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The Influence of Ramp Geometry on The Performance of Non-Toll Roads Around the Merging

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Abstract: Movement from toll roads via toll off-ramps and joining local roads often results in traffic jams and queues which significantly affect motorists' travel time. This study aims to determine the influence of ramp geometry on the performance of non-toll roads around the merger area. Geometric ramps are physical characteristics of ramps that involve length, width, height, slope angle, and other elements that affect the way vehicles enter or exit the roadway. Merger is a process of combining and then crossing two or more paths into one genre and then crossing over. From the VISSIM simulation analysis and discussion results, it was found that the capacity and geometry of the off-ramp had a very good influence on the intersection due to the combination of vehicles from the off-ramp and other connecting roads around an intersection, with an increase in ramp capacity, namely by adding 1 lane so that achieved a reduction in queue length from the existing condition of 350 m to 36 m and with Level of Service (LOS) E becoming Los C.

Keywords: t*oll Roads; off-ramps; traffic jams; ramp geometry; VISSIM simulation*

1. Introduction

1.1 Background

Merging areas on non-toll roads often become points prone to traffic jams and accidents. The geometric design of the ramp is inadequate and can result in problems moving traffic from the ramp to the main road or from the main road to the ramp. Speed, capacity and level of comfort in merging traffic are greatly influenced by the geometric characteristics of the ramp.

Good ramp geometry design can improve traffic flow, reduce collisions, and optimize walking capacity around merging. Therefore, the research will further examine the continued impact of ramp geometry on local road performance in the merger area. It is hoped that the results of this research can be used as a basis for improving the geometric design of existing ramps and increasing traffic efficiency and safety in the merged area.

For many people, traffic jams are an annoyance and so are making personal schedules. However late their economic efforts may be, this is a financial loss. However, for some other people, for people who understand economics, this actually becomes a financial loss. And there are also those who think this is life in a big city. [1] (S. Kumarage, 2004).

The construction of roads, toll roads, and bridges is infrastructure that is currently aimed at increasing connectivity to facilitate the mobility of people and goods. Internal supervision is carried out at the construction stage in order to achieve construction results that are in accordance

with expectations and plans. Additionally, with monitor, identify, and anticipate possible problems that arise so that action can be taken as early as possible. [2](NA Failusuf et al., 2018).

Toll roads and connectivity with road local each other support the surrounding area like the zones that have activity new then the off-ramp is a liaison road toll with local roads that are busy at certain times so that experience declined performance The road (LOS) is congested. V/C ratio is the standard used in evaluating level service road (LOS) that has a mark of no more than 1. [3](Subiantoro et al., 2022).

Ramps are very important in connecting toll roads with inner city road environments. Wang et al in their research evaluated travel time and vehicle emissions in a 2 lane on and off-ramp setting. The ramps have affected the performance limits on the ramp setup. [4](X. Wang et al., 2020).

The impact of congested road transport channels is causing severe traffic jams and very long queues of vehicles. The solution to this problem is to dynamically arrange long queues at each intersection point in a balanced manner. The model used is a stochastic model for vehicle queues with arrival rates determined based on a Poisson distribution and service at intersection points based on an exponential distribution. Demonstration of the dynamics of the queuing model is shown by simulation using Sim Events MATLAB-Simulink. The simulation results show that the dynamic queuing mode can minimize the impact of more regular vehicle density compared to the use method. [5](E. Harahap et al., 2017).

In their research, Zhao et al used multi discipline by combining the data to be analyzed, traffic simulation models, and field observations. Road geometry is also taken into consideration including the latest traffic volume, the driver's timing signal behavior is also a consideration of the condition of the infrastructure. The analysis needs to pay attention to residents and their points of view, pedestrians, local business people, and relevant authorities so that the freeway must be able to connect with local roads that pass on-ramps and exit routes. [6](Zhao et al., 2017).

