

Pedestrian Safety Design in Bandung Institute of Technology (ITB)

Reni Fatimatuz ZAHRO^a, Harun alRasyid Sora LUBIS^b, Rudy Hermawan KARSAMAN^c

^a *Research Assistant of Institut Teknologi Bandung, Bandung, 40132, Indonesia*

^{b,c} *Lecturer of Civil Engineering, Institut Teknologi Bandung, Bandung, 40132, Indonesia*

^a *E-mail: reni.zahro@gmail.com*

^b *E-mail: halubis@si.itb.ac.id*

^c *E-mail: ruherkar@yahoo.com*

Abstract: Bandung Institute of Technology (ITB) which located in Bandung, Indonesia, covers an area of 186,830 m² and has 20,901 students. Many pedestrians and motorists share a common space of roadway, the conflict of which may harm the pedestrians while traversing the roadway, while the existing dedicated pathways are rarely used. The consequences of this problem are frequent conflict between pedestrians and vehicle users are observed in this area. There are several zones in ITB which has no adequate facility for pedestrians, so they prefer not to use the available facility such as zebra cross and pedestrian pathway or breezeways. The behavior and perception of pedestrians were observed to provide suitable design of pedestrian facilities and signs. The result of this research is a design of road furniture that can improve pedestrian safety and provide better amenities for the road users in ITB campus.

Keywords: Pedestrian safety; pedestrian facility.

1. INTRODUCTION

Road safety has become a global problem. According to WHO report, in 2010 reached 1.24 million deaths and more than 30 million injuries worldwide caused by traffic accidents occur every year. The highest number of accident achieved on rider motorized, followed by driver/passenger bus, and then pedestrian. The most serious problem faced by pedestrians in Indonesia is the lack of pedestrian facilities. The development of pedestrian facilities in Indonesia is not become a priority yet, compared to motorized vehicle facilities.

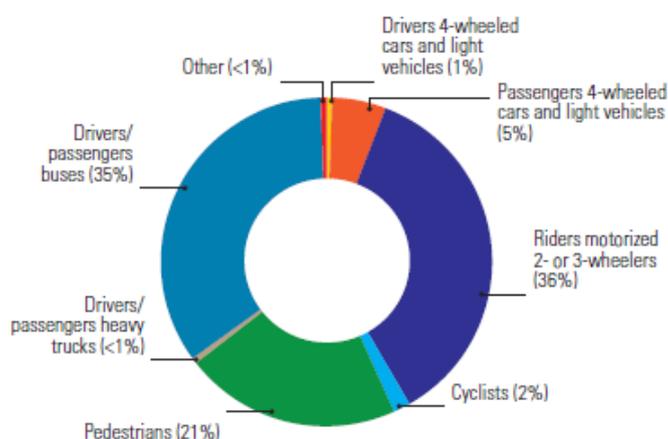


Figure 1. Death by Road User Category in Indonesia
Source: WHO, *Global status report on road safety, 2013*

Bandung Institute of Technology (ITB) which has 20,901 students is an area with the high rate of road users. Either pedestrians or vehicle users' movement is presented in the

campus area. Based on observation, there are several zones in ITB which has no adequate facility for pedestrians such as sign and crossing mark. Besides, pedestrians prefer not to use the available facility that has been design for them. It caused by inadequate pedestrian facilities such as damaged pathway and the lack of mark and sign. The consequence of that problem is the safety level of pedestrians become a little bit lower.

Based on those conditions, it is necessary to study the level of pedestrian safety in ITB. By this study, it is expected to provide recommendations about the improvement and installation for pedestrian facilities in the campus area.

However, the problems that must be solved in this study are follows:

1. Identifying the conflict that may happen between pedestrians and vehicle users;
2. Minimizing the conflict that may happen in the campus area;
3. Designing segregation movement in the campus area;
4. Designing convenient pedestrian facilities in the campus area.

2. LITERATURE REVIEW

2.1 Pedestrian Safety

According to NGO Pelangi transport researcher, Soejachmoen (2004) in Sinar Harapan, the first step must be done to achieve a good road safety is by applying the hierarchy of the road. Those hierarchy consists of: (a) pedestrian, (b) non-motorized vehicle user, (c) public transport, and (d) privately owned motorized vehicle.

