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Optimizing Toll Exit Design for High-Speed Rail Accessibility Using VISUM Traffic Modeling

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ABSTRACT

Improving accessibility to high-speed rail stations is essential for ensuring efficient and integrated transportation systems. Tegalluar Station, part of the Jakarta–Bandung High-Speed Railway network, is currently served by toll exits that were not designed for high traffic demand, resulting in congestion and reduced network performance. This study aims to evaluate and optimize toll exit configurations to improve accessibility to Tegalluar Station. Traffic modeling and scenario analysis were conducted using PTV VISUM, supported by calibrated origin–destination matrices and evaluated through Multi-Criteria Analysis. Four development alternatives were assessed based on traffic volume, queue length, travel time, network performance, spatial constraints, and cost. The results show that the full-access scenario combining the existing KM 149 toll exit with additional on–off ramps at KM 151 generates the highest traffic demand, reaching 19,956 vehicles per day, while also improving traffic distribution across the network. However, multi-criteria evaluation indicates that a staged development strategy provides the most effective and feasible solution. Gradual implementation starting from optimization of existing access significantly reduces congestion and improves accessibility without overloading the surrounding road network. These findings demonstrate that simulation-based and multi-criteria planning offers a robust decision-support framework for toll exit design supporting high-speed rail accessibility.

Keywords: *Toll exit design; High-speed rail accessibility; VISUM modeling; Traffic simulation; Multi-criteria analysis.*

1. Introduction

The development of mass transportation modes such as the Jakarta-Bandung High Speed Train is one of the important achievements in efforts to modernize the national transportation system. Tegalluar Station, located in the Bandung Regency, serves as one of the main nodes in the high-speed train network [1]. Although it has been designed to support high mobility and intermodal connectivity, integrating access to the station from both private vehicles and public transport still poses several challenges. One of the main issues is the limited design and capacity of the exit from the toll access, which is directly connected to the station area. [2]. These problems include the potential for traffic congestion, the lack of optimal vehicle flow, and limited space for movement during peak hours [3].

The development of high-speed rail infrastructure, such as the Indonesia-China High Speed Train serving Tegalluar Station, requires adequate accessibility to ensure its effectiveness. However, the current access system relies heavily on existing toll exits that were not originally designed for high passenger movement volumes. Without proper traffic engineering interventions, increased demand can lead to congestion, delays, and inefficiencies.

Previous studies on intermodal access (e.g., Xie & Levinson, 2011; Tamin, 2014) highlighted the importance of integrating transportation infrastructure with the surrounding network. However,

Vol. 6, No. 2, pp. 219-232
Submit: 24-06-2025 |
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Publish: 30-01-2026 |

research on access design strategies for high-speed train stations in the Indonesian context is still limited.

This study aims to fill the gap by analyzing and optimizing toll exit alternatives near Tegalluar Station using the VISUM traffic modeling software. The study evaluates various configurations for operational efficiency and proposes recommendations for future planning.

The novelty of this study lies in integrating VISUM-based traffic simulation with a multi-stage toll-exit optimization framework to support high-speed rail accessibility, a combination rarely applied in toll-access planning for intermodal transport hubs in developing countries.

2. Material And Method

Throughout 2024, PT KCIC (Whoosh) has recorded as many as 6.06 million passengers using Whoosh from and to four high-speed train stations, namely Halim, Karawang, Padalarang, and Tegalluar Summarecon. Whoosh has proven to be, and continues to be, the go-to choice for quick, convenient travel [4].

The Whoosh with the Halim Station to Padalarang route will be the public's main choice in 2024, with a total of 2 million passengers served, followed by the Padalarang – Halim route with 1.9 million passengers, and Halim – Tegalluar Summarecon with 748 thousand passengers. Halim Station became the busiest station, serving 3.1 million passengers in 1 year. Followed by Padalarang with 2.2 million passengers, Tegalluar Summarecon with 741 thousand passengers, and Karawang with 2,000 passengers [4].

The Directorate General of Highways of the Ministry of Public Works has planned the development of a toll road network in West Java to improve connectivity and support economic growth. Some important information regarding this development is:

1. Toll Network Improvement
   Toll road sections that are already operating: Cisumdawu Toll Road (Cileunyi-Sumedang-Dawuan), connecting Bandung, Majalengka, and Kertajati Airport. Bogor-Ciawi-Sukabumi (Bocimi) Toll Road Section 1 & 2, connecting Bogor and Sukabumi.
   Toll road section in the development stage: Bocimi Toll Road Sections 3 & 4, extending the connection between Bogor and Sukabumi. The Jakarta-Cikampek II South Toll Road reduces congestion and increases access to the southern area of Jakarta. Patimban Access Toll Road, connecting Patimban Port with the Trans Java toll road.
2. The Gedebage-Tasikmalaya-Cilacap (Cigatas) Toll Road Construction Priority Project, a national strategic project that connects West Java with Central Java along 108 km.
   Bandung Intra-Urban Toll Road (BIUTR) to reduce congestion in the city of Bandung.

Bogor Ring Road (BORR) Section 3B Toll Road, to reduce congestion in the center of Bogor city [5].

On this road, there is often traffic jams during peak hours. This study aims to determine the capacity and performance of existing traffic on Jalan Jendral Suharto. This research was analyzed using the Indonesian Road Capacity Guidelines (PKJI2014). Traffic performance analysis begins with calculating traffic flow during peak hours, roadside obstacles, road capacity, degree of saturation, and analysis of the average speed of the space [6]

The survey on traffic volume calculation on the TB Simatupang Road and the JORR Exit Ramp of the Fatmawati Toll was conducted for 9 hours (06.00-08.00, 13.00-15.00, and 18.00-20.00) in September 2023. Traffic counts by category for each direction are recorded every 15 minutes. To convert various vehicle categories to a general scale, use passenger car units (smp) according to MKJI 1997 [7].

