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Design Factors and Criteria for Building a Non-Level Pedestrian Crossing at an Urban Campus

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Abstract.
Bandung Islamic University (UNISBA) is in a densely populated urban area of Bandung. UNISBA lecture and administrative buildings are scattered in several locations. In architecture typo-morphology terms, a campus building with this environmental setting is often referred to as an urban campus. The high traffic flow on these roads, together with the intense conflict between road crossers, often results in congestion due to vehicle deceleration needed to allow pedestrian crossing. To facilitate the need for the movement for the users of the UNISBA campus buildings and minimize conflicts with road users, infrastructure that connects the UNISBA campus buildings is needed to facilitate pedestrian crossing. The pedestrian crossing could be in the form of a level crossing in the same elevation as the road or a non-level crossing situated above or under the road. The type of pedestrian crossing studied in this paper is a non-level pedestrian crossing in the form of a pedestrian bridge. In designing the infrastructure for non-level crossings, it is necessary to pay attention to the movement patterns that occur and the factors that influence willingness to use. This study aims to determine the movement pattern of UNISBA campus facility users consisting of students, lecturers, educational staff, and visitors by using quantitative origin-destination spatial analysis. Descriptive exploratory factor analysis was also used to determine the preferences of the users of the UNISBA campus buildings to use non-level crossings. The results of this analysis will be the basis for designing non-level accessibility between UNISBA campus buildings.

Keywords: pedestrian crossing, pedestrian bridge, urban campus, urban design, urban mobiity

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1. INTRODUCTION

Bandung Islamic University (UNISBA) located mainly in Jl. Tamansari No. 1, Bandung on an area of 1 ha in the heart of Bandung city urban area. Along with the increasing number of students and study programs opened, several buildings around Jl. Tamansari,

such as Jl. Ranggagading, Jl. Ranggamalela, and Jl. Purnawarman was built to meet the needs of UNISBA academic and administrative activities.

The typology of campus buildings with the context of high-density urban locations such as UNISBA in architecture is often referred to as an urban campus [1]. The main issues that are often faced in an urban campus are limited land and the negative impacts caused by its existence such as traffic jams. As an urban campus, UNISBA cannot be separated from these problems. In carrying out their daily activities, students, lecturers, education staff and visitors often must cross the busy streets that separate the UNISBA campus buildings. The high traffic flow on these roads, together with the intense conflicts between road crossers, often results in long congestion due to slowing vehicles to giving way for road crossers (Figure 1). The congestion is exacerbated by the presence of vehicles parked on the road and the presence of traders around the campus. Congestion due to the slowing of vehicles, which provides opportunities for road pedestrians, occurs at certain times, especially at the end of class hours.

To facilitate the need for the movement of users of the UNISBA campus buildings and minimize conflicts with road users, infrastructure is needed in the form of non-level crossing routes, either in the form of a pedestrian bridge

or an underpass that connects the UNISBA campus buildings. In designing the infrastructure for non-level crossing, it is necessary to pay attention to the movement patterns that occur as well as the factors that influence the willingness to use the non-level pedestrian crossing.

Figure 1: Road crossers and traffic jam caused by it in UNISBA campus Jl. Tamansari.

2. METHODOLOGY

2.1. State of the Art

The existence of campus is an interaction of the two existential needs of the university, the need to be isolated from the crowd, and the need to be integrated with community

life [1]. The choice of campus location with consideration of these two needs gave birth to two main characteristics of the campus physical form, namely the “ivory tower” type and the urban campus [1]. “Ivory tower” campuses are generally characterized by wide building distances, wide entrances, and an extensive road network within them. Meanwhile, urban campuses generally have a close distance between buildings and pedestrian access between buildings and blend with the context of the surrounding environment in terms of height and building front boundaries. Examples of “ivory tower” campuses in Indonesia are generally located on the outskirts of cities such as the Jatinangor, Sumedang, University of Indonesia, Depok, Hasanudin University, Makassar, and others. While examples of urban campuses are generally located in densely urban areas such as the Unisba, Tarumanegara University, Bina Nusantara University, Jakarta, and others. However, several campuses characterized by ”ivory tower” are also found in densely populated urban areas due to the urbanization process in areas that were originally suburbs such as those at the Bandung Institute of Technology and Padjadjaran University, Dipati Ukur, Bandung.

