ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

Available online at
https://jurnalteknik.unisla.ac.id/index.php/CVL

https://doi.org/10.30736/cvl.v2i2

Analysis of Potential Hazards and Risks of Work Accidents by Using the HIRARC Method On Earthwork and Geosynthetics

Sekar Ayu Kuncaravita[1*] ,Rizki Astri Apriliani[2] ,Muhammad Lawdy D.V.[3] ,Dayat Indri Y[4]

[1*,2,3,4] *Faculty of Engineering, Dr. Soetomo University.*

Email : [1*]sekar.ayu@unitomo.ac.id [2]rizki.apriliani@unitomo.ac.id [3]lawdy@unitomo.ac.id [4]dayatindri@unitomo.ac.id

A R T I C L E I N F O

Article History :
Article entry : 23-10-2024
Article revised : 02-01-2025
Article received : 15-03-2025

Keywords :
Potential Hazards and Riks, Work accident, HIRARC, Occupational health and safety (K3)

IEEE Style in citing this article :
S. A. Kuncaravita, R. A. Apriliani, M. Lawdy D.V, and D. Indri Y, "Analysis of Potential Hazards and Risks of Work Accidents by Using the HIRARC Method On Earthwork and Geosynthetics", civilla, vol. 10, no. 1, pp. 59–68, Mar. 2025.

A B S T R A C T

The world of construction always has potential hazards and risks that always endanger the safety and health of workers. The occurrence of work accidents is an event that is always unexpected and can cause losses, both for the construction company and the workers. This study aims to determine the potential hazards in an effort to reduce work accidents in the Banjarsari- Dukuh Tengah road improvement project in Sidoarjo Regency. The method used in this research is hazard identification risk assessment and risk control (HIRARC). The results showed that in the construction of the Banjarsari- Dukuh Tengah road improvement project in Sidoarjo Regency, especially in earthworks and geosynthetics, there were 10 jobs in the Banjarsari- Dukuh Tengah road improvement project in Sidoarjo Regency showing that the potential hazards were 2 activities classified as having a "low risk," 3 activities with a "medium risk," and 5 other activities with a "high" risk. To overcome these problems, suggestions for improvement are given so that workers carry out work activities in accordance with standard operating procedures (SOPs) and wear personal protective equipment (PPE).

1. Introduction

Various kinds of work accident risks are always the main reason for a project to be late so a risk analysis is needed to find out the reasons and solutions to any problems that arise in the project. Work accidents are unexpected activities that can disrupt the activities of a construction project in the form of injury illness or death [1][2]. All risks that occur arise due to errors in the work system such as poor machinery, less credible worker attitudes, poor building construction conditions, lack of personal protective equipment, environmental factors such as noise, lighting, air temperature and so on that can be found in construction projects.

The Banjarsari - Dukuh tengah road improvement project in Sidoarjo Regency has a variety of potential accident risks from various jobs, one of which is in earthwork and geosynthetics. Some of the

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

risks that may occur in earthwork and geosynthetics will be analyzed for the risk of work accidents using the hazard identification risk assessment and risk control (HIRARC) method.

After analyzing using the hazard identification assessment and risk control (HIRARC) method, it will be known the causes of the risk of work accidents, for example, due to the condition of old heavy equipment, uncertain weather, human error (machine operators or workers), and the absence of location safety signs [3][4]. while the impact of the risk of work accidents is that workers experience minor/severe injuries or death due to falling or being hit by heavy equipment and so on.

HIRARC is one of the completion methods in analyzing the risks that occur in the workplace and determining the severity level of the risk of work accidents in the workplace area [5][6]. HIRARC consists of three stages, namely:

a. Hazard identification

It is a method to find out the existence of potential hazards in the workplace in a job that includes machinery or work equipment. Hazard identification is one of the efforts to prevent work accidents for workers.

b. Risk assessment

That conducting a risk assessment of hazards in the work area by assessing the potential hazards that have been identified to make it easier to determine the risk level of the hazard. The risk assessment uses two parameters, namely severity and likelihood [7][8]. The likelihood scale is measured from risks that never occur or rarely occur to occur every time. At the same time, the severity scale is measured from the smallest to the largest value [9].

