Study of the Effect of Mixed Land Use on the Level of Service of Tukad Pakerisan Road Section Denpasar

Ni Made Widya Pratiwi, Anak Agung Rai Asmani K, Dewa Ayu Nyoman Sriastuti, Anak Agung Gede Sumanjaya*

Correspondence Email: deee.widya@gmail.com
Civil Engineering Study Program, Faculty of Engineering and Planning, Universitas Warmadewa, Denpasar, Bali-Indonesia

Abstract. Roads are infrastructure intended for the movement of vehicles, people and/or goods in the form of roads and supporting facilities, while traffic is the traffic space for the movement of vehicles and people in road traffic space (Law No. 22 of 2009). Movement is formed due to activities carried out not in their place of residence, meaning that the relationship between spatial areas is very instrumental in creating travel and land use distribution patterns affect travel patterns, making a very close relationship between land use and transportation, where transportation as a benchmark in spatial interactions between regions and plays an important role in the development of a region, forming a land-use transport system (Tamin O.Z., 2000). Denpasar City as the center of activity in Bali cannot be separated from transportation problems such as traffic congestion and inconvenience like other big cities. Tukad Pakerisan Road, located in the South Denpasar area, is a two-lane two-way road, as an alternative link to and from the Denpasar city center gate, becoming a rapidly developing area in the last 5 years because this area has market activities, campuses, schools, culinary, residential, offices, and shops. The data used in this study consisted of primary data, where in collecting primary data, surveys were carried out, namely road geometric surveys, vehicle speed surveys, traffic volume surveys and side obstacles. Secondary data in the form of population data is obtained from the Denpasar City Statistics Agency in 2022. The data analysis method used is the Indonesian Road Capacity Manual (MKJI, 1997) and the Indonesian Road Capacity Guidelines (PKJI, 2014). Based on primary data analysis, it is found that Tukad Pakerisan road is an undivided two-lane two-way road (2/2 TT), primary environmental road function, length of section 1000 m, width of Rumaja 9 m, width of road body 7 m, width of kerb / shoulder 1 m, width of vehicle lane 3,5 m. The maximum traffic volume occurs at the afternoon peak hour of 11:00-12:00 am at 1889 skr / hour, high side obstacle class and commercial environment of 500-899 events per hour, free flow speed of 32.32 Km / hour. From the secondary data, the capacity value of the road section is 2208.1 skr / hour / lane, the degree of saturation is 0.68, the travel time is 0.04 hours, the instantaneous speed is 24.5 Km / hour, so that from the comparison of travel speed with the degree of saturation, the level of service of the Tukad Pakerisan road section is B, while from the degree of saturation value, the level of service has a value of C where the flow is stable but the speed of moving and moving vehicles is limited by traffic conditions, the driver is limited in choosing the speed.

Keywords: Road sections; land use; level of service

1. Introduction

Transportation is the activity of moving people and goods from one place to another. Transportation problems that are always faced by big cities in Indonesia are traffic congestion problems. Movement is formed as a result of activities carried out not in their place of residence, meaning that the relationship between spatial areas is very instrumental in creating travel and land use distribution patterns affect people's travel patterns, making a very close relationship between land use and transportation, where transportation is an indicator as a benchmark in spatial interaction between regions and plays an important role in the development of a region, forming a land-use transport system, so that land use can be realized properly, the transportation needs must be met properly(Tamin O.Z., 2000).

Denpasar City as the center of activity in Bali cannot be separated from transportation problems such as traffic congestion and inconvenience like other big cities. Tukad Pakerisan Road located in the South Denpasar area is a two-lane two-way road, as an alternative link to and from the Denpasar city center gate, which is currently a rapidly developing area in the last 5 years, because this area has market activities, campuses, schools, culinary, residential, offices, and shops that cause traffic delays in the morning during school and work hours, as well as during school and work return hours as well as dense market and shop activities.

