Competition measures of TOD point to Central Business Districts in Surabaya using travel time approach (a case study: Joyoboyo Terminal)

A A Zahra and E Ahyudanari*

1 Departement of Civil Engineering, Institut Teknologi Sepuluh Nopember (ITS), Raya ITS Street, Surabaya 60111

*Corresponding author e-mail: ervina@ce.its.ac.id

Abstract. Several areas are planned to be transit-oriented development in Surabaya, one of which is Joyoboyo. Joyoboyo Terminal will be developed as a transit point in Joyoboyo TOD. At present, Joyoboyo Terminal functions as a park and ride building. The accessibility of the Joyoboyo terminal is measured by total travel time to Surabaya CBD. In this study, we used Google maps and Moovit to obtain the total travel time by private vehicles and public transport to 7 Surabaya CBDs. The results of the travel time survey show better accessibility using a private vehicle (car) than public transport (bus/city transport). The travel time difference was about 4 to 20 minutes. This research also provided an accessibility map from Joyoboyo TOD to Surabaya CBD

1. Introduction

People need the development of facilities that integrates their activities with the required movements. This integration is the concepts of Transit-Oriented Development (TOD). The concept of TOD is attempted to be applied in Surabaya. This effort is shown from the proximity of the city center and transit points [1]. In 2014, Surabaya Government with the World Bank, Hansen, City Form Lab, and several instances conducted research related to city corridor development in Surabaya. Joyoboyo transit is one of the terminal that will be developed following the TOD concept. The previous research recommended five potential locations along the Surabaya Mass Rapid Transit (SMART) corridor to be a TOD area, one of which is the Joyoboyo area [2]. The Surabaya Mass Rapid Transit is planned in the north-south corridor by Suro tram and east-west corridor by Boyo rail, and both corridors meet in the Joyoboyo area. Thus, this research took place in Joyoboyo Terminal. Future development of Joyoboyo planned by the Transportation Authority of Surabaya and the World Bank can be seen in figure 1.

The development of TOD requires support from the use of public transport for daily commuting. The Surabaya government need to restrict the usage of private vehicles by implementing traffic demand management (TDM). Some countries have successfully reduced the number of vehicles entering the city with the TDM concept, such as Cambridge, Singapore, Perth, Beijing, Dublin, Greater Vancouver Region, London, Trondheim, Southern California, Portland, and Auckland [3]. Providing park and ride buildings is one of the TDM implementations by the Surabaya Government.
Currently, public transportation in Surabaya merely depends on the city transport and bus that has not been upgraded yet into the public transport system, such as bus rapid transit system. The Bus Rapid Transit (BRT) system has been successful in shifting private vehicle usage to public transport in several countries [4–6]. One of the facilities to accommodate the transfer of private vehicle mode to public transport is the availability of park and ride. However, the availability of park and ride will not optimally function if there is no public transport system pass through its location.

In Europe, the park and ride are built to prevent traffic congestion and high parking demand in the city center [7]. The location of the parking lot must be adjacent to the transit corridor, with a maximum 15-minute headway of public transport [8]. Surabaya has already had seven parks and ride spots along the Suroboyo Bus route, which is managed by the government. One of those parking and ride buildings is located in Joyoboyo Terminal. Therefore, this research would determine the accessibility of transit point in Joyoboyo TOD.

Accessibility is a measure of comfort or convenience about the interaction of land use with one another [9]. If the land use is far to one another and transportation network between the land uses are in bad condition, then the accessibility is low. High internal TOD accessibility can be characterized by the ‘safe, uninterrupted, and interconnected’ access to pedestrians and cyclists within the block, so all the blocks are connected. Arterial roads still dominate the access to the CBD in the Surabaya area because the city railroad is across along the outer city. It is then assumed that there is a need to do analysis related to the accessibility from the terminal to the CBD. The accessibility of this research focuses on competitive measures in travel time.

