

# Determination of Volume Capacity Ratio (VCR) and Level of Service (LOS) of the Bottleneck Area of Doña Josefa Bridge in Gapan City

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**Abstract**— Vehicular traffic congestion is an emergent problem in many developing cities since the steep increase in the number of vehicles does not match the pace of increase of road infrastructures. The City of Gapan, a 4th class city in the province of Nueva Ecija, Philippines, is one of the cities which experiences heavy traffic flow daily. The main objective of this research is to determine the Volume Capacity Ratio (VCR) and Level of Service (LOS) of the bottleneck area of Doña Josefa Bridge in Gapan City. VCR measures the amount of traffic on a given roadway relative to the amount of traffic the roadway was designed to accommodate while LOS is used to qualitatively define the operating conditions of a roadway. This study utilized Traffic Volume Survey to gather data. The data were tallied, tabulated, and computed to determine the Peak Hour Volume (VCR) and Passenger Car Unit (PCU) that would be used to compute the Volume Capacity Ratio (VCR) and determine the Level of Service (LOS). The results showed that during peak hour throughout the seven days of the week, the VCRs fell under the bracket of 0.7-0.84. The Level of Service are determined to all be at LOS D which means that the road experiences moderate to heavy traffic; traffic is approaching unstable flow with nearly all drivers restricted and the service volume is at tolerable capacity. From the results, the researchers concluded that there is moderate to heavy traffic in the bottleneck area of Doña Josefa Bridge and thus, remedial measures and traffic management methods are needed to be implemented over the next five years to alleviate the congestion.

**Index Terms**— Bottleneck, Bridge, LOS, PCU, PHV, Traffic Congestion, VCR.

## 1. Problem and its Setting

Most of the population is concentrated in large cities and mobility is one of its most basic needs. In modern societies, the used of automotive vehicles is the preferred way to accomplish mobility. However, according to Vergel and Yai (2018) road capacity has not increased significantly in the past years thereby unable to catch up with the rapid rise in traffic flow. This means that vehicular traffic congestion is an emergent problem in many developing cities since the steep increase in the number of vehicles does not match the pace of increase of road infrastructures.

Traffic congestion also leads to variety of social, economic, and environmental problems. Cao et al. (2018) explained that drivers, when stuck in traffic congestion, are facing a higher risk of arriving late at their destination, causing great levels of stress. The stress may further transform into impatience, carelessness, and hence increase the occurrence rate of traffic accidents and other social problems like road rage.

Traffic congestion also leaves a negative impact to the environment. The longer the vehicles remain stuck on traffic, the more fuel they consume resulting in more vehicle exhausts. This pose risk to any inhabitants in the vicinity of the road traffic environment since they will be inhaling polluted air.

Moreover, traffic congestion can also lead to a declining economy. Manuel (2019) explained that Manila is losing around 3 billion pesos each day because of its traffic problem. When vehicles are stuck on traffic, they cannot reach their destination on time. This means delayed deliveries of goods, products, and services. The gas consumed during the trip would also hike up making the proprietors earn less.

The City of Gapan, a 4th class city in the province of Nueva Ecija, Philippines, is one of the cities which experience heavy traffic flow daily. Gapan City is one of the component cities of Nueva Ecija and is considered the footwear capital of the north and the official pilgrimage city of patron Divine Shepherdess.

According to the official site of Gapan, the city is located in the Southeastern part of Nueva Ecija. It is bounded on the North by the Municipality of San Leonardo, on the East by the municipalities of Peñaranda and Gen. Timio, on the West by the Municipalities of San Isidro and Candaba, Pampanga, on the South by the Municipality of San Miguel, Bulacan.

The main road that traverses Gapan City is the Pan-Philippine Highway, also known as the Maharlika Highway. It is the longest system of roads and bridges in the Philippines (Reconnecting Asia, 2021). It is the busiest road in the city since excluding private owned vehicles and public vehicles such as jeepneys and buses, all the huge delivery trucks from Northern Luzon traverses this highway.

As a developing city, Gapan continues to prosper which also leads to its own share of transport and traffic problems. One of

which is the traffic congestion due to the bottleneck in Doña Josefa Bridge. Doña Josefa Bridge connects Castellano, San Leonardo and San Vicente (Bucana), Gapan City. It is also along the busiest road in the city, the Pan-Philippine Highway. According to a US Department of Transportation report, bottlenecks are responsible for 40% of the overall congestion, followed by incidents, such as car accidents with 25%, bad weather with 15%, work zones with 10%, and poor traffic signal timing and special events with 5% each one.

