Evaluation of Fire Passive Protection System in Housing (Case Study: Tegal Sari II Mandala, Medan)

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Abstract. Fire disaster is one of disaster that causes many losses to many parties both material and life losses. As the Indonesian population increases, housing and residence also continue to increase as well. However, limited areas and uneven population growth cause uneven development of housing. Many developments are done without considering the residence comfort and safety, so they are very vulnerable to disaster. Fire passive protection system is one of the building protection from the danger of fires. Tegal Sari II Mandala Medan is one of the densely populated housing area that continues to grow in Medan. As the housing keeps growing, this area needs a fire protection system that meets standards. This study aims to evaluate the effectivity level of passive protection systems in a housing area with a case study in Tegal Sari II Mandala, Medan City. The data analysis method that is used is a descriptive qualitative method by describing the physical data from the residential environment, which is being observed. Then, the collected data is evaluated using the Analytical Hierarchy Process Method. The result of the study designs that are more protective of the danger of fires in the environment and buildings.

1. Introduction

Fire is a disaster that causes a lot of harm to nature and society because it can happen anytime and anywhere. Fires in buildings and the environment can occur due to several factors, such as hostile nature conditions or due to human negligence that causes uncontrolled fires and lead to material and life losses. Fires are problems that often occur in residential areas. The increase in population growth every year causes rapid growth in development. Potential impact of the fire disaster that maybe happened is many potential losses both in material and in life losses that become threats in densely populated housing areas, especially in the city of Medan. Two fire protection systems can be applied in buildings to overcome fires, both of these protection systems have an important role to overcome fires. These protection systems consist of an active fire protection system and a passive fire protection system. In principle, in overcoming fires the passive protection system is the priority, after that the active protection system is done to overcome the fires. [1]

Fire protection system in buildings and environment is a system that consists of instrument, equipment, and facilities, both installed and built on buildings that are used for active protection systems and passive protection systems as well as management methods to protect buildings and their environments against the hazard of fire. Passive fire protection system is a fire protection system formed or built through the regulation of the buildings’ material usage and structural components, compartmentalization or separation of buildings based on the level of fire resistance, as well as protection against openings. [2]
The absence of gathering place for evacuation when a fire breaks out, narrow fire trucks lane, and all of those are worsened by the increasing number of developments that are not equipped with active or passive protection systems. [3]

Housing referred to in this study is a group of houses that function as residential places, both in urban and rural areas, which are equipped with environmental facilities and infrastructure as a result of efforts to fulfill the criteria of livable homes. Therefore, the purpose of this study is to evaluate the suitability of the passive fire protection system in housing with standards and related regulations and then to provide recommendations on fire prevention efforts that can be applied to subsequent housing development.

2. Method
In this study, the research method that is used is qualitative research with a descriptive observation method in collecting primary data in the study area. Observation is an activity to get the information needed to present an actual picture of an event or phenomenon in the field. [4]

At the data processing stage, data analysis that is collected in this study is in the form of qualitative descriptive data. Measurement basis uses a subjective scale that will obtain an objective decision using the AHP (Analytical Hierarchy Process) method which is processed using Microsoft Excel.

Evaluation criteria are rated through pairwise comparisons. According to Saaty (1983), for various problems, a scale of 1 to 9 is the best scale in expressing opinions. The values and definitions of qualitative opinions from the Saaty comparison scale can be seen in the following table:

| Value | Explanation |
|-------|-------------|
| 1     | The two elements are of the same importance |
| 3     | One element is a little more important than the other element |
| 5     | One element is more important than the other element |
| 7     | One element is clearly more important than the other element |
| 9     | One element is absolutely more important than the other element |
| 2,4,6,8 | If doubtful, between the two neighboring numbers |

The evaluation variables and sub-variables are divided into four levels in assessing the level of reliability of the fire passive protection system in this study area as described in the following table.

| Value | Explanation |
|-------|-------------|
| 1     | There are no components of the passive fire protection system. |
| 2     | There are some components of the passive fire protection system, but not standardized. |
| 3     | There are components of the passive fire protection system and standardized. |
| 4     | There are all components that standardized. |
The final stage is to identify the reliability value of the passive fire protection system, with the following rating scale table:

| Value          | Explanation |
|----------------|-------------|
| $1 \leq x < 1.6$ | Worse       |
| $1.61 \leq x < 2.20$ | Bad         |
| $2.21 \leq x < 2.80$ | Fair        |
| $2.81 \leq x < 3.40$ | Good        |
| $3.41 \leq x \leq 4$ | Best        |

### 3. Results and Discussions

The research location is in the city of Medan, North Sumatra, in the district of Medan Denai. The study was conducted in housing in the neighborhood of Tegal Sari II Mandala with ± 0.87 km² (87 Ha) wide area. Tegal Sari II Mandala Urban Village consists of 15 (fifteen) environments.

