

Risk Assessment for Building Construction Sites in Myanmar

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A proactive, rigorous approach to safety planning and management is one of the most construction goals. To create a safe working environment, we have to identify the hazards which may encounter in construction and assess their impacts. Building construction is a high-hazard place and workers engage in many activities that may expose them to serious hazards. Accidents or serious safety violation can impact not only project cost but also project schedule. Serious accidents can cause even project shutdown.

Risk assessment is a systematic method of identifying and analysing the hazards associated with an activity and establishing a level of risk for each hazard. It is carried out by identifying risk and using appropriate control measure to minimize the risk. The hazards cannot be completely eliminated, and thus there is a need to define and estimate an accident risk level possible to be presented either in quantitative or qualitative way.

II. Identification of the Hazard

Hazard identification is the crucial first step of risk assessment. One of the root causes of construction injuries, illnesses and incidents is the failure to identify or recognize hazards that are present or that could have been anticipated. The most common types of hazards identified in the construction are as follows;

1. Working at Height Hazards
2. Excavation Hazards
3. Demolition Hazards
4. Movement of People and Vehicles Hazards
5. Work by using Equipment Hazards
6. Manual and Mechanical Handling Hazards

ABSTRACT

In Myanmar, construction industries carry on to become safety first. There are many hazards and risks in construction that can cause employee injuries and illnesses. In order to be safe, risk assessment technique is widely used in international but less in Myanmar. So this paper aims to help what kind of risks can occur and to know how to reduce these risks by using additional controls. Firstly, it is required to collect data. Therefore, three construction companies in Mandalay (Myanmar) are chosen. Hazards are obtained from the observed data. Questionnaires concerned with likelihood and severity are collected from the project engineers in these sites. The results from questionnaires are used to evaluate the risks. The evaluated risks are reviewed whether these are acceptable or additional controls are required to reduce risks. On the basis of outcome results, risk prioritization number charts can be obtained. Thus, this study can provide for developing necessary controls to reduce risks and to be safe for construction industries.

KEYWORDS: risk assessment technique, questionnaires, risk prioritization number

I. INTRODUCTION

No matter how valuable a facility or structure may be, it is no valuable than the health and welfare of the people who build and use the building. Safety is one of the major factors that have to be considered in building construction.

7. Electrical Hazards

8. Chemical and Biological Hazards

9. Physical and Psychological Hazards

III. Risk

A risk is the likelihood of a substance, activity or process to cause harm. Risk is also linked to the severity of its consequences. A risk can be reduced and the hazard controlled by good management. Activities often called high risk are in fact high hazard. There should only be high residual risk where there is poor health and safety management and inadequate control measures.

A. Risk Evaluation

Risk evaluation is the process of comparing on estimated risk against given risk criteria to determine the significance of the risk. Once the hazards are identified, it needs to evaluate risk that is presented by these hazards.

B. Risk Control

The next stage in the risk assessment is the control of the risk. In established workplaces, some control of risk will already be in place. The effectiveness of these controls needs to be assessed so that an estimate of the residual risk may be made. Many hazards have had specific acts, regulations or other recognized standards developed to reduce associated risks. Where there are existing preventative measures in place, it is important to check that they are working properly and that everybody affected has a clear understanding of the measures. The following hierarchy defines the order of considering the controls, one or a combination of several kinds of controls may be chosen to implement. Hierarchy of controls is shown in Figure 1.



Figure1. Hierarchy of Controls

C. Risk Assessment

Risk assessment is the overall process of hazard identification, risk evaluation and risk control. Risk assessment methods are used to decide on priorities and to set objectives for elimination hazards and reducing risks. Wherever possible, risks are eliminated through selection and design of facilities, equipment and processes. If risks cannot be eliminated, they are minimized by the use of physical controls or as a last resort, through systems of work and personal protective equipment. The goal of risk assessment is to reduce all residual risks to as low a level as reasonably practicable.

IV. Data Collection

Data are collected from three construction companies in Mandalay. The data are conducted in the form of a questionnaire to collect each construction risk factors and its probability of occurrence. The questionnaire sets are prepared using the significant factors identified by the literature and organization of these companies. The questionnaire sets contain two parts. The two parts are;

1. Hazard and severity assessment and
2. Likelihood assessment.

A. Hazard Identification for Construction Companies

Hazard identification is the process of finding, listing, and characterizing hazards. Only significant hazards, which could result in serious harm to people, should be identified. Trivial hazards should be ignored. Hazards will vary from workplace to workplace but the checklist shows the common hazards that are significant in many workplaces. The methodology used for hazard identification is based on the mainly past experience of organizations and participation.