![Figure 1. Joyoboyo TOD Development](image)

2. Study Area

From previous research [10], Joyoboyo TOD is divided into five blocks, in which delimitation of each block can be seen in figure 2. Those five blocks are located in Wonokromo Subdistrict, consisting of Darmo, Jagir, Ngagel, Ngagel Rejo, Sawunggaling, and Wonokromo Districts. The area of Joyoboyo TOD is 180.54 ha and dominated by residential areas. The Joyoboyo Terminal, as a transit point, is located in Block 1 as presented in figure 2.
3. Methodology

Indicators to determine accessibility can be measured by travel distance, travel cost, and travel time [10]. This research used travel time as a parameter of accessibility. The travel time data from Joyoboyo TOD to Surabaya CBD was obtained from a one-week travel time survey for private vehicles with Google maps. For public transportation travel time data was obtained from Moovit per 30 minutes of departure. The methodology used in this study can be seen in figure 3.

The travel time obtained from the survey was classified into six classes Level of Services [11], as shown in table 1. Those classifications of LOS were added to GIS to create an accessibility map.

4. Walking Speed

This research needed to adopt the walking speed to determine walking access time. Walking speed can be calculated by the distance traveled divided by the time taken to walk. It is influenced by environmental factors, traffic conditions, and pedestrian characteristics. People will walk slower in dense traffic areas with uncomfortable and unsafe pedestrian facilities. However, it tends to be faster if people walk on wide sidewalks equipped with roadside protection barriers, even in dense traffic areas.
The average people walking speed is 0.83 m/s [12]. Manual on Uniform Traffic Control Devices (MUTCD) states that the people walking speed when crossing a signal crossing is 1.22 m/s [13]. Meanwhile, the Institute of Transportation Engineers surveyed in Florida at a pedestrian-dense location and found the people walking speed was 0.76 m/s.

In Indonesia, from a pedestrian survey in Bandung found the people walking speed was 1.08 m/s [14] and was 1.4 m/s while disaster evacuation simulation in Padang [15]. Nusdwinuringtyas (2018) did a research using 6 Minute Walk TES (6MWT) method in healthy Indonesian ethnic aged 18-50 years and found the average walking speed of male was 1.61 m/s and female was 1.56 m/s. This research used 0.83 m/s as walking speed for analysis of total travel time by public transport.

5. Central Business District
CBD can be interpreted as a part of the city that has the highest density from diverse activities [17]. At present, CBD is not just a place for a commercial and retail center, but also residential and entertainment facilities, e.g. malls. Thus, people can work, get entertained, eat, and sleep in one area. Several characteristics of CBD are shown in table 2.

Table 2. Characteristics of CBD.

| Researcher | High Buildings | Office Cluster | Financial District | multi-story | At Main Road | High Land Value | Not Densely Housing |
|------------|----------------|----------------|--------------------|-------------|--------------|-----------------|-------------------|
| [18]       | ✓              | ✓              | ✓                  | ✓           | ✓            | ✓               | ✓                 |
| [19]       | ✓              | ✓              | ✓                  | ✓           | ✓            | ✓               | ✓                 |
| [20]       | ✓              | ✓              | ✓                  | ✓           | ✓            | ✓               | ✓                 |
| [21]       | ✓              | ✓              | ✓                  | ✓           | ✓            | ✓               | ✓                 |
| [22]       | ✓              | ✓              | ✓                  | ✓           | ✓            | ✓               | ✓                 |
| [17]       | ✓              | ✓              | ✓                  | ✓           | ✓            | ✓               | ✓                 |
| [23]       | ✓              | ✓              | ✓                  | ✓           | ✓            | ✓               | ✓                 |

Table 2 presents that all sources stated that CBD has the characteristics of high office building concentration. Besides, all sources also stated that CBD is in the area of many multi-story buildings that have differentiation of functions, except [17]. Yu (2015) argues that a CBD area can be rated from the density of population activity, so it does not have to consist of high buildings. CBD is in an area that has a high land value and not dense residential areas [17,18,20–22]. It is different from which states that the CBD area is in a densely populated area.

