(2026), 4 (1): 413-426 **Scientica** 3021-8209

Jurnal Ilmiah Sain dan Teknologi

EVALUATION OF PASSIVE FIRE PROTECTION SYSTEM IN DENSE RESIDENTIAL AREAS (CASE STUDY: NELAYAN INDAH DISTRICT, MEDAN LABUHAN)

M. Salman Ihsan [1], N.Vinky Rahman [2]

[1]*Architecture Departement, Faculty of Engineering, Universitas Sumatera Utara, Medan, 20155, Indonesia*

*Corresponding Author:salmanihsan1707@gmail.com; vinkyrahman@gmail.com

Abstract

This study aims to analyze and provide recommendations regarding the passive fire evacuation system in the Nelayan Indah area. Fire is something that cannot be avoided and is estimated by the time and place of occurrence in human life, including in residential areas. Fire can cause losses to both property and life. Fire disasters can be caused by various factors. Among them are the lack of public awareness and readiness for the dangers and handling of fires and the lack of available fire protection system facilities and infrastructure. This study aims to analyze and provide recommendations regarding the passive fire evacuation system in the Nelayan Indah area. To overcome fires, there are two types of protection systems, namely active fire protection systems and passive fire protection systems. In this study, the passive fire protection system used is preferred to overcome fires. This study took place in the densely populated settlement of Nelayan Indah. The location has the potential for fires because many buildings use flammable materials, the distance between buildings is close together and strong wind conditions because it is located in the coastal area. Medan Labuan. The research method used is AHP. Based on the results of the study, the Nelayan Indah area has a low reliability of the fire protection system because many factors are not in accordance with the provisions related to the fire protection system. So that appropriate recommendations are given to be implemented in the Nelayan Indah area, such as improving firefighting facilities and infrastructure, increasing community discipline and knowledge regarding fires, and making better use of existing facilities and infrastructure.

Article History

Submitted: 4 Februari 2026

Accepted: 7 Februari 2026

Published: 8 Februari 2026

Key Words

AHP ,Fire, Passive Protection System

1. Introduction

There are many countries that are prone to various types of disasters, both natural disasters and disasters caused by humans, one of which is Indonesia. One of them is a fire disaster [1]. One of the problems that cannot be separated from humans is fire. [2][3]. That is because many fires occur due to human negligence, but there are other aspects that cause fires, namely technical factors [8]. Fire disasters are disasters that cannot be predicted in terms of time and place of occurrence so that they can cause many losses to society and nature [4]. Losses that can be caused by fires include property losses, business disruptions, and loss of life [5].

Triggers for fire disasters are low public understanding and awareness of the dangers of fire, minimal public readiness in experiencing and overcoming the dangers of fire, a fire response system that has not been realized and integrated, lack of adequate infrastructure and facilities for building fire protection systems [3]. Other things that cause the easy spread of fire during a fire are the lack of availability and implementation of an optimal fire protection system and in accordance with building technical requirements regulations, the existence of a response system that has not been properly integrated, the level of public understanding of the dangers of fire which is still relatively low and readiness in dealing with and overcoming the dangers of fire [9].The level of public dependence on related technical institutions, namely the Fire Department, is still very high. This should be reduced considering that

Firefighters need time to get to the location of the fire. Meanwhile, the process of spreading the fire very quickly requires extinguishing to be carried out as soon as possible by the community [6]. The unavailability of evacuation locations when a fire occurs, limited access for fire engines, and increasing environmental growth that is not equipped with proper protection systems, both passive and passive, can worsen the occurrence of fires [7].

