

Location Determinants of Campus Bus Stop to Support Green Campus Program

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Abstract— The basic principle of green transportation planning in the UNS campus is to reduce the number of motor vehicles in the campus area by: improving the comfort of pedestrians, increasing usage of bicycles and campus buses and restricting the usage of parking lots. UNS needs to prepare the infrastructures required to support the success of the program, including the provision of campus bus stop locations. The characteristic of UNS is hilly, with many alternative roads leading to the areas of certain faculties requiring special consideration in determining the locations of the campus bus stops. Therefore, this study analyzes the determinants of the location of special campus bus stop in UNS which fit users requirements and qualify for safety and comfort requirements of users of the campus buses and other road users. The most important determinants of the location of the stop, from the most important determinant to the least important, were 1) comfortable and shady location, followed by 2) within walking distance to destination, 3) integrated with other modes, and the last was 4) good road geometry condition.

Keywords— bus stop, campus bus, green campus, green transportation, locationdeterminant

I. INTRODUCTION

The concept of green transportation is a concept used so that an entire transportation system is more environmentally friendly. Green transportation is an approach used to create transportation with little or no greenhouse gas emission by reducing the usage of fossil fuel [5]. Greenhouse gas is one of the causes of global warming, and greenhouse gas from transportation is between 15 to 20 percent and will keep increasing if not regulated [4].

As one of the large Indonesian universities, Sebelas Maret University has great concern for the environment. This is shown in the participation of UNS in Green Campus ranking by UI Metric. A good result was achieved by UNS in 2014 by being ranked 8th in UI *Green Metric* assessment. One of the

assessments in green campus is policy and implementation in transportation by using the concept of green transportation.

There are two things that should be considered in determining bus stop location i.e. operators of vehicles which will use bus stop facilities and bus users. From the point of view of vehicle operators, the determination of bus stop location is influenced by operational cost, served traffic demand, and available transportation facilities (road network and other transportation facilities). On the other hand, bus users consider accessibility by foot and integration with other transportation modes.

The basic principle of the planning of green transportation in UNS campus is reducing the number of motor vehicles in the campus area by: improving the comfort of pedestrians, increasing usage of bicycles and campus buses and restricting the usage of parking lots. UNS should prepare infrastructures to support the success of the program, including providing campus bus stop locations. The characteristic of UNS is hilly, with many alternative roads leading to the areas of certain faculties requiring special consideration in determining the locations of the campus bus stops.

Therefore, an analysis of determinants of locations of special campus bus stop in UNS was conducted. The result of this study is expected to recommend locations of campus bus stops within UNS campus area, Kentingan, which fit users needs and qualify for safety and comfort requirements of campus bus users and other road users.

II. RESEARCH METHOD

The research method used was descriptive qualitative method with ranking analysis. Descriptive qualitative analysis is used when a research focuses on solving actual issues based on the current condition during the research. Ranking analysis is an analysis to calculate respondents' opinions on questionnaire variables which have been answered based on scores in the range of 1-10. Total score of each factor is sorted

from largest to smallest. The analysis result is total score of factor ranking questionnaire obtained from the total score of respondents' opinions. The respondents were academicians, i.e. students, lecturers, and staffs.

The collected data included primary data and secondary data. Primary data consisted of: walking distance, bus stop location potential, respondent's gender, respondent's age, distance from bus stop to destination, and assessment of location determinant in the questionnaire. Secondary data consisted of: campus bus route, UNS campus map, and total student of every faculty, total lecturer, total staff.

III. RESULT AND DISCUSSION

A. Respondents' Description

The main survey was performed on 5 variables which had been validated. There were more female respondents than male, and the dominating age in the survey was 16-20 years old. The respondents' description of each faculty is shown in Table 1.

TABLE 1
DESCRIPTION OF SURVEY RESPONDENTS

Faculty	Gender		Age (years)				Total
	Female	Male	16-20	21-25	26-30	>30	
Agriculture (FP)	15	15	4	24	-	2	30
Economy (FE)	15	23	5	31	-	2	38
Literature and Fine Arts (FSSR)	22	15	23	10	2	2	37
Education Science (FKIP)	59	31	60	24	1	5	90
Engineering (FT)	13	29	14	25	1	2	42
Law (FH)	9	9	9	7	1	1	18
Social and Political Sciences (FSIP)	22	14	15	19	-	2	36
Medicine (FK)	21	10	22	6	-	3	31
Mathematics and Natural Sciences (FMIPA)	14	12	16	8	-	2	26
Total	190	158	168	154	5	21	348

Source: Primary data analysis (2014)

B. Analysis of the Determinants Location of Campus Bus Stop

Analysis of the determinants of the location of campus bus stop was determined based the total score of each assessed factor. The factor which the highest score was the main factor in determining bus stop locations. The next biggest score was the next determinant. The factors analyzed were 1) Comfortable and shady location, 2) minimum walking distance to destination, 3) integrated with other modes and 4) good vertical and horizontal geometric conditions. The determinants location of campus bus stop is shown in Table 2.

