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EVALUATION OF NONCONFORMITY TO PEDESTRIAN SAFETY MEASURE IN IMMEDIATE AREA OF LRT CAWANG-DUKUH ATAS CONSTRUCTION SITE

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ABSTRACT

The practice of providing safe temporary facilities for pedestrians during the execution of infrastructure projects is still challenging due to project complexity and the management of existing traffic flow. The challenge of ensuring pedestrian safety also becomes a concern in Jakarta, Indonesia, which currently has many ongoing infrastructure projects. The execution of these projects along existing main roads demands contractors to close some road lanes including pedestrian accesses. The circumstance highlights the importance of investigating the current practice in providing safe temporary pedestrian access. This study aims to investigate the safety and comfort measure of pedestrian access adjacent to the construction site. Nonconformities to safety findings from the field later are used as a basis for expert interviews in order to acquire recommendations. This research took a case study of the Light Rail Transit (LRT) project with a section length of 3.6 km. Observations took place every 100 meters and all nonconformities to safety data were recorded. Findings showed that among the potential nonconformities to safety, only six of those factors occurred frequently which later became the basis of questionnaire development for semi-structured expert interviews. Three experts from different backgrounds were chosen. Content analysis was used to analyze the data. Field observation result shows that among the six factors of nonconformity to safety, the unavailability of the separator system between the pedestrian access and road lane becomes the most occurred factor. The research demonstrates that in order to provide safety for pedestrians, access should be prepared with a minimum width of 90-100 cm, durable and stable surface, as well as a barrier that ensures safety against traffic and construction work. This study recommends the practical considerations for pedestrian safety as well as policies in terms of contractor's organization and government in a broader perspective.

Keywords : Light rail transit; Nonconformity; Pedestrian; Project site; Safety

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1. INTRODUCTION

In recent years, the construction sector has become one of the most growing sectors in Indonesia. While the construction development accelerates, many construction projects still face safety issue. The Occupational Health and Safety (OHS) system in the Indonesian construction industry has not been well implemented. Although the government has issued regulation and guidelines on OHS system for public works, the negligence in its implementation are still underway. It needs to be highlighted that safety consideration is not only within the project site but also at the surrounding area.

Increased traffic and transport infrastructure are some challenges every city is dealing with (Zahra & Herlily, 2018). In a transport project, pedestrian safety may be considered during its execution. They have rights in traffic including the rights to access pedestrian facilities (Sari, Nahry, & Agah, 2015). However, safety issues related to pedestrian facilities are still below standard requirements. Lack of construction site barriers and lighting, the absence of traffic management, and the lack of access for pedestrians around the project can still be found in many construction projects in Indonesia (Caesario, 2015). While there has been a lot of research on OHS system for construction workers in Indonesia, the safety concerns towards pedestrians has not been studied previously.

Understanding the importance of OHS system implementation and its necessity for public in surrounding area of a project places a great important role for public safety. Indonesian Law number 29 year 2009 regarding Traffic and Road Transport stipulates that in managing traffic, prioritizing pedestrian safety and comfort becomes essential. Circular of Minister of Public Works and Public Housing number 02/SE/M/2018 stated that pedestrian in surrounding construction area is provided with temporary pedestrian facilities such as separation from conflicts with vehicles at the project site and with traffic. The facilities must be safe, secure, easily accessible, comfortable and as close as possible. When the implementation is not taken into consideration, accident can occur to a pedestrian who is by chance close to the project. Two accidents reportedly happened and afflicted pedestrians near an apartment construction project in South Jakarta. The first accident occurred when an iron bar hit a woman causing a broken rib. A similar accident from the same project has killed another passerby who walked around the perimeter (Pratama, 2018). This circumstance illustrates the vulnerability of pedestrian safety from the ongoing project activities in Indonesia.