Based on hierarchy that written above, pedestrian is the road users' that has to be the main priority. Moreover, pedestrian is the only road user who doesn't wear any protective equipment to protect them from the injury that may happen to them.

2.2 Pedestrian Facilities

According to the Guideline of Urban Pedestrian, formal pedestrian facilities consist of:

1. Pedestrian lane
 - a. Sidewalk
 - b. Cross walk:
 - Crossing pedestrian bridge
 - Zebra cross
 - Pelican cross
 - Tunnel
 - c. Non-sidewalk
2. Compliments of pedestrian lane
 - a. Sign
 - b. Mark
 - c. Traffic light
 - d. Compliment facilities.

According to Indonesian Department of Transportation, pedestrian facility planning has to consider:

- a. Continuity. Pedestrian facility should be continuous, direct, and straight to the destination place.
- b. Safe and security. Pedestrian should feel safe and secure during their walk, either on their own path (sidewalk) or on the shared-use path.

- c. Comfort. The surface of pedestrian facilities should be flat, dry, and not slippery when it rains, wide enough. If necessary, it can be given a comfortable ladder.
- d. Pedestrian facilities have to be identified/noticed easily and quickly by pedestrian.

To make a proper design pedestrian facilities, there are some data that should be collected according to Guideline of Urban Pedestrian:

- 1. Vehicle volume
- 2. Pedestrian volume
- 3. Crossing pedestrian volume
- 4. Geometric data

Moreover, the procedure to make a proper crossing facilities can are:

- 1. Calculate the volume of crossing pedestrian (P)
- 2. Calculate the vehicle volume (V)
- 3. Calculate PV^2
- 4. Determine the width of path way
- 5. Determine the proper crossing facilities according to table below

Table 1. Crossing Facilities According to PV^2

PV^2	P	V	Recommendation
$>10^8$	50-1100	300-500	Zebra Cross
$>2 \times 10^8$	50-1100	400-750	Zebra Cross with waiting lane
$>10^8$	50-1100	>500	Pelican
$>10^8$	>1100	>300	Pelican
$>2 \times 10^8$	50-1100	>750	Pelican with waiting lane
$>2 \times 10^8$	>1100	>400	Pelican with waiting lane

Source: *Guideline of Urban Pedestrian*

2.3 Existing Condition in ITB

Pedestrian path (walk path) in ITB designed on the west and east part. Unfortunately this walk path does not reach all the area in ITB, such as library, PAU, School of Business and Management, mathematic, and industrial engineering building. So when it rains, students will be stuck on that building and not be able to move to another building easily. Besides, there's no sign or marking path that can direct pedestrians to stay on their path.

