Analysis of Construction Safety Management System Based on the Ministry of Public Works and Housing Regulation No.10 of 2021 (Case Study: Basement Construction Project of the Great Mosque of Serang City)

Siti Asyiah[1*], Rifky Ujianto[2], Mush'ab 'Abdu Asy Syahid[3], Dwi Novi Setiawati[4], Mariana Feronica Damanik[5], Syarahbil[6]
[1,2,3,4,5,6] Department of Civil Engineering, Sultan Ageng Tirtayasa University, Indonesia

Article Info

Article history:

Received, February 17, 2025
Accepted, April 2, 2025
Published, April 30, 2025

Keywords:

Basement, SMKK, IBPRP, PPE (Personal Protective Equipment)

ABSTRACT

The Indonesian Government through the Minister of Public Works and Housing has recently issued Regulation Number 10 of 2021 concerning guidelines for the Construction Safety Management System (SMKK). This regulation must be implemented during construction as it is part of project planning and control. The objectives of this research are to analyze the level of influence of PUPR Ministerial Regulation No.10 of 2021 on improving SMKK implementation in the basement construction project of the Great Mosque of Serang City, to identify hazards that can cause accidents in the construction work, and to determine control action plans to reduce the risk level of accidents in the Serang City Grand Mosque basement construction work. The conclusion is that PUPR Ministerial Regulation No. 10 of 2021 concerning SMKK has a significant impact. This regulation emphasizes the importance of work safety in construction projects, including the Serang City Grand Mosque basement construction. By using the Hazard Identification, Risk Assessment, Risk Control Determination, and Opportunity (IBPRP) method, potential hazards can be identified for each type of work. The identification of work risks assessed with low risk level is 23 types of work (32.41%), medium risk level is 39 types of work (54.92%), and high risk level is 9 types of work (12.67%) from a total of 71 work risks. From the analysis of risk control identification using the IBPRP table, one high-risk level work was selected, namely the first floor structure work with the sub-work of formwork dismantling and risk identification of scaffolding collapse. The risk controls identified are using support pipes to strengthen the scaffolding and installing 2-layer railings on the scaffolding, conducting toolbox meetings, safety induction, job training, and ensuring the scaffolding is safe to use, and using PPE (safety shoes, safety helmet, vest, long-sleeved work clothes, gloves, and full body harness).

Available online at http://dx.doi.org/10.62870/fondasi

Corresponding Author:

Siti Asyiah,
Department of Civil Engineering,
Sultan Ageng Tirtayasa University,
Jl. Jendral Soedirman Km 3, Banten, 42435, Indonesia.
Email: *siti.asyiah@untirta.ac.id

1. INTRODUCTION

Infrastructure development in Indonesia continues to increase over time. This is based on increasing societal needs, ranging from construction of roads, ports, airports, buildings, and other facilities including building construction. Buildings are physical manifestations of construction work that are integrated with their location and function as places for humans to conduct activities, whether for residence or living quarters, religious activities, business activities, social activities, cultural activities, or special activities [1]. The population continues to increase as the years change in Serang City, with significant and steady development every year. This can be seen from the total population of Serang City which increased by 2.31% from the previous year and over time [2]. With the increasing population of Serang City, transportation needs also increase. This certainly creates problems in the parking area sector which continues to grow. To address this issue, the Serang City government is working to reduce these problems with the solution of building a basement parking area at the Serang City Grand Mosque, which is a historic mosque complex located in Serang city. The presence of a basement will certainly require soil excavation. This is a common part and is the first step in establishing a building [3]. This mosque was originally built in 1870 by order of the local Muslim community and was inaugurated on February 14, 1872. While a project in the construction sector is underway, there will always be risks in every work process. This is unfortunate in the construction sector because this sector is one of the highest contributors to workplace accidents compared to other sectors [4]. The construction sector's high rate of workplace accidents is also influenced by insufficient safety culture, lack of training, and incomplete provision of personal protective equipment (PPE) [9], [21]. Previous studies have shown that safety performance on construction projects is strongly affected by management commitment, worker competence, and the implementation of structured safety programs [15], [21]. Furthermore, the cost allocation for safety management is often overlooked, even though studies indicate that proper budgeting for safety can significantly reduce accidents and improve project performance 29, 10.

