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IMPLEMENTATION OF HIRARC METHOD ON ERECTION GIRDER WORK OF SOUTH JAPEK II TOLL ROAD CONSTRUCTION PROJECT PACKAGE 3

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Abstract

The development of infrastructure is progressing rapidly, particularly for National Strategic Projects, such as the construction of the Jakarta-Cikampek Toll Road (Japek) South II Package 3, which is currently in progress. This toll road project also includes the construction of several interchanges that utilize girders in the process. The purpose of this study is to identify the dominant risk and risk control in erection girder work in the Japek Selatan II Package 3 toll road project. The project commenced during a challenging time when Indonesia was facing the adverse effects of the Covid-19 pandemic, adding an additional obstacle to infrastructure work. Girder Erection Work, in particular, has recorded various types of accidents over the past few years. In response, the Ministry of Public Works and Public Housing has issued Ministerial Regulation No. 10 of 2021, which provides guidelines for Construction Safety Management Systems (SMKK). By employing the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) method, it is anticipated that construction practitioners can effectively manage risks and reduce workplace accidents in this project. Additionally, the Probability Impact Matrix (PIM) will be utilized to identify the most likely hazards and risks that could significantly impact the project's implementation in the event of an accident. In this study, out of the 57 variables validated by experts, the respondents identified 17 risks classified as high-risk and determined 8 main/dominant risks in the girder erection work of the Jakarta-Cikampek Toll Road Japek South II Package 3 Project. Subsequently, control measures and mitigations are planned for these 8 main risks.

Keywords: Risk, HIRARC, SMKK, Occupational Health and Safety (OHS), Erection Girder

INTRODUCTION

Infrastructure plays an important role as one of the driving wheels in terms of economic growth and nation development. The existence of adequate infrastructure is needed in Indonesia. The impact is the importance of maintaining road infrastructure for the safety and comfort of road users and transportation (Tanamal et al., 2023).

Work safety elements are very important in the implementation of construction projects. The Construction Safety Management System (PUPR: 2021) is part of the construction work implementation management system in the context of implementing security, safety, health, and sustainability in each construction work (Fassa, 2021; Jazayeri & Dadi, 2017). Construction Occupational Safety and Health (K3) is all activities

to ensure and protect the safety and health of workers through efforts to prevent work accidents and occupational diseases (BPSDM KemenPUPR: 2019). Work safety is very important in the implementation of construction projects because of the Construction Safety Management System (SMKK) (Yiu et al., 2019).

The implementation of SMKK in Indonesia is still inadequate (Pambudi & Harjanto, 2020). This is shown by the large number of work accidents as explained by Mr. Wahyu Hendrastomo on June 29, 2022 who stated that during 2017 to 2021 there were many construction work accidents, both major and minor which were likely caused by disorderly K3 (Hendrastomo et al., 2022). This results in the need for construction safety risk management in project implementation.

With the enactment of a new regulation, namely PUPR Minister Regulation No. 10 of 2021, it has actually regulated the Construction Safety Management System Guidelines (Gheisari & Esmaeili, 2019). But if you look at previous records from the Ministry of Public Works and Public Housing, since the last 3 years, namely 2019 to 2021, there have been more than 10 cases of construction accidents in road infrastructure projects resulting in at least four workers dying and 11 other workers suffering injuries. Work accidents were dominated by cases of girder collapse and crane collapse. Work accidents not only cause casualties, but also cause economic losses that are not small. Many work accidents are dominated by elevated road work as well as bridge work that uses girders and the like (Purwayudhaningsari et al., 2023).

Erection Girder work is included in work that is on the critical path of toll road construction projects, this work requires handling starting from the diversion of traffic flow, the use of heavy equipment as support such as CRANE 180T for service lifting equipment and CRANE 250T for main lifting equipment and Erection Box Girder Length 50 meters (Khalim et al., 2020). Moreover, the projects currently being carried out in the conditions of the Covid-19 pandemic, of course, there are other things that are very important and also influential in activities in all aspects.

The purpose of this study is to identify the application of SMKK in Erection Girder work in Japek Selatan II Package 3 Toll Road Project Identify the main risks to Erection Girder work in Japek Selatan II Package 3 Toll Road Project. Planning control and control of the main risks in the Erection Girder work at the Japek Selatan II Package 3 Toll Road Project.