The main purpose of building a toll road at level or laying a toll road is to reduce traffic jams, but congestion still occurs, especially on connecting sections between exit roads and land road intersections. From the results of the traffic survey, the characteristics of traffic operations on the sections and the main influencing factors are the length of the connecting sections. Combined model to calculate the long section link between the urban expressway and the proposed intersection. VISSIM is used to simulate currents. Then cross under _ currents and calculate the connecting section length. The comparison results show that based on length calculations, travel time, average delay, parking time, and queue length are reduced to varying degrees, which verifies the rationality of the calculation model. [7](F Wang et al., 2022)

1.2 Research Objectives

The aim of this research is to;

a) Analyze the effect of ramp geometry on traffic flow around the merge area.
b) Evaluate the geometric impact of the ramp on traffic flow and accidents in the merge area.
c) Study the effect of ramp geometry on walking capacity around the merger.
d) Provide recommendations for improving geometric ramp design to improve non-toll road performance in the merger area.

The research location is on the exit road of JORR Pondok Pinang and Simpang Ciputat Raya – Pondok Pinang.

(a) (b)

Fig 1. (a) JORR Toll Exit Ramp Research Location dan (b) Jalan Pondok Pinang – Lebak Bulus.

2. Literature Review

An Empirical study done to three slope road different in One system toll road (JORR) for know influence slope the to connection third variable Then cross ; density , speed and volume then cross . The result show that difference speed between vehicle weight and vehicle no the weight at 3.5% slope is 56%~109% more tall compared to with slope 0%. This thing show that on the way more steep , vehicle heavy tend more reduce the speed compared to vehicle No heavy. [8] (Nahry et al., 2018).

The important role of Majapahit Road results in vehicle queues and traffic delays, vehicle build-up, travel time delays (delays), and decreased road service levels. Analysis of the performance of urban roads, with performance indicators namely current Traffic (Q), capacity (C), degree of saturation / Degree of Saturation (DS), and free flow speed are applied _ with various performance indicators, namely free flow speed (FV), as well as analyzing the level of service (Level of Service/LOS) on the road section Based on the results of calculations that occurred in 2017, it is necessary to look for solutions/alternatives to reduce the degree of sign saturation (DS) by increasing the sign capacity.. [9] (R Mudiyono et al., 2017)

Ramp regulations other than JBH Bina Marga regulations are as follows, Hiking trails The climbing lane is intended to accommodate trucks: heavily laden trucks or other vehicles that move slower than other vehicles in general so that other vehicles can overtake slow vehicles without having to change lanes. Climbing routes must be provided on road sections that have a large, continuous slope and relatively dense traffic volume.

Placement of climbing routes, based on freeway geometric planning for toll roads, must be carried out with the following provisions:

a) If the critical length is exceeded, have a VLHR > 25,000 SMP/day, and a percentage of trucks > 15%.

b) The minimum width of the ramp is 3.60 m. [10](Standard Toll Road Geometry , Highways 2015)

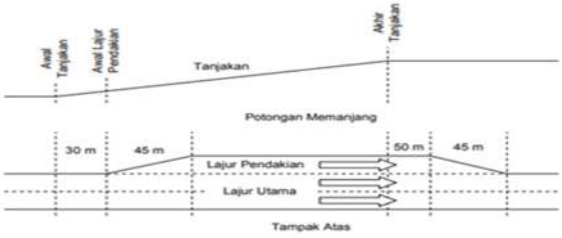


Fig 2. Climbing lane typical.

Source: Standard Bina Marga Toll Road Geometry

Fig 3. Areas of influence on ramp and off ramp.

Source: Standard Geometry of the Bina Marga Toll Road

Traffic flow in the exit area is closely related to the combination of main parameters including acceleration and deceleration, lane length, and area mesh length. In this case, an optimization model for geometric elements in the design of toll road entrances and exits based on driver characteristics is proposed. Using VISSIM for in-depth traffic simulation evaluates the effect of optimization based on characteristics. Then the results of the cross and calculations obtained an average decrease in delays of 18.1% and an average increase in traffic smoothness of 13.6%. [11](W. Zhang et al,.2019).

Based on queuing theory, the degree of saturation of a function is the probability of an abundance cycle occurring which is a function of demand and capacity. Measuring possible overflow and demand cycles can estimate capacity based on the connection function. From the queuing model that occurs, deviation signals from stochastic characteristics can be estimated. Then the queue length and delay are also obtained from the parameter estimates, and the proposed model is verified under No-bore simulation conditions. Meanwhile, in model validation, the capacity gain is in a saturated condition (the cycle on the detector is filled to full condition in the light green phase) and if the capacity being considered is the possible flow rate measured as a reference. [12](N. Wu et al., 2016).