Based on the explanation above, to get the level of road service, it is necessary to analyze the performance of the road section on the road section seen from mixed land use, so this research is important to do.

Problem Formulation

Based on the background description above, it can be stated that the problem formulation in this study is How are the characteristics and influence of mixed land use on the performance of the Tukad Pakerisan Denpasar road section?

Research Objectives

On the basis of the background and formulation of existing problems, the objectives to be achieved in this study are to analyze the characteristics and influence of mixed land use on the performance of the Tukad Pakerisan Denpasar road section.

2. Literature Review

Road segment

Based on the 2014 Indonesian Road Capacity Manual, urban road segments include four types of roads, namely:

- Medium road type 2/2TT;
- 4/2T type highway;

- 6/2T type highway;

- One-way roads of types 1/1, 2/1, and 3/1.

Capacity analysis for undivided road types (2/2TT) is conducted for both directions of traffic, for divided road types (4/2T and 6/2T) the capacity analysis is conducted per lane, each direction of traffic, and for road types with one-way traffic movement, the capacity analysis is the same as the approach for divided road types, namely per lane for one direction of traffic. For road types with more than six lanes, the capacity can be analyzed using the provisions for 4/2T road types.*2.2 Arus Lalu Lintas*

The planned traffic flow data is used as the basis for determining the width of traffic lanes or the number of traffic lanes, in the form of design hour traffic flow (QJP) determined from the LHRT, using the k factor.

QJP=LHRT x k……..(1

Where:

LHRT = annual average traffic volume determined from a traffic count survey for one full year divided by the number of days in the year, expressed in skr/day.

k = plan hour factor, determined from a study of hourly traffic flow fluctuations during the year. Usable k values for urban roads range from 7% to 12% (smp/h)..

Side Obstacle Class

The side obstacle class is determined from the sum total of the frequency of occurrence values for each type of side obstacle considered, each of which has been multiplied by its weight. The frequency of occurrence of the side obstacles was calculated based on field observations for a one-hour time period along the observed segments. The weights of the types of side obstructions were determined from Table 1, and the criteria for KHS based on this frequency of occurrence were determined in accordance with Table 2.

Table 1. Weighting of Side Barriers

No.	Type of Major Side Obstacles	Weight
1	On-street and crossing pedestrians	0.5
2	Public vehicles and other vehicles that stop	1.0
3	Vehicles exiting/entering side or roadside land	0.7
4	Slow vehicle flow (non-motorized vehicles)	0.4

Source: PKJI, 2014

Table 2. Side Obstacle Class Criteria

Side Obstacle Class	Frequency value of occurrence (on both sides) multiplied by weight	Special characteristics
Sangat rendah, SR	< 100	Residential areas, frontage roads available
Low, R	100 – 299	Residential areas, there are some public transportation (angkot).
Medium, S	300 – 499	Industrial area, there are several ece along the side of the road.
High, T	500 – 899	Commercial areas, there is high street-side activity.
Very High, ST	> 900	Commercial areas, there is street-side market activity.

Source: PKJI, 2014

Ekivalen Kendaraan Ringan (ekr)

Ekr for light vehicles is one and ekr for heavy vehicles and motorcycles is set as shown in Table 3 and Table 4.

Table 3. Light vehicle equivalent for road type 2/2TT

Road type	Traffic flow total two-way (kend/hr)	KB	ekr SM Traffic lane width, LJalur	
			≤ 6 m	> 6 m
2/2TT	< 3700	1.3	0.5	0.40
	≥ 1800	1.2	0.35	0.25

Table 4. Light vehicle equivalent for divided and one-way roads

Road Type	Traffic flow per lane (kend/hr)	ekr	
		KB	SM
2/1, and 4/2T	< 1050	1.3	0.40
	≥ 1050	1.2	0.25
3/1, and 6/2D	< 1100	1.3	0.40
	≥ 1100	1.2	0.25

Free Flow Speed (V_B)

The VB value for light vehicles (KR) is set as the basic criterion for road segment performance, the VB values for heavy vehicles (KB) and motorcycles (SM) are set as reference only. The VB for KR is usually 10-15% higher than other vehicle types. VB is calculated using equation 2.