The access road *Exit Toll* KM 151 Padalarang-Cileunyi Toll Road on line A is in the form of *an off-ramp* from the direction of Padalarang and *an on-ramp* towards Cileunyi. Meanwhile, the access road *Exit Toll* KM 151 Padalarang-Cileunyi Toll Road on line B is an off-ramp from the direction of Cileunyi to the Moda Transfer Area at the *KM 149* rest area.

The *Exit Toll Gate* System KM 151 Padalarang-Cileunyi Toll Road on line A, both those exiting from the direction of Padalarang and those entering the direction of Cileunyi are affected by the

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Vol. 6, No. 2, pp. 219-232
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payment system, where the payment system follows a payment system that is properly running, namely closed because the toll fee depends on the distance or gates, where tapping the card at the gate of origin and *tapping* card at the destination gate for payment.

As shown in the **picture** of the KM 151 Exit Toll *Road, the access road* of the Padalarang-Cileunyi Toll Road consists of:

1. *Off Ramp* GBLA : facilitate the movement of the Padalarang-Cileunyi Toll Road on line A from the direction of Padalarang to the GBLA access road and KCJB Tegalluar station.
2. *On Ramp* Line-A : facilitates movement from KCJB Tegalluar station and surrounding areas to the Padalarang-Cileunyi Toll Road on Line A towards Cileunyi.
3. *Off Ramp* Sweet-B : facilitate the movement of the Padalarang-Cileunyi Toll Road on line B from the direction of Cileunyi to Moda Shifts who were before the *rest area* KM 149.

The layout of the KM 151 Exit Toll *access road* on Line A & Line B of the Padalarang-Cileunyi Toll Road is as follows:

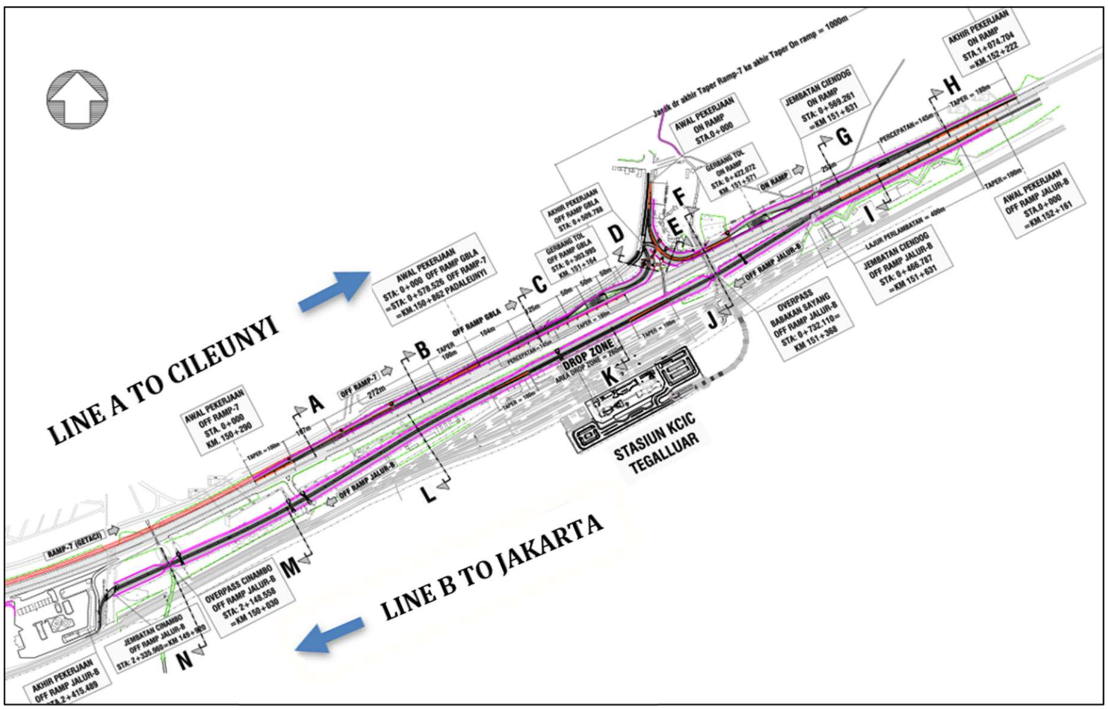

Figure 1. Research Flow Chart: Lay out access road, Exit Toll KM 151 Line A & B Padalarang-Cileunyi Toll Road
Source: Basic Design & ROW Plan Exit Toll Access at KM 151 Line A & B Padalarang-Cileunyi Toll Road, 2023

Several researchers have emphasized the importance of seamless integration between expressways and rapid rail stations (Yatskiv et al., 2019). VISUM has been widely used in evaluating transportation networks (PTV Group, 2022). Studies by Rahardjo et al. (2020) and Hidayat (2021) used a similar simulation model to assess urban access routes, confirming its reliability in scenario-based evaluations. This study expands on the findings by applying VISUM to a new context: evaluating toll exit configurations to support national strategic infrastructure projects in Indonesia.