**Figure 1.** Location of Tegal Sari II Mandala in Medan: (a) Location of Medan Denai district in Medan (b) location of Tegal Sari II Mandala in Medan Denai district
There are some facilities at Tegal Sari II Mandala Medan include schools, mosques, churches, kiosks or shops, markets, etc. In addition to that, Tegal Sari Mandala II Medan is also equipped with drainage channels, PLN and PDAM. However, for fire fighting equipment, there are no hydrants in the yard and fire posts around the housing area. Some public facilities such as schools, mosques, and churches can be used as evacuation sites for residents of housing to temporarily settle when fires happened or another natural disaster.

Figure 2. Layout of Tegal Sari Mandala II Medan

The condition of buildings in this area are various but the building elements are dominated by wood materials for doors, windows, roof truss, and some walls. This causes the spread of fire when fires occur more quickly because wood is a combustible material. Moreover, the houses in this area are close as the distance between buildings that are too small or one building to another is connected by goods or vegetation that can spread the fire. This environment does not seem to apply a passive fire

Figure 3. Housing Facilities: (a) Mosque (b) Primary School.
protection system in its construction. From calculations using Microsoft Excel, it is known the weight rating for the sub-variable components of the passive fire protection system consisting of buildings, environmental roads, water supply, and rescue facilities.

### Table 4. Weight Valuation of Each Component

| Component Fire Passive Protection Systems On Environment | Weight |
|--------------------------------------------------------|--------|
| Building 35.36%                                        |        |
| • Fire Resistant Construction                          | 0.33   |
| • Building Materials                                   | 0.33   |
| • Distance Between Buildings                           | 0.22   |
| • Fire Distribution                                    | 0.12   |
| Environment Road 23.52%                                |        |
| • Pavement Coat                                        | 0.35   |
| • Depth Of Pavement Coat                               | 0.24   |
| • The Outer Radius Of Entrance                         | 0.24   |
| • Obstacle Free Path                                   | 0.18   |
| Water Supply 23.52%                                    |        |
| • Outdoor Hydrant                                      | 0.50   |
| • Other Water Source                                   | 0.50   |
| Rescue Facility 17.60%                                 |        |
| • Evacuation Room                                      | 0.50   |
| • Accessibility of Residents                           | 0.30   |
| • Evacuation Barrier                                   | 0.20   |

The reliability of the passive fire protection system is done by multiplying the weights and reliability rating scale. Here are the results of the passive assessment reliability variable fire protection system in Tegal Sari II Mandala Medan.

### Table 5. Total Weight Valuation of Grade Component

| Component Fire Passive Protection Systems On Environment | Value | weight | Amount | Total |
|--------------------------------------------------------|-------|--------|--------|-------|
| Building 35.36%                                        |       |        |        |       |
| - Fire Resistant Construction                          | 2     | 0.33   | 0.66   | 2.12  |
| - Building Materials                                   | 2     | 0.33   | 0.66   |       |
| - Distance Between Buildings                           | 2     | 0.22   | 0.45   |       |
| - Fire Distribution                                    | 3     | 0.12   | 0.36   |       |
| Environment Road 23.52%                                |       |        |        |       |
The results of the sum of the weights and the variable reliability values are recalculated and multiplied by the variable weight percentages of the passive fire protection system.

**Table 6.** The value of the reliability of the passive fire protection system in the environment

| Component Fire Passive Protection Systems On Environment | Value | weight | Amount |
|---------------------------------------------------------|-------|--------|--------|
| Building                                                | 2.12  | 35.36% | 0.75   |
| Environment Road                                        | 2.90  | 23.52% | 0.47   |
| Water Supply                                            | 2.00  | 23.52% | 0.47   |
| Rescue Facility                                         | 2.30  | 17.60% | 0.40   |
| total                                                   | 2.10  |        |        |

4. Conclusions
The results of the evaluation carried out showed that the passive fire protection system for housing in Tegal Sari Mandala II Medan was incomplete and did not meet the standards under applicable theories and requirements. Repairing the fire protection system in housing is needed as an effort to prevent fires in the environment that can occur at any time.

The evaluation results using Microsoft Excel are 2.10 (bad), which means that the components of the passive fire protection system in Tegal Sari II Mandala Medan do not meet the standards and references of fire theory and the passive environmental protection system. The following details the results of the analysis of the components of the passive fire protection system for the environment in housing with a case study in Tegal Sari II Mandala Medan. First, the building variable gets a reliability value of 2.12 (bad). This is caused by components that do not meet the standards at the study site. Second, the Environmental road variable obtains a reliability value of 2.00 (bad). This is caused by components that do not meet the standards and theories of environmental fire protection passive systems. Third, the variable Water supply gets a reliability value of 2.00 (bad). This is caused by components that are not available at the study site. And finally, the rescue facility variable gets a reliability value of 2.30 (Fair). However, some components still do not meet the standards and theories of environmental fire protection passive systems.
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