VB = (VBD + VBL) x FVBHS x FVBUK……(2

Notes:

VB = free flow speed for KR under field conditions (km/h)

VBD = basic free flow speed for KR

VBL = speed adjustment value due to road width

FVBHS = free speed adjustment factor due to side obstacles on roads that have shoulders or roads equipped with kerbs / sidewalks with kerb distance to the nearest obstacle

FVBUK = free speed adjustment factor for city size.

Capacity (C)

For 2/2TT road types, C is determined for the total two-way flow. For 4/2T, 6/2T, and 8/2T road types, the flow is determined separately per direction and the capacity is determined per lane. Segment capacity can be calculated using equation 4.

C = C0 x FCLJ x FCPA x FCHS x FCUK……(4

Description:

C = capacity, skr/hr

C0 = basic capacity, skr/hr

FCLJ = capacity adjustment factor related to lane width or traffic lanes

FCPA = capacity adjustment factor related to directional separation, only on undivided roads

FCHS = capacity adjustment factor related to KHS on shouldered or kerbed roads

FCUK = capacity adjustment factor related to city size

Degree of Saturation (D_J)

DJ is the primary measure used to determine the performance level of a road segment. The DJ value indicates the quality of traffic flow performance and varies between zero and one. A value close to zero indicates unsaturated flow, i.e. a free flow condition where the presence of other vehicles does not affect other vehicles. Values close to 1 indicate flow conditions at capacity, moderate flow density with a certain flow speed that can be maintained for at least one hour. DJ is calculated using the equation 6).

DJ = Q/C……(6

keterangan:

DJ = derajat kejenuhan

Q = arus lalu lintas, skr/jam

C = kapasitas,skr/jam

Travel Speed (V_T)

Travel speed (VT) is the actual speed of the vehicle whose magnitude is determined based on the function of DJ and VB described above.

Travel Time (W_T)

Travel time (WT) can be determined based on the value of VT in traveling the analyzed road segment of length L, equation 7) illustrates the relationship between WT, L and VT.

WT = L/VT…….(7

keterangan:

WT = waktu tempuh rata-rata kendaraan ringan, jam

L = panjang segmen, km

VT = kecepatan tempuh kendaraan ringan atau kecepatan rata-rata ruang kendaraan ringan (space mean speed, sms), km/jam

3. Method

Research Design

In detail, the research design can be seen in the scheme below:

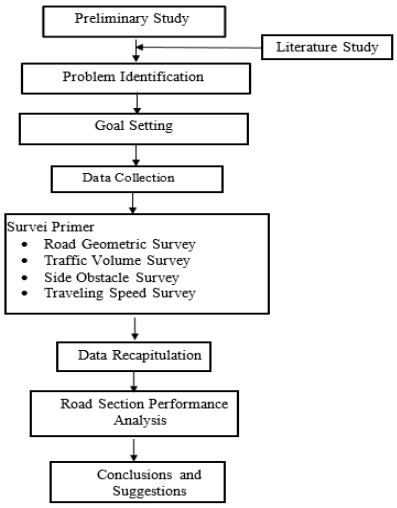


Fig 1. Research Design

Data Collection Technique

In collecting primary data, various surveys were conducted, namely road geometric surveys, vehicle speed surveys, and traffic volume surveys in the presence of side barriers. While secondary data was taken from the Denpasar City Statistics Agency.

Research Location

The research location can be seen in Figure 2 below:



Fig 2. Research Location

4. Results And Discussion

Road Section Analysis

Based on the results of the survey that has been carried out, it is found that Jalan Tukad Pakerisan Denpasar is an undivided two-lane two-way road (2/2 TT) with the road function of Primary Environment. The research location has a section length of 1000 m, width of Rumaja 9 m, width of the road body 7 m, width of kereb / shoulder 1 m, width of vehicle lane 3.5 m.

