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THE DESIGN OF MITIGATION MODEL OF WORK ACCIDENT RISK BY APPLYING INTERPRETIVE STRUCTURAL MODELING METHOD

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ABSTRACT

Work accidents that happens in construction industry is more often comparing to others industries, it is 32%. So that construction work has risk of accident because its area is outdoor. The causes of accident comes from the worker or manpower itself. Based on this, it is important to mitigate the risk that can cause the accident. The method used in this research is Interpretive Structural Modeling (ISM). Risk mitigation that has high driver power is applying the standard of OSH for the High Rise Building worker, learning MSDS (Material Safety Data Sheet). Workers must have SKT ((Technical Skills Certificate) or TSC (Technical Skill Certificate), Upgrading OSH Management. While mitigation of giving space in setting and removing the scaffolding. All the setting of scaffolding must be checked by the certificated officer. Working method must be suited with the condition of worker and the socialization of the dangerous of spilled paint, create and obey the lifting plan, isolate the cable connection based on the PUIL 2000. Those who are in quadrant II has low level of Driver Power so that these variables have no power to influence other variables in the system. It is hoped that work accident can be decreased and it can minimize the risk (zero accident) for the construction workers.

KEYWORDS : Mitigation, Risk, Work Accident.

1. INTRODUCTION

Construction industry has significant different characteristic comparing with other industries. This difference is in the condition and work system, in construction project almost all of jobs done by manpower with many specializations that create different problems in each work (Andi, et.al 2005). Besides, this kind of work has a high risk of work accident (Handayani, 2017).

According to Sepang (2013), construction work is such a complexity that involved construction materials, construction equipment, construction method, construction cost, and manpower that may cause accidents. In line with Mohamed (2002), he states that construction industry is well known as the industry that has a low level of work safety comparing with other industries. It is same with what has been written in Kompas (2016) that the work accident which happens in construction industry is more often than other industries; it is 32%, manufacture industry 31,6%, transportation industry 9,2%, forestry industry 3,8%, mining industry 2,6%, and other industries 20,7%. It can be concluded that construction work has a high risk in work accident because this kind of working located in outdoor area (Maryani, 2012)

The risk of work accident in construction work comes from its manpower itself (Handayani, 2017) and (Andi et.al, 2015), it is different with Reason (19995) in Andi et.,al (2015) states that work accident is the result of organization and management, while Sutarto (2008) states there are 3 factors that influence the work safety in construction site, they are management, workplace condition, and the workers' awareness. The mitigation of work accident can prevent the accident so that there is a correlation between the mitigation to overcome the risk. In order to resolve the risk in work accident, it needs to understand the correlation between one mitigation of risk and others. So that in modeling the correlation between mitigation model of work accident using interpretive structural modeling (ISM), because this method is widely used in modeling the problem of systems (Sianipar, 2012). The objective of this research is modeling the mitigation plan of work accident in order to reduce accident in construction project.

2. METHODOLOGY

This research applies *Interpretive Structural Modeling* (ISM) in overcoming OSH risk that happens in construction project, and the steps are:

2.1. The Identification of Risk Mitigation.

Before identifying risk mitigation, for the first we should understand the potential risk that should be resolved. The potential risk based on the result of research from Handayani (2017). The identification of risk mitigation done by discussing with the expert toward FGD (Focus Group Discussion). Besides, identification is also done by the study of literature based on HIRARDC. This identification is aimed to understand the appropriate of mitigation in handling the risk by considering its trigger.

2.2. Deciding the type of each mitigation contextually.

Comparison is used in deciding the type of relation, it compares risk mitigation by using contextual relation, which most of it are; the influence, the cause and verbs which deals with risk mitigation (Kanungo and Jain; 2009)

2.3. Creating Structural Self-Interaction Matrix (SSIM) by using pairwise.

In analyzing the relation between elements, contextual relation with what kind of type the relation is, which one element triggers other elements, it stated in this third phase. The relation between 2 sub element (i and j) and the direction of those elements are questioned (Thakar dkk., 2007). There are four symbols in stating the relation:

V = for relation of mitigation risk i to risk j, one way, the existence of mitigation i triggered mitigation j

A = for mitigation j to i, one way. Mitigation j exist if only mitigation i is done

X = it is for mitigation I to mitigation j and from j to i, two ways, those two mitigations are triggered each other

O = if the relation among mitigation seems not valid (not connected)

2.4. Creating Reachability Matrix (RM) and checking the transitivity.

In this phase, it is focused on the making of Reachability, and this is a binary matrix