A problem that has existed for a long time that is How to estimate queue length at the intersection signal in real-time. Difficult problem When the link signal is very dense. Therefore, our approach can estimate long time-dependent queues even when the link signal is fulfilled with a long queue.[13](HX Liu et al., 2009).

Using a simulation-optimization logic solution, the proposed model will first estimate the off-ramp queue length, resulting from the module signal, to evaluate the resulting impact on the main road expressway, and then incorporate the impact back into the control objective to do so. repeated searches. For Optimal cycle length and phase duration with genetics. [14] (Y. Chen et al., 2021)

Discussion of minimum access and exit distances in terms of road safety aspects. The safety aspect studied is to look for the relationship between toll road geometric aspects and the level of accidents that occur. The accidents that occurred were divided into three categories, namely; accidents that cause death, cause injuries and total accidents. The prediction model that will be created is a debate on the three types of accidents with aspects of toll road geometry.[15] (D. Santoso et all., 2020).

3. Research Method

Flowchart of methods:

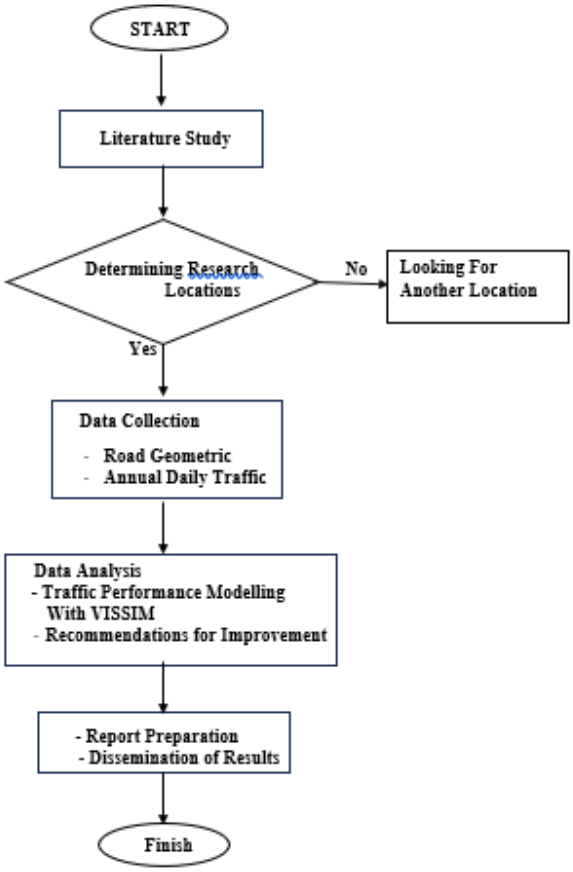


Fig 4. Flowchart of methods.

This methodological study will include the steps and approaches used to determine the effect of geometric ramps on the performance of non-toll roads around the merger area. The following methodological steps are applied:

1) Literature Study: Conduct a literature review to understand previous studies that have been carried out in this field. This will help in formulating a conceptual framework and identifying relevant variables. _
2) Determining Research Locations: Selecting a number of locations on non-toll roads that have merging areas
3) Data Collection: Collect the necessary field data, including past traffic data such as the latest traffic volume, speed, and traffic density around the merging area.
4) Analysis: Analyse existing data collected using appropriate statistical methods - To identify the relationship between ramp geometric characteristics and walking performance around the merge.
5) Traffic Performance Model: Using the VISSIM traffic simulation software for the performance model by combining various geometric path scenarios.
6) Recommendations for Solutions: Based on research findings, design recommendations for ramp geometric improvements are prepared that can improve the performance of non-toll roads around the merger area.
7) Report preparation: Compile a research report containing all the results, findings, recommendations, and conclusions of this research.

8) Dissemination of Results: Sharing study results with relevant stakeholders _ such as local governments, transportation agencies, and highway engineers through seminars, conferences, or scientific publications.

This methodology will be a study to comprehensively explore the influence of ramp geometry on the performance of non-toll roads around the merger area and provide valuable recommendations for road improvement design.

