

Chemical Safety in Quarrying (Jerlan Kuari Sdn. Bhd., Terengganu)

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Abstract. Chemical safety is one of the most frequent aspect neglected in quarries. The case study is to map out the quarrying processes conducted at Jerlan Kuari Sdn Bhd, Terengganu, to study the effect of chemicals used in each of the processes, to study the implementation of safety requirements enforced by DOSH at Jerlan Kuari Sdn. Bhd and last but not least to propose methods to mitigate the effect of the chemicals. By studying documents, observations, distributing questionnaires and interviews, the severity and frequency of chemical risks in Jerlan Kuari Sdn. Bhd. were measured. The participants for this research includes all the workers that are exposed to chemicals during work and were divided into their work unit. In order to understand the data, these methods were used to analyze it; (a) frequency rate, (b) mean index, and (c) Hazard Identification, Risk Assessment and Risk Control(HIRARC). The results indicate the level of hazards and the possible risk for each chemical on the workers when Personal Protective Equipment (PPE) is inadequately used. Based on the result obtained, it was proposed for the management team to enforce the use of PPE compliant to DOSH Guideline and to continue updating the chemical registers as per the regulations in Use and Standard of Exposure of Chemical Hazardous to Health (USECHH).

Introduction

Construction industry plays a vital role in the economic development of a certain country. This huge industry can be broken down into smaller sectors such as materials, labors, etc. One of the main materials used for construction work (e.g. highway, building) is aggregates. And this essential material can only be produced by quarries. In order to run the aggregates production process, a lot of chemicals such as oils, explosives, etc., were used. And these chemicals can be hazardous towards the person working with it if it is not handled with care and without a proper protection.

Hazardous chemicals, once entered our body, will have a great effect on our inner organs. In worst cases, attacking our lungs, failuring our kidney and many more. Based on Social Safety Corporation (SOSCO), a significant increase of occupational lung disease in Malaysia was shown in the year of 2010 where 103 numbers of cases were reported compared to 54 numbers of cases in year 2009. These numbers keep increasing until year 2013 with 146 cases and fall to 107 cases on year 2014[1]. Meanwhile, Worksafe California studied that about 2,200 people had lost their life each year suffering from pneumoconiosis (caused by inhaling too many dust), silicosis (lung fibrosis) and cancers as an effect to long exposures to hazardous chemicals at work [2].

Hence, in order to understand more about the risk of hazardous chemicals on workers, a research had to be done in Jerlan Kuari Sdn. Bhd. to study the process of quarrying and to propose method(s) to enhance the safety of the quarrying process. Below are the primary objectives of this research:

- i. To map the quarrying processes conducted at Jerlan Kuari Sdn Bhd, Terengganu.
- ii. To study the effect of chemicals used in each of the processes.
- iii. To study the implementation of safety requirements enforced by DOSH at Jerlan Kuari Sdn. Bhd., Terengganu.
- iv. To propose methods to mitigate the effect of the chemicals.

Methodology

Preliminary Investigation In this early stage, concerning problems were first identified and then the scopes were narrowed down to smaller topics. And later, the main topic was decided. Hence, the aim and objectives of the scopes were defined.

Literature Review For literature review, quarrying activities were the first topic to be looked and then followed by the work units in the quarry, chemicals involved for each work unit and its hazardous risk, Chemical Health Risk Assessment (CHRA), the safety regulations in Jerlan Kuari Sdn. Bhd., the Guidelines on the use of PPE Against Chemical Hazards according to the Department of Occupational Safety and Health (DOSH) and lastly, the quarrying products.

Respondents A total number of 15 participants were selected to fill up the questionnaires distributed. Only the employers that had been working with Jerlan Kuari Sdn. Bhd. for more than one month and are willingly agreed to be a part of this study were selected. The respondents must also be working with chemicals in their job scope.

Questionnaire Outline For the purpose of ensuring that the respondents are going to fully understand the questions, the questionnaire sets were printed in English and also the national official language, Malay language.

The questionnaires were separated into 4 parts, Section A, Section B, Section C, and Section D. Each part focuses on a certain objectives of this study in order to simplify the data analyzing process later on. For example, the first part (Section A) includes the general details of the respondent such as their gender, age, working experience and also the amount of working hours per day. It also covers the work unit of the respondent and some brief questions on their health history. Meanwhile, in the second part (Section B), the respondents were able to rate the condition of their health during their years working at the quarry.