Table 1. Likelihood Scale

Level	Criteria	Description
5	Almost Certain	One day event more than 1
4	Likely	One week event more than 1
3	Possible	Occurrence of more than 1 month
2	Unlikely	One year event more than 1
1	Rare	One year event less than 1

Table 2. Severity scale

Level	Criteria	Description
1	Insignificant	No injuries, minimal economic losses
2	Minor	Minor injury, moderate economic loss
3	Moderate	Moderate injuries, health needs, impact on large economic losses
4	Major	more than one person suffered severe injury, impact of large losses, interruption of production
5	Catastrophic	More than one person is severely injured, the impact of economic loss is very large and the impact of the cessation of all activities.

To determine the risk level of the hazard risk, the formula [10] can be used:

Risk = likelihood x severity (1)

After processing the formula to get the risk results, the next step is to enter the calculation results into the risk matrix column. This matrix is useful for determining the level of risk of potential hazards that have been identified [11]. The risk matrix can be shown in table 3.

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

Table 3. Risk Matrix

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

Based on table 3, the risk assessment is categorized into 3 categories, namely: (a) green color, this green color is included in the low risk whose handling does not require any action; (b) yellow color, this color is included in the medium risk whose handling needs action; and (c) red color, included in the high risk whose handling requires action and control.

c. Risk Control

Risk control is the stage of managing potential hazards and work accidents in the workplace so there is a need for risk control to minimize the potential hazards that occur. Risk control efforts can be carried out using a hierarchical control approach [12].

Earthwork and geosynthetics are the main part of the pillars of the construction of the Banjarsari- Dukuh Tengah road improvement project in Sidoarjo Regency because the benchmark for the success of a major road construction is in earthwork and geosynthetics. The scope of work carried out on this earthwork includes ordinary excavation work, excavation of pavement without a cold milling machine, selected embankment from the source of excavation, and cutting selected trees with a diameter of more than 50 - 75 cm. Excavation, embankment and cutting activities are carried out manually by humans with machines or heavy equipment, in the work area workers carry, lift, push, pull, and bend. If the work is done repeatedly with uncertain duration and improper body position, it can cause work-related accidents.

Based on field studies on the Banjarsari- Dukuh Tengah road improvement project in Sidoarjo Regency, there are still many potential hazards of work accidents that can make workers sick or even lose their lives. Of course, this is not desired by all workers. This research was made to know the potential hazards to overcome work accidents in the Banjarsari- Dukuh Tengah road improvement project area, Sidoarjo Regency, to create a safe and comfortable work environment.

2. Research Method

The steps in this research process are as follows:

a. Preliminary Study and Literature Study

A preliminary study is the first step to finding out the problems that occur at the research site to get the data used [13]. The data is obtained by direct observation of the research location and interviews with workers.

As for the literature study, literature references were obtained regarding theories that could strengthen the research. The theories used include; work accidents, work risks, occupational hazards, occupational safety and health (K3), and hazard identification risk assessment and risk control (HIRARC).

b. Problem Formulation

From direct observation at the research location, it was found that there were problems that occurred, namely the potential hazards and the level of risk of work accidents on the Banjarsari-Dukuh Tengah road improvement project in Sidoarjo Regency which resulted in worker discomfort while working. Therefore, to minimize the potential for work accidents, it is necessary to identify hazards, assess risks, and control risks to prevent the occurrence of potential work accident hazards using the HIRARC method [14][15].

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

c. Risk control

In the last process, controlling the risk of hazards in the work environment is an action to reduce the risk of work accidents which can be done by following five hierarchies [16], namely eliminating risk controls that are permanent and must be applied to be the first choice, replacing dangerous tools and materials with tools and materials that are safe for safety, carrying out engineering as a control effort that changes the structure of the work object so as not to be exposed to the risk of occupational hazards, administrative control as a work system provider to reduce the potential for occupational hazards, and the use of personal protective equipment to prevent work accidents as a common means used in a short time and is temporary.