The entire load is carried out using the PTV VISUM software, Where this software is integrated with GIS, Can perform scripts using Python, C++, etc., Management of interesting data display because it is synchronized directly with each object that has been created, has many layers that can represent each function such as zones, road networks, routes, territorial boundaries, POIs, etc.,

JICE Journal Innovation of Civil Engineering

Vol. 6, No. 2, pp. 219-232
Submit: 24-06-2025 |
Accepted: 31-12-2025 |
Publish: 30-01-2026 |

advanced analysis procedures such as 4-step models, freight model, activity-based model, public transportation, tour-based model, complete charging process such as Linear User Cost Equilibrium, Incremental Assignment, User Equilibrium, DynamicUser Equilibrium, Bi Criterion Stochastic User Equilibrium (TRIBUT), Stochastic Equilibrium, Dynamic Stochastic Equilibrium.

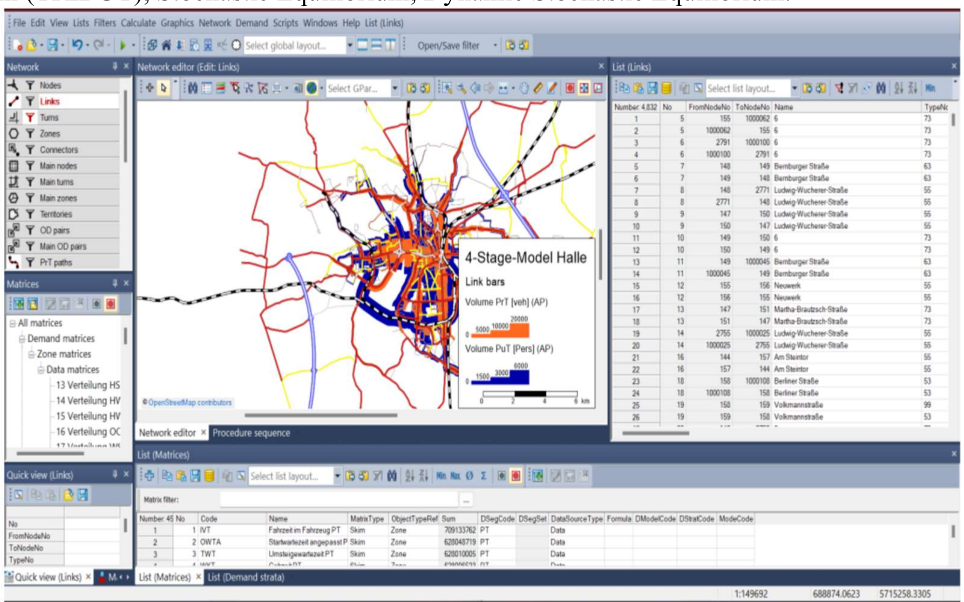

Figure 2. 4-stage modeling using Visum

2.1. Method

The research methodology began with a field survey that included road network conditions, classified traffic volumes, travel times, and data from the Destination. The survey was conducted simultaneously, primarily to measure traffic volume and travel time. Before implementation, the study area was identified, the survey location was determined, and procedures were prepared in accordance with Highway Traffic Regulation No. 02/SE/DP/2024.

The traffic analysis process follows a flowchart that includes three types of data: base-year network data, validation data, and data for simulation of the prediction model. Baseline and validation data are obtained through surveys, while prediction data are forecasted by accounting for factors of future change. This transportation planning model involves four stages: travel generation, trip distribution, mode selection, and route selection.

Traffic data is collected through traffic counting surveys and CCTV footage for more than 24 hours to ensure accuracy and minimize human error. This data is used to compile and validate the origin-destination (OD) matrix by integrating survey results on vehicle volume, destination origin, and travel time. The matrix is then calibrated using a balancing or growth factor approach to reflect actual conditions.

Transportation modeling was carried out using VISUM software, starting with input of road network data, traffic zones, vehicle volumes, and the OD matrix. The model is calibrated with actual traffic and travel time data, and then executed for trip distribution, mode selection, and route assignment. The simulation results were analyzed quantitatively and visually to evaluate the existing conditions and planning scenarios. This approach assumes that the rise and pull of movement are influenced by the characteristics of each zone, which can be effectively modeled in VISUM [8].

The selection of alternative development scenarios uses the Multi-Criteria Analysis (AMK) approach, namely to assess the proposed construction of the KM 151 Exit Toll Access Road. The Multi-Criteria Analysis (AMK) method is used to evaluate road access planning alternatives against predetermined criteria. The process begins with identifying alternatives and relevant criteria, then weighting each criterion according to its level of importance. Evaluation is carried out by assigning

Vol. 6, No. 2, pp. 219-232
Submit: 24-06-2025 |
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Publish: 30-01-2026 |

a score to each alternative, then calculating the total value using methods such as Simple Additive Weighting (SAW) and the Analytical Hierarchy Process (AHP). The flowchart is shown in Figure 3 below.

