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Traffic Congestion Analysis and Ten-Year Traffic Condition Forecasting Using the PKJI 2023 Method
(Case Study : Siliwangi Cicurug-Benda Road)

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Abstract

Sukabumi Regency in West Java has experienced rapid development, increasing the need for efficient transportation infrastructure to support mobility and goods distribution. One strategic corridor is the Siliwangi Cicurug–Benda Highway section STA 30+000–STA 31+000, which often experiences congestion, particularly during operational disruptions of major infrastructure such as Bocimi Toll Road Section 2. This study analyzes road performance using the PKJI 2023 method before and after the toll road resumed operation. Results show that traffic volume decreased from 4,290 vehicles/hour during toll disruption to 3,788 vehicles/hour after reopening. Road capacity was recorded at 3,352.3 smp/hour, while the degree of saturation (DJ) improved from 0.85 to 0.70, indicating better traffic performance. Traffic growth projections for the next decade show vehicle volume increasing from 2,480.03 smp/hour in 2026 to 3,708.76 smp/hour in 2035, with DJ exceeding the recommended limit of 0.85 starting in 2029 and reaching 1.11 in 2035. Road widening is proposed as a solution, increasing capacity to 4,216.40 smp/hour and reducing DJ from 0.74 to 0.59, thus improving performance. However, projections indicate DJ may again exceed acceptable limits by 2035, suggesting the need for additional long-term traffic management strategies to maintain optimal road performance.

Keywords: Road Performance, PKJI 2023, Degree of Saturation, Road Widening, Traffic Projection

1. INTRODUCTION

Cicurug District is one of the administrative regions in Sukabumi Regency, encompassing an area of approximately 52.16 km², which constitutes merely about 1.25% of the total area of Sukabumi Regency, measured at 4,164.2 km² (BPS, 2024). Despite its relatively modest size, this district accommodates around 140,806 residents, rendering it the most densely populated district in the regency (BPS, 2024). According to data published by the Central Bureau of Statistics, Sukabumi Regency has witnessed a notable increase in population between 2015 and 2024, which has been linked to a corresponding surge in motor vehicle ownership and road use intensity (Pakri & Rahayu, 2021; Yulianto & Subakti, 2022). This demographic growth has had a direct impact on community mobility, contributing to rising traffic volumes and escalating congestion on several key arterial roads (Setyawan & Santosa, 2020).

One of the most critically affected segments is the Siliwangi Cicurug-Benda Road, spanning from STA 30+000 to STA 31+000. This segment serves as a national road with a 2/2-TT configuration, located within a highly active area characterized by markets, retail establishments, and various community centers (Fitzpatrick & Nowlin, 2020; Sharma &

Singh, 2019). Roadside activities such as loading and unloading of goods, coupled with irregular on-street parking, further reduce the effective capacity of the roadway, thereby intensifying congestion—a pattern consistently observed in urban environments with dense commercial frontage (Turner & Combs, 2015; Bekker et al., 1999). The situation was exacerbated in mid-2024 when the operation of Bocimi Toll Road Section 2 was suspended due to a landslide, necessitating traffic diversions through this already congested segment (BPS, 2024). Data collected in 2024 indicated that the degree of saturation on this road reached a value of 0.85, approaching the maximum threshold stipulated by the Indonesian Highway Capacity Guidelines (PKJI, 2023) (Permadi et al., 2023).

Several prior studies have investigated traffic performance under diverse influencing factors. For instance, Permadi et al. (2023) conducted an analysis of the Ahmad Yani Street segment in Sukabumi City to evaluate the impact of on-street parking using the MKJI 1997 method and PTV-VISSIM software simulation, revealing a significant increase in the degree of saturation from 0.40 to 0.92 and a decline in the level of service from C to E. Similarly, Fahilah et al. (2024) examined the performance of an unsignalized intersection at Karang Tengah–Nagrak using field surveys, least squares forecasting, and the PKJI 2023 framework. Their study highlighted the necessity of road widening interventions to sustain acceptable intersection performance up to 2025, although persistent growth trends signaled the need for further long-term mitigation (Fridman, 2008; Roeva, 2012). Additionally, Tarigan (2024) explored the impact of side friction on vehicle speeds in traditional market areas, concluding that side friction exerted a more pronounced effect on passenger car speeds than on motorcycles—a finding consistent with observations by Ningrum et al. (2023), who reported that high frequencies of side friction activities were closely correlated with increased traffic volumes and substantial congestion on Dr. Muhammad Isa Road in Palembang. Broader studies by Jain and Tiwari (2017) and Wang et al. (2011) also emphasize how heterogeneous traffic compositions and side activities can severely affect roadway capacities.

