E-ISSN: 2528-388X
P-ISSN: 0213-762X

INERSIA
Vol.21, No.1, May 2025

Impact Analysis of Condongcatur Underpass Construction Plan with Traffic Simulation PTV VISUM and PTV VISSIM on Road Network Performance

Muhamad Yusup *, Ahmad Munawar, Muhammad Zhudy Irawan

Department of Civil and Environmental Engineering, Universitas Gadjah Mada, Yogyakarta 565223, Indonesia

Keywords:
Underpass
PTV VISUM
PTV VISSIM

ABSTRACT

It is planned to build an Underpass for the Condongcatur intersection to improve traffic performance and overcome the congestion that occurs. The purpose of this research is to analyze the existing traffic performance around the Condongcatur Underpass construction area, predict the impact caused, and formulate efforts to handle traffic impacts and analyze how effective it is in overcoming the congestion that occurs. This research uses two transportation model approaches to analyze the road network using PTV VISUM and PTV VISSIM software. Assessment of road section performance is based on MKJI 1997 and assessment of intersection performance using output from VISSIM modeling. The results of research on existing conditions show the performance of the affected road network with a v / c ratio value between 0.21 - 1, 23 (Level of service B - F). While the performance of the intersection in existing conditions is at level of service F with an average delay value of 191.46 seconds and a maximum queue length of 502 meters. At the time of construction there were 12 road sections affected by the construction of the Condongcatur Underpass. The road section with the highest percentage increase in v / c ratio value occurs on the Padjajaran road section by 167% which was originally in service category C to F. In operational conditions, the Padjajaran Road section with the Underpass is in the B and C service level categories. Then for the performance of the intersection with the Underpass is at level of service C with each delay value of 32.71 seconds and a maximum queue length of 148 m. The performance results on road sections and intersections provide better results with the Underpass compared to existing conditions.

Introduction

Yogyakarta as a province with a favorite educational and tourist destination in Indonesia causes high vehicle mobilization every day. This has an impact on the occurrence of congestion, especially at intersections that are the meeting point for the flow of vehicles entering the city of Yogyakarta and vehicles continuously heading out of the city. The location with the highest delay and queue length is the Condongcatur intersection. Condongcatur intersection serves out-of-town vehicle movements to Magelang, Klaten, Solo, and surrounding areas as well as in-town movements to Yogyakarta and Sleman Regency. The current performance of the Condongcatur intersection is in the Level of Service (LoS) F category with a queue length of 129 m and an average delay of 102 seconds [1]. In an effort to improve traffic performance and overcome congestion, the construction of an Underpass is planned for the Gejayan or Condongcatur intersection.

Based on PM No. 17 of 2021 which regulates Traffic Impact Analysis, it states that every activity that has an impact or disturbance on the smooth running of traffic must be carried out a study on Traffic Impact Analysis, which specifically states the type of activity in question in the form of infrastructure activities [2]. This research examines traffic performance in existing conditions, the impact that occurs during the construction period with the Condongcatur Underpass development plan, and post-development after the underpass operates through a modeling approach carried out in micro simulation with PTV Vissim and the impact in macro simulation with PTV Visum.

Several previous studies have been conducted related to handling traffic impacts using PTV VISSIM microsimulation modeling on the Surabaya Dolog Roundabout Underpass infrastructure development plan

*Corresponding author.
E-mail: muhamadyusup122@gmail.com

https://doi.org/10.21831/inersia.v21i1.64292
Received 22nd July 2023; Revised 1st June 2025; Accepted 9th June 2025
Available online 12th June 2025

[3], Pemalang-Batang Toll Road Access Development [4], and Venue Building Renovation and GBK Area Arrangement [5]. Then research related to the use of macro simulation models with PTV VISUM was carried out to analyze traffic movements in Surakarta City predicted by MAT in 2025 [6] and the development of a transportation model for Palembang city based on four-step transportation modeling [7]. In previous research, there has been no research related to the use of simulation models by integrating macro modeling with PTV VISUM and micro modeling with PTV VISSIM on urban ring roads.

Methods

2.1 Research Data

The research data consisted of primary and secondary data. Primary data was obtained from direct surveys in the field through traffic counting surveys conducted during peak vehicle hours in the morning time period at 06.00 - 08.00 WIB, afternoon at 11.00 - 13.00 WIB, and afternoon at 15.00 - 18.00 WIB with classified vehicle types in the form of heavy vehicles (HV), light vehicles (LV), Motorbikes (MC), and unmotorized (UM). Then to find out the speed of the vehicle is done through the Spot Speed survey. Other data uses secondary data obtained from relevant agencies in accordance with research needs. While secondary data collection is obtained from related agencies according to research needs.

Secondary data that will be used include DIY spatial and land use map. Data on the population and ownership of motorized vehicles in Sleman Regency (Sleman Regency in Figures 2021) derived from BPS Sleman Regency [8]. Data on the population and ownership of motorized vehicles in Bantul Regency (Bantul Regency in Figures 2021) from BPS Bantul Regency [9]. Data on the population and ownership of motorized vehicles in Yogyakarta City (Yogyakarta City in Figures 2021) from BPS Yogyakarta City [10]. Data on traffic flow and performance of the affected area's road network obtained from the Yogyakarta City Transportation Office [11]. Last, Data on the origin destination matrix (MAT) of DIY Province in the 2016 DIY People's Travel Origin Destination Study document and the 2017 DIY Transportation Master Plan [12].

The traffic flow data modeled is the highest 1-hour data with the number of road sections affected in this study as many as 43 sections with the number of links formed in the PTV VISUM modeling of 84 link data. The simulation model has two interconnected components: travel demand information that describes passenger travel needs and supply information that describes the transportation network, traffic zones (such as residential areas) and public transport [13].