In the CBD, there is a “multi-story” building that provides various trade and services characterized by the presence of supermarkets or malls [17,18,20,22]. Battino, Borruso, & Donato (2012), Yu (2015) and Yogi (2017) state that the CBD area is marked by the presence of a banking headquarters (financial district). About the traffic condition, Battino, Borruso, & Donato (2012) and Pissourios (2014) state that the CBD is located at the main arterial road and has high traffic density. Thus, it can be concluded that CBD area has the following characteristics:
1. CBD consists of high office building concentration.
2. CBD is in an area of many high-rise buildings that have differentiation of functions.
3. CBD is located across a high land value zone.
4. Within the CBD, there is a multi-story building that provides trade and services.

5.1. CBD in Surabaya
The development of the CBD area in Surabaya was discussed in the master plan for spatial planning (Rencana Induk Tata Ruang dan Wilayah) in 1973 [24]. At that time, the city government had permitted
the construction of a Segi Delapan CBD area in West Surabaya. According to Johan Silas, the Segi Delapan area had indeed been projected to become Surabaya’s business center since 1973.

In the 2016-2021, the document of Surabaya City Mid-Term Development Plan (Rencana Pengembangan Jangka Menengah Kota Surabaya) states that the CBD area in Surabaya is located at Jl. Mayjend Sungkono, Jl. Kutisari, Jl. Mulyosari, Jl. Ngagel-Pucang, Jl. Kertajaya, Jl. Ahmad Yani, West Outer Ring Road, West Inner Ring Road, Jl. Kalianak, Jl. Dharmahusada, Jl. HR Muhammad, UP VIII Hamlet Pakis, Pakuwon Trade Center, East Coast and Puncak CBD Wiyung. Meanwhile, the document of Surabaya City Corridor Development Report by the World Bank in 2014 states that Surabaya CBD stretches between Keputran and Genteng (Tunjungan Area).

Surabaya City is divided into 12 Development Units (DU), and then DUs were assessed as having proximity with four main characteristics of CBD. It obtained 7 CBD areas in Surabaya located in Tunjungan; Genteng; Segi Delapan; Yono Suwoyo; Sungkono; Wiyung and MERR. Those 7 CBDs are located across the high land value zone in Surabaya as can be seen in figure 4.

![Figure 4. Location of Surabaya CBD.](image)

6. Travel Time Survey

6.1. Travel Time by Private Vehicle
The data needed for Google Maps travel survey is ‘origin’ and ‘destination’ point. Then, it will show several alternative routes that can be selected. The first step is selecting 44 road segments to be surveyed as can be seen in figure 5. Those 44 selected roads are the route passed from Joyoboyo TOD to 7 CBD points in Surabaya. The coordinates of 44 road sections obtained from Google Earth seen in table 3.

![Figure 5. 44 Road segments to be surveyed.](image)
After a one-week survey, the private vehicle travel time data of 44 segments can be seen in figure 6. Figure 6 shows that several road segments have a relatively extended travel time, while other streets have a peak hour every day.

![Figure 6. Private vehicle travel time data graphs in one week.](image)

The graph in figure 6 shows the travel time of each segment. The total travel time was obtained by summing up the travel time of the roads that have passed; the result can be seen in table 3. The total travel time was then classified according to the LOS classification in table 1.

