimes interfered by issues that can cause integration between them. Construction site safety can be influenced by decisions made through the initial stages of design process by designers. Safety considerations during design stage means considering site safety proceedings and observations so as to ensure the safety of labor force in construction sites. [Behm, M., 2005]

Although Regulations enacted and many hard workings have been done in order to decrease the rate of accidents and fatalities in construction phase such as Occupational Safety and Health (OSHA), statistics gathered by safety related organizations such as ministry of labor, Social security organization (SOCSO), health and safety executive (HSE) and many others show unpleasant numbers of accidents and deaths and if not but very little improvement in safety and health compliance.

Reduction in number of accidents and fatalities is the ultimate aim of construction safety and health management in order to improve the overall performance of site activities that can reduce the risks of delay, cost, quality, labor turnover, and inefficiency and etc. Studies have been done on the influence of considering safety issues in design stage and fortunately it is proven that addressing construction site safety in design stage will reduce the probability of occurrence of accidents and fatalities. Problem statement

Based on statistics provided by safety and health organizations and formal evidences, construction industry includes a broad range of fatalities and accidents. Labor forces at construction sites are exposed to a variety of hazards that can cause permanent or temporary disability and also lead to fatality. Construction incidents will lead to delay in the process of project progress, increase in expenses and incurring a loss to contactors reputation and reliability. [Wang et al., 2006]

Statistics of HSE (Health and safety executive) shows that in U.K. construction workers are 5 times more likely to die because of accidents in construction sites and 2 times more likely to be seriously injured compared to the average rate of death and injuries for all other industries (HSE 2000) [Gregory Carter et al., 2006]. Construction workers in USA are more than three times likely to die because of accidents in construction sites and one worker out of each 6 workers is predicted to experience serious injury each year [Kartam, N. A., 2006].

Accidents that are reported to SOCSO (social security organization) are presented by DOSH (Department Of Occupational Safety and Health) as annual reports which show that notwithstanding safety regulations and standards the numbers of fatalities in construction sites are still high with imperceptible improvement in accidents reduction.

