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The Influence of Occupational Safety for Iron Frame Installation Project Workers Using FMEA Approach in CV. Sinar Surya Abadi Sidoarjo

Rusdiyantoro[1], Helga Adityawan[2]
[1,2)] Teknik Industri, Universitas Adibuana Surabaya, Indonesia
e-mail : rusdiyantoro@unipasby.ac.id

Abstract – CV. Sinar Surya Abadi is a company engaged in the installation of iron frames. The manufacture of these products cannot be separated from hazardous equipment such as grinders, plasters, and others. This causes the risk of accidents at work. Thus the application of Occupational Safety and Health (K3) is very important to implement. Based on these problems, a study was made regarding the influence of work safety for project workers including iron with the FMEA approach on CV. Sidoarjo Eternal Sunshine. Occupational Health and Safety is a situation that affects the health and safety of workers or other employees. Occupational accidents can be reduced by implementing occupational safety and health (K3). FMEA is a structured procedure to identify and prevent as many failure modes as possible. FMEA focuses on preventing defects, increasing safety, and increasing customer satisfaction. The advantage of this FMEA is that it can improve the quality of control of the implementation of K3 so that it can prevent work accidents. FMEA serves to determine the actions of prioritized risks. The use of FMEA is also used to find out what potential risks exist in a production process. And also used to analyze failures from human error or the machine used.

Keyword: Refinement of Iron; K3; FMEA; Failure Mode

1. INTRODUCTION

CV. Sinar Surya Abadi is a company engaged in installing iron frames. The products produced by this company are mosque dome roofs, enamel domes, sloping roofs or pyramids, construction pipe construction, and other steel construction. The manufacture of these products certainly cannot be separated from dangerous equipment such as grinders, plasterers, etc. This causes the risk of accidents while working. Thus, the implementation of Occupational Safety and Health (K3) is very important to implement.

Product development and sustainability are important combinations and conditions starting from the design stage, selection of raw materials, typical products, product waste, (Rusdiyantoro, 2015) and especially the risks of such development. With work that is full of risks, the solution to overcome this needs to be research on the impact of work safety for workers on the project to install iron frames on CVs. Sinar Surya Abadi Sidoarjo. This research will focus on what risks will occur and how to overcome or prevent these risks from occurring. Where this risk is closely related to accidents during project work which can be overcome by implementing occupational safety and health (K3) appropriately and appropriately.

Work accidents can be reduced by implementing occupational safety and health (K3). K3 factors and the work environment must be considered, such as employees wearing Personal Protective Equipment, environmental conditions when working so that conditions are comfortable. The influence of K3 can be determined using the FMEA (Failure Mode and Effect Analysis) approach. (Arifuddin, 2022)

FMEA is a structured procedure to identify and prevent as many failure modes as possible. FMEA focuses on preventing defects, improving security, and increasing customer satisfaction. The advantage of FMEA is that it can improve quality control of K3 implementation so that it can prevent work accidents. (Elfira Vidian Paquita, 2022)

2. METHODS

The method used in this research is the Failure Mode and Effect Analysis (FMEA) method. FMEA aims to give weight to the assessment of factors that cause potential

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failure. In the process, FMEA will observe factors that cause potential failure, where these factors are obtained from identifying the causes of failure. Factors obtained from FMEA identification will be the main priority in handling failures. Data collection in this research was by interviews and using questionnaires. Questions asked during interviews and questionnaires are based on observations made on the CV. Sinar Surya Abadi Sidoarjo.

3. RESULTS AND DISCUSSION

This research data was taken using a questionnaire distributed to several respondents. The selection of respondents was carried out on project managers, safety engineers, safety engineer staff and field staff. From the preliminary survey that was carried out, the results of the risk variables were obtained which were not much different from the variables obtained in the previous stage. The results of this preliminary survey can be seen in table 1.