Based on the analysis, the order of the determinants of the locations of campus bus stops, from the highest score, was: comfortable and shady locations, minimum walking distance to destination, integrated with other modes, good geometric condition (not on corners and slopes).

TABLE 2
THE RESULT OF ANALYSIS OF DETERMINANTS OF THE LOCATION OF CAMPUS BUS STOP

Factor	Score	Percent (%)	Mean (%)	Σ
Bus stop locations comfortable and shady	3124	22,087	20,158	1,343
Bus stop locations near destination (close walking distance to and from destination)	2801	19,803		1,691
Bus stop locations near facilities of other vehicles, e.g.: near city bus stops or campus bike parking facility (integrated with other modes)	2740	19,372		1,927
Bus stop locations in good road geometric condition	2739,5	19,369		1,577

Source: Primary data analysis (2014)

C. Location Factor of Bus Stop Being in Comfortable and Shady Location

On the first position of determinants of locations of bus stop was comfortable and shady location. Passengers spend a lot of time waiting for buses, at least in most Italian cities. It's very important that they don't feel like they're wasting time or not safe. The quantity and quality of waiting room (and the surroundings) are very important to consider. First, the area must be able to accommodate all potential passengers, including at peak hours, and there should be no mixture with other users (waiting passengers and streetwalkers) [6]. For better waiting condition, basic facilities such as seats, bus stops, and good lighting must be available in every stop. Good waiting condition enable streetwalkers to do their activities, such as reading, resting, which will prevent feeling of wasting time. *Washington Metropolitan Area Transit Authority (WMATA) Guidelines on Passenger Shelter* section [3] states that bus stops help to protect passengers when waiting for buses from sunlight and other weathers. Bus stop type and model depends on the options in local cities and communities.

From the statement above, a conclusion was drawn that bus stops can be placed in areas under the shades of trees or other buildings in the areas or areas with no shade while providing facilities to protect passengers from the sunlight. However, bus stop facilities don't only provide safety, but also comfort.

D. Location Factor of Bus Stop Being Near Destination

This factor was tightly related to walking distance and distance between stops. These are contradictory, so it's important to determine which to be prioritize, passengers or operators. Passengers wanted bus stops as near as possible to their destinations to shorten the walking distance, however for

operators more stops meant short and inefficient distance between the stops, increasing the operational cost of the buses.

The best locations for bus stops that there three determinants, which are 400 m interval between bus stops in highways, separate land for bus stops which don't merge with road (bus bay), and slope [7]. The ideal distance to study distance between stops is almost 400 m, but closer distance in city centers and residential areas is perhaps required to meet passengers' needs. Covered area is defined as percentage of total urban area within 5 minutes (primary) and 10 minutes (secondary) of walk and the availability of transit station. During planning, it can be assumed that for the majority of potential users of transit, if it's within 5 minutes (400 m) of walking distance, the users will switch to other modes [8].

In this determination of bus stop, ideal distance between bus stops was expected, so that not all faculties have this facility because some faculties are near each other. The neighboring faculties are FISIP-FH-FKIP with total distance (FISIP-FKIP) around 248 m. It's too close to provide bus stop facility for each faculty, causing high operational cost for the buses, so appropriate distance must be found where passengers don't have to walk too far. Based on that consideration, users heading to FISIP, FH, and FKIP must stop at the bus stop in front of Building 1 of FH, so that passengers heading to FISIP and FKIP can walk. The furthest walking distance from FH to FISIP is 174 m, and FH-FKIP 74 m

E. Location Factor of Bus Stop Being Integrated with Other Modes

Good accessibility is always attempted by planning highly integrated transportation network, whether the facilities (vehicles) or infrastructures (bus stops/shelters/corridors). Several modes will be operated to support the campus bus program, such as campus bike. Campus bikes help users reach their destinations if the walking distance seems far. Campus bikes will have pools near bus stops. So that passengers can switch transportation mode quickly and easily.