2.2 Research Location

The Condongcatur Underpass Development Plan will be built in the administrative area of Sleman Regency, namely Jalan Arteri Utara No. Ruas 018-11-K, Jl. Padjajaran (Sleman), Gejayan, Condongcatur, Kapanewon Depok, Kab. Sleman, DI Yogyakarta.

2.3 Analysis Method

The analysis method used in this research uses a two-model approach to analyze the existing road network. The method for modeling the macro road network using PTV VISUM software and micro modeling for the research location using PTV VISSIM. Assessment of road section performance is guided by MKJI 1997 and assessment of intersection performance using output from VISSIM modeling. Modeling is carried out for three scenarios, namely modeling of existing conditions, construction phase, and operational phase. In the construction period modeling, two impact handling scenarios will be carried out in the form of traffic flow diversion and road widening. Then for the operational stage, the performance of the road network will be modeled in the next 5 years without the underpass and with the underpass.

Result and Discussion

3.1 Data Processing and Formation of OD Matrix

The number of road sections affected in this study is 42 sections with the number of links formed in the PTV VISUM modeling of 84 link data. In this study, 10 travel origin and destination zones were determined, which were divided into 8 internal zones and 2 external zones. Internal zones are zones in the study area that will be greatly affected by existing traffic movements. Therefore, it is determined that the internal zone boundaries in this study are the administrative sub-districts in Sleman Regency. While the external zone is a zone that is outside the boundaries of the study area with less influence on traffic movements. So that for the external zone, 2 zones were determined, namely Bantul Regency and Yogyakarta City as presented in the Table 1.

To run the PTV VISUM modeling process based on 2016 prior matrix data, it is necessary to determine the loading system to be used [12]. To run the PTV VISUM modeling process based on 2016 prior matrix data, it is necessary to determine the loading system to be used. In this study, the road network loading uses the Equilibrium Assignment that is available in the PTV VISUM loading operation.

Route selection with equilibrium assignment procedure produces better test statistics and performance in estimating the parameters of the transportation demand model [14]. In this study, the road network loading uses the Equilibrium Assignment that is available in the PTV VISUM loading operation. Based on the modeling results in the initial conditions using the 2016 prior matrix data as shown in Figure 1, there is a considerable difference between the modeled volume and the traffic volume observed directly in the field in 2022.

The highest traffic volume occurs on link 3 of Padjajaran road (North Ringroad) which is the eastern arm of Condongcatur 4-Signal Intersection which will be built Underpass. The traffic volume on this road section is 8,203 smp/hour while the traffic volume from direct observation in the field in 2022 is 2,391 smp/hour. Statistical test results of modeling results with PTV VISUM before calibration as shown in Figure 2. While the comparison of traffic volume per link before estimation shows a considerable difference as shown in Figure 3.

Table 1. Division of zones in the research area

Zone Numbers	Zone Name	Zone Classification
1	Depok subdistrict	Internal
2	Ngaglik subdistrict	
3	Sleman subdistrict	
4	Mlati subdistrict	
5	Godean subdistrict	
6	Kalasan subdistrict	
7	Berbah subdistrict	
8	Gamping subdistrict	
9	Yogyakarta City	Eksternal
10	Bantul Regency	

Figure.1 PTV VISUM modeling output results with prio matrix 2016

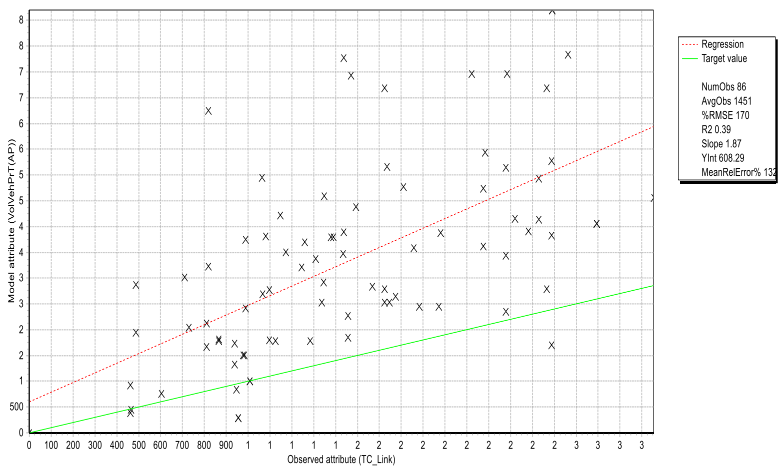

Figure 2. Statistical test results of PTV VISUM modeling with prio matrix 2016 before calibration

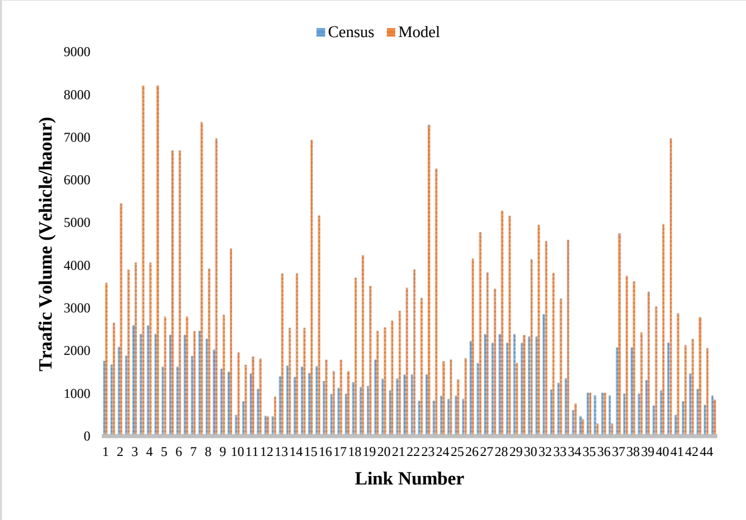

Figure 3. Comparison of traffic volume per link before estimation

Judging from the results of the traffic loading in Figure 3 and the statistical test of Figure 2, for the existing conditions in 2022 without the addition of Condongcatur Underpass Infrastructure, the existing traffic volume cannot describe the real conditions in the field. The statistical test results show an R2 value of 0.39, an RMSE of 170%, and a GEH < 5 of 7%. While the standards set for the value of GEH < 5 must meet > 50% so that the model results have not met the requirements [15].