The Indonesian Government through the Minister of Public Works and Housing has recently issued Regulation Number 10 of 2021 concerning Construction Safety Management System guidelines. The Construction Safety Management System (SMKK) rules are required to be implemented during construction because they are also part of project planning and control. Construction Safety Management System is part of the construction work implementation management system to ensure the realization of construction safety [5]. Occupational Health and Safety is a protection effort aimed at ensuring workers and others at the workplace are always in a safe and healthy condition, and that each production is used safely and efficiently [6]. For work safety, Personal Protective Equipment (PPE) is needed, which is defined as standard Occupational Health and Safety equipment in construction projects that is very important and must be used to protect oneself from accidents or hazards that may occur in the construction process [7], [27]. Hazard Identification, Risk Assessment, Risk Control Determination, and Opportunities (IBPRP) is the process of identifying hazards, assessing and controlling risks, and assessing opportunities. The IBPRP contains construction safety risks at each stage of work calculated by multiplying the frequency level value and the severity level of hazard impact [8].

The application of IBPRP or similar risk management methods, such as HIRADC and JSA, has been proven effective in identifying and mitigating hazards in various construction projects in Indonesia [11], [14], [24]. The implementation of SMKK is not only a regulatory requirement but also a strategic approach to ensure the sustainability of construction projects and protect public safety [17]. Research also shows a strong positive correlation between the implementation of OHS and risk management with project success and reduction in accident rates [20].

In general, construction is an activity of building facilities and infrastructure. Additionally, construction can also be defined as buildings or infrastructure units in one or several areas. In brief, construction is defined as the overall object of a building consisting of structural parts. For example, the construction of a building structure is the overall form or build of the building structure [13]. A basement is a level or several levels of a building that is wholly or partly located below ground level, so it can be said that a basement is an underground space that is part of a building [14]. The causes of accidents are divided into 2 groups, namely direct and indirect causes. Direct or primary causes are caused by unsafe behavior and unsafe work environment conditions, while indirect causes can be caused by human factors, environment, and management of someone in carrying out something [15]. This research conducts an Analysis of the Construction Safety Management System (SMKK) According to PUPR Ministerial Regulation No. 10 of 2021 (Case Study: Basement Construction Project at the Great Mosque of Serang City).

2. METHODS

The method used was conducting a field survey to obtain workplace accident data located at the Serang City Grand Mosque basement project using the IBPRP (Hazard Identification, Risk Assessment, Risk Control Determination, and Opportunities) table [5]. The research stages are:

1. Formulating the background, problem statement, research objectives, problem techniques, research benefits, and research originality.
2. Compiling a literature review in the form of previous research used as references.
3. Collecting data in the form of primary and secondary data that supports research success.
4. Processing and analyzing data using Microsoft Excel and the IBPRP table (Hazard identification, risk assessment, risk control determination, and opportunities) with reference to PUPR Ministerial Regulation No. 10 of 2021.
5. Drawing conclusions from the research results.

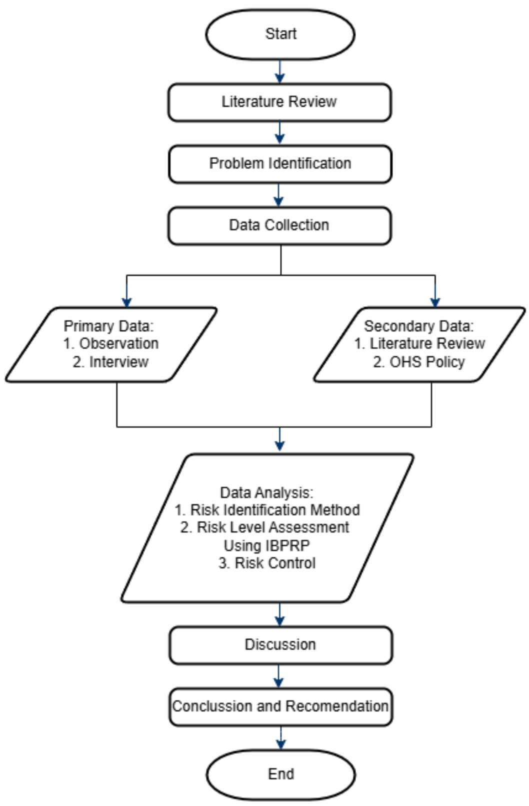

Figure 1. Research Flow Diagram

3. RESULTS AND DISCUSSION

In this research, risk identification and risk control data were obtained which were then used for the IBRP table aimed at assessing the magnitude of risk techniques before control was carried out and after control was carried out with the aim of reducing workplace accidents [9].