B. Types of Hazards

The most common types of hazards on construction sites in this study area are (1) falling people and falling objects from height, (2) falling people into the pit, (3) falling debris, noise and vibration from demolition (4) slip on wet floor, striking with obstacles due to movement of people during working, (5) broken handles on chisels and hammer, flying particles from breaking up stone or concrete, (6) dropping a load and poor posture during lifting operation by manual and mechanical, (7) inhaling cement dust and exposure to skin with cement during concrete work, (8) contact to eyes with radiation during welding work, (9) temperature extreme during working under direct sunlight, (10) noise and vibration during concrete work by station pump and (11) poor ventilation during working on confined space.

C. Risk Evaluation for Construction Companies

In this step of the process, risks are evaluated from the hazards identified in the preceding stage. The severity and likelihood of harm that can be caused by a hazard is considered. The purpose of risk evaluations is to decide whether or not a risk is tolerable.

D. Risk Matrices

The WSH code recognizes the various risk evaluation methods and matrices practiced and preferred by workplaces. In this study, the numeric 5x5 risk matrix shown in Table 1 is used. When using the numeric 5x5 matrix, all references to the scales (i.e., 1, 2, 3, 4 or 5) should be read in context of the Risk Matrix selected (e.g., “Minor”, “Moderate” or “Major” in lieu of “1”, “2”, “3”, “4” or “5”). When Hazard Identification is completed, proceed with risk evaluation procedure.

Table1. 5x5 Risk Matrix with Numeric Ratings

Severity (S)	Likelihood (L)				
	Rare (1)	Remote (2)	Occasional (3)	Frequent (4)	Almost Certain (5)
Catastrophic (5)	5	10	15	20	25
Major(4)	4	8	12	16	20
Moderate (3)	3	6	9	12	15
Minor(2)	2	4	6	8	10
Negligible (1)	1	2	3	4	5

E. Assessment of Severity

With the existing risk controls and residual risks in consideration, rate the most likely severity outcome of the possible injury or ill-health identified. When using the 5x5 matrix, the following guidance given in Table 2 should be used in selecting the level of severity.

Table2. Severity Rating

Level	Severity	Description
5	Catastrophic	Death, fatal disease or multiple major injuries.
4	Major	Serious injuries or life-threatening occupational diseases (includes amputations, major fractures, multiple injuries, occupational cancers, acute poisoning, disabilities and deafness).
3	Moderate	Injury or ill-health requiring medical treatment (includes lacerations, burns, sprains, minor fractures, dermatitis and work-related upper limb disorders).
2	Minor	Injury or ill-health requiring first-aid only (includes minor cuts and bruises, irritation, ill-health with temporary discomfort).
1	Negligible	Negligible injury.

F. Assessment of Likelihood

With the existing risk controls and residual risks in consideration, rate the likelihood that the hazard may cause the injury/ ill-health. When using the 5x5 matrix, the following guidance given in Table 3 should be used in selecting the level of likelihood.

Table3. Likelihood Rating

Level	Likelihood	Description
1	Rare	Not expected to occur but still possible.
2	Remote	Not likely to occur under normal circumstances.
3	Occasional	Possible or known to occur.
4	Frequent	Common occurrence.
5	Almost	Certain continual or repeating experience.

V. Results of Risk Evaluation

By using questionnaire survey data from project engineer, risk can be evaluated. According to possible injuries, severity score is taken. The likelihood data are obtained. Risk prioritization number is resulted by multiplying severity and likelihood. Risk evaluation results of Company A, Company B and Company C are shown in Table 4 to Table 9, respectively.

