Can Building Density Influence the Amount of BRT Trans Semarang Ridership

by Anita Ratnasari

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I Oktaviani[1], D I K Dewi[1], and A R Rakhmatulloh[1]

[1] Department of Urban and Regional Planning, Diponegoro University, Jl. Prof. Soedarto Tembalang, Semarang, Indonesia

Corresponding e-mail : [1]inge.oktaviani19@pwk.undip.ac.id

Abstract. Low ridership of bus rapid transit (BRT) can lead to public transport inadequacy problem. The amount of ridership in a particular area may be influenced by built environment in the surroundings. This study focuses on of the built environment, building density at neighbourhood level. This paper aims to analyze the relationship between building density and amount of BRT Trans Semarang ridership. This study uses a quantitative method with multiple linear regression as the analysis tool to analyze the relationship between the two. The findings show only high density, or building of more than eight stories has a relation to number of Trans Semarang corridor I ridership. It shows that building which has function as an office or place to work can generate BRT Trans Semarang passengers who is walking.

Keywords : ridership, pedestrian, BRT, building density

1. Introduction

The Bus Rapid Transit (BRT) in Semarang City, Indonesia that is realized in the form of Trans Semarang has been operating for approximately 9 years, however until now the Trans Semarang system has not met the basic standards of BRT issued by the ITDP (Institute of Transportation & Development Policy). This is because Trans Semarang is still classified as semi BRT [1]. In addition, the operation of Trans Semarang gets less got public interest [2]. Improvement of the BRT system should focus to increase the Trans Semarang passengers since it's still below the standard of General Directorate of Land Transportation (Direktur Jenderal Perhubungan Darat). This is caused by passengers and pedestrian movements are the main keys in transportation systems including public transportation operations [3]. In addition, the success rate in public transportation is most visible, most measurable, and highest compared to the growth of users or passengers (Pucher & Kurth, 1996) in [4].

Since more than 80% passengers of Trans Semarang take a walk to reach BRT stations [5], it needs to investigate what factors could effect the various number of pedestrians. The movement of pedestrians is more difficult to predict because it does not have a definite route and is usually influenced by the surrounding conditions and environmental factors [6]. According to C. Kim, Parent, & vom Hofe (2018)

individual travel movements are influenced by many factors, such as weather [6,8–10], sociodemography [11,12], and built environment [13–16]. Even based on research conducted by Sun, Oreskovic, Lin (2014) changes in the built environment on the Chinese University of Hong Kong Campus can increase the intensity of students to walk.

In addition, pedestrian movements are also influenced by internal factors because each individual has different walking behavior which is categorized as positive walking attitude and negative walking attitude. Positive walking attitude is defined as the willingness of individuals to walk because they consider the activity important, while negative walking attitude is an unavailability of individuals to walk because they do not consider the activity important (Joh, Nguyen, & Boarnet, 2012).

Although there are individuals who have negative walking attitude, the volume of the pedestrian can be increased by changing the factors that influence it so that the individual can have positive walking attitude. This has been investigated by Greenwald and Boarnet (2001), Appleyard (2003), Southworth (2005) in (Mondschein, 2018) that changes in the built environment, such as mixed-use neighborhoods, design changes, or security can improve walking activities. Thus, changes to the built environment are still needed to create a pleasant walking experience.

Data and Methods

The study area of this research was Corridor I of BRT Trans Semarang that serves from Mangkang to Penggaron area. The authors selected corridor I to be the study area based on the various land use along the corridor. Various land use could lead to various building density.

The analysis combined two datasets: 1) numbers of Trans Semarang ridership and 2) building density. The numbers of Trans Semarang ridership in Coridor I were obtained from primary survey by counting the passengers who get in and get off in each BRT stations. Ridership volumes were collected from three different periods : (i) peak morning (6.00 a.m. to 7.00 a.m), (ii) noon period (from 12.00 to 01.00 p.m.), and (iii) peak afternoon (from 4.00 p.m. to 5.00 p.m.). These daily volumes were collected on the same weekday.