One of the ongoing infrastructure projects in Jakarta is the Light Rail Transit (LRT) project. The project has seven corridors that connect main areas of Jakarta. Some of corridors have not been constructed while others are under construction. The section of Cawang to Dukuh Atas is the first phase of LRT development with a total length of 10.5 km. The project site is parallel with the main roads that connect east part of Jakarta with south and central parts. The limited area for project site between road and existing building triggers some problems. The requirement of space for the construction cause lessening of road lanes and eliminating of pedestrian paths. The ongoing construction project has some problems concerning pedestrian safety. As a busy corridor, pedestrian is affected by the project due to access limitation. Although in some parts of the project perimeters are provided with temporary pedestrian accesses, these accesses are still vulnerable to accident.

This research focuses on nonconformity to safety identification from the pedestrians' perspective. As one of the stakeholders of the project, pedestrians' point of view related to the project can affected the ongoing project activities. This study aims to identify potential

nonconformity issues related to safety. A case study of LRT Cawang-Dukuh Atas project with the section of 3.6 km is used to understand the potential nonconformity issues to pedestrian safety of ongoing construction activities.

2. PEDESTRIAN SAFETY

Research on the pedestrian safety and comfort using temporary facilities near ongoing project has never been studied in Indonesia. However, accidents and dangers are threatening pedestrians who pass the area around the project due to construction activities. The accidents can be in several terms such as crushed by construction materials, hit by construction equipment, fell into a hole in the vicinity, exposed to sharp objects as well as dust and noise pollution. The accidents are triggered due to several causes as tools or machines that are not calibrated accordingly, the signs are not installed properly, perimeter surface are not maintained regularly (Health and Safety Executive (HSE), 2009; Whitting Law, 2017).

Safety system for pedestrian around the ongoing project works becomes very important. Contractors must accommodate the need of safety not only for the workers within the project site but also for passerby on the outer perimeter of the project. Based on the Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways, there are several important requirements in providing temporary access for pedestrians around the construction projects (U.S. Department of Transportation: Federal Highway Administration, 2009), which are:

1. Impact on public facilities such as schools, bus stop, and others;
2. Impact on existing pedestrian flow;
3. Information needed for pedestrians, such as work areas and exit ways;
4. Pedestrian facilities, such as a pedestrian lane width, road surface, and the road margins;
5. Junctions, the placement of crosswalks, and additional signs;
6. Adequate diversion roads caused by the closure of the existing pedestrian access;
7. Adequate protection for pedestrians which separate project workspaces and road traffic, overhead protection, and others;
8. Continuous control for pedestrian access during construction project;
9. Temporary nighttime lighting;
10. Paths that support road users who have a disability; and
11. Access to housing, business areas, and others.

While these requirements become necessity to safety, the implementation of pedestrian safety systems around ongoing projects is not easily executed. In the case that the project site is in a heavy traffic area, some constraints occur due to (1) the need of additional barriers, (2) the initial project planning that inadvertently exclude pedestrian safety, (3) limited area of project, (4) the number of buildings, pedestrian and vehicles, (5) the flow of project vehicle that affects the speed of traffic, (6) the need to maintain the road operation, and (7) the increase of illegal pedestrian crossing (Bilton, 2012). Barrier is normally provided to separate the project site with the outer area. In the heavy traffic area, additional barrier is required as a separator between pedestrian access and vehicle lanes. Economically, the addition becomes a burden for the contractor who is not taken into account the necessity of pedestrian safety during initial project planning. Other consideration related to the traffic is the decreasing of main road lanes. The main road traffic is usually heavy and the number of lane reduction cause the increase in traffic density. The situation is becoming more complicated when

project vehicles enter or exit the road. The project vehicle movement needs to consider pedestrian safety. Other constraint faced as the project located in the dense area is establishment of site planning. Contractor needs to decide that the site has enough space for construction activities. On the other hand, the issues related to pedestrian safety and traffic density must be planned from the beginning so that obstacles during implementation can be avoided.