Table4. Risk Evaluation Results of Company A

No	Hazard Identification			Risk Evaluation			
	Work Activity	Hazards	Possible injury	Existing controls	S	L	RPN
1	Working on a scaffold	Falling people	Leg injury	Make sure provide scaffold with toe boards and guard rails. Make sure apply safety nets.	3	3	9
		Falling objects	Abrasion	Make sure all persons wearing safety helmets. Keep tools and materials in boxes, tool bags and pouches.	2	4	8
2	Earthwork excavation by using manual	Falling people	Incident	Excavated materials are placed away from excavation edge.	1	3	3
		Materials falling on workers	Incident	Provide guardrails to excavation. Notice to warn person of excavation. Workers must wear helmet and safety footwear.	1	3	3
3	Demolition by using equipment	Falling debris	Abrasion	Provide safe footing in the form of sound flooring or scaffolds for persons working on exterior wall. Use of chutes for dropping debris.	2	4	8
		Noise and vibration from pneumatic drill	Minor injury (Ear)	Putting on ear protector such as ear plugs or ear muffs. Replacing equipment with quieter one. Maintenance of the machinery or tools.	1	5	5

4	Movement of people during working	Slip on wet floor	Backaches	Cleaning up spills, drips and leaks immediately. Using slip-resistance floor waxes. Putting up signs or barriers.	3	3	9
		Struck with obstacles such as bricks, blocks or timber	Leg injury / minor injury	Keeping carefully the rest of the materials after working. Make sure wearing safety shoes.	2	5	10
		Struck by moving or falling objects	Hand / Leg abrasion	Keep tools and materials in boxes, tool bags and pouches.	2	3	6
5	Working by using equipment	Broken handles on chisels and hammers	Abrasion / minor injury	Regular inspection of hand tools.	2	4	8
		Chipped or loose hammer heads that fly off or slip	Abrasion / minor injury	Repairing of defective tools. Avoid overhead work areas.	2	3	6
		Flying particles from breaking up stone or concrete	Hay fever / Conjunctivitis	Make sure use safety glasses and face shield.	2	5	10
		Contact with hot or abrasive machine	Scalding / Laceration	Use and maintain carefully machine.	2	4	8
6	Lifting operation by manual and mechanical	Dropping a load	Leg laceration	Make sure all workers wearing safety shoes.	2	5	10
7	Concrete work	Inhaling cement dust	Asphyxiation	Put on suitable respirator (mask).	1	5	5
		Exposure to skin with cement	Skin damage	Wear impervious hand gloves/safety boots.	2	4	8
8	Welding	Inhaling welding fume	Asphyxiation	Put on suitable respirator (mask).	1	4	4
		Contact to eye with radiation	Conjunctivitis	Goggles are used to protect bright lights.	2	5	10
9	Working under direct sunlight	Temperature extreme	Illness	First-Aid kits, medical facilities	2	4	8
10	Concrete work by station pump	Noise and vibration	Minor injury (Ear)	Use ear plugs and ear muffs.	1	5	5
11	Working in confined space	Poor ventilation	Asphyxiation	Respirator	1	2	2

According to based on survey data shown in Table 4, movement of people during working, working by using equipment, lifting operation by manual and mechanical and welding have RPN value 10. They are highest RPN value in this site. Although, these must be taken existing risk controls which are high RPN value. So, these should be performed additional controls. Other hazards should be taken too additional controls because they are in yellow zone. But, even “earthwork excavation” and “working in confined space has RPN 2. So, they don’t need to take additional controls.

