Development Study of Pedestrian Bridge at Gramedia Bookstore Jalan Raden Intan Bandar Lampung

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ABSTRACT. Bandar Lampung with high enough population densities has provides transportation facilities for pedestrian such as pedestrian bridge. This pedestrian bridges spread at Bandar Lampung’s traffic congested area, shopping centre nor education centre. Jl. Raden Intan as one of primary collector road with four lanes one direction at Bandar Lampung has high LHR (average daily traffic) movement pattern especially at morning, day and afternoon rush hour that make it difficult for pedestrian who want to cross the road. Therefore pedestrian bridge at this section Jl. Raden Intan highly needed especially at in front of Gramedia Bookstore with large amount of crossing pedestrian volume. From this research and analysis, found that number of LHR (average daily traffic) at Jl. Raden Intan shows large number traffic volume that is 4509 passenger car unit/hour at morning rush hour (07.00-08.30), with value of V/C Ratio or Degree of Saturation reach 0.92 (E category), while the amount of pedestrian who cross ahead from Gramedia Bookstore to Bank Muammalat is 29 people per 15 minutes. Other than that based on the calculation results of pedestrian volume and traffic volume at rush hour as follow: average pedestrian volume at rush hour is 146 people/hour between the range 100-1250 people/hour and traffic volume 7521 vehicles/hour over than 7000 vehicles/hour, and also the value \( PV^2 = 1.682 \times 10^{10} \) which is means the value of \( PV^2 \) worth over \( 2 \times 10^8 \), moreover the speed plan Jl. Raden Intan between 60-80 km/hour above 70 km/hour. Based on the calculation and analysis above, it can be concluded transportation facilities recommended for Jl. Raden Intan is pedestrian bridge.

1. Introduction
The population of Bandar Lampung reached 960,695 inhabitants with density of population 5678 people per km\(^2\) (Central Statistics Agency / BPS of Lampung Province, 2014). As the developing city, Bandar Lampung has transportation problems one of which is provision of supporting facilities for pedestrian who meet road safety.

Jl. Raden Intan as one of primary collector road with four lanes one direction and speed plan 60-80 km/hour, so has high Average Daily Traffic movement system especially at morning, day and afternoon rush hour that make it difficult for pedestrian who want to cross the road. For those reasons, the pedestrian bridge at Jl.Raden Intan is highly needed especially with large amount of crossing pedestrian volume.

Pedestrian bridge function as mode transfer walking pedestrian to crossing pedestrian, around area with very high vehicle movement. Therefore, pedestrian bridge as safety alternative avoiding traffic accident as well traffic congestion since zebra cross and pelican are not able to solve the pedestrian problem well.
2. Literature Review

This section provides an overview of available Indonesia globally study on some important perspective of pedestrian operations in urban networks, and also based on the type of crossing means.

Pedestrian behaviour in urban networks was described by Hoodendoorn and Bovy (2004) in Zheng and Elefteriadou (2016) as hierarchical structure with: strategic level (departure time choice); tactical level (activity scheduling and route choice); and operational level (road crossing and interactions). The tactical decision interacts with the operational level when, for example, pedestrian travel route may change due to available crossing facilities, and pedestrian crossing location may affect the pedestrian overall travel time. This structure explains the relationship among these three levels and emphasizes the necessity for an integrated method for pedestrian operation analysis. However, most existing studies ignore these mutual impacts, and pedestrian travel time is typically analyzed only at the intersection level. Thus, in order to approximate the pedestrian perspective, it is necessary to develop a pedestrian travel time model that considers the entire trip.

2.1 Crossing Pedestrian Facility

Crossing pedestrian facility is one of pedestrian facilities on the highway to concentrate pedestrian who want to cross the road. Ideally all road crossings using type of crossing separate from road, which means there is no possibility conflict between pedestrian and vehicle (Susilo, 1984 in Andreas, 2012).

Based on Decree of the Land Transportation General No: SK.43/AJ 007/DRJD/97 about Pedestrian Facilities Engineering in the City Area, crossing pedestrian facility divided into 2 (two) levels which are one level crossing and interchange crossing.

a. One Level Crossing

One level crossing for pedestrian consists of zebra cross with protector, zebra cross without protector, pelican with protector and pelican without protector.

b. Interchange Crossing

Interchange crossing for pedestrian consists of pedestrian bridge and pedestrian tunnel.