For the next part (Section C), the respondents were given the chance to rank the regularity of their exposure to chemicals and also their PPE practice at work. Lastly, for Section D, the respondents were required to answer questions such as the level of awareness for chemical safety and their satisfactory level on the safety practices at their workplace.

The data collected from the questionnaires were analyzed by using frequency rate. Meanwhile, only Section B and C were analyzed by using mean index rate. Mean index rate is used to produce an average value for each part. The table below shows the level of chemical risk on the respondent for each mean index range.

Table 1: Mean Index Value and Description

Index	Level of chemical risk on the respondent
$1.00 \leq \text{Mean Index} < 1.50$	Not affected at all
$1.50 \leq \text{Mean Index} < 2.50$	Slightly affected
$2.50 \leq \text{Mean Index} < 3.50$	Moderately affected
$3.50 \leq \text{Mean Index} < 4.50$	Affected
$4.50 \leq \text{Mean Index} \leq 5.00$	Extremely affected

Chemical Health Risk Assessment There are 10 steps needed to be done before producing a Chemical Health Risk Assessment (CHRA) report [3]. In short, these steps are;

- Step 1 : Decide on a competent assessor
- Step 2 : Gather all the information concerning chemicals, work & work activities

- Step 3 : Divide the work activities that involve chemicals into work units
- Step 4 : Determine the degree of hazards for each chemicals

- Step 5 : Evaluate the exposure of the chemicals on the workers by using the frequency rating and also duration rating

Frequency and duration rating of exposure are described below:-

- a) Frequency rating

Table 2: Rating for frequency of exposure and its definition

Rating	Description	Definition
5	Frequent	Potential exposure one or more time per shift or per day
4	Probable	Exposure greater than one time per week
3	Occasional	Exposure greater than one time per month
2	Remote	Exposure greater than one time per year
1	Improbable	Exposure less than one per year

- b) Duration rating

Table 3: Rating for duration of exposure

Rating	Total Duration of Exposure	
	% work hour	Duration per 8-hour shift or per 40-hour week
5	>87.5%	>7 hours/shift or >35 hours/week
4	50-87.5%	4 to 7 hours/shift or 20 to 35 hours/week
3	25-50%	2 to 4 hours/shift or 10 to 20 hours/week
2	12.5-25%	1 to 2 hours/shift or 5 to 10 hours/week
1	<12.5%	< 1 hour/8hrs shift or <5 hours/week

- Step 6 : Assess the adequacy of the present control measures
- Step 7 : Conclude the assessment

Table 4: Classification of risk

Conclusion	Risk Decision
C1	Risk not significant now
C2	Risk significant but adequately controlled
C3	Risk significant and not adequately controlled
C4	Insufficient information
C5	Uncertain about exposure

- Step 8 : Identify actions needed to be taken according by the DOSH guidelines

Table 5: Recommendation(s) for each C Rating

C Rating	Recommendation for the Action to be Taken
C1	End current assessment. A review of the assessment is in five years or if the situation changes.
C2	Precautions are needed to maintain controls and lessen the chances of higher exposure happening. Regardless of the already available precautions, additional measures are still required in order to regain control if a high-risk event occurs. Determine if monitoring or health surveillance is required to check on the effectiveness of controls. A review of the assessment is in five years or if the situation changes.
C3	Identify and implement immediate measures for preventing or controlling exposure. Establish the need to stop the process. Begin review of longer terms control requirements. Determine if monitoring or health surveillance is required.
C4	Further steps will be taken by the company and the assessor to acquire the information needed.

C5 Qualitative assessment will be recommended for inhalation exposure which technique and standard for measurement are available. Other option will be referred to specialists.

- Step 9 : Summary report that includes the executive summary, background, findings and conclusion
- Step 10: Review assessment to confirm whether the risk of the situation has changed or if there is a need to change the control plans or alter the exposure parameters.

Data Analysis

Questionnaire Analysis All 15 questionnaires distributed were returned with full answers. The respondents are embodied of 47% from crushing work unit (7 workers), 27% from blasting and drilling (4 workers), and 13% each for welding and workshop (2 welding workers and 2 workshop technician).