3.2 Estimation of Origin-Destination Matrix with Fuzzy TFlow Method

In this study, to be able to estimate the Origin-Destination Marx using the TFLowFuzzy method that is available in the PTV VISUM software. MAT estimation with TFLowFuzzy is useful for performing Matrix Correction so that it can produce a new MAT that is in accordance with the 2022 observation conditions. The loading results after the estimation process with TFLowFuzzy are shown in Figure 4. While the results of the stochastic test and comparison of traffic volumes in Figure 5 and Figure 6.

Based on Figure 5, there is a significant increase in the statistical test results before and after the MAT Estimation process with the TflowFuzzy method. The R2 parameter (coefficient of determination) which was previously 0.39 increased to 0.89. GEH < 5 increased by more than 50% to 63%, and a decrease in %RMSE from 170 to 15. This indicates that after the MAT estimation process with TflowFuzzy, the modeled traffic volume is close to or equal to the existing traffic volume conditions in 2022. So, it can be concluded that road network modeling with PTV VISUM Software is acceptable. After the estimation process and obtaining the appropriate trip origin-destination matrix, loading is then carried out on the affected road network to determine traffic performance in the existing conditions of the base year 2022.

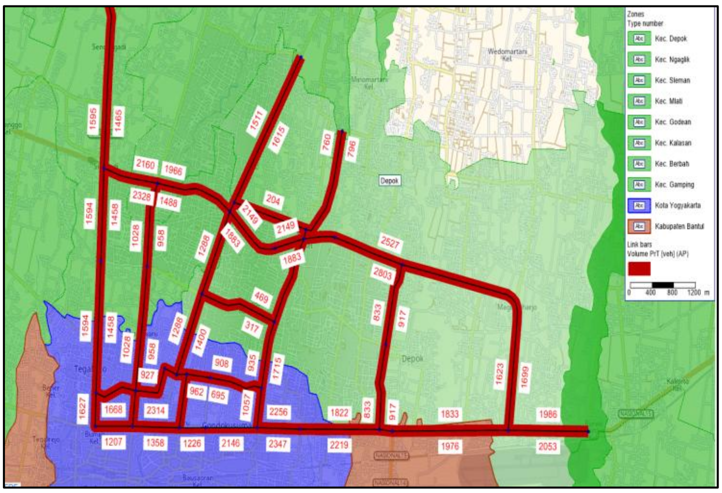

Figure 4. Traffic loading results after estimation process with TflowFuzzy method

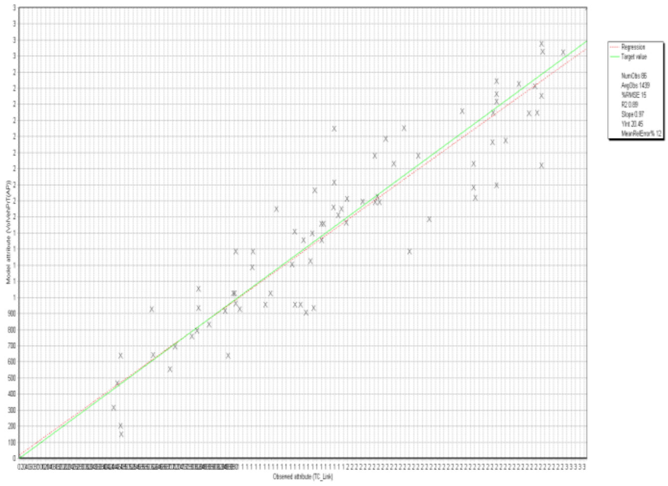

Figure 5. Statistical test results of ptv visum modeling after estimation process with Tflowfuzzy method

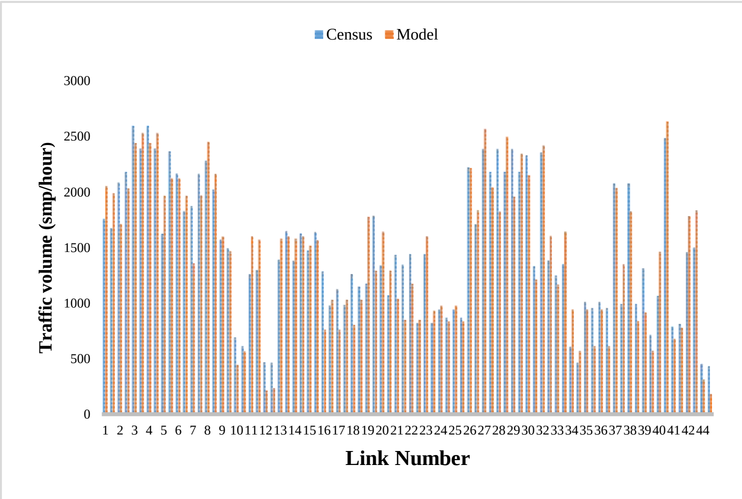

Figure 6. Comparison of traffic volume per link after estimation with TflowFuzzy

3.3 Simulation of Existing Condition Road Network Performance

Simulation of Existing Road Network Performance is a loading simulation process on the affected road network to determine the performance of road sections in 2022 before the Condongcatur Underpass Infrastructure Development. Figure 7 shows the results of the current existing condition traffic loading (Year 2022). The parameters used in assessing the performance of road sections are based on the v/c ratio value or degree of saturation. Furthermore, a classification is carried out to determine the level of service of the road from the value of A to F [16]. A road section can be categorized as a road section with type A level of service if the free flow conditions are high speed with low traffic volume. Drivers can choose their desired speed without hindrance and the v/c ratio is 0.00 to 0.19. Level of service type B if in the steady flow zone, drivers have sufficient freedom to choose their speed and the v/c ratio is 0.20 to 0.44. Level of service type C if in the steady flow zone, drivers are restricted in their choice of speed and the v/c ratio is 0.45 to 0.74. Level of service type D if traffic is approaching unstable flow, where almost all drivers will be restricted. The volume of service is related to the acceptable capacity and the v/c ratio is 0.75 to 0.85. Level of service type E when traffic volumes are close to or at capacity, traffic flow is unstable, drivers stop frequently and the v/c ratio is 0.86 to 1.00. Level of service type F when traffic flow conditions are forced or jammed at very low speeds. Long queues of vehicles. There are large obstacles and the scope of the v / c ratio is more than 1.00.