Table 1 Preliminary Survey Results

No	Potential risk	Relevant	Not Revelant
	Material and labor risks		
1	Long delivery of tools and materials	√	
2	Increase in material prices	√	
3	The volume of material sent is incorrect	√	
4	Damage and loss of materials in the field	√	
5	Lack of material storage space	√	
6	Lack of competent workforce	√	
7	Poor material quality	√	
	Implementation risk		
8	Incompatibility of foundation design	√	
9	Weakness of the dome foundation	√	
10	Incomplete and limited equipment	√	
11	Equipment that is no longer suitable	√	
12	Errors in structural calculations and analysis	√	
13	Problem with implementation coordination	√	
14	Heavy equipment accidents	√	
15	Heavy equipment is not working properly	√	
	Job management		
16	Lack of project manager experience	√	
17	Lack communication and coordination between parties involved in the project	√	
18	Poor implementation methods	√	

Apart from assuming that the risk is likely to occur or not, the preliminary survey assessment is also carried out by looking at and observing conditions in the field directly. Because if it is only done by assuming without looking at the conditions in the field, the results will likely be different from the actual conditions in the field. Based on this preliminary survey, a risk ranking can be carried out for each variable. The severity value in FMEA can be calculated in table 2.

Table 2 Failure Mode Effect and Analysis (Severity)

No	Potential risk	Failure mode	Effect	Risk event	Severity scale					SI	Category	Scale
1	Long delivery of tools and materials	Delivery of goods is late due to travel constraints	Work is delayed	Work is not completed on time	1	2	3	4	5	76	T	4
					0	0	2	2	1			
2	Increase in material prices	Price increase due to increase in fuel prices	Work costs become inflated	Prices do not match the agreement	1	2	3	4	5	28	R	2
					3	2	0	0	0			

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3	The volume of material sent is incorrect	There is not enough/excess material	If it is not enough then you have to buy more material	The work takes longer because you have to buy less material	1	2	3	4	5	24	R	2
					4	1	0	0	0			
4	Damage and loss of materials in the field	Reduced work materials	Reduces materials must be purchased immediately	Buy missing materials so that the price becames higher	1	2	3	4	5	52	C	3
					0	2	3	0	0			
5	Lack of material storage space	Materials will be easily stolen	Materials will decrease	Buy materials again	1	2	3	4	5	60	T	3
					0	0	5	0	0			
6	Lack of competent workforce	An error occurred during project work	Correcting the error	Work exceeded the target time	1	2	3	4	5	52	C	4
					0	2	1	2	0			
7	Poor material quality	Products become damaged more quickly	Products become of lower quality	Customer will no longer trust the company	1	2	3	4	5	44	C	3
					0	4	1	0	0			
8	Incompatibility of foundation design	Disappointed customers	There are complaints from customers	Cancellation of cooperation	1	2	3	4	5	32	R	2
					2	2	1	0	0			
9	Weakness of the dome foundation	There was damage to the dome	There were complaints	Customer no longer trusted the company	1	2	3	4	5	76	T	4
					0	0	2	2	1			
10	Incomplete and limited equipment	Companies renting equipment	Rental costs are expensive	Costs can be a bit inflated	1	2	3	4	5	68	T	3
					0	0	3	2	0			
11	Equipment that is no longer suitable	Equipment is not working properly	Work is delayed	Work is not completed on time	1	2	3	4	5	28	R	2
					3	2	0	0	0			
12	Errors in structural calculations and analysis	Project not suitable	Project failed	Customer disappointed	1	2	3	4	5	68	T	3
					0	0	3	2	0			
13	Problem with implementation coordination	Miscommunication occurs	Project becomes a mess	Work id delayed	1	2	3	4	5	48	C	2
					0	3	2	0	0			
14	Heavy equipment accidents	Worker injured	Work delayed	Work not completed on time	1	2	3	4	5	64	T	3
					0	0	4	1	0			
15	Heavy equipment is not working properly	Tool becomes damaged	Work is delayed	It takes time to repair the tool	1	2	3	4	5	80	T	4
					0	0	2	1	2			
16	Lack of project manager experience	Managers find it difficult to organize workers	Work is messy	Work is not completed on time	1	2	3	4	5	72	T	3
					0	0	2	3	0			
17	Lack communication and coordination between parties involved in the project	Miscommunication occurs	Work is messy	Work is not completed on time	1	2	3	4	5	68	T	4
					0	1	2	1	1			
18	Poor implementation methods	Work is less organized	Work is delayed	Work is not completed on time	1	2	3	4	5	56	C	4
					0	3	1	0	1			

Severity is the first step to analyze risk by calculating how much impact/intensity the event affects the process output. Here is how to calculate the severity index.