RESEARCH METHOD

Data Collection Techniques used in this study include literature studies, site observations, interviews/questionnaires conducted to obtain data for this research analysis consisting of experts in the field of road construction, K3 fields, academic experts, project managers, project managers and project supervisors and documentation (Grau et al., 2012).

During observation and interviews at the location, data related to project implementation activities, the application of K3 in the field, and data on the possibilities that occur, will be collected to determine research variables (Maturidi, 2014). Research variables can be obtained from literature studies (scientific journals, books and other

literature) in this study the determination of the number of questions has no limit. The condition of the project to be studied will also affect variables, for example due to pandemic conditions, so researchers are expected to make a list of questions in accordance with the research objectives.

The next stage is continued with risk assessment with the aim of evaluating the magnitude of the risk and the impact scenario that will be caused. This risk level analysis is used by the *Perform Qualitative Risk Analysis* process in *PMBOK® Guide 5th Edition* as a guideline.

Table 1 Index Scale

Qualitative Measures of Impact			
Scale	**Likelihood**	**Impact of time and cost on projects**	
		Time	**cost**
VHI	>70%	> 1 week	> 250 million
HI	51%-70%	1 week	101 - 250 million
MED	21%-50%	< 7 days	51 - 100 million
LO	5%-20%	1 day	10 - 50 million
VLO	<5%	< 1 day	< 10 million

(Source: Processed by author)

From table 1 of the Index Scale, it can be seen that the index scale is divided into five levels, namely VHI *(Very High), HI* (High*), Med* (Medium), *LO (Low)* and VLO (Very *Low)*. The next step is to calculate the importance of the risk using the following formula:

Risk Score = Probability x Impact (1)

Description :

Risk Score = Risk importance

Probability = Assess the likelihood of risk occurring

Impact = Assess the impact of the risks that occur.

Once the scale of probability, impact and importance of risk is known, the next step is to map the three values into a matrix.

PROBABILITY	**0,9**	0,045	0,09	0,18	0,36	0,72
	0,7	0,035	0,07	0,14	0,28	0,56
	0,5	0,025	0,05	0,1	0,2	0,4
	0,3	0,015	0,03	0,06	0,12	0,24
	0,1	0,005	0,01	0,02	0,04	0,08
		0,05	**0,1**	**0,2**	**0,4**	**0,8**
		IMPACT				

Figure 1 Risk Assessment Matrix with Probability Impact Matrix (Processed by author)

Figure 1 shows the results of risk grouping using a matrix. From figure 1 it can be known which risks are likely to occur large, cause significant impacts and require serious treatment.

Risk assessment is an attempt to calculate the magnitude of a risk and determine whether the risk is acceptable or not, Risk assessment is used to determine the level of risk in terms of the likelihood of occurrence (*likelihood)* and severity (*severity)* that can be caused (Ramli, 2010). Qualitative method according to AS/NZS 4360 standard, likelihood is given a range between a risk that rarely occurs to a risk that can occur at any time. For severity or *severity* is categorized between events that do not cause injury or only minor losses that are most severe if they can cause fatal events (death) or major damage to company assets (Mayer, 2015). Data Analysis of this qualitative research was carried out using the *Probability Impact Matrix* (PIM) related to the SMKK project sourced from PUPR Minister Regulation No. 10 of 2021