In general, the performance of road sections on the affected road network in existing conditions is at the level of service or LoS (Lever of Service) B to F. For road sections located on the southern arm of the Condongcatur intersection of the Condongcatur Underpass Development plan, the Affandi road section is in LoS (Lever of Service) D condition for the South to North traffic direction and LoS C for the North to South traffic direction with traffic volumes of 1434 smp / hour and 1345 smp / hour. While on the Padjajaran road which is a national road is at the level of service or LoS (Lever of Service) B and C with the highest traffic volume is on the east arm of the Condongcatur intersection of the Condongcatur Underpass Development plan of 2,594 smp / hour and 2,391 smp / hour. The Condongcatur Underpass development plan will cross along the national road from the west and east of the Condongcatur Intersection to serve the movement of vehicles heading out of town.

3.4 Simulation of Road Network Performance under Construction

The Road Network Modeling simulation for the construction activity phase uses the existing condition traffic flow volume in 2022 with the plan charged with additional activities at the Condongcatur intersection. The Underpass construction plan will cross through the Padjajaran road section from east to west and vice versa. Due to the absence of Detail Engineering Design (DED) drawings of the planned Underpass construction activities, the existing Underpass kentungan will be used. During construction activities on the Padjajaran road section, there will be a narrowing of the west and east arms of the Condongcatur intersection. The capacity of the road section which was originally 4,653 narrowed to 1,551 in each direction due to construction work in the middle of the road. This makes four-wheeled vehicles have to move to the slow lane at a distance of 500 meters from the intersection. The construction vehicle pull was not taken into account because the transportation of heavy equipment and materials is carried out at night or outside peak vehicle hours so that it does not coincide with vehicle activities that are calculated as peak hours in the analysis process of this study. The results of road network loading in existing conditions are shown in the Figure 8.

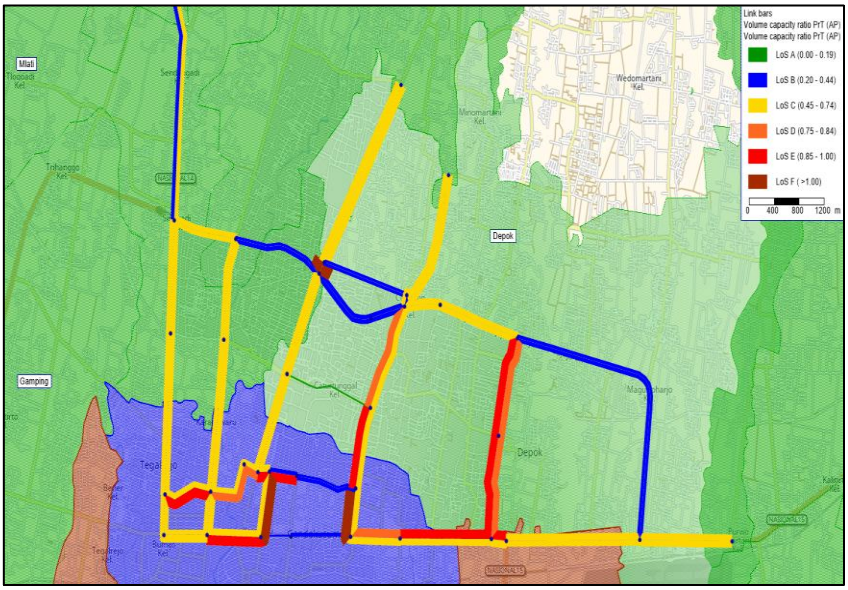

Figure 7. Simulation of existing condition traffic performance without Condongcatur underpass construction

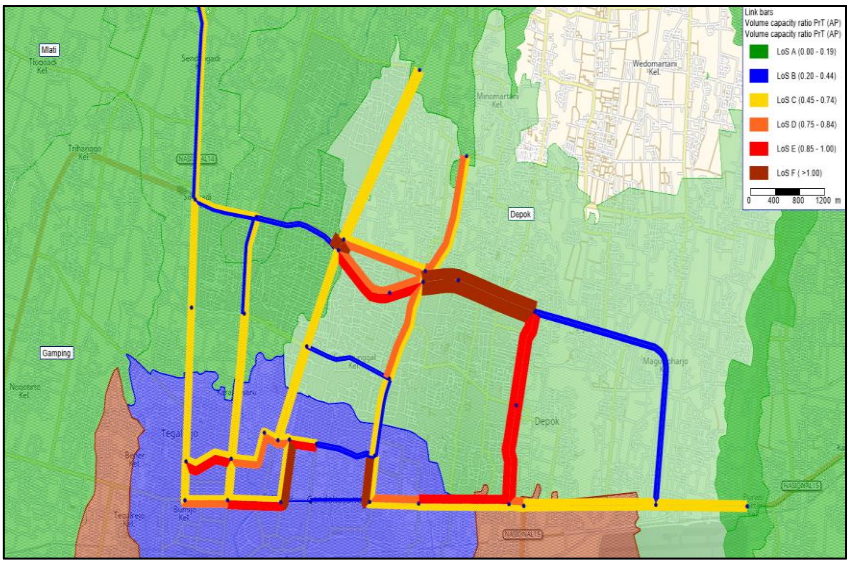

Figure 8. Simulation of traffic performance during construction of Condongcatur underpass development plan