$$S = \frac{\sum_{i=0}^{5} a_i x_i}{\sum_{i=0}^{4} x_i} \times 100\%$$

$$S = \frac{\sum_{i=0}^{5} (1\times 0)+(2\times 0)+(3\times 2)+(4\times 1)+(5\times 2)}{(5\times 5)} \times 100\%$$

$$S = \frac{2}{2} \times 100\% = 80\%$$

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From the severity index results of 80%, it is obtained that the failure mode at the project location is included in the "T" category. The following classification categories from the assessment scale on severity, occurrence and detection are as follows:

- Very low / very small(SR/SK) = $0.00 \leq S \leq 12.5$
- Low/small (R/K) = $12.5 \leq S \leq 37.5$
- Fair/moderate (C) = $37.5 \leq S \leq 62.5$
- Height/large (T/B) = $62.5 \leq S \leq 87.5$
- Very height/very large= $87.5 \leq S \leq 100$

Based on this preliminary survey, a risk ranking can be carried out for each variable. The Occurance value in FMEA can be calculated in table 3.

Table 3 Failure Mode Effect and Analysis (Occurance)

No	Potential risk	Failure mode	Couse	Occurance scale					OI	category	Scale
1	Long delivery of tools and materials	Delivery of goods is late due to travel problems	Delivery is stuck in traffic jams, roads are too narrow, roads are damaged	1	2	3	4	5	68	T	4
				1	0	2	0	2			
2	Increase in material prices	Simultaneous price increase	Fuel prices rise, dollar prices rise	1	2	3	4	5	40	C	2
				0	2	3	0	0			
3	The volume of material sent is incorrect	Material is insufficient/excessive	Supplier sends the wrong quantity	1	2	3	4	5	48	C	2
				0	4	0	1	0			
4	Damage and loss of materials in the field	Work materials are reduced	Materials are not tidied up when workers rest or return from work	1	2	3	4	5	52	C	2
				0	2	3	0	0			
5	Lack of material storage space	Materials will be easily stolen	Materials are left on the side of the road without being covered in plastic or tied	1	2	3	4	5	44	C	3
				2	0	3	0	0			
6	Lack of competent workforce	Errors occur during project work	Recruitment of worker does not match competency, there is no training period	1	2	3	4	5	84	T	4
				0	0	1	2	2			
7	Poor material quality	Product become damaged more quickly	In order to meet insufficient funds	1	2	3	4	5	28	R	2
				4	0	1	0	0			
8	Incompatibility of foundation design	Disappointed customer	Miscommunication occured between customer and worker	1	2	3	4	5	32	R	3
				2	2	1	0	0			
9	Weakness of the dome foundation	Damage to the dome	The material is of poor quality	1	2	3	4	5	36	R	2
				3	0	2	0	0			
10	Incomplete and limited equipment	Company rents equipment	Rental costs are expensive	1	2	3	4	5	68	T	3
				0	0	3	2	0			
11	Equipment that is no longer suitable	Equipment does not work properly	Equipment has been used for long time and is outdated	1	2	3	4	5	64	T	3
				0	2	0	3	0			
12	Errors in structural calculations and analysis	Project do not match	Miscommunication occurs between customers and workers	1	2	3	4	5	60	T	3
				1	0	2	2	0			
13	Problem with implementation coordination	Miscommunication occurs	Inexperienced manager	1	2	3	4	5	48	C	2
				0	3	2	0	0			
14	Heavy equipment accidents	Workers injured	Lack of implementation of K3 and work SOPs	1	2	3	4	5	64	T	3
				0	0	4	1	0			
15	Heavy equipment is not working properly	The equipment is damaged	The equipment is old and worn out	1	2	3	4	5	64	T	3
				0	1	2	2	0			
16	Lack of project manager experience	Managers find it difficult to manage workers	Managers are inexperienced	1	2	3	4	5	72	T	3
				0	0	2	3	0			
17	Lack communication and coordination between parties involved in the project	Miscommunicatiion occurs	Work is messy	1	2	3	4	5	68	T	4
				0	1	2	1	1			
18	Poor implementation methods	Work is less organized	Workers do not apply SOPs when working	1	2	3	4	5	56	C	4
				0	3	1	0	1			

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Based on this preliminary survey, a risk ranking can be carried out for each variable. The detection value in FMEA can be calculated in table 4.