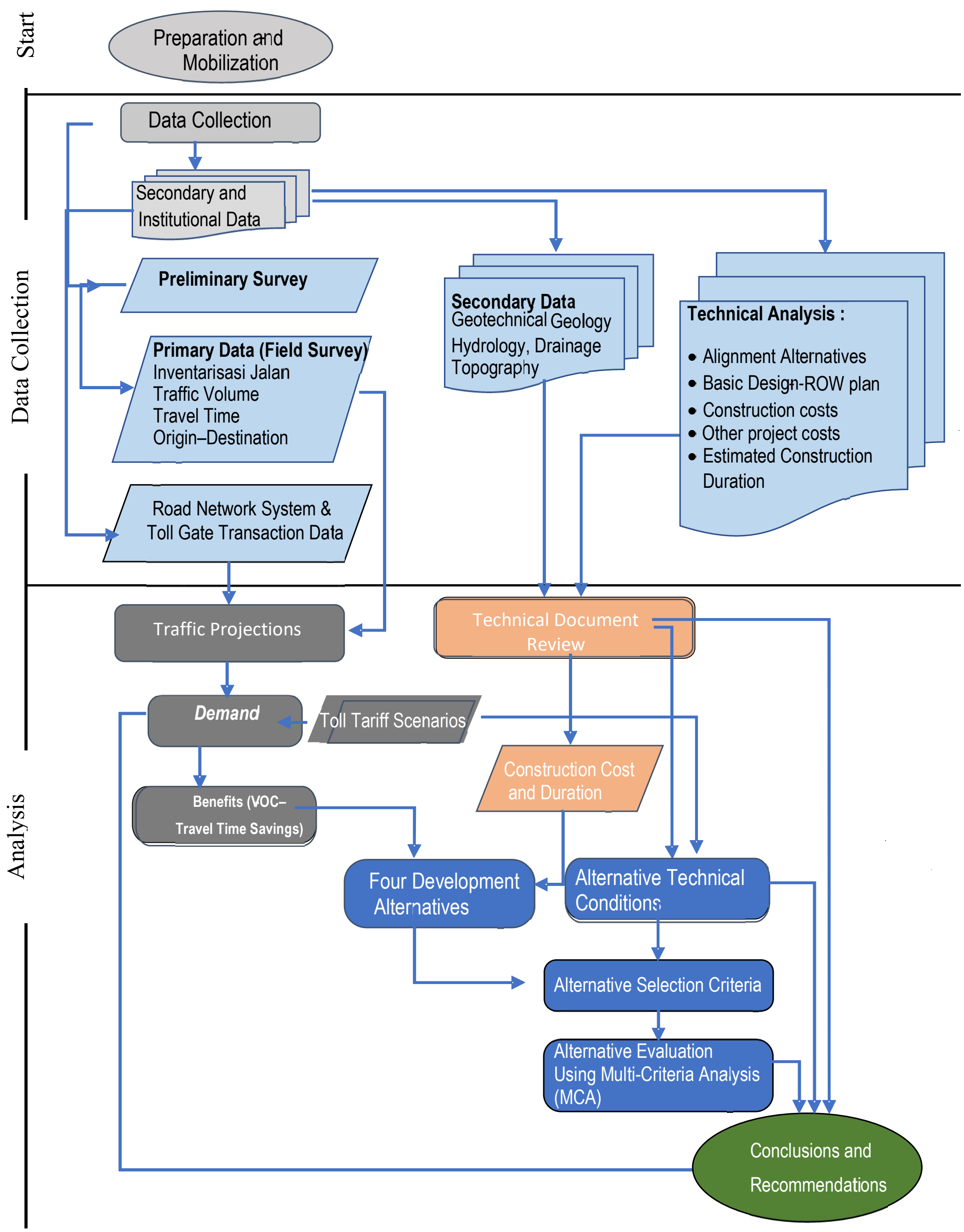

Figure 3. Research Flow Chart

JICE Journal Innovation of Civil Engineering

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3. Result and Discussion

3.1. Overview of KCJB Tegalluar Station Accessibility

Figure 4. Accessibility of KCJB Tegalluar Station

Accessibility to Tegalluar Station shows various lines and bridges that are planned or under construction to improve connectivity. One of the main accesses is the KM 149 Toll Road (Padalarang-Cileunyi Toll Road). In addition, there is an KM 148 Emergency Access, which can be used if opened in the KM 149 Toll Road area.

Several bridges and connecting roads are also planned to facilitate access to the station. The Cinambo Bridge (2a) will connect the Summarecon area with Jl. Cinirancang and support the widening of Jl. Cinirancang on the south side. Alternatively, the Bailey Bridge (2b) can also be used as a connecting line to Tegalluar Station. In addition, the Cimekar Bridge (3) is planned as a link from Cimekar Station to the road to GBLA, with the widening of Jl. Cibiru-Cimekar to increase traffic capacity. Meanwhile, the Cibiru Bridge (4), built by KCIC, will be widened on Cibiru Street on the north side to facilitate mobility in the area.

In addition to the tracks and bridges, there are facilities such as the Tegalluar Station Moda Transfer Area, which is designated as the passenger drop-off area. KM 151 exit toll access is also planned with an on-off ramp on line A and an off ramp that functions as a Mode Transfer on line B to support the smooth flow of vehicles to and from the station.

Some important landmarks along this access road include GBLA Stadium and Cimekar Station, which serve as strategic points for transportation connectivity. The Al-Jabbar Mosque is also one of the icons located near the main thoroughfare. In addition, the Tegalluar HSR Depot serves as the main maintenance facility for KCJB.

3.2. Survey Results

The results of traffic recording in the field will be tabulated based on time and vehicle type, which are recorded per hour and grouped into categories: Motorcycle/Scooter, Sedan/Minibus/Jeep, Public Transportation, Medium Bus, Large Bus, Pick up/box/2-axle truck, Large 2-axle truck, 3-axle truck, 4-axle truck, and 5-axle truck.