3. Description and Technical

a. Research Location

The research location chosen for the concrete road construction project or rigid pavement method is on the village connecting road between Banjarsari and Dukuhtengah Village located in Buduran District, Sidoarjo Regency as follows:

Table 4. Project General Information

Name of Work	Package Banjarsari - Dukuhtengah Road Improvement
Contractor	CV. XYZ
Project ceiling value	Rp 12,800,000,000
Project Contract Value	Rp 12,539,599,880
Implementation Period	150 Calendar Days
Work Location	Buduran Sub-district
Road Length	1,883 meters
Road Width (m) / Road Thickness (cm)	5 m / 20 cm

b. Data collection techniques

Data collection techniques are methods used to collect information that will be processed and analyzed for research purposes. Based on how it is collected, data is divided into two, namely primary data and secondary data. Primary data is information obtained and processed directly by researchers from the subject or object of research (through observation, questionnaires, or interviews), while secondary data is information obtained indirectly from the subject or object of research. The data is obtained from various sources using different methods. The sources and methods of data collection in this study are as follows observation and interview.

c. Data Analysis Technique

The data that has been collected is neatly arranged and then analyzed from primary and secondary data to compare. In this study, the data analysis techniques used were:

1. Data Reduction

Data reduction refers to the process of selecting, focusing, simplifying, abstracting, and transforming raw data that occurs in written notes. Data reduction occurs continuously throughout the life of a qualitatively oriented project.

2. Data Model (Data Display)

After the data is reduced, the next data analysis activity is the data model. Model as a collection of organized information that allows for a description of conclusions and taking action. Meanwhile, models in everyday life vary from the measurements taken. done. Seeing an impression helps us understand what is happening and
do something further analysis or action based on that understanding. The presentation of data through brief descriptions in the form of narrative text makes it easier for researchers to understand what is currently happening.

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

3. Conclusion Drawing and Verification

The third step of data analysis activities is drawing and verifying conclusions. From the beginning of data collection, researchers begin to decide what things mean, noting regularities, patterns, explanations, possible configurations, causal pathways, and propositions.

Researchers formulate conclusions as temporary findings which are carried out by synthesizing all the data collected. Researcher will change the data if there is no strong evidence supporting the next stage of data collection, but if the data evidence and findings in the field that the researcher finds in the early stages are consistent and valid, the conclusions obtained are credible. The conclusion is in the form of findings that are a description or description of the Risk of Work Accidents Using the HIRARC Method on the Banjarsari Road Improvement Project - Dukuhtengah Sidoarjo Regency.

4. Results and Discussions

Hazard Identification

Identification of hazard sources using the HIRARC method on the Banjarsari-Dukuhtengah road improvement project in Sidoarjo Regency is organized based on the level of risk that occurs in the work environment. In each hazard identification, it will be known what hazards occur in each activity in the work activities that have been identified. The following are the results of observations and interviews with the technical team of K3 experts and workers which can be seen in the table 5.

Table 5. Hazard and Risk Identification

No	Stages Work Process	Identification Hazard	Risk
1	Excavation work with excavator	The excavator swing was too tight and the track roller broken	Falling material carried by excavator
2	Landfill work	Exposed to underground utilities	Foot slips while working
3	Grading	Falling materials not properly placed	Injury to hands, feet or back from heavy loads or falling materials
4	Compaction	changing, wet or slippery ground surface,	Slip injuries (minor injuries to broken bones or head injuries)
5	Cutting of higher parts of the soil	excessive dust, especially in dry or rocky areas.	Exposure to dust can cause respiratory problems, eye irritation
6	Geosynthetics installation	lifting, pulling or pushing heavy or bulky geosynthetics materials.	Back injuries, muscle strains and spinal problems
7	Ground drainage work	underground utilities such as power lines	Electrocution can cause serious burns, electric shock or death.
8	Embankment Construction	Unstable materials	increases the risk of injury.
9	Felling work tree with Chainsaw	Tool injures worker	Hand slightly injured by blade
10	Tree pruning work	Worker exposed to tree splash	Eyes exposed to sawdust

Source: Research Results (2024)

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

Risk Assessment

At this stage, it is used to determine the risk level of a hazard if the hazard has been identified. Risk assessment is carried out by determining two parameters, namely the possibility (likelihood) and severity of each work process. Likelihood is used to assess the frequency of work accidents that occur [17].