The Medan City Fire Department recorded that in 2021 there were 208 fire cases in the city of Medan. This incident resulted in 2 deaths and 27 injuries, while material losses reached 30 billion. In 2017, a fire broke out in two semi-permanent houses on Jalan Khaidir Blok AA, Nelayan Indah sub-district. At the time of the incident, residents tried to put out the fire, but the wooden material of the house caused the fire to quickly spread to the house next door. This research took place in a densely populated settlement in Medan city, Medan Labuhan, Nelayan Indah. This settlement is one of the densely populated settlements located on the coast, Nelayan Indah Village, Medan Labuhan. When discussing the Nelayan Indah settlement, the general view that emerges is a densely populated settlement, semi-permanent buildings, and narrow road access.

This location has the potential for fire, with the condition of the building using flammable materials allowing fire can spread to other houses, added to the strong wind conditions and high levels of solar heat because it is located in a coastal area. So with this, it is very important to research the evaluation of passive fire protection systems in settlements in Nelayan Indah, Belawan. Fire will not occur if the protection system is in accordance with the established standards [13]. the number of fires can be reduced if appropriate safety standards have been implemented [14][13].

There are two types of fire protection systems, namely passive fire protection systems and active fire protection systems. The passive fire protection system is a system used to protect everyone in a location by making construction components and designs in such a way [15]. Protection against building collapse during a fire, preventing flashover, providing an opportunity for occupants to evacuate, providing the building with the ability to function safely, and providing an opportunity for firefighters to save themselves [16]. The component of the passive fire protection are water supply, environmental roads,rescue facilities and buildings from Table 1.

Table 1. Passive Fire Protection System Components

Refrence	Passive Fire Protection System Component	Conclusion
(Deliana, 2015)	-Building Quality -Building Density -Facilities and Infrastructure	-Environmental Roads -Buildings -Water Supply -Rescue Facilitie
(Kementerian PUPR, 2016)	-Buildings -Environmental Roads -Drinking Water Provision -Environmental Drainage -Waste Water Management -Waste Management -Fire Protection	
(Zulkarnaini et al.,2019)	-Roads -Drainage -Drinking Water Provision -Waste Management -Waste Water Management -Fire Safety -Public Open Space	

Based on the results of the conclusions from the three comparative studies above, the references that will be used for analysis are obtained from the variables and sub-variables in the Nelayan Indah environment from Table 2.

Table 2. Passive Fire Protection System Variabel

Aspect	Component
Environmental Roads	-Pavement Layer -Pavement Layer Road Width -ObstacleFree Roads
Buildings	-Safe Distance Between Buildings -FireResistant Construction and Building Materials
Water Supply	-Water Source -Distance to Water Source -Accessibility of Water Source -Distance of BPBD to Research Location
Rescue Facilities	-Evacuation Room for Occupants and Goods After a Fire -Evacuation Barriers -Accessibility of Occupants and Firefighters for Rescue and Evacuation

Fire protection system for buildings has a distance between buildings and building construction. Fire-resistant construction is a construction whose structure is resistant to fire and is able to withstand loads. Fire-resistant construction in the form of fire barriers, fire walls, outer walls that are associated with the location of the protected building. Environmental planning includes providing water sources such as hydrants or reservoirs. To facilitate firefighting agencies[17]. The water supply to the passive fire protection system is influenced by the water source, the distance of the water source and the distance of the BPBD. In one environment, if there is no reliable water distribution system, it is permissible to install or provide a water source such as a reservoir, pressure tank, elevation tank, or subscribe to water from the fire department or other approved systems and in accordance with applicable standards and regulations. The water supply for what is needed must be at least 2400 liters / minute and be able to flow water for at least 45 minutes during the firefighting process. The distance in question is the minimum distance required from the fire department to reach the location of the fire. Firefighters must be at the scene within a maximum of 15 minutes after a fire occurs.

To prevent accidents or injuries during evacuation during an emergency, each building must be equipped with a means of exit for the building occupants, so that they have enough time to safely escape. Consists of evacuation space, evacuation barriers, and accessibility. The minimum distance between the assembly point area and the fire location is 20 m which aims to protect users from debris or other hazards. Evacuation routes must not obstruct access and maneuvering of fire engines.

