



Performance Analysis of Interchanges and Roads in Pura Besakih, Karangasem District, Bali Province

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Abstract. This analysis was conducted to analyze the performance of intersections and sections around Besakih Temple, especially during religious ceremonies. A field traffic data survey was conducted by installing a handycam at a predetermined point to determine the performance of intersections and roads. Furthermore, secondary data collection is carried out to support the completeness of the required traffic data. So that the traffic data is obtained. After the data is collected, the analysis of intersections and roads is carried out. From the results of the study, it is found that (1) the performance of the intersection is: the postal one intersection has a traffic volume of 7305.3 pcu/hour, a capacity of 5367.61 pcu/hour, a degree of saturation of 1.369, a delay of 19.2 seconds, and an intersection service level. C. At Postal Intersection 2, the traffic volume is 4973.5 pcu/hour, the capacity is 2810.24 pcu/hour, the degree of saturation is 1.77, the delay is 22.06 seconds, and the service level of the intersection is D. At Postal Intersection 3, the traffic volume is obtained traffic is 7391.4 pcu/hour, capacity is 3924.02 pcu/hour, degree of saturation is 1.88, delay is 23.19 seconds and the service level of intersection D. So that the average intersection volume exceeds the capacity of the intersection. (2) The performance of the road segment is only sought for the degree of saturation: the Winana road section is 0.67, the Besakih highway is 0.46, the Kedugung highway is 0.25 and the Batusesa highway is 0.048.

Keywords: performance, roads, intersections, traffic

INTRODUCTION

Transportation is an inseparable need for all elements of society, both in urban and rural areas [1]. Economic and population growth are indicators that influence the increase in vehicle ownership, so access to public transportation is slowly decreasing due to the affordable prices of vehicles such as cars and motorbikes[9]. Therefore, this rapid growth can cause traffic conflict problems such as accidents, congestion, pollution, and so on [10].

The traffic problems often occur at the intersection around Besakih Temple, namely at Simpang Jl. Kedugung – Jl. Raya Menanga – Jl. Raya Besakih, Simpang Jl. Raya Batusesa – Jl. Raya Besakih, and Simpang Jl. Raya Menanga – Jl. Ps. Besakih Animals [2]. The traffic problems at the intersection around Besakih Temple are caused by religious ceremonies held on certain days, such as during the survey, namely during the Panca Wali Krama Ceremony, held once every ten years. All Balinese people, especially those of the Hindu faith, come to perform prayer ceremonies for several days based on the announcement made by the Besakih Temple ceremony committee. The Hindu community and tourists also witnessed and enjoyed the prayer procession. This causes the volume of vehicles passing at the intersection to increase, as well as both private and public transportation, causing traffic jams and conflicts.

Analysis of unsignalized intersections and road sections on Jalan Suwung Batan Kendal - Jalan Pemelisan shows that the level of service at the intersection without a signal is the level of service E. Meanwhile, the level of service on road sections in the Sidakarya area is on Jalan Suwung Batan Kendal east approach = E, road Suwung Batan Kendal

west approach = C, and Pemelisan road = D [7]. Evaluation of intersections and road sections in Denpasar City with a case study specifically on W.R. Supratman – Jalan Gadung, Jalan W.R. Supratman – walk. Plawa results were obtained at the intersection of W.R. Supratman – Jalan Ratna – Jalan Plawa; the service level for Jalan Ratna is B, Jalan W.R. West Supratman is C, Jalan W.R. Supratman East is C, and Jalan Plawa is C at the intersection of Jalan W.R. Supratman – Gadung road, level of service on W.R. road. Supratman Timur is C, Jalan W.R. West Supratman is C, and the Gadung road section is A [8]. From the observations, a similar condition has been found, namely that there are frequent queues of vehicles, especially during religious ceremonies and Hindu holy holidays at the intersection of Simpang Jl. Kedugung – Jl. Raya Menanga – Jl. Raya Besakih, Simpang Jl. Raya Batusesa – Jl. Raya Besakih, and Simpang Jl. Raya Menanga – Jl. Ps. Besakih Animals. Apart from that, it is not yet known how the performance of this intersection occurs during peak conditions for religious ceremonies and alternative solutions to overcome existing problems. Therefore, it is necessary to evaluate the performance of unsignalized intersections and road sections in the Besakih Temple area (Case Study of Simpang Jl. Kedugung – Jl. Raya Menanga – Jl. Raya Besakih, Simpang Raya Batusesa – Jl. Raya Menanga).