Table 6 Risk Assessment

No	Stages Work Process	L	C	S	Risk Level
1	Excavation work with excavator	2	3	6	Moderate risk
2	Landfill work	2	1	2	Low risk
3	Grading	2	4	8	Moderate risk
4	Compaction	4	4	16	High risk
5	Cutting of higher parts of the soil	5	3	15	High risk
6	Geosynthetics installation	4	4	16	High Risk
7	Ground drainage work	2	1	2	Low Risk
8	Embankment Construction	2	3	6	Moderate risk
9	Felling work tree with Chainsaw	5	3	15	High risk
10	Tree pruning work	5	4	20	High risk

Source: Research Results (2024)

Based on Table 5, the likelihood and frequency of accidents are categorized as follows: A score of 5 indicates that an accident occurs more than once a day; a score of 4 indicates more than once a week; a score of 3 means more than once a month; a score of 2 indicates more than once a year; and a score of 1 means less than one occurrence per year. Severity assessment refers to the possible severity of the injury. This assessment uses a scale from 1 to 5. A score of 1 indicates no injury, a score of 2 means a minor injury, a score of 3 indicates a moderate injury, a score of 4 indicates a severe injury sustained by more than one person, and a score of 5 signifies a fatal injury and major loss that causes the cessation of all work activities. The risk level for each activity is determined by multiplying the likelihood and severity scores. The results of the risk assessment for 10 works on the Banjarsari- Dukuhtengah road improvement project in Sidoarjo District showed that the potential hazards varied according to the risk score. From the assessment results, there were 2 activities classified as having a “low” risk, 3 activities with a “medium” risk, and 5 other activities with a “high” risk.

Risk Control

The final step in the HIRARC method is to establish risk controls for the potential hazards that have been identified and assessed. Risk control aims to eliminate potential hazards in the work environment [18]. Risk assessment is used to reduce risks at a high level. Risk control measures are implemented according to the order of priority in the risk control hierarchy. The risk control improvements by the risk control hierarchy according to the AS/NZS 4360 standard proposed on earthworks and geosynthetics on the Banjarsari-Dukuh Tengah road improvement project in Sidoarjo Regency are as follows [19][20]:

1. Excavation work with excavator, proposed improvements schedule periodic maintenance to prevent damage to tools that can cause interference or accidents and

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

require workers to wear personal protective equipment (PPE) in the form of safety shoes, helmets, and gloves.

2. Landfilling work, proposed improvements include making a standard operating procedure (SOP) for good and correct landfilling work, and requiring workers to wear PPE in the form of safety shoes and gloves.
3. Grading, Proposed improvements include making safety procedures for workers and requiring workers to wear PPE.
4. Compaction work, Proposed improvements are scheduling routine maintenance to prevent damage to tools that could result in disruptions or accidents, and requiring workers to wear personal protective equipment (PPE) such as safety shoes, helmets, and gloves.
5. Cutting work on higher parts of the ground, proposed improvement: workers are required to always wear personal protective equipment (PPE) such as masks, gloves, and protective glasses.
6. Geosynthetics installation work, the proposed improvement is to make a standard operating procedure (SOP) on how to lift wood material properly and correctly and require workers to wear PPE in the form of safety shoes and gloves.
7. Land Drainage Work, Proposed improvements include making safety procedures for workers and requiring workers to wear PPE.
8. Embankment construction work, proposed improvements, checking soil conditions before work begins, and workers are required to use PPE.
9. Tree-felling work with chainsaw, proposed improvement: workers must wear protective gloves and work according to the applicable SOP.
10. Tree Trimming Work, Proposed improvements require stricter supervision of workers to ensure they always use masks and other PPE.

5. Conclusion and Suggestion

5.1 Conclusion

Based on the results of research that has been conducted using the HIRARC method on the Banjarsari- Dukuhtengah road improvement project in Sidoarjo Regency, it can be concluded that workers are not fully aware of the dangers of work accidents in the work area and have not been equipped with personal protective equipment, which makes them vulnerable to work accidents. The data shows that moderate risk jobs that fall in the 6 to 8 range include digging with an excavator, grading, as well as building up embankments. Aside from these graded scores, the chances of an incident happening remains on the lower side of the scale, but the consequences are still moderate. On the other end, activities like compaction and soil cutting, along with felling work using a chainsaw, also including tree pruning which scores the highest in risk accounting twenty due to both high incident rate and dire consequences, score between 15 to 20, showing major concern. Lastly, activities such as landfill, as well as drainage work score two or lesser, meaning these chores have the lowest chances and consequences tied to them. In conclusion, this information is useful along with providing a risk model system, troubling the operational safety while construction is taking place as well. For high risk activities, it allows resource as well as effort focus in the right areas without having to think much.

