Distance analysis of U-turn round facilities for sustainable urban development (case study of Ahmad Yani Road, Tirtayasa and Cilegon road)

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Abstract. Cilegon City is an industrial city with internal and internal movements occurring on one access road stretching from Jalan Raya Cilegon, Jalan Ahmad Yani, and Jalan Sultan Ageng Tirtayasa. This arterial road section has a total road length of 5 km that passes through the Cilegon City area, which is the center of activity. Efficient use of traffic space by arranging the traffic space efficiency is used the distance between U-turns so that delays and queues are low. As long this road network has the highest volume of 2,399 pcu/h with an average speed of 32 km/h and reaching a VCR of 0.8 has a median number of 13-point openings, the number of uncontrolled U-turns causes many conflicts traffic that will cause traffic disruption when a vehicle makes a U-turn. The purpose of this study is to improve the performance of the road network in the Area of the City of Cilegon by knowing the best distance between U-Turns. Simulation analysis uses Vissim software to produce the ideal distance for each opening in the Cilegon City arterial road, which is then utilized in the arrange of the U-turn facility itself. The method used is the calculates of existing traffic performance and simulation to determine the ideal distance between U-Turn facilities. The simulation results with the ideal Vissim model of the distance between the turning facilities were 650 meters with an average delay of 17.56 seconds, a network speed of 33.07 km/h, a total distance of 28,453.34 km, and the total travel time to be 847.30 hours.

Keywords: distance, Network Performance, U-Turn facility

1. Introduction

The city of Cilegon, as one of the cities in Banten, which is the Java Island entrance has quite heavy traffic and an urban area accessible only to one main road. This city is on the northwestern tip of Java Island, on the edge of the Sunda Strait. It is an industrial city connected to the Jakarta – Merak toll road.

The city of Cilegon only has direct access, which extends from Jl. Raya Cilegon, Jl. Ahmad Yani and Jl. SA Tirtayasa is 5 kilometers long, resulting in the heavy traffic of the three roads where the heaviest traffic reaches 150 pcu-minute/km on Jl. Ahmad Yani and the highest vehicle volume of 2399 pcu/hour. The existing road conditions (Jl. Raya Cilegon, Jl. Ahmad Yani, and Jl. SA Tirtayasa) where it gets denser during peak hours, especially in the morning where the VC Ratio reaches 0.8 with a speed of 32 km / hour[1]

This is also influenced by the fact that the road is a shopping center and shopping center, most of which do not have parking space and makes traffic space narrow due to the large number of vehicles parked on the road’s side, so that vehicle space is blocked. However, this median’s existence is also followed by the availability of a median opening (U-Turn) as a vehicle turning facility. Uncontrolled turnback facilities will cause traffic delays when a
vehicle makes a, where the average delay at each U-turn reaches 10 seconds with a total of 13 U-Turns, the distance of each turning back facility (U-Turn) not more than 400 meters.

Besides, many turn-around facilities also can to cause conflicts between vehicles and vehicles and pedestrians. With a road length of 5 km and a median number of openings (U-Turn) of 13 points as evidenced by a travel time of up to 20 minutes, it is necessary to research to determine the ideal distance and arrangement of the turn-around facility based on traffic performance.

2. Literature View

2.1 U-Turn Facility

The median is the part of the road that is impassable by a vehicle with an elongated shape parallel to the road, located on the axis/center of the road, intended to separate the opposite traffic flow. The median may be in the form of an elevated median, a lowered median, or a flat median.

The median section or U-Turn facility is planned to accommodate the vehicle in order to perform a U-turn movement a divided road type and can accommodate to cut and turn right. In the Pedoman Perencanaan Putaran Balik (U-Turn) [2], U-Turn is the vehicle’s traffic movement to turn back or turn 180°.

The median section for turning can be done at the following locations:
1) Locations between intersections to accommodate turning movements are not provided at the intersection.
2) Locations near the intersection to accommodate turning movement will affect the constant movement and turning movement at the intersection. Turning movement can be planned at a location with quite wide median near street approaches that have few openings.
3) Locations where there are critical public activities such as hospitals or other activities related to road activities. Openings for this purpose are required on the streets with access control and on divided roads with low traffic volume.
4) Locations on non-controlled road, is access where a turning facility at an optimum distance is provided to serve the development of the edge area and minimize the pressure for the return facility in front of it. The 400-800 meter gap between openings is considered sufficient in some cases.