3.1 Risk Identification

In every job performed by a project, there are always surrounding dangers [10], caused by several negligences that can cause workplace accidents. Therefore, in this Serang City Grand Mosque basement project, hazard and risk identification is carried out. To obtain hazard identification, the Construction Safety Management System (SMKK) is implemented, namely by collecting references related to the research object, especially related to potential hazards with identification for all observation objects [11]. As an example, the following is the result of risk identification analysis on Floor 1 Structure work.

Table 1. Risk Identification in Floor 1 Structure Work

Work	Risk Identification
Reinforcement Bar Fabrication	Pierced, scratched, or pinched by reinforcement bars Hit by reinforcement bars Pierced by binding wire
Reinforcement Installation	Falling Hit by scaffolding
Formwork Installation	Hit by handtools Hit by collapsing formwork

3.2 Risk Level Assessment

After conducting risk identification, the next step is determining risk assessment which aims to know the hazard risks that occur. This risk assessment is taken from the analysis results using the IBPRP table and using the matrix in the Risk Level Determination Matrix which aims to determine the risk being reviewed [12].

Table 2. Risk Level Determination Matrix

	Severity				
Frequency	**1**	**2**	**3**	**4**	**5**
1	1	2	3	4	5
2	2	4	6	8	10
3	3	6	9	12	15
4	4	8	12	16	20
5	5	10	15	20	25

Note:
1 – 4 : Low Risk Level
5 – 12 : Medium Risk Level
15 – 25 : High Risk Level

Where: Frequency can be symbolized by (A) and Severity (K), with Risk Value being the Multiplication of Frequency and Severity (AxK) and Risk Level symbolized by (TR)
As an example, it can be seen in the following table:

Table 3. Example of Risk Level in Floor 1 Structure Work

Risk Identification	Frequency / Likelihood (A)	Impact / Severity (K)	Risk Value (AxK)	Risk Level (TR)
Reinforcement Bar Fabrication				
Pierced, scratched, or pinched by reinforcement bars	3	2	6	Medium
Hit by reinforcement bars	3	5	15	High
Pierced by binding wire	1	1	1	Low
Reinforcement Installation				
Falling	3	5	15	High
Hit by scaffolding	3	4	12	Medium
Formwork Installation				
Hit by handtools	2	3	6	Medium
Hit by collapsing formwork	2	4	8	Medium

3.3 Risk Control

After conducting risk level assessment, the next step is determining control which aims to reduce or eliminate the hazard risks that will occur. The control techniques used in this research use risk reduction techniques as follows [5]:

1. Elimination
2. Subtitution
3. Engineering Control
4. Administrative Control
5. Personal Protective Equipment (PPE)

To obtain hazard risk control, the Construction Safety Management System (SMKK) is implemented. The steps that need to be taken include collecting references related to the research object, especially related to potential hazards with identification for all observation objects [5].

As an example, it can be seen in the following table:

Table 4. Example of Risk Control in Floor 1 Structure Work

Risk Identification	Control
Reinforcement Bar Fabrication	
Pierced, scratched, or pinched by reinforcement bars	1. Eliminating or protecting sharp parts of the reinforcement 2. Conducting toolbox meeting and safety induction and work training; 3. Using PPE (Safety shoes, safety helmet, vest, and long-sleeved work clothes).
Hit by reinforcement bars	1. Providing storage yard, installing safety signs, conducting toolbox meeting and safety induction, and procedures for storing reinforcement bars; 2. Using PPE (Safety shoes, safety helmet, vest, and long-sleeved work clothes).
Pierced by wire	1. Installing guards or wrapping on sharp wire ends 2. Using PPE (Safety shoes, safety helmet, vest, and long-sleeved work clothes).

Reinforcement Installation	
Falling or slipping during installation	1. Using scaffolding designed safely; 2. Installing safety railings, conducting toolbox meeting, safety induction and job training; 3. Using PPE (Safety shoes, safety helmet, vest, and long-sleeved work clothes).
Hit by scaffolding	1. Using wheel locks on scaffolding to prevent movement; 2. Ensuring scaffolding is sturdy, using wheel locks when scaffolding is not moving, installing safety line, and safety signs; 3. Using PPE (Safety shoes, safety helmet, vest, long-sleeved work clothes, and safety glasses).
Formwork Installation	
Hit by handtools	1. Inspecting handtools before use, conducting toolbox meeting, and maintaining focus while working; 2. Using PPE (safety shoes, safety helmet, vest, long-sleeved work clothes, and gloves).
Hit by collapsing formwork	1. Ensuring formwork is strong and rigid, conducting toolbox meeting, installing safety line, and safety signs; 2. Using PPE (Safety shoes, safety helmet, vest, long-sleeved work clothes, and safety glasses).