The research location is in the Nelayan Indah Block F area. Nelayan Indah is one of the sub-districts in Medan Labuhan District, Medan City, North Sumatra. It has a land area of 40 hectares that stretches from North to South. Previously, Nelayan Indah was a mangrove and swamp area. The administrative boundaries of Nelayan Indah sub-district are in the North bordering Medan Labuhan East Longitude, in the South bordering Medan Deli Sub-district, in the West bordering Medan Marelan, and in the East bordering Deli Serdang Regency. The location of this area is at an altitude of 0-150 meters above sea level with a flat topography

located on the coast so that the wind speed is quite high. The reason for choosing Nelayan Indah as the research location is because Nelayan Indah is one of the densely populated residential areas in Medan City with flammable building materials and access to the location is quite far from the highway. Thus, an evaluation of the passive protection system in this settlement is needed in order to prevent and minimize fires. Block F was chosen based on factors, namely that there had been a fire disaster in this block, there was a connecting route in the form of a damaged bridge in this block, and block F was the longest block in Nusa Indah, which could be a representative for other blocks.

2. Methods

The type of research that will be used in this study is a mixed method. This is because data related to existing conditions will be analyzed using qualitative methods through descriptive analysis, while for the analysis of the reliability value of the fire protection system using quantitative methods through AHP. Qualitative research is conducted in natural conditions, researchers conduct surveys of information sources. In this study, the instrument is a person (human instrument), namely the researcher himself and the information analysis is inductive. Qualitative research can be tried by conducting a survey or direct observation at the research location, namely the Nelayan Indah Medan Labuhan sub-district and conducting direct interviews with local residents regarding the condition of the passive protection system at that location. The reason for choosing this method is in accordance with the purpose of the study, namely to provide an explanation in the form of a clear picture of the phenomenon or indication of the condition of fire protection system facilities and infrastructure in the Nelayan Indah Medan Labuhan area in the form of a series of words that ultimately want to produce a theory. The quantitative method used is AHP. AHP (Analytical Hierarchy Process) is one way that can be used to obtain alternative conclusions from a problem. The first step in using the AHP method is to determine the sub-variables and variables, then the variables are called sorted based on their priority scale, this is necessary when processing data using a initial matrix.The criteria used are to see how important one variable is to another variable, create an initial matrix.

After sorting, then fill in the initial matrix columns based on 9 scales of importance, then enter the normalization matrix in Table 3.

Table 3. Scale of Interest

Value	Description
1	Criterion A is as important as criterion B
3	A is slightly more important than B
5	A is clearly more important than B
7	A is clearly more important than B
9	A is absolutely more important than B
2,4,6,8	When in doubt between two adjacent values

After that, the normalization matrix is summed up for each row, then divide the results of the normalization matrix by the total number in the sum of the values to determine the priority vector and temporary weight by summing the multiplication between the initial cell matrix and the priority vector normalization matrix cell. Then create a percentage weight by dividing the temporary weight and the total temporary weight multiplied by 100%, so that the final weight will be obtained. There are assessment criteria for determining the reliability value of an environment's passive protection system. The condition values of the components of the

passive environmental fire protection system are divided into four assessment levels, namely in Table 4.

Table 4. Component Availability Rating Scale

Value	Description
1	There are no components of the environmental passive fire protection system.
2	Some components of environmental passive fire protection systems are available but do not meet standards.
3	Several standard-compliant passive environmental fire protection system components are available
4	All components are available and meet standards

3. Results and Analysis

Each component of the element must be assessed for its reliability. The weight of each element is classified according to the relative importance of each component.

3.1 Enviromental Roads

The environmental road conditions for fire engine access in the Nelayan Indah sub-district consist of two types of roads. The first type of road is a concrete road with a width of 6 m which functions as the main road connecting between blocks and between the Nelayan Indah sub-district and the YosSudarso arterial road. The second road is a block environmental road that has a width of 1.9-3 m made of concrete. At the case study location, namely Environment 1 block F, the condition of the block road has a size of only 1.9-2 m in Figure 1.