3. METHODS

This research adopts a qualitative case-based approach. It started with the development of a case study design to set objective and research plan. Later, procedure and protocol for data collection was determined. Two approach of data collection were applied i.e. field observations and semi-structured expert interviews. According to Leicht, Hunter, Saluja, and Messner (2010), observation is one of the oldest methods in scientific research. It is qualitative in nature. Field observation and recording are common techniques in traffic conflict studies (Lawalata & Agah, 2011). Field observation was conducted for eight days with some variation in time of the day. During observation, source of nonconformity that affect pedestrian safety were recorded. The observation became the basic of interview development. A pilot interview was undertaken to examine the developed questions. The validator was selected based on his expertise in the field of traffic safety. A total of 15 questions were validated which later used in the interview to three experts from different backgrounds, i.e. an academic, a practitioner at a mass transport infrastructure project, and a consultant from an organization that promotes the importance of pedestrian's safety.

Data from interviews were transcribed and analyzed using Content Analysis (CA). It is a method to analyze qualitative data in the form of written or symbolic material (Neuman, 2014). It is often used to analyze pictures or scripts by counting the frequency of codes or specified words to making inferences about the underlying meanings of sentences (Brown, Hansen-Brown, & Conte, 2011). Table 1 below illustrates the coding scheme for CA developed in this study.

Table 1. Coding Scheme of Interview Results

No	Categories	Conformity Issues	Examples of Statement
1	Separators	• Types of separators • Improper installations	"Not all separators made from Moveable Concrete Barrier (MBC), some parts used traffic cones. Hence, motorcycle can enter the access" (Respondent 3)
2	The width/space	• Inadequate width • Challenges in providing space	"It's not enough. The minimum width for pedestrian access should be raised from 45cm to 90cm if the function is only as people's access" (Respondent 1)
3	Damaged access	• Damaged access • Bases are not durable	"The bases (made of plywood) seems like a very emergency step conducted by the contractor" (Respondent 2)
4	Temporary fences	Improper fences	"Project fences must be clean, installed in upright position, straight, and sturdy (Respondent 3)
5	Materials and equipment	Materials & equipment found in the access	"Pedestrian access must be clean from any construction materials and equipment" (Respondent 2)
6	Motorized vehicle	Motorcyclists enter the pedestrian access	"Bollard installation is recommended even though it will increase the cost" (Respondent 1)
7	Covers	• Inadequate covers for piling work	"The current system is less effective because the cover was placed only at one side and will not be

No	Categories	Conformity Issues	Examples of Statement
		• Dust and noise pollutions	able to overcome the movement of dust by air" (Respondent 3)

4. RESULTS AND DISCUSSION

4.1. Results from Field Observations

Field observations were conducted for eight days. Some nonconformity issues that can be found around the temporary pedestrian access includes:

1. **Unavailability of separator between pedestrian access and road lanes**. Figure 1 (a) below illustrates the ineffective existing separator systems. Contractor provided cones as separator at a certain distance. However, there were some empty parts which are not protected which may lead to collision between the pedestrians and vehicles.
2. **Inadequate pedestrian access width**. Temporary pedestrian access on the perimeter of the project has improper width as shown in Figure 1 (b). Some location had enough space for two people to pass; but in most location, the access was only able to be passed by one person. According to Technical Planning of Pedestrian Facilities published by the Ministry of Public Works and Housing (2018), the minimum width of effective access is 75cm for a single pedestrian and 150cm for two or crossing pedestrians. Narrow access caused pedestrian to exit the access and enter the road lane when another came from the other direction.
3. **Improper access bases**. Contractor had provided flat surface floor on the pedestrian access. Mainly made of plywood, the floor is not resilient to weather and frequent pass of pedestrian. Other problem occurred was the disorganized placement of plywood that left some gaps in between as shown in Figure 1 (c).
4. **Instability of temporary fence**. Fences are used in the project site to increase security. While it is a necessity to protect the project from off-site features, fence is also built to protect the surrounding environment from the effects caused by construction activities. In order to meet its purpose, fence is built with certain requirement in term of scale and proportion. The LRT project was secured using aluminum sheet or MBC as the base with aluminum sheet on top of it as temporary fences. However, the fences installation in some part of the project perimeter was not executed accordingly (Figure 1 (d)); thus, the fences may cause harm to pedestrian who happened to be near the location.
5. **Damaged pedestrian access**. Damages to the main road and pedestrian access as part of the road are unavoidable when the project was executed. The movement of heavy equipment around the project and the rain water were the major reasons for the damage. In Figure 1 (e), holes were evident in the pedestrian access. The damaging access affected pedestrian flow when crossing upon it and may cause accident, particularly when the holes were filled with water during rainy season.
6. **Improper construction materials placement**. Construction materials were often found in the temporary pedestrian access. The material placement is not only narrower the width of pedestrian access but also causing accident when pedestrian stumble upon the material (Figure 1 (f)).
7. **Improper heavy equipment placement**. The limited space of the project site forces heavy equipment to be placed off-site in the pedestrian access. It is shown in Figure 1 (g), heavy equipment was parked in temporary pedestrian access causing the unavailability access for pedestrians.
8. **Inappropriate motorcyclists' behavior**. Pedestrian safety around LRT project site is not only exposed from construction activities and the access condition, it is also disrupted