The minimum distance between the opening and median opening width[3] is described in the Table 1.

| Road Function | Luar Kota | Urban |
|---------------|-----------|-------|
|               | Openings Distance (km) | Openings Space (m) | Openings Distance (km) | Distance Pinggir Kota | Dalam Kota | Opening Space (m) |
| Arteri        | 5         | 7      | 2,5     | 0,5       | 4                     |
| Collector     | 3         | 4      | 1,0     | 0,3       | 4                     |

Source: Pedoman Konstruksi dan Bangunan: Perencanaan Median Jalan (2004)

Planning for the location of the return round facility must consider several aspects of road and traffic geometric planning, including:
1) Street function
2) Street classification
The rotating facility must be equipped [4] with:

1) Retarding lane in approach lane entry;
2) The adequate turning radius for all types of vehicles according to road use class; and
3) Speed lane to join the mainline.

U-turns are permitted at locations with sufficient width for vehicles to make a turn without any violation/damage to the pavement’s exterior. U-turns should not be permitted in continuous traffic as they may have impact on traffic operations, including reduced speed and the possibility of accidents.

2.2 Vissim application program
VISSIM is one of the transportation applications that can display microscopic simulations based on time and behavior developed for urban traffic models. This program can be used to analyze traffic operations under the confines of road line configurations, traffic composition, traffic signals, etc. So that this application can help to simulate various transportation engineering alternatives and the most effective level of planning. Not only about the road network, but also for intersections, public transportation, and pedestrians.

In simple terms, modeling using VISSIM is divided into five stages:

1) Identify the scope of the area to be modeled.
2) Data collection
3) Network coding
4) Error checking
5) Model calibration and validation

The data requirements to build a model using VISSIM are:

1) Geometric data
2) Data traffic
3) Vehicle characteristics

The data requirements to build a model using VISSIM to be used are geometric data, traffic volume, vehicle proportions, vehicle routes, and APIII / intersection priority data.

3. Research Methodology
In this case, the research method can be interpreted as a series of actions to obtain information in data with predetermined goals and benefits. This research is a type of comparative research, which is a study that compares several simulation results to the distance between U-turn points to obtain the best distance with the lowest delay.

The initial activity of the research was to identify the problem of the number of turn-around facilities that affect traffic performance along the observed road sections, to collect traffic data, and to perform simulations with several alternative U-Turn distances. The data collected includes traffic volume, delays and road inventory. In this study, the authors compared several delay conditions with various alternative distances between U-Turns.

This activity is a stage of observation and monitoring of conditions in the field to then formulate problems that will be used as research material. Observations were made in the City of Cilegon, precisely on median urban arterial roads where there are many turn-around facilities that have the potential to cause a decrease in the performance of the primary arterial roads and increase traffic congestion.
This stage is the process of identifying problems that occur in Cilegon City to obtain problem formulations that are more focused on the study location that will be used as research material, in this case relating to the effect of turning facilities on traffic on primary arterial roads.

This study requires two types of data, namely secondary data and primary data as the basis for solving problems that have been formulated previously.

Secondary data is data that has been compiled and obtained from several agencies related to the data required in this study. Secondary data required are as follows.

1) Road network map
2) Road geometric data
3) General Data of Cilegon City Transportation Patterns 2019
4) Laws and regulations
5) Land Use Map

Observations were made in the City of Cilegon, precisely on median urban arterial roads where there are many turn-around facilities that have the potential to cause a decrease in the performance of the primary arterial roads and increase traffic congestion.

Primary Data Collection

In this study, primary data was obtained through field surveys along Ahmad Yani, Tirtayasa and Raya Cilegon roads which were carried out for 16 hours starting at 06.00 - 21.00 to collect the following data.

1) Inventory survey U-Turn to determine the condition of the existing infrastructure, the location of the turn-around facility as the object of research. Inventory data U-turn obtained directly from the field includes the length of the U-turn, the width of the U-turn, the distance of each opening, the number of openings and the direction system and land use conditions.

2) Classified traffic volume enumeration survey which is intended to determine the level of traffic density on the section U-Turn based on the classified traffic volume and the direction of traffic flow and the type of vehicle in a certain time unit with direct enumeration in the field. The purpose of conducting this survey is to obtain traffic volume data and to find out the peak hour period at each point of the survey location.