Because of the limited land, an urban campus must make a trade-off between the provision of educational facilities (classrooms, laboratories, libraries, etc.) and supporting facilities (parking, open spaces, places of worship, etc.) [2]. The problem of mobility in the urban campus environment is a concern in several research topics. It is realized that the use of private vehicles must be provided with disincentives on urban campuses due to limited land owned. On the other hand, it is necessary to support non-motorized movements (pedestrians and bicycles) to create sustainable urban mobility. Riggs highlights the problem of limited land on the urban campus and its relation to the provision of parking lots and policies that can be implemented to encourage the use of public transportation [2].

The design of the pedestrian facilities within the urban campus is crucial in creating a system of the sustainable movement. Aspects of landscape design and the response to the local climate from planning pedestrian and cycling facilities in the campus environment are important things to consider in creating a humane environment [3]. Meanwhile, the use of spaces on campus in accordance with the cultural interaction of the local community is a concern in creating social sustainability for the urban campus [4].

There are several principles in designing a pedestrian-friendly environment known as the “five C principles” [5], namely:

1. *Connections*: The route is connected to the destination.

2. *Convenience*: Ease of using the means.
3. *Convivial*: Attractive, encourage people to use them.
4. *Comfortable*: Comfortable to use according to applicable standards
5. *Conspicuousness*: Clarity of information systems and directions

Several studies have taken a more user-based experience approach in planning pedestrian facilities [6-8]. Pedestrian crossing typologies can be categorized into: (1) non-level (footbridges and underpass); and (2) at-level (pedestrian crossing with/without signalling). On at-level pedestrian crossing design, a safety consideration of pedestrian could be in the form of Raised Pedestrian Crossing (RPC) which serves as a pedestrian crossing and traffic calming [7]. However, this design should be taking into consideration of emergency vehicles and bus movement requirements [7]. In contrast to Cadena [3] and Agrawal [7] found that routes and shortest distances and safe crossings were the main concern of pedestrians, while aesthetic aspects and visual attractions in the surrounding environment were considered not critical factors. In the context of unmarked road pedestrian crossing, the shortest route itself is influenced by conflict-avoidance movement with passing vehicles and stop-and-go motions that resulted in a slightly inclined trajectory of the crossing route [8]. Research that identifies movement patterns and preferences of pedestrians in an urban campus environment as a design foundation has never been done before.

2.2. Approach

The approach used in this research is a quantitative approach to determine the movement patterns of users of UNISBA campus facilities by using origin-destination analysis which is translated spatially (Figure 2). The movement patterns analysed were grouped based on the type of user (students, lecturers, staff, visitors), and the day of the lecture in one week. To determine the design criteria, a literature study was conducted by an exploratory descriptive factor analysis approach. Exploratory factor analysis is not carried out with theoretical hypotheses so that the grouping conclusions on the factors will be made based on what will be obtained in the analysis. The research variables are aspects that need to be considered in the design of a non-level crossing which includes connectivity, accessibility, security, comfort, and attraction. The other analysis technique used in this research is the statistical analysis technique which includes factor analysis and origin-destination analysis. Origin-destination survey is a way to study travel patterns by knowing the origin and destination of trips. In this study, the survey results

will be translated spatially. Data analysis will be grouped based on the travel frequency and perceived barrier of movement patterns.

