ANALYSIS OF THE RELIABILITY OF THE BUILDING SAFETY SYSTEM IN KI HADJAR DEWANTARA KODIKLATAL BUILDING ON FIRE HAZARDS PREVENTION

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ABSTRACT

This study aims to determine the reliability value of the fire system and the safety of the KI Hadjar Dewantara building in the case of a fire. This research questionnaire was conducted twice. The Analytical Hierarchy Process (AHP) method will be applied to the first questionnaire to obtain the weighting of the fire variables which includes site completeness, rescue facilities, passive protection systems, and active protection systems. The second questionnaire used the check-list method based on the Minister of Public Works Regulation Number 26 of 2008 to determine the reliability value of the building in the event of a fire. The results for the reliability value of the Ki Hadjar Dewantara building from Mako Kodiklatal using the AHP method and the check-list respectively are as follows: 91.93% and 91.45%. So, it can be concluded that the building security system in case of a fire is in “Good” condition.

Keywords: *Fire, Reliability, AHP*

1. INTRODUCTION

Building in a building is a physical form of construction work that is integrated with its position, partly or wholly which functions as a residence or residence and other activities. (Permen PU No.26 of 2008). The need for open or closed space is needed to carry out all activities, along with organizational development. The development of the building requires developers and building owners to consider safety aspects, one of which is fire safety. Fire incidents have occurred in buildings owned by the Indonesian Navy, the last incident in 2020 there was a fire at the Headquarters building. Research on the building reliability system in the Indonesian Navy for preventing fire hazards has never been carried out to date. The Indonesian Navy has many buildings that have stood on average for more than 10 years, from several buildings in the Indonesian Navy, including the building at the Indonesian Navy Educational Institute in the Surabaya area, namely the building at Ki Hadjar Dewantara Command of the Doctrine and Training of the Indonesian Navy (Kodiklatal), where many main officials have offices in the building. In the building there are also many military activities in terms of administration and important items or archives, this is the basis for researching fires to ensure safety and disaster prevention for the building itself and its contents. (Permen PU No.26 of 2008).

In multi-story buildings there is a high risk of fire hazards, therefore a reliable fire protection system is needed. A reliable fire protection system is a means of preventing fire. For fire prevention, Ki Hadjar Dewantara Mako Kodiklatal Building, the building is equipped with a reliable fire protection system.

To find out the existing protection system in the Ki Hadjar Dewantara Mako Kodiklatal Building, further research is needed. This research refers to the "Regulation of the Minister of Public Works Number 26 of 2008"

The objectives of this study include:

a. Analyzing the reliability of the building at Ki Hadjar Dewantara Mako Kodiklatal Building using the Analytical Hierarchical Process (AHP) method.

b. Reviewing the suitability of the fire protection system at the Ki Hadjar Dewantara Mako Kodiklatal Building with the "Minister of Public Works Regulation Number 26 of 2008" as a guide in conducting this research.

2. MATERIAL AND METHODS

2.1 Definition of Fire

The definition of a fire according to the Department of Manpower (Depnaker) is a rapid exothermic oxidation reaction of a fuel accompanied by the onset of fire or ignition.

2.2 Understanding The Analytical Hierarchy Process (AHP) Method

Analytical Hierarchy Process (AHP) is a decision support method developed by a mathematics professor at the University of Pittsburgh, Thomas L. Saaty. AHP is a method for making a sequence of alternative decisions and selecting the best alternative when deciding with several objectives or criteria for making certain decisions.

AHP method completion stages

a. Analyze the problem and determine the solution as desired.

b. Creating a hierarchical structure of AHP that begins with a general-purpose, then continues with criteria and is finalize with alternatives.

c. Form a pairwise comparison matrix. The paired matrix filling is obtained from the results of the questionnaire to the respondents. An example of a pairwise comparison matrix can be seen in Table 1

Table 1 Pairwise Comparison Matrix

Elemen	A1	A2	A3	A4
A1	A_{11}	A_{12}	A_{13}	A_{14}
A2	A_{21}	A_{22}	A_{23}	A_{24}
A3	A_{31}	A_{32}	A_{33}	A_{34}
A4	A_{41}	A_{42}	A_{43}	A_{44}
Total	ΣA_1	ΣA_2	ΣA_3	ΣA_4

(source: Saaty, 1990)

The matrix elements are obtained by comparing one element to another. A11 is a comparison between element A1 and element A1. A12 is a comparison between element A1 and element A2.

d. Calculate the eigenvector value of each matrix pair. The vector's eigenvalues are the weight of each element. The steps to get the eigenvector value are as follows:

1) Multiply the elements of the matrix in one row and be rooted in the power of n like the formula below:

$$Wi = \sqrt[n]{a11 \times a12 \times \dots\dots\dots a1n}$$

2) Calculate priority vector or eigenvector

$$Xi = \frac{wi}{\Sigma wi}$$

e. Then perform the weighted sum vector obtained from the multiplication between the original matrix and the normalized eigenvector.