Table 2. Road section affected by Condongcatur underpass construction activities based on V/C ratio value

Link number	Road section name	Existing road network performance		Road Network Performance during Construction		Percentage increase/ decrease
		Degre of saturation (V/C ratio)	Level of Service (LoS)	Degre of saturation (V/C ratio)	Level of Service (LoS)	
5	Jl. Padjajaran (West – East)	0.60	C	1.16	F	92%
6	Jl. Padjajaran (East- West)	0,54	C	1.45	F	167%
7	Jl. Padjajaran (West – East)	0.60	C	1.16	F	92%
8	Jl. Padjajaran (East- West)	0.54	C	1.45	F	167%
9	Jl. Padjajaran (West – East)	0.40	B	0.79	D	96%
10	Jl. Padjajaran (East- West)	0.46	C	0.98	E	112%
11	Jl. Padjajaran (West – East)	0.46	C	0.98	E	112%
12	Jl. Padjajaran (East- West)	0.40	B	0.79	D	96%
23	Jl Sawitsari	0.24	B	0.72	C	201%
47	Jl Seturan	0.82	D	0.93	E	13%
49	Jl Seturan	0.82	D	0.93	E	13%
61	Jl Pangeran Diponegoro	0.61	C	0.85	E	40%
63	Jl RW. Monginsidi	0.78	D	1.50	F	94%
73	Jl Colombo (Depan UNY)	0.34	B	0.58	C	73%
77	Jl Angga Jaya	0.65	C	1.68	F	158%
81	Jl Agro (West – East)	0.17	A	0.64	C	280%
82	Jl Agro (East- West)	0.11	A	0.67	C	485%

Figure 8 shows that with the construction activities of the Underpass construction at the Condongcatur intersection, some road sections experienced a decrease in performance and level of service, especially on road sections around the location of the activity. Based on Table 2, there are at least 12 road sections that are most affected during construction activities. The Padjajaran Road section of the west and east arms of the Condongcatur intersection experienced the most significant performance decline of 167%, which was originally at level of service C to F. Then some other road sections also experienced a decrease in the level of service caused by vehicles choosing other routes in achieving their travel destinations to avoid the buildup that occurred around the underpass construction site.

3.5 Proposed Recommendations for Handling Impacts during Construction

Traffic impact management recommendations are provided to improve the performance of the road network which is still in a poor state and requires special treatment during the construction period.

3.5.1 Recommendation- 1 Diversion of Traffic Flow during the Construction Period

To unravel the volume of traffic flow that occurs on the Padjajaran road section (Condongcatur intersection) due to narrowing during the construction period, it is necessary to arrange traffic engineering management. The flow diversion management is given as follows. First, traffic flow from the north of the Underpass construction plan,

namely Anggajaya road heading south, is moved through Sawitsari road then to Kaliurang road. Second, convert Sawitsari road into a one-way street from east to west.
The results of road network loading with alternative recommendation 1 are shown in Table 3.

Figure 9 shows the results of traffic loading on the road network during construction with alternative-1, where there are several road sections that have improved, especially those that occur on sections around the construction site. Table 5.5 shows that Jalan Padjajaran in the direction of B-T (Link 9) from LoS D to C, then Jl Affandi (Link 41-44) from LoS D-E to C-D. However, there are also several road sections that have decreased their level of service as a result of the transfer of traffic flow. The most visible is on Jalan Padjajaran in the T-B direction (Link 10), which originally had LoS E performance to F. So, it can be concluded that the first recommendation will improve the performance of some road sections and reduce other sections as a result of the displacement of traffic flow due to the diversion of flow and the implementation of one-way roads on Jl. Sawitsari.

Table 3. Comparison of Road Section Performance Affected by Construction Activities (Do Nothing) and Alternative Recommendation- 1 (Do Something) of Condongcatur Underpass Development Based on V/C Ratio Value

Link number	Road section name	Road network performance during construction		Road network performance under construction alternative- 2		Percentage increase/ decrease
		Degre of saturation (V/C ratio)	Level of Service (LoS)	Degre of saturation (V/C ratio)	Level of Service (LoS)	
5	Jl. Padjajaran (West – East)	1.16	F	0.72	C	-38%
6	Jl. Padjajaran (East- West)	1.45	F	0.80	D	-45%
7	Jl. Padjajaran (West – East)	1.16	F	0.72	C	-38%
8	Jl. Padjajaran (East- West)	1.45	F	0.80	D	-45%
9	Jl. Padjajaran (West – East)	0.79	D	0.38	B	-52%
10	Jl. Padjajaran (East- West)	0.98	E	0.74	D	-24%
11	Jl. Padjajaran (West – East)	0.98	E	0.74	D	-24%
12	Jl. Padjajaran (East- West)	0.79	D	0.38	B	-52%
23	Jl Sawitsari	0.72	C	0.52	C	-28%
47	Jl Seturan	0.93	E	0.86	E	-7%
49	Jl Seturan	0.93	E	0.86	E	-7%
61	Jl Pangeran Diponegoro	0.65	C	0.61	C	-6%
63	Jl RW. Monginsidi	0.81	D	0.75	D	-7%
73	Jl Colombo (Depan UNY)	0.34	B	0.32	B	-7%
77	Jl Angga Jaya	0.67	C	0.59	C	-12%
81	Jl Agro (West – East)	0.27	B	0.14	A	-46%
82	Jl Agro (East- West)	0.25	B	0.14	A	-45%