from the vehicles, mainly motorcycles, in the main road. During the peak hour, motorcycles often took the lane that was intended for pedestrians. In some cases, motorcyclist used pedestrian access for stopping as shown in Figure 1 (h). Moreover, lack of motorcyclist traffic awareness caused some motorists to use pedestrian access from the opposite direction.

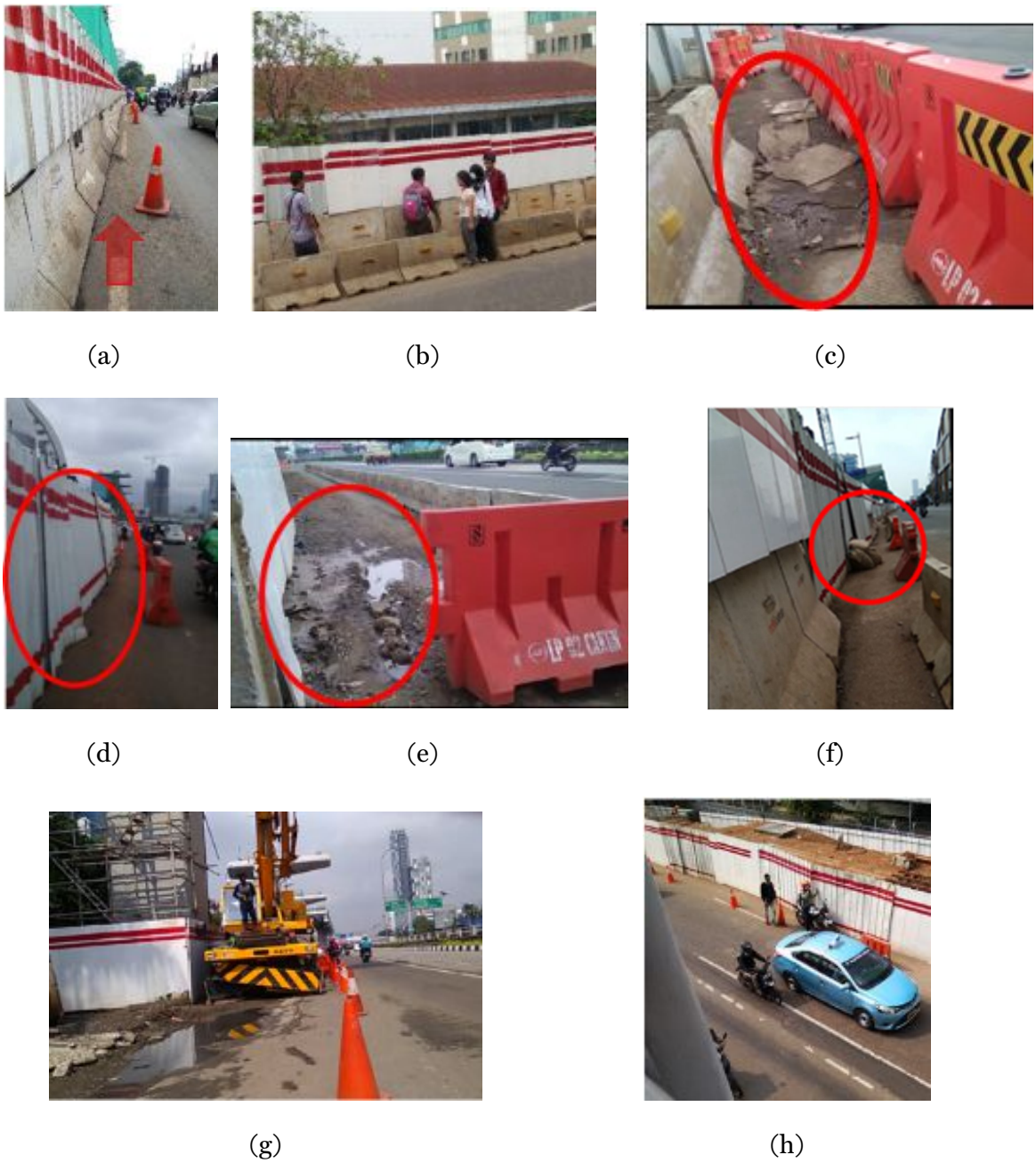

Figure 1. Hazard to Pedestrian Access due to Conformity to Safety

Potential nonconformity to safety that may occur in every 100 meters of pedestrian access can be seen in Table 2. As shown in the table, unavailability of separator between pedestrian access and road lanes becomes the most detected nonconformity to safety issue found along around 3.6 km of section observed. Field observation found that the length of the absence of separators was varied from 30 cm to 100 cm. Thus, some places are vulnerable for

pedestrians who pass through the access due to the unavailability of separator. The condition is worsened because the unavailability of separator triggers motorcyclists' misbehavior. Seven incidents were occurred causing pedestrians were exposed to accident. The motorcyclists usually entered the pedestrian access to avoid traffic congestion.

Table 2. Number of Nonconformity to Safety at the Observed Pedestrian Access

No	Nonconformity to Safety	Total Occurrences Along the 3.6 km Pedestrian Access (per 100m)
1	Unavailability of separator between pedestrian access and road lanes	35 events
2	Inadequate pedestrian access width	33 events
3	Improper access bases	9 events
4	Instability temporary fence	31 events
5	Damaged pedestrian access	18 events
6	Improper construction materials placement	4 events
7	Improper heavy equipment placement	4 events
8	Inappropriate motorcyclist's' behavior	7 events