1) Test the consistency vector (CV) by dividing the weighted sum vector with normalized vector values.

2) Calculate the value which is the average value of the consistency vector.

3) To test the consistency of the hierarchy, the terms of the comparison matrix are acceptable if the CR value is <0.1. The CR value is obtained from the equation:

$$CR = \frac{CI}{RI}$$

$$CI = \frac{(\lambda\, maks - n)}{(n-1)}$$

With:

CR = consistency ratio

CI = consistency index

λmaks = the largest eigenvalue of the matrix

RI = eigenvalues in the matrix order

The RI value depends on the matrix order, the RI value can be seen in Table 2

Table 2. RI Value

Ordo (n)	1	2	3	4	5	6	7	8
Nilai RI	0,00	0,00	0,58	0,90	1,12	1,24	1,32	1,41
Ordo (n)	9	10	11	12	13	14	15	
Nilai RI	1,45	1,49	1,51	1,48	1,56	1,57	1,59	

4) Repeat steps number 3, number 4, number 5, and number 6 for all levels of the hierarchy.

Value of Reliability Level

Table 3 Criteria for assessing the reliability of a fire protection system

Value	Suitability	Reliability
80% < B ≤ 100%	according to requirements	Good
60 % < C ≤ 80%	It is attached but there is a small proportion of agencies that do not meet the requirements	Fair
K ≤ 60%	It doesn't fit at all	Poor

(Source: Research and Development Center for Housing, Ministry of Public Works, building fire safety inspection, 2005)

Fire Protection System

The fire protection system in buildings is a system that consists of equipment, equipment, and facilities, both installed and constructed in buildings that are used both for active protection systems, passive protection systems, and management methods to protect the building and its environment against fire hazards

a. Completeness of the site

Site completeness components include water sources, environmental roads, distances between buildings and yard hydrants

b. Means of rescue

Fire rescue means include egress and egress construction.

c. Passive Protection System

The Passive protection system covers levels of fire resistance of building structures, compartmentalization of spaces, and protection of openings.

d. Active protection system

The Active protection system includes detection of fire alarms both manual and automatic, water-based fire extinguishing systems such as sprinklers, standpipes, and fire hoses, and chemical-based fire extinguishing systems, such as fire extinguishers and the occurrence of fires (Permen PU No.26 of 2008).

e. The Weighting of KSKB components (reliability of the building safety system)

Table 4 Weighting of Protection Parameters Building fire

No.	Component	Weight
1.	Completeness of Site	25
2.	Rescue Facility	25
3.	Passive Protection	26
4.	Active Protection	24

(Source: Research and Development Center for Housing, Ministry of Public Works, building fire safety inspection, 2005)

3. RESEARCH METHODOLOGY

This research was conducted at Ki Hadjar Dewantara Building, Kodiklatal Bumimoro Krembangan, Surabaya.

4. RESULTS AND DISCUSSION

4.1 Analysis of Building Safety System Component Assessment (KSKB)

Assessment of Building Safety System Components (KSKB) against fire hazards in the Ki Hadjar Dewantara Kodiklatal building was carried out using 2 methods, namely, the Analytical Hierarchy Process (AHP) method and the checklist method based on Regulation of the Minister of Public Works No. 26 of 2008. The components of a fire protection system in buildings: site equipment, rescue facilities, passive protection systems, and active protection systems.

4.2 Analysis of Research Results Based on Technical Guidelines for Building Fire Safety Inspection Using the Analytical Hierarchy Process (AHP) Method

Establish a hierarchy of protection systems fire in buildings.