Vol. 6, No. 2, pp. 219-232
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Publish: 30-01-2026 |

Table 1. Traffic Survey Results

Location	Day	Peak Hours	Volume (Kend/jam)	Dominant Composition	Remarks
Cimareme	Holidays	15:00–16:00	>3,500 (total), >1,000 (without motor)	Motorcycles (72.4%), Passengers (18.2%)	Intercity routes near tourist areas
Purwakarta	Holidays	17:00–18:00	Not mentioned	Motorcycles (78.5%), Passengers (16.1%)	Intercity routes near tourist areas
Buah Batu	Holidays	16:00–17:00	~5,000 (including motor)	Motorcycles (60.5%), Sedans/Minibuses/Jeeps (30.2%)	City center, Padaleunyi Toll Access
Kopo	Work	06:00–07:00	>8,000 (including motor)	Motorcycles (67.3%), Sedans/Minibuses/Jeeps (20.95%)	City centre, daily routine movement routes
Pasteur Toll Gate 2	Work (August 12, 2024)	Daily	29,266 vehicles/day	–	Destinations Cikampek & Cileunyi
Kalitama Toll Gate 2 & 6	Work (August 12, 2024)	Daily	29,195 vehicles/day	–	Destinations Jakarta

Source: Survey Results, 2024

Traffic surveys show that vehicle volume is quite high, both on tourist routes and in the city center. On holidays, the location of Cimareme and Purwakarta, which is an intercity route near tourist areas, is dominated by two-wheeled vehicles. In Cimareme, traffic peaks at 15:00–16:00, with more than 3,500 vehicles per hour, of which 72.4% are motorcycles. Meanwhile, in Purwakarta, motorcycle dominance even reached 78.5% between 17:00–18:00.

In urban areas, traffic volumes are also high. In Buah Batu from 16:00–17:00 on holidays, the volume reached around 5,000 vehicles per hour, dominated by motorcycles (60.5%) and passenger cars such as sedans and minibuses (30.2%). In Kopo on weekdays from 06:00–07:00, more than 8,000 vehicles per hour were recorded, with motorcycles dominating 67.3%.

In addition, daily data from toll gates shows significant figures. On August 12, 2024, the Pasteur 2 Toll Gate recorded 29,266 vehicles heading to Cikampek and Cileunyi, while the Kalitama 2 & 6 Toll Gate recorded 29,195 vehicles heading to Jakarta. This data reflects the high intensity of traffic across various types of areas, including tourism areas, city centers, and toll road networks.

Furthermore, using traffic data from the primary survey results, a series of analyses was conducted to obtain the Matrix of Origin of the Destination for the study area, as shown in Figure 5.

Vol. 6, No. 2, pp. 219-232
Submit: 24-06-2025 |
Accepted: 31-12-2025 |
Publish: 30-01-2026 |

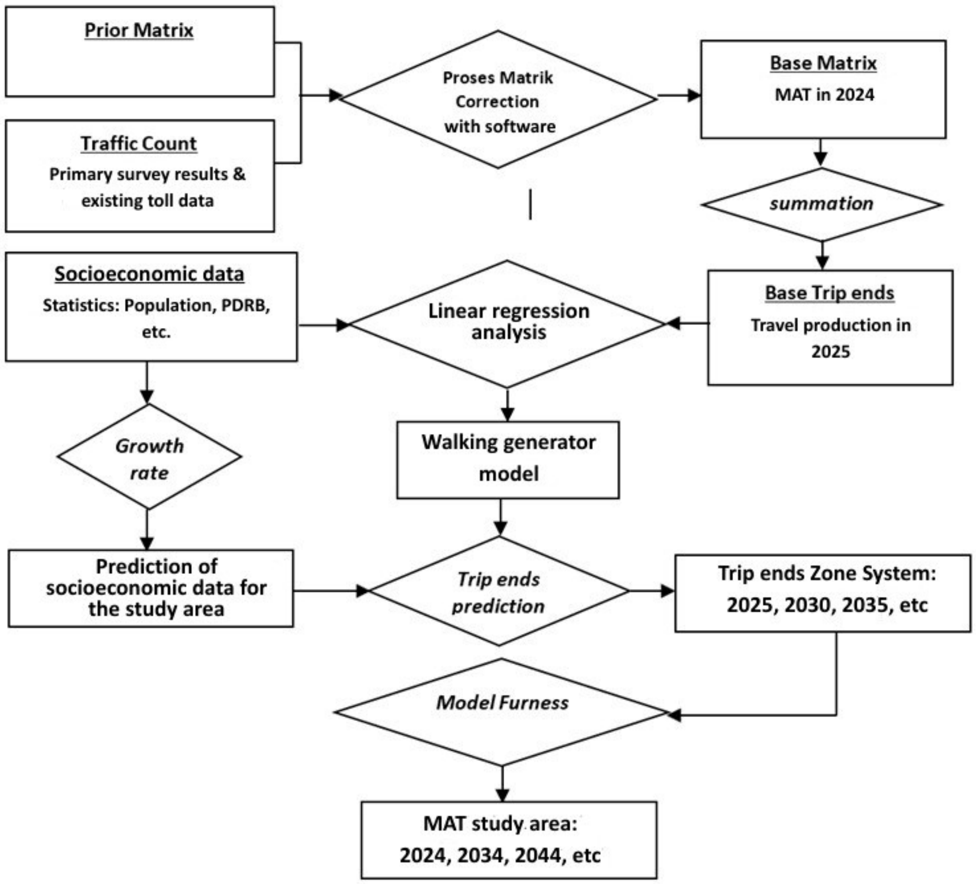

Figure 5. Analysis Processes of The Origin-Destination Matrix

The calibration process, by comparing model results with field-survey traffic volume data, especially for the data dated August 12, 2024, indicated the validity of the MAT model for traffic modeling analysis. The comparison of the results of the model output and the traffic volume data from the field survey gave a deviation value (R2) of 0.8311. The R2 value is still quite good (> 0.8), so that the built model can be used for future traffic modeling analysis.