Table 4. Failure Mode Effect and Analysis (Detection)

No	Potential risk	Failure mode	Design control	Skala detection					DI	Kategori	Skala
1	Long delivery of tools and materials	Delivery of goods is late due to travel problems	Ordering materials must be several days before the work day	1	2	3	4	5	76	T	4
				0	0	2	2	1			
2	Increase in material prices	Simultaneous price increase	Minimize funds for other things	1	2	3	4	5	56	C	3
				0	2	2	1	0			
3	The volume of material sent is incorrect	Material is insufficient/excessive	Ensure the volume of materials with the supplier before delivery	1	2	3	4	5	64	T	3
				0	0	4	1	0			
4	Damage and loss of materials in the field	Work materials are reduced	Materials are tied and covered in plastic before being left home by workers	1	2	3	4	5	28	R	2
				3	2	0	0	0			
5	Lack of material storage space	Materials will be easily stolen	Create a simple materials warehouse	1	2	3	4	5	52	C	4
				2	0	2	0	1			
6	Lack of competent workforce	Errors occur during project work	Conduct competency training for workers	1	2	3	4	5	68	T	3
				0	0	3	2	0			
7	Poor material quality	Product become damaged more quickly	Look for suppliers who sell higher quality materials	1	2	3	4	5	36	R	2
				3	0	2	0	0			
8	Incompatibility of foundation design	Disappointed customer	Immediately make improvements to the design	1	2	3	4	5	48	C	2
				0	4	0	1	0			
9	Weakness of the dome foundation	Damage to the dome	Make sure the basic foundation is strong before cementing	1	2	3	4	5	44	C	2
				2	0	3	0	0			
10	Incomplete and limited equipment	Company rents equipment	Renting goods of good quality	1	2	3	4	5	72	T	3
				0	0	2	3	0			
11	Equipment that is no longer suitable	Equipment does not work properly	Rent equipment that is still suitable	1	2	3	4	5	44	C	3
				0	2	2	1	0			
12	Errors in structural calculations and analysis	Project do not match	Perform structural calculations repeatedly and ensure they are correct before the project is carried out	1	2	3	4	5	68	T	2
				0	0	3	2	0			
13	Problem with implementation coordination	Miscommunication occurs	Carry out more detailed coordinated communication so that there are no misunderstandings	1	2	3	4	5	72	T	3
				0	0	2	3	0			
14	Heavy equipment accidents	Workers injured	Workers must be stricter about K3 and apllicble sops	1	2	3	4	5	64	T	3
				0	0	4	1	0			
15	Heavy equipment is not working properly	The equipment is damaged	Use and store the equipment according to the applicable SOP, so that equipment maintanance is better maintained	1	2	3	4	5	60	C	2
				1	0	2	2	0			
16	Lack of project manager experience	Managers find it difficult to manage workers	Choose managers who are experienced and familliar with other workers	1	2	3	4	5	72	T	3
				0	0	2	3	0			
17	Lack communication and coordination between parties involved in the project	Miscommunicatiion occurs	Work in accordance with applicable K3 and SOP	1	2	3	4	5	72	T	4
				0	1	2	0	2			
18	Poor implementation methods	Work is less organized	Apply sops when applicable	1	2	3	4	5	64	T	4
				0	2	1	1	1			

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Based on the FMEA calculation, the risk priority number (RPN) can be calculated. The RPN value in FMEA can be calculated in table 5.

Table 5. Risk Priority Number (RPN)