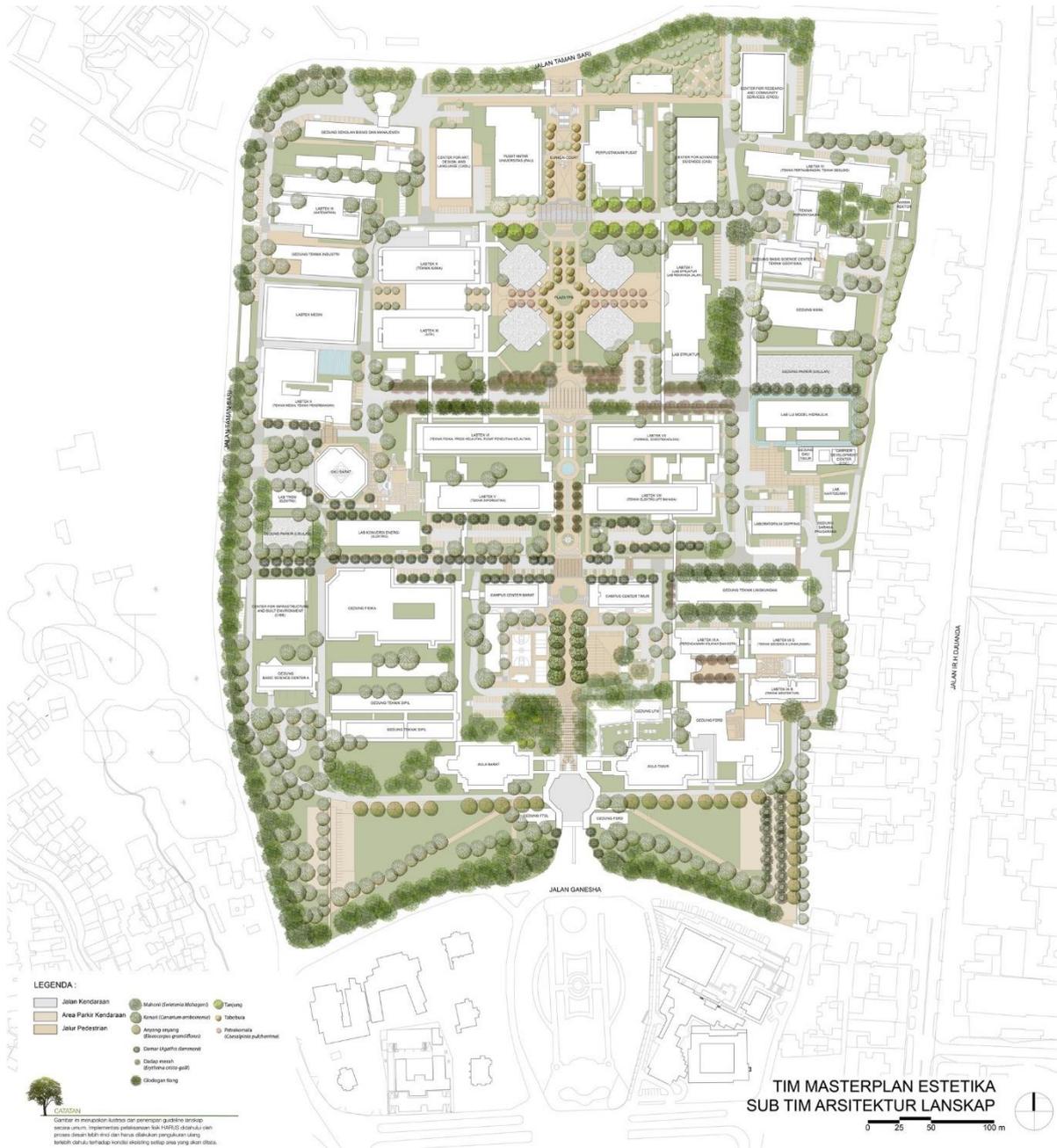


Figure 2. Bandung Institute of Technology (ITB) Map
 Source: Illustrative Landscape Masterplan of ITB

Generally, the condition of sidewalks in ITB is good enough. But there's some area that still not fulfills the Guideline of Urban Pedestrian. According to the guidance, minimum width of sidewalk should be 1.5 meter, but there's only 75 centimeter at the location. Besides, there are some damages on the sidewalk surface. Detail of this condition can be seen on pictures below:



Figure 3. Example of Sidewalk Condition: inadequate walk path width
Source: researcher documentation

According to the observation, ITB already had difable facilities for pedestrian in ITB, but it's not integrated yet. The difable facilities are installed in some location only, not covered all walk path in ITB.



Figure 4. Example of Sidewalk Condition: inadequate difable facilities
Source: researcher documentation



Figure 5. Example of Sidewalk Condition: adequate difable facilities
Source: researcher documentation

2.4 Role Model

PGN headquarter office located in KH. Zaenal Arifirin Street No. 20 Central Jakarta, is used as a role model for design pedestrian facilities in ITB. This office has clear and adequate mark and sign to direct road users' at their lane. Besides, there are safety officers who will supervise all of the road users' to obey the rule and using the path they belong into.

Here's some of mark and sign around PGN headquarter office:



Figure 6. Pedestrian Sign
Source: researcher documentation



Figure 7. Mark on Walk Path
Source: researcher documentation



Figure 8. Mark on Crossing Point
Source: researcher documentation

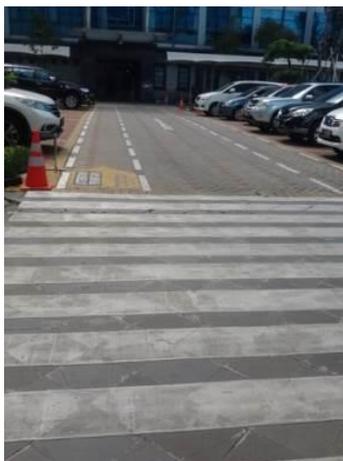


Figure 9. Pedestrian Walk Path and Zebra Cross
Source: researcher documentation

3. METHODOLOGY

This research uses descriptive quantitative method. Descriptive method is used for describing pedestrian behavior in ITB and their awareness of their safety during walking in campus area. While quantitative method can be used in processing data from traffic counting.