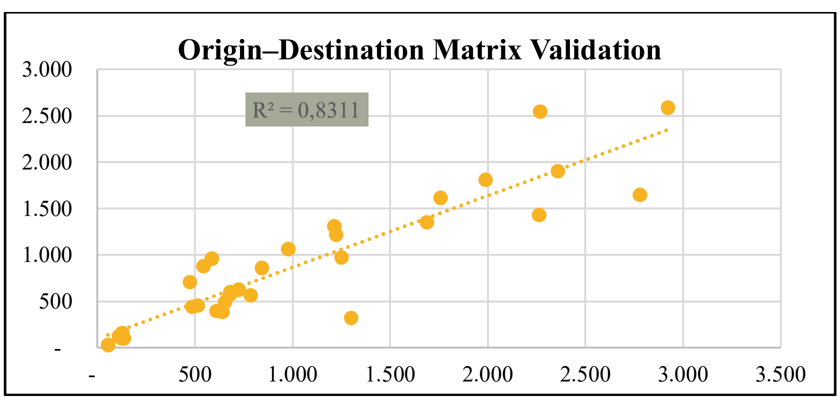

Figure 6. Origin-Destination Matrix Validation

JICE Journal Innovation of Civil Engineering
Vol. 6, No. 2, pp. 219-232
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Publish: 30-01-2026 |

3.3. Discussion

The KM 151 Padaleunyi Toll Exit was built to increase accessibility to KCIC Tegalluar Station and support the Jakarta-Bandung multimodal transportation system. This exit shortens the travel time from the center of Bandung, which previously took 40-45 minutes, to only 15-20 minutes through a strategic direct route, equipped with multi-storey intersections and the Cibiru Hilir Bridge.

Given the existing access at KM 149 (Summarecon Access), which is only about 2 km from the KM 151 access plan (Tegalluar Access), a Multi-Criteria Analysis (AMK) was conducted to evaluate the effectiveness of each toll access. The alternatives assessed include a combination of exit/on-ramp functions at both points. The proposed amendments are

- Alternatif 1 : Do-nothing (KM. 149 Summarecon Eksisting).
- Alternatif 2 : KM 149 Summarecon Existing + KM 151 Tegalluar Route A On-Off Ramp + Line B Off Ramp, which functions as a Mode Transfer.
- Alternatif 3 : KM 149 Summarecon Existing + KM 149 Summarecon On-Ramp towards Cileunyi + KM 151 Tegalluar Off-Ramp towards Jakarta.
- Alternatif 4 : KM 149 Summarecon Existing + KM 149 Summarecon On-Ramp in the direction of Cileunyi + KM 149 Summarecon Off-Ramp from the direction of Cileunyi to Summarecon.

Figure 7. Alternative 1 & 2

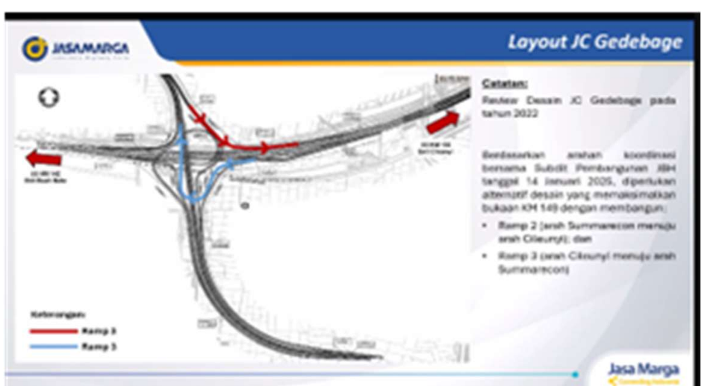

Figure 8. Alternatives 3 and 4

3.4. Traffic Load Analysis

The travel load model was used to predict the impact of the KM 151 Exit Toll Lines A and B on the performance of the Padalarang–Cileunyi Toll Road. The **calibration of the Destination Origin Matrix (MAT) was** carried out on the toll road network (Cipularang and Padaleunyi Toll

JICE Journal Innovation of Civil Engineering
Vol. 6, No. 2, pp. 219-232
Submit: 24-06-2025 |
Accepted: 31-12-2025 |
Publish: 30-01-2026 |

Roads), national roads, and surrounding local roads. Road network charging is carried out using Visum software. The method used is the classic toll assignment based on user equilibrium. The toll cost and time value (VoT) are converted to impedance in the model, expressed in seconds. The toll rate is assumed to be IDR 769/km for the Cipularang Toll Road and IDR 339/km for Exit KM 151, based on the 2024 tariff. The vehicle time value is calculated based on the UMR for the hinterland area (Bandung and its surroundings), assuming an hourly rate of IDR 49,151 per vehicle.

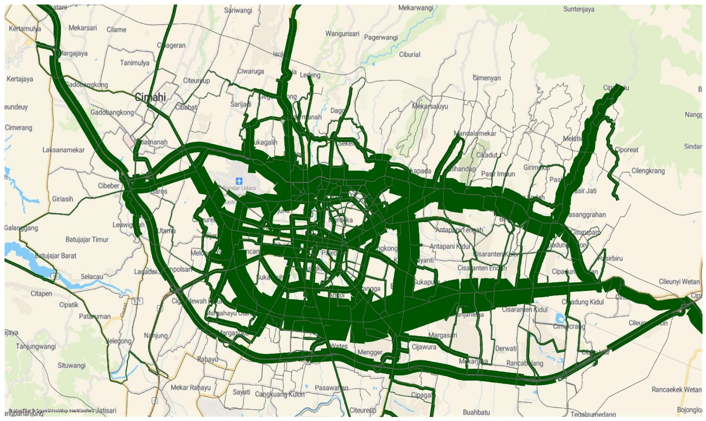

Figure 9. Load Results / Flow Band

In the image below, a comparison of Alternative 1 Without On *& Off Ramp* Handling Tegalluar and Alternative 2 with the Do Something Scheme for Making Full Access 151 plus the Do Nothing Scenario (existing 149))