RESEARCH METHODOLOGY

The steps in this research method start from determining the survey location and data to be reviewed and determining the strategies required for data collection [3]. The next step at the designated study location is to identify the problem. Then, the steps continue with problem definition and goal setting. The next step is to continue with a pilot survey on a small scale to find out what methods and tools can be used and are suitable for surveying in the field and determine the location of the tools and surveyors [5]. This is followed by collecting the necessary data. Primary data consists of traffic volume and geometry of intersections and road sections obtained from surveys. Meanwhile, secondary data consists of population numbers and maps of research locations obtained from relevant agencies outside the research [4]. Furthermore, traffic volume is surveyed regarding traffic variation, peak hour traffic, percentage of non-motorized vehicles, and turning movements [6].

After all the data has been collected from the survey results, the performance of intersections and road sections is analyzed by calculating all the necessary data and entering formulas according to the road capacity manual to get the desired results. After the results are obtained, an analysis of the results is then carried out so that the feasibility of the intersection and road section can be determined, and the results can be used as parameters or future references to maximize performance.

RESULT AND DISCUSSION

Performance analysis of intersections around Besakih Temple

Calculations are then carried out according to MKJI based on the data obtained in the field.

Junction Post 1

Capacity (C) = $2700 \times 0.88 \times 1 \times 0.86 \times 0.86 \times 2.51 \times 1.03 \times 1.1 = 4879.64$ passenger car units/hours

Degree of saturation (DS) = $Q/C = 7305.3/4879.64 = 1.49$

Average delay (DT1) = $2 + (8.2078 \times 1.369) - ((1 - 1.369) \times 2) = 15.2$ seconds/passenger car units

Average delay on main roads (Dma) = $1.8 + (5.8234 \times 1.369) - ((1 - 1.369) \times 1.8) = 10.4$ seconds/passenger car units

Average delay of minor roads (Dmi) = 0

Delay (D) = $4 + 15.2 = 19.2$ seconds/passenger car units

(QP%)upper limit = $(47.71 \times 1.369) - (24.68 \times 1.369^2) + (46.47 \times 1.369^3) = 138.8\%$

(QP%)lower limit = $(9.02 \times 1.369) + (20.66 \times 1.369^2) + (10.49 \times 1.369^3) = 77.9\%$

Chance of queuing = $77.9\% - 138.8\% \approx 78\% - 139\%$

Junction Post 2

Capacity (C) = $2700 \times 0.88 \times 1 \times 0.86 \times 0.86 \times 1.265 \times 1.07 \times 1.1 = 2810.24$ passenger car units /hours

Degree of saturation (DS) = $Q/C = 4973.5/2810.24 = 1.77$

Average delay (DT1) = $2 + (8.2078 \times 1.77) - ((1 - 1.77) \times 2) = 18.06$ seconds/passenger car units

Average delay on main roads (Dma) = $1.8 + (5.8234 \times 1.77) - ((1 - 1.77) \times 1.8) = 13.49$ seconds/passenger car units

Average delay of minor roads (Dmi) = 0

Delay (D) = $DG + DT1 = 4 + 18.06 = 22.06$ seconds/passenger car units

(QP%) upper limit = $(47.71 \times 1.77) - (24.68 \times 1.77^2) + (46.47 \times 1.77^3) = 224.81\%$
(QP%) lower limit = $(9.02 \times 1.369) + (20.66 \times 1.369^2) + (10.49 \times 1.369^3) = 118.86\%$
Chance of queuing = $118.86\% - 225.81\% \approx 119\% - 225\%$

Junction Post 3

Capacity (C) = $2700 \times 0.88 \times 1 \times 0.86 \times 0.86 \times 1.4 \times 1.35 \times 1.1 = 3924.02$ passenger car units/hours
Degree of saturation (DS) = $Q/C = 7391.4/3924.02 = 1.88$
Average delay (DT1) = $2 + (8.2078 \times 1.88) - ((1 - 1.88) \times 2) = 19.19$ seconds/ passenger car units
Average delay on main roads (Dma) = $1.8 + (5.8234 \times 1.88) - ((1 - 1.88) \times 1.8) = 14.33$ seconds/passenger car units
Average delay of minor roads (Dmi) = 0
Delay (D) = $DG + DT1 = 4 + 19.19 = 23.19$ seconds/passenger car units
(QP%) upper limit = $(47.71 \times 1.77) - (24.68 \times 1.77^2) + (46.47 \times 1.77^3) = 311.24\%$
(QP%) lower limit = $(9.02 \times 1.369) + (20.66 \times 1.369^2) + (10.49 \times 1.369^3) = 159.6\%$
Chance of queuing = $159.6\% - 311.24\% \approx 160\% - 312\%$

