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Traffic Congestion Analysis of the Central Business District of San Pablo City, Laguna, Phillipines.

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Abstract. Planning sustainable management and ease of transport requires the identification of certain transport problems that most urban cities suffer from—one of which is traffic congestion. Traffic congestion is one of the major transportation problems in the Philippines. This had been the impending case in the bottleneck areas in San Pablo City, wherein perceptive observation and transport reviews showed the major roads, especially *Jose Rizal Avenue* and *Marcos Paulino Avenue,* have traffic congestion issues. The study assessed traffic congestion on the three study sites, namely: *M.L.Quezon-Colago Avenue Intersection*, *Hermanos Belen St-M.Paulino St Intersection.* and *M.Paulino St-M.Leonor St. Intersection*. Through the use of traffic parameters such as Volume Capacity Ratio, Level of Service, and Travel Time Index, it was found out that there was a presence of traffic congestion on the study sites; results showed that the traffic congestion was caused by the number of tricycles in the area, and the location's land use. The study concludes the presence of traffic congestion, and recommends the review and proper implementation of traffic policies, and the construction of transport facilities.

Keywords: Traffic Congestion, Volume Capacity Ratio, Level of Service, Travel Time Index, Transportation

1. Introduction

Transport is the movement of people, goods and information by any conceivable means, for any conceivable purpose (Scheiner, 2012). There are several factors that affect the increase in transportation demand such as the rapid increase in travel demand without the increase in the capacity of the transportation facility; the need to transport people, goods and services; and the concentration of trips of different modes in different time and space (Cal, n.d). Hence, the sudden increase in transportation demand leads to traffic congestion. Traffic congestion is the phenomenon where vehicles impede each other's movement as demand for road spaces approaches its full capacity (OECD, 2007). It is one of the pressing transport problems that urban cities suffer from. Traffic congestion is also described as the users' relative expectation of the road (OECD, 2007) and is considered as a transport cost (Todd Litman, 2009). On the other hand, it is also perceived that traffic congestion creates a work-live environment and encourages the development of transportation services for the development of such key industries (Lee and Erickson, 2014; Kresl and Singh, 2012).

Traffic congestion can be measured and defined using different methods and variables such as Capacity, Density, Volume Capacity Ratio, Level of Service, and Travel Time Index. Capacity, in this context, measures the total number of vehicles that can utilize a road network per hour (Matthew and Rao, 2007); while Density refers to the total present number of vehicles on a certain road unit in a given time (Rijn, 2004). Volume Capacity Ratio is computed through the conversion of intenstiy values (present number of vehicles per hour) to passenger car equivalent divided by the total road capacity (DPWH, 2013). However, in some cases, qualitative measures of traffic congestion are also being used. Level of service, on the other hand, is the qualitative counterpart of capacity which is often based on measure of effectiveness; it uses travel time, density and delay as parameters (Matthew and Rao, 2007). The Travel Tıme Index (TTI) measures congestion density and vehicle speed during peak hours. Aside from the methods stated above, there are still a number of methods to evaluate traffic congestion. Experts recommend the use of a various evaluation techniques to gather a more accurate and comprehensive congestion evaluation (Litman, 2015). In some countries and regions, specific methods have been developed to accurately define the level of congestion in their roads. In California, for example, the Department of Transportation uses average speed as a parameter (Varaiya, 2011). In Michigan, level of service (LOS) is used, while Denver utilizes vehicle miles, hours of travel and average travel speed (Bertini, 2006).

In the Philippines, Metro Manila alone loses 2 billion USD or 2% of the country's GDP in 2000 due to traffic congestion (Regidor, 2012). Recently, an executive order (E.O. 172 of 2014) banning trucks in Metro Manila from 5:00 a.m. to 9:00 p.m. was implemented, resulting to economical and market price changes.

The goal of the study is to assess the traffic congestion situation of the selcted transport nodes in the Central Business District of San Pablo City, Laguna. Specifically, the study aims to: (a) determine the vehicular intensity of the transport nodes; and (b) determine the traffic congestion level of the transport nodes using Volume Capacity Ratio and Level of Service.