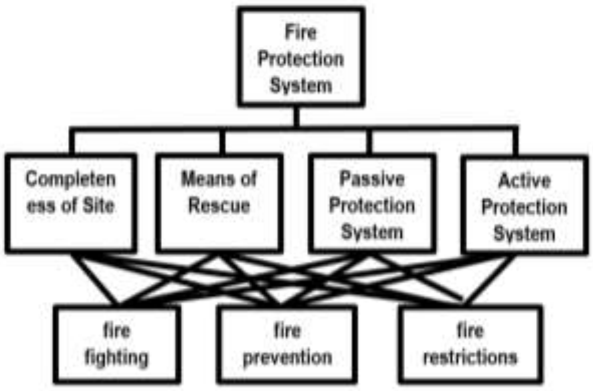

Figure 1. The Hierarchical arrangement of fire protection systems in buildings

The next step is, each the fire protection system carried out a comparative assessment for each of the criteria, with the following ratings:

a. Calculation of weight regarding fire prevention by comparing each component, with a comparative assessment as follows:

1) Completeness of site: means of rescue = 3: 1 means that completeness of site is slightly more important in supporting fire prevention than means of rescue.

2) Site completeness: passive protection system = 1: 1 means that site completeness is as important as a passive protection system in supporting fire prevention.

3) Completeness of the site: active protection system = 3: 1 means that the completeness of the site is a little more important in supporting fire prevention rather than active protection systems.

4) Rescue means passive protection system = 3: 1 means that the means of rescue are slightly more important in supporting fire prevention than passive protection systems.

5) Means of rescue: active protection system = 5: 1 means that the means of rescue are more important in supporting fire prevention than an active protection system.

6) Passive protection systems: active protection systems = 3: 1 means that passive protection systems are slightly more important in supporting prevention fire rather than active protection systems.

The paired comparison component with the reference for fire prevention is then assessed in the form of a matrix as follows:

Table 5. Comparison components paired with reference fire prevention

	Completeness of Site	Means of Rescue	Passive Protection System	Active Protection System
Completeness of Site	1	3	1	3
Means of Rescue	1/3	1	1	5
Passive Protection System	1	1	1	3
Active Protection System	1/3	1/5	1/3	1

b. Calculate the weight of each matrix pair. The steps for getting weighted are as follows:

1) Calculate the eigenvalues of the

vector by multiplying the elements of the matrix in one row and the power of n as the formula below:

$$Wi = \sqrt[n]{a11 \times a12 \times \dots \dots \dots \dots a1n}$$

Site Completeness System	$Wi = \sqrt[4]{1x3x1x3}$	= 1,732
Rescue Facility System	$Wi = \sqrt[4]{1/3x1x1x5}$	= 1,136
Passive Protection System	$Wi = \sqrt[4]{1x1x1x3}$	= 1,316
Active Protection System	$Wi = \sqrt[4]{(1/3x1x\ 1/3\ x1)}$	= 0,386
	Total	= 4,547

2) Calculate normalized eigenvector for each component, with the following formula:

$$Xi = \frac{wi}{\Sigma wi}$$

The Weight of The Site Completeness System	X_1 = 1,732/4,547 = 0,379
The Weight of The Rescue Facility System	X_2 = 1,136/4,547 = 0,249
The Weight of The Passive Protection System	X_3 = 1,316/4,547 = 0,288
The Weight of The Active Protection System	X_4 = 0,386/4,547 = 0,084

3) Then perform the weighted sum vector which is obtained from the multiplication between the original matrix and the normalized eigenvector.

$$\begin{vmatrix} 1 & 3 & 1 & 3 \\ 1/3 & 1 & 1 & 5 \\ 1 & 1 & 1 & 3 \\ 1/3 & 1/5 & 1/3 & 1 \end{vmatrix} \times \begin{vmatrix} 0{,}379 \\ 0{,}249 \\ 0{,}288 \\ 0{,}084 \end{vmatrix} = \begin{vmatrix} 1{,}666 \\ 1{,}085 \\ 1{,}169 \\ 0{,}357 \end{vmatrix}$$

Thus, the value of the weighted sum vector is obtained that is:

- Completeness system weight = 1.666 footprint
- The weight of the facility system = 1.085 rescue
- Passive protection system weight = 1.169
- The weight of the active protection system = 0.357

4) Test the consistency vector (CV) by dividing the weighted sum vector with normalized vector values

The Weight of The Site Completeness System	CV = 1,666/0,379 = 4,397
The Weight of The Rescue Facility System	CV = 1,085/0,249 = 4,365
The Weight of The Passive Protection System	CV = 1,169/0,288 = 4,060
The Weight of The Active Protection System	CV = 0,357/4,547 = 4,220