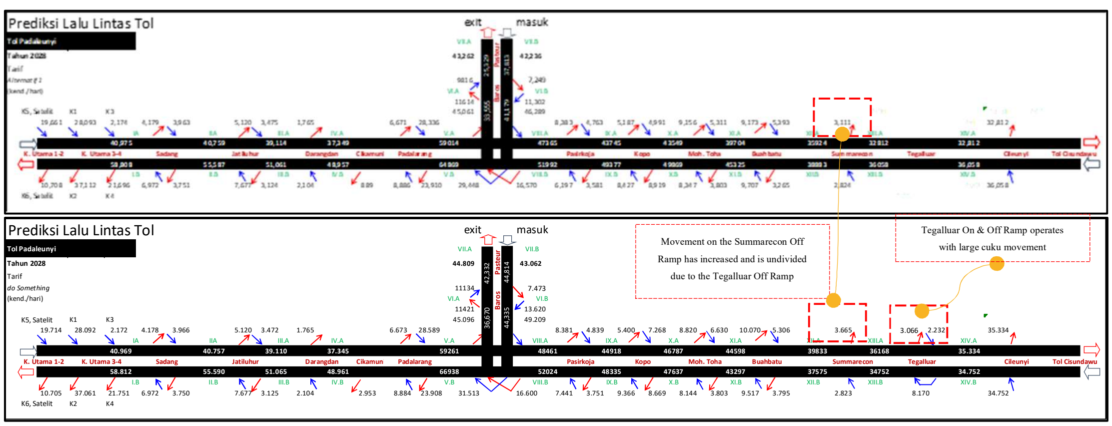

Figure 10. Load Results / Flow Band

3.5. Travel Load Simulation Results

The traffic indicators from the travel load simulation displayed include: traffic volume, system travel time, system travel distance, and average speed within the road network. These traffic indicators will then be used in conducting economic and financial analysis.

Based on the modeling results, the largest number of movements is observed for Alternative 2 (Summarecon Existing Scenario equipped with the Construction of on/Off Ramp Tegalluar KM 151 and On Ramp Tegalluar Direction Jakarta, which also functions as a Mode Shift from KCJB to Road mode). This is because in Alternative 2, there are more movement growth zones around the Tegalluar Toll exit (KM 151 Padalarang-Cileunyi), as shown in Table 2.

JICE Journal Innovation of Civil Engineering

Vol. 6, No. 2, pp. 219-232
Submit: 24-06-2025 |
Accepted: 31-12-2025 |
Publish: 30-01-2026 |

Table 2. Alternative Selection Resume

Tahun	Alternatif 1		Alternatif 2					Alternatif 3				Alternatif 4			
	Off Ramp 149 dari Jakarta	On Ramp 149 ke Jakarta	Off Ramp 149 dari Jakarta	On Ramp 149 ke Jakarta	Off Ramp 151 dari Jakarta	On Ramp 151 ke Cileunyi	On Ramp 151 arah Jakarta dari Cileunyi (Perpindahan Moda)	Off Ramp 149 dari Jakarta	On Ramp 149 ke Jakarta	On Ramp 149 ke Cileunyi	On Ramp 151 arah Jakarta dari Cileunyi (Perpindahan Moda)	Off Ramp 149 dari Jakarta	On Ramp 149 ke Jakarta	On Ramp 149 ke Cileunyi	Off Ramp 149 dari Cileunyi
2028	3.111	2.824	3.665	2.823	3.066	2.232	8.170	4.621	2.823	2.319	8.188	4.514	2.823	2.401	1.595
2030	3.575	3.043	3.962	3.043	3.567	2.338	8.812	5.070	2.950	2.386	8.838	4.949	2.972	2.386	1.671
2035	5.301	3.587	4.877	3.549	5.263	2.603	10.308	6.611	3.549	2.652	10.270	6.271	3.549	2.652	1.852
2040	6.767	4.540	5.506	4.452	7.507	2.819	11.595	8.387	4.452	2.869	11.296	7.864	4.452	2.869	1.992
2044	7.318	4.813	5.666	4.638	8.943	2.667	11.717	9.464	4.638	2.923	11.751	8.940	4.638	2.923	2.025

3.6. Alternative Election Results

The selection of the most effective and efficient alternatives is based on Accessibility, Traffic Aspects (Results of Road Load Modeling), Spatial Constraints, Technical and Non-Technical Aspects, and Cost Aspects. Based on these aspects, a criterion assessment and weighting for each alternative were carried out using the Multi-Criteria Analysis (AMK) method. The most effective and efficient alternative selection was then carried out as follows.