2.2 One Level Crossing

Selection criteria for one level crossing:

a. Based on the empirical formula \( PV^2 \), where \( P \) is the flow of pedestrian crossing along 100 meter per hour (people/hour), and \( V \) is the flow of vehicle per hour in 2 (two) directions (vehicle/hour)

b. The value of \( P \) and \( V \) is the average flow of pedestrian and vehicle in 4 (four) peak hours a day with initial recommendations such as Table 1.

| \( PV^2 \) | Pedestrian Volume (P) (people/hour) | Vehicle Volume (V) (vehicle/hour) | Type of Facilities |
|-----------------|--------------------------------|----------------------------------|-------------------|
| \( >10^8 \)      | 50 - 1100                       | 300 - 500                        | Zebra Cross (ZC)   |
| \( >2 \times 10^8 \)| 50 - 1100                       | 400 - 750                        | ZC with protector  |
| \( >10^8 \)      | 50 - 1100                       | \( >500 \)                        | Pelican (P)       |
| \( >10^8 \)      | \( >1100 \)                      | \( >300 \)                        | Pelican (P)       |
| \( >2 \times 10^8 \)| 50 - 1100                       | \( >750 \)                        | Pelican with protector |
| \( >2 \times 10^8 \)| \( >1100 \)                      | \( >400 \)                        | Pelican with protector |

Source: Directorate General of Bina Marga, *Pedestrian Facilities Engineering in the City Area* (1997)
Pedestrian determination charts
Source: Directorate General of Bina Marga, *Pedestrian Facilities Engineering in the City Area* (1997)

### 2.3 Interchange Crossing

Selection criteria for interchange crossing:

- **a.** Based on the empirical formula \((PV^2)\), where \(P\) is the flow of pedestrian crossing along 100 meter per hour (people/hour), and \(V\) is the flow of vehicle per hour in 2 (two) directions (vehicle/hour)
- **b.** The value of \(PV^2\) more than \(2 \times 10^8\), pedestrian flow (P) more than 1100 people/hour, the flow of vehicle in 2 (two) directions value (V) more than 750 vehicle/hour, which taken from 4 (four) peak hours.
- **c.** On the road with the speed plan 70 km/hour
- **d.** On the strategic area with no possibility for pedestrian to crossing but through pedestrian bridge

Factors to be considered in the use of interchange crossing according to Peter Bottomley (in Amalia L, 2005)

- **a.** Level of safety and secure factor to avoid accident occurrence
- **b.** Calculation quantitatively of conflict between pedestrian and vehicle
- **c.** Cost efficiency
- **d.** Use accuracy of crossing pedestrian facility especially interchange crossing in term of design and location, as well as comfort and convenience using

Selection criteria for interchange crossing based on Tanan and Sailendra (2011) from their book ‘*Training Module for Technical Planning of Pedestrian Facilities*’ is the value of \(P\) flow of pedestrian crossing in each hour reach over \(>1100\) people/hour, with the value of \(V\) flow of vehicle per hour reach over \(>750\) vehicle/hour and the value of \(PV^2\) reach over \(>2 \times 10^8\). From these variety of values can be recommended interchange crossing.

Furthermore explained the requirements of pedestrian bridge are:

- **a.** Technical condition of crossing bridge construction follow decree of planning for pedestrian bridges for pedestrian in urban area
- **b.** Pedestrian crossing bridge is a building for crossing pedestrian from side to other side cross section of the road. Pedestrian bridge must be build with strong construction and easy to maintain
- **c.** Pedestrian bridge has minimum width 2 meters with maximal ladder gradient 20°
- **d.** If pedestrian bridge also for bicycles then minimum width is 2.75 meters
e. Pedestrian bridge must be equipped with an adequate fence
f. At the centre of the bridge must be equipped with slab which can be used as a wheelchair facility for disabilities
g. Location and bridge building must be in accordance with the needs of pedestrians and as well as aesthetic
h. Pedestrian bridge placement should not reduce the effective width of sidewalk

While the requirements for pedestrian tunnel are as follows:

a. The technical provision of tunnel pedestrian follow the specification of tunnel technique
b. The tunnel must be equipped with adequate lightning. The specification for placement of lighting will be arranged in a separate document
c. Pedestrian tunnel has minimum width 2,5 meters. If the tunnel also for bicycle then minimum width is 2,75 meters
d. Minimum height of pedestrian tunnel is 3 meters.

3. **Research Methods**

Regional study directed in accordance with the problems identification, be concentrated at Jl. Raden Intan especially in front of Gramedia Bookstore. This is because at rush hour traffic flow increases making it difficult for pedestrians to cross the street.

3.1 **Primary Data**

Primary data collection is done directly by traffic counting survey at study location, with the purpose of obtaining accurate information related with road network traffic performance around study location. Beside the traffic counting, another survey are also done such as crossing pedestrian survey and geometry traffic survey.

The point of survey area assigned at Jl. Raden Intan in front of Gramedia Bookstore, namely survey point “S” by placing four surveyor at the location.