Table5. Risk Evaluation Results of Company B

No	Hazard Identification			Risk Evaluation			
	Work Activity	Hazards	Possible injury	Existing controls	S	L	RPN
1	Working on a scaffold	Falling people	Hand / Leg injury	Make sure provide scaffold with toe boards and guard rails. Make sure apply safety nets.	3	4	12
		Falling objects	Incident	Make sure all persons wearing safety helmets. Keep tools and materials in boxes, tool bags and pouches. Secure objects properly.	1	4	4
2	Earthwork excavation by using manual	Falling people	Leg injury	Excavated materials are placed away from excavation edge.	2	3	6
		Materials falling on workers	Incident	Provide guardrails to excavation. Notice to warn person of excavation. Workers must wear helmet and safety footwear.	1	4	4
3	Demolition by using equipment	Falling debris	Shoulder injury	Provide safe footing in the form of sound flooring or scaffolds for persons working on exterior wall. Use of chutes for dropping debris.	2	4	8
		Falling people	Hand injury	Make sure provide with guard rails. Wear safety harness.	3	3	9
		Noise and vibration from pneumatic drill	Incident	Putting on ear protector such as ear plug or ear muff. Replacing equipment with quieter one. Maintenance of the machinery or tools.	1	5	5
		Electric shock	Incident	Wear electric gloves during handling electrical equipment. Remove defective plug, socket, wires. Be careful wrong connection and poor contact.	1	3	3
4	Movement of people during working	Strucking with obstacles such as bricks, blocks or timber	Abrasion / minor injury	Keeping carefully the rest of the materials after working. Make sure wearing safety shoes.	2	5	10
		Struck by moving or falling objects	Abrasion / minor injury	Keep tools and materials in boxes, tool bags and pouches.	2	5	10
5	Working by using equipment	Broken handles on chisels and hammers	Incident	Regular inspection of hand tools. Repairing of defective tools. Avoid overhead work areas.	1	3	3
		Chipped or loose hammer heads that fly off or slip	Incident	Regular inspection of hand tools. Repairing of defective tools. Avoid overhead work areas.	1	3	3
		Flying particles from breaking up stone or concrete	Conjunctivitis	Make sure use safety glasses and face shield.	1	5	5
		Contact with hot or abrasive machine	Scalding / Laceration	Use and maintain carefully machine.	2	4	8
6	Lifting operation by manual and mechanical	Dropping a load	Abrasion	Make sure all workers wearing safety shoes.	2	5	10
		Poor posture during lifting or poor lifting technique	Backaches	Firm grip, avoid lifting heaviest loads with hand.	2	5	10
7	Concrete work	Exposure to skin with cement	Skin damage	Wear impervious hand gloves/ safety boots.	2	5	10
8	Welding	Inhaling welding fume	Asphyxiation	Put on suitable respirator (mask).	1	4	4
		Contact to eye with radiation	Conjunctivitis	Goggles are used to protect bright lights.	2	4	8
9	Working under direct sunlight	Temperature extreme	Heat stroke/ leg cramps/ faint.	First-Aid kits, medical facilities	2	4	8
10	Concrete work by station pump	Noise and vibration	Minor injury (Ear)	Use ear plugs and ear muffs.	1	5	5

According to based on survey data shown in Table 5, falling people in “working on a scaffold” has 12 RPN. So, it is the highest all of them. Work activities which have RPN 10 of yellow zone are “movement of people during working”, “lifting operation by manual and mechanical” and “concrete work”. Other activities have average RPN 5. They truly need to make additional controls. Among them, electric shock hazard of “demolition by using equipment” and broken handle on chisel and hammer of “working by using equipment” have RPN 3. So, they don’t need to make additional controls.

Table6. Risk Evaluation Results of Company C

No	Hazard Identification			Risk Evaluation			
	Work Activity	Hazards	Possible injury	Existing controls	S	L	RPN
1	Working on a scaffold	Falling people	Leg injury	Make sure provide scaffold with toe boards and guard rails. Make sure apply safety nets.	3	3	9
		Falling objects	Abrasion / Minor injury	Make sure all persons wearing safety helmets. Keep tools and materials in boxes, tool bags and pouches. Secure objects properly.	1	4	4
2	Working at height by using ladder	Falling people	Abrasion / Minor injury	Make sure provide with guard rails. Use stable, level and firm ladder.	1	3	3
3	Earthwork excavation by using manual	Materials falling on workers	Incident	Excavated materials are placed away from excavation edge. Provide guardrails to excavation. Notice to warn person of excavation. Workers must wear helmet and safety footwear.	1	3	3
4	Demolition by using equipment	Falling debris	Abrasion / Minor injury	Provide safe footing in the form of sound flooring or scaffolds for persons working on exterior wall. Use of chutes for dropping debris.	2	4	8
		Noise and vibration from pneumatic drill	Incident	Putting on ear protector such as ear plug or ear muff. Replacing equipment with quieter one. Maintenance of the machinery or tool.	1	5	5
5	Movement of people during working	Strucking with obstacles such as bricks, blocks or timber	Abrasion / minor injury	Cleaning up spills, drips and leaks immediately. Using slip-resistance floor waxes. Putting up signs or barriers.	2	4	8
		Struck by moving or falling objects	Hand injury	Keeping carefully the rest of the materials after working. Make sure wearing safety shoes.	2	5	10
6	Working by using equipment	Broken handles on chisels and hammers	Incident	Keep tools and materials in boxes, tool bags and pouches.	3	5	15
		Chipped or loose hammer heads that fly off or slip	Incident	Regular inspection of hand tools. Repairing of defective tools. Avoid overhead work areas.	1	3	3
		Flying particles from breaking up stone or concrete	Conjunctivitis	Regular inspection of hand tools. Repairing of defective tools. Avoid overhead work areas.	1	3	3
		Contact with hot or abrasive	Abrasion / Minor injury	Make sure use safety glasses and face shield.	1	4	4
7	Lifting operation by manual and mechanical	Contact with hot or abrasive	Abrasion / Minor injury	Use and maintain carefully machine.	2	4	8
		Dropping a load	Leg injury / Minor injury	Make sure all workers wearing safety shoes.	2	5	10
8	Working with electrical equipment	Poor posture during lifting or poor lifting technique	Hand injury / Minor injury	Firm grip, avoid lifting heaviest loads with hand.	1	5	5
		Electric shock	Incident	Wear electric gloves during handling electrical equipment. Remove defective plug, socket, wires. Be careful wrong connection and poor contact.	1	2	2
9	Concrete work	Exposure to skin with cement	Skin damage	Wear impervious hand gloves/safety boots.	2	5	10
10	Welding	Inhaling welding fume	Hay fever	Put on suitable respirator (mask).	2	4	8
10	Welding	Contact to eye with radiation	Conjunctivitis	Goggles are used to protect bright lights.	2	4	8
11	Working under direct sunlight	Temperature extreme	Heat stroke / Leg cramps	First -Aid kits, medical facilities	3	4	12
12	Concrete work by station pump	Noise and vibratio	Minor injury (Ear)	Use ear plugs and ear muffs.	1	5	5