The access is increasingly unsafe for pedestrians because its average width is only around 45 cm which only can accommodate one person. Vulnerability is even worse when pedestrians in opposite directions pass. One of them has to leave the access and enter the road lane. The access is not only unsafe because of its narrow width but also due to the damage on its surface. Several damages including holes and puddle were found in the area of observation with a total of 18 events. Some holes were covered with flat-surface material so pedestrians can safely pass the area. But the use of easily damaged materials causes new problems for pedestrians. There were nine related events where the utilization easily damaged materials caused less effective safety measure.

Meanwhile, the temporary fences that provided as pedestrians protection from the effects of the construction work were not installed properly. There were 31 events related to improper temporary fence installation. It becomes one of the most common nonconformity to safety found in the field observed. Among the nonconformity to safety issues found in the field, improper construction materials and heavy equipment placement have the least issue occurrence. Nonetheless, the occurrence of these nonconformities is unacceptable because pedestrian safety remains a priority in construction safety measures.

4.2. Results from Expert Interviews

Based on interview analysis, the findings are grouped and discussed in Table 3. Here, nonconformity to safety issues are narrowed down into seven sections and supported by findings from field observations. Furthermore, experts' opinions are summarized and presented in three aspects which consists of opinions related to safety factors, comfort factors, and recommendations.