Chemical Health Risk Assessment 24 numbers of chemicals were detected in all 4 work unit. And 19 were categorized in risk significant category 1, 7 in blasting and drilling, 1 in crushing, 7 in workshop work and 4 in welding work. Meanwhile, the balance of 5 chemicals are considered non-risk significant where 2 chemicals are in crushing, 2 are in workshop work and 1 in welding work.

In terms of C Rating which is taken according to the DOSH guideline, 5 chemicals are labeled as C1 (risk are not significant now), 18 are known as C3 (risk are significant and not adequately controlled), and 4 chemicals as C4 (having insufficient information). These results can be viewed in Table 6.

Respondent Information (Frequency Rate) Male contributes a 100% of the respondents, showing a clear sign that male are more preferred when involving quarrying activities. 40% of the respondents are 20 to 29 years old (6 workers), 26.7% are 30 to 39 years old (4 workers), 20% are 40 to 49 years old (3 workers), and the balance of 13.3% are 50-59 years old (2 years old). Most of them have more than 7 years of working experience which gives us 40% on that count with 6 person in total, meanwhile the rest of 60% which is divided equally into 3 categories, admitted that they have either 1 to 2 years, 3 to 4 years or 5 to 6 years. All 15 of the workers are termed to 5 to 8 working hours per day. Fortunately, none of the respondents had ever suffered from chronic illnesses or had to take medicines in the long term. This indicates that most of the workers are still young however experienced, and are expose to the same amount of hours to the chemicals. It also shows that the respondents are in a good health condition.

Health Condition while Working with the Chemicals Throughout their years of working and handling the chemicals, the respondents are only slightly affected with severe coughing and sore eye, where the mean index computed for those health conditions are 1.6 and 1.53. These are the least slightly affected value from the range of 1.5 to 2.5. 9 workers had seldom suffered from severe coughing. Meanwhile, 1 respondent complained that he often suffers from sore eyes and 6 respondents complained that they seldom suffer from this illness.

In addition, chest pain, breathing difficulties, skin disease, burns, heart attack and stroke, fall in the not affected at all category with the sequence of highest mean index to the lowest with 1.4 for chest pain, 1.27 for breathing difficulties, 1.2 for skin disease, 1.13 for burns, and lastly 1.0 for heart attack and stroke.

Personal Protective Equipment Practices at the Workplace Scoring a high mean index with 5.0 and 4.27 for mouth and nose and foot protection, all the respondents admit that they always wear foot protection while at work and 11 respondents said that they always wear mouth and nose protection while handling the chemicals. Tailing close is the practice of head protection with the

mean index of 4.33 which indicates that the workers are almost always wear head protection at the workplace.

Subsequently, often wearing hand and eye protection, the workers marked a 3.2 and 2.87 value for each mean index. However, the workers only seldom wear face protection with a low mean index value of 2.07 and never wear body protection with the lowest mean index value of 1.0.

Chemical Safety Awareness All 15 workers admit that they are aware of the importance of safety at the workplace and had been given safety briefing. They are also conscious of the significance of wearing protective equipment at work. Even though, all 100% of them are satisfied with the current level of chemical safety at the quarry, 12 of them still hope that the level of chemical safety there can be improve for better protection against the possible hazardous risk.

Discussion

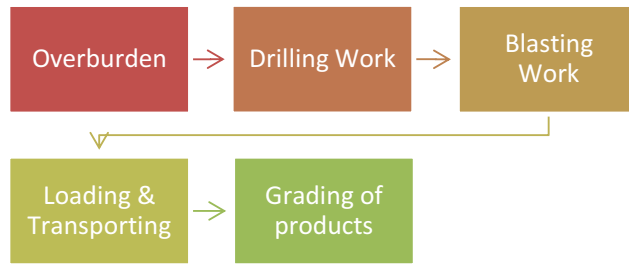


Figure 1: Flowchart of quarrying activities

Achievement on Objective 1:(To map the quarrying processes conducted at Jerlan Kuari Sdn. Bhd.) The mapping of the quarry can be seen in Figure 1 above where the first activity to be undertaken is the overburden work which is a process of cleaning up the area. Then, the drilling work will take place. This is one of the important task in order to make a hole in the quarry face which then will be filled with explosives in order to crack and excavate the stones easier.

Next, the excavated stones were loaded and transported to the stone crusher plane to be graded according to the desired sizes. The stones will undergo 3 stages of crushing process, namely primary, secondary and tertiary crushing.