TABLE 1. Performance of the intersection around Besakih Temple

No	Aspect	Times	Volume (passenger car units /hours)	Capacity (passenger car units/hours)	Degree of Saturation (DS)	Delay (passenger car units/hours)	Queue Opportunities (%)
1	Junction Post 1	11.00-12.00	7305.3	5367.61	1.369	19.2	78%-139%
2	Junction Post 2	11.00-12.00	4973.5	2810.24	1.77	22.06	119%-225%
3	Junction Post 3	11.00-12.00	7391.4	3924.02	1.88	23.19	160%-312%

It can be seen in Table 1, which states that the intersection at post 1 has a volume of 7305.3 passenger car units/hour and a delay of 19.2. The post-two intersection has a volume of 4973.5 passenger car units/hour and a postponement of 22.06. The post-three intersection has a volume of 7391.4 passenger car units/hour and a delay of 23.19.

Performance Analysis of Roads Around Besakih Temple

Data was obtained based on the field survey results, which then calculated the capacity and degree of saturation.

Kedugung Road Section

Capacity (C) = $2,700 \times 0.87 \times 0.94 \times 0.89 \times 0.86 = 1815.23$ passenger car units/hours
From these calculations, the capacity is 1815.23 passenger car units/hours
Degree of saturation (DS) = $Q/C = 274.8/1815.23 = 0.25$
The resulting degree of saturation was 0.25

Menanga Road Section

Capacity (C) = $2,700 \times 0.87 \times 1.0 \times 1.0 \times 0.86 = 2169.78$ passenger car units/hours
Degree of saturation (DS) = $Q/C = 1255.9/2169.78 = 0.67$
And the degree of saturation was obtained at 0.67

Besakih Highway Section

Capacity (C) = $2,700 \times 0.87 \times 1.0 \times 0.87 \times 0.86 = 2043.63$ passenger car units/hours
The Besakih highway has a capacity of 2043.63 passenger car units/hours
Degree of saturation (DS) = $Q/C = 796.3/2169.78 = 0.46$
The degree of saturation is 0.46

Batusesa Road Section

Capacity (C) = $2,700 \times 0.87 \times 1.0 \times 0.89 \times 0.86 = 1797.92$ passenger car units/hours
From the calculation results, the capacity of the Batusesa road is 1797.92 passenger car units/hours.

Degree of saturation (DS)= $Q/C = 83/2169.78 = 0.048$
The degree of saturation was obtained at 0.048

TABLE 2. Performance of Roads Around Besakih Temple

No	Nama Ruas Jalan	Traffic Volume (passenger car units/hours)	Capacity (passenger car units/hours)	Degree of Saturation
1	Kedugung Road Section	274.8	1815.23	0.25
2	Menanga Road Section	1255.9	2169.78	0.67
3	Besakih Highway Section	796.3	2169.78	0.46
4	Batusesa Road Section	83	1797.92	0.048

In Table 2, the performance of the Kedungu Road Section has a saturation degree of 0.25; the Menanga Road Section has a saturation degree of 0.65, the Besakih Highway Section has a saturation degree of 0.46, the Batusesa Road Section has a saturation degree of 0.048

Alternative Solutions

According to the results that have been discussed, it can be said that all road performance has a degree of saturation <0.75 , and all intersections have a degree of saturation >1 . To avoid traffic jams and undesirable things, creating a one-way traffic circulation pattern and creating new alternative roads for better traffic management is necessary. As an alternative traffic circulation pattern, vehicles entering from the Kedugung highway go north towards the Menga road. After that, exactly 100 meters before the parking lot at Besakih Temple, there is a large area that has the potential to allow vehicles to exit directly onto the Besakih road. For the exit, vehicles are directed towards the Batusesa road, which will exit at Rendang village. This can make traffic circulation around Besakih Temple run effectively and not cause congestion. This can be reassessed because the traffic requirements during religious ceremonies at Besakih Temple are large and require sufficient traffic arrangements and capacity to accommodate pilgrims or people who will perform prayers there.