4.3. Discussion and Recommendation

Six nonconformity safety issues are becoming the main concerns during the construction of infrastructure project in Jakarta. The availability of proper pedestrian access that ensures safety is lacking. Data exhibits that two major problems come from the provision of separator and the width of pedestrian access. The project is underway in a very limited area between

existing buildings and a heavy traffic road. The previously four-lane road was reduced into two-lane road with the almost the same daily traffic condition. The limitation is added by the need to provide pedestrian access. This condition triggers the contractor to reduce the width of pedestrian access. On the other hand, the absence of regulation, policy or standard related to specification and procedure for separator between pedestrian access and road lane has affected the contractor in performing its safety measure based on its judgement.

While the contractor provides some safety measures for pedestrian who passes by the project's perimeter, some consideration is needed to validate a process that maintains safety measure. The consideration becomes particularly important when the contractor handles a project in densely populated area with heavy traffic condition. Farooqui, Ahmed, and Azhar (2008) recommend considerations related to preparation and preplanning process of pedestrian safety including inspection of safety controls and monitoring as well as procedure evaluation for effectiveness. Inspection of safety measure is conducted in regularly basis to maintain its conformity to safety. At the same time, a competent worker is assigned to monitor the effectiveness of safety measure.

Based on the analysis from observation and experts' judgment, some considerations are required regarding pedestrian safety measure. Construction project located in urban area has its specific challenges. The challenges faced are even greater if the project is adjacent to the heavy traffic road so that consideration of pedestrian safety becomes priority. Additionally, the circular of the Minister of Public Works and Public Housing has stipulated the need for facilities for pedestrians that meet safety requirements. Pedestrian safety concern includes in the construction planning and executing process. It is started in contract development that includes article(s) that regulates the provision of pedestrian access and its safety measure. Contractor is required to provide Standard Operating Procedure (SOP) that set instructions in providing pedestrian access conformed to safety principles. The safety measures include:

1. The provision of a safe and convenient access with minimum width of 90-100 cm to allow walking handicap pedestrian benefits the access. The access base selection needs to meet durability and stability aspects.
2. The availability of separator between pedestrian access and road lanes. The separator can be provided by elevating pedestrian access above road lane or placing barriers made from a solid material.
3. The presence work zone safety signage and lamp as guidance for pedestrian and vehicle.
4. The provision of steady temporary fence that provides safety and prevent unauthorized movement into project site

Table 3. Interview Data Analysis Matrix

Safety Issue	Observations	Experts' Opinions		
		Safety Factors	Comfort Factors	Recommendations
Unavailability of separator between pedestrian access and road lanes	• The absence of separators on some places along pedestrian access • Types of separators used: MCB, plastic road	• The use of MCB is safer because the weight of material can resist the impact of vehicle collision rather than plastic barriers and road cones	The absence of separators in some places indicates that the contractor does not fully aware of the pedestrians' comfort due to their insecurity about their safety	1. Contract include clause(s) related to SOPs for pedestrians' safety 2. Elevated pedestrian access is constructed using concrete hence separator installment becomes optional 3. Plastic barrier is reinforced with sand

Safety Issue	Observations	Experts' Opinions		
		Safety Factors	Comfort Factors	Recommendations
	barriers, and traffic cones	• Plastic barriers can be used but require reinforcement using water or sand • Barriers need to be placed continuously to provide safety for pedestrians		or water to achieve sturdiness 4. Contractor provides: • Handrails where the separators cannot be installed • Rotary lamps as guidance for pedestrian and vehicle at night time 5. In the case that contractor has only traffic cones as separator, police line is mandatory to determine a boundary between the pedestrian access and road lane
Inadequate pedestrian access width	The average of access width is approximately around 45 cm or less	Narrow space with the capacity to accommodate only one person may cause pedestrian leaving the access when passing others. Accidents potentially occur to pedestrian who leaves the access and enters road lane.	The minimum pedestrian access width is 120 cm. Narrower access width causes inconvenience for pedestrian.	1. The minimum width of pedestrian access is standardized to 90-100 cm, thus pedestrian with wheel chair can benefit the access 2. Project signs and charts are installed to provide information regarding the ongoing project and its impact to the pedestrian 3. Preliminary surveys should be performed before project execution to estimate to pedestrian access requirement
Damaged pedestrian access	• Several damages including holes and puddle were found on some parts of pedestrian access • Some holes were covered with unstable flat-surface material	Holes can cause pedestrians to fall	Damaged access can cause discomfort and decelerate pedestrian's pace	1. Damaged along pedestrian access is repaired according to safety standard 2. Base material is selected in regards to its durability and stability