5) Calculate the value which is the average value of the consistency vector.

$$\lambda\, maks = \frac{(4{,}397 + 4{,}365 + 4{,}060 + 4{,}220)}{4} = \frac{17{,}042}{4} = 4{,}260$$

6) Calculate the value of the consistency index (CI) with equations

$$CI = \frac{(\lambda\, maks - n)}{(n-1)}$$

$$CI = \frac{(\lambda\, maks - n)}{(n-1)} = \frac{(4{,}260 - 4)}{(4-1)} = 0{,}087$$

7) Testing the consistency ratio (CR) value, the random index value (RI) for the matrix order of 4 was 0.90 from Table 2.4. The value of the consistency ratio (CR) can be accepted if the value is less than 0.1. The value of the consistency ratio (CR) can be calculated using the formula

$$CR = \frac{CI}{RI}$$

$$CR = \frac{0{,}087}{0{,}90} = 0$$

The value of the consistency ratio (CR) was obtained 0.096 is smaller than 0.1, the value is consistent and acceptable

8) Repeat the above steps for all criteria thus, the weighting of the fire variables can be seen in Table 6

Table 6. Weighting of fire variables for Ki Hadjar Dewantara Kodiklatal building using the AHP method

No	Component	The Weight (%)
1	Site Completeness	41
2	Rescue Facility	23
3	Passive Protection	21
4	Active Protection	15
TOTAL		100

(**Source**: the result of data processing, 2020)

4.3 Calculation of the Reliability Value of the Building Safety System (NKSKB) Against Fire Hazard Using the Analytical Hierarchy Process (AHP) Method

a. Completeness of Site

Table 7. Results of the completeness of site calculation

No	SUB KSKB	Assessment Notation	Investigative Value (%)	The Weight (%)	Assesment Condition (%)
I.	Completeness Of Site				
1	Water Sources	B	100	41	41
2	Road Neighborhood	B	100	41	41
3	Distance Between Buildings	C	70	41	29
4	Hydrant Page	B	100	41	41
Avarage					38

b. Rescue facility

Table 8. The Result of rescue facility calculation

No	SUB KSKB	Assessment Notation	Investigative Value (%)	The Weight (%)	Assesment Condition (%)
I.	Passive Protection				
1	Exit	B	90	23	21
2	Road Construction	B	100	23	23
Avarage					22

c. Passive protection system

Table 9. The Result of Passive Protection System Calculation

No	SUB KSKB	Assessment Notation	Investigative Value (%)	The Weight (%)	Assesment Condition (%)
I.	Passive Protection				
1	Fire Resistance of Building Structure	B	100	21	21
2	Compartementalization of Space	C	100	21	21.06
3	Protections of Opening	B	88.99	21	18.72
Avarage					20.28

d. Active Protection System

Table 10. The Result of Active Protection System Calculation

No	SUB KSKB	Assessment Notation	Investigative Value (%)	The Weight (%)	Assesment Condition (%)
I.	Active Protection				
1	Fire Alarm Detector	B	100	15	15
2	Siamese Connection	B	100	15	15
3	Light Fire extinguisher	B	100	15	15
4	Hidran	B	100	15	15
5	Sprinkler	B	83.33	15	12.26
6	Smoke Control	K	50	15	7.4
7	Smoke Detection	C	75	15	11
8	Smoke Disposal	C	62.5	15	9.2
9	Fire Elevator	K	0	15	0
10	Emergency light	C	80	15	12
11	Emergency electricity	B	100	15	15
12	Space control operation	B	100	15	15
Avarage					11.66

(Source: The Result of Data Processing)

4.4 Calculation of the Reliability Value of the Building Safety System (NKSKB) Against Fire Hazard Based on Regulation of the Minister of Public Works Number 26 Years 2008 (Checklist Method)

a. Completeness of Site

Table 11. The Result of the Completeness of Site

No	SUB KSKB	Assessment Notation	Investigative Value (%)	The Weight (%)	Assesment Condition (%)
I.	Completeness of Site			25	
1	Water Sources	B	100	27	6.75
2	Road Neighborhood	B	100	25	6.25
3	Distance Between Buildings	C	70	23	4.03
4	Hydrant Page	B	100	25	6.25
TOTAL					23.28