According to based on survey data shown in Table 6, “movement of people during working” and “working under direct sunlight” has RPN 15 and RPN 12. They need to do more carefully in work. Even existing controls are taken, their RPN values are higher than average level of yellow zone. So, additional controls are truly needed for these work activities. “Working on a scaffold”, “demolition”, “working by using equipment” and other work activities are average yellow zone. “Working at height by using ladder”, “earthwork excavation by using manual” and “working with electrical equipment” are lower levels than others. Workers in this site have to do carefully for these activities. So, they do not perform additional controls.

VI. Risk Control for Construction Companies

Risk controls are the activities implemented to mitigate risks. Controls can attempt to avoid the risk in its entirety. Or the control may be designed to prevent the risk from occurring. In many cases, the risk may attempt to reduce the losses associated with an activity. Taking actions to eliminate health and safety risk so far as is reasonably practicable. Where risk cannot be eliminated, then implementation of control measures is required, to minimize risks. A hierarchy of controls has been developed and is described below to assist in selection of the most appropriate risk control measures. Risk control procedures are as follows;

1. Additional controls
2. Re-evaluation with additional controls

A. Additional Controls

Compare the existing controls against the Hierarchy of Control. When considering additional measures to reduce risk, the more effective measures in the hierarchy of control should be considered first.

B. Re-evaluation with Additional Controls

When Additional Control(s) have been decided, re-rate the Severity, Likelihood and RPN scores. The new risk control RPN shall not be higher than the risk evaluation RPN. Risk control results after making additional controls of Company A, Company B and Company C are shown in Table 7 to Table 9 respectively.

Table7. Risk Control Results of Company A

No	Hazard Identification			Risk Control			
	Work Activity	Hazards	Possible injury	Additional controls	S	L	RPN
1	Working on a scaffold	Falling people	Leg injury	Close supervision during replacement work.	3	2	6
		Falling objects	Abrasion	Make sure safe work procedure by administrators. Check workplace by engineers.	2	2	4
2	Earthwork excavation by using manual	Falling people	Incident	NA	1	3	3
		Materials falling on workers	Incident	NA	1	3	3
3	Demolition by using equipment	Falling debris	Abrasion	Check workplace by engineers.	2	3	6
		Noise and vibration from pneumatic drill	Minor injury (Ear)	Check workplace by engineers. Make sure safe work procedure by administrators.	1	3	3