From the mapping of the quarrying activities, we can simplify the recording of data by dividing the workers into work units of blasting and drilling, crushing, workshop technician and also welding workers. Other than that, we can also identify what chemicals were used in each of the work units.

Achievement on Objective 2:(To study the effect of chemicals used in each of the processes)

Table 6: Chemicals’ Hazard Category, Risk Analysis and Assessment Conclusion for Work Unit

Details	Work Units			
	Blasting & Drilling Operator	Crushing Operator	Workshop Technician	Welding Worker
No. Of Chemicals	7	3	9	5
Hazard Category				
Very Toxic (HR 5)	0	0	0	0
Toxic & Corrosive (HR 4)	1	1	0	1
Harmful & Irritant (HR 3)	6	0	5	3
Mild Irritant (HR 2)	0	0	2	0
Non-Hazardous (HR 1)	0	2	2	1
Risk Analysis				
Risk Significant Cat. 1	7	1	7	4
Risk Significant Cat. 2	0	0	0	0
Risk Not Significant	0	2	2	1

Assessment Conclusion					
C1		0	2	2	1
C2		0	0	0	0
C3		8	1	7	2
C4		0	0	2	2
C5		0	0	0	0

Based on the summary of the tabulation of Chemical Health Risk Assessment(CHRA) as shown in the table above, there is 3 chemicals categorized as toxic and corrosive, 14 categorized as harmful and irritant, 2 are categorized as mildly irritant and another 5 are categorized as non-hazardous.

However, after analyzing the questionnaire distributed to the workers in the quarry and computing the mean index of the respondents' health reaction towards the chemicals, only 2 out of 8 of the health condition were considered as slightly affected and the rest are not affected at all.

Achievement on Objective 3(To study the implementation of safety requirements enforced by DOSH at Jerlan Kuari Sdn. Bhd.)

Table 7: The Suitability and Adequacy of the Existing Cover Measures for each Chemical Involved

Work Unit	Chemical Involved	Tasks	Route of Entry	Existing Cover Measures	Suitable & Effective	Adequate
Blasting and Drilling Operator	Jet Lube J-75	The chemical is applied to the coupling of drilling rod manually.	Ingestion Skin Eye	Leather glove	No Yes No	No Yes No
	Perfo XC 40	Engine oil for compressor. The chemical is manually poured into oil compartment from 18L container.	Ingestion Skin Eye	Leather glove	No Yes No	No Yes No
	Shell COREN A Oil RS 32	As compressor oil. The chemical is manually poured into oil compartment from 18L container.	Inhalation	Leather glove	No	No
	Diesel	As compressor fuel. Close system operation using air pump to transfer the chemical into fuel compartment.	Inhalation Ingestion Skin Eye	Leather glove	No No Yes No	No No Yes No
	Diesel + Ammonium Nitrate	2L Diesel is mixed with 25kg of Ammonium Nitrate. The mixture is stirred manually.	Inhalation Ingestion Skin Eye	No PPE is worn	No No No No	No No No No
	Mobil Almo 257	As hydraulic oil for drilling machine. It is manually poured into oil compartment.	Inhalation Skin Eye	No PPE is worn	No No No	No No No
	Granite	Dust exposure during drilling activity.	Inhalation Skin Eye	Disposable mask Leather glove	Yes Yes No	No Yes No
	Mobil Nuto H100	As hydraulic oil for drilling machine. Chemical is manually poured from 200L drum into 18L container and it is manually poured into oil compartment.	Nil	Surgical mask	Yes	Yes