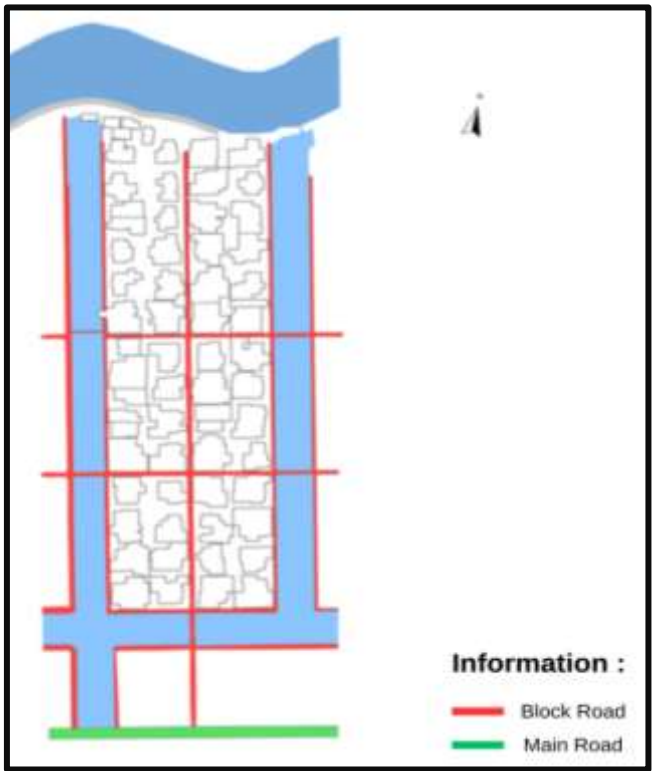

Figure 1 Road conditions in Block F of the Nelayan Indah area

The first type of road made of concrete has a width of 6 m. The second road is a block environment road that has a width of 1.9-3 m. At the case study location, namely Environment 1 block F, the condition of the block road has a size of only 1.9-2 m.

Figure 2 Block Road Condition

In Figure 2 we see on the main road, the road conditions based on the survey are free from obstacles or barriers to be easily passed by firefighters. However, when it rains, several block roads can be covered by high tide and several connecting bridges between alleys are known to still have many holes or are not available so that they can be an obstacle when fire protection occurs. The following is an analysis of the roads in the Nelayan Indah area, especially in Block F in Table 5.

Table 5. Environmental Road Analysis

Teory	Source	Data	Analysis	Point
The pavement should be made of metal, paving blocks or reinforced layers.	Permen PU, 2008	The road material on site is cast concrete	Because it is covered by a layer of pavement, it is suitable for fire trucks to pass through.	4
Should be as flat as possible with a slope not exceeding 1:8.3		The road is relatively flat	Suitable for fire trucks to pass through	
Minimum width3.5m, minimum length 15m	Permen PU, 2008	The main road of Nelayan Indah is 6m wide, while the block roads are only 1.9-2m.	Based on the data, it is known that the road width is not up to standard. Fire trucks cannot enter the block road, but only the main road.	2
Public road for traffic with full entry	UU No.2 tahun 2022	There are several speed bumps on the	The road is relatively	2

control without anything in the way of the road.		main road, while on the block road there are potholes	passable but at low speed.
The pavement layer must always be free from obstructions from other parts of the building, trees, plants or other things and must not obstruct the path between the pavement and non-access areas.	Permen PU, 2008	There are several shade trees with a height of 2-4 m whose branches reach the road. In addition, there are still several holes in the road.	This may obstruct firefighter access routes.
The minimum height of the free space or car entrance is 4.5 m to allow fire extinguishing equipment to pass through.		At the location, there is nothing that disturbs the height of the free space, there are only a few shade trees on the side of the main road and the block.	Clearance height according to regulations

3.2 Building

The building distance in question is the minimum distance required by a building as a safe distance during a fire. In fire protection efforts, the building's equidistant line is useful for preventing the spread of fire to surrounding buildings Figure 3.