2. Methods

The study aimed to accomplish two major tasks: (1) the assessment of the vehicular intensity of vehicles of the study areas; and (2) the assessment of traffic congestion using quantitave (VCR) and qualitative (LOS) parameters. The team selected three different transport nodes for the study, namely: (A) Manuel L. Quezon-Colago Cipriano Avenue Intersection, (B) Hermanos Belen St.-M.Paulino St. Intersection, and (C) M.Paulino-M.Leonor St. Intersection, reffered as Nodes A, B and C (Figure 1). These nodes were perceived by the LGU and local residents as road systems with traffic congestion. To reflect the effect of rush hours and "rush days" to the level of traffic congestion, different schedules were assigned for the collection of vehicle intensity and VCR. GIS was used for visualization purposes. The DPWH standards for road capacity was also utilized for the conversion of road lengths into road capacities.

2.1. Study Area

The study was conducted in the City of San Pablo in the province of Laguna. San Pablo is geographically located at $14^0 4'$ north latitude and 121^0 19'east longitude. The city is surrounded by municipalities such as Alaminos in the west, Calauan in the northwest, Nagcarlan in the northeast, Rizal in the east, Batangas in the southeastern tip, Tiaong and Dolores, and Quezon in the south. The city's location provides access from the said municipalities to different locations such as Calamba City, Metro Manila and Sto. Tomas in Batangas. That being said, traffic congestion may affect the city's accesibility, resulting to economic changes such as price increases on resources and services. It may also affect the productivity of workers as travel time increases and alloted working hours decrease due to the decrease in travel speeds. The measurement of traffic congestion may provide the LGU necessary information needed in the sustainable management and planning of transport services in the city.

2.2. Vehicular and Traffic Count

The researchers established a schedule of vehicle intensity collection to determine the levels of congestion depending on its temporal conditions. A week was devoted for each transport nodes.

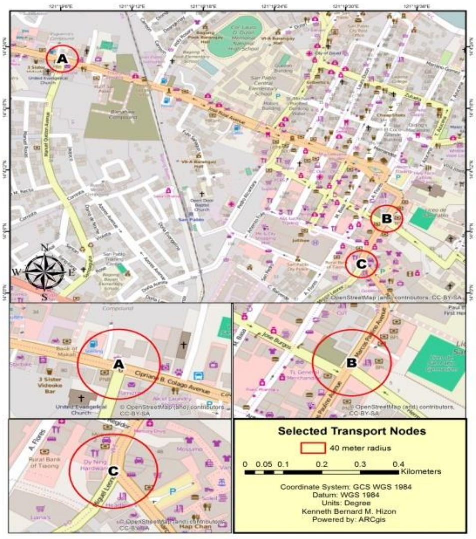

Figure 1. Selected Transport Nodes Map

The collection was done every conventional rush hours (7:00-8:00 am and 4:00-5:00 pm) and conventional non rush hours (10:00 am to 11:00 am). This was done every Thursdays, Fridays and Saturdays for three consecutive weeks, representing a normal weekday, rush hour weekday and a weekend, respectively. A separate trial week was also conducted in order to reduce the level of inaccuracies during the actual counting. The number of vehicles per transport node were then converted into its respective intensity, using the formula below:

$$Intensity = \frac{Number\ of\ Vehicles}{Unit\ of\ time}$$

Traffic count was done through the conversion of the vehicle intensity values to its respective passenger car unit equivalent. These values were first converted in accordance to the DPWH standards, and were then computed with the road capacities to come up with the Volume Capacity Ratio (see the formula below) and its corresponding LOS values (Table 1).

$$Volume\ Capacity\ Ratio = \frac{Number\ of\ vehicles\ (PCU)}{Road\ Capacity}$$

Table 1. Volume Capacity Ratio and Level of Service Standards

Volume Capacity Ratio	Level of Service
0.1-0.20	A (Free flowing)
0.21-0.50	B (Relatively Free Flowing)
0.51-0.70	C (Moderate Traffic)
0.71-0.85	D (Moderate/Heavy Traffic)
0.86-1.00	E (Heavy Traffic)