Building density in this study was divided into 3 categories, low, medium, and high density. According to Duduta (2013) the definitions for low, medium, and high density are used :

- Low density. Some or all of the station area is developed, with buildings no more than two stories high.
- Medium density. The entire station area is developed, with buildings of three to eight stories.
- High density. The entire station area is developed, with a predominance of high-rise buildigs (over eight stories high)

Table 1. The List of Variables

Measure	Variable	Unit
Trans Semarang ridership	Sum of passengers who is walking to and from bus stations per day	Number of people
Low density	Ratio of number of building with 1-2 stories to all of buildings in an area	Decimal
Medium density	Ratio of number of building with 3-8 stories to all of buildings in an area	Decimal

High density	Ratio of number of building with >8 stories to all of buildings in an area	Decimal

Thus, dataset of building density was obtained by observing the building stories through site visit or by using Google Street View by looking for the building stories. The authors examined building density around each of 40 BRT stations at the "neighbourhood level". Referring to [14] "neighbourhood level" is a radius circular buffer area around the center of observation point which is in this study referred to bus stations as seen on Figure 1. The authors selected 200 m as a measure of neighbourhood level due to distance between one bus station to another in Corridor I was 400 m.

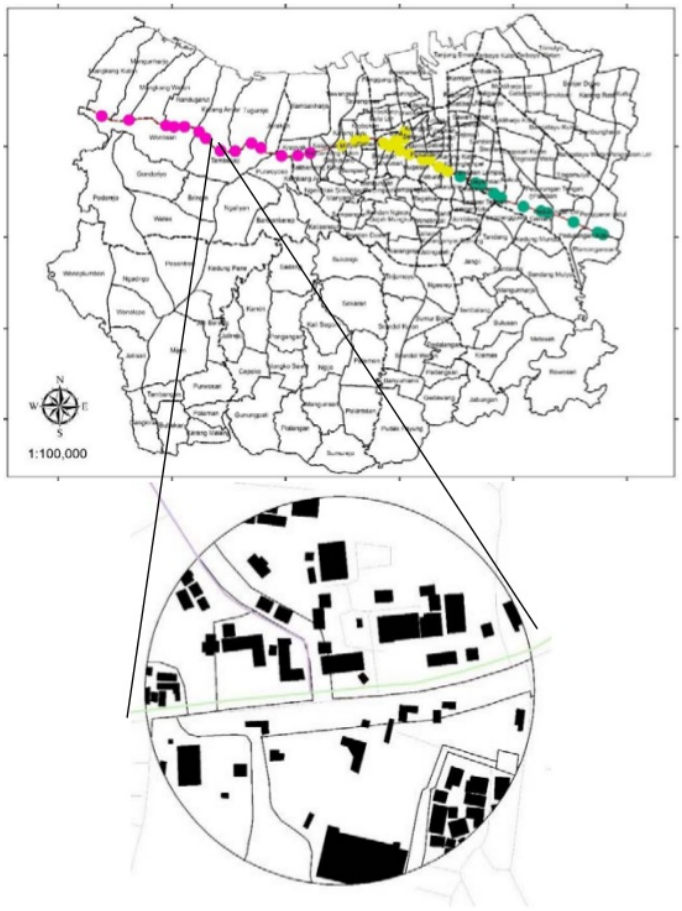

Figure 1. Neighbourhood Level

Quantitative methodologies were used to explain the effect of building storey density on number of Trans Semarang ridership in a station. The authors used multiple linear regression test with stepwise method to analyze the link between the two. In the model, dependent variable is Trans Semarang ridership and independent variables are low, medium, and high density. The authors examined the association of total of Trans Semarang ridersip per day in 40 bus stations and the proportion of low, medium, and high density at 40 neighbourhood level area. SPSS 20.0 software with significance level, was set at $p<0.05$ were used in all statistical analyses.

3. Results

Table 2. Descriptive statistics of Variables

	Mean	Std. Deviation
Dependent variable		
Trans Semarang ridership	41.85	45.253
Independent variable		
Low density	0.8917	0.17978
Medium density	0.0967	0.16056
High density	0.0116	0.04081

Table 3. Results of Regression Analysis

Variable	Coefficient	*p*
High density	721.72	.000
Constant	33.47	.000
R	.651	

p<0.05

Based on Table 2 there are 15 bus stations which have number of ridership exceed the average. Those bus stations in this study are classified as crowded bus stations. 9 out of 15 crowded bus stations are located in Semarang City Centre. Only 4 bus stations which has high density proportion at its neighbourhood level. But there are only 3 bus stations which have the proportion exceeds the average.