3) A queue survey was conducted to determine how long and how many vehicles were delayed in making a U-turn. The queue survey at the U-Turn is carried out directly in the field by measuring the average queue length and the number of vehicles at the busiest hour or the busiest traffic.

4) Delay Survey Delay survey is conducted by calculating the delayed time when making a U-turn. The delay survey is carried out directly in the field by calculating the time of the vehicle from before turning until the vehicle is free and calculating the time the other vehicle is delayed behind the car that makes a U-turn.

4. Analysis and Problem Solving

4.1 Analysis of Existing Road Performance

Analysis of the performance of each road section for structuring and the effect of the distance between U-Turn facilities on arterial roads in Cilegon City was done by dividing the arterial roads in the city of Cilegon into 13 segments based on the U-Turn facility's location with details (Table 2).
Table 2 Round Facility Point

| No | Round Facility Point                      | Length Segmen (m) |
|----|------------------------------------------|-------------------|
| 1  | U-Turn 1 Junction PCI                    | 165               |
| 2  | U-Turn 2 Junction Teuku Umar Road(local) | 170               |
| 3  | U-Turn 3 In front of Restaurant (GB)     | 300               |
| 4  | U-Turn 4 In front of Outlet Celcius      | 577               |
| 5  | U-Turn 5 In front of Bank BNI Syariah    | 867               |
| 6  | U-Turn 6 Junction KH Wasyid Road         | 277               |
| 7  | U-Turn 7 In front of Yamaha              | 465               |
| 8  | U-Turn 8 In front of Matahari Store      | 619               |
| 9  | U-Turn 9 In front of Mayor’s house       | 246               |
| 10 | U-Turn 10 In front of Agung Mosque       | 120               |
| 11 | U-Turn 11 In front of Sate Cilegon       | 257               |
| 12 | U-Turn 12 Junction Antasari              | 157               |
| 13 | U-Turn 13 In front of Honda              | 355               |

a) Road Section Capacity
Jl. Raya Cilegon to Jl. SA Tirtayasa has the same capacity, namely 2732.4 pcu/h, because these roads have the same geometric roads, road types, and side obstacles, namely commercial shopping areas (Figure 1).

b) Traffic Volume
The traffic volume of Jalan Raya Cilegon – SA Tirtayasa in the research study area was obtained from the enumeration survey that was converted into pcu/h. The road segment with the most enormous traffic volume is Jalan Ahmad Yani 3 with 2399 pcu/h, and the smallest volume is Jalan Raya Cilegon 1 with a volume of 1478 pcu/h.

c) VC Ratio
According to the calculation of the VC Ratio, it can be seen the level service of the roads. The calculation of the VC Ratio is the ratio between the total volume and the capacity of the sections. The highest ratio is Jalan Ahmad Yani 3 with V/C Ratio 0.88. As for the lowest rate of VC Ratio is Jalan Raya Cilegon 1 as much as 0.54.

d) Speed
The road speed in Jalan Raya Cilegon – SA Tirtayasa was obtained from the MCO Survey (Moving Car Observer). The road segment with the highest average speed is Jalan Raya Cilegon 2 at 42 km/h. Meanwhile the road that has the lowest average speed is Jalan Ahmad Yani 2, which is 31 km/h.

e) Road Service Level
The lowest level of service is Jalan Ahmad Yani 3 with V/C Ratio of 0.88 at 32 km/h. The top-level of service was Jalan Raya Cilegon 1 with a V/C Ratio of 0.54 at 40 km/h.
4.2 Transportation Modeling Using Vissim Software

a) Zoning
Zoning is dividing or splitting of an area or a region into several parts, according to function and purpose. This zoning is used to facilitate the travel distribution process to the next stage (Table 3).

| No | Zone | Access                      |
|----|------|-----------------------------|
| 1  | 1    | Jl. Raya Cilegon 2          |
| 2  | 2    | Jl. Pondok Cilegon Indah   |
| 3  | 3    | Jl. Teuku Umar             |
| 4  | 4    | Jl. Imam Bonjol            |
| 5  | 5    | Jl. KH Wasyid              |
| 6  | 6    | Jl. Ishak                  |
| 7  | 7    | Jl. Panjaitan              |
| 8  | 8    | Jl. Bojonegara 1           |
| 9  | 9    | Jl. Sastradikarta          |
| 10 | 10   | Jl. Pangeran Antasari      |
| 11 | 11   | Jl. SA Tirtayasa           |
b) Proportion of Modal Choice

