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RISK ASSESSMENT FOR SAFETY AND HEALTH ALGORITHM FOR BUILDING CONSTRUCTION IN OMAN

SAUD SAID AL-ANBARI

FK 2015 168

RISK ASSESSMENT FOR SAFETY AND HEALTH ALGORITHM FOR BUILDING CONSTRUCTION IN OMAN

By

SAUD SAID AL-ANBARI

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, Faculty of Engineering, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

April 2015

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in Fulfilment of the requirement for the degree of Doctor of Philosophy

RISK ASSESSMENT FOR SAFETY AND HEALTH ALGORITHM FOR BUILDING CONSTRUCTION IN OMAN

By

SAUD SAID AL-ANBARI

April 2015

Chairman: Khalina binti Abdan, PhD
Faculty: Engineering

Building construction is extremely hazardous. Numerous fatal and non-fatal vocational injuries occur due to the unique nature of the building construction workplace. The swift expansion of the Omani economy has led to the extensive expansion of infrastructure and resources in the construction sector. Hazard Identification, Risk Assessment and Risk Control (HIRARC) is a structured approach for identifying, evaluating and controlling hazards in the work place. Risk assessment matrices are widely used to evaluate risks related to such hazards. Existing risk matrices are designed based on brainstorming sessions, which may make these matrices risky to use because such sessions are based mainly on experience and knowledge about the decision at hand.

The general objective of this study is to carry out a Risk Assessment for Safety and Health (RASH) algorithm for building construction in Oman and to develop a calculation methodology to evaluate safety and health. The RASH algorithm is defined by overall risk, which is equivalent to the sum of Risk Safety Safety, Risk Safety Health, Risk Health Safety, and Risk Health Health. By implementing definitions of safety and health on the identified extreme and high-risk levels, the key risks in this study have been classified into safety risks and health risks. Then, the safety risks have been categorized into 11 factors, and the health risks have been categorized into 8 factors.

Using these two categories of risk, four scenarios reflecting the four zones of the occupational safety and health risk matrix were designed. Then, 40 safety and health specialists were involved in carrying out a risk assessment using the existing method of risk analysis (RA) and the new proposed method of RASH. The Wilcockson Ranked Test was applied to evaluate the differences between these two methods. It was found that there were differences between the percentages of correct answers found by the two methods, as follows: 75% of RASH answers were correct, and 40% of RA answers were correct. The results revealed that the two methods are significantly different ($z = 0.357$, $p < 0.01$). It was also found that RA respondents tend to overestimate risk, even when conditions were very safe. This common mistake has cost and time implications in construction activities.

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It was found that 60% of evaluations using RA might be estimated mistakenly. From the analysed results, it is recommended that organizations refrain from relying on the RA to prepare risk assessments and mitigation plans. Instead, it is suggested that results be verified with an alternative method of assessing risk, such as RASH. In conclusion, RASH is an alternative and effective method for the assessment of safety and health risks in building construction in Oman.

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ALGORITMA PENILAIAN RISIKO UNTUK KESELAMATAN DAN KESIHATAN PEKERJAAN UNTUK PEMBINAAN BANGUNAN DI OMAN

Oleh

SAUD SAID AL-ANBARI

April 2015

Pengerusi: **Prof.Madya Khalina binti Abdan, PhD**
Fakulti: **Kejuruteraan**

Pembinaan bangunan adalah suatu tempat kerja yang sangat berbahaya di mana kecederaan vokasional boleh membawa maut atau tidak paling kerap berlaku disebabkan aktiviti kerja yang unik dan berbahaya. Pengembangan pantas ekonomi Oman telah membawa kepada peningkatan tinggi pada infrastruktur dan sumber dalam sektor ini. Pengenalpastian bahaya, penilaian risiko dan pengawalan risiko Hazard Identification, Risk Assessment & Risk Control (HIRARC) adalah satu pendekatan berstruktur untuk mengenalpasti, menilai dan mengawal risiko bahaya di tempat kerja. Untuk analisa risiko (RA), matrik penilaian risiko telah digunakan secara meluas. Matrik sediada direkabentuk berdasarkan sesi sumbang saran yang menjadikan keputusan yang diambil hasil dar inya adalah berisiko digunakan. Ini kerana keputusan tersebut adalah berdasarkan pengalaman dn pengetahuan penilai semata-mata.