3.4 IBPRP Table

After obtaining data from risk identification and risk control results by the author, the next step is compiling the IBPRP table which is used to prevent accidents by identifying hazards and risks in the work [5]. In compiling the IBPRP table, the author requested field supervisor assistance within the project to check the IBPRP table creation [6].

Table 5. Hazard Identification, Risk Assessment, Risk Control Determination, and Opportunities (IBPRP) for Basement Construction Project of the Great Mosque of Serang City

No	Details		Risk Level Assessment				Remaining Risk Assessment			
	Hazard Identification	**Risk**	**A**	**K**	**Risk Value (A×K)**	**Risk Level (TR)**	**A**	**K**	**Remaining Risk Value (A×K)**	**Remaining Risk Level (TR)**
					Preparation Works					
A	**Site Clearing**									
1	Hit by falling tree	Minor to severe physical injury	2	3	**6**	Medium	1	3	**3**	Low
2	Bitten by insects	**Minor injury**	4	1	**4**	Low	1	1	**1**	Low
3	Bulldozer or dump truck overturns	Physical injury and heavy equipment damage	2	4	**8**	Medium	1	4	**4**	Low
B	**Bored Pile Survey**									
4	Slipping and falling on muddy ground	**Minor injury** and damaged survey equipment	3	2	**6**	Medium	2	2	**4**	Low

5	Exposed to sunlight	Dehydration, Visual disturbance due to glare, and Sunburn	4	2	**8**	Medium	3	2	**6**	Medium
C	**Heavy Equipment Mobilization**									
6	Traffic accident	Death, Heavy equipment damage, and Property damage	3	3	**9**	Medium	2	4	**8**	Medium
7	Vehicle overturns	Severe physical injury, Vehicle damage, and Property damage	2	3	**6**	Medium	2	2	**4**	Low
		Land Excavation Work								
D	**Basement Area Excavation**									
8	Buried by soil collapse	Severe to Fatal injury	2	4	**8**	Medium	1	4	**4**	Low
9	Hit by excavator	Fatal injury	2	5	**10**	Medium	1	5	**5**	Medium
10	Excavator overturns and falls into excavation	Operator injury and Heavy equipment damage	1	4	**4**	Low	1	2	**2**	Low
		Foundation Works								
E	**Drilling with Bore Pile Mini Crane**									
11	Falling into excavation hole	Fatal injury	3	2	**6**	Medium	1	3	**3**	Low
12	Slipping due to standing water mud	Minor injury	3	2	**6**	Medium	2	2	**4**	Low
13	Scratched by drill bit	Minor injury	2	2	**4**	Low	2	2	**4**	Low
14	Bore mini crane is unbalanced	Severe injury & equipment damage	2	4	**8**	Medium	1	4	**4**	Low
F	**Bore Pile Casing Installation**									
15	Hit by bore pile casing	Severe injury	2	5	**10**	Medium	1	5	**5**	Medium
16	*Sling breaks*	Fatal injury	1	5	**5**	Medium	1	4	**4**	Low
17	*Crane imbalance*	Fatal injury & equipment damage	3	5	**15**	High	1	5	**5**	Medium
G	**Bore Pile Reinforcement Fabrication**									
18	Punctured, scratched, or pinched by reinforcement bars	Minor injury	3	2	**6**	Medium	2	2	**4**	Low
19	Struck by reinforcement bars	Minor to fatal injury	3	5	**15**	High	1	4	**4**	Low