Table 3 presents the association between high density and BRT Trans Semarang ridership based on multiple linear regression analysis. The R for the fitted model was 0.651. The collinearity statistics (VIF) showed that no significant multicollinearity existed among the independent variables.

The results of the multiple linear regression analysis indicated a statistically significant association ($p<0.05$) between high density and BRT Trans Semarang ridership. The density of high-rise buildings that are located in Semarang City Center, the CBD area where the number of BRT users is greater than in the suburban area.

High density represents building with more than eight stories and most of them have a function as an office. High density variable has positive effect to BRT Trans Semarang ridership. This finding relates to the previous study that showed 35% (second biggest) BRT users have purpose to go for working [5]. Thus, it can add an explaination that building which has function as an office or place to work can generate BRT Trans Semarang passengers who walk.

As many as 3 bus stops are classified as crowded (number of ridership is more than average), the areas around those bus stops have a proportion of buildings with more than eight floors that exceeds the average proportion. These stops include UDINUS, Gramedia, and Simpang Lima as seen on Figure 2.

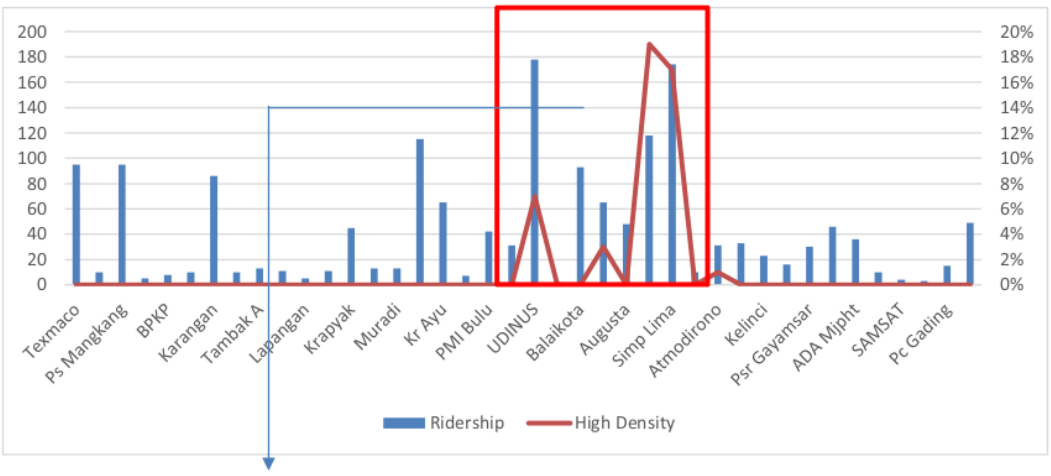

Figure 2. Correlation between number of high density that exceeds average number to amount of ridership

4. Conclusions

Trans Semarang Corridor I users who are dominated by passengers traveling by foot to and from the bus station are influenced by the surrounding environment, one of which is building density. Based on the results of the analysis that has been carried out, in order to increase Trans Semarang TOD can do interventions around the BRT transit station to generates many passengers. Beside that, planners should pay increased attention to the characteristics of the current built environment as they make decisions taking to promote environmental changes.

Based on the results of the regression analysis, it is known that only high building density which has a relationship with the number of BRT users. While building density is low and moderate, it has no relationship with the number of BRT users. This proves that the large number of BRT users who walk can be influenced by the surrounding environment in several areas. The density of high-rise buildings is located in Semarang City Center, the CBD area where the number of BRT users is greater than in the suburban area.

Methodological limitations in this study contained of the aspects of building density in the analyses were limited to those that could be objectively measured. The demographic factors of population, which my be associated with number of ridership, were not considered in the analyses due to lack of micro-level data availability. Recommendation based on this study is There needs an adjustment between Detailed Spatial Planning (RDTRK) and the existing conditions related to the study about the height of the building in city centre because the conditions can be determined to exceed eight floors in Detailed Spatial Planning

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