![Picture 2. Survey location for traffic counting and pedestrian crossing](image_url)
3.2 Secondary Data
For this current research, the secondary data given of Spatial Plan of Bandar Lampung (Rencana Tata Ruang Wilayah RTRW) Year 2011-2030, issued by Bappeda Kota Bandar Lampung. Furthermore secondary data in Bandar Lampung in Figures 2014, issued by BPS and Bappeda. In addition, secondary data required next is the road network map Bandar Lampung in Auto Cad format, which was issued by Bappeda Lampung Province.

The implementation procedures for survey and data processing stage starting with the implementation survey procedure: the form and equipment preparation, conducting survey, collecting survey result. Followed by a stage of data compilation: volume of crossing pedestrian, volume of vehicles, speed vehicle.

The next stage is data analysis stage which aims to analyse the problems that exist for the proposed solutions and consideration of the impact of future problems: counting PV, crossing pedestrian (P) and vehicle volume (V), road capacity, speed vehicle, the characteristics of pedestrians.

After done data analysis stage, the next is test phase of data analysis which purpose whether there is a relationship between a pedestrian crossing with traffic passing on the road crossings are reviewed as proposed solutions to problems.

The last stage is the step of determining conclusions: giving the use of conformity assessment crossing facilities, and giving the use of conformity assessment of pedestrian facilities to be built.

3.3 Survey Data
The preliminary survey to collect geometry data been done the day before the traffic counting survey, the information given include road wide effective, length of the segment, lane width, side walk.

The data traffic volume held on Thursday, July 21 2016 for 6 hours representative morning, day and afternoon busy hours (06.30-08.30, 11.00-13.00, 16.00-18.00).

The condition of the average daily traffic at Jl. Raden Intan shows the volume of traffic is more dense in the morning (07.30-07.40) compare to during another peak hour that is 792 pcu/10 minutes or 4509 pcu/hour. The density of activity Jl. Raden Intan can be understood since Jl. Raden Intan is the axis that connects to the central government and trade center. Average daily traffic hour Jl. Raden Intan 2943 pcu/hour. This condition can be understood since Jl. Raden Intan is the backbone of urban roads in Bandar Lampung, liaison area of residence, place of activity and education area.

![Average Daily Traffic Condition of Jl. Raden Intan](image)

**Picture 3.** The condition of average daily traffic Jl. Raden Intan

*Source: Analysis results, 2016*
Average daily traffic condition Jl. Tulang Bawang for total 2 directions towards Arjuna neither Gramedia intersection, show higher traffic volume in the peak hour at morning season (06.30 – 06.40) compare to peak hour at noon season, which is 190 pcu/10 minutes, maximum traffic volume towards Arjuna reach the highest level 115 pcu/10 minutes at approximately time between 06.30 – 06.40.

The cause of the traffic flow density Jl. Tulang Bawang is an alternative access from Jl. Raden Intan to Jl. HOS Cokroaminoto either Jl. Jendral Sudirman, as the center of trip generation.

### 3.4 Pedestrian Data

Crossing pedestrians data is calculated at 15 minute intervals during the two hours represent the time morning, day and afternoon busy hour. Crossing pedestrian data be divided into 2 (two) groups there are crossing pedestrian from Muammalat Bank into Gramedia Bookstore and crossing pedestrian from Gramedia Bookstore into Muammalat Bank.

**Graph 4.** The condition of average daily traffic Jl. Tulang Bawang
Source: Analysis results, 2016

**Graph 5.** The volume of crossing pedestrian at Jl. Raden Intan on Thursday, July 21 2016
Source: Analysis results, 2016
3.5 Urban Roads Performance Based on HCM

The Highway Capacity Manual or in Indonesia we used to call it Manual Kapasitas Jalan Indonesia (MKJI, 1997) provides guidelines, concepts and computational procedure in highway facilities, including highway, urban road, interurban road, signalized and unsignalized intersection, pedestrian and bicycle on the performance on these systems. The most current edition of HCM provides several methodologies for evaluating the pedestrian Level of Service (LoS) of the different urban street facilities.

Urban roads’s Level of Service (LoS) or urban roads performance in the area study calculated and analysed based on the value of capacity, degree of saturation, travel speed, free flow and also travel time. The results of the performance calculation roads for rush hour each morning, afternoon and evening given below.