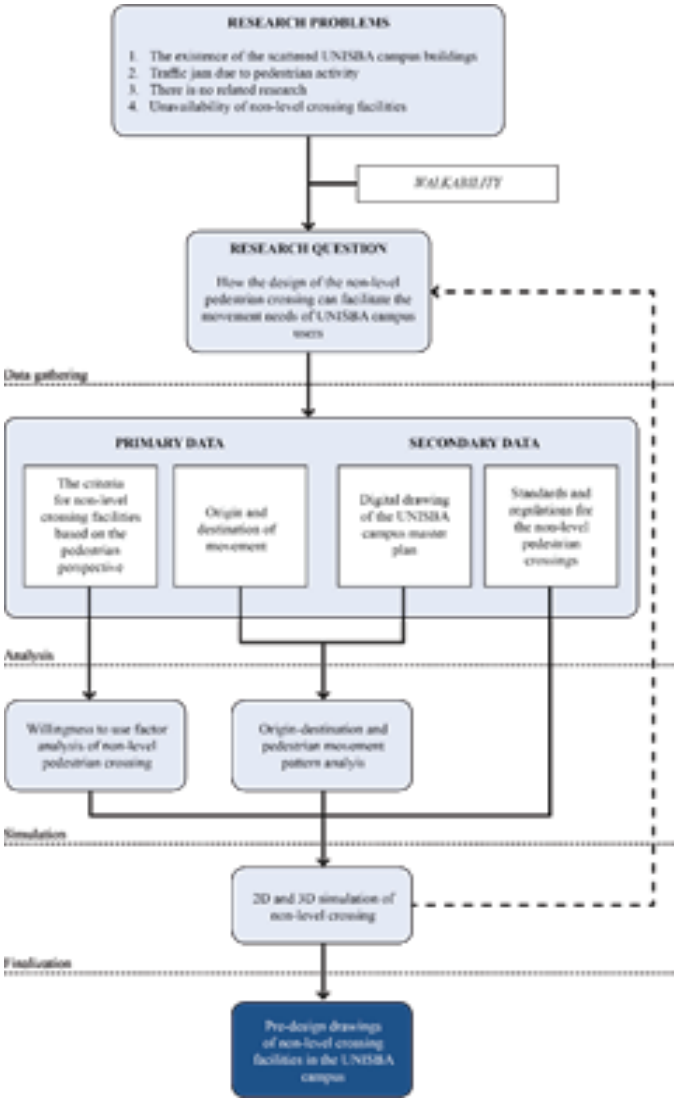

Figure 2: Theoretical framework of the research.

3. RESULTS AND DISCUSSION

3.1. Normative criteria

In conducting a literature review on normative criteria, content analysis was carried out from scientific journal articles and scientific books that discuss pedestrian facility design and urban design in general (table 1). Several normative criteria are also contained in standards and regulations which contain technical provisions for non-level pedestrian

crossing facilities. Some technical regulations categorizing non-level pedestrian crossing as pedestrian bridge and pedestrian tunnel. The results of the literature review are classified according to the pedestrian-friendly environmental design principles known as the “five C principles”[5] with the addition of one criterion, namely *safety*.

Table 1: Normative criteria of non-level pedestrian crossing.

Design Factors	Llewelyn-Davies [5]	Agrawal [7]	Cadena [3]	PUPR 2018
Connections	Route that connected to destination	Shortest route and distance		
Convenience	Ease of use			Crossings that are not level must be easily accessible by persons with disabilities, for example by adding ramps or by elevator
Convivial	Attractive means, attracting people to use it	The aesthetic and visual aspects are not a critical factor	Landscape design	Pedestrian bridge locations and structures should suit pedestrian needs and aesthetics
Comfortable	Comfortable to use according to applicable standards		Response to the climate	The pedestrian tunnel should consider the facilities of the airflow system as needed
Conspicuousness	Clarity of information systems and directions			
Safety		Safe crossing		The pedestrian tunnel should be constructed of strong construction and easy to maintain. Tunnels must be equipped with adequate lighting. Pedestrian bridges must be equipped with adequate fences.

3.2. Origin-Destination Patterns

The questionnaire was distributed to 100 respondents in the September 2020 period who were part of the Academic Community. The questionnaire was distributed through the Google Form application because, at the moment, there were no campus activities due to the COVID-19 situation. Based on the graph below, 41% of respondents stated that they often travel between buildings in the UNISBA area, 34% stated quite often, 17% stated that they were very frequent, and 8% stated that they rarely travel between buildings in the UNISBA area (Figure 3). About 45% of

respondents stated that the weather was an obstacle when traveling between buildings. Especially during heavy rains which require respondents to wait for the rain to stop a little to continue their journey. 34% answered that security is an obstacle to traveling between buildings, especially respondents who have to crossroads that are prone to accidents when crossing or road crimes. 12% said the ineffective route was a barrier. The route was taken by the respondent to get from one building to another sometimes had to go through a winding route and climb upstairs, causing it to take longer. The remaining 9% stated that route quality is a barrier to travel. Especially when users must pass through a pedestrian path that is already in a damaged condition.

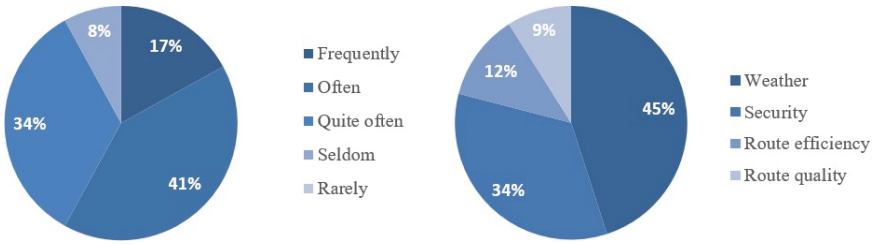

Figure 3: Inter-building travel frequency according to respondents (left) and perceived travel barriers according to respondents (right)..

