Contingency planning for fire protection in built environment: Risk analysis in campus area

D Rahmawati1,2, A Pamungkas1,2, A M Navastara1,2, M Yusuf1,2, G A Rahadyan1,2 and K D Larasati1,2

1Urban and Regional Planning Department,
2Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia, 60111

Email: d_rahmawati@urplan.its.ac.id

Abstract. Urban and Regional Planning Department, Institut Teknologi Sepuluh Nopember has experienced small fire incident in Computer Laboratory, in the middle of 2015. This incident is caused by short circuiting and electricity used in high activities. In addition, the buildings have not yet equipped with evacuation paths strategies nor fire protection system. This article aims to describe the contingency plan formulation process of fire incident in campus building concerning the hazard, vulnerability, and risk level of fire. The method used is based on disaster risk management process, included identify the hazard, measure the vulnerability, analyse the risk level of fire, then analyse the assembly point and evacuation routes to formulate the contingency plan. The finding shows that the fire risk level is categorised into high, medium, and low fire risk. Then, based on scoring analysis, we found the best route to assembly point in the Northwest side of the building. The results are then combined with the stakeholders perception consists of Department’s managers, employees, head of the laboratory and students to formulate contingency plans as an improvement over a fire preparedness. Contingency plan consists of scenarios, policies and strategies according to the fire prevention sectors.

Keywords: fire incident, evacuation, contingency, campus building

1. Introduction

Institut Teknologi Sepuluh Nopember (ITS) campus building needs to be aware of fire hazard, based on fire incidents occurred at last 10 years. Bureau of Academic, Student Affairs, and Planning building as the center of ITS student’s archives burned down and caused material losses, particularly the important documents. In 2002, the fire incident even occurred in the copse area between Urban and Regional Planning and Geomatics Department buildings. Then, in 2012 the same incident happened in front of Faculty of Marine Technology buildings. In August 2015, the fire incident occurred in the area between Robotics and National Ship Design and Engineering Center (Nasdec) buildings caused by grass burning activity [1]. These incidents mostly caused by high temperatures and weather that worsen into rapidly spread fire.

In addition to temperature and weather factors, the fire incidents in Computer Laboratory in the 3rd floor, Urban and Regional Planning Department building in the middle of 2015 was caused by short circuiting. That incident was quickly handled so it holds down the fire hazard. Campus building is holding significant role in teaching and studying activities. The students often use the electrical terminal...
more than necessary or exceed the capacity. This habit of highly electricity used on campus ITS, particularly in Urban and Regional Planning Department building are potentially triggering fire hazard. In addition, the buildings are vertically type and have un-equipped with evacuation paths nor fire protection system. The existing fire protection is only fire extinguisher placed at several points of the building.

The risk of fire is in different level for each building rely on building material, assets, building users, and others. Considered by unpredictable fire incident and fire hazard without adequate fire protection system, contingency plan should be needed. This article is trying to describe the formulation of contingency plan in campus building based on the problem statement that a campus has many assets to be protected, the other hand the vulnerability is in high level.

![Image 1](https://example.com/image1)

**Figure 1.** Urban and Regional Planning Department Building. Source: [2]

### 2. Methods

The method used in formulating the contingency plan is based on disaster risk management process. The stages to formulate the contingency plan consist of identifying the building fire hazard, measuring the vulnerability and analysing the risk level of fire in campus building by overlay method using ArcGIS software. The risk level then confirmed to the users in campus building through Focus Group Discussions (FGD) among students, faculty members, and staff to get more information. Then we analyse the assembly point and evacuation routes using scoring method. This output is used to formulate a participative contingency plan.

Participatory Action Research (PAR) method is used to find the best solution for campus building’s contingency planning. PAR combined study and stakeholders empowerment as an approach to research in building users that emphasizes participation and action [3]. Based on the research by Pamungkas et. al., PAR is effectively method in building community capacity on urban fire risk management [4]. This method conclude several improvements on community such as community knowledge of hazard mapping and community awareness in fire risk incidents. Mentioned in Table 1 are the variables used.

| Indicator    | Variables                      |
|--------------|-------------------------------|
| Hazard       | Flammable goods               |
|              | Heat releasing goods          |
| Vulnerability| Valuable assets               |
|              | Users density                 |
|              | Users habit                   |
|              | Building height               |