Building upon these earlier studies, the present research addresses a distinct gap by focusing specifically on a comparative analysis of the capacity and performance of the Siliwangi Cicurug-Benda Road segment before and after the reopening of Bocimi Toll Road Section 2. Moreover, this study aims to project the traffic conditions on this segment over the next decade using the PKJI 2023 methodology, integrating growth models consistent with least squares approaches (Yulianto & Subakti, 2022). The scientific novelty of this work lies in its integration of comparative performance assessment and long-term forecasting on a segment directly influenced by major traffic diversion events, a perspective not comprehensively covered in previous research (Pakri & Rahayu, 2021; Setyawan & Santosa, 2020).

Accordingly, this study seeks to analyze the differences in traffic volume, capacity, and operational performance of the Siliwangi Cicurug-Benda segment under two distinct conditions—when Bocimi Toll Road Section 2 was non-operational and after it resumed operation. In addition, it aims to forecast traffic flow conditions for the next ten years and evaluate potential alternative solutions, such as road widening, to ensure that the level of service remains within acceptable standards as outlined in PKJI 2023 (Jain & Tiwari, 2017; Sharma & Singh, 2019). Through this research, it is anticipated that valuable empirical insights and adaptive traffic management recommendations can be provided to support sustainable road infrastructure planning in anticipation of future increases in traffic demand (Turner & Combs, 2015; Fridman, 2008).

2. RESEARCH METHOD

A. Research Location

This research was conducted on the Siliwangi Cicurug-Benda Road segment, located between STA 30+000 and STA 31+000, in Cicurug District, Sukabumi Regency, West Java. This segment is an essential interurban road that frequently experiences congestion due to high traffic volume and roadside activities. The location of the study can be seen in Figure 1.

Figure 1 Siliwangi Cicurug-Benda Road segment, located between STA 30+000 and STA 31+000 (source: google maps)

B. Research Data

Data collection was carried out through field surveys (primary data) and by obtaining supporting documents from relevant institutions (secondary data).

Primary data were collected through direct observation and measurements at the study site. The following primary data were gathered:

1. Road geometric characteristics, including carriageway width, shoulder width, and number of lanes. It was noted that this road segment does not have a median separator.
2. Traffic volume data, collected using the Traffic Counter application. Vehicle counts were performed manually and recorded on prepared data sheets. The classification followed standard vehicle types. Observations were conducted in 1-hour intervals to obtain hourly traffic volumes.
3. Roadside activity observations, which involved documenting pedestrian activities and parked or stopping vehicles that could affect traffic flow.

Secondary data were obtained from governmental agencies and academic literature. These included:

1. Motor vehicle registration data in Sukabumi Regency from 2014 to 2023, sourced from the Bapenda West Java website, to be used for predicting traffic growth over the next 10 years.
2. Literature studies from documents such as PKJI (2023), conference proceedings, undergraduate theses, scientific journals, and government regulations relevant to this research.

Population data from Cicurug and nearby districts (Parungkuda and Cidahu), obtained from the Sukabumi Regency Central Bureau of Statistics.

Data analysis was conducted based on the theoretical framework outlined in the literature review. After traffic counts were completed during designated observation periods, data

were processed to obtain the total number of vehicles by type. Using passenger car equivalents (PCE or EMP), these counts were converted into a uniform unit (PCU/hour) following the guidelines in PKJI (2023).

Capacity analysis was performed for the road segment after Bocimi Toll Road Section 2 resumed operation. This included calculations using:

- Average Daily Traffic (ADT),
- Adjustment factors for lane width FCL
- Directional distribution FCPA
- Side friction and shoulder width FCHS.

The objective was to determine the segment capacity, peak hour volume, and the corresponding degree of saturation. Road performance was analyzed based on ADT, calculated capacity, population data, and geometric characteristics to determine:

- Degree of saturation (DJ),
- Passenger car speed and travel time,
- Level of service (LOS).