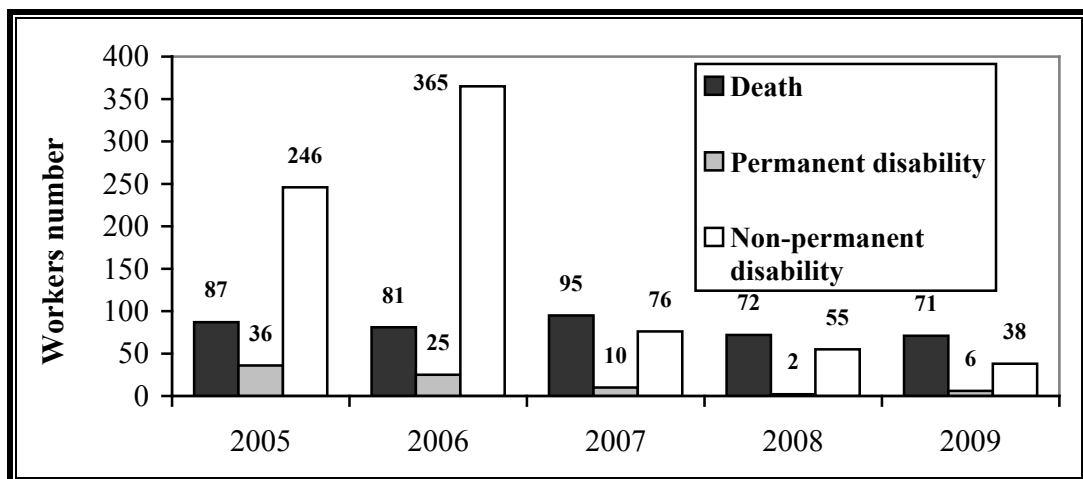


Figure 1.1 – Statistics of construction accidents - Source: DOSH annual report

Figure 1 shows the number of fatal accidents in Malaysian construction industry which have been reported to SOCSO for the year 2005 to 2009. According to statistics 406 fatality, 79 permanent disabilities and 780 nonpermanent disabilities have been reported to SOCSO for 5 years which cannot be ignored. Occupational Safety and Health Act (OSHA) was introduced on 25th of February 1994 in Malaysia and was enforced since then by law; according to statistics the introduction and application of OSHA has reduced the number of accidents in construction industry in Malaysia from 159 fatal accidents in year 2000 to less than 100 fatal accidents for each year during the years 2005-2009 but accidents are happening in construction sites yet.

Based on statistics of Social Security Organization (SOCSO) in 2000 the rate of deaths in Malaysian construction industry was 3 times as compared to other industries. Industrial accidents have direct and indirect costs; based on statistics of SOCSO the compensation paid out to industrial accidents and diseases by SOCSO reach to 650 million ringgits. The indirect cost of accidents is estimated to be 8 to 33 times of direct costs; therefore the total costs of accidents account for billions of ringgits. [Abdul Rahim Abdul Hamid et al., 2003]

Construction has one of the highest accident rates of all industries in the UK and this is also the situation in other parts of the world. However, whilst we have reliable information on fatal injuries, non-fatal RIDDOR (Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995) reports are subject to significant under-reporting. [R.A. Haslam et al., 2005]

According to annual reports of Health and Safety Executive (HSE) the construction industry in U.K. introduces the highest rate of accidents compared to all industries and this is the situation in almost all around the world. Based on HSE reports fatal accidents are all recorded while non-fatal injuries are mostly underreported. As it is shown in figure 1.2, 53 fatal injuries is reported in 2008/09p which shows a decrease of 26% as of year 2007/08 for 72 fatal injuries. The rate has

also shows an inclination of 26%, from 3.4 to 2.5. Although the rate and the number of fatal injuries have reduced by 47% since 1999/00, the current scenario in construction industry is not satisfactory in terms of safety and health. [www.hse.gov.uk/construction/pdf/conintreport.pdf]

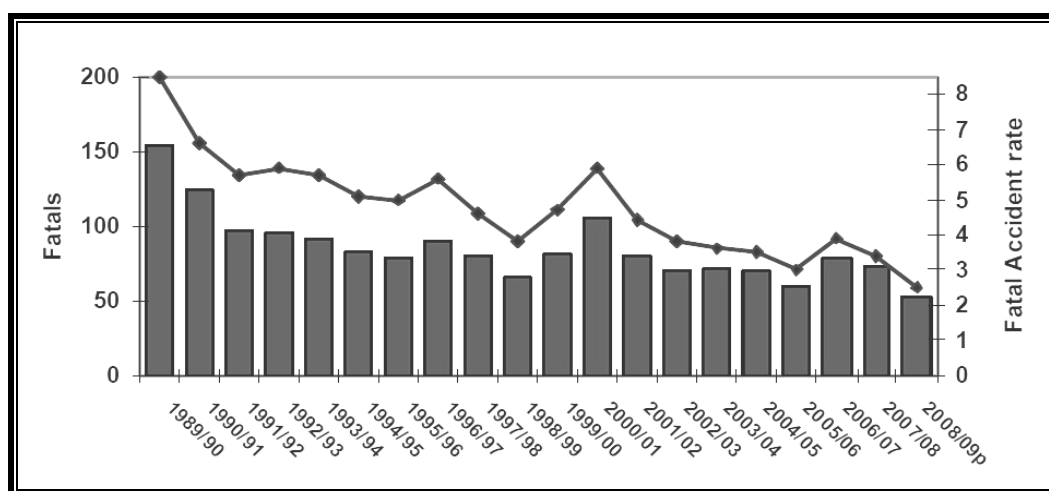


Figure 1.2 - Construction workers' fatal injuries reported by HSE (April 1989 to March 2009)

According to reports by HSE the number of “falls from height” account for almost half number of all fatal accidents in construction industry. Struck by object, struck by moving vehicle, electricity and collapse are other higher rates of fatal accidents in construction industry in U.K.