Crushing Operator	Mobilux EP 2 Grease	It is manually pumped using hand pump into crusher bearing compartment.	Nil	Leather glove Surgical mask	Yes	Yes
	Granite	Dust exposure during crushing activity.	Inhalation Skin Eye	Disposable mask Leather glove	Yes Yes No	No Yes No
Workshop Technician	Diesel	The chemical is manually pumped into lorry's oil compartment.	Inhalation Ingestion Skin Eye	Cotton glove Safety boot	No No No No	No No No No
	ELFOLN A 68	This chemical is manually transferred from 208L to small container using funnel before it is being transferred to lorry and excavator.	Skin Eye	Rubber glove Safety boot	Yes No	Yes No
	Perfo XC 40	The chemical is manually transferred from 208L to small container using funnel before it is being transferred to lorry and excavator.	Ingestion Skin Eye	No PPE is worn	No No No	No No No
	400 Heavy Duty	The chemical is applied manually to lorry and excavator.	Inhalation Skin Eye	Rubber glove Safety boot	No No No	No No No
	WD-40	This chemical is sprayed onto rusted bolt and nuts manually.	Inhalation Ingestion Skin Eye	No PPE is worn	No No No No	No No No No
	Thinner 888	The chemical is poured manually into paint solution to dilute the concentration.	Inhalation Skin Eye	Hardware mask	No No No	No No No
	Crown Gloss	This chemical is manually mixed with thinner. The mixture is stirred before applying it to lorry's body part using spray gun or brush.	Skin Eye	Hardware mask	No No	No No
OSCAR Grease	The chemical is applied manually to bearing, hose and some part of excavator or lorry using a grease pump.	No Info	No PPE is worn	No Info	No Info	
Undercoat Ken-Kote	This chemical is mixed with thinner manually. The mixture is stirred before applying it to lorry's body part using spray gun or brush.	No Info	Hardware mask	No Info	No Info	
Welding Operator	Carbon Dioxide Gas	Metal Inert Gas(MIG) Welding. Using MIG welding wire with CO ₂ gas. It is applied to the lorry's body, the excavator's bucket and other machineries.	Nil	Face shield Leather glove	Yes	Yes
	ER70S-6 Welding Wire	Metal Inert Gas(MIG) Welding. Using MIG welding wire with CO ₂ gas. It is applied to the lorry's body, the excavator's bucket and other machineries.	Inhalation Skin Eye	Leather glove Face shield	No Yes Yes	No Yes Yes
	RB 26(Mild Steel)	Directly welding on the surface of lorry, excavator and machineries.	Inhalation Skin Eye	Leather glove Face shield	No Yes Yes	No Yes Yes
	LB 26	Directly welding on the surface of lorry, excavator and	Inhalation Skin	Face shield Leather	No Info	No Info

	machineries.	Eye	glove		
Flux Welding	Welding activity to seal small hole and rejoin the piping.	Inhalation Skin Eye	Face shield Leather glove	No Info	No Info

Table above lists out the existing cover measures implemented at Jerlan Kuari Sdn. Bhd. Other than that, it also shows the possible route of entry of the chemicals and if the current cover measures are suitable and adequate based on the safety requirements enforced by the Department of Occupational Safety and Health (DOSH) Malaysia.

But based on the questionnaire as in Table 4.6.3, the mean index of the PPE practice in the workplace indicates that only 1 out of 7 PPE practice is not widely used in the quarry which is the body protection.

Achievement on Objective 4:(To propose methods to mitigate the effect of the chemicals)

Table 8: The Recommendations for Improvisation for each Chemical Involved in All Work Units

Work Unit	Class	Chemical Involved	Recommendations	
Blasting and Drilling Operator	C3	Jet Lube J-75	<ul style="list-style-type: none"> To enforce the usage of DOSH P95 disposable mask and mono goggle/safety glass for adequate oral and eye protection To engage Hygiene Technician 1 to conduct personal exposure monitoring for Oil Mist using NMAM 5026 To engage Occupational Health Doctor(OHD) to conduct medical surveillance for Mineral Oil since the chemicals are listed in Schedule 2 of USECHH if the result of exposure monitoring 50% of PEL. 	
		Perfo XC 40	To enforce the usage of DOSH P95 disposable mask and mono goggle/safety glass for adequate oral and eye protection.	
		Shell CORENA Oil RS 32	To enforce the usage of DOSH P95 disposable mask for adequate respiratory protection.	
		Diesel	To enforce the usage of DOSH P95 disposable mask and mono goggle/safety glass for adequate respiratory, oral and eye protection.	
		Ammonium Nitrate	To enforce the usage of DOSH P95 disposable mask and mono goggle/safety glass for adequate respiratory, oral and eye protection.	
			Mobil Almo 257	<ul style="list-style-type: none"> To enforce the usage of DOSH P95 disposable mask, Nitrile glove and mono goggle/safety glass for adequate respiratory, skin and eye protection. To engage Hygiene Technician 1 to conduct personal exposure monitoring for Oil Mist using NMAM 5026. To engage Occupational Health Doctor(OHD) to conduct medical surveillance for Mineral Oil since the chemicals are listed in Schedule 2 of USECHH if the result of exposure monitoring 50% of PEL.
	C1	Mobilux EP2 Grease Mobil Nuto H100	To end current assessment and to repeat the assessment in the next 5 years.	
	C3	Granite	<ul style="list-style-type: none"> To consider an engineering control such as foam dust suppression system to reduce dust exposure to the workers. To enforce the usage of DOSH approved N95 disposable mask and mono goggle/safety glass for adequate respiratory and eye protection. 	
	Crushing		<ul style="list-style-type: none"> To engage Hygiene Technician 1 to conduct personal exposure 	