20	Injured by bar cutter tool	Minor injury	2	4	**8**	Medium	2	2	**4**	Low
21	Pinched by bar bender machine	Minor injury	2	4	**8**	Medium	1	4	**4**	Low
22	Electrocuted and burned	Fatal injury to death	1	5	**5**	Medium	1	4	**4**	Low
23	Punctured by binding wire	Minor injury	1	1	**1**	Low	1	1	**1**	Low
H	**Installation of Bore Pile Reinforcement**									
24	Struck by bore pile reinforcement bars	Severe physical injury	2	5	**10**	Medium	1	5	**5**	Medium
25	Exposed to sparks during reinforcement welding	Injuries, skin burns, and radiation exposure	2	1	**2**	Low	1	1	**1**	Low
26	Electrocuted	Fatal injury to death	3	5	**20**	High	2	5	**10**	Medium
27	*Sling failure*	Fatal injury	1	5	**5**	Medium	1	4	**4**	Low
28	*Crane imbalance*	Cedera fisik Fatal injury and equipment damage	3	5	**15**	High	1	5	**5**	Medium
I	**Installation of Tremie Pipe**									
29	Scratched by sling wire	Minor injury	1	1	**1**	Low	1	1	**1**	Low
30	Scratched while rotating the concrete bucket	Minor injury	1	1	**1**	Low	1	1	**1**	Low
J	**Concrete Casting**									
31	Splashed by ready-mix concrete materia	Irritation	1	1	**1**	Low	1	1	**1**	Low
32	Hit by truck mixer during maneuvering	Fatal injury	1	5	**5**	Medium	1	4	**4**	Low
K	**Removal of Tremie Pipe**									
33	Scratched by leftover concrete on the concrete bucket	Minor injury	2	1	**2**	Low	1	1	**1**	Low
34	Scratched by the coarse sling wire of the tremie pipe	Minor injury	2	2	**4**	Low	1	2	**2**	Low
L	**Bore Pile Casing Removal**									
35	Hit by bore pile casing	Minor injury	2	2	**4**	Low	2	1	**2**	Low
						Basement Floor Work				
M	**Bouwplank Installation**									
36	Hit by handtools	Minor to severe injury	2	3	**6**	Medium	1	3	**3**	Low
37	Slipping and falling due to muddy ground	Minor injury	2	1	**2**	Low	2	1	**2**	Low
N	**Pile Cap and Tie Beam Excavation**									
38	Hit by excavated soil	**Minor injury**	3	1	**3**	Low	2	1	**2**	Low

39	Excavator overturns and falls into excavation	Operator physical injury and Heavy equipment damage	1	4	**4**	Low	1	3	**3**	Low
O	**Bore Pile Breaking**									
40	Hit by sledgehammer during breaking	Minor injury	2	2	**4**	Low	1	3	**3**	Low
41	Scratched or pierced by concrete reinforcement	Minor injury	2	2	**4**	Low	2	1	**2**	Low
P	**Pile Cap and Tie Beam Reinforcement**									
42	Pierced, scratched, or pinched by reinforcement bars	**Minor injury**	3	2	**6**	Medium	3	1	**3**	Low
43	Hit by reinforcement bars	Minor to fatal injury	3	5	**15**	High	1	4	**4**	Low
44	Hit by bar cutter cutting tool	Fatal injury	2	4	**8**	Medium	2	4	**8**	Medium
45	Pinched by bar bender tool	Fatal injury	2	4	**8**	Medium	1	4	**4**	Low
46	Electric shock and Fire	Fatal injury to death	1	5	**5**	Medium	2	2	**4**	Low
47	Pierced by binding wire	**Minor injury**	1	1	**1**	Low	1	1	**1**	Low
Q	**Pile Cap and Tie Beam Formwork with Brick**									
48	Hit by brick material	Minor to severe injury	2	2	**4**	Low	1	2	**2**	Low
49	Hit by concrete fragments	Minor injury	5	1	**5**	Medium	3	1	**3**	Low
R	**Pile Cap and Tie Beam Concreting**									
50	Hit by ready mix concrete material splatter	Irritation	1	1	**1**	Low	1	1	**1**	Low
51	Hit by mixer truck during maneuvering	Fatal injury	1	5	**5**	Medium	1	4	**4**	Low
S	**Basement Floor Reinforcement**									
52	Pierced, scratched, or pinched by reinforcement bars	Minor injury	3	2	**6**	Medium	2	2	**4**	Low
53	Pierced by binding wire	Minor injury	1	1	**1**	Low	1	1	**1**	Low
T	**Concreting**									
54	Hit by ready mix concrete material splatter	Irritation	1	1	**1**	Low	1	1	**1**	Low
55	Hit by mixer truck during maneuvering	Fatal physical injury	1	5	**5**	Medium	1	4	**4**	Low
56	Tremor due to vibrator	Hand vibration	5	1	**5**	Medium	3	1	**3**	Low
					Floor 3 Structure Work					
U	**Reinforcement Bar Fabrication**									

