EVALUATION OF PASSIVE FIRE PROTECTION SYSTEMS IN SUPERMALL BUILDINGS

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ABSTRACT

Evaluation of a passive fire protection system is an effort to find out how feasible a fire protection system is in a building. One of the main problems arising from fire hazards in mall buildings is fire protection systems that do not meet standards. This study aims to analyze the building fire protection system, with the Sun Plaza Medan case study with a total of six floors and one basement, and located in the city center. The method used in this study is descriptive qualitative and quantitative, with a variable observation stage which is then carried out by a comparison process using the Analytical Hierarchy Process. This AHP method is helpful for researchers to get the results needed. Evaluation results obtained at shopping centers (case studies: Sun Plaza Medan) can be categorized as good, although several components do not meet the standards. Several recommendations were made for changes by testing, to obtain an increase in the value of the reliability of the passive fire protection system in the case study.

***Keywords**: AHP method, fire protection system evaluation, Mall.*

INTRODUCTION

A building has the potential for a fire. What's more, if the building is made of combustible material or used to store combustible materials. According to the Regulation of the Minister of Public Works No.26 / PRT / M / 2008 concerning the requirements of fire safety systems in buildings and the environment explained that, "The management of fire prevention systems is an effort to prevent the occurrence of fire or expand the fire area to another room, or the prevention efforts are widespread fire to buildings or other buildings ". A good protection system design is needed so that the building is alert in dealing with fires and minimizes losses due to fires, especially in public facilities and buildings that accommodate many people [1].

One mall that meets some of the above facilities is Sun Plaza. Sun Plaza is a middle to the high-end shopping center in the strategic commercial area of Medan, North Sumatra, Indonesia. It was inaugurated on January 1, 2004. Its strategic location makes this shopping center crowded with students, students, and domestic and foreign tourists. Sun Plaza is also adjacent to the Office of the Governor of North Sumatra, Medan Grand Mosque (the largest mosque in Sumatra), Medan State 1 High School, and Cambridge Apartments. At this shopping center, there is the Cinemaxx cinema and the Sogo department store.

In addition to providing facilities for visitor satisfaction, Sun Plaza also provides safety facilities that can prevent the occurrence of a disaster such as a fire, namely a fire protection system. Based on these matters, the authors intend to further study the passive fire protection system of the Sun Plaza building and know the value of its reliability. By knowing the value of fire protection system reliability, there can also be a shortage or weakness of the fire protection system of the Sun Plaza building.

LITERATURE REVIEW

1. Passive Fire Protection System

A passive fire protection system is a fire protection system that aims to block or withstand the rate of spread of smoke, toxic gases, fire and heat that occurs during the firing process for a certain period. Passive fire protection systems usually consist of structural protection to protect the frame of the building or to prevent the spread of fire which is generally measured from its resistance to fire [2].

The fire protection system was previously set in the Government regulations. PU No.45 / PRT / M / 2007, Minister of Public Works Regulation No. 26 / PRT / M / 2008 30 December 2008 concerning Technical Requirements for Fire Protection Systems in Buildings and the Environment, SNI 03-1736-2000 Procedures for planning a passive protection system for prevention of fire hazards in building houses and buildings and NFPA 101, in regulations - the regulation has been explained in connection with regulations or standards for passive fire protection systems related to standard fire stairs, Emergency Lighting, Smoke Control, Compartmental and Separation, Corridors, Emergency Doors, Sites, and fireproof construction.

2. Definition of AHP Method

Analytical Hierarchy Process (AHP) Is a method to solve a complex situation that is not structured into several components in a hierarchical arrangement, by giving a subjective value about the importance of each variable relatively, and determining which variable has the highest priority to influence the results in the situation [3]

The hierarchy process is a model that provides opportunities for individuals or groups to build ideas and define problems by making their assumptions and obtaining solutions.

3. Steps for using the AHP method

To get the results of the reliability of a building, the steps must be carried out ar; (1) Determination of Variables and Sub-Variables; (2) Sorting each variable and sub-variable based on its importance, all variables and sub-variables are given importance criteria for processing data on the AHP matrix. The criteria used is to see how important one variable is to another variable; (Table 1).

Table 1. Interest Scale

Value	Information
1	Criteria A is equally important with criterion B
3	Criteria A is slightly more important than criterion B
5	Criteria A is definitely more important than criterion B
7	Criteria A Very clearly more important than criterion B
9	Criteria A Absolute is more important than criterion B
2,4,6,8	When in doubt between two adjacent values

(3) Creating an initial matrix, After all the variables and sub-variables are sorted then the next is to create an initial matrix, filling in each column of the matrix with nine reference scales of interest; (Table 2).