Historical data on the total number of registered vehicles from 2014 to 2023 were processed to compute traffic growth projections using forecasting techniques, providing an estimate of the potential increase in traffic volume over the next 10 years. The forecasted additional volume each year was added to the 2025 base volume (after Bocimi Toll Road Section 2 resumed operation). This approach provided projected traffic volumes up to 2035.

As a traffic engineering intervention, road widening was proposed as an alternative solution to enhance road capacity. The design widths tested were based on the Indonesian Ministry of Public Works and Public Housing Regulation No. 5 of 2023 on Technical Requirements for Roads. Finally, traffic volume forecasts for the next 10 years were combined with the recalculated road capacities under the widening scenario to analyze future performance, assessing whether the proposed solution would maintain an acceptable level of service.

C. Research Flowchart

To summarize the overall methodology, a research flowchart illustrating the sequence of data collection, processing, analysis, and forecasting is presented in Figure 2.

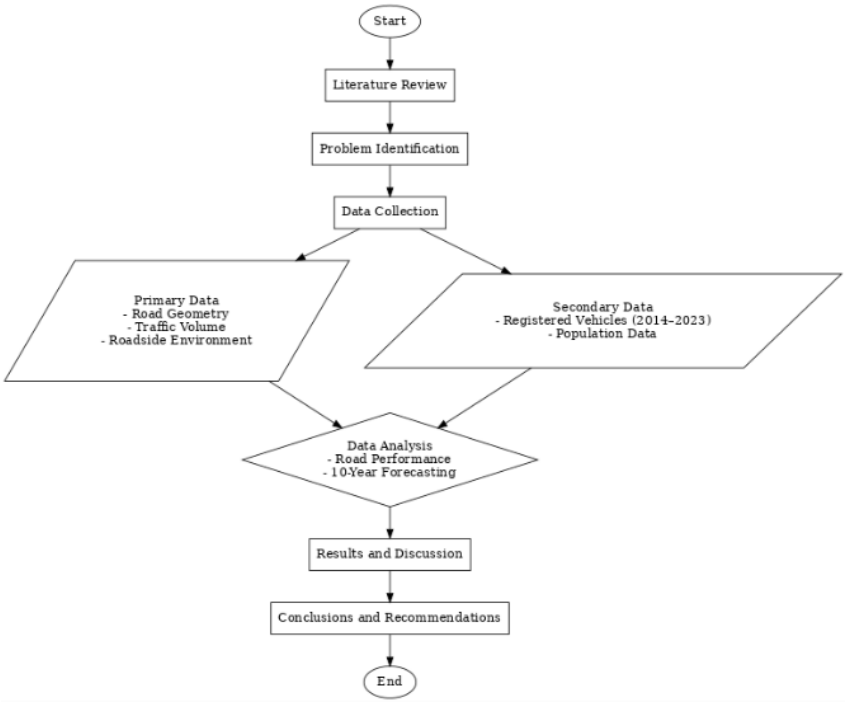

Figure 2 Research Flowchart

3. RESULT AND DISCUSSION

The Siliwangi Cicurug–Benda road segment (STA 30+000 – STA 31+000) serves as a Class I arterial, linking critical activity centers in Cicurug District, Sukabumi Regency. This segment traverses an area with intense commercial land use, frequent pedestrian movements, and roadside operations such as parking and goods unloading, all contributing to very high side friction.

Field observations revealed a two-lane undivided roadway (2/2 TT) with an effective width of 8 meters, consisting of 3.5 m and 4.5 m lanes, a 0.5 m shoulder, and lacking a median. Under these geometric and operational conditions, the calculated segment capacity was approximately 3,352 PCU/hour.

Traffic surveys indicated that during the temporary closure of Bocimi Toll Section 2 in 2024, the segment experienced a peak volume of 2,857 PCU/hour, resulting in a degree of saturation (DS) of 0.85 (LOS E), indicating unstable flow prone to delays. After the toll resumed operations in early 2025, the peak flow reduced to 2,344 PCU/hour, improving the DS to 0.70 (LOS C), demonstrating more stable yet still constrained traffic conditions.