### Table 3. The coordinates points and total travel time of private vehicle.

| No. | Start point | Endpoint | Street Name | Total Travel Time | LOS |
|-----|-------------|----------|-------------|-------------------|-----|
| 1   | -7.2982387084, 112.737781844 | -7.29639805772, 112.739124018 | Jl. Darmo | 00:01:02 | D |
| 2   | -7.29639805772, 112.739124018 | -7.28992506819, 112.738881701 | Jl. Darmo | 00:03:18 | D |
| 3   | -7.28992506819, 112.738881701 | -7.27749267544, 112.741215289 | Jl. Darmo | 00:07:22 | D |
| 4   | -7.27749267544, 112.741215289 | -7.27314036875, 112.742049686 | Jl. Urip Sumoharjo | 00:08:23 | D |
| 5   | -7.27314036875, 112.742049686 | -7.26976035728, 112.741629183 | Jl. Basuki Rahmat | 00:09:25 | D |
| 6   | -7.26976035728, 112.741629183 | -7.262512946, 112.740559958 | Jl. Basuki Rahmat | 00:12:15 | C |
| 7   | -7.262512946, 112.740559958 | -7.2667242045, 112.741375711 | Jl. Basuki Rahmat | 00:10:27 | D |
| 8   | -7.2667242045, 112.741375711 | -7.26280847192, 112.741303595 | Jl. Basuki Rahmat | 00:11:31 | C |
| 9   | -7.26280847192, 112.741303595 | -7.25860688033, 112.733473131 | Jl. Embong Malang | 00:14:41 | C |
| 10  | -7.25860688033, 112.733473131 | -7.25600140463, 112.734178477 | Jl. Blauran | 00:15:43 | C |
| 11  | -7.25600140463, 112.734178477 | -7.25582683001, 112.736984927 | Jl. Praban | 00:17:14 | C |
| 12  | -7.25582683001, 112.736984927 | -7.26280847192, 112.741303595 | Jl. Tunjungan | 00:19:31 | C |
| 13  | -7.26280847192, 112.741303595 | -7.26442907377, 112.745456975 | Jl. Gubernur Suryo | 00:12:36 | C |
| 14  | -7.26442907377, 112.745456975 | -7.26775139628, 112.744419424 | Jl. Pang. Sudirman | 00:13:38 | C |
| 15  | -7.26775139628, 112.744419424 | -7.27301235816, 112.742420453 | Jl. Pang. Sudirman | 00:12:46 | C |
| 16  | -7.27301235816, 112.742420453 | -7.26667422189, 112.744732191 | Jl. Embong Wungu | 00:11:27 | C |
| 17  | -7.26667422189, 112.744732191 | -7.26881114477, 112.743943599 | Jl. Embong Gayam | 00:11:27 | C |
| 18  | -7.26881114477, 112.743943599 | -7.29129721186, 112.742970984 | Jl. Bengawan | 00:05:24 | D |
| 19  | -7.29129721186, 112.742970984 | -7.27700692881, 112.745261067 | Jl. Ngagel | 00:09:59 | E |
| 20  | -7.27700692881, 112.745261067 | -7.27628007308, 112.746172825 | Jl. Sulawesi | 00:10:59 | E |
| 21  | -7.27628007308, 112.746172825 | -7.27453273475, 112.746763704 | Jl. Gubeng | 00:11:59 | E |
| 22  | -7.27453273475, 112.746763704 | -7.26864104369, 112.750534955 | Jl. Gubeng | 00:14:03 | E |
| 23  | -7.26864104369, 112.750534955 | -7.26635152369, 112.751042222 | Jl. Sumatera | 00:15:03 | E |
| 24  | -7.26635152369, 112.751042222 | -7.26454518641, 112.745828673 | Jl. Pemuda | 00:16:42 | D |
| 25  | -7.26454518641, 112.745828673 | -7.29639805772, 112.739124018 | Jl. Diponegoro | 00:02:05 | E |
| 26  | -7.29639805772, 112.739124018 | -7.2924814325, 112.737171023 | Jl. Diponegoro | 00:02:05 | E |
| 27  | -7.2924814325, 112.737171023 | -7.29564309763, 112.732324991 | Jl. Ciliwung | 00:03:16 | C |
| 28  | -7.29564309763, 112.732324991 | -7.29255107038, 112.72844178 | Jl. Adityawarman | 00:05:37 | C |
| 29  | -7.29255107038, 112.72844178 | -7.292186310027, 112.719166671 | Jl. M. Sunkono | 00:07:35 | C |
| 30  | -7.292186310027, 112.719166671 | -7.28844525977, 112.707236172 | Jl. M. Sunkono | 00:11:00 | C |
| 31  | -7.28844525977, 112.707236172 | -7.28142241207, 112.684788282 | Jl. HR Muhamad | 00:18:00 | C |
IOP Conf. Series: Materials Science and Engineering 930 (2020) 012066 doi:10.1088/1757-899X/930/1/012066

The locations of 19 selected minutes from 06:00 to 22:00 in Moovit as can be seen in Table 3 was added to GIS to create the accessibility map by private vehicle, as shown in Figure 7.