Safety Issue	Observations	Experts' Opinions		
		Safety Factors	Comfort Factors	Recommendations
Instability temporary fence	• Unstable temporary fence was entirely built from aluminum sheet • Temporary aluminum sheet fence supported by MBC were improperly installed	The improper installation of aluminum sheet as temporary fence can lead to collapse that injures pedestrians	The improper installation causes inconvenience for pedestrian due to fear of falling fences	1. Contractor needs to develop standard and procedure in order to control the installation of temporary fence 2. For utilization of light material as temporary fence, ballast becomes necessary to provide stability
Improper construction materials and heavy equipment placement	Construction materials, waste materials, and equipment were placed in pedestrian access	Given limitation of the access width, the existence of materials and equipment on pedestrian access risks pedestrian safety particularly during nighttime	The smaller the width of access results in inconvenience for pedestrians	1. Materials and equipment should be placed inside the project site 2. Information or worker with safety information attribute is available to guide pedestrian when material and equipment are in the process to enter the project site 3. A parking space for heavy equipment is provided outside the project site to avoid obstructing pedestrian access
Inappropriate motorcyclists' behavior	Where separators are unavailable, some part of pedestrian access is occupied by motorcycle to park or to avoid congestion	Pedestrians is exposed to danger in the circumstance of motorcycle entering the access	The presence of motorcycle in pedestrian access causes inconvenience.	Some mitigation alternatives are available to prevent motorcycle entering pedestrian access, i.e. continuous separators and elevated access

In a broader perspective, government needs to understand the fundamental of construction safety is not only for within construction site but also the immediate area of the site. Accidents in project construction may involve construction workers and people around the site. Regulation, policy and standard for safety of workers have been affirmed earlier. Nonetheless, the awareness of pedestrian safety needs to be raised by implementing safety conformity regulation for immediate area of a project site especially project in urban area. On the other hand, pedestrians should also be aware of any project activities.

5. CONCLUSIONS AND FUTURE WORK

This paper presents the current practices in providing temporary pedestrian access in immediate area of project site. The findings show that the current practices need to be improved to ensure pedestrians' safety and comfort. Based on the field observation, there are six types of nonconformity to safety found in the temporary pedestrian access along the infrastructure project. The major nonconformity to safety is the provision of separator and the width of pedestrian access.

In addition, this research provided two factors that affect pedestrians in the temporary access, namely safety factors and comfort factors. The nonconformity factors generate insecurity of pedestrian regarding their safety and comfort while passing the access. Pedestrian concern about their safety related to the potential of accident is not only from the project and the insufficient access but also the motorcycle entering the access.

Field observation shows the actual current practices of temporary pedestrian access. The identification of potential nonconformity to safety factors from field observations is crucial to grasp a better understanding of the matter. Expert interviews confirmed the nonconformity to safety factors on the project site. The analysis result delivers recommendations for both contractor and government to provide better practices in the future. Regulation focusing on pedestrian safety in immediate area of construction project corroborate with related standard can minimize the likelihood of accident to passerby. Certain specifications of pedestrian access as the width and material; separator; of signage and lamp; as well as of temporary fence are required to be taken into account in the policy.

Further studies can be done to identify better solutions to provide temporary pedestrian access as a result of ongoing project execution. This study explains the essential of temporary pedestrian in Cawang-Dukuh Atas LRT Project; however, in order to understand pedestrian safety measure in immediate area of construction site in broader perspective, a more thorough research can be conducted to recognize the real problem an offer solution to pedestrian safety. An integrated model to provide appropriate temporary pedestrian access can be developed based on this study. Future work may also include an in-depth cross analysis from both qualitative and quantitative data sources. A quantitative survey towards pedestrians passing these temporary facilities can be carried out to confirm the findings from this study.

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