- If relation (i, j) noted as V so input (i, j) in RM become 1 and (j, i) become 0
- If relation (i, j) noted as A so input (i, j) in RM become 0 and (j, i) become 1
- If relation (i, j) noted as X so input (i, j) in RM become 1 and (j, i) become 1
- If relation (i, j) noted as O so input (i, j) in RM become 0 and (j, i) become 0

2.5. Matrix Test with Transitivity.

Transitivity is the basic assumption to ISM which is used to achieve Final Reachability Matrix (FRM). Transitivity states that if element A has relation with element B and element B has relation with element C. if the element of risk mitigation (i and j) from RM is zero (0), so there are no direct or indirect correlation from mitigation i to j. RM actually has no this character because there is only indirect relation from element i to j, input (i and j) and also zero (0). The direct relation can be shown up by changing FRM to successive power till there is no input, this condition is finished if it reaches $M_{n-1} < M_n = M_{n+1}$. The application of the Transitivity is done by checking cells in reachability matrix with value 0, whether it is fulfill the regulation of transitivity or not.

2.6. Deciding partitionary level from reachability matrix.

It includes the extraction from hierarchical ordering from RM by partitioning in this phase. The objective of this phase is to become the first input for the creating of digraph from RM. The level partition uses elements in sj and si. Reachability set R(si) consist of some its elements and other unsure that can be reached by si. There are also some elements that reach si that act as the antecedent A(si). Next, the interaction from some reachability and antecedent ($R(s_i) \cap A(s_i)$). The element $R(s_i) = (R(s_i) \cap A(s_i)$ is the top element from ISM hierarchy. The top element has no relation to the other element above its hierarchy. If the top element was identified so they will be separated from other elements. The same process continuous to all elements. This identification level is helpful in creating digraph and the last model of ISM.

2.7. Creating digraph with eliminated transitivity connection.

The first digraph included transitivity relation comes from the conical shape from RM. The conical matrix gained from the RM partition with the arranging of element based on its level, which mean all elements with the same level are collected, element that has most zero (0) in half of diagonal and the element that has most 1 in the below of it. To make the digraph simple, it is erased to get the last one. If there is a relation between risk i and j, it shown by the arrow which headed from i to j.

2.8. Converting graph to ISM and checking the inconsistency conceptually.

The result of digraph from this phase is converted to ISM by eliminating the information from the element point. Finally the ISM model is checked for its compatibility.

3. RESULT AND DISCUSSION

Potential risk and its causes that should be done based on the research of Handayani (2017). The plan of risk mitigation that has been identified by the experts and the literature HIRARDC shows as below in Table 1.

Table 1. Potential Risk and Mitigation Risk

No	Risk	Causes	Mitigation
1	Confined	Limited workplace	Give space when setting and removing the scaffolding
2	Fall	Scaffolding was broken	Each of the setting scaffolding must be checked by the certificated Scaffolder
3	Inhaling the chemical substance	Workers do not aware of OSH	The work method is suited with the condition of the job, and give the socialization of the dangerous of the spilled paint
			Studying MSDS (material safety data sheet
4	The material substance hit the skin	Workers do not wear the proper suit.	The working method should follow SNI (Indonesian National Standard)
			OSH Management Improvement

No	Risk	Causes	Mitigation
5	Electrocution	Shorted	Isolate the cable connection based on the PUIL 2000
6	Electrocution	Get a shock from electricity	Isolate the cable connection based on the PUIL 2000
7	Fall	The construction method is not standard	Follow the standard of OSH for working in high place
8	Scratched	The worker is unskillful	The worker must have SKT (Technical Skill Certificate)
9	Slipped and fall	There is no handle	Provide railing and board for footing
10	Confined	Mistake in manual handle	Creating and obeying the lifting plan
11	Dropped of material	In a rush	Applying OSH in High Rise Building
12	Hand cramps	Get less rest	Create the SOP
13	Fall	Working while joking	Each of the setting scaffolding must be checked by the certificated Scaffolder
14	Eyes got material, hand scratched, finger cute, get the coating liquid	Careless	Create the SOP of cutting equipment
15	Inhale the chemical substance, fall in hole, excavatgor hit, hand scratched	Less of OSH commitment	Sign located and workplace safety Do *Safety Morning* and *Safety Induction*

The risk mitigation that has been identified by OSH experts in Table 1 and the next is comparing risk mitigation in matrix relation by using contextual or correlation of each risk mitigation. The next step in building the hierarchy model of ISM. The relation between risks, for instance, for cell (i_1, j_{15}) it says got score 4, which means it has no relation, in cell (i_1, j_4) it says got 1, which means i_1 can trigger risk for j_4. While in (i_1, j_9) it says got 2 which means risk mitigation i_1 fulfilled if only risk mitigation j_9. Is done.