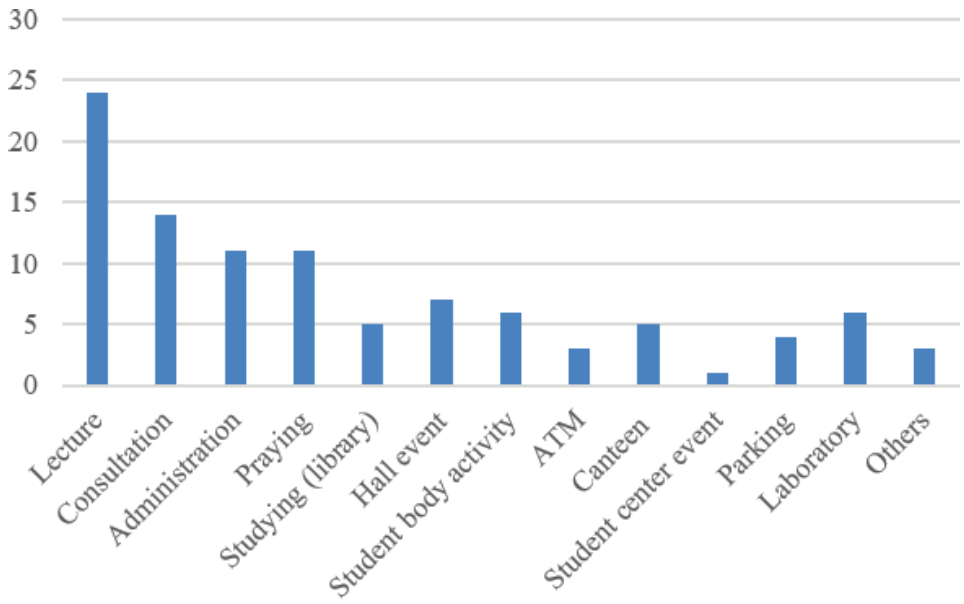

Figure 4: Purpose of inter-building travel according to respondents.

Based on the Figure 4, the purpose of the most frequent trips is to carry out lectures, consultation, administrative matters, and praying. The rest are for conditional activities carried out in the hall, student centre, library, ATM, canteen, laboratory, and the parking

No.	Pedestrian Node Points	Origin And Destination Movement
١.	 Legends: Tamansari ١ Buildings Dean's Building Faculty of Medicine Rectorate Building LPPM Building Faculty of Postgraduate Node ١ condition: 	Switching modes of transportation from motorized vehicles to walking, either starting or ending, to and from the Taman Sari ١ area. Academic members of the rectorate building, post-graduate building, and medical building which have the purpose of travel are related to the functions in the Taman Sari ١ area. For example: go to the mosque or ATM. Academic from the Taman Sari ١ area head to the Minimarket and Bank across the street, and vice versa. This node requires pedestrians to cross Jalan Taman Sari. The characteristic of this secondary local road is a two-way asphalt pavement with a width of ٩+ meters. At this node, the volume of pedestrian movement is very high and traffic jams often occur during peak hours.
٢.	 Legends: Tamansari ١ Buildings Dean's Building Faculty of Medicine Rectorate Building LPPM Building Faculty of Postgraduate	Switching modes of transportation from motorized vehicles to walking, either starting or ending, to and from the Taman Sari ١ area cut through the parking area. The academic community of the rectorate, postgraduate, and faculty of medicine with travelling purpose related to Taman Sari ١. Academic members from the Taman Sari ١ area go to the Rectorate Building and vice versa. The academic community from the Taman Sari ١ area headed to the Faculty of Medicine or vice versa. Academic members from the Taman Sari ١ area go to Postgraduate and vice versa. Academic members from the Taman Sari ١ area go to the LPPM Building or vice versa.

Figure 5: Characteristics of origin and destination movement at several node points.

lot. The characteristics of the origin of the pedestrian movement at each node are described in the following table 2.

4. CONCLUSION

The comparisons between normative criteria and origin-destination patterns relatively in-line. In terms of connections, users demand that non-level pedestrian crossing to connect the movement nodes that frequently passed- by in the Unisba campus area. Meanwhile, in the comfort factor, users translating it into protection from the weather since there is a lack of covered walkways in the Unisba campus area. Safety factors gave significant attention to users because of the urban setting. Lastly, the quality of the route is mentioned as equal to the convivial factor. Users want a non-level pedestrian

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Figure 6: Continued.

crossing that has a representative design on the Unisba image. This research will be followed- up into the formulation of the design concept, principal, and simulations.

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Figure 7: Continued.

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