Potential locations for transit are north and south gates. The north gate is located in Jl. KH Dewantara where City Transport 03 operates and the south gate is located in Jl. Ir. Sutami where Bus BST (Batik Solo Trans) is located. Thus, the bus stops will be placed near those gates and each bus stop will have a bike pool so that bus passengers who want to switch modes can be facilitated.

F. Location Factor of Bus Stop Being in Good Road Geometry

Areas with bus stops are risky due to slope, so there should be notice boards to inform and remind passengers to be careful. In other words, road surface of stops should be made from materials which increase friction to prevent buses from slipping [7]. TCRP Report states that rising roads are related to topography and excavation and filling considerations. Generally, maximum gradient for 40 feet (13 meters) busses is between 6 and 8 percent. Recommended gradient of change between the road and side road is less than 6 percent. Proper

height of sidewalks for efficient passenger service is 6-9 inches (16-23 cm) [1]. If the sidewalks are too high, buses can't pull over near bus stops and users in wheelchairs will have difficulty boarding. If the sidewalks are too low or uneven, the elderly and passengers with limited mobility will have difficulty boarding and alighting buses. Effective usage of buses with low floors also influence the height of the sidewalks.

The Decision of Directorate General of Land Transportation Number: 271/HK.105/DRJD/96 on Technical Guidance of the Engineering of Public Transport Stopping Places Chapter I Point C Clause 5 states that the general requirement of public transport stops is not disturbing traffic and Chapter I Point C Clause 1b states that regarding the location of bus stop from traffic space, minimum distance between bus stop and intersection is 50 meters [2]. Bus stops mustn't be placed in intersections or corners, so it should be placed in straight roads.

UNS campus is a hilly area, so there are high slopes and curved roads. There are several critical points which should be noted, such as around FT, FKIP corner, FISIP corner, and Rectorate corner because those points are the current stops of campus buses. Traffic conflicts often happen in these points, so bus stops should be placed there. There are also vulnerable areas around FE rising intersection, FE rising road toward FISIP, and from Graduate Program Building to Nurul Huda Mosque. These areas have high slopes, so the road gradients are also high. Bus stops aren't placed along the slope from FE to FISIP. In the slope from Graduate Program Building to Nurul Huda Mosque, it will be placed in front of the Graduate Program Building, so the slope isn't too sharp, and bus stops also won't be placed in corners. Passengers heading toward or coming from the destinations above must walk at least 50 m (depending on point of origin).

G. Location Recommendation

From the result of the analysis of the determinants of the locations of campus bus stops in Kentingan, the recommended locations are shown in Figure 2.

IV. CONCLUSIONS

Determinants of the locations of campus bus stops by importance were: 1) comfortable and shady location, followed by 2) within walking distance to destination, 3) integrated with other modes, and the last was 4) good road geometry condition.

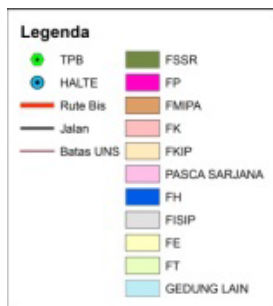
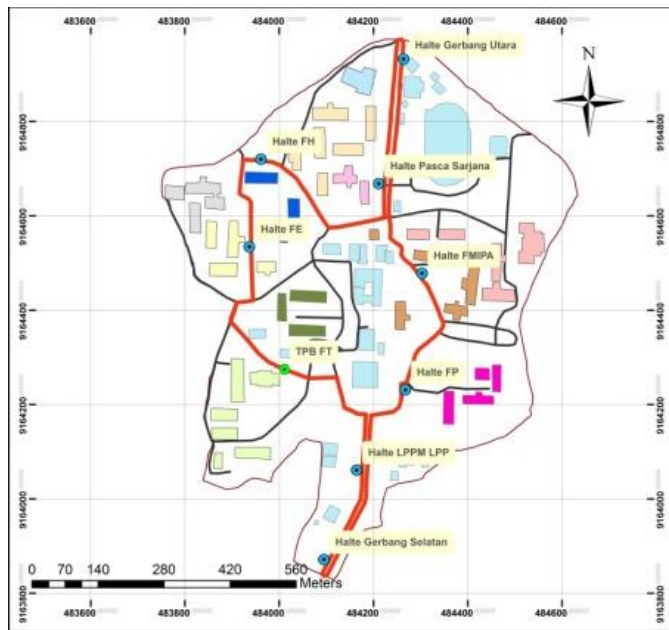


Fig. 1 Determination of locations of campus bus stops based on factor analysis

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