3.1 Site Research

The research took place at ITB campus. Site research to take traffic counting data is divided into three zones that are picked up based on the potential conflict that may happen between pedestrians and vehicle user. Based on observation, the three zones are widely travelled by pedestrians and vehicle user but there are no crossing facilities for pedestrians yet. Traffic counting data took three hours during peak hour; 07.00 am to 08.30 am and 04.30 pm to 6.00 pm. Detail of traffic counting site research can be seen at the appendix.

3.2 Interview

To know pedestrians behavior in ITB, it is needed doing an interview with students in ITB. This interview is conducted two weeks in May 2014. The entire question were consist of three parts. The first part to obtain information about pedestrian behavior and awareness of their safety, second part to gather pedestrian opinion about the existing condition of pedestrian facilities, and the third part is to determine which aspect that should be improved so they will obey pedestrian rule.

For each question in the first part respondents were required to indicate on a scale ranging from 0= never to 3=always about the frequency of using pedestrian facilities, such as breezeway and crossing facility.

3.3 Sample

The minimum number of sample calculated with Slovin's formula:

$$n = \frac{N}{1+Ne^2} \quad (1)$$

while:

- n : sample amount
- N : population amount
- e : error tolerance

$$n = \frac{N}{1 + Ne^2}$$

$$= \frac{20,901}{1 + (20,901 \times 0.05^2)}$$

$$= 392,48 \cong 392 \text{ responden}$$

4. RESULT AND DISCUSSION

4.1 Traffic Counting Analysis

a. Campus Center

Pedestrian and vehicle volume are needed to determine what kind of crossing facility that fit in the area. Pedestrian and vehicle volume at Campus Center lane can be seen in the table below:

Table 2. Pedestrian and Vehicle Volume at Campus Center Lane

Time (1 hour)	pedestrian flow (people/hour/25 meter)			PV ² (people/hour/100 meter)
	Parallel (v)	Cross (P)	Vehicle (V)	
07.00 - 08.00	22	465	420	328,104,000
07.05 - 08.05	17	417	435	
07.10 - 08.10	16	382	453	
07.15 - 08.15	15	372	471	
07.20 - 08.20	12	370	497	
07.25 - 08.25	14	367	498	
07.30 - 08.30	15	376	505	383,557,600
16.30 - 17.30	19	1047	312	407,676,672
16.35 - 17.35	18	1028	290	
16.40 - 17.40	17	1001	262	
16.45 - 17.45	10	984	248	
16.50 - 17.50	10	922	231	
16.55 - 17.55	10	823	223	
17.00 - 18.00	12	723	209	126,325,452

Source: survey result

According to the guideline, with the $PV^2 = 4.08 \times 10^8$ crossing facilities that needed by this lane is pelican cross. But since this data took at peak hour only, zebra cross will still fit for this area. If it necessary, hazard can be put there to make vehicle user give their attention on this area more.

b. Widya Plaza

The PV^2 result in Widya Plaza is 1.26×10^7 . According to the guideline, this lane doesn't need any crossing facility yet. The detail can be seen in the appendix.

c. Sunken Court

For Sunken Court lane that got $PV^2 = 7.85 \times 10^7$. Based on the guideline, this lane does not need any crossing facility yet.

According to the guideline, Sunken Court is classified as Type II Class III road (Road with 2 traffic lane and moderate velocity in a crossing without traffic light.). So, minimum width of Sunken Court sidewalk is 1.5 meter.