Table 2. Example of Filling in the AHP Initial Matrix Column

	Criteria A	Criteria B	Criteria C
Criteria A	**1**	3	1
Criteria B	1/3	**1**	5
Criteria C	1/1	1/5	**1**
Total	2.33	4.20	**7**

(4) Creating a Normalization Matrix; (a) Add up all the values in each row of the normalization matrix after that, total the values obtained; (b) Determine the vector priority by dividing the results of stage 5 with the total number of values in step 5; (c) Determine temporary weights by: (Cell 1 initial matrix * cell 1 prioritizing normalized matrix-matrix) + (Cell 2 initial matrix * cell 2 prioritizing normalized matrix-matrix) + ………..; (d) Make weight percentages by: Temporary weight : the total amount of temporary weight * 100%; (e) Final Weight. (Table 3)

Table 3. Example of Filling in the AHP Normalization Matrix Column

	Criteria A	Criteria B	Criteria C
Criteria A	**1 / 2.33**	3 / 4.20	1 /7
Criteria B	0.33 / 2.33	**1 / 4.20**	5/ 7
Criteria C	1 / 2.33	1/5	**1 / 7**
Total	1	1	1

METHODOLOGY

This type of research is quantitative descriptive research. Descriptive research is a type of research that describes facts about an object, in this case, Sun Plaza Medan. The results of the study are then compared with the standard theories that have been studied. Qualitative research is carried out by conducting direct observations to research locations and interviews with related parties.

RESULT AND DISCUSSION

Sun plaza field began to open in 2004, precisely on January 1, 2004. Ownership of buildings on the street Kh. Zainul Arifin No.7, Medan City, North Sumatra has held by Lippo Group and managed by Lippo Malls. With parking capacity reaching 2,000 cars and 2,000 motorbikes, this building became the largest mall building in Medan. This 6-storey mall (including the Lower Ground and Ground Floor) has designed with the concept of a family mall.
Reliability Calculation of Sun Plaza Medan Building Passive Fire Protection System
The following is the calculation of the level of reliability of the Sun Plaza Medan building fire passive protection system.
Variable
Sort Variables based on interests (Table 4).

Table 4. Description of Variables

A	Site (Environmental Roads)
B	Evacuation Line
C	Construction and Building Structures
D	Building Safety Management

Initial Variable Matrix
Assessment of the importance of each variable in the AHP matrix based on the scale of importance (Table 5).

Table 5. Initial Variable Matrix

	A	B	C	D
A	1,00	0,50	2,00	0,50
B	2,00	1,00	0,33	2,00
C	0,50	3,00	1,00	2,00
D	2,00	0,50	0,50	1,00
	5,50	5,00	3,83	5,50

Variable Normalization Matrix

Weight obtained from the calculation of the normalization matrix and the end will be multiplied by the number of weights for each sub-variable. (Table 6).

Table 6. Variable Normalization Matrix

	A	B	C	D	Number in line	Periority Vektor	weight	Percentage Weight (%)
A	0,18	0,10	0,52	0,09	0,89	0,22	1,01	33
B	0,36	0,20	0,09	0,36	1,01	0,25	0,90	30
C	0,09	0,60	0,26	0,36	1,32	0,33	0,75	25
D	0,36	0,10	0,13	0,18	0,78	0,19	0,39	13
	1,00	1,00	1,00	1,00	4,00		3,04	100

Sub Variables of Site Variables (Environmental Roads)
Sort Sub Variables based on interests. The order of Sub Variable interests of Variable Site. (Table 7).

Table 7. Sub Variable Interest Sequences of Site Variables (Environmental Roads)

Code	Sub Variables
A. Site Variables (Environmental Roads)	
1A	Distance from Fire Department Location
2A	Fire Department
3A	Inter-building distance
4A	Site Evacuation Area
5A	Water Supply

Creating an Initial Sub Variable matrix from Site Variables (Environmental Roads). (Table 8)

Table 8. Initial Sub Variable Matrix of Site Variables (Environmental Roads)

	1A	2A	3A	4A	5A
1A	1,00	2,00	0,50	3,00	0,33
2A	0,50	1,00	3,00	0,50	2,00
3A	2,00	0,33	1,00	0,50	3,00
4A	0,67	2,00	2,00	1,00	3,00
5A	3,00	0,50	0,33	0,33	1,00
	7,17	5,83	6,83	5,33	9,33

Making Sub Variable Normalization matrix of Site Variables (Environmental Roads). (Table 9).