Figure 3 Top view of block F, Nelayan Indah

Based on the survey, it can be seen that the distance between buildings varies. Based on this, the distance between buildings is predominantly below 3 m, so it does not comply with applicable fire protection standards. The initial condition of the building in Nelayan Indah was a wooden stilt house with a couple model. It has an area of 20-30 m² for each house. However, population growth has caused the size of the original house to be insufficient to live in. This has caused many Nelayan Indah residents to renovate by adding brick buildings to the stilt house.Nelayan Indah area has an average building height of around 3-8 meters so that it has a minimum distance between buildings of 3 meters Figure 4.

Figure 4 The original house of the Nelayan Indah area

In UU No. 28 of 2002 concerning Buildings, fire-resistant construction is a construction whose structural elements are fire-resistant and are able to withstand structural loads as stated in the Fire Resistance Level (TKA) of building elements, which includes resistance to load, fire spread (integrity) and heat spread (insulation).From the results of observations made, the fire resistance level (TKA) of housing in the Nelayan Indah area is included in type C. Type C fire resistance level is a construction whose building structure components are made of combustible materials and are not intended to be able to withstand structurally against fire. Plan original house in Nelayan Indah Figure 5.

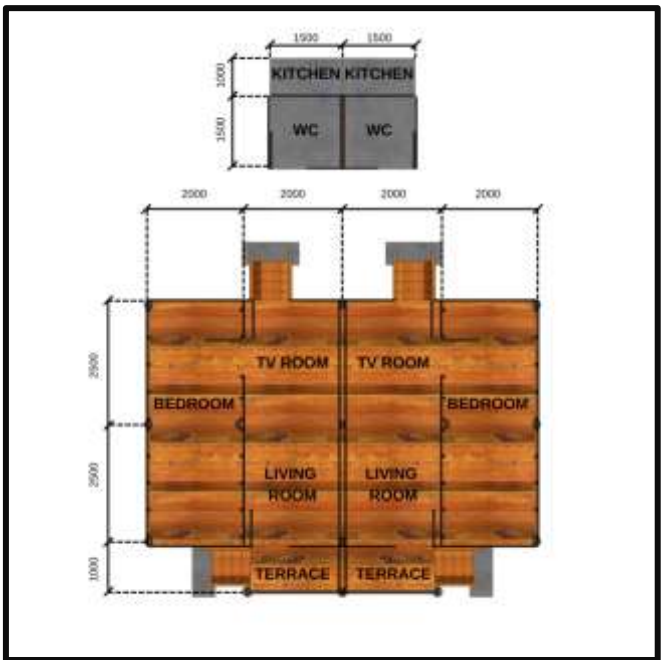

Figure 5 Layout The Original House

Analysis of existing data related to buildings in the Nelayan Indah area in the Table 6.

Table 6. Building Analysis

Teory	Source	Data	Analysis	Point
Minimum house spacing of 3 m	Permen PU, 2008	There are 15 out of 43 houses that have a distance between buildings that complies with the regulations.	Based on this, it can be seen that the distance between buildings in block F still does not meet the minimum requirements for a fire protection system.	2
Construction whose forming structure is fireproof and structurally capable of withstanding loads	Permen PU, 2008	The building materials used by houses in Nelayan Indah predominantly use wood and boards. But there are also those with concrete materials.	Therefore, the houses in Nelayan are categorized as flammable.	2

3.3 Water Supply

The water source in the research area comes from PDAM's drilled wells. The community also uses brackish canal water to water the plants Figure 6.

Figure 6 Water Source Nelayan Indah

The closest water source for the community that can be used as a water source during a fire is water from the canal. The distance from the canal to the community's house is 2-6 m depending on the position of the house. The nearest fire extinguishing unit from the Nelayan Indah area is the Medan Belawan unit. Based on the survey, it can be seen that the distance from the Belawan fire extinguishing unit to Nelayan Indah is 7.1 km with a travel time of 16 minutes in smooth road conditions. The water analysis in Table 7.