4	Movement of people during working	Slip on wet floor	Backaches	Check workplace safety by elimination. Close supervision during replacement work.	3	1	3
		Struck with obstacles such as bricks, blocks or timber	Leg injury / minor injury	Make sure personal protective equipment. Make sure safe work procedure by administrators.	2	3	6
		Struck by moving or falling objects	Hand / Leg abrasion	Make sure safe work procedure by administrators. Check workplace by engineer.	2	1	2
5	Working by using equipment	Broken handles on chisels and hammers	Abrasion / minor injury	Make sure personal protective equipment. Close supervision during replacement work.	2	2	4
		Chipped or loose hammer heads that fly off or slip	Abrasion / minor injury	Make sure personal protective equipment.	2	2	4
		Flying particles from breaking up stone or concrete	Hay fever / Conjunctivitis	Make sure personal protective equipment.	2	4	8
		Contact with hot or abrasive machine	Scalding / Laceration	Make sure personal protective equipment.	2	3	6
6	Lifting operation by manual and mechanical	Dropping a load	Leg laceration	Make sure personal protective equipment.	2	4	8
7	Concrete work	Inhaling cement dust	Asphyxiation	Make sure personal protective equipment.	1	4	4
		Exposure to skin with cement	Skin damage	Make sure personal protective equipment.	2	3	6
8	Welding	Inhaling welding fume	Asphyxiation	Make sure personal protective equipment.	1	3	3
		Contact to eye with radiation	Conjunctivitis	Make sure personal protective equipment.	2	4	8
9	Working under direct sunlight	Temperature extreme	Illness	Close supervision during substitution work.	2	3	6
10	Concrete work by station pump	Noise and vibration	Minor injury (Ear)	Make sure personal protective equipment. Make sure safe work procedure by administrators.	1	3	3
11	Working in confined space	Poor ventilation	Asphyxiation	NA	1	2	2

Table8. Risk Control Results of Company B

No	Hazard Identification			Risk Control			
	Work Activity	Hazards	Possible injury	Additional controls	S	L	RPN
1	Working on a scaffold	Falling people	Hand / Leg injury	Close supervision during replacement work.	3	3	9
		Falling objects	Incident	Make sure safe work procedure by administrators. Check workplace by engineers.	1	2	2
2	Earthwork excavation by using manual	Falling people	Leg injury	Close supervision during replacement work.	2	2	4
		Materials falling on workers	Incident	Make sure safe work procedure by administrators. Check workplace by engineers.	1	2	2
3	Demolition by using equipment	Falling debris	Shoulder injury	Check workplace by engineer	2	3	6
		Falling people	Hand injury	Check workplace by engineer	3	2	6
		Noise and vibration from pneumatic drill	Incident	Check workplace by engineers. Make sure safe work procedure by administrators.	1	3	3
		Electric shock	Incident	NA	1	3	3
4	Movement of people during working	Struck with obstacles such as bricks, blocks or timber	Abrasion / minor injury	Make sure personal protective equipment. Make sure safe work procedure by administrators.	2	3	6
		Struck by moving or falling objects	Abrasion / minor injury	Make sure safe work procedure by administrators. Check workplace by engineer.	2	3	6

5	Working by using equipment	Broken handles on chisels and hammers	Incident	NA	1	3	3
		Chipped or loose hammer heads that fly off or slip	Incident	NA	1	3	3
		Flying particles from breaking up stone or concrete	Conjunctivitis	Make sure personal protective equipment.	1	4	4
		Contact with hot or abrasive machine	Scalding / Laceration	Make sure personal protective equipment.	2	3	6
6	Lifting operation by manual and mechanical	Dropping a load	Abrasion	Make sure personal protective equipment.	2	4	8
		Poor posture during lifting or poor lifting technique	Backaches	Make sure personal protective equipment.	2	4	8
7	Concrete work	Exposure to skin with cement	Skin damage	Make sure personal protective equipment.	2	4	8
8	Welding	Inhaling welding fume	Asphyxiation	Make sure personal protective equipment.	1	3	3
		Contact to eye with radiation	Conjunctivitis	Make sure personal protective equipment.	2	3	6
9	Working under direct sunlight	Temperature extreme	Heat stroke/ leg cramps/ faint.	Check workplace by engineer	2	3	6
10	Concrete work by station pump	Noise and vibration	Minor injury (Ear)	Make sure personal protective equipment. Make sure safe work procedure by administrators.	1	3	3