57	Pierced, scratched, or pinched by reinforcement bars	Minor injury	3	2	**6**	Medium	3	2	**6**	Medium
58	Hit by reinforcement bars	Minor to fatal injury	3	5	**15**	High	1	4	**4**	Low
59	Hit by bar cutter cutting tool	Fatal injury	2	4	**8**	Medium	2	2	**4**	Low
60	Pinched by bar bender tool	Fatal injury	2	4	**8**	Medium	1	4	**4**	Low
61	Electric shock and Fire	Fatal injury to death	1	5	**5**	Medium	2	2	**4**	Low
62	Pierced by binding wire	Minor injury	1	1	**1**	Low	1	1	**1**	Low
V	**Reinforcement Installation**									
63	Falling	Fatal injury	3	5	**15**	High	1	5	**5**	Medium
64	Hit by scaffolding	Severe physical injury	3	4	**12**	Medium	1	4	**4**	Low
65	Electric shock and Fire	Fatal injury to death	1	5	**5**	Medium	1	3	**3**	Low
W	**Formwork Installation**									
66	Hit by handtools	Severe physical injury	2	3	**6**	Medium	1	3	**3**	Low
67	Hit by collapsing formwork	Severe physical injury	2	4	**8**	Medium	1	4	**4**	Low
X	**Concreting**									
68	Hit by ready mix concrete material splatter	Irritation	1	1	**1**	Low	1	1	**1**	Low
69	Tremor due to vibrator	Hand vibration	5	1	**5**	Medium	3	1	**3**	Low
Y	**Formwork Dismantling**									
70	Falling	Fatal injury	3	5	**15**	High	1	5	**5**	Medium
71	Scaffolding collapse	Fatal injury	3	5	**15**	High	1	5	**5**	Medium

From the work stages analyzed using the Hazard Identification, Risk Assessment and Opportunities (IBPRP) method, the risk level assessment results in percentage (%) are as follows:

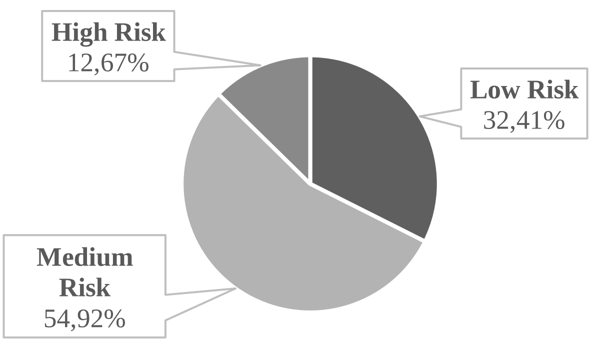

Figure 2. Risk Level Diagram

From the diagram above, the results from the IBPRP table show work risk identification with low risk level assessment of 23 jobs (32.41%), medium risk level assessment of 39 jobs (54.92%), and high risk level assessment of 9 jobs (12.67%) from a total of 71 work risks.

4. CONCLUSION

The Public Works and Housing Ministerial Regulation (Permen PUPR) No. 10 of 2021 concerning Construction Safety Management System (SMKK) has a significant impact on the Serang City Grand Mosque basement construction. This regulation emphasizes the importance of work safety in construction projects, including basement construction. By using the Hazard Identification, Risk Assessment, Risk Control Determination, and Opportunities (IBPRP) method, potential hazards can be identified for each job. There are 5 types of work, 25 sub-works, and 71 work risk identifications with a total of 23 low risk levels, 39 medium risk levels, and 9 high risk levels. 23 low risk levels, 39 medium risk levels, and 9 high risk levels represent 32.41% of jobs with low risk level, 54.92% with medium risk level, and 12.67% with high risk level. From Hazard Identification, Risk Assessment, Risk Control Determination, and Opportunities (IBPRP), control plans are obtained through elimination, substitution, engineering techniques, and personal protective equipment (PPE).