6.2. Travel Time by Public Transport

Those 44 points were surveyed with Google Maps for a private vehicle, 19 points of which were surveyed with Moovit as can be seen in Table 4. The origin point entered was Joyoboyo Terminal and the destination points entered were those 19 points. Public transport travel time data was taken per 30 minutes from 06:00 - 22:00 in Moovit. This software shows three recommendation lines that can be selected and show the time for bus/city transport arrival. Thus, the travel time data from Moovit was the accumulation of travel time itself and waiting time for bus/city transport arrival. The locations of 19 destination points, selected bus/city transport line, and travel time to the CBD can be seen in table 4.

Table 3 shows the average travel time of private vehicle (car) from Joyoboyo TOD to Tunjungan CBD located in Jl. Basuki Rahmat (number 6) was 12 minutes 15 seconds; The travel time is in the range of 1-28 minutes. The LOS classification in table 3 was added to GIS to create the accessibility map by private vehicle, as shown in Figure 7.

Table 4. The coordinates points, selected line and travel time of public transport.

| No. | Endpoint coordinate | Line       | Travel Time | LOS |
|-----|---------------------|------------|-------------|-----|
| 1   | -7.27749267544, 112.741215289 | R1R2       | 00:20:00    | F   |
| 2   | -7.27314036875, 112.742049686 | R1R2       | 00:24:00    | F   |
| 3   | -7.262512946, 112.740559958 | R1R2       | 00:27:00    | F   |
| 4   | -7.25586283001, 112.736984927 | V → R3R4   | 00:34:00    | F   |
| 5   | -7.26442907377, 112.74545975 | V          | 00:13:00    | C   |
| 6   | -7.26775139628, 112.744419424 | V/ P2 / PAC 2 / DA / BUS C / P1 | 00:33:00 | F   |
| 7   | -7.27301235816, 112.74242045 | V/ R1R2 / P2 / PAC 2 / DA / BUS C / P1 | 00:35:00 | F   |
| 8   | -7.29255107038, 112.72844178 | TV         | 00:06:00    | D   |
| 9   | -7.29186310027, 112.719166271 | TV         | 00:10:00    | D   |
| 10  | -7.28142241207, 112.684788282 | TV         | 00:19:00    | C   |
| 11  | -7.28891783742, 112.677607966 | TV         | 00:21:00    | C   |
| 12  | -7.27693721619, 112.689733904 | TV → DKB   | 00:17:00    | E   |
| 13  | -7.29129271186, 112.742970984 | F          | 00:05:00    | D   |
| 14  | -7.27453273475, 112.746763704 | F          | 00:11:00    | E   |
| 15  | -7.2645418641, 112.745828673 | F → N      | 00:22:00    | D   |
| 16  | -7.27620708026, 112.781170256 | S → WK     | 00:30:00    | D   |
| 17  | -7.28938265529, 112.780669905 | S          | 00:27:00    | C   |
| 18  | -7.3072765921, 112.719650771 | DKB        | 00:06:00    | C   |
| 19  | -7.31349174903, 112.702368469 | JM         | 00:14:00    | D   |
Using public transport from the Joyoboyo TOD to Tunjungan CBD (number 3) requires 27 minutes. Other CBDs areas are taken at various times, from 6 minutes to 37 minutes. Those LOS classification in table 3 were added to GIS to create the accessibility map by public transport, as shown in figure 7.

**Figure 7.** Accessibility map of private vehicle and public transportation.

6.3. **Total Travel Time**

The advantages offered by private vehicles is ‘door to door service’. While the travel time data of public transit in table 4 above have not been added with walking time from the bus stop to CBD points. The walking distance was calculated using ArcGIS. For example, in the Segi Delapan CBD, it needs to walk from the bus stop to the CBD point, as shown in figure 8.