6	Working by using equipment	Broken handles on chisels and hammers	Incident	NA	1	3	3
		Chipped or loose hammer heads that fly off or slip	Incident	NA	1	3	3
		Flying particles from breaking up stone or concrete	Conjunctivitis	Make sure personal protective equipment.	1	3	3
		Contact with hot or abrasive machine	Abrasion / Minor injury	Make sure personal protective equipment.	2	3	6
7	Lifting operation by manual and mechanical	Dropping a load	Leg injury / Minor injury	Make sure personal protective equipment.	2	4	8
		Poor posture during lifting or poor lifting technique	Hand injury / Minor injury	Make sure safe work procedure by supervisor.	1	4	4
8	Working with electrical equipment	Electric shock	Incident	NA	1	2	2
9	Concrete work	Exposure to skin with cement	Skin damage	Make sure personal protective equipment.	2	4	8
10	Welding	Inhaling welding fume	Hay fever	Make sure personal protective equipment.	2	3	6
		Contact to eye with radiation	Conjunctivitis	Make sure personal protective equipment.	2	3	6
11	Working under direct sunlight	Temperature extreme	Heat stroke / Leg cramps	Close supervision during replacement work.	3	3	9
12	Concrete work by station pump	Noise and vibration	Minor injury (Ear)	Make sure personal protective equipment. Make sure safe work procedure by administrators.	1	3	3

Table9. Risk Control Results of Company C

No	Hazard Identification			Risk Control			
	Work Activity	Hazards	Possible injury	Additional controls	S	L	RPN
1	Working on a scaffold	Falling people	Leg injury	Close supervision during replacement work.	3	2	6
		Falling objects	Abrasion / Minor injury	Make sure safe work procedure by administrators. Check workplace by engineers.	1	2	2
2	Working at height by using ladder	Falling people	Abrasion / Minor injury	NA	1	3	3
3	Earthwork excavation by using manual	Materials falling on workers	Incident	NA	1	3	3
4	Demolition by using equipment	Falling debris	Abrasion / Minor injury	Check workplace by engineers.	2	3	6
		Noise and vibration from pneumatic drill	Incident	Check workplace by engineers. Make sure safe work procedure by administrators.	1	3	3
5	Movement of people during working	Slip on wet floor	Abrasion / minor injury	Check workplace safety by elimination. Close supervision during replacement work.	2	2	4
		Struck with obstacles such as bricks, blocks or timber	Abrasion / minor injury	Make sure personal protective equipment. Make sure safe work procedure by administrators.	2	3	6
		Struck by moving or falling objects	Hand injury	Make sure safe work procedure by administrators. Check workplace by engineer.	3	3	9

C. Risk Prioritization Number Charts of Construction Companies

There are different kinds of work activities and two types of RPN. The comparison results of RPN for construction companies are shown in Figure 2 to Figure 4 respectively.

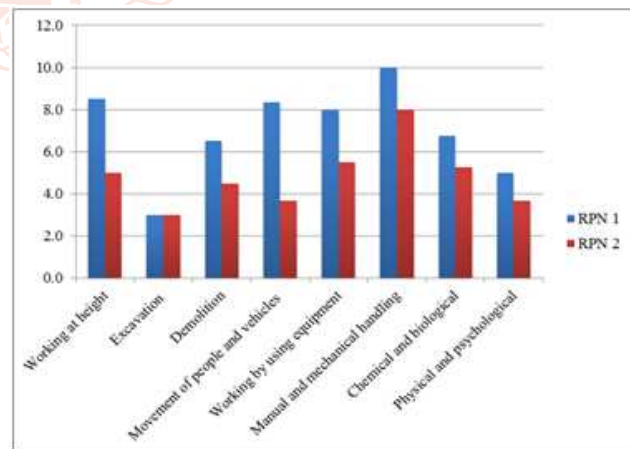


Figure2. RPN Chart of Company A

This chart shows the risk prioritization number of Company A. In this chart, manual and mechanical handling is the highest risk level compare to other hazards. Those RPN 1 and RPN 2 are in yellow zone. It can't change zone but reduce the level of risk. RPN 1 and RPN 2 of 'working at height', 'demolition', 'movement of people' and 'vehicles, working by using equipment' and 'chemical and biological hazards' are in yellow zone. Among them, in physical and

psychological hazard, the level of RPN 1 during existing control is in yellow zone. After additional control, it changes to the green zone. Excavation is the lowest level which RPN 1 and RPN 2 are green zone. In green zone, risks are acceptable and additional controls are not needed.