No	Potential risk	Failure mode	Effect of failure	Cause of failure	Current control	Existing conditions			
						S	O	D	RPN
1	Long delivery of tools and materials	Delivery of goods is late due to travel problems	Work is delayed	Delivery is stuck in traffic jams, roads are too narrow, roads are damaged	Ordering materials must be several days before the work day	4	4	4	64
2	Increase in material prices	Simultaneous price increase	Work costs become inflated	Fuel prices rise, dollar prices rise	Minimize funds for other things	2	2	3	12
3	The volume of material sent is incorrect	Material is insufficient/excessive	If it is not enough then you have to buy more material	Supplier sends the wrong quantity	Ensure the volume of materials with the supplier before delivery	2	2	3	12
4	Damage and loss of materials in the field	Work materials are reduced	Reduces materials must be purchased immediately	Materials are not tidied up when workers rest or return from work	Materials are tied and covered in plastic before being left home by workers	3	2	2	12
5	Lack of material storage space	Materials will be easily stolen	Materials will decrease	Materials are left on the side of the road without being covered in plastic or tied	Create a simple materials warehouse	3	3	4	36
6	Lack of competent workforce	Errors occur during project work	Correcting the error	Recruitment of worker does not match competency, there is no training period	Conduct competency training for workers	4	4	3	48
7	Poor material quality	Product become damaged more quickly	Products become of lower quality	In order to meet insufficient funds	Look for suppliers who sell higher quality materials	3	2	2	12
8	Incompatibility of foundation design	Disappointed customer	There are complaints from customers	Miscommunication occured between customer and worker	Immediately make improvements to the design	2	3	2	12
9	Weakness of the dome foundation	Damage to the dome	There were complaints	The material is of poor quality	Make sure the basic foundation is strong before cementing	4	2	2	16
10	Incomplete and limited equipment	Company rents equipment	Rental costs are expensive	Rental costs are expensive	Renting goods of good quality	3	3	3	27
11	Equipment that is no longer suitable	Equipment does not work properly	Work is delayed	Equipment has been used for long time and is outdated	Rent equipment that is still suitable	2	3	3	18
12	Errors in structural calculations and analysis	Project do not match	Project failed	Miscommunication occurs between customers and workers	Perform structural calculations repeatedly and ensure they are correct before the project is carried out	3	3	2	18
13	Problem with implementation coordination	Miscommunication occurs	Project becomes a mess	Inexperienced manager	Carry out more detailed coordinated communication so that there are no misunderstandings	2	3	3	18
14	Heavy equipment accidents	Workers injured	Work delayed	Lack of implementation of K3 and work SOPs	Workers must be stricter about K3 and apllicble sops	3	3	3	27
15	Heavy equipment is not working properly	The equipment is damaged	Work is delayed	The equipment is old and worn out	Use and store the equipment according to the applicable SOP, so that equipment maintanance is better maintained	4	3	2	24

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16	Lack of project manager experience	Managers find it difficult to manage workers	Work is messy	Managers are inexperienced	Choose managers who are experienced and familliar with other workers	3	3	3	27
17	Lack communication and coordination between parties involved in the project	Miscommunicatii on occurs	Work is messy	Work is messy	Work in accordance with applicable K3 and SOP	4	4	4	64
18	Poor implementation methods	Work is less organized	Work is delayed	Workers do not apply SOPs when working	Apply sops when applicable	4	4	4	64

To calculate the RPN value, the following formula is used.

$$R = s \times o \times d$$

$$S = 4 \times 4 \times 4$$

$$S = 64$$

Based on the risk priority number value above, the priority improvements that must be carried out first are obtained from the mode of accident that occurred, namely material and labor risks and work management. This is because the RPN failure mode value for the potential risk of long delivery of tools and materials is 64, lack of communication and coordination between parties involved in the project is 64, and poor implementation methods are 64. From the results of the calculated RPN values, the highest failure mode values obtained in the mosque dome construction project are:

1. Long delivery of tools and materials
2. Lack of communication and coordination between parties involved in the project
3. Poor implementation methods

4. CONCLUSION

The conclusions obtained from the processing and analysis that have been carried out are as follows:

1. From the severity index results, the highest severity value was obtained, namely 80%, which is included in the "T" (High) category at project locations where heavy equipment is not working properly, which can cause the effects/impact of the equipment to be damaged. To avoid this, maintenance of work tools must be paid very strict attention to, so that the tools can function properly.
2. From the results of the occurrence index, the highest occurrence value was obtained, namely 84%, which is included in the "T" (High) category in handling failure modes in employment where there is a lack of competent workers, which is caused by the recruitment of workers not in accordance with competence and no training period. . To avoid this, the recruitment of workers must be in accordance with the worker's competency and skills required, then basic training is held as a training period for new workers so that workers can understand better when they enter the field.
3. From the results of the detection index, 76% is included in the "T" (High) category in handling failure modes for long delivery of tools and materials. To overcome this, material orders must be made several days before the work is carried out so that the material does not experience delays in delivery because the material has arrived at the project site earlier.
4. From the results of the RPN calculation, the highest value is 64. Based on these results, the priority improvements that must be made first regarding the mode of accident that occurred are material risks from the workforce and work management. This is caused by the RPN failure mode value for the potential risk of long delivery of tools and materials of 64, lack of communication and coordination between parties involved in the project of 64, and poor implementation methods of 64.

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5. Form the calculated RPN results, the highest failure mode value obtained in the mosque dome constructing project is:
   a. Long delivery of tools and materials
   b. Lack of communication and coordination between parties involved in the project
   c. Poor implementation methods

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