Table 2. Risk Mitigation

No	Mitigation
1	Give space when setting and removing the scaffolding
2	Each of the setting scaffolding must be checked by the certificated Scaffolder
3	The work method is suited with the condition of the job, and give the socialization of the dangerous of the spilled paint
4	Studying MSDS (material safety data sheet
5	The working method should follow SNI (Indonesian National Standard)

No	Mitigation
6	OSH Management Improvement
7	Isolate the the cable connection based on the PUIL 2000
8	Follow the standard of OSH for working in high place
9	The worker must have SKT (Technical Skill Certificate)
10	Provide railing and board for footing
11	Creating and obeying the lifting plan
12	Applying OSH in High Rise Building
13	Create the SOP
14	Create the SOP of cutting equipment
15	Sign located and workplace safety
16	Do *Safety Morning* and *Safety Induction*

3.1. Structural Self-interaction Matrix (SSIM)

The data of the relation among risk mitigation in SSIM by converting number into the letter which says relation category (AVXO). The next is creating reachability matrix (RM), it is by changing SSIM into binary matrix. It is replaces symbol V, A, X, and O with 0 and 1. The result can be seen in Table 3.

Table 3. Reachability Matrix

Variabel	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Driver Power
1	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	4
2	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	4
3	0	0	1	1	1	0	0	0	1	0	0	0	0	0	0	0	4
4	0	0	0	1	1	1	0	1	1	0	1	0	1	1	0	0	8
5	1	0	0	0	1	0	1	1	1	0	1	1	1	1	0	0	9
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
7	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	2
8	1	1	0	0	0	1	0	1	1	0	1	1	0	0	0	0	7
9	1	1	1	0	1	1	1	1	1	0	1	1	1	1	1	0	13
10	0	0	0	0	0	1	0	1	0	1	0	0	0	0	1	0	4
11	0	0	0	0	0	1	0	0	1	0	1	1	1	1	0	0	6
12	1	1	0	0	0	1	0	1	0	1	1	1	1	1	1	0	10
13	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	3
14	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	3
15	0	0	0	0	0	1	0	1	0	1	1	0	0	0	1	0	5
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
Dependence	8	7	4	6	7	11	5	9	9	5	9	9	9	9	6	2	

The next is creating Conical Matrix (Lower Triangular Format) by arranging variable based on the level in Reachability Matrix Final. This Canonical Matrix will be helpful in making the Digraph Structural Model. Canonical Matrix that has been arranged can be seen on Table 4.

Table 4. Canonical Matrix

Variabel	7	9	6	13	14	11	12	1	1	4	16	5	8	3	15	10	DP	Level
7	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	2	I
9	1	1	1	0	1	1	1	1	1	0	1	1	1	1	1	0	13	I
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	I
13	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	3	II
14	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	3	III
11	0	0	0	0	0	1	0	0	1	0	1	1	1	1	0	0	6	IV
12	1	1	0	0	0	1	0	1	0	1	1	1	1	1	1	0	10	IV
1	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	4	IV
2	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	4	V
4	0	0	0	1	1	1	0	1	1	0	1	0	1	1	0	0	8	V
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	V
5	1	0	0	0	1	0	1	1	1	0	1	1	1	1	0	0	9	V
8	1	1	0	0	0	1	0	1	1	0	1	1	0	0	0	0	7	VI
3	0	0	1	1	1	0	0	0	1	0	0	0	0	0	0	0	4	VI
15	0	0	0	0	0	1	0	1	0	1	1	0	0	0	1	0	5	VI
10	0	0	0	0	0	1	0	1	0	1	0	0	0	0	1	0	4	VI
Dependence	8	7	4	6	6	11	5	9	9	5	9	9	9	9	6			

The score of Driver Power gained from the sum of scores in column horizontal j, while Dependence Power gained from the sum of scores in vertical i.

3.2. Driver Power Dependence Matrix

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The next step is classifying the key variable which is important to develop the program. Those variables are divided into 4 parts, those are; driver, linkage, autonomous, and dependent (Pfohl, 2011). Dependence from those variables is in the Figure 1