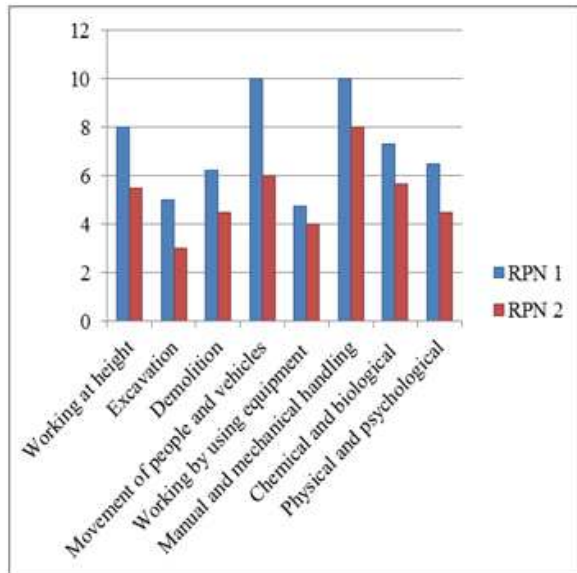


Figure3. RPN Chart of Company B

The chart shows the risk prioritization number of Company B. First of all, the level of RPN 1 of “movement of people and vehicles” and “manual and mechanical handling” are the same which are in yellow zone. By taking additional control, the level of RPN 2 is significantly fall but it is still higher than compare to other hazards which is still in yellow zone. The levels of “working at height, demolition, chemical and biological, physical and psychological” are the same yellow zone. The yellow zone of excavation is changed to the green zone after taking additional control. The yellow zone of working by using by equipment does not change to the green zone until taking additional control.

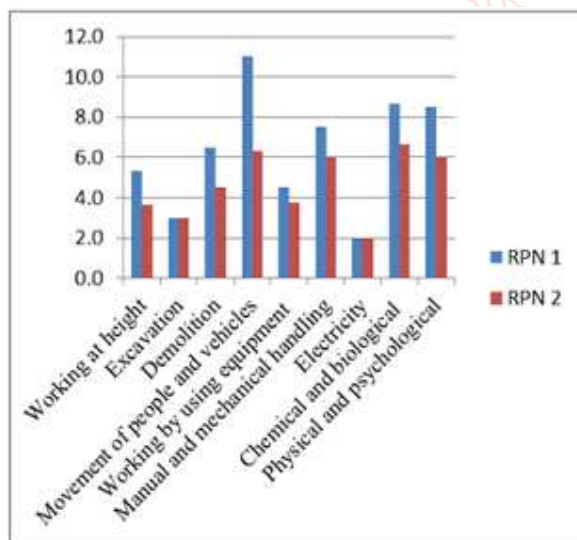


Figure4. RPN Chart of Company C

The chart shows the risk prioritization number of Company C. In this chart, the value of RPN1 of “movement of people and vehicles” are the highest in all. After taking additional control, RPN 2 is still in yellow zone but risks are reduced. In excavation and electrical hazards, the level of RPN 1 is in green zone, in which risks are acceptable and additional controls are not needed. In other hazards, RPN 1 and RPN 2 are in yellow zone both during existing control and after taking additional control.

VII. Conclusions

If there is no proper construction safety procedure, the required work result cannot be obtained. In construction safety, risk assessment is important to reduce risks. In this study, three construction companies in Mandalay (Myanmar) are chosen. The charts which RPN 1 (during existing controls) is compared with RPN 2 (after additional controls) for each construction company are presented. From risk prioritization number chart, RPN 1 and RPN 2 of each activity and the changes to lower levels can be known by making up necessary controls as the jobs progress. Construction projects cannot deeply control the risks for all levels. But controlling procedures used in these projects are acceptable. The project engineers should prepare additional controlling procedures for major items of projects. Therefore, this study can be beneficial for construction safety system and project engineers will know how to reduce the risk of such constructions.

When three construction companies are inspected, “working at height”, “movement of people and vehicles” and “manual and mechanical handling” of each construction company are generally taken as risks. These activities are maximum risk levels when compare other work activities. They do not change from yellow zone until additional controls are made. So, when machine and scaffold damage, they are eliminated and substituted with good one as further controls than PPE.

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