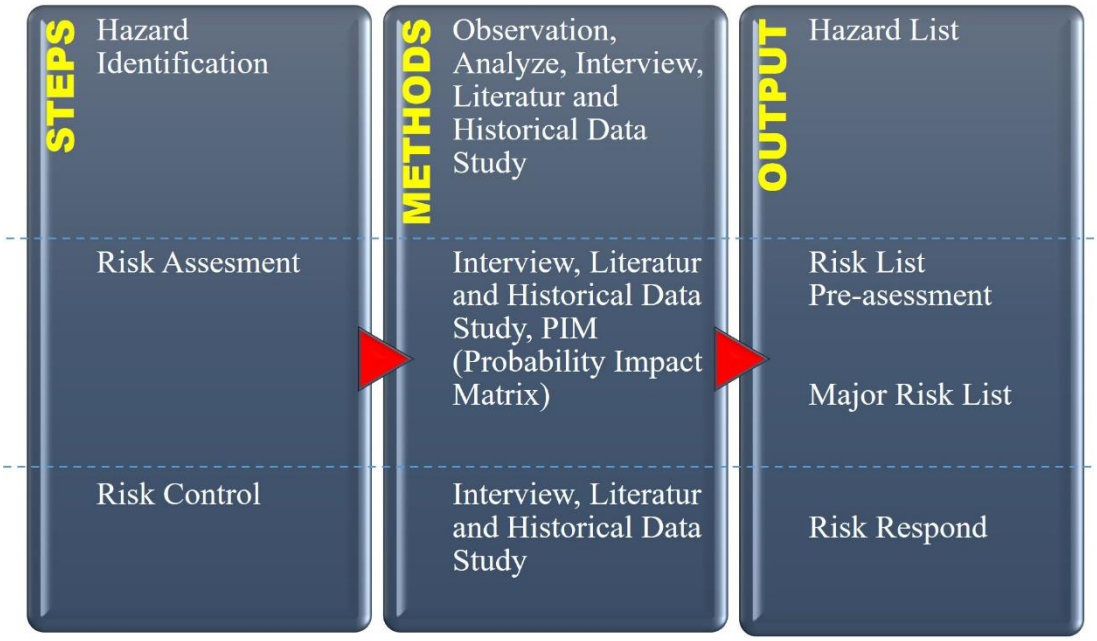

Figure 2 Flow of Research Stages
Source : (Processed by author)

RESULT AND DISCUSSION

From the results and expert answers regarding variables that affect the hazards and risks to the safety of erection girder work construction in the Japek Selatan II Package 3 Toll Road Construction Project, 57 variables have been validated by experts, then a follow-up questionnaire will be prepared which will be distributed to respondents. The respondents to be addressed are people who influence work in the field, contractors, technicians, and other workers (Wang et al., 2016).

From respondents who answered this questionnaire, 30 respondents were obtained who filled out this questionnaire divided into filling criteria, namely: :

1. Type of Work : Consultant / contractor : 18 people, Civil servant / ASN: 11 person, Academician / lecturer : 1 person

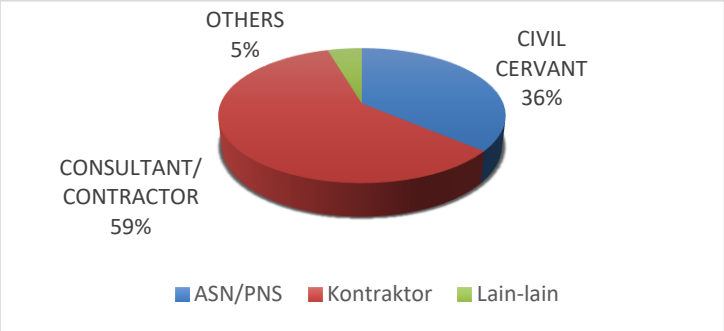

Figure 3 Respondent's Type of Work

2. Questionnaire answerers based on last education: Magister Degree: 9 people, Bachelor Degree: 16 people, and High School: 1 person

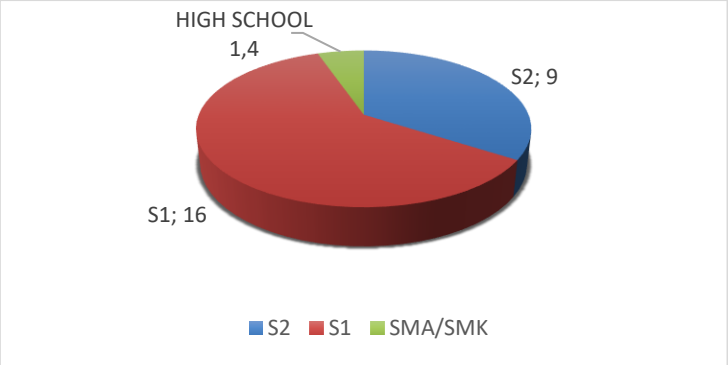

Figure 4 Respondent's Last Education

3. Questionnaire answerers based on length of work experience: >20 years: 4 people, 10-20 years: 10 people, 6-10 years: 7 people, 1-5 years: 9 people