### Table 2. Calculation of urban roads performance Jl. Raden Intan based on HCM

| Time          | Volume (vehicle/hour) | Flow (pcu/hour) | Capacity (pcu/hour) | Degree of Saturation | Velocity (km/jam) |
|---------------|-----------------------|-----------------|---------------------|----------------------|-------------------|
| 06.30-07.30   | 9795                  | 4389            | 4765                | 0.92                 | 34.3              |
| 07.30-08.30   | 9917                  | 4316            | 4765                | 0.91                 | 34.5              |
| 11.00-12.00   | 5224                  | 2629            | 4765                | 0.55                 | 45.0              |
| 12.00-13.00   | 5148                  | 2582            | 4765                | 0.54                 | 45.1              |
| 16.00-17.00   | 5390                  | 2629            | 4765                | 0.55                 | 45.0              |
| 17.00-18.00   | 6970                  | 3232            | 4765                | 0.68                 | 42.5              |

Source: Analysis results, 2016

The value of Jl. Raden Intan’s V/C Ratio reach the lowest level at 0.92 on morning peak hour 06.30-07.30, with the highest vehicle velocity 45,1 km/jam. This road performance shows that Jl.Raden Intan as the main road access to connect residence area to place of activity, central government and education area. This also caused pedestrians at Jl. Raden Intan find difficulty to cross the road since the dense vehicle so high that no opportunities for pedestrians to cross.

3.6 Recommendations of Pedestrian Bridge

After learning in detail about the volume and patterns movement and performance of urban roads in the study area using MKJI, also crossing pedestrian data from Muammalat Bank to Gramedia Bookstore and reverse direction, next could be synergized data that exists as a decisive criterion in choosing a crossing facility that is used by engineering facilities in the Region Walking City DPU issued by Directorate General of Highways.

1. **P** is the flow of crossing pedestrians along 100 m each hour (pedestrian /hour) and **V** is vehicle flow each hour

2. **P** and **V** are an average flow of pedestrians and vehicle at 4 rush hour. So that **P** and **V** are summed every hour to obtain empirical formula **PV**^2^.

### Table 3. A review on the bridge crossing facilities Jl. Raden Intan on Thursday, July 21 2016

| Time          | P (people/hour) | V two directions (kend/jam) | P.V2       | 4(P.V2)_maximum |
|---------------|-----------------|-----------------------------|------------|-----------------|
| 06.30-07.30   | 111             | 9795                        | 1,065E+10  | 1,065E+10       |
| 07.30-08.30   | 171             | 9917                        | 1,682E+10  | 1,682E+10       |
| 11.00-12.00   | 148             | 5224                        | 4,039E+09  | 4,039E+09       |
| 12.00-13.00   | 154             | 5148                        | 4,081E+09  | 4,081E+09       |
To recommend crossing facilities in accordance with existing requirements can be calculated from the volume of pedestrian and the highest volume of vehicle of peak hours. Which is when the average value of large such calculations below:

\[
P = \frac{(111 + 171 + 148 + 154)}{4} = 146 \text{ pedestrian/hour}
\]
\[
V = \frac{(9795 + 9917 + 5224 + 5148)}{4} = 7521 \text{ vehicle/hour}
\]

Then the average number of pedestrians at rush hour is 146 pedestrians/hour, between 100-1250 pedestrians/hour. The amount of vehicle volume 7521 > 7000 pcu/hour, and produced PV^2 = 1.682E+10 which is mean PV^2 > 10^{10}.

Based on the walking engineering facilities in the urban roads territory issued by DPU The Directorate General of Highway, can be deduced that the facilities recommended using the Pedestrian Bridge.

4. Conclusion and Recommendation

From this research and analysis, found that number of LHR (average daily traffic) at Jl. Raden Intan shows large number traffic volume that is 4509 passenger car unit/hour at morning rush hour (07.00-08.30), with value of V/C Ratio or Degree of Saturation reach 0.92 (E category), while the amount of pedestrian who cross ahead from Gramedia Bookstore to Bank Muammalat is 29 people per 15 minutes. Other than that based on the calculation results of pedestrian volume and traffic volume at rush hour as follow: average pedestrian volume at rush hour is 146 people/hour between the range 100-1250 people/hour and traffic volume 7521 vehicles/hour over than 7000 vehicles/hour, and also the value PV^2=1,682x10^{10} which is means the value of PV^2 worth over 2x10^9, moreover the speed plan Jl. Raden Intan between 60-80 km/hour above 70 km/hour. Based on the calculation and analysis above, it can be concluded transportation facilities recommended for Jl. Raden Intan is pedestrian bridge.

This research only do the traffic counting and pedestrians crossing at 6 (six) hours consisting of 2 (two) peak hours at morning, 2 (two) peak hours at noon and another 2 (two) peak hours at evening. For better results on next research, the survey shall do 12 (twelve) hours nonstop from early morning (06.00) to late evening (18.00) in order to obtain the real movement pattern.

For effective pedestrian bridge use, shall do the following like widening the road pavement and build up a fence on the median. Lack of side barriers and traffic smooth causing increased vehicle speed so it will complicate pedestrians to cross the road, hopefully will make crossing pedestrian using pedestrian bridge.
5. References

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