Table 7. Water Analysis

Teory	Source	Data	Analysis	Point
For natural water sources, it must be equipped with piping/drafting equipment (drafting point)	Ibmpkp.pu.go.id	The water source used for daily needs in Nelayan Indah is a water source owned by PDAM. There is also a natural water source in the form of canal water that can be used.	The absence of a suction / pump for the use of canal water means that the available water cannot be used optimally.	2
The maximum distance of the water source is 50 m	Ibmpkp.pu.go.id	The water source is in front of the house which is bordered by the road. Meanwhile, the PDAM water source is at two points.	The water source is not too far away and easy to reach.	4
The maximum time for firefighters to reach the fire location is 15 minutes.	dindamkar.go.id	It is known that the distance between BPBD and Nelayan Indah is 7.1 km with a travel time of 16 minutes in smooth road conditions	The time needed to reach the research location exceeds the maximum time for firefighters, which is 15 minutes. Sothis is not in accordance	2

3.4 Means Rescue

During the rescue process, open land is a facility that can change function from empty land to an evacuation site during a fire. During the rescue process, the field is a facility that can change function from an open field to an evacuation site during a fire. Open space as an evacuation site must be on the same plot except for roads, rivers or public places adjacent to the plot, but no more than 6 meters away. There was no proper evacuation space available at the research location. The available yards did not reach the minimum number because the houses were close together and did not have a boundary line.

Based on the survey, it can be seen that the evacuation route is free from obstacles except on the bridge section. Due to the unavailability of standard evacuation space in the area around block F, the community must take an evacuation route to the main road in Table 8.

Table 8. Means Rescue

Teory	Source	Data	Analysis	Point
The standard gathering point is an area with a minimum area of 30m² and a minimum height of 2 m..	NFPA, 2000	The distance between houses is only 1-3 m and does not have a proper boundary line	Because the distance between houses is close together, there is no proper gathering point, so residents can only gather on the road.	1
The route must be free from obstacles	NFPA, 2000	On the evacuation route there are obstacles in the form of holes in the road	Holes in the road hinder evacuation in the event of a fire	1
Evacuation routes must not block the access and maneuvering of firefighting vehicles.	NFPA, 2000	The evacuation path at the site only has a size of 1.5-2 m fire.	Because there is no adequate evacuation route, the fire vehicle access is on one lane. This can make it difficult for both the community and fire officers.	1
The minimum distance of the gathering point area to the fire location is 20m which aims to protect users from debris or other hazards.	NFPA, 2000	There are no adequate gathering points so that the community gathering location is only on the road area.	Because the community gathering location is on the road area, this does not meet the minimum distance of the gathering point to protect users	

After the value of each component is known, then the weight of each component is calculated using Microsoft Excel software. After the weight of each sub variable has been known using Microsoft Excel, then the next stage of assessment is carried out on each research variable using the component availability assessment scale. Then the calculation of the sum of component values is carried out in Table 9.

Table 9. Total Reliability Value ofNelayan Indah's Passive Protection System

Component	Weight	Reliability Value	Amount	Total	Value
Pavement Layer	0,37	4	1,48		
Road Width	0,70	2	1,40		
Freeway	0,35	2	0,70	**3,59**	0,90
Distance Between	0,4	2	0,79		
BuildingsConstruction	0,22	2	0,45	**1,24**	0,31
Water Source	0,28	2	0,56		
Distance of Water Source	0,29	4	1,15		
Achievement	0,22	4	0,87		
Distance of BPBD	0,34	2	0,67	**3,25**	0,81
Evacuation Room	0,18	1	0,18		
Evacuation Barrier	0,22	1	0,22		
Accessibility	0,21	1	0,21	**0,60**	0,15
Reliability Value					**2,17**

Based on the table above, the results of the total value of the reliability of the passive fire protection system at Nelayan Indah are not good, with a reliability value of 2,17 out of a total value of 4.