Volume Capacity Ratio (VCR) measures the amount of traffic on a given roadway relative to the amount of traffic the roadway was designed to accommodate. The term Level of Service (LOS) on the other hand is used to qualitatively define the operating conditions of a roadway depending on several factors such as speed, travel time, maneuverability, delay, and safety. The LOS of a facility is designated with a letter, A to F, with A representing the best operating conditions and F the worst (Qadr et al., 2019).

According to Department of Public Works and Highways' Traffic Capacity Manual, a VCR of around 0.60 is considered the trigger for alerting the planners to think heavily about remedial measures (traffic management, road widening or bypass/diversion/flyover/ring road construction) to be implemented over the next five years to relieve congestion.

It is in this light that the researchers decided to conduct a study to determine the existing Volume Capacity Ratio (VCR) and subsequently Level of Service (LOS) of the bottleneck area of Doña Josefa Bridge in Gapan City.

#### A. Objective of the Study

The objective of this study is to evaluate the traffic conditions within the bottleneck region of Doña Josefa Bridge situated in Gapan City. Specifically, it aims:

- To determine the Peak Hour Volume (PHV) of vehicles passing through Doña Josefa Bridge.
- To determine the Passenger Car Unit (PCU) of the bottleneck area of Doña Josefa Bridge.
- To compute for the Volume Capacity Ratio (VCR) of the bottleneck area of Doña Josefa Bridge.
- To identify the Level of Service (LOS) of the bottleneck area of Doña Josefa Bridge.

## 2. Methodology

#### A. Research Design

Since the study was about determining the Volume Capacity Ratio (VCR) and Level of Service (LOS) of the bottleneck area of Doña Josefa Bridge in Gapan City, the researchers decided to utilize a descriptive research method, making use of survey as the instrument for gathering data. A Traffic Volume Survey was utilized to gather the traffic volume data of the roads involved. Other complementary information will be obtained through secondary sources such as official websites and other credible references.

According to the Office of Research Integrity (ORI) of San Diego State University (SDSU), a descriptive study is one in which information is collected without changing the

environment (i.e., nothing is manipulated). A descriptive study was utilized by the researchers since it is the best method for collecting information that will demonstrate the relationships of variables. The goal of this research was to determine the level of traffic in the bottleneck area of Doña Josefa Bridge in Gapan City through observation and calculation of traffic volume, making use of VCR and LOS to describe the traffic.

#### B. Research Instrument

The primary research instrument that was employed by the researchers was the Traffic Volume Survey. According to Singh and Singh (2016), the basic aim of traffic surveys is to capture data that accurately reflects the real-world traffic situation in the area. Traffic volume surveys are conducted to know the volume of traffic moving on the roads and classification of roadway vehicles at a particular section during a particular time.

The researchers counted the number of vehicles using the manual counting method of standing by the side of the road and recording their observations on traditional medium such as pen and paper. The data they gathered would then be tabulated and analyzed afterwards.

#### C. Data Analysis

In this study, the researchers used the Volume Capacity Ratio System (VCR) which determines the Level of Service (LOS) of the bottleneck area of Doña Josefa Bridge found in Pan-Philippine Highway. Volume Capacity Ratio tells the volume of traffic on a given roadway relative to the amount of traffic the roadway was designed to accommodate.

When calculating the VCR, the researchers determined the Passenger Car Equivalent Factors (PCEF) listed in the Traffic Capacity Standard set by the Department of Public Works and Highways (DPWH). To determine the passenger car unit (PCU), which can be used to gauge the speed of traffic on a particular roadway, multiply the PCEF by the traffic volume or the Peak Hour Volume (PHV).

#### D. Calculation of Passenger Car Equivalent Factors

Table.1. Passenger Car Equivalent Factors

Vehicle Type		
No.	Description	PCEF
1	Motor-tricycle	2.5
2	Passenger car	1.0
3-5	Passenger and good utility and small bus	1.5
6	Large bus	2.0
7	Rigid Truck, 2 axles	2.0
8	Rigid Truck, 3+ axles	2.5
9	Truck semi-trailer, 3 and 4 axles	2.5
10	Truck semi-trailer, 5+ axles	2.5
11	Truck semi-trailer, 4 axles	2.5
12	Truck semi-trailer, 5+ axles	2.5

#### Calculation of Peak Hour Volume (VCR) in PCU

$$PCU = \text{SUM} (PHV_{VT1} \times PCEF_{VT1} + PHV_{VT2} \times PCEF_{VT2} + \dots + PHV_{VTn} \times PCEF_{VTn})$$