### Table 1. The Variables Observed
| Indicator              | Variables                          |
|-----------------------|------------------------------------|
| Assembly Point        | Emergency facilities               |
|                       | Area capacity                       |
|                       | Distance to access assembly point   |
| Evacuation Path       | Route length                        |
|                       | Route width                         |
|                       | Time                                |
|                       | Road capacity                        |
| Contingency Plan      | Stakeholders role                   |
|                       | Resources                            |

Sources: [5] [6] [7] [8]

3. Results

3.1. Mapping of Fire Hazard in Campus Building
In hazard assessment, there are 2 influenced variables consist of flammable goods and heat releasing goods. We observe the distribution of them and classified each variable into several values (between number 1 until number 3) based on Health Safety & Environment Operational Procedure Standard (2016).

The output of hazard mapping, the building is valued as high and low hazard level.

1. High Potential Hazard Level
   The high hazard level is caused by flammable and heat released goods which are closely located. In 1st floor, it caused by unprotected power supply located in open spaces and less than 1 m² area surrounding electricity panel. In 2nd and 3rd floor, several power sources are over capacity used. High voltage cables are potentially peel caused by the rodents.

2. Low Hazard Level
   Having low hazard level means there are flammable and heat released goods which are unclosely located so that it doesn’t potentially caused fire.

3.2. Vulnerability Assessment
In terms of vulnerability, we calculate with three kinds of vulnerability that are social vulnerability with variables of users density and users habit, economic vulnerability includes variable valuable assets, and physical vulnerability has variables of building height and emergency facilities availability.

The output of vulnerability assessment is also valued as high and low vulnerability level.

1. High Potential Vulnerability Level
   The high vulnerability level is dominantly caused by social aspects. It was users habit in power sources using mostly in the classes of 1st floor and computer room in 3rd floor. In economic aspect, it caused by the distribution of valuable assets such as student’s theses, important archives, laptops and projectors mostly in 2nd floor. Short circuiting caused by mistaken use of electricity are also potentially vulnerable.

2. Low Vulnerability Level
   Low vulnerability level is area which generally far located from power sources and it has few valuable assets.

3.3. Building Fire Risk Assessment
A building fire risk mapping is an overlaying process among the assessment outputs on hazard, vulnerability and capacity. Furthermore, community capacity level is being judged from observation on community habit and emergency facilities availability in their building. For the capacity, most of the building areas are assumed in low level of capacity. Most of the users have limited adaptation to the fire incident.
3.4. **Determining the Assembly Points and Best Evacuation Routes**

In determining the assembly points of fire, it considered by several criteria such as:
1. Assembly point in public facilities and offices should provide 60 x 60 cm² spaces area with minimum height of 2 meters for each person;
2. It should be considered to the wind flow;
3. The maximum distance between building to assembly point should be 45 meters without sprinklers;
4. Calculated the minimum time travel to evacuate; and
5. It should be the accessible areas.

Based on criteria above, there are 2 properly areas for assembly point. It was open spaces in the north-west of Building A and green open spaces in the south of Building A. The two points are the nearest assembly point used by building users during self-evacuation while fire incidents.
Specifically for evacuation, we propose an evacuation routes after considering risk maps and route analysis. The effective routes was analysed based on several influenced variables consist of road capacity, route length, route width, and minimum time travel using scoring analysis. Figure 4 illustrates alternatives evacuation routes for each floor that are;

1. Route passing 1st, 2nd, and 3rd floor of Building A to Point 1
2. Route passing 1st, 2nd, and 3rd floor of Building B to Point 2

3.5. Contingency Planning
Contingency plan is a preparation plan for immediate response or determined the safety standard requirement to disaster. In contingency plan, we define the scenario of possible disaster; possible resources for immediate response; and actions plan for effective immediate response. Focus Group Discussion (FGD) is used to discuss those three key outputs. FGD can also build a commitment among stakeholders particularly in implementing the contingency plan. There are useful ways to formulate
contingency fire plan by integrate knowledge of stakeholders as building users, also the experience of the technical personnel competent in handling the fire [9].