**Figure 8.** Walking distance from bus stop to segi delapan CBD.

Figure 8 shows the walking distance from the bus stop to Segi Delapan CBD (coordinate number 33, see table 4) is 988 meters. The walking time equals to the distance from the bus stop was divided by walking speed (0.83 m/s). Thus, the total travel time by public transport to Segi Delapan CBD can be calculated as follow:

\[
\text{Walking Time} = \frac{\text{Distance from bus stop (meter)}}{\text{Walking speed (0,83 m/s)}}
\]

\[
= \frac{988}{0.83} \, \text{m/s}
\]

\[
= 1190 \, \text{second} \approx 19 \, \text{minute 50 second}
\]

Total Travel time = (Waiting time + estimated bus / angkot travel time) + walking time

\[
= 17 \, \text{minute} + 19 \, \text{minute 50 second}
\]

\[
= 36 \, \text{minute 50 second}
\]
The walking distance and walking time in another 6 CBDs were calculated in the same step as above, and the result can be seen in table 5. Thus, it obtained the whole total travel time using public vehicles and private vehicles as can be seen in table 6 and figure 9.

### Table 5. Walking time from bus stop to CBD points.

| Central Business District | Distance from Bus Stop (meter) | Walking Time |
|--------------------------|-------------------------------|--------------|
| Tunjungan                | 283                           | 00:05:41     |
| Genteng                  | 264                           | 00:05:18     |
| Sungkono                 | 188                           | 00:03:47     |
| Segi Delapan             | 988                           | 00:19:50     |
| Yono Suwoyo              | 297                           | 00:05:58     |
| Wiyung                   | 669                           | 00:13:26     |
| MERR                     | 175                           | 00:03:31     |

### Table 6. Total travel time by public transport and private vehicle.

| Central Business District | Public Transport Waiting + Travel Time | Walking Time | Total Travel Time by Public Transport | Total Travel Time by Private Vehicle |
|--------------------------|----------------------------------------|--------------|--------------------------------------|-------------------------------------|
| Tunjungan                | 00:27:00                               | 00:05:41     | 00:32:41                            | 00:12:15                           |
| Genteng                  | 00:22:00                               | 00:05:18     | 00:27:18                            | 00:16:42                           |
| Sungkono                 | 00:10:00                               | 00:03:47     | 00:13:47                            | 00:07:35                           |
| Segi Delapan             | 00:17:00                               | 00:19:50     | 00:36:50                            | 00:22:38                           |
| Yono Suwoyo              | 00:21:00                               | 00:05:58     | 00:26:58                            | 00:22:30                           |
| Wiyung                   | 00:14:00                               | 00:13:26     | 00:27:26                            | 00:11:45                           |
| MERR                     | 00:30:00                               | 00:03:31     | 00:33:31                            | 00:25:40                           |

![Figure 9. Total travel time from Joyoboyo TOD to Surabaya CBDs.](image)

From the table 6 and figure 9 shows the total travel time of taking public transport (city transport/bus) from Joyoboyo TOD to Tunjungan CBD, in which endpoint coordinate number 3, was 32 minutes 41 seconds; Sungkono CBD (number 9) was 13 minutes 47 seconds; Yono Suwoyo CBD (number 11) was 26 minutes 58 seconds; Segi Delapan CBD (number 12) was 36 minutes 50 seconds; Genteng CBD (number 15) was 27 minutes 18 seconds; MERR CBD (number 16) was 33 minutes 31 seconds; and Wiyung CBD (number 19) was 27 minutes 26 seconds. Table 6 also shows that the private vehicle had faster travel time to those 7 CBD points.
7. Conclusion
This research was designed to calculate the travel time from Joyoboyo Terminal, a TOD transit point, to Surabaya CBD. The results of the travel time survey show that private vehicles had better accessibility to Surabaya CBD. The difference travel time by public transport and a private vehicle in Tunjungan CBD was about 20 minutes 26 seconds; in Genteng CBD was about 10 minutes 36 seconds; Sungkono CBD was about 6 minutes 12 seconds; Segi Delapan CBD was about 14 minutes 12 seconds; Yono Suwoyo CBD was about 4 minutes 28 seconds; Wiyung CBD was about 15 minutes 41 seconds, and MERR CBD was about 7 minutes 51 seconds. This difference occurred because public transport needed extra time for waiting for bus/city transport arrival and walking time from the last bus stop. It is recommended for future research to find several scenarios to develop better accessibility from Joyoboyo Terminal, especially for public transport mode. Therefore, it can bring the success of ‘ride’ in the park and ride concept as well as ‘transit’ in transit-oriented development concept itself.