Objektif umum kajian ini adalah untuk menjalankan penilaian risiko keselamatan dan penilaian risiko kesihatan Risk Assessment for Safety and Risk Assessment for Health (RASH) Algoritma untuk pembinaan bangunan di Oman dan seterusnya membangunkan kaedah pengiraan untuk menilai RASH. Dengan menggunakan takrif keselamatan dan kesihatan yang telah dikenalpasti sebagai berisiko tahap tinggi, risiko utama dalam kajian ini telah dikelaskan kepada risiko keselamatan dan risiko kesihatan. Kemudian risiko keselamatan telah dirumuskan kepada 11 faktor dan risiko kesihatan kepada 8 faktor. Algoritma RASH ditakrifkan oleh risiko keseluruhan yang menjumlahkan risiko keselamatan keselamatan, risiko keselamatan kesihatan, risiko kesihatan keselamatan, dan risiko kesihatan kesihatan.

Dengan menggunakan dua kategori tersebut di atas, empat senario telah direkabentuk mencerminkan empat zon dalam matriks risiko keselamatan dan kesihatan pekerjaan. Kemudian, 40 pakar keselamatan dan kesihatan terlibat untuk penilaian risiko menggunakan kaedah analisis risiko (RA) sedia ada dan kaedah baru yang dicadangkan (RASH). Ujian Wilcockson Ranked telah digunakan untuk menilai perbezaan kepentingan antara kedua-dua kaedah. Terdapat perbezaan di antara peratusan jawapan diperbetulkan dalam dua kaedah (RASH) 75 % dan (RA) 40%. Keputusan mendedahkan bahawa kedua-dua kaedah mempunyai perbezaan kepentingan yang jauh berbeza ($z = 0.357$, $p > 0.01$). Responden juga cenderung

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untuk menganggar risiko pada tahap yang tinggi walaupun keadaan tersebut selamat. Keputusan yang kerap sebegini akan memberi implikasi pada kos dan masa.

Didapati 60% daripada komponen penilaian menggunakan RA berkemungkinan tersilap dalam membuat anggaran. Daripada analisa keputusan, adalah disyorkan untuk tidak bergantung pada RA semata mata dalam penilaian risiko dan penyediaan pelan mitigasi organisasi. Kajian ini mencadangkan agar RASH digunakan sebagai kaedah alternatif untuk mengesahkan penilaian risiko kaedah RA. Kesimpulannya kaedah RASH didapati memberikan kesan yang lebih tepat untuk membuat penilaian risiko keselamatan dan kesihatan dalam pembinaan bangunan di Oman.

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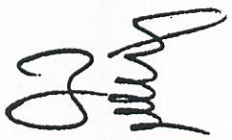

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ALGORITMA PENILAIAN RISIKO UNTUK KESELAMATAN DAN KESIHATAN PEKERJAAN UNTUK PEMBINAAN BANGUNAN DI OMAN

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Pembinaan bangunan adalah suatu tempat kerja yang sangat berbahaya di mana kecederaan vokasional boleh membawa maut atau tidak paling kerap berlaku disebabkan aktiviti kerja yang unik dan berbahaya. Pengembangan pantas ekonomi Oman telah membawa kepada peningkatan tinggi pada infrastruktur dan sumber dalam sektor ini. Pengenalpastian bahaya, penilaian risiko dan pengawalan risiko Hazard Identification, Risk Assessment & Risk Control (HIRARC) adalah satu pendekatan berstruktur untuk mengenalpasti, menilai dan mengawal risiko bahaya di tempat kerja. Untuk analisa risiko (RA), matrik penilaian risiko telah digunakan secara meluas. Matrik sediada direkabentuk berdasarkan sesi sumbang saran yang menjadikan keputusan yang diambil hasil dar inya adalah berisiko digunakan. Ini kerana keputusan tersebut adalah berdasarkan pengalaman dn pengetahuan penilai semata-mata.