CONCLUSION

Based on calculations of the performance of the intersections around Besakih Temple, the saturation degree of all DS intersections was >1.0 , namely at the post one intersection, the volume was 7305.3 pcu/hour, the capacity was 5367.61 pcu/hour, the degree of saturation was 1.369, the delay was 19.2 seconds, and the level of service at intersection C. At intersection post 2, the volume was 4973.5 pcu/hour, the capacity was 2810.24 pcu/hour, the degree of saturation was 1.77, the delay was 22.06 seconds, and the level of service at intersection D. At intersection post 3, the volume is 7391.4 pcu/hour, the capacity is 3924.02 pcu/hour, the degree of saturation is 1.88, the delay is 23.19 seconds, and the level of service at intersection D. So the traffic volume exceeds the intersection capacity.

Based on the calculation of the performance of the roads around Besakih Temple, the degree of saturation for all road sections is $DS < 0.75$; namely, on the Menga road, the degree of saturation is 0.67; on the Besakih highway, it is 0.46; on the Kedugung highway, it is 0.46. 0.25, and on the Batusesa highway, it was obtained 0.048. The traffic volume obtained was on the Menga road section, which was found to be 1255.9 pcu/hour, the Kedugung highway was 274.8 pcu/hour, the Besakih highway was 796.3 pcu/hour, and the Batu Sesa highway was 83 pcu/hour. The capacity obtained on the Menga highway is 2169.78 pcu/hour; on the Besakih highway, it is 2043.63 pcu/hour; on the Kedugung highway, it is 1815.23 pcu/hour; and on the Batusesa road, it is 1792 pcu/hour. So, the traffic volume is almost close to capacity.

Based on the results of the discussion, it can be concluded that all road performance has a degree of saturation <0.75 , so there is no problem. Meanwhile, for the performance of all intersections, $DS > 1$ is obtained. To prevent unwanted congestion, creating a one-way traffic circulation pattern and/or new alternative roads for better traffic management is necessary, considering population growth and the large number of tourists or domestic or foreign guests who come to Bali, especially Pura Besakih, as a temple. It's the biggest in Bali.

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REFERENCES

- [1] Alamsyah, A.A. 2013 .*Rekayasa Lalu Lintas*, Penerbit Universitas Muhammadiyah Malang.
- [2] Badan Pusat Statistik Karangasem. 2017. *Karangasem Dalam Angka 2017*. Berita Resmi Statistik Karangasem.
- [3] Dirjen Perhubungan (Dephub). 1998. *Pedoman Penyelenggaraan Parkir*. Jakarta: Direktorat Jendral Perhubungan Darat.
- [4] Direktorat General Bina Marga Departemen Pekerjaan Umum. 1997. *Manual Kapasitas Jalan (MKJI) 1997*. Jakarta: Kementrian Pekerjaan Umum.
- [5] Morlok, E.K., 1991, *Pengantar Teknik dan Perencanaan Transportasi*. Terjemahan Johan K. Hainim, Erlangga, Jakarta.
- [6] Oglesby, Clarkson. H. 1999. *Teknik Jalan Raya*. Penerbit Erlangga, Jakarta.
- [7] Paramartha, A.A.N. D. 2015. *Kinerja Simpang dan Ruas Jalan Disekitarnya di Kota Denpasar. (Studi Kasus: Jl. Suwung Batan Kendal – Jl. Pemelisan)*. Tugas Akhir, Program Studi Teknik Sipil Fakultas Teknik Universitas Udayana, Bukit Jimbaran.
- [8] Pontoh, R. R. 2015. *Evaluasi Kinerja Simpang dan Ruas Jalan di Kota Denpasar (Studi Kasus: Jl. W.R. Supratman – Jl. Gadung, Jl. W.R. Supratman – Jl. Ratna – Jl. Plawa*. Tugas Akhir, Program Studi Teknik Sipil Fakultas Teknik Universitas Udayana, Bukit Jimbaran.
- [9] Tamin, O. Z. 2000.*Perencanaan dan Pemodelan Transportasi.Edisi kedua*.ITB, Bandung.
- [10] Warpani, S.P., 2002, *Pengelolaan Lalu Lintas dan Angkutan Jalan*; Penerbit ITB, Bandung.