(Source: The Result of Data Processing)

b. Rescue facility

Table 12. The Result of the Rescue Facility

No	SUB KSKB	Assessment Notation	Investigative Value (%)	The Weight (%)	Assesment Condition (%)
II.	Rescue Facility			25	
1	Exit road	B	90	52	11.7
2	Road Construction	B	100	48	12
TOTAL					23.7

(Source: The Result of Data Processing)

c. Passive Protection System

Table 13. The Result of the the Passive Protection System

No	SUB KSKB	Assessment Notation	Investigative Value (%)	The Weight (%)	Assesment Condition (%)
III.	Passive Protection System			26	
1	Fire Resistance of Building Structures	B	100	36	9.36
2	Compatementalization of Space	B	100	32	8.32
3	Protections of Opening	B	88.99	32	7.40
TOTAL					25.08

(Source: The Result of Data Processing)

d. Result of the the Active Protection System

Table 14. The Result of the the Active Protection System

No	SUB KSKB	Assessment Notation	Investigative Value (%)	The Weight (%)	Assesment Condition (%)
IV	Active Protection				
1	Fire Alarm Detector	B	100	9	2.16
2	Siamese Connection	B	100	8	1.92
3	Light Fire extinguisher	B	100	9	2.16
4	Hidran	B	100	9	2.16
5	Sprinkler	B	83.33	9	1.80
6	Smoke Control	K	50	8	0.96
7	Smoke Detection	C	75	9	1.62
8	Smoke Disposal	C	62.5	7	1.05
9	Fire Elevator	K	0	7	0
10	Emergency light	C	80	9	1.728
11	Emergency electricity	B	100	8	1.92
12	Space control operation	B	100	8	1.92
TOTAL					19.40

(Source: The Result of Data Processing)

4.5 Comparison between the Reliability Value of the Building Safety System (NKSKB) Against Fire Hazards Using the Analytical Hierarchical Process (AHP) Method based on the Minister of Public Works Regulation Number 26 of 2008 (Checklist Method)

Table 15. The recapitulation results of the NKSKB calculation for the KI Hadjar Dewantara Kodiklatal building use the AHP method

No	Component	The Weight (%)	The Rating Result (%)
1	Site Completeness	41	38
2	Rescue Facility	23	22
3	Passive Protection	21	20.28
4	Active Protection	15	11.66
TOTAL		100	91.94

(Source: The Result of Data Processing)

Table 16. Results of the recapitulation of the NKSKB calculation results for the KI Hadjar Dewantara Kodiklatal building using the checklist method

No	Component	The Weight (%)	The Rating Result
1	Site Completeness	25	23.28
2	Rescue Facility	25	23.7
3	Passive Protection	26	25.08
4	Active Protection	24	19.40
TOTAL		100	91.46

(Source: The Result of Data Processing)

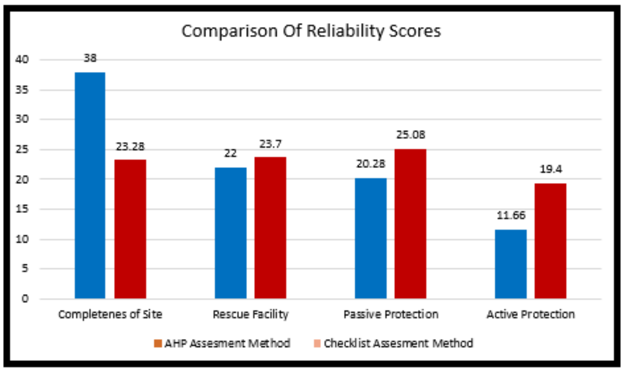

Figure 2. Comparison of the NKSKB reliability value of the KI Hadjar Dewantara Kodiklatal building (Source: 2020 data processing results)

Based on the calculations and system above, it is known that there is a difference between the assessment using the Analytical Hierarchy Process (AHP) and using the checklist method. The assessment using the Analytical Hierarchy Process (AHP) obtained a value of 91.93%, while the assessment used the checklist method obtained a value of 91.45%. From the two methods used there is a difference of 0.48%. From the assessment of the reliability of the Ki Hadjar Dewantara Kodiklatal building using both methods, the reliability value was obtained in good condition.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

The conclusions of this research are as follows:

a. Equipment for fire protection system in Ki Hadjar Dewantara Kodiklatal building in "good" condition.

b. The fire protection system in the building is almost complete, only there is no fire lift.

c. Based on the calculations made, the reliability value of the Building Safety System (NKSKB) against fire hazards in the Ki Hadjar Dewantara Kodiklatal Surabaya building was obtained using the AHP method, the value was 91.93%, while the assessment using the checklist method obtained a value of 91.45%. From the two methods used there is a difference of 0.48%. Based on this NKSKB, the fire protection system in this building is classified as reliable.

d. Core The technical recommendations given to the results of this research are periodic maintenance and repair of any existing fire protection facilities, repair of damaged elements, and addition of fire protection elements that are not yet available.