Objektif umum kajian ini adalah untuk menjalankan penilaian risiko keselamatan dan penilaian risiko kesihatan Risk Assessment for Safety and Risk Assessment for Health (RASH) Algoritma untuk pembinaan bangunan di Oman dan seterusnya membangunkan kaedah pengiraan untuk menilai RASH. Dengan menggunakan takrif keselamatan dan kesihatan yang telah dikenalpasti sebagai berisiko tahap tinggi, risiko utama dalam kajian ini telah dikelaskan kepada risiko keselamatan dan risiko kesihatan. Kemudian risiko keselamatan telah dirumuskan kepada 11 faktor dan risiko kesihatan kepada 8 faktor. Algoritma RASH ditakrifkan oleh risiko keseluruhan yang menjumlahkan risiko keselamatan keselamatan, risiko keselamatan kesihatan, risiko kesihatan keselamatan, dan risiko kesihatan kesihatan.

Dengan menggunakan dua kategori tersebut di atas, empat senario telah direkabentuk mencerminkan empat zon dalam matriks risiko keselamatan dan kesihatan pekerjaan. Kemudian, 40 pakar keselamatan dan kesihatan terlibat untuk penilaian risiko menggunakan kaedah analisis risiko (RA) sedia ada dan kaedah baru yang dicadangkan (RASH). Ujian Wilcockson Ranked telah digunakan untuk menilai perbezaan kepentingan antara kedua-dua kaedah. Terdapat perbezaan di antara peratusan jawapan diperbetulkan dalam dua kaedah (RASH) 75 % dan (RA) 40%. Keputusan mendedahkan bahawa kedua-dua kaedah mempunyai perbezaan kepentingan yang jauh berbeza ($z = 0.357$, $p > 0.01$). Responden juga cenderung

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untuk menganggar risiko pada tahap yang tinggi walaupun keadaan tersebut selamat. Keputusan yang kerap sebegini akan memberi implikasi pada kos dan masa.

Didapati 60% daripada komponen penilaian menggunakan RA berkemungkinan tersilap dalam membuat anggaran. Daripada analisa keputusan, adalah disyorkan untuk tidak bergantung pada RA semata mata dalam penilaian risiko dan penyediaan pelan mitigasi organisasi. Kajian ini mencadangkan agar RASH digunakan sebagai kaedah alternatif untuk mengesahkan penilaian risiko kaedah RA. Kesimpulannya kaedah RASH didapati memberikan kesan yang lebih tepat untuk membuat penilaian risiko keselamatan dan kesihatan dalam pembinaan bangunan di Oman.

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I certify that a Thesis Examination Committee has met on ..... to conduct the final examination of SAUD AL-ANBARI Mattar on his thesis entitled "RISK ASSESSMENT ALGORITHM FOR SAFETY AND HEALTH (RASH) FOR CONSTRUCTION OF BUILDINGS IN OMAN" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the PhD of Engineering.

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CHAPTER 1

INTRODUCTION

1.1 Background

Building construction is extremely hazardous. Numerous fatal and non-fatal vocational injuries occur due to the construction workplaces' unique nature (Hyoung et al., 2009). The risks in construction have a highly dynamic nature caused by the various feedback processes involved in the project life cycle (Nasirzadeh et al., 2008). Construction sites are characterized by the use of many diverse resources, continual changes, poor working conditions, unstable employment, and tough working environments (e.g., dust, noise, handling of cargo, vibration and direct weather exposure). In addition, legal records, documentation and statistical data created by companies are usually insufficient for risk determination (Emre et al., 2008). Moreover, building construction requires the coordination of different interdependent operations, sub-contractors and contractors, which may result in increased risk of injury. Therefore, there is a considerable need to develop an effective safety and health risk assessment procedure to improve construction project performance (Farnad et al., 2008). Risk assessments are used to asses risks and their target impacts, as well as to put corresponding measures in place for making decisions (Yuan et al., 2009).

The expeditious expansion of Oman's economy implies future colossal expansion of infrastructures and resources. Although this provides opportunities to estimate stakeholders' effectual safety and health, risk assessment methods to manage the risks associated with fluctuating building construction activities is important for implementing projects and project objectives, including safety, health, cost, time, quality and environmentally sustainable development.

Between 2013 and 2014, Omani construction industries witnessed a doubling in contracts awarded across sectors, from approximately US $6,963 million to US $12,648 million, following the continued expansionary fiscal policy of the government, which is likely to drive investment and growth across sectors in the long run (Research and Markets, 2013).