4. Conclusions

Evaluation of the reliability of the passive fire protection system in Nelayan Indah was carried out by giving values to the components of the passive fire protection system using Microsoft Excel software. After the evaluation, it was found that the condition of the passive fire protection system in Nelayan Indah was incomplete and did not meet the standards in accordance with the theory and requirements. The existing problems tend to be numerous, so that improvement efforts are needed to improve safety against fire disasters that can occur at any time.

The results of the evaluation using Microsoft Excel were not good, with a reliability value of 2,17; meaning Nelayan Indah does not have components of the passive fire protection system in accordance with the standards and references. This causes the passive fire protection system in the research location to be improved. The following are the conclusions from the results of the analysis of the passive fire protection system elements in the Nelayan Indah environment:

1. The environmental road received a value of 3,59 (Very Good), although it is said to be very good, there are several components whose quality must be maintained.
2. The building received a score of 1,24 (Poor), this is because the distance between buildings has not reached the minimum building distance in the passive protection system standard. In addition, there are still many buildings that use flammable materials such as wood.
3. Water supply received a score of 3,25 (Good), although it received a good score, there are still components that still need to be repaired.
4. Rescue facilities received a score of 0,6 (Poor), because there is no adequate space and evacuation routes in the environment.

6. Acknowledgments

Acknowledgements This journal is designed to determine the assessment of passive fire protection systems in an area. The author hopes that this research can be a learning experience to plan a better fire protection system in a densely populated area.

7. Conflict of Interest

The authors whose names are listed below certify that the manuscript do not have conflict of interest

M.Salman Ihsan

This statement is signed by all the authors to indicate agreement that the above information is true and correct (a photocopy of this form may be used if there are more than 10 authors):

Author's name (typed)	Author's signature	Date
M.Salman Ihsan		21Oktober 2024

References

References use Vancouver stylewithnumberingorder as follow:

[1] N. V. Rahman, L. A. Sinaga, and Y. E. Mahwani, "Analisa Sistem Proteksi Kebakaran Pasif Pada Perumahan Di Wilayah Perkotaan," *Semin. Nas. Kearifan Lokal dalam Keberagaman untuk Pembang. Indones.*, pp. 229–240, 2017.

[2] D. A. Hidayat, Suroto, and B. Kurniawan, "Evaluasi Keandalan Sistem Proteksi Kebakaran Ditinjau Dari Sarana Penyelamatan Dan Sistem Proteksi Pasif Kebakaran Di Gedung Lawang Sewu Semarang," *J. Kesehat. Masy.*, vol. 5, no. 5, pp. 134–145, 2017.

[3] M. Heri Zulfiar and A. Gunawan, "Evaluasi Sistem Proteksi Kebakaran pada Bangunan Hotel UNY 5 Lantai Di Yogyakarta," *Semesta Tek.*, vol. 21, no. 1, pp. 65–71, 2018, doi: 10.18196/st.211212.

[4] N. V. Rahman and A. S. Ginting, "Evaluation of Fire Passive Protection System in Housing (Case Study: Tegal Sari II Mandala, Medan)," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 452, no. 1, 2020, doi: 10.1088/1755-1315/452/1/012094.

[5] G. Gogendra and Andriyani, "Analisis Penerapan Sistem Proteksi Kebakaran Pasif dan Sarana Penyelamatan dalam Upaya Program Emergency Response Plan di Jakarta Eye Center Kedoya Tahun 2020," *Environ. Occup. Heal. Saf. J.*, vol. 1, no. 2, pp. 129–142, 2020.

[6] B. H. I. Roziana, S. Murtiadi, and Akmaluddin, "ANALISIS FAKTOR-FAKTOR YANG MEMPENGARUHI KEHANDALAN SISTEM PROTEKSI KEBAKARAN PADA BANGUNAN GEDUNG NEGARA DI KOTA MATARAM," vol. XX, no. 2, pp. 119–126, 2015.