Table 3. Minimum Width of Sidewalk

Road Classification		Minimum Standart	Minimum Width (exeception)
Type II	Class I	3.0	1.5
	Class II	3.0	1.5
	Class III	1.5	1

Source: Guideline of Urban Pedestrian Planning

4.2 Interview Analysis

Respondents who become the subject of this research are students in ITB. The total number of respondents were 109, consist of all faculty in ITB. Here is the distribution of respondents:

Table 4. Distribution of Respondents' Faculty

Faculty	Amount	Percentage
Faculty of Mathematics and Natural Science	10	9.17
Faculty of Civil and Environmental Engineering	13	11.93
School of Electrical Engineering and Informatics	8	7.34
School of Architecture, Planning and Policy Development	8	7.34
Faculty of Industrial Technology	11	10.09
Faculty of Mechanical and Aerospace Engineering	9	8.26
Faculty of Mining and Petroleum Engineering	9	8.26
School of Life Science and Technology	8	7.34
Faculty of Art and Design	7	6.42
Faculty of Earth Science and Technology	8	7.34
School of Business and Management	7	6.42
School of Pharmacy	11	10.09
Total	109	100.00

Source: data proceed

Based on interview result, there is 20.18% students who rarely using pedestrian path in ITB. It caused by pedestrian path existing condition that does not fully provide the nearest route to students' destination. Student intensity in using pedestrian path in ITB can be seen on Table 4. Besides, there is barely sign that guide pedestrian to remain on their path.

Table 5. Distribution of Using Pedestrian Path

Intensity of using pedestrian path	Amount	Percentage
Always	27	24.77
Often	55	50.46
Rare	22	20.18
Never	5	4.59
Total	109	100.00

Source: data proceed

For the second part, respondents were questioned about their opinion of pedestrian facilities in ITB. The result can be seen at Table 5.

Table 6. Pedestrian Facilities in ITB According to Respondents Opinion

Pedestrian Facilities Condition	Amount	Percentage
Good	34	31.19
Enough	62	56.88
Not adequate	13	11.93
Total	109	100.00

Source: data proceed

4.3 Improving Sidewalk Facilities

The third part of interview talks about respondent suggestion to improve pedestrian facilities that will be discussed at this section. This part is divided into two section; sidewalk and walk path.

Improving pedestrian facilities to minimize conflict between pedestrian and vehicle user can be done the following ways:

- a. Installing zebra cross at traffic counting location: Campus Center, Plaza Widya, and Sunken Court.
- b. Dividing the movement lane as follows:
 - Outer lane road that are used for vehicles;
 - The central lane that is set aside for pedestrians;
- c. Repairing the damaged sidewalks and restructuring in order to comply with the standards such as construct new sidewalk.
- d. Installing the signs instructions pedestrian lanes at each entrance gate of the campus.



Figure 10. Pedestrian Sign at Entrance Gate

Source: <http://www.safefiredirect.co.uk/>

- e. Installing instruction signs so that the pedestrian remain on track. These signs can be placed at several points along the path of pedestrians.



Figure 11. Pedestrian Sign to Remain on Track

Source: <http://www.safetysignsandnotices.co.uk/>

- f. Creating marks for pedestrian path along the walk path.
- g. Creating some warning marks in cross section to make pedestrians more careful when crossing.
- h. Build a tunnel that will connect pedestrians from ITB front gate to Salman Mosque.

4.4 Improving Walk Path Facilities

To enhance the functionality of an existing breezeway/walk path, it is needed to do some labor as follows:

- a. Connecting the shelter with an existing breezeway/walk path on campus. It is intended that pedestrians are not be soaked when the rain falls.
- b. Adding a pedestrian path and the assembly point according to Masterplan Estetis ITB, such as Pedestrian Damar and Pedestrian Bungur.
- c. Improving difable pedestrian facilities in ITB. The width of difable facility can be design like the picture below:

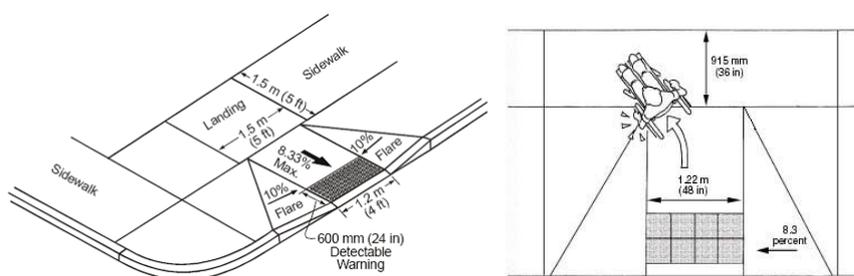


Figure 12. Difable Facility Design

Source: <http://www.fhwa.dot.gov/>

4.5 Pedestrian Safety Behavior

According to Kelman (1958), to improve safety behavior of pedestrian in ITB, some labor that can be tried is by improving student knowledge, mainly on regulations aspect, procurement, and maintenance of the existing pedestrian facilities.