Several improvement proposals have been proposed to reduce the risk of work accidents that may be experienced by workers while carrying out earthworks and geosynthetics on the Banjarsari- Dukuhtengah road improvement project in Sidoarjo Regency. The three main improvement proposals are to ensure that workers follow the established SOPs and use personal protective equipment (PPE) appropriate to the type of activity they are performing.

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

5.2 Suggestion

Suggestions in this study are that project implementation is expected to always carry out regular controls so that potential hazards and work accidents can be avoided and minimized. The implementing contractor may need to pay attention to OHS as a meaningful input for the company and can be used as a safety factor for workers, and the work environment in general, especially in road improvement projects and the need for occupational safety protection for workers involved in the work field because construction projects are very complex in the process of carrying out a job and involve human resources, equipment, materials, and applied technology. Therefore, the rules must be strict for everyone involved to ensure the safety of everyone.

References

[1] Yusmaini, E. P. Rahayu, dan A. Alamsyah, "Risk Analysis of Occupational Safety and Health Using the HIRARC Method on Nurses at the Inpatient Installation of," vol. 10, no. November 2023, hal. 77–85, 2024.

[2] A. R. Mubarroq, T. Yulianto, M. W. Nugroho, dan T. Sundari, "IDENTIFIKASI BAHAYA KESELAMATAN KESEHATAN KERJA (K3) (Studi Kasus : Pekerjaan Rehabilitasi / Pemeliharaan Berkala Ruas Jalan Tampingmojo-Tambak Beras)," vol. 04, no. 02, hal. 123–130, 2024.

[3] R. Amalia, D. Herwanto, dan W. Rana Zahra, "Analisis Potensi Bahaya Dan Risiko Kecelakaan Kerja Dengan Menggunakan Metode Hazard Identification Risk Assessment and Risk Control (Hirarc) Pada Pemotongan Kayu," *Ind. Inov. J. Tek. Ind.*, vol. 13, no. 1, hal. 13–19, 2023, doi: 10.36040/industri.v13i1.4523.

[4] D. Riskawati; adiasa, Iksan; Rahman, "ANALISIS POTENSI BAHAYA UNTUK MEMINIMALISIR RISIKO KECELAKAAN KERJA PADA PROYEK PEMBANGUNAN JETTY PLTMGU LOMBOK PEAKER DI PT. XYZ MENGGUNAKAN METODE HIRARC," vol. 6, no. 1, 2025.

[5] H. Mauliyani, N. Romdhona, A. Andriyani, dan M. Fauziah, "Identifikasi Risiko Keselamatan Kerja Metode (Hirarc) Pada Tahap Pembuatan Tangki Di Pt. Gemala Saranaupaya," *Environ. Occup. Heal. Saf. J.*, vol. 2, no. 2, hal. 163, 2022, doi: 10.24853/eohjs.2.2.163-174.

[6] J. A. Bagus, Alfin Rizki; Saifuddin, "Analisis dan usulan perbaikan risiko kecelakaan kerja dengan metode HIRARC (Hazard Identification Risk Assesment And Risk Control) di PT Putra Jawamas," vol. 8, no. 1, hal. 249–256, 2025.

[7] M. O. Bustamin, W. A. Nugroho, dan U. U. Kuroumang, "Analisis Risiko Kecelakaan Kerja pada Proyek Apartemen Klaska Residence Surabaya," *Publ. Ris. Orientasi Tek. Sipil*, vol. 4, no. 2, hal. 82–89, 2022, doi: 10.26740/proteksi.v4n2.p82-89.

[8] S. Umam, Khotibul; Suseno, "Analisis K3 Pada Pekerja Bagian Proses Fabrikasi Plate Tangki dengan," 2025.

[9] B. F. Aprilla dan D. Yulhendra, "Penerapan Metode HIRARC dalam Menganalisis Risiko Bahaya dan Upaya Pengendalian Kecelakaan Kerja di Area Crusher dan Belt Conveyor PT. Semen Padang," *J. Bina Tambang*, vol. 8, no. 1, hal. 203–212, 2023.