Table 3. Alternative Selection Resume

Alternatif	Short Description	Number of Ramps	Total Volume (Kend/Day)	Main Notes	AMK Score
1	Do Nothing: Exit & On Ramp Summarecon arah Jakarta	2	5.953	Focus on the Summarecon area, limited coverage	8,03
2	Full Access: Summarecon + On/Off Ramp Tegalluar KM 151 + KCIC Mode	5	19.956	High movement due to new growth zones	7.30
3	On Ramp Cileunyi from Summarecon & Tegalluar towards Jakarta + Transition Mode	4	17.951	On Ramp to Cileunyi is not optimal (only Summarecon residents)	7.83
4	Exit & On Ramp Summarecon towards Cileunyi + Off Ramp towards Jakarta	4	11.333	Lowest movement, limited ramp	7.33

Considering the results of the selection of the alternative scenario above and considering the existing access conditions on KM 149 of the Padalarang-Cileunyi Toll Road (Summarecon Access), which is adjacent to the KM 151 Access plan (Tegalluar Access), it is recommended that the development stages be as follows:

- **Phase 1: Access to the existing KM 149**
  In Phase 1, the main strategy is focused on optimizing existing conditions to boost overall road network performance. This effort includes increasing the efficiency and capacity of the existing road network, particularly by optimizing the role of non-toll roads as access providers. The goal is for the potential traffic (demand) to grow gradually and in a directed manner, until it shows a significant spike around the *KM 149* Exit Toll.
  This gradual approach emphasizes that development is not directly focused on new infrastructure, but rather starts from the maximum utilization of available assets. After the network performance shows a high increase in demand at the strategic point, the construction of direct access to KM 149 will be carried out to accommodate the increasing flow of vehicles.
  The next stage is the development of KM 151, a follow-up step after the needs at KM 149 are

Vol. 6, No. 2, pp. 219-232
Submit: 24-06-2025 |
Accepted: 31-12-2025 |
Publish: 30-01-2026 |

met and traffic load shifts. This strategy not only supports the cost efficiency of development but also ensures that investments are made based on urgency and actual needs data.

- **Stage 2: Access KM 149 Existing + *On Ramp* KM 149 towards Cileunyi + *Off Ramp* Line B KM 151, which functions as a Mode Transfer**
  At this stage, KM 149 *On Ramp* was built towards Cileunyi to facilitate the movement of vehicles from Summarecon to Sumedang, Garut, Tasikmalaya and others, besides that a transfer point was also built at KM 151 Line B to make it easier for KCJB users who will go to the City Center area or continue their journey to other areas around it, the need for this mode transfer place needs to be coordinated again with KCIC both for location and availability.
- **Stage 3: Stage 2 + Off Ramp KM 149 from the Cileunyi direction**
  At this stage, KM 149 *Off Ramp* was built from Cileunyi to Summarecon to facilitate movement from Sumedang, Garut, Tasikmalaya, and their surroundings through Cileunyi, both for tourism and for residents living around Summarecon. At this stage, a mode transfer area is still needed to facilitate KCJB users who will go directly to the station. The construction of the KM 149 Off Ramp from the direction of Cileunyi needs to be coordinated again with KCIC regarding the selection of the structure and horizontal clearance at the crossing point with the KCJB rail bridge.
- **Stage 4: Stage 3 + *On-Off Ramp* KM 151 Line A**
  If *the* KM 149 Toll Access is already dense enough with traffic flow, then the next stage is built *On* and *Off Ramp* KM 151 Line A as an effort to provide a choice of KM 149 toll users so that traffic around *the Exit Toll is* no longer congested, besides that it is hoped that the KM *151 On* and *Off Ramp* can also generate new movements.

3.7. Spatial and Land Use Analysis

The development of the KM 151 Toll Exit and the surrounding area cannot be separated from the broader context of spatial planning, namely transit-oriented development (TOD), which aims to create an integrated area among residential, commercial, and transportation uses.

According to the Detailed Spatial Plan (RDTR) of the Regency and City of Bandung, the area around the KM 151 Toll Exit is planned as an urban development zone and a Transit Oriented Development (TOD) area that supports the creation of a new economic center, with a mixed-use concept such as housing, commercial areas, and public facilities. However, the realization in the field has not fully gone according to plan, as there is still a lot of land in agricultural or vacant areas, and urban sprawl in the form of informal settlements that are not integrated with the existing spatial plan [9] [10].

The main challenge in land use is uncontrolled development. Most of the land around the toll exit has been turned into commercial and residential areas[11], which, although they increase economic activity, are not accompanied by good spatial Management. One impact is the growth of illegal settlements along the road to the station and the toll exit [12].

The construction of the KM 151 Toll Exit has a significant impact on various aspects. Socially, the existence of toll exits increases community mobility, especially for residents of Tegalluar and Gedebage who previously had difficulty accessing the center of Bandung. Now, access is faster and more efficient, though itis important to be aware of the potential for gentrification amid a surge in land prices in the area [13]. From an economic perspective, this development has attracted large investments, especially in the property sector, with the rise of housing, shopping centers, and hotels [14]. The increase in land prices, which has exceeded 100% over the last two years, shows that this area has the potential to become a new economic growth center in East Bandung. However, environmental impacts also arise, including increased air pollution and noise from higher vehicle volumes, as well as the risk of flooding and declining environmental quality from land conversion without adequate controls.

Vol. 6, No. 2, pp. 219-232
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4. Conclusions

VISUM-based modeling shows that staging is the most appropriate solution in increasing the accessibility of Tegalluar Station, with the order of optimizing existing conditions, the construction of on Ramp KM 149 towards Cileunyi to facilitate the movement of vehicles from Summarecon to Sumedang, Garut, Tasikmalaya then continued with the construction of Off Ramp KM 149 from the direction of Cileunyi to Summarecon to facilitate movement from Sumedang, Garut, Tasikmalaya and its surroundings through Cileunyi, finally if the KM 149 Toll Access is quite dense with traffic flow, then the next stage will be built On and Off Ramp KM 151 Line A.

This study underscores the importance of using simulation-based planning in integrating toll road access with national transportation hubs. Further studies need to account for dynamic traffic conditions and broader multimodal integration. The proposed approach provides a practical decision-support tool for transportation planners and policymakers in designing efficient toll exit systems that enhance accessibility, reduce congestion, and improve operational performance around high-speed rail stations.

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