4. Analysis And Calculations

ramps, and toll exits during peak hours in the morning 06.00-08.00, afternoon13.00-15.00, and evening 18.00-20.00. This data will be used as the basis for analysis and calculations and the survey results can be seen in the following table;

Study of geometric data of road locations. From GPS data, it is known that the Ciputat - Pondok Pinang intersection has a slope of 5.6% towards the Ciputat - Pondok Pinang intersection with a length of 200 m, and the 750 m grade is relatively flat.

Table 1. Geometry Data.

Description	Length (m)	Width / lane (m)	Outer road shoulder (cm)	Inner road shoulder (cm)
JORR Pondok Pinang exit ramp	950	3,5	20	20
Ciputat Raya intersection	140	3,5	20	20
Kartini Street	100	3,5	20	60

Source: 2023 Data Analysis

Traffic calculations generated from the survey to Average Daily Traffic can be seen in Table 2 Average Daily Traffic Volume (ADT) (pcu/hour) as follows;

Primary data on average daily traffic (ADT) at the Pondok Pinang intersection in the morning 06.00-08.00, afternoon13.00-15.00, and evening afternoon 18.00-20.00,can be seen in Table 2. The average daily traffic volume per hour and a graphic image of the percentage of vehicle types are below.

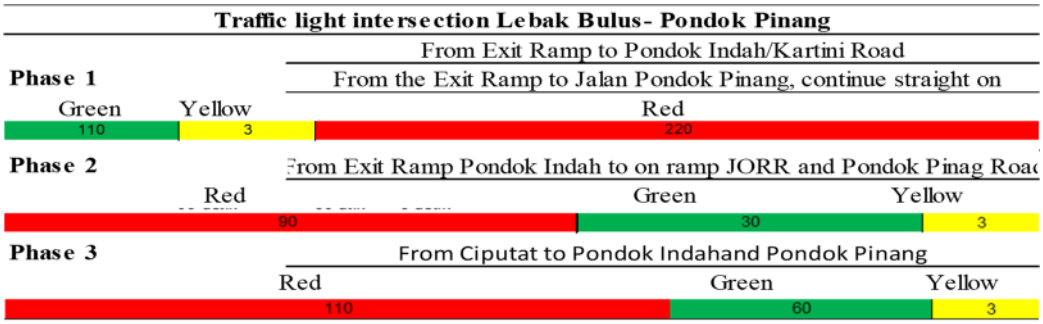
Table 2. Average Daily Traffic Volume per hour.

Hours	Direction VolumeExit ramp Pondok Pinang - Kartini	Direction Volume Pondok Pinang - Kartini	Direction Volume Ciputat - Kartini
Morning Rush Hour			
06.00 - 07.00	1308	635	1730
07.00 - 08.00	1455	750	1874
Afternoon Rush Hour			
13.00 -14.00	1318	629	1306
14.00 -15.00	1196	552	1172
Evening Rush Hour			
18.00 -19.00	1345	593	1514
19.00 -20.00	1260	534	1306

Source: 2023 Data Analysis

Results of the APILL Survey at the Ciputat Raya – Pondok Pinang intersection are in the following in Table 3. Steering Tool Phase traffic.

Table 3. Steering Tool Phase traffic.



Analysis of the degree of saturation every hour during peak hours is calculated using the 1997 Indonesian Road Capacity Manual (MKJI '97) method as follows:

The population in DKI Jakarta based on data from the Central Statistics Agency (BPS) for the period December 2022 is 10,748,820.00 people.

Factors that influence the capacity of city roads are the width of the track or lane, the presence or absence of road dividers/medians, road shoulders/roadside barriers, road slope, urban or outer city areas, and city size. The urban formula shows the following:

$$C = Co \times Fcw \times Fsp \times Fcf \times Fccs \quad (1)$$

Where:
C = Capacity (pcu / hour), passenger car units (pcu)
Co = Capacity basic (pcu /hour), usually used figure 2300 pcu / hour
FCw = Adjustment factor wide road
FSp = Adjustment factor separation direction
FCf = Adjustment factor obstacle side and shoulder of the road / kereb
FCcs = Adjustment factor size city

Calculation results capacity tabulated in table 4. Calculation Results Capacity like under this ;

Table 4. Calculation Results capacity.