#### Calculation of Capacity (Basic Hourly Car Capacity)

Table.2. Basic Hourly Car Capacity

Carriageway Width	Hourly PCU	
	Rural	Urban
Single < 4 meters	600	600
4-5 meters	1200	1200
5.1-6.0 meters	1900	1600
6.1-6.7 meters	2000	1700
6.8-7.3 meters	2400	1800
2x6.7 or 2x7.3 meters	7200	6700

The researchers determined the Basic Hourly Car Capacity (in PCU) listed in the Traffic Capacity Standards of DPWH based on the carriageway width of the roadway. Once all the necessary data were collected, the researchers used the formula of the Volume Capacity Ratio.

$$VCR = \frac{\text{Peak Hour Volume}}{\text{Basic Hourly Car Capacity}}$$

$$VCR = \frac{PHV}{BHCC}$$

The Volume Capacity Ratio tells what level of service a given roadway has. The Level of Service (LOS) indicates the traffic flow rate on a given roadway which are as follows. LEVEL OF SERVICE (LOS)

Table.3. Level of Service

LOS	CHARACTERISTICS	VCR
A	Condition of free-flow with high speeds and low traffic volume. Drivers can choose desired speeds without delays.	0.00-0.19
B	In the zone of stable flow. Drivers have reasonable freedom to select their speed.	0.20-0.44
C	In the zone of stable flow. Drivers are restricted in selecting their speed.	0.45-0.69
D	Approaches unstable flow with nearly all drivers restricted. Service volume corresponds to tolerable capacity.	0.70-0.84
E	Traffic volume near or at capacity. Flow is unstable with momentary stoppages.	0.85-1.00
F	Forced or congested flow at low speeds. Long queues and delays.	>1

### 3. Results and Discussions

This chapter includes the presentation, analysis and interpretation of data gathered regarding determining the Volume Capacity Ratio (VCR) and Level of Service (LOS) of the bottleneck location in Doña Josefa Bridge in Gapan City.

Data were derived from the Traffic Volume Survey conducted in San Vicente, Gapan City, and available traffic data on the Department of Public Works and Highways' official website.

The data were tallied, tabulated, and organized according to the different specific concerns raised. The collected data were presented through graphical presentation using tables. The presentation of the data of the study are as follows.

#### 1) Factors Affecting Basic Car Hourly Capacity (BHCC).

- Number of Lanes. According to the Road Traffic Information by Department of Public Works and Highways (DPWH), the bottleneck region of Doña Josefa Bridge has two (2) lanes.
- Carriageway or lane width. According to the Road Traffic Information by Department of Public Works and Highways (DPWH), the bottleneck region of Doña Josefa Bridge has a carriageway or lane width of twelve (12) meters.

#### 2) Peak Hour Volume (PHV). This section presents the peak hour volume (PHV).

Table 4. Peak Hour Volume

PAN PHILIPPINE HIGHWAY					
PEAK HOUR VOLUME					
Day	Cars	Trucks	Motors	Buses	Passenger and Goods Utility and Small Bus
Monday	544	365	1502	9	64
Tuesday	524	333	1569	9	57
Wednesday	466	379	1508	9	60
Thursday	415	331	1503	8	55
Friday	528	301	1536	8	53
Saturday	602	297	1602	30	68
Sunday	595	286	1553	25	57

Table 4 presents the vehicle types and the total number of vehicles travelling across Doña Josefa Bridge throughout the seven days of a week. It was observed that the number of cars travelling through Doña Josefa Bridge during peak hour (5:00PM – 6:00PM) are 544, 524, 466, 415, 528, 602, and 595. For the volume of trucks, the numbers are 365, 333, 379, 331, 301, 297, and 286. For motor-tricycles, the volume of vehicles is 1502, 1569, 1508, 1503, 1536, 1602, and 1553. Large buses have 9, 9, 9, 8, 8, 30, and 25 for its traffic volume count. Last, for passenger and goods utility and small bus the numbers are 64, 57, 60, 55, 53, 68, and 57. The number of vehicles corresponds to Monday to Sunday respectively.

3) **Passenger Car Unit (PCU).** This section presents the Passenger Car Unit (PCU).