Improving students' knowledge about pedestrian facilities in ITB can be implemented during new student orientation. This one can be a presentation and tour in campus area to describe various lanes and its function in ITB. For example, the central lane area reserved for pedestrians and the outer lane road set aside for vehicle users. The most important lesson that has to be taught is how to behave safely on the ITB road. In addition, sanctions for road users who do not comply with the rules can also be applied.

Another way that can be emulated is to follow the implementation of pedestrian awareness-raising program in Oregon. One of the most successful program is do a regularly 30-minute interactive presentation about pedestrian facilities and appropriate behavior.

5. CONCLUSION

From this study can be concluded as follows:

1. Conflict between pedestrians and vehicle users in ITB can be reduced by:
 - a. Putting up signs and marks for pedestrians. These markers need to be made along the walk path so that pedestrians are more aimed.
 - b. Install zebra cross at Campus Center.
 - c. Build a tunnel to connect pedestrians from campus to Salman Mosque.
2. Conflict that may occur between fellow pedestrians can be minimized by:
 - a. Widening the sidewalks that are less compliant;
 - b. Repairing the damage sidewalks;
 - c. Installing the cover on drainage channels;
 - d. Creating a continuous pedestrian corridor from the front gate to the rear gate so that pedestrians will not be soaked when it was raining.
3. Segregation movement that can be applied to reduce potential conflict among road users is by dividing ITB's lane into three:
 - a. Outer lane used for vehicles;
 - b. The middle lane for pedestrians;
4. Traffic signs indicating pedestrians can be placed at every entrance to the campus. The warning signs can be placed in every point of the crossing. The warning signs can also be painted as marks on the road.

APPENDIX

Pedestrian and Vehicle Volume at Plaza Widya (Second point of Traffic Counting)

Time (1 hour)	pedestrian flow (people/hour/25 meter)			PV ² (people/hour/100 meter)
	Parallel (v)	Cross (P)	Vehicle (V)	
07.00 - 08.00	55	201	54	2,344,464
07.05 - 08.05	65	166	56	
07.10 - 08.10	68	138	58	
07.15 - 08.15	65	133	58	
07.20 - 08.20	70	152	59	
07.25 - 08.25	70	148	69	
07.30 -08.30	73	151	73	3,218,716
16.30 - 17.30	45	437	85	12,629,300
16.35 - 17.35	42	430	80	
16.40 - 17.40	42	426	79	
16.45 - 17.45	38	416	76	
16.50 - 17.50	37	373	68	
16.55- 17.55	36	378	63	
17.00 - 18.00	34	348	59	4,845,552

Pedestrian and Vehicle Volume at Sunken Court (Third point of Traffic Counting)

Time (1 hour)	pedestrian flow (people/hour/25 meter)			PV ² (people/hour/100 meter)	
	Parallel (v)	Cross (P)	Vehicle (V)		
07.00 - 08.00	188	216	86	6,390,144	
07.05 - 08.05	189	204	93		
07.10 - 08.10	167	199	96		
07.15 - 08.15	165	213	93		
07.20 - 08.20	165	223	95		
07.25 - 08.25	173	239	95		
07.30 - 08.30	163	237	100		
16.30 - 17.30	242	567	186	78,463,728	
16.35 - 17.35	235	528	175		
16.40 - 17.40	238	504	159		
16.45 - 17.45	239	484	142		
16.50 - 17.50	234	436	130		
16.55 - 17.55	235	419	116		
17.00 - 18.00	231	375	99		
					14,701,500

Traffic Counting Location



Note:

- → 1st Traffic Counting Location: Campus Center
- → 2nd Traffic Counting Location: Plaza Widya
- → 3rd Traffic Counting Location: Sunken Court