[10] Estri Kartika, Endang Purnawati Rahayu, Kamali Zaman, Herniwanti, dan Nopriadi, "Analisis Manajemen Risiko dengan Metode AS/NZS 4360:2004 pada Tangki Timbun Minyak di Riau," *Afiasi J. Kesehat. Masy.*, vol. 7, no. 1, hal. 218–226, 2022, doi: 10.31943/afiasi.v7i1.193.

[11] D. H. M. Mantiri, G. Y. Malingkas, dan R. J. M. Mandagi, "Analisis pengelompokan

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

dan pengendalian risiko kecelakaan kerja berdasarkan aturan SMK3 menggunakan metode ranking pada proyek pembangunan instalasi rawat inap RSUD Maria Walanda Maramis Minahasa Utara," *J. Ilm. Media Eng.*, vol. 10, no. 2, hal. 105–116, 2020, [Daring]. Tersedia pada: https://ejournal.unsrat.ac.id/index.php/jime/article/view/31236

[12] V. Monoarfa dan R. N. B. Miolo, "Penerapan Keselamatan dan Kesehatan Kerja (K3) Menggunakan Metode HIRARC Pada UMKM Pabrik Tahu," *J. Pengabdi. Ekon.*, vol. 02, no. 01, hal. 1–6, 2022.

[13] T. Santoso, N. Budiharti, S. Haryanto,) Program, dan S. T. Industri, "Upaya Pengendalian Resiko Kecelakaan Kerja Dengan Metode Job Safety Analysis Pada Pekerjaan Pembuatan Produk Tahu Di Desa Ploso , Kab. Jombang, Jawa Timur," *J. Mhs. Tek. Ind.*, vol. 4, no. 2, hal. 238–247, 2021.

[14] E. W. Abryandoko, "Dengan Menggunakan Metode Hirarc Dan Safety," *J. Rekayasa Sipil*, vol. 12, no. 1, hal. 50–57, 2018.

[15] M. Kurnianingtias, "Analisis Manajemen Risiko Keselamatan dan Kesehatan Kerja (K3) dengan Metode Hazard Identification Risk Assessment and Risk Control (HIRARC) di Workshop Garmen Kampus Tekstil," *J. Tekst. J. Keilmuan dan Apl. Bid. Tekst. dan Manaj. Ind.*, vol. 5, no. 2, hal. 77–87, 2022, doi: 10.59432/jute.v5i2.37.

[16] M. F. Pratama, E. Ismiyah, dan A. W. Rizqi, "Analisis Risiko (K3) Metode Hazard Identification Risk Assesment And Risk Control (HIRARC) di Departemen Laboratorium PT. ABC," *J. Ilm. Giga*, vol. 25, no. 2, hal. 88, 2022, doi: 10.47313/jig.v25i2.1922.

[17] D. O. Santoso, M. D. Kurniawan, dan H. Hidayat, "Analisa Risiko Keselamatan dan Kesehatan Kerja Menggunakan Metode HIRARC di PT. INHUTANI 1 UMI GRESIKHUTANI 1 UMI GRESIK," *J. Media Tek. dan Sist. Ind.*, vol. 6, no. 1, hal. 12, 2022, doi: 10.35194/jmtsi.v6i1.1580.

[18] R. S. Mulyani R.Y, Kusnadi, "Analisis Risiko K3 Menggunakan Metode Hazard Identification Risk Assessment and Risk Control (HIRARC) Pada Pekerja di PT XYZ Yoane," *J. Ilm. Wahana Pendidik.*, vol. 8 No.3, no. 3, 2021, doi: 10.5281/zenodo.6301688.

[19] S. R. Tri Handari dan M. S. Qolbi, "Faktor-Faktor Kejadian Kecelakaan Kerja pada Pekerja Ketinggian di PT. X Tahun 2019," *J. Kedokt. dan Kesehat.*, vol. 17, no. 1, hal. 90, 2021, doi: 10.24853/jkk.17.1.90-98.

[20] D. N. Putri dan F. Lestari, "Analisis penyebab kecelakaan kerja pada pekerja di proyek konstruksi : Literatur review," *J. Kesehat. Masy.*, vol. 7, no. 1, hal. 451–452, 2023.

ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

Study of Groin Structure Planning On a River Bend In Padang Mancang Village