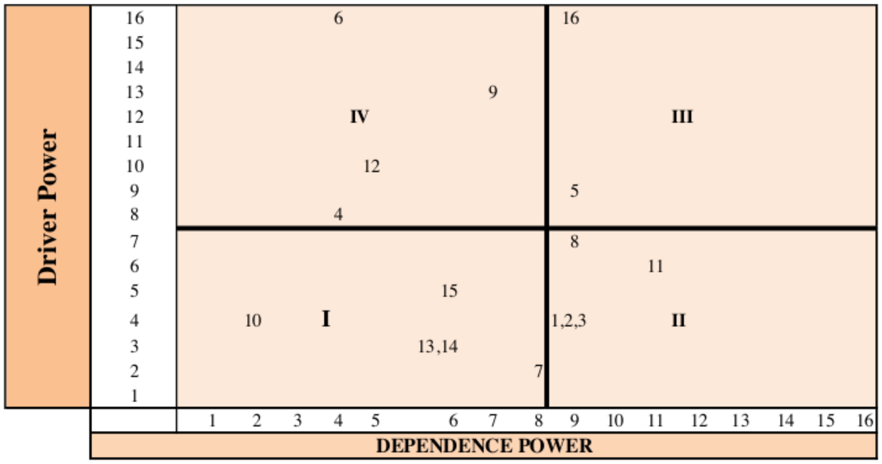

Fig. 1 Driver Dependent Matrix

Risk mitigation in 12, 4, 9, and 6 which is located in quadrant IV have a high driver power, so that this variable has power to influence other variables in the system (Retno, 2013) and these risk mitigation as a key factor in managing risk events. These mitigations are: Applying standard of OSH in High rise Building, Learning MSDS (Material Safety Data Sheet), workers must have the certificate SKT (Technical Skills Certificate) or TSC (Technical Skill Certificate), Upgrading OSH Management. While mitigation of giving space in setting and removing the scaffolding. All the setting of scaffolding must be checked by the certificated officer. Working method must be suited with the condition of worker and the socialization of the dangerous of spilled paint, create and obey the lifting plan, isolate the cable connection based on the PUIL 2000. Those who are in quadrant II has low level of Driver Power so that these variables have no power to influence other variables in the system (Laili, 2014)

Quadrant I. Weak Driver-Weak Dependent Variable (Autonomus), risk mitigation in this quadrant has a relatively small or unrelated influence (Mirah, 2014). Risk mitigation in quadrant I that are: Create the SOP, Create the SOP of cutting equipment, Sign located and workplace safety, Provide railing and board for footing, Isolate the cable connection based on the PUIL 2000

Quadrant III: Strong driver-strongly dependent variable (linkage). Risk mitigation in this position will support the success in addressing the causes of OSH risk that may lead to risk events. Where as if action is not taken from this risk mitigation then the risk incident cannot overcome. Risk mitigation in quadrant III that is work method must follow SNI (Indonesian national standard), Conduct Safety Morning And Safety Induction.

3.3. Structured Hierarchy of OSH Risk Mitigation

Preparation of hierarchical structure model based on Driver Power and level. (Pfohl 2010), The results of the study put the overall mitigation in 6 levels as shown in Figure 2. The hierarchy level determination indicates the dependence between mitigation at the lower level.

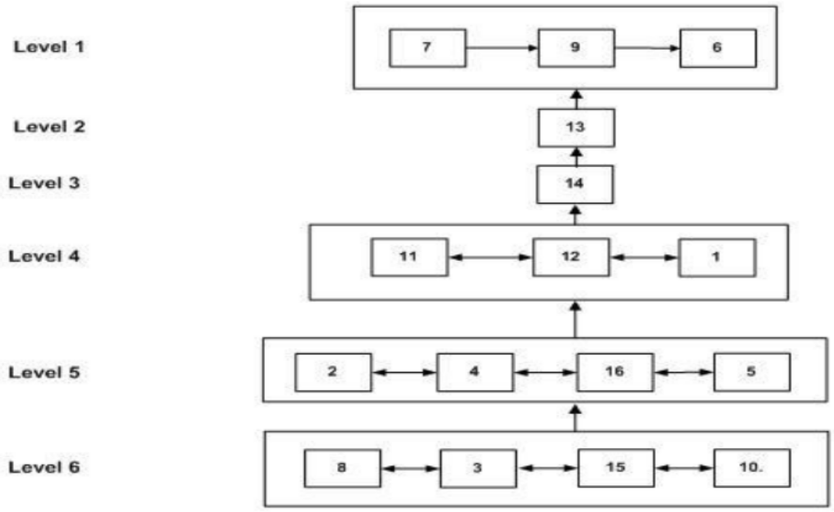

Fig. 2 Structured Hierarchy Model of OSH Risk Mitigation

4. CONCLUSION

The ISM technique produces a structural model of risk mitigation and a DP-D matrix to interact the hierarchy and linkages between each risk mitigation. The risk mitigation that should be done in overcoming the work accident is by applying the standard of OSH in the work of High rise Building. Learning MSDS (Material Safety Data Sheet), workers must have SKT (Technical Skill Certificate), Upgrading OSH Management. By having this risk mitigation, it is hoped that work accident can be decreased and it can minimize the risk (zero accident) for the construction workers.

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