Future Traffic Demand Projection Without Road Improvements

To predict future traffic loads, historical data on registered vehicles in Sukabumi Regency from 2014 to 2023 was analyzed using the least squares method. This projection indicated a continuous growth in motor vehicle ownership, leading to an estimated traffic demand as shown below.

Tabel 1 Forecasted Traffic Volume for the Next 10 Years

Year	Traffic Volume (PCU/h)
2026	2,480
2027	2,617
2028	2,753
2029	2,890
2030	3,026
2031	3,163
2032	3,299
2033	3,436
2034	3,572
2035	3,709

Using this forecast and maintaining current road geometry (capacity **3,352 PCU/h**), the DS was projected over the next decade, revealing the following trend.

Tabel 2 Degree of Saturation Forecast Without Improvements

Year	DS
2026	0.74
2027	0.78
2028	0.82
2029	0.86
2030	0.90
2031	0.94
2032	0.98
2033	1.02
2034	1.07
2035	1.11

These projections indicate that by 2029, the segment would exceed the recommended threshold (DS > 0.85), moving into LOS D-E transition, and by 2035 would reach LOS F, characterized by forced flow with significant queues and delays.

An engineering solution was explored by widening the carriageway by 3 meters, increasing the total width to 11 m, and expanding the shoulder to 1 m. This improvement raised the estimated capacity to approximately 4,216 PCU/hour, a 26% increase from the existing configuration. When applying the same traffic growth forecasts under this enhanced scenario, the DS progression over the next decade was recalculated as follows.

Tabel 3 Degree of Saturation Forecast After Road Widening

Year	DS
2026	0.59
2027	0.62
2028	0.65
2029	0.69
2030	0.72
2031	0.75
2032	0.78
2033	0.81

Year	DS
2034	0.85
2035	0.88

Compared to the no-widening scenario, the widening effectively postpones the approach to critical saturation by approximately 5 to 6 years. The DS remains below the threshold of 0.85 through 2034, signifying operations within LOS C to D — stable to moderately constrained flow. Only in 2035 does it approach LOS E, indicating operations near capacity.

This analysis highlights that without intervention, the Siliwangi Cicurug–Benda segment will face progressive congestion, reaching unacceptable service levels within a decade. The proposed widening substantially mitigates this risk, providing greater operational resilience and maintaining service quality at acceptable levels for a longer period.

However, the fact that DS is still projected to reach 0.88 by 2035, even after widening, underscores the need for integrated solutions beyond geometric expansion alone. These may include:

1. Access management and regulation of roadside activities, particularly informal parking and loading which were major contributors to side friction.
2. Pedestrian safety infrastructure to reduce direct interference with traffic flow.
3. Coordination with land use planning authorities to control future development intensity along the corridor.

In summary, while the carriageway widening represents an effective short-to-medium-term intervention, it should be viewed as part of a broader strategy combining geometric, regulatory, and demand management measures to sustainably address long-term mobility demands in Sukabumi.

4. CONCLUSION

The reopening of Bocimi Toll Section 2 resulted in a reduction of traffic volume by 502 vehicles per hour (from 4,290 to 3,788 veh/h) on Jalan Raya Siliwangi Cicurug–Benda STA 30+000 – STA 31+000. The calculated capacity of the road segment is 3,352.32 PCU/hour. The level of service (LOS) improved from E (DS = 0.85) during the toll closure to C (DS = 0.70) after the toll resumed operation, indicating a shift from near-capacity unstable flow to a more stable traffic condition. Traffic flow projections indicate that the volume on Jalan Raya Siliwangi Cicurug–Benda STA 30+000 – STA 31+000 will continue to increase from 2,480.03 PCU/hour in 2026 to 3,708.76 PCU/hour by 2035. Consequently, the degree of saturation is expected to exceed 0.85 by 2029 (DS = 0.86) and reach 1.11 by 2035, signaling a significant risk of congestion that necessitates further interventions. An appropriate mitigation measure is widening the carriageway and shoulders. This solution increases the road capacity from 3,352.3 to 4,216.40 PCU/hour, effectively reducing the degree of saturation from 0.74 to 0.59, maintaining LOS C. Projections over the next ten years indicate that the DS will remain below 0.85 until 2033, but will exceed this threshold in 2034–2035, highlighting the need for additional long-term strategies.

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