Direction	Basic Capacity (Co) (pcu/hour)	Capacity Adjustment Factor				Capacity (C) (pcu/hour)	Queue (m)
		Directional Separation (FCsp)	Directional Separation (FCsp)	Side Obstacles (FCsf)	City Size (FCcs)		
B-T	1450	1	1	1	1.05	1523	250
U-T	2700	0.87	1	0.97	1.05	2392	350
S-B	2700	0.87	1	0.97	1.05	2392	0

Source: 2023 Analysis Data

Notes:

B is West from the Ramp Pondok Pinang exit towards to T is East (Jalan Kartini) and U is North from Ciputat towards to T (Jalan Kartini) and S is South towards to B T is East (Jalan Kartini)

Finding The degree of saturation (DS) is presented in Table 5.

$$DS = Q/C \qquad Q = C0 \qquad (2)$$

Table 5. Results of calculation of Degrees of Saturation (DS).

Time	From Direction	Total vehicles (pcu/hour) (Q)	Capacity (C) (pcu/hour)	Degree of saturation (DS)
06.00-08.00	B-T	1596	1660	1.0
18.00-20.00	B-T	1094	1138	1.0
06.00-08.00	T-B	752	782	1.0
18.00-20.00	T-B	591	615	1.0

Source : 2023 Analysis Data

Notes: B is West from the Ramp Pondok Pinang exit towards, T is East (Jalan Kartini) and S is South from Ciputat towards T (Jalan Kartini), T is East (Jalan Pondok Pinang),

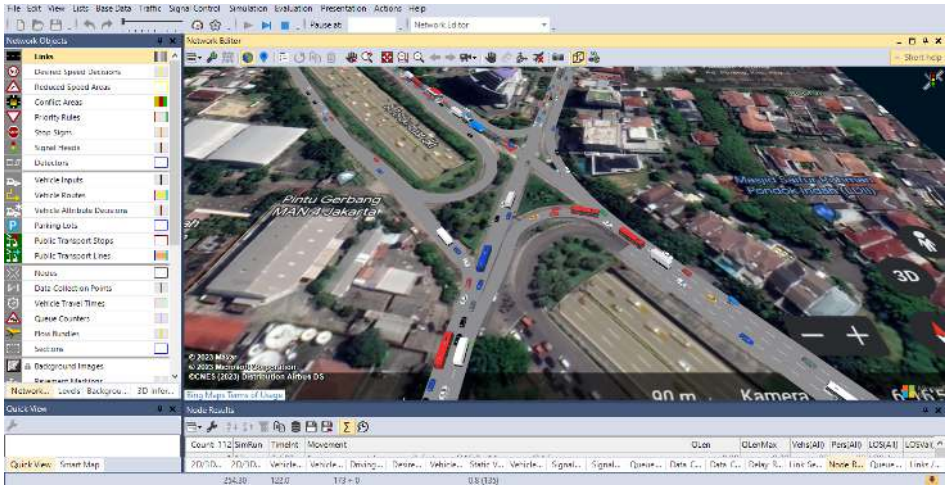


Fig 5. Simulation existing Off -Ramp and Intersection Pondok Pinang.

Simulation VISSIM existing produces at the intersection Pondok Pinang postponed 36 seconds / pcu, queue 103 m including LOS C, for the Pondok Pinang Exit ramp produces a delay of 64 sec / pcu, queue length 122 incl greetings LOS E and for location intersection Pondok - Pinang road Kartini delay of 103 seconds / pcu, and queue amounting to 274 m incl in Los E.

5. Result And Discussion

Simulation results of the existing VISSIM with LOS E values, then a simulation is carried out with the assumption of widening or adding lanes on the JORR Pondok Pinang Exit ramp, Jalan Kartini, and Jalan Raya Ciputat which are available as shown in Fig. 5. Simulation of increasing road performance.