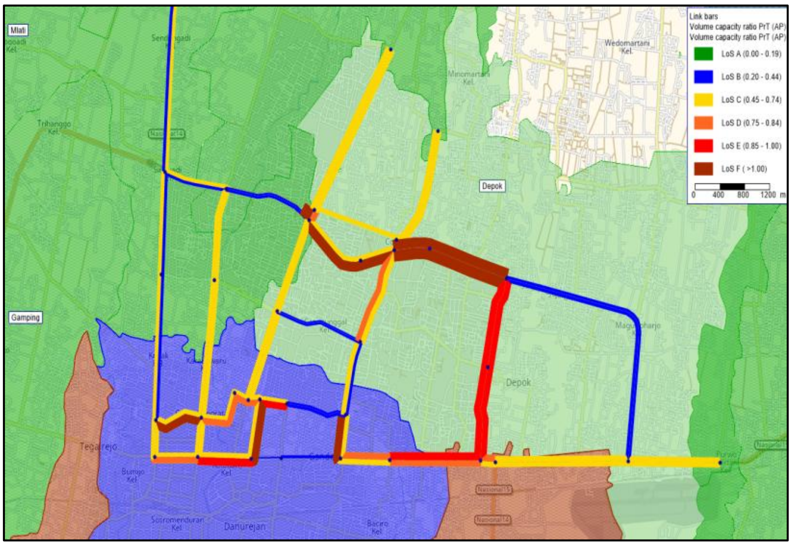

Figure 9. Simulation of Traffic Performance during Construction of Condongcatur Underpass Alternative- 1

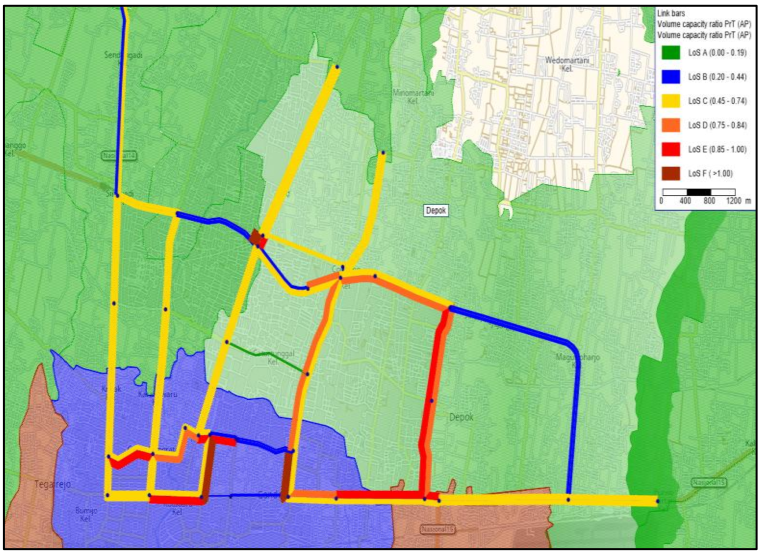

Figure 10. Simulation of Traffic Performance during Construction of Condongcatur Underpass Alternative- 2

3.5.2 Recommendation- 2 Widening the Road

Then the second alternative recommendation is proposed by widening the road in each slow lane first. There will be a widening of ± 3 meters on each of the south and north sides. Therefore, to prevent bottlenecks that occur when approaching the intersection due to Condongcatur Underpass construction activities, road widening takes precedence so that it will increase capacity during the construction period. With the additional lanes in the slow lane with a total width of 7 meters, each direction will have a capacity of 3168 which was previously only 1551.

Figure 10 and Table 4 show the results of traffic loading on the road network with the addition of the second alternative, where the changes that occur are quite significant in improving the performance of the existing road network, especially in the area around the construction site. Road sections that experienced improvements, especially those that occurred on sections around the construction site such as Padjajaran road (Link 5-12), on average experienced a decrease in the v / c ratio value of 24% - 52% from the original LoS D - F to B - D. Then Jl Sawitsari (Link 23-24) experienced a decrease in the v / c ratio of 28% with LoS performance C. As well as several other road sections as listed in Table 4. It can be concluded that the second recommendation by widening the slow lane or frontage of Condongcatur Underpass will provide better improvement recommendations in reducing the potential congestion that occurs during the construction period.

Table 4. Comparison of Road Section Performance Affected by Construction Activities (Do Nothing) and Alternative Recommendation- 2 (Do Something)

Link number	Road section name	Road network performance during construction		Road network performance under construction alternative- 2		Percentage increase/ decrease
		Degre of saturation (V/C ratio)	Level of Service (LoS)	Degre of saturation (V/C ratio)	Level of Service (LoS)	
5	Jl. Padjajaran (West – East)	1.16	F	1.25	F	8%
6	Jl. Padjajaran (East- West)	1.45	F	1.41	F	-3%
7	Jl. Padjajaran (West – East)	1.16	F	1.25	F	8%
8	Jl. Padjajaran (East- West)	1.45	F	1.41	F	-3%
9	Jl. Padjajaran (West – East)	0.79	D	0.58	C	-27%
10	Jl. Padjajaran (East- West)	0.98	E	1.23	F	26%
11	Jl. Padjajaran (West – East)	0.98	E	1.23	F	26%
12	Jl. Padjajaran (East- West)	0.79	D	0.58	C	-27%
23	Jl Sawitsari	0.72	C	0.58	C	-20%
47	Jl Seturan	0.93	E	0.93	E	0%
49	Jl Seturan	0.93	E	0.93	E	0%
61	Jl Pangeran Diponegoro	0.65	C	0.66	C	3%
63	Jl RW. Monginsidi	0.81	D	0.80	D	-1%
73	Jl Colombo (Depan UNY)	0.34	B	0.34	B	1%
77	Jl Angga Jaya	0.67	C	0.63	C	-7%
81	Jl Agro (West – East)	0.27	B	0.32	B	20%
82	Jl Agro (East- West)	0.25	B	0.21	B	-15%

3.6 Road Network Performance Projections for the Next 5 Years Without Underpasses

To determine the projected volume of traffic flow in the next 5 years, the growth factor analysis approach is used. The vehicle growth factor is obtained from annual vehicle ownership data issued by the Sleman Regency Statistics Agency, Bantul Regency Statistics Agency, and Yogyakarta City Statistics Agency, in 2021. While the average vehicle growth that occurred in Sleman Regency, Bantul Regency, and Yogyakarta City during the period 2017 to 2020 was 2.07% [8], 6,02% [9], and 10,58% [10]. So, it can be concluded that the average growth of vehicles from the three districts / cities within the scope of the study area is 6.22%. Road network loading in the next 5 years without the Underpass as shown in Figure 11.