[7] S. Sukawi, G. Hardiman, N. A. DA, and Z. A. P, "Evaluasi Sistem Proteksi Kebakaran Pada Bangunan Rumah Susun (Studi Kasus : Rusunawa Undip)," *Modul*, vol. 16, no. 1, p. 35, 2016, doi: 10.14710/mdl.16.1.2016.35-42.

[8] Serani, T. Lina, and Isyatun, "Penerapan Manajemen Risiko Kebakaran di Area PT. Wilmar Bioenergi Indonesia," *Lingkung. dan Keselam. Kerja*, vol. 2015, pp. 1–7, 2015, [Online]. Available: https://www.neliti.com/id/publications/14606/penerapan-manajemen-risiko-kebakaran-di-area-produksi-pt-wilmar-bioenergi-indone.

[9] I. Y. Salena, M. Safriani, and Novrizal, "Identifikasi Sistem Proteksi Kebakaran serta Tingkat Keandalan Keselamatan Bangunan Fakultas Kesehatan Masyarakat di Universitas Teuku Umar," *J. Pendidik. Tek. Bangunan dan Sipil*, vol. 5, no. 2, pp. 50–58, 2019.

[10] M. A. Sholeh, Suroto, and I. Wahyuni, "Analisis sistem proteksi kebakaran aktif pada rumah sakit gigi dan mulut x di kota bandung," *J. Kesehat. Masy.*, vol. 9, no. 1, pp. 51–57, 2021, [Online]. Available: http://ejournal3.undip.ac.id/index.php/jkm.
[11] M. Reza, A. Sasmita, and E. L. Sadewo, "Analisis Sistem Proteksi Kebakaran Gedung Laboratorium Teknik Mesin Fakultas Teknik Universitas Riau," *J. Kaji. Tek. Mesin*, vol. 5, no. 1, pp. 22–28, 2020, doi: 10.52447/jktm.v5i1.2427.
[12] M. L. Sari and T. Sukwika, "Sistem Proteksi Aktif Dan Sarana Penyelamatan Jiwa Dari Kebakaran Di Rsud Kabupaten Bekasi," *J. Ilmu Kesehat. Bhakti Husada Heal. Sci. J.*, vol. 11, no. 2, pp. 190–203, 2020, doi: 10.34305/jikbh.v11i2.184.
[13] R. A. Kowara and T. Martiana, "Analisis Sistem Proteksi Kebakaran sebagai Upaya Pencegahan dan Penanggulangan Kebakaran (Studi di PT. PJB UP Brantas Malang)," *J. Manaj. Kesehat. Yayasan Dr. Soetomo*, vol. 3, no. 1, pp. 70–85, 2017.
[14] N. A. Putri, Martono, Mawardi, K. J. Setyono, and Sukoyo, "Analisis Sistem Proteksi Kebakaran Sebagai Upaya Pencegahan Dan Penanggulangan Kebakaran," *J. Manaj. Kesehat. Yayasan RS.Dr. Soetomo*, vol. 3, no. 1, p. 69, 2019, doi: 10.29241/jmk.v3i1.90.
[15] B. Romadhon, "Analisis Proteksi Kebakaran Pada Perusahaan Produksi Gas Dan Pembangkit Listrik," *Indones. J. Occup. Saf. Heal.*, vol. 7, no. 2, p. 142, 2018, doi: 10.20473/ijosh.v7i2.2018.142-151.
[16] Suprapto, "SISTEM PROTEKSI KEBAKARAN PASIF KAITANNYA DENGAN ASPEK KESELAMATAN JIWA (Passive fire protection and life safety)," *J. Permukim.*, vol. 2, no. 2, 2007.
[17] "Permen PU No. 26/PRT/M/2008," 26/PRT/M/2008, 2008.