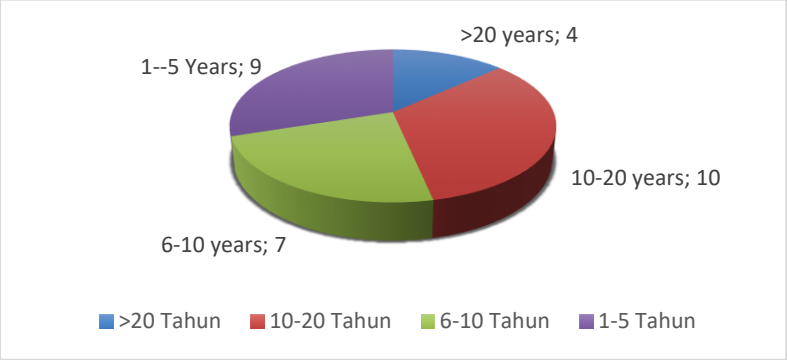

Figure 5 Respondent's Length of Work Experience

4. Erection girder work that has been done by respondents, among others:
   a. Japek Selatan Package 3, Japek Elevated, Semarang Bawen Project Package 6, Palembang LRT Project
   b. ATP, Termanu, Paspro, Bocimi, Japeksel
   c. Airport Railway Line
   d. Bridges on Serpong - Cinere Toll Road &; Bridges on Cisumdawu Toll Section 5b &; 6a
   e. Becakayu Toll Road Project Wiyoto Wiyono Connection
   f. Underpass Project
   g. Pump Station 3-2 Bandar Aceh

h. JLNT Antasari, Ulujami Toll Road, YIA Airport, JIS

1. Types of girders that have been worked on by respondents with experience working on erection girders :
   a. I-Girder : 70 %
   b. Box Girder : 55 %
   c. U-Girder : 25 %
   d. T-Girder : 0%
   e. Plate Girder : 10%
2. Girder Installation Method that has been done by respondents with experience working on erection girders :
   a. Crawler Crane : 81 %
   b. Launcher Girder : 52,4 %
   c. Lainnya : 9,5 %
3. Girder Length, a segment of Girder that has been worked on by respondents with experience working on erection girders :
   a. 45 meter
   b. 25-120 meter
   c. 12 segmen
   d. 40 meter - 50 meter
   e. +- 40 Meter dan SB Arch (Komposit Girder) Bentang Panjang 50 - 70 Meter
   f. 40 meter
   g. 50meter /8 segmen
   h. 7 meter
4. Girder products that have been worked on by respondents with experience working in erection girders :
   a. WBP, Witon
   b. WBP, Adhimix, Witon, Bukaka, Gunanusa, Waagner
   c. Girder Indonesia
   d. PT. Bakrie Metal Industries dan PT Waskita Beton Precast Tbk
   e. Adhi precast
   f. Waskita Precast
   g. Wika
   h. Witon

Of the 58 risk variables asked, the results were obtained which included low risk as many as 4 variables, medium risk 37 variables and high risk 17 variables. The 17 variables that include high risk, the description is as follows: :

Table 2 Assessment of High Risk Level Variables using the Probability Impact Matrix

VARIABEL	ACTIVITIES	IMPACT/HAZARD	RISK
X21	Lifting Frame Girder Installation Work	Death	Crane rollover
X23	Lifting Frame Girder Installation Work	Death	Worker Falls from Height
X24	Lifting Frame Girder Installation Work	Death	Hit by falling girders
X26	Mobilization and Loading Girder Work	Broken Girder, Damaged Material	Dropped girder

VARIABEL	ACTIVITIES	IMPACT/HAZARD	RISK
X27	Mobilization and Loading Girder Work	Death	Sling breaks up regarding workers
X28	Mobilization and Loading Girder Work	Death	Crane rollover
X40	Setting PCI Girder	Serious Injury, Death	Snapped precast concrete
X41	Setting PCI Girder	Serious Injury, Death	Crushed by heavy equipment
X44	Bracing PCI Girder	Death	Worker Falls from Height
X46	Bracing PCI Girder	Broken Girder, Damaged Material	Dropped girder
X47	Erection PCI Girder	Serious Injury, Death	Hit by falling girders
X48	Erection PCI Girder	Serious Injury, Death	Worker Falls from a Height
X50	Erection PCI Girder	Broken Girder, Damaged Material	Dropped girder
X51	Erection PCI Girder	Serious Injury, Death	Rolling girder hitting worker
X52	Erection PCI Girder	Serious Injury, Death	Crane rollover
X53	Erection PCI Girder	Broken crane	Crane rollover
X56	Pelepasan Sling	Serious Injury, Death	Worker Falls from Height