Oman (officially: the Sultanate of Oman) is an Arabian country located in the southwest of Asia on the southeast coast of the Arabian Peninsula. It has a strategically important position at the mouth of the Arabian Gulf (figure 1.1), where it is bordered by the United Arab Emirates(UAE)in the northwest, Saudi Arabia in the west and Yemen in the southwest. It also shares marine borders with Iran and Pakistan. Oman's coast is formed by the Arabian Sea in the southeast and the Gulf of Oman in the northeast.

Figure 1.1: Sultanate of Oman map

Identifying risk is the first step of the Risk Assessment of Safety and Health (RASH) method, in which potential risks associated with projects in construction are identified. As an integrative part of identifying risk, this classification of risk attempts to organize the various risks affecting building construction. The impacts of occupational illnesses and injuries affect not only safety and health, but also economics, due to the high costs associated with work injuries. Hinze et al. (2006) noted that safety and health in construction have obtained attention because of workers' increasing insurance compensation premiums, resulting from immense cost increases in medical care for convalescents and work injuries.

Building construction is one of the largest employment sources in any country, as well as one of the most dangerous and risky industries (Mriyas, 2009). In building construction, workers carry out a great variety of activities. Each activity is associated with a specific risk. Studies on causal analyses of accidents are widespread in the literature, including the literature on building construction (Cameron et al., 2008). Workers who perform a task are directly exposed to its associated risks and submissively exposed to risks produced by close co-workers. In addition, the technicians responsible for managing and controlling projects are also exposed to different risks (Barandan, 2004). Thus, there are a number of risk factors affecting safety in construction. These factors will be discussed in the following section.

Carrying out risk assessment enables control measures to be devised, which enables a subsequent analysis of the relative importance of risks. This can help in making decisions regarding which controls are the most cost effective and appropriate. According to a health and safety executive:

> Risk assessment is not an end to itself. It is a means to better management of safety. It is a thinking process which enables management of determined priorities and allocates resources in a way which will better control or eliminate risks to health and safety at work. (Saravana et al., 2013)

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Although, to date, there is no solid information regarding construction accidents in Oman, preliminary data collected by the Ministry of Health (Watfa 2009) show that occupational accidents and diseases represent a real burden to social and healthcare services. Studies on the burden of occupational injuries and diseases indicate that 4% of the world's Gross Domestic Product (GDP) is lost as a cost of these occupational injuries and diseases.

While this burden may represent a future concern, this area has not been previously researched by others. However, the hazards identified in building construction sites can be used as a model hazards. The developed risk evaluation process will, thus, be similar across locations, allowing it to be implemented in other workplaces. As a result, a general risk assessment procedure can be developed.

Generally, risk assessment is carried out in two parts: quantitative assessment and qualitative assessment. These two parts are not mutually exclusive. Qualitative assessment is easier, since the focal object's probability is estimated based upon known risk information and the applied circumstances being considered. In contrast, in quantitative risk, the assessment is subjective to personal judgments, which are backed by generalised risk data (MacAuslan, 1993). The aim of this study is to develop a new RASH methodology that reduces errors made during risk judgements.

1.2 Purpose of RASH

Although occupational health and safety are well established as the basis for developing health and safety standards, no methodology to estimate associated risks has been consistently applied in the derivation of occupational health and safety standards. Currently, the matrices used to estimate risk factors include people (workers), environment, property, cost and reputation. No clear distinctive matrix is made exclusively for occupational health and safety. The development of an independent matrix for occupational safety and health will protect workers from compromising their lives through other factors.

1.3 Project scope

The scope of this research comprises building construction projects in Oman handled by top contractors. Key risks in safety and health in building construction are carefully identified using data from local authorities, HAZID reports and scurvies. Interview sessions were carried out with safety and health experts in the construction companies. Moreover, a field survey was distributed to workers and safety and health experts who worked with clients, contractors and consultants via questionnaires. The field survey targeted people who were directly involved in building construction projects. The research was conducted during the construction phase of 2013 and was limited to occupational risk assessment ORA using 5X5 matrices.

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1.4 Objective

The general objective of this study is to develop an algorithm for the assessment of risks for safety and health (RASH) at building construction sites. More specifically, the study:

1) Defines the key risks in safety and health in building construction,
2) Develops a comprehensive method of risk assessment for safety and health in building construction, and
3) Evaluates the significance of the new proposed method against the existing method of risk assessment for safety and health.

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