Spanish construction industry accounts for 30% of all fatal accidents occur in all industries during 2000 to 2006 which is approximately 350 deaths of workers each year. (Ministerio de Trabajo e Inmigración, Subsecretaría de Trabajo y Asuntos Sociales, 2006); Human disaster, delay in project, increased costs and reputation damage are some unreasonable results of construction injuries and accidents.

The fact that the traditional safety approach is “amendment after accident” infuse the wrong belief that safety engineers are responsible just after the happening of any construction accidents; this belief will lead to unpleasant effects such as physical harms, financial expenses, delay of construction process and many other obstacles through the smooth running of the construction projects. [Roozbeh Ghaderi et al., 2011]

Labor organization of countries reveal statistics on workers accidents in different industries and based on these statistics construction industry has the one of the highest potential of safety and health risks. In addition construction incidents are leading to delay in the process of project progress, increase in expenses and incurring a loss to contractors reputation and reliability (Wang et al, 2006). [Roozbeh Ghaderi et al., 2011]

Designers have to recognize their responsibility through safe design so as to ensure the safety of workers in construction sites. There is a necessity on reducing the rate of accidents by considering safety issues during the design phase of any construction project prior to application of safety and health acts and regulations because the ability to influence the safety and health of the construction site will be reduced through the construction projects life cycle. Initial stages of construction projects mainly preliminary and detailed design are likely to have more ability to affect the safety and health issues of construction phase of projects.

1.2 Aim and objectives of the research

The aim of this research is to enhance safety during the construction phase, to achieve the above aim the following objectives have been formulated:

- i. To study the construction site hazards

- ii. To study factors affecting construction site hazards in the design stage
- iii. To propose suggestions in the design stage to reduce construction site hazards

1.3 Scope of the research

The research has been focused on studying hazards in Malaysian building construction. Respondent to this research for collecting data were safety officers, safety supervisors and project managers who were working in Malaysian construction industry.

1.4 Methodology in brief

Each research has a methodology in order to achieve its aim and objectives. The aim of this research is going to be achieved through several stages which constitute the methodology of the research. The following phases are not fixed and during the progress of research they may change.

Phase 1: Preliminary stage

Selection of the research topic through reading articles and journals, problem finding, determining the aim and objectives of the research and determination of the research scope constitutes the 1st phase of research.

Phase 2: literature review

Previous literatures related to topic will be reviewed. Secondary data consist of books, articles in journals and internet will be scrutinized to achieve an overview of the previous studies, researches, results and analysis.

Phase 3: Data collection

Besides collecting information from secondary data, the objectives of the research will be studied through primary data in 3rd phase; predesigned questionnaires will be distributed and semi-structured interviews will be conducted for this reason. Safety professionals, managers and officers constitute the respondents of primary data collection in this phase of research.

Phase 4: Analysis and discussion

Analysis of data which have been collected in previous phases is will be performed; a summary of results will be prepared to conduct a discussion with expert panels to ensure the accuracy of results.

Phase 5: Conclusion and recommendation

Followed by analysis of data, the conclusion is made and based on conclusions recommendations and suggestions will be proposed.