After classifying risks that have a high level of risk, the main or dominant risk is determined from the risk determination criteria according to PUPR Regulation no. 10 of 2021 and an assessment based on the Probability Impact Matrix (PIM) Ifeanyi, (2019), Of the 17 variables above, it can be concluded for hazards and risks with a high risk value determination, there are several similarities between several erection girder work activities. The similarity of these risks to obtain the main risk obtained from the results of measuring the determination of the level of risk which is included in the high risk category, 8 risk variables are obtained, namely :

Table 3 Hazard and Major Risk Result Using Probability Impact Matrix

NO	IMPACT (HAZARD)	RISK
1	Death	Crane rollover
2	Death	Worker Falls from Height
3	Death	Hit by falling girders
4	Broken Girder, Damaged Material	Dropped girder
5	Death	Sling breaks up regarding workers
6	Serious Injury, Death	Snapped precast concrete
7	Serious Injury, Death	Crushed by heavy equipment
8	Broken crane	Crane rollover

Table 4 Respon of Major Risk

1	**(X21, X28, 52, X53)**	**HAZARD**	**Death**	**RISK**	**Crane Rollover**
	Eliminasi	Preparation of a flat, stable and sturdy footing for cranes, competent crane operators			
	Substitusi	Replacing cranes with appropriate capacities			
	Engineering Control	Check Shop drawing, calculation sheet material, erection tools and systems, Check the carrying capacity of the crane runway soil (>8%), check the flatness of the crane runway, check wind speed *continuously*, Work according to *the Work methode statement* SOP, install warning signs2, SWA when there is a discrepancy, proper emergency evacuation route.			
	Administrasi Control	K2K recommendations, COE, JSA recommendations, Work Permits, Personnel health check results before work,			
	APD	Helmet, Vest, Safety Shoes, *Full Body Harness*, Gloves			
	Avoidance	Prepared a large enough area as a safe area.			
	Transfer	Not done			
2	**(X23, X44, X48, X56)**	**HAZARD**	**Death**	**RISK**	**Worker Falls from Height**
	Eliminasi	Workers must be in good health. Before duty, workers are checked for health.			
	Substitusi	Not done			
	Engineering Control	Check working drawings, Check the calculation of the strength of the ascending ladder access, check the calculation *of the strength of the life line and its stand, Test the ability of* the life line,			
	Administrasi Control	Tagging access scafolding and stairs used, Work permit at height (Certified worker), ambush warning,			
	APD	Helmet, Vest, Safety Shoes, *Full Body Harness*, Gloves			
	Avoidance	Not done			
	Transfer	Not done			
3	**(X24, X47)**	**HAZARD**	**Death**	**RISK**	**Crushed by falling girders**
	Eliminasi	Make sure the latches and slings are safe, not brittle, in good condition. Maximum lifting 80% of lifting capacity			
	Substitusi	Not done			
	Engineering Control	Check the lay out of work in the field, Inspection of the girder mounting runway before stressing and erection, calculation of bracing material when the girder is still in the stressing bed, Initial lifting test			
	Administrasi Control	K2K recommendations, COE recommendations, Job Safety Analysis (JSA), Work Permits, Personnel health check results before work,			

	APD	Helmet, Vest, Safety Shoes, *Full Body Harness*, Gloves
	Avoidance	Prohibit people from being under girders when lifted (up to a certain distance)
	Transfer	Not done
4	**(X25, X50, X51)**	**HAZARD** **Broken Girder, Damaged Material** **RISK** **Dropped girder**
	Eliminasi	Make sure the latches and slings are safe, not brittle, in good condition. Maximum lifting 80% of lifting capacity Using a new sling for one project and should be replaced periodically
	Substitusi	Not done
	Engineering Control	Check working drawings, check *jacking force document calculations* according to girder proposals, check stress equipment calibration, check sling certificates, rigging accessories check test by PJK3, ambush in the field and warning and prohibition signs, Socialization to road users, Initial test of lifting
	Administrasi Control	K2K recommendations, COE recommendations, Job Safety Analysis (JSA), Work Permits, Personnel health check results before work,
	APD	Helmet, Vest, Safety Shoes, *Full Body Harness*, Gloves
	Avoidance	Not done
	Transfer	Not done
5	**X27**	**HAZARD** **Death** **RISK** **Sling breaks up regarding workers**
	Eliminasi	Slings are always in good working order Using a new sling for one project and should be replaced periodically
	Substitusi	Not done
	Engineering Control	Check working drawings, Check jacking force *document calculations according to* girder proposals, check stressing equipment calibration, Check sling certificates, rigging accessories check test by PJK3, ambush in the field and warning and prohibition signs, Socialization to road users, Initial lifting test, Check the strength of rigging accessories according to Permenkertrans 8 2020 concerning Lifting Equipment
	Administrasi Control	K2K recommendations, COE recommendations, Job Safety Analysis (JSA), Work Permits, Personnel health check results before work,
	APD	Helmet, Vest, Safety Shoes, *Full Body Harness*, Gloves
	Avoidance	Not done
	Transfer	Not done