3.7 Road Network Performance Projections for the Next 5 Years with Underpasses

At this stage, the road network modeling simulation process is carried out in the next 5 years (year 2027) with the addition of new infrastructure in the form of an Underpass at the Condongcatur intersection. The Origin-Destination Matrix loading used is the MAT estimated by TflowFuzzy which has been adjusted to the projected growth target of traffic flow in 2027 using Furness iteration. With the addition of the Underpass at the Condongcatur intersection, there is a change in capacity on the Padjajaran road section which previously amounted to 4653 smp / hour to 4700 smp / hour. This is because there is an additional widening of the road section by ± 3 meters for each of the north and south sides. Then the change in speed on the road section with the Underpass becomes a free flow speed with a value of 54 km / hour.

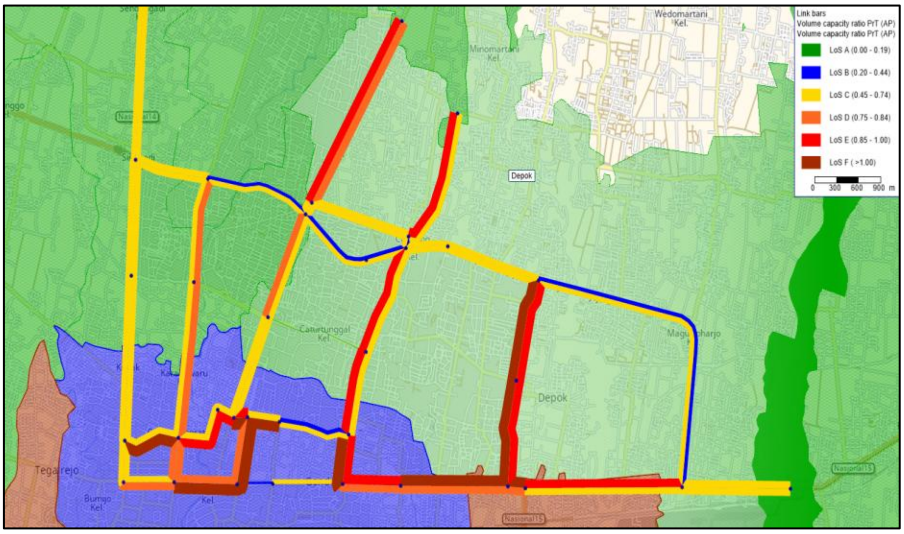

Figure 11. Simulation of Future 5-Year Traffic Performance without Infrastructure Changes

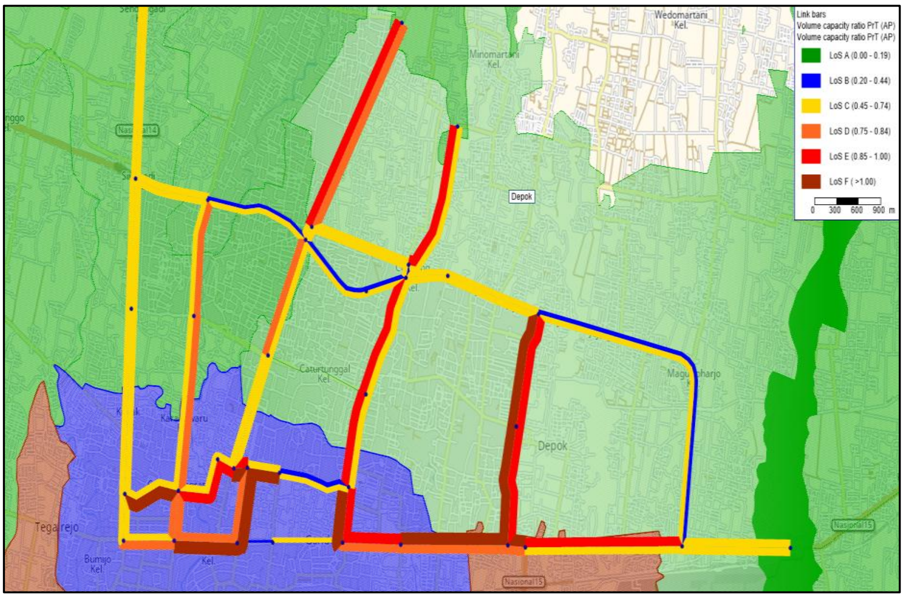

Figure 12. Simulation of traffic performance for the next 5 years with the Condongcatur Underpass

After running the re-loading for the 2027 network modeling with the Underpass, the results were obtained as shown in Figure 12. On the Padjajaran road section with the Underpass there was a decrease in the v / c ratio value by 5-29% even though it was still in the same Level of Service (LoS) category, namely B to C. The most significant change occurred on Jalan Affandi (link 41-46), where there was a decrease of 15-45% from level of service E and C to D and B, respectively. Then other road sections that are quite far from the Underpass construction site are still in the same performance category or Level of Service (LoS). This is due to the increasing flow of passing traffic in the next 5 years.

3.8 Modeling the Condongcatur intersection with PTV VISSIM

To be able to provide a clearer picture of changes in performance, especially at the Condongcatur intersection in solving the current congestion problem, micro-scale modeling is used with the help of PTV VISSIM software. Modeling using Vissim will be carried out for conditions without additional Underpass infrastructure (Without Project) and with the Underpass (With Project) with the performance parameters taken are the delay value and queue length at the Condongcatur intersection.