Table 5. Passenger Car Unit (PCU)

PASSENGER CAR UNIT (PCU)		BHCC
Monday	5325.5	6700
Tuesday	5382.5	6700
Wednesday	5291.5	6700
Thursday	5098.5	6700
Friday	5216	6700
Saturday	5511.5	6700
Sunday	5328	6700

Table 5 shows the computed Passenger Car Unit (PCU). For Monday, the value of PCU is 5325.5. 5382.5 for Tuesday. Wednesday has 5291.5. As for Thursday, the value of PCU is 5098.5. Friday has 5216, while Saturday has 5511.5. Lastly, Sunday has 5328 for its PCU. The Basic Hourly Car Capacity (BHCC) is determined to be 6700 PCU since the carriageway width is twelve (12) meters and is in an urban area.

4) **Volume Capacity Ratio (VCR).** This section presents the Volume Capacity Ratio (VCR).

Table 6. Volume Capacity Ratio

VOLUME CAPACITY RATIO (VCR)	
Monday	0.7949
Tuesday	0.8034
Wednesday	0.7898
Thursday	0.7610
Friday	0.7785
Saturday	0.8226
Sunday	0.7952

Table 6 shows the computed Volume Capacity Ratio (VCR). For Monday, the value of VCR is 0.7949. For Tuesday, the VCR is 0.8034. Wednesday on the other hand has 0.7898 for its VCR. For Thursday, the value of VCR is 0.7610. For Friday, the VCR is 0.7785. While Saturday has 0.822. Lastly, Sunday has 0.7952 for its VCR.

5) **Level of Service (LOS)**

Table 7. Determination of Level of Service (LOS)

LEVEL OF SERVICE (LOS)	
Monday	LOS D
Tuesday	LOS D
Wednesday	LOS D
Thursday	LOS D
Friday	LOS D
Saturday	LOS D
Sunday	LOS D

Table 7 shows the corresponding Level of Service (LOS) based on the computed Volume Capacity Ratio (VCR). All LOSs were determined to fall to LOS D which means that the bottleneck area in Doña Josefa Bridge from Monday to Sunday, during peak hour, experiences moderate/ heavy traffic; traffic approaches unstable flow with nearly all drivers restricted and service volume is at tolerable capacity.

#### 4. Conclusion

##### A. Summary of Findings

The data derived through the Traffic Volume Survey revealed the following results:

##### 1) Peak Hour Volume (PHV)

The tabulated Peak Hour Volume (PHV) showed that there was a large volume of vehicles passing through Doña Josefa Bridge during peak hour from Monday to Sunday. Motors and tricycles were biggest in terms of amount followed by cars, trucks, buses, and passenger and goods utility and small buses respectively.

##### 2) Passenger Car Unit (PCU)

The computed Passenger Car Units (PCU) showed that the maximum number of vehicles that can pass a given point on a lane or a roadway during one hour was not exceeded since all the computed PCU is less than the Basic Hourly Car Capacity (BHCC).

##### 3) Volume Capacity Ratio (VCR)

The computed Volume Capacity Ratio (VCR) throughout Monday to Sunday during peak hour all fell under the bracket of 0.7-0.84.

##### 4) Level of Service (LOS)

All Level of Services (LOS) were determined to fall under LOS D which means that the bottleneck region of Doña Josefa Bridge from Monday to Sunday, during peak hour experiences moderate to heavy traffic.



## B. Conclusion

Based on the research findings and on the data gathered, the following are the conclusions that were drawn by the researchers.

The researchers concluded that vehicles travelling across the bridge were mostly dominated by motorcycles and tricycles, when discussing about shear number, followed by cars, trucks and buses. This contributes to the traffic congestion since motors and tricycles are slow-moving vehicles (25-30 km/hour as normal maximum speed) which causes considerable queuing on roads according to Road Traffic Information by Department of Public Works and Highways (DPWH).

The researchers also concluded based on the computed Volume Capacity Ratios (VCR) and determined Level of Services (LOS) during peak hour from Monday to Sunday, there is moderate to heavy traffic in the bottleneck area of Doña Josefa Bridge found along Pan-Philippine Highway in Gapan city.

Thus, to alleviate the worsening traffic congestion in the bottleneck area of Doña Josefa Bridge, remedial measures and traffic management procedures are needed to be implemented over the next five years.

## 5. Recommendations

Based on the findings and conclusions by the researchers, the following recommendations are hereby presented.

- The researchers recommend a rerouting using bypass road utilizing a parallel bridge, due to the geographical location of Gapan City, as one of the primary measures to alleviate the worsening traffic congestion.
- The researchers suggest for future researchers to formally propose an in-depth study focusing on the architectural and structural design of the bypass road and parallel bridge including the cost analysis and financial evaluation.
- The researchers also recommend future researchers to use this study as a reference to any future research endeavors related to this. It is recommended to use this study as a springboard for any future studies that can add to the existing pool of knowledge available.

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