Traffic Volume Analysis

The results of the morning, afternoon, evening and average peak hours were obtained. The results of the peak hour volume data analysis are shown in Table 6 and Figure 3.

Table 6 Traffic Volume during Morning, Afternoon, and Peak Hours

No.	Peak Time	Vehicle Type			Number (vehicle/hour)	Quantity (skr/hr)
		KR	KB	SM		
1	07.00-08.00	514	18	4422	4954	1641.1
2	11.00-12.00	664	25	4779	5468	1888.75
3	17.00-18.00	636	5	4729	5370	1824.25
Average					4344	1515.2

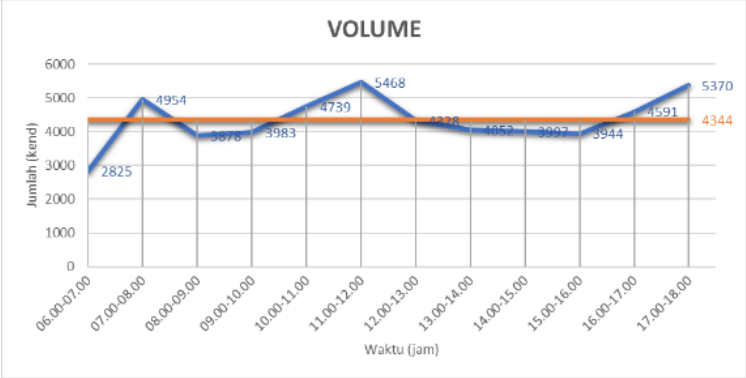


Fig 3. Traffic Volume Chart

From the results of the traffic volume survey, it is known that the peak hour is at 11:00-12:00 pm with a peak hour volume of 5,468 vehicles / hour or 1,888.75 skr / hour from the traffic flow fluctuation data obtained the average volume is 4,344 vehicles / hour or 1,515.2 skr / hour. This average volume value is used in this analysis.

Side Obstacle Analysis

Based on the results of the survey, the class of side obstacles on Jalan Tukad Pakerisan Denpasar obtained the following class of side obstacles:

Table 7. Side Obstacle Class for Tukad Pakerisan Street Denpasar

No.	Road Name	Segmen	KHS	Event frequency value (both sides) per hour	Special characteristics
1.	Jalan Tukad Pakerisan Denpasar	200m	T	500 - 899	Commercial areas, there is high street-side activity.

From Table 7 it is known that the class of side obstacles at the research location is High. This condition is because the weighted number of events per 200 m per hour (two sides) is between 500 - 899. The research location is located in a Commercial Area, there is high road side activity, which uses Side Obstacle Class "T".

Free Flow Speed Analysis

Based on the results of the calculation, the free flow speed on Jalan Tukad Pakerisan Denpasar is 32.32 km / hour.

Road Capacity Analysis

The following is the calculation of road section capacity for the Tukad Pakerisan Denpasar Road section:

- The basic capacity (Co) is 2900 skr/hr / lane.

- Lane width is 7 meters so the effective lane width factor (FCLJ) is 1.

- The direction separation factor (FCPA) is 1.00 because the road section is divided 50% - 50% (two directions).

- The capacity adjustment factor for the effect of side obstacles (FCHS) with a kerb width of 1 m is 0.81.

- The city size adjustment factor (FCUK) is 0.94.