6	**X40**	**HAZARD**	**Serious Injury, Death**	**RISK**	**Terjepit beton precast**
	Eliminasi	Not done			
	Substitusi	Not done			
	Engineering Control	Check working drawings, check *jacking force document calculations* according to girder proposals, check stress equipment calibration, check sling certificates, rigging accessories check test by PJK3, ambush in the field and warning and prohibition signs, Socialization to road users, Initial test of lifting			
	Administrasi Control	K2K recommendations, COE recommendations, Job Safety Analysis (JSA), Work Permits, Personnel health check results before work,			
	APD	Helmet, Vest, Safety Shoes, *Full Body Harness*, Gloves			
	Avoidance	Prohibit people from being under girders when lifted (up to a certain distance)			
	Transfer	Not done			
7	**X41**	**HAZARD**	**Serious Injury, Death**	**RISK**	**Crushed by heavy equipment**
	Eliminasi	Not done			
	Substitusi	Not done			
	Engineering Control	Check Shop drawing, calculation sheet material, erection tools and systems, Check the carrying capacity of the crane runway soil (>8%), check the flatness of the crane runway, check wind speed *continuously*, Work according to *the Work methode statement* SOP, install warning signs2, SWA when there is a discrepancy, proper emergency evacuation route.			
	Administrasi Control	Steressing work permit, erection work permit, work permit at height, welding work permit, work area zoning according to safety plant, PIC On Duty In the field.			
	APD	Helmet, Vest, Safety Shoes, *Full Body Harness*, Gloves			
	Avoidance	Prohibit people from being under girders when lifted (up to a certain distance)			
	Transfer	Not done			
8	**X53**	**HAZARD**	**Broken Crane**	**RISK**	**Crane Rollover**
	Eliminasi	Preparation of a flat, stable and sturdy footing for cranes, competent crane operators			
	Substitusi	Not done			
	Engineering Control	Check Shop drawing, calculation sheet material, erection tools and systems, Check the carrying capacity of the crane runway soil (>8%), check the flatness of the crane runway, check wind speed *continuously*, Work according to *the Work methode statement* SOP, install warning signs2, SWA when there is a discrepancy, proper emergency evacuation route.			
	Administrasi Control	Steressing work permit, erection work permit, work permit at height, welding work permit, work area zoning according to plant safety, PIC On Duty In the field.			

APD	Helmet, Vest, Safety Shoes, Gloves
Avoidance	Not done
Transfer	Not done

CONCLUSION

From the research on the Japek Selatan II Package 3 Toll Road Construction Project, it was concluded that several references were obtained 68 variables that affect girder work which are divided into girder erection work activities. After verifying, clarifying and validating experts to determine variables that affect and have risks to erection girder work in the Japek Selatan II Package 3 Toll Road Construction Project, 58 variables were obtained which were used to distribute questionnaires to respondents to determine the factors or high / dominant risk. The dominant Risk Factors that affect the *erection girder work* in the Japek Selatan II Package 3 Toll Road Construction project according to the results of *the Probability Impact Matrix*, 17 types of Hazard and Risk activities that fall into the high Risk category are as follows (1). Divided into 3 main Hazards, namely: Death, Severe Injuries and Damaged Materials. (2) Classified into 8 main risks, namely crane rollover, workers falling from a height, being hit by falling girders, falling girders, broken slings hitting workers, pinched by precast concrete, crushed by heavy equipment.

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