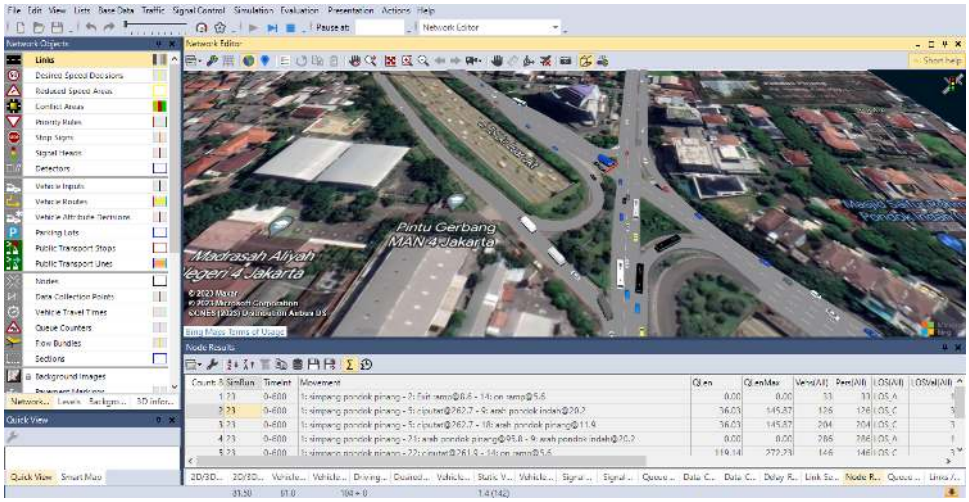


Fig 6. Simulation improves road performance.

From the results of the VISSIM simulation, the existing conditions and additional capacity, namely the addition of 1 (one) lane at the Pondok Pinang, Ciputat and Kartini Off-Ramp locations, can be seen in table 6. Capacity - Existing queues and additional lanes as well as fig. 6. Capacity Graph – Existing queues and additional lanes.

Table 6. Capacity Graph – Exixting Queues and additions lane.

Direction	Exixting capacity (C) (pcu/hour)	Existing Queue (m)	Existing add lane Capacity +Lane(C) (pcu/hour)	add lane Queue (m)
B-T	1523	250	3045	29
U-T	2392	350	2392	21

Source: 2023 Analysis Data

Notes:

B is West from the Ramp Pondok Pinang exit towards to T is East (Jalan Kartini) and U is North from Ciputat towards to T (Jalan Kartini).

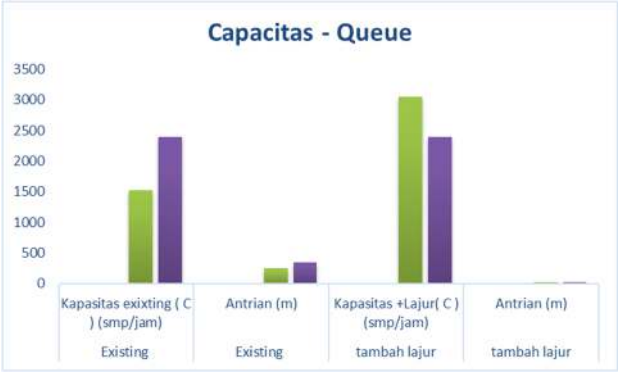


Fig 7. Chart Capacity – Existing and Additional Queues lane.

Finding the existing condition, Delay, Queue Length, and LOS after engineering the addition of lanes, we obtained that at the Pondok Pinang intersection, the delay was 17 seconds/pcu, the queue was 29 m including LOS B, for the Pondok Pinang Exit ramp it produced a delay of 27 seconds/pcu, the queue length was 21 including LOS B greetings and for the Pondok Pinang Jalan Kartini intersection, the delay is 26 seconds/pcu and the queue is 36 m, including in Los B.

6. Conclusion

The toll exitramp/off-ramp's geometric design greatly influences connectivity integration to local road intersections. From the results of research at the JORR Pondok Pinang and Ciputat Raya off-ramp locations, it is clear that off-ramps greatly influence the performance of local road intersections, and from the VISSIM simulation results at the existing intersection location, the performance of roads E and in the engineering simulation of adding lanes to the JORR local road ramp and Simpang toll exit adapt lower road performance to LOS B and C. Length of off-ramp and surrounding slope conditions 5% is very influential on the size of the vehicle so it is recommended that the road slope be <5% accordingly Bina Marga standard design.

Study advanced expected can add enhancement design for engineers and takers _ policy in planning net and road toll.

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