References
[1] Handayani K D M E and Ariastita P G 2016 Sustainability of transportation in Surabaya through the development of transit oriented development areas J. Tataloka 16 108–15
[2] Hansen & SUTD Lab 2014 Surabaya Urban Corridor Development Program (Surabaya)
[3] Syabri I 2011 The Influence of Railway Station on Residential Property Values-Spatial Hedonic Approach The Case of Serpong’s Railway Station J. Teor. dan Terap. Bid. Rekayasa Sipil 18 291–300
[4] Robert C 2006 Public Transport and Sustainable Urbanism: Global Lesson (California: California Digital Library)
[5] Pradipita E G, Suroso and Suharini E 2014 Efektivitas BRT (Bus Rapid Transit) Trans Semarang Sebagai Moda Transportasi di Kota Semarang Geo-Image 3 1–4
[6] Singh Y J, Lukman A, He P, Flacke J, Zuidegeest M and Maarseveen M van 2015 Planning for Transit Oriented Development (TOD) Using a TOD Index (Washington D.C.: Transport Research Board)
[7] Milosavljevic N and Simicevic J 2019 Sustainable Parking Management (Serbia: Elsevier)
[8] Spillar R J 1997 Park and Ride Planning and Design Guidelines (New York: Parsons Brinckerhoff Inc.)
[9] Black J A 1979 Urban Acessibility and Transport Policy Transp. Commun. Bull. Asia Pacific
[10] Nadyla A and Nurlaela S 2018 Pengukuran Tingkat Keseimbangan Node dan Place di Kawasan Transit Oriented Development (TOD) Terminal Joyoboyo, Surabaya J. Transp. 1 100–5
[11] Nahdalina and Tamin O Z 1998 Analisis Dampak Lalu Lintas (Andall) J. Perenc. Wil. dan Kota 5 16–25
[12] ITDP 2017 TOD Standard vol 3 (Jakarta: ITDP)
[13] Knoblauch R L, Pietrucha M T and Nitzburg M 1996 Field studies of pedestrian walking speed and start-up time Transp. Res. Rec. 1538 27–38
[14] Auhari A 2010 Pedestrian facilities planning on Dr. Setiabudhi street, Bandung (Pasundan University)
[15] Yosritzal, Kemal B M, Purnawan and Putra H 2018 An observation of the walking speed of evacuees during a simulated tsunami evacuation in Padang, Indonesia IOP Conf. Ser. Earth Environ. Sc. 140 1–8
[16] Nusdwinuringtyas N 2018 Six Minute Walking Distance Cut-off Point in Indonesian (Mongoloid) Population Med. J. Indones. 68 389–94
[17] Yu W, Ai T and Shao S 2015 The analysis and delimitation of Central Business District using network kernel density estimation J. Transp. Geogr. 45 32–47
[18] Murphy R E and Vance J E 1954 Delimiting the CBD Econ. Geogr. 30 189–222
[19] Sun Y 2011 Development and characteristics of central business district under the philosophy of health Procedia Eng. 21 258–66
[20] Battino S, Borruso G and Donato C 2012 Analyzing the Central Business District: The case of
Sassari in the Sardinia Island *Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics)* 7334 *LNCS* 624–39

[21] Taubenbock H, Klotz M, Wurm M, Schmieder J, Wagner B and Esch T 2013 Delimiting central business districts - A physical approach using remote sensing *Joint Urban Remote Sensing Event 2013* (Sao Paulo: IEEE) pp 17–20

[22] Pissourios I A 2014 A historical overview and critical analysis of town centre delimitation methodologies *Bull. Geogr.* 25 155–65

[23] Yogi A 2017 *Central Business District (CBD) - Explained with Examples*

[24] Erawan A 2015 Segi Delapan Surabaya Barat, CBD Baru Kota Pahlawan *Rumah.com*