REFERENCES

[1] Steven and M. Waty, "MANAJEMEN RESIKO KESELAMATAN DAN KESEHATAN KERJA (K3) PADA PROYEK KONSTRUKSI," *JMTS: Jurnal Mitra Teknik Sipil*, vol. 3, no. 3, pp. 547–554, 2020.
[2] "Badan Pusat Statistik Kota Serang," 2023.
[3] Y. Laurens, R. Mardiaman, and E. H. Manurung, *PEMILIHAN METODE KONSTRUKSI TOP DOWN PADA PEKERJAAN KONSTRUKSI BASEMENT PROYEK INDONESIA SATU*, Seminar Cendikiawan., vol. 1. 2019.
[4] A. Manihuruk, "ANALYSIS OF DEVELOPMENT AND SPATIAL PATTERN OF MINIMARKET DISTRIBUTION IN KALIURANG ROAD CORRIDOR," *Science and Environmental Journals for Postgraduate*, vol. 3, no. 2, pp. 61–69, Jun. 2021, [Online]. Available: http://senjop.ppj.unp.ac.id/index.php/senjop/
[5] *Peraturan Pemerintah Pekerjaan Umum Dan Perumahan Rakyat Republik Indonesia Nomor 10 Tahun 2021 Tentang Pedoman Sistem Manajemen Keselamatan Konstruksi*. 2021.
[6] S. Ramli, *Sistem Manajemen Keselamatan dan Kesehatan Kerja OHSAS*, 1st ed. Jakarta: Dian Rakyat, 2010.
[7] W. Ervianto, *Manajemen Proyek Konstruksi*. Yogyakarta: Andi, 2005.
[8] *Standar Operasional Prosedur Identifikasi Bahaya, Penilaian Risiko, Penentuan Pengendalian Risiko, Dan Peluang*. 2021.
[9] Salami, *Kesehatan dan Keselamatan Lingkungan Kerja*. Yogyakarta: Gajah Mada University Press, 2016.
[10] Tarwaka, *Gajah Mada University Press*. Surakarta: Harapan Press, 2016.
[11] M. Yusuf, D. Adiwinata, and D. Pontan, "EVALUASI PENERAPAN SISTEM MANAJEMEN RISIKO KESELAMATAN DAN KESEHATAN KERJA PADA PROYEK GREEN CONSTRUCTION (Studi Kasus: Proyek Haryono Data Center)," *Jurnal Rekayasa Lingkungan Terbangun Berkelanjutan*, vol. 01, no. 02, pp. 310–316, Dec. 2023, doi: 10.25105/jrltb.v1i2.17324.
[12] Astuti, D. W., Panjaitan, D. Y. P., Eka Murtinugraha, R., & Pd, M. (2012). PELAKSANAAN SISTEM MANAJEMEN KESELAMATAN DAN KESEHATAN KERJA (K3) PADA PROYEK KONSTRUKSI BANGUNAN (Studi kasus pada Proyek Kota kasablanka). *Jurnal Menara Jurusan Teknik Sipil FT.UNJ, Vol. VII*(2), 29–37.
[13] Risiko, A., Pembangunan, P., Basement, P., Sulawesi Denpasar, J., & Muka, W. (n.d.). *I Wayan Muka Analisis Risiko Pada Proyek Pembangunan Parkir Basement Jalan Sulawesi Denpasar 155 MEDIA KOMUNIKASI TEKNIK SIPIL*.

[14] Tagueha. Winda Purnama, Mangare, J. B., & Arsyad, T. Tj. (2018). MANAJEMEN RESIKO KESELAMATAN DAN KESEHATAN KERJA (K3) PADA PROYEK KONSTRUKSI (Studi Kasus: Pembangunan Gedung Laboratorium Fakultas Teknik Unsrat). *Jurnal Sipil Statik, Vol. 6*(11), 907–916.

[15] Deisy Rawis Jermias Tjakra, T., Tj Arsjad, T., & Masalah Keselamatan dan Kesehatan Kerja, A., "Perencanaan Biaya Keselamatan dan Kesehatan Kerja (K3) pada Proyek Konstruksi Bangunan (Studi Kasus: Sekolah St. Ursula Kotamobagu)," Jurnal Sipil Statik, vol. 4, no. 4, pp. 241–252, 2016.

[16] Feri Setiabudi, A. B., "Analisis JSA dan IBPRP Berdasarkan Permen PUPR No.21 Tahun 2019," Jurnal Sipilsains, vol. 12, 2022.

[17] Gilang Prakoso Putra Pamungkas, "Manajemen Risiko Bahaya Berbasis HIRADC pada Pekerjaan Bore Pile (Studi Kasus: Proyek Gedung Sembilan Lantai Universitas Alma Ata Yogyakarta)," 2021.

[18] Hadhinata, C., Mirza, D. M., & Pratama, A., "Implementasi Metode Pelaksanaan Konstruksi Pile Cap Proyek Pembangunan Gedung Penunjang Pembelajaran Universitas Negeri Malang di Era Pemberlakuan Pembatasan Kegiatan Masyarakat (PPKM)," n.d.

[19] Hidayati, R., "Pengaruh Kesehatan Keselamatan Kerja (K3) dan Motivasi Kerja terhadap Kinerja Karyawan (Studi Pada Karyawan Pg. Djombang Baru)," BIMA: Journal of Business and Innovation Management, vol. 2, no. 3, pp. 258–270, 2020.

[20] Machfudiyanto, R. A., & Mubarok, I. S., "Evaluasi Implementasi Sistem Manajemen Keselamatan Konstruksi Proyek Infrastruktur Jalan Tol pada Kondisi Pandemi COVID-19 di Indonesia (Studi Kasus Jalan Tol ABC)," Jurnal Infrastruktur, vol. 8, no. 2, pp. 107–115, 2022.