For the fire scenario based on fire risk map and Minister of Labour Decree Number 186/MEN/1999 on Fire Response Unit, we defined 3 types of fire. There are small fire, middle fire group I, and middle fire group II [10]. These 3 scenarios was determined based on the fire incident scale as follows;

**Table 2. Fire Scenarios and Extinguishing Process Suggestion**

| No. | Scenario          | Fire Conditions                                                                 | Extinguishing Process                                                                 |
|-----|------------------|---------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| 1.  | Small-Scale Fire Incident | The burnt area was caused by low level flammable goods, so that the fire could be slowly spreading. | The building users can extinguish the fire without any assistant from fire brigade using water, fire extinguisher or cutting off the electric current (if the case is short circuiting). The extinguishing process may take about 5-10 minutes. |
| 2.  | Middle-Scale Fire Incident Group I | The burnt area could be less than 2.5 meters area (room-scale) | The building users can extinguish the fire without any assistant from fire brigade using water, fire extinguisher or cutting off the electric current (if the case is short circuiting). The evacuation process could be take place. The extinguishing process may take about 5-10 minutes. |
| 3.  | Middle-Scale Fire Incident Group II | The burnt area could be less than 4 meters area (building-scale) | The building users should evacuate their selves in which they need assistant from local fire brigade to extinguish the fire. The extinguishing process may take about more than 180 minutes. |

In terms of possible resources for immediate response, we have identified four main possible resources that are: open space, water supply, megaphone, and emergency facilities. The open spaces is useful to minimize the risk of fire spreading to surrounding building. The community can also use open spaces as an assembly point in emergency situation. Water supply is needed to extinguish the fire. The supply can be from fire trucks, water tank, underground water storage and drainage. There are 2 units of megaphone which are useful to spread the information on fire incidents. Other facilities relevant to safety standard requirement of fire risk are fire extinguisher and circuit breaker. The building should provide at least 1 unit fire extinguisher for each floor.

In the formulating of fire contingency plan we identify eight key groups of actors for emergency response, that are: fire brigade agency, police officers, campus security unit, department manager, equipment staff, administrative staff, security staff, and students. All the actors are then have their own roles in certain sector. We classify the actions into four sectors that are; sector of management and coordination; rescue and protection; health; and infrastructures, as follow:

**Table 3. Distribution Roles of Contingency Actors**

| Sector                  | Actor                          | Distribution Roles                                                                 |
|-------------------------|--------------------------------|-------------------------------------------------------------------------------------|
| Management and Coordination | Information Controller (administrative staff) | • Receive a call of fire incident report from the witness;  
|                          |                                | • Contact the Rescue and Protection sector to verify the report by ground check;  
|                          |                                | • Break the electric current flow if caused by a short circuiting;  
|                          |                                | • Contact the Campus Security Unit, Fire Brigade Agency and Police Officer for help when middle-scale fire incident group II was occured;  
|                          |                                | • Contact the nearest hospital if any injured. |
### Sector | Actor | Distribution Roles
--- | --- | ---
**Rescue and Protection** | Floor Manager (equipment staff) | • Report the accident to the Information Controller when seeing the fire;  
• Extinguish the fire when small-scale fire incident was occurred.  
Fire Fighter (security staff) | • Report the accident to the Information Controller when seeing the fire;  
• Guide the building users to exit through evacuation routes;  
• Calm down the panic situation at assembly point;  
• Guide the movement when the situation is completely safe.  
Support Team: Fire Brigade Agency | • Extinguish the fire when middle-scale fire incident group II was occurred.  
Support Team: Police Officers | • Ensure the safety when fire extinguishing process.  
Support Team: Campus Security Unit | • Help the Fire Brigade Agency in security processes and ensure the accessibility of fire trucks.  
**Health** | First Aid Team (equipment staff or students) | • Secure the victims;  
• Prepare the medicine and medical equipments;  
• Contact the Information Controller if transferring process to hospital is needed;  
• Take the victim to the medical centre or nearest hospital;  
• Distribute the masks.  
Support team (students) | • Help the First Aid Team in first aid processes.  
**Infrastructures** | Department Manager | • Plan and implement infrastructure procurement policies.  
Facilities Team Unit (equipment staff) | • Periodically control the emergency facilities;  
• Help the Rescue and Protection sector in rescue processes if needed.  

### 4. Conclusion
In making campus building’s contingency plan, fire risk analysis is the beginning step to provide safety standard requirement. Two ways communication such as FGD and interview can encourage the community to be involved in designing the contingency plan such as building fire risk mapping, evacuation plan, and resources identification up to making contingency plan. Therefore, the output of contingency plan (such as fire risk maps, evacuation plan, and contingency actors) is as important as the making process (analysis and FGD). Further, this building contingency planning can be applied in the ITS campus policy.

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