Table 9. Sub Variable Normalization Matrix of Site Variables (Environmental Roads)

	1A	2A	3A	4A	5A	Number in line	Periority Vektor	Weight	Percentage Weight	Total Weight
1A	0,14	0,34	0,07	0,56	0,04	1,15	0,23	1,51	36,98	37
2A	0,07	0,17	0,44	0,09	0,21	0,99	0,20	1,09	26,84	27
3A	0,279	0,057	0,146	0,0938	0,3214	0,90	0,18	0,59	14,39	14
4A	0,09	0,34	0,29	0,19	0,32	1,24	0,25	0,45	11,15	11
5A	0,42	0,09	0,05	0,06	0,11	0,72	0,14	0,43	10,65	11
Total	1,00	1,00	1,00	1,00	1,00	5,00		4	100	

Sub Variables of Variable Evacuation Route
Sort Sub Variables based on interests. The order of the Sub Variable importance of the Evacuation Route Variables. (Table 10)

Table 10. Sub Variable Interest Sequences of Evacuation Route Variables

Code	Sub Variables
B. Evacuation Route	
1B	Signboard
2B	Emergency Lighting
3B	Emergency Stairs
4B	Evacuation Corridor

Create the initial Sub Variable matrix from the Variable Evacuation Route. (Table 11)

Table 11. Initial Sub-Variable Matrix of Evacuation Route Variables

	1B	2B	3B	4B
1B	1,00	3,00	4,00	0,50
2B	0,33	1,00	0,50	2,00
3B	0,25	2,00	1,00	0,50
4B	2,00	0,50	2,00	1,00
	3,58	6,50	7,50	4,00

Make Sub Variable Normalization matrix from Evacuation Route Variables. (Table 12)

	1B	2B	3B	4B	Number in line	Periority Vektor	Weight	Percentage Weight	Total Weight
1B	0,28	0,46	0,53	0,13	1,40	0,35	1,74	52,69	53
2B	0,09	0,15	0,07	0,50	0,81	0,20	0,37	11,23	11
3B	0,07	0,31	0,13	0,13	0,64	0,16	0,62	18,64	19
4B	0,56	0,08	0,27	0,25	1,15	0,29	0,58	17,44	17
	1,00	1,00	1,00	1,00	4,00		3,30	100	

Sub Variables of Construction Variables and Building Structures

Sort Sub Variables based on interests. The order of Sub Variable interests of the Variable Construction and Building Structure. (Table 13)

Table 13. Sub Variable Interest Sequences of Construction Variables and Building Structures

Code	Sub Variables
C. Construction and Building Structure	
1C	Wall Construction Resistance
2C	Roof Construction Resistance
3C	Type of Interior Material
4C	Design and Spatial Planning

Creating an initial matrix of Sub Variables from Construction Variables and Building Structures. (Table 14)

Table 14. Initial Sub-Variable Matrix of Construction Variables and Building Structure

	1C	2C	3C	4C
1C	1,00	5,00	6,00	5,00
2C	0,20	1,00	9,00	5,00
3C	0,17	0,11	1,00	5,00
4C	0,20	0,20	0,20	1,00
	1,57	6,31	16,20	16,00

Making Sub Variable Normalization matrix of Construction Variables and Building Structures. (Table 15)

Table 15. Sub Variable Normalization Matrix of Construction Variables and Building Structure

	1A	2A	3A	4A	Number in line	Periority Vektor	Weight	Percentage Weight	Total Weight
1A	0,64	0,79	0,37	0,31	2,11	0,53	3,01	53,74	54
2A	0,13	0,16	0,56	0,31	1,15	0,29	1,81	32,27	33
3A	0,11	0,02	0,06	0,31	0,50	0,12	0,54	9,59	10
4A	0,13	0,03	0,01	0,06	0,23	0,06	0,25	4,41	4
JLH	1,00	1,00	1,00	1,00	4,00		5,60	100	

Sub Variables of Building Safety Management Variables
Sort Sub Variables based on interests. The order of Sub Variable importance of Variabael Building Safety Management. (Table 16)

Table 16. Sub Variable Interest Sequences of Building Safety Management Variables

Code	Sub Variables
D. Building Safety Management	
1D	Human Resources (Building Fire

	Management)
2D	Training and Simulation
3D	Periodic Inspection

Create an initial matrix of Sub Variables from a Building Safety Management Variable. (Table 17)