![Figure 3 Proportion of Modal Choice](image)

From the diagram above it can be seen that the mode most travels on arterial road is 71.78% motorbikes, while the least mode are medium busses, small trucks, and UM at 0.2% (Figure 3).

c) Travel Loads

By utilizing Vissim software to assess the micro-flow traffic based on the information provided (input) in road networks and traffic requests. This software will self-manage traffic in the road network according to its origin and destination by using routes based on the shortest travel time. The output of traffic charges with Vissim software demonstrates the kind of traffic that can be used as a basis for traffic management. The charges were done by using the volume and speed of each road segment.

d) Validation of the Road Network Model

After the road network model is built, validation is done by using the Chi-Square Test (Table 4). Data validation itself is a testing process of models with surveys to assess whether the network model created represents conditions in the field.

| Table 4 Validation |
|--------------------|
| I. HYPOTHESES      |
| Ho: Model with Aligned Survey |
| H1: Model with the survey is not aligned |
| II. Value Confidence Level | 95% | 0,05 |
| III. Degrees of Freedom | (v) = (k-1) = 26 |
| IV. So, the Chi Square Value Table | (X² table) = 38,8851 |
| V. Calculating X² count | 32,225 |
| VI. Decision Rule : |
| Ho is accepted if X² count < 38,88514 |
| H1 is accepted if X² count > 38,88514 |
| VII. Decision : |
| Ho ACCEPTED |
Based on the calculations, X² count = 32.22, then X² count < 38.89 (X² table) so H₀ is accepted. In conclusion, the model results are in line with the observation results, it can be used because it represents conditions in the field.

e) Existing Network Performace

Along the Jalan Raya Cilegon - Jalan SA Tirtayasa as a road network currently has the following performance (Table 5).

**Table 5 Existing Network Performance**

| Parameter                | Network Performance |
|--------------------------|---------------------|
| Delay Average (s)        | 19.81               |
| Network Speed (km/h)     | 31.28               |
| Total Travel Distance (km)| 28.188             |
| Total Time Travel (h)    | 901.04              |

4.3 Simulation

The U-turn facility simulation applies the distance between the U-Turn, which is calculated from the end of the median to the next median with a distance per 500 m, 550 m, 600 m, 650 m, 700 m, and 800 m without paying attention to any intersections to find the ideal distance with the best road network performance. This arrangement was made by utilizing Vissim software, with changes in distance between U-turn facilities so that after structuring it can be known the performance of the road network after structuring (Table 6).

**Table 6 All of Alternative Network Performance**

| Parameter                | Distance between U-Turn |
|--------------------------|-------------------------|
|                           | Alternative 1 | Alternative 2 | Alternative 3 | Alternative 4 | Alternative 5 | Alternative 6 |
|                           | 500 M         | 550 M         | 600 M         | 650 M         | 700 M         | 800 M         |
| Delay Average (s)        | 19.81         | 18.45         | 18.35         | 18.01         | 18.63         | 19.05         | 19.84         |
| Network Speed (km/h)     | 31.28         | 32.35         | 32.32         | 32.35         | 32.3          | 32.36         | 32.2          |
| Total Travel Distance (km)| 28.188       | 27.493.82     | 27.403.69     | 27.376.22     | 27.734.94     | 27.467.43     | 28.044.83     |
| Total Time Travel (h)    | 901.04        | 849           | 847           | 846           | 858           | 848           | 870           |

Of the six proposed alternatives, it can be seen that only Alternative 3 shows an increased performance in traffic where the average delay decreases to 18.01 seconds, the network speed increases to 32.35 km/h, the total travel distance becomes 27,376.22 km, and the total travel time is 846.29 hours. Therefore, from several simulation analysis namely Alternative 1 to Alternative 6, it can be concluded that the ideal distance along CBD arteries in Cilegon City is 600 meters.