[21] Maddeppungeng, A., Asyiah, S., & Prasetyo, F., "Pengaruh Kontraktor dan Kondisi Lingkungan terhadap Bahaya Kesehatan dan Keselamatan Kerja (K3) di Proyek The Canary," Fondasi: Jurnal Teknik Sipil, vol. 11, no. 1, pp. 44–66, 2022.

[22] Nuzula, F., M Saleh, S., & Darma, Y., "Analisis Sistem Manajemen Keselamatan Konstruksi pada Proyek Preservasi Jalan BTS. Aceh Tengah/Nagan Raya-Lhok Seumot-Jeuram," Jurnal Arsip Rekayasa Sipil Dan Perencanaan, vol. 6, no. 1, pp. 12–21, 2023, doi: 10.24815/jarsp.v6i1.27139.

[23] Pangkey, F., Malingkas, G. Y., & Walangitan, D., "Penerapan Sistem Manajemen Keselamatan dan Kesehatan Kerja (SMK3) pada Proyek Konstruksi di Indonesia (Studi Kasus: Pembangunan Jembatan Dr. Ir. Soekarno-Manado)," Jurnal Ilmiah Media Engineering, vol. 2, no. 2, pp. 100–113, 2012.

[24] Pou, Moh. N. R., Bumulo, R., & Fitriana, N., "Evaluasi Sistem Manajemen Keselamatan dan Kesehatan Kerja (SMK3) Pekerjaan Drainase pada Proyek Rekonstruksi Jalan Prof. Jhon Aryo Katili Kota Gorontalo dengan Menggunakan Metode IBPRP," Jurnal Vokasi Sains Dan Teknologi, vol. 3, no. 1, pp. 17–22, 2023, doi: 10.56190/jvst.v3i1.41.

[25] Putra, L. A., "Implementasi Sistem Manajemen (Implementation of Management System of Occupational Health and Safety on Cut and Fill Job Road Construction Project)," 2021.

[26] Rekayasa, J., Sains, dan, Amanda Putri, A., Hasiany Siregar, S., Prasetio, B., & Teknologi Infrastruktur dan Kewilayahan, J., "Job Safety Analysis (JSA) Konstruksi Basement pada Proyek Pembangunan Gedung B Rumah Sakit Umum Muhammadiyah Metro Provinsi Lampung," vol. 6, no. 1, n.d.

[27] Situmorang, R., Sari, O. L., & Saputra, A. A. I., "Rencana Keselamatan Konstruksi (Studi Kasus Gedung Laboratorium Terpadu 2 Institut Teknologi Kalimantan)," Compact: Spatial Development Journal, vol. 1, no. 2, 2022.

[28] Tannya Awuy, Pratasis, P. A. K., & Mangare, J. B., "Faktor-Faktor Penghambat Penerapan Sistem Manajemen K3 pada Proyek Konstruksi di Kota Manado," Jurnal Sipil Statik, vol. 5, no. 4, pp. 187–194, 2017.

[29] Yuliana, N. P. I., & Yuni, N. K. S. E., "Analisis Anggaran Biaya Keselamatan dan Kesehatan Kerja Proyek Konstruksi Gedung SMA N 2 Abiansemal," PADURAKSA: Jurnal Teknik Sipil Universitas Warmadewa, vol. 9, no. 2, pp. 201–211, 2020, doi: 10.22225/pd.9.2.1792.201-211.

[30] Reza Muafiq, "Pengaruh Budaya Keselamatan dan Kesehatan Kerja (K3) Terhadap Kinerja Proyek Konstruksi," UPN Veteran Jawa Timur, 2021.
[31] Ade Jaya Saputra, "Tingkat Pengetahuan dan Kesadaran Berperilaku K3 Mahasiswa Teknik Sipil Universitas Internasional Batam," 2021.
[32] Afrizal Surya Erlangga, "Studi Penerapan Sistem Manajemen Keselamatan Konstruksi (SMKK) pada Perusahaan Konstruksi di Kota Makasar (Permen PUPR No.10 Tahun 2021)," 2021.
[33] Ida Bagus Dharma, "Analisis Komponen Biaya Sistem Manajemen Keselamatan Konstruksi (SMKK) Menurut Permen PUPR No 10 Tahun 2021 (Studi Kasus: Pembangunan Ruang Perawatan Wing Utara Tahap 1 RSU Payangan)," Politeknik Negeri Bali, 2022.
[34] Charles, D., "Personal Protective Equipment Standards in Construction Projects," 1999.