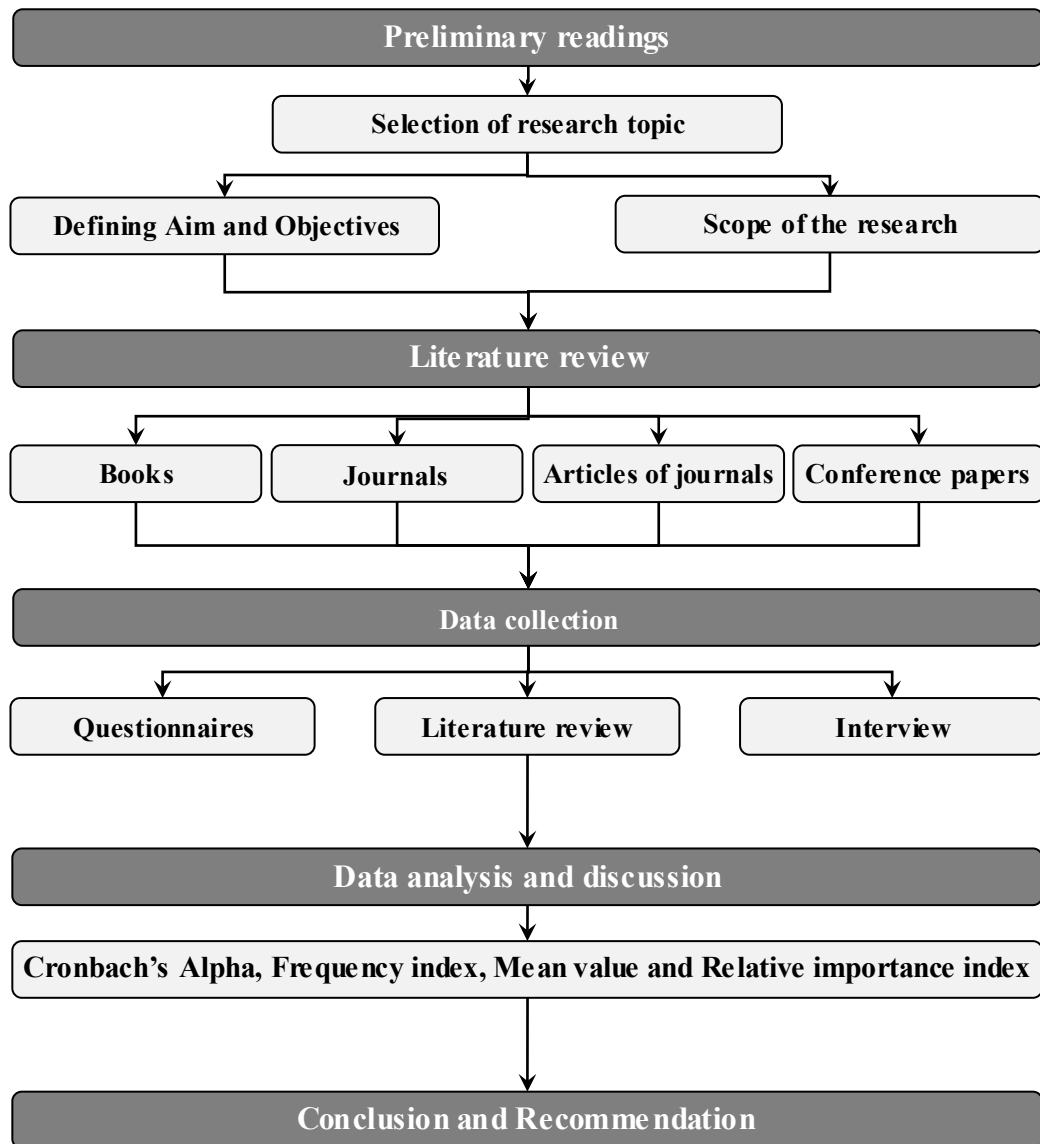


Figure 1.3 - Research methodology flowchart

1.5 Significance of research

This significance of this research is to address safety and health hazards of construction site activities through the design stage of construction projects. The results of this research will help designers to consider hazards in their design so as to

enhance the safety and health of construction workers during the construction phase of projects.

1.6 Expected findings

The research is aimed at finding design solutions and suggestion relevant to construction workers' safety at the design stage of projects. The results of this research will help designers to recognize the hazards which endanger the life of workers so that they can consider these issues in their design.

On the other hand:

- i. Enhancing safety and health at construction sites
- ii. Encouraging designers to consider safety in design

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