Table 17. Initial Sub-Variable Matrix of Building Safety Management Variables

	1A	2A	3A
1D	1,00	5,00	0,33
2D	0,20	1,00	0,25
3D	3,00	4,00	1,00
	4,20	10,00	1,58

Making Sub Variable Normalization matrix of Construction Variables and Building Structures. (Table 18)

Table 18. Sub Variable Normalization Matrix of Building Safety Management Variables

	1D	2D	3D	Number in line	Periority Vektor	Weight	Percentage Weight	Total Weight
1D	0,24	0,50	0,21	0,95	0,32	1,02	30,27	30
2D	0,05	0,10	0,16	0,31	0,10	0,60	17,89	18
3D	0,71	0,40	0,63	1,75	0,58	1,75	51,84	52
	1,00	1,00	1,00	3,00		3,37	100	

After all the variables and sub-variables are calculated, the next thing to do is to provide reliability values according to the current state of the building. Following are the results of building reliability. (Table 19)

Table 19. Number of Reliability Value for Passive Fire Protection Systems

No.	Sub Variables	Weight	Availability Value	Total	Total	Value
A. The Site (Environmental Path) 33%						
1A	Distance of Fire Department To Location	37	4	148		
2A	Fire Fighting Access Point	27	2	54		
3A	Inter-building distance	14	2	28	296	98
4A	Site Evacuation Area	11	3	33		
5A	Water Supply	11	3	33		
B. Evacuation route 30%						
1B	Signboard	53	3	159		
2B	Emergency Lighting	11	2	22	289	87
3B	Emergency Stairs	19	3	57		
4B	Evacuation Corridor	17	3	51		
C. Construction and Building Structure 25%						
1C	Wall Construction Resistance	54	3	162		
2C	Roof Construction Resistance	33	3	99	293	73
3C	Type of Interior Material	10	2	20		
4C	Design and Spatial Planning	4	3	12		
D.Building Safety Management 13%						
1D	Human Resources (Building Fire Management)	30	2	60		
2D	Training and Simulation	18	2	36	200	26
3D	Periodic Inspection	52	2	104		
VALUE OF RELIABILITY						**284**

Results of Reliability Assessment :

Variable Availability Value; (1) = It has absolutely no components according to reliability requirements; (2) = It has components, but all do not match reliability requirements; (3) = It has some components that match reliability requirements; (4) = All components match reliability requirements.

Reliability Assessment of Fire Passive Protection System:

$100 < x \leq 160$	=	Bad
$160 < x \leq 220$	=	Less
$220 < x \leq 280$	=	Enough
$280 < x \leq 340$	=	Good 284
$340 < x \leq 400$	=	Very Good

From the results of the calculations above, obtained the value of the reliability of the passive fire protection system in Sun Plaza Medan, namely 284 which is in the Good category.

CONCLUSION

Evaluation of a passive fire protection system can be done by analyzing data which then determines the variables and sub-variables. Each sub-variable is then calculated by using the AHP method supported by Microsoft Excel Software. This AHP method is very helpful for researchers to get the results needed. And the results of the reliability value obtained from the Sun Plaza Medan building's passive fire protection system is 284 out of a total value of 400. With this value, the reliability of the passive protection system in the Sun Plaza Medan building can be categorized as good, although there are some components that still do not meet the standards. Humans have individual personalities, but humans are also social beings, living in a society in a collectivity. In fulfilling this social need, human beings behave socially in their environment which can be observed from behavioral-environmental phenomena, user groups and the place where activities occur.

Based on the recommendations obtained, there are several proposals for increasing the value of the reliability of the passive fire protection system in the Sun Plaza Medan building. The result of the recommendation test shows that there is an increase in the value of the reliability of the passive fire protection system in the sun plaza building. These changes can occur if improvements and additions to some elements are lack such as the addition of emergency stairs, the addition of signage, repair of doors and changes in materials in buildings.

The results of the reliability obtained in the building fire passive protection system based on the design proposal of Sun Plaza Medan is 284 to 328 and still in the Good category. With this value, the reliability of the passive protection system in the Sun Plaza Medan building can be categorized as good, although there are some components that still do not meet the standards. Based on the calculation of the results of the proposed design, each variable has a reliability value, among others; (a) Site (Environmental Road) = 350, in the Good category;(b) Evacuation Line = 378, in the Very Good category;(c) Construction and Building Structure = 293, in the Good category; (d) Building Safety Management = 200, in the Less category.

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