5.2 Suggestion

The suggestions of this research are as follows:

a. Filling the questionnaire using the AHP method must be done carefully. Filling the questionnaire with the AHP method should be done to those who are experts in their fields with a sufficient number of questionnaires so that the results are more accurate.

b. The "checklist form" that is used is quite effective in checking the fire protection system in the Ki Hadjar Dewantara Kodiklatal Surabaya building

c. It is hoped that the building manager will maintain an active protection system and complement the missing protection system, so that fire risk awareness can run well.

d. To achieve the "GOOD" criteria for buildings in the Indonesian Navy in the Surabaya region in particular and in Indonesia, in general, requires synergy between the government, in this case, the Fire Service and the Indonesian Navy as evidenced by professionalism in implementing regulations regarding the system. building safety against fire hazards.

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REFERENCES

Blogspot.co.id/2013/02/pengentuk-analitycal-hierarchy-process.html, accessed on 28 September 2017, 14.00 WIB.

Donnya, 2013. Fire extinguisher. http: //www. fire extinguishing tool. co / smoke-detector /, accessed at 1September 2017, at 08.00 WIB.

Https://Work Safety System. blogspot.co.id/2015/08/system designer basics.html, accessed on September 1, 2017, at 08.30WIB.

Http://semiberbagi.blogspot.com/2016/03/penjelas-complete-ahp-analytical.html, accessed on 28 September 2017, 14.00 WIB.

Iskandar, 2016. Smoke detection. https://patigeni.com/fungsi-pendeksi- asap /. accessed on September 1, 2017, at 11.00 WIB.

Decree of the Minister of Public Works. (2000). No.10 / KTSP / 2000 Technical Provisions for Safeguarding Against Fire Hazards in Buildings and the Environment.

Nono purnomo, 2015. The working principle of hydrants. https://patigeni.com/princip-kerjahydrant-system, accessed at 1September 2017, 10:00 WIB.

Nurul amalia humaira, 2017. Fire protection system. Https://infomigas.org/sistem- fire-protection-active-and-passive /, accessed on September 1 2017, at 08.30 WIB.

Regulation of the Minister of Public Works. (2008). No.26 / PRT / 2008 Technical Requirements for Fire Protection Systems in Buildings and the Environment.

Rangga Pratama, 2017. Reliability Analysis of Building Safety Systems Against Fire Hazards (Case study: Eria Bunda Mother and Child Hospital Building, Pekanbaru City). Undergraduate Thesis, Faculty of Engineering, Riau University.

Saberindo pacific, 2017. The theory of the fire triangle. http://saberindo.co.id/teori-segektronik- api /. Accessed on 1 December 2017, 14.35 WIB

SNI 03-1735-2000, Planning Procedures for Building Access and Environmental Access for Prevention of Fire Hazards in Buildings.

SNI 03-1736-2000, Planning Procedures for Passive Protection Systems for Prevention of Fire Hazards in Houses and Buildings.

SNI 03-1746-2000, Procedure for Planning and Installing Exit Means for Rescue of Fire Hazards in Buildings.

SNI 03-3985-2000, Procedures for Planning, Installation and Testing of Fire Detection and Alarm Systems for Prevention of Fire Hazards in Buildings.

SNI 03-3989-2000, Procedure for Planning and Installing Automatic Sprinkler Systems for Fire Hazard Prevention in Buildings.

SNI 03-6571-2001, Fire Smoke Control System in Buildings.

SNI 03-6574-2001, Procedures for Designing Emergency Lighting, Directional Signs and Hazard Warning Systems in Buildings.

Tirta meydanu dirja, 2011. System smoke control.http: //elektronikaindustri3.blogspot.co.i

d / 2014/03 / smoke-control-systems-and.html, accessed September 12017, 11.00 WIB.

Tri Gunawan, 2011. Building reliability inspection system in preventing fire hazards. Postgraduate Thesis, Faculty of Engineering, Sebelas Maret University, Surakarta.

Wahyu asyari muntoha, 2015. siamese- connection.