The modeling calibration process uses adjustments to driver behavior. Traffic flow volume is the main variable when comparing field survey volumes with VISSIM software simulated volumes in the Driver Behavior calibration process. This refers to previous research and becomes an integration process with macro modeling using VISUM [17]. The GEH test used to validate the traffic simulation results requires a value that is said to be valid if the GEH value is <5, while the MAPE test shows the percentage of forecasting accuracy with a maximum value limit of <50%. Table 5 shows the highest GEH test value of 3.81 which is still smaller than 5 so that in general the modeling is acceptable. In the next process, these settings are used to simulate the model at the Condongcatur intersection without activities (without project) and with the additional Underpass infrastructure (with project).

Based on Table 6, the performance of the affected intersection under existing conditions has an average queue length of 502 meters with an average delay of 191.46 seconds. So that in general the Level of Service (LoS) of the Condongcatur intersection is included in the F category. This indicates that the service at the intersection is very bad so there needs to be recommendations for improvements to reduce queues and delays that occur.

The analysis used in this scenario is the condition during the first operational year of construction with the underpass. Using previous traffic volume data, additional underpasses were modeled. Table 7 shows changes in intersection performance in operational conditions with the Underpass scenario at the Condongcatur intersection. The parameters of queue length and average delay have improved from the previous performance of 99.9 meters with a delay of 28.87 seconds. So that the service at the intersection has increased significantly from the previous category F to C. This indicates that the construction of the Underpass is effective in reducing congestion that occurs at the Condongcatur intersection.

Then the analysis of the performance of the Condongcatur intersection is forecasting in the next 5 years. Simulations were conducted to see the performance conditions of the intersection with the Underpass and without the Underpass in 2027. In that year it is assumed that the Condongcatur Underpass has operated to serve traffic movements at the research location. Based on Figure 13, it can be seen that both the delay value and the queue length have decreased quite a lot with the Condongcatur Underpass. This indicates that the Underpass Development plan is effective as a long-term handling recommendation in overcoming congestion at the research study location.

Tabel 5. Validation of Simulated Volume after Calibration process with GEH and MAPE test

No	Road Section Name	Volume (vehicle/hour)		*GEH*	Percentage Absolute Error
		Observation	Model		
1	Jl Padjajaran (T)	3640	3414	3.81	6.21
2	Jl Padjajaran (B)	3628	3483	2.43	4.00
3	Jl Anggajaya (U)	2142	2135	0.15	0.33
4	Jl Affandi (S)	2746	2596	2.90	5.46
				MAPE	4.00

Tabel 6. Existing Condition Intersection Performance

No	Intersection name	Arm of intersection	Max queue length (m)	delay (seconds)	Level of Service (LoS)
1	Condongcatur intersection *(Without Project)*	Jl Padjajaran (T)	136.72	88.09	LoS F
		Jl Padjajaran (B)	502.00	19.97	
		Jl Anggajaya (U)	153.29	169.26	
		Jl Affandi (S)	231.99	238.14	
	Average		502.00	191.46	

Tabel 7. Intersection performance under Operating Conditions

No	Intersection name	Arm of intersection	Max queue length (m)	delay (seconds)	Level of Service (LoS)
2	Condongcatur Intersection *(With Project)*	Jl Padjajaran (T)	34.59	28.25	LoS C
		Jl Padjajaran (B)	79.37	22.59	
		Jl Anggajaya (U)	93.87	34.19	
		Jl Affandi (S)	99.90	34.71	
	Average		99.90	28.87	

4. Conclusion

The performance of the road network in existing conditions based on the v / c ratio value ranges from 0.21 - 1.23 with Level of Service B - F. And the Condongcatur intersection in existing conditions has an average delay of 191.46 seconds with a level of service category F (Very bad).

Based on modeling during the construction period there are 12 road sections affected by the construction of the Condongcatur Underpass, especially the Padjajaran road section, the level of service drops to category F. The best alternative recommendation is to increase capacity by widening the slow lane by ± 3 meters.

At the time of operation there was a significant improvement in the road sections around the activity location with the Underpass. Especially on Affandi road (link 41-46) in category Los B, Padjajaran road in category Los B and C, and Condongcatur intersection rise to category Los C. So that the construction of the Condongcatur Underpass is effective in overcoming congestion at that location.

The suggestions that can be conveyed for further research are future research can use the latest data, especially the OD Matrix, to more accurately represent people's travel between zones, to develop the current modeling, future research can add validation parameters other than traffic flow data such as travel time, travel cost, air pollution level, and other schemes, and the scope of the research can be further developed by enlarging the scope of the study area and combining other infrastructure development plans such as the Solo - Yogyakarta Toll Road Development.

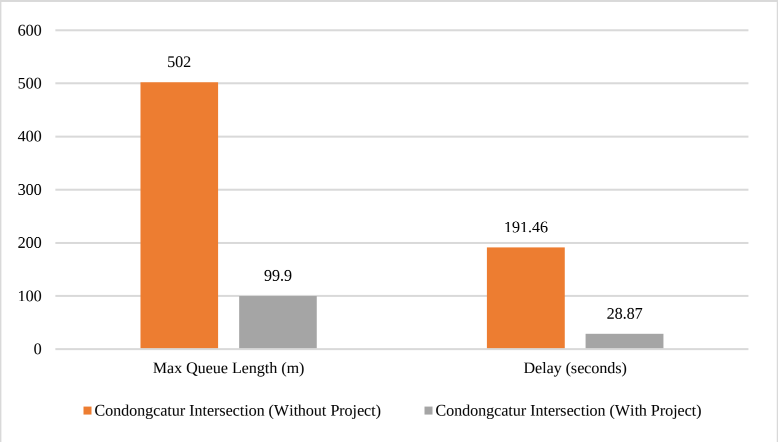

Figure 13. Comparison of Queue Length and Delay under With Project and Without Project conditions in 2027

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