The suggestion to improve the performance of the road sections by applying the distance between U-Turns is to make changes to the ideal distance approach obtained and taking into account the land use conditions with the distance between the U-Turn facilities below (Table 7).
Table 7 The Simulation Recommendation Round Facility Point

| No. | Location before | Round Facility | Location after | Recommendation distance between U-turn |
|-----|-----------------|----------------|----------------|----------------------------------------|
| 1   | Junction PCI    | U-Turn 1       | Junction PCI   | U-Turn 1                               | 165 |
| 2   | Junction Jl. Teuku Umar (lokal) | U-Turn 2 | In front of Restaurant (GB) | U-Turn 2 | 609 |
| 3   | In front of Restaurant (GB) | U-Turn 3 | In front of Toko Celcius | U-Turn 3 | 534 |
| 4   | In front of Celsius Outlet | U-Turn 4 | In front of SPBU Ahmad Yani | U-Turn 4 | 600 |
| 5   | In front of Bank BNI Syariah | U-Turn 5 | In front of Ramayana | U-Turn 5 | 632 |
| 6   | Junction KH Wasyid | U-Turn 6 | In front of Mie Kangkung | U-Turn 6 | 642 |
| 7   | In front of ATPM MC 1 | U-Turn 7 | In front of Sate Cilegon | U-Turn 7 | 789 |
| 8   | In front of Mall | U-Turn 8 | In front of Honda | U-Turn 8 | 636 |
| 9   | In front of Mayor’s House | U-Turn 9 |             |             |     |
| 10  | In front of Agung Mosque | U-Turn 10 |             |             |     |
| 11  | In front of Warung Sate | U-Turn 11 |             |             |     |
| 12  | Junction Antasari | U-Turn 12 |             |             |     |
| 13  | In front of ATPM Mc 2 | U-Turn 13 |             |             |     |

This arrangement is done by utilizing Vissim software, with changes in the distance between the U-turn facilities obtained from ideal distances except for the UT1 PCI intersection, due to its being too close to the public corner Simpang APILL Serdang. It will be applied only to vehicles entering Jalan Pondok Cilegon Indah, not allowed to make a U-Turn, existing provisions along with land use so after the structuring it can be seen the performance of final road network after structuring (Figure 4).

From the table, it is seen that the performance gas increased from the existing conditions, namely the average delay to 17.56 seconds, network speed increased to 33.07 km/h, and total travel time to 847.3 hours.

Figure 4 Arrangement of U-Turn facility

5. Conclusion
The conclusions are drawn from the research result if the effect of distance between U-Turn facilities on CBD traffic in Cilegon city are as follows.
1) Modeling existing traffic conditions using Vissim software where existing road network on median arterial roads in Cilegon city includes an average delay of 19.81 seconds,
network speed of 31.28 km/h, total travel distance 28,188 km, and total travel time is 901.04 hours.

2) A simulation analysis was done using Vissim software an alternative experiment of the distance between turning facilities starting from 500 meters, 550 meters, 600 meters, 650 meters, 700 meters, and 800 meters. By looking for the lowest average delay, the ideal distance for a median arterial road in Cilegon city is 600 meters.

3) Arrangement of U-Turn facility using an ideal distance of 600 meters was done in addition to referring the ideal distance, it is also taking consideration of land use conditions around the location so that the distance between turning facilities is 165 meters, 609 meters, 534 meters, 600 meters, 632 meters, 642 meters, 789 meters, and 636 meters. After applying the Vissim model, the road network performance results show an increase where the average delay decreases to 17.56 seconds, the network speed increases to 33.07 km/h, the total travel distance to 28.453.34 km, and total time to 847.30 hours.

6. Suggestion
Some suggestions may be offered based on the result of the research include the following:

1) Alternative treatment applications related to the arrangement of U-Turn facilities needs to be done to improve the performance of the arterial road network in Cilegon city.

2) Based on traffic performance, to obtain the ideal distance between turn-around facilities on arterial roads in Cilegon City, it is recommended to use an ideal distance of 600 meters between U-Turn facilities accompanied by consideration of land use conditions around the location of the median opening.

3) It is necessary to provide 15 U-Turn signs at 8 U-Turn facility locations.

4) It is important to socialize with the public regarding U-Turn facility’s arrangement so that the public knows the latest conditions. It is necessary to enforce the law by the police against people who violate the facility’s terms.

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