So the capacity of the Tukad Pakerisan Denpasar road section is:

C = C0 x FCLJ x FCPA x FCHS x FCUK

C = 2900 x 1 x 1,00 x 0,81 x 0,94

C = 2208,1 skr/hour/lane

Based on the results of the above calculations, it is known that the capacity (C) on the Tukad Pakerisan Denpasar Road section is 2208.1 skr / hour / lane

Degree of Saturation

The following is an analysis of the degree of saturation at the highest peak hour for Jalan Tukad Pakerisan Denpasar:

- Peak hour traffic volume = 1888.75 skr/hour

- Average traffic volume = 1515.2 skr/hour

- Road capacity = 2208.1 skr/hour

So the Degree of Saturation (DJ) is:

When Peak Hour Volume

DJ = Q/C

DJ = 1888,75/2208,1

DJ = 0,85

When Volume Average :

DJ = Q/C

DJ = 1515,2/2208,1

DJ = 0,68

Based on the results of the above calculations, it is known that the degree of saturation on the Tukad Pakerisan Denpasar Road section is 0.68.

Travel Time Analysis

The following is the calculation of travel time on Jalan Tukad Pakerisan Denpasar:

Travel Time (WT)

WT = 1/VT

WT = 1/24,5

WT = 0.041 jam

4.8 Road Service Level

The level of service of the road on the traffic on Tukad Pakerisan Denpasar Road is located at level D when viewed from the comparison of travel speed with the degree of saturation (Transportation Research Board 1994) as shown in Figure 4 and Figure 5.

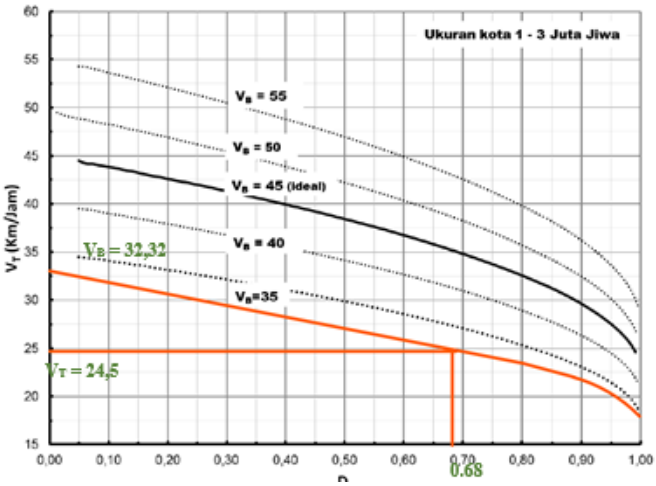


Fig 4. Speed Level as a function of Q/C for 2/2 TT roads

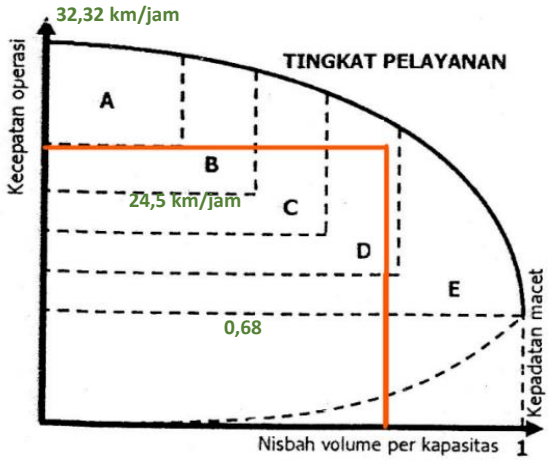


Fig 5. The level of service of a road based on a comparison of the degree of saturation compared to the travel speed

For Level of Service roads that are reviewed by the degree of saturation value only, according to MKJI 1997, have a value of C, The flow is stable but the speed of movement and vehicle movement is limited by traffic conditions, the driver is limited in choosing the speed.

Reference

[1] BPS Kota Denpasar, 2022, *Denpasar Dalam Angka 2022*, BPS Kota Denpasar.

[2] Departemen PU, 1997, *Manual Kapasitas Jalan Indonesia*, DirjBina Marga, Jakarta.

[3] Pusjatan Balitbang, 2014, *Pedoman Kapasitas Jalan Indonesia*, Kementrian Pekerjaan Umum, Jakarta.

[4] Tamin O.Z. (2000). *Perencanaan & Pemodelan Transportasi.Edisi 2*. ITB.