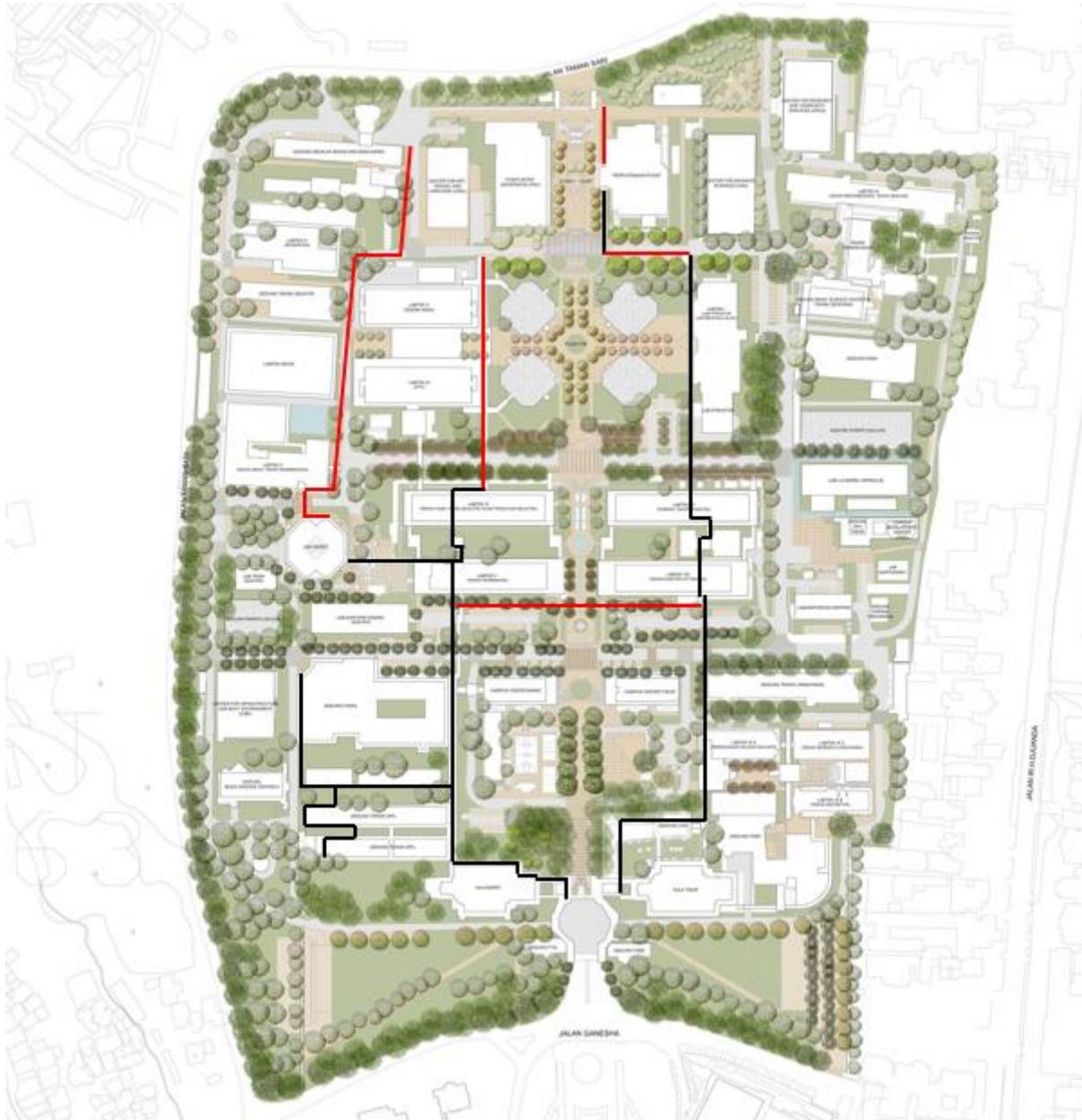
Proposed Difable Path in ITB



Note:

- : Existing Difable Path
- : Proposed Difable Path

Proposed Pedestrian Breezeway



Note:

— : Existing Breezeway

— : Proposed Breezeway

Proposed Tunnel Entrance Gate from ITB Campus to Salman Mosque



Note:

: Entrance Gate

: Tunnel Path Way

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