Operator		monitoring for Crystalline Silica using NMAM 7500. <ul style="list-style-type: none"> To engage Occupational Health Doctor(OHD) to conduct medical surveillance for Free Crystalline Silica since the chemicals are listed in Schedule 2 of USECHH if the result of exposure monitoring 50% of PEL. 	
Workshop Technician	C1	DELVAC 1330 MOBIL ATF 220	To end current assessment and to repeat the assessment in the next 5 years.
		Diesel	To enforce the usage of DOSH P95 disposable mask and mono goggle/safety glass for adequate respiratory, oral and eye protection.
		ELFOLNA 68	To provide DOSH approved mono goggle for adequate eye protection.
	C3	Perfo XC 40	<ul style="list-style-type: none"> To enforce the usage of DOSH P95 disposable mask, Nitrile glove and mono goggle/safety glass for adequate respiratory, skin and eye protection. To engage Hygiene Technician 1 to conduct personal exposure monitoring for Oil Mist using NMAM 5026. To engage Occupational Health Doctor(OHD) to conduct medical surveillance for Mineral Oil since the chemicals are listed in Schedule 2 of USECHH if the result of exposure monitoring 50% of PEL.
		400 Heavy Duty	To enforce the usage of DOSH P95 disposable mask, Nitrile glove and chemical goggle/safety glass for adequate respiratory, skin and eye protection.
Welding Operator		WD-40	To use P95 Respirator for adequate respiratory protection.
		Thinner 888	To enforce the usage of DOSH P95 disposable mask, Nitrile glove and chemical goggle/safety glass for adequate respiratory, skin and eye protection.
		Crown Gloss	To enforce the usage of DOSH P95 disposable mask, Nitrile glove and chemical goggle/safety glass for adequate respiratory, skin and eye protection.
	C4	OSCAR Grease Undercoat Ken-Kote	To review CHRA whenever there is a change in chemical or process use or as directed by DG DOSH or every five years.
	C1	Carbon Dioxide Gas	To end current assessment and to repeat the assessment in the next 5 years.
Welding Operator	C3	ER70S-6 Welding Wire	<ul style="list-style-type: none"> To enforce the usage of DOSH approved N95 disposable mask for adequate respiratory protection. To engage Hygiene Technician 1 to conduct personal exposure monitoring for Manganese, Copper using NMAM 7300. To engage Occupational Health Doctor(OHD) to conduct biological and medical surveillance for Manganese since the chemicals are listed in Schedule 2 of USECHH if the result of exposure monitoring 50% of PEL.
	C4	LB 26 Flux Welding	To review CHRA whenever there is a change in chemical or process use or as directed by DG DOSH or every five years.

Conclusion

The results show that the workers are mostly protected and which is why they are almost not affected by the chemicals. However, a few recommendations can still be made for the quarry in order to improve their level of hazardous chemical safety.

The management team should continue to update the chemical registers as per USECHH Regulation and to include the recommended PPE in Standard Operation Procedure. Besides, the management must also monitor the usage of PPE for full compliance to DOSH Guidelines on the Use of PPE against Chemical Hazards. By continuing to conduct Safe Handling of Chemicals Training which shall be conducted at least once in every 2 years as per USECHH Regulations, the workers might have a better understanding on the importance of chemicals safety.

And for future research, it is recommended that the scope of research is widen and not focused on just one quarry.

References

- [1] Department of Occupational Safety and Health, Malaysia Official Website
<http://www.dosh.gov.my/index.php/en/osh-info-2/occupational-health/398-statistics-socso>
(Accessed on 27th September 2015)
- [2] Worksafe Organization, California Official Website
<http://www.worksafe.org/about/index.html> (Accessed on 27th September 2015)
- [3] DOSH Malaysia, 2000. *CHRA Manual 2000*.