3. Results and Discussions

3.1. Vehicular Intensity

Traffic intensity is defined as the number of vehicular units per unit of time. The results show that for Node A, tricycles have the highest recorded vehicular intensity (642 units), followed by cars and motorcycles (358 units) and jeepneys (289 units). Specifically, the public utility vehicles with the highest intensities were recorded during a Thursday and a Friday both at 7:00-8:00 AM. On the other hand, private vehicles have the highest recorded intensity during a Friday, 10:00-11:00 AM and 4:00-5:00 PM. The vehicular intensities in Node A shows that the flow of traffic, especially the public vehicles, are affected by the morning rush hours.

The results also show that for Node B, tricycles have the most recorded vehicular intensity with 1442 units. The highest recorded intensities for cars and motorcycles were 399 and 312, respectively, while while jeepneys had 289. The same traffic flow pattern was observed in this node, where tricycles and jeepneys have the highest recorded intensity during Thursday and Friday morning rush hours. On the other hand, cars and motorcycles have the highest recorded intensity during a Saturday at 7:00-8:00 AM and 4:00-5:00 PM. It was also found that in Node C, tricycles have the highest intensity with 1172 units, followed by cars with 499 units, and motorcycles and jeepneys at 217 and 107 units, respectively. The highest intensity of public utility vehicles were collected during 4:00-5:00 PM (jeepneys on a Saturday) while cars and motorcycles at Saturday during 10:00-11:00 AM and at 7:00-8:00 AM, respectively (Table 2).

The patterns and variations on the flow of traffic on the three nodes are all affected by factors such as: travel time, type of built structures, and demand for vehicles. These study sites are all located in the city's Central Business District (CBD); this explained the demand for short travel vehicles. The CBD has a mix land use type of urban land use, which is characterized by the small distances between the residential, commercial, institutional, and special areas. The short distances between the areas increase the population's demand for short travel vehicles, like jeepneys and tricycles, since walking is not the primary option in the area, due to poor pedestrian side walks and, due to hot and humid weather (Hizon, 2016).

Table 2. Vehicular Intensity of the three study areas

Day	Time	Transportation Mode					
		Tricycle	Jeepney	Cars	Motor	Truck	Shuttle
Node A: Manuel L. Quezon- Cipriano Colago Avenue Intersection							
Thursday	7:00-8:00	569	276	215	246	0	0
	10:00-11:00	556	253	176	344	20	0
	4:00-5:00	480	250	223	366	10	0
Friday	7:00-8:00	642	289	320	330	18	1
	10:00-11:00	505	227	208	407	32	1
	4:00-5:00	479	244	358	275	17	1
Saturday	7:00-8:00	502	259	310	325	35	1
	10:00-11:00	513	230	228	399	16	0
	4:00-5:00	475	262	312	347	28	1
Node B: Marcos Paulino St.-Hermanos Belen St. Intersection							
Thursday	7:00-8:00	1442	84	244	253	10	0
	10:00-11:00	1233	60	132	200	11	0
	4:00-5:00	1,156	147	174	232	7	0
Friday	7:00-8:00	1270	58	129	238	5	0
	10:00-11:00	1256	88	184	211	12	0
	4:00-5:00	1138	41	177	230	6	0
Saturday	7:00-8:00	502	259	310	325	35	0
	10:00-11:00	513	230	228	399	16	0
	4:00-5:00	475	262	312	347	28	0
Node C: Marcos Paulino St-M.Leonor St. Intersection							
Thursday	7:00-8:00	1060	76	157	161	2	0
	10:00-11:00	1019	61	177	214	17	0
	4:00-5:00	1172	73	222	206	0	0
Friday	7:00-8:00	994	94	158	156	3	0
	10:00-11:00	1106	67	123	146	14	0
	4:00-5:00	1025	76	213	166	12	0
Saturday	7:00-8:00	1028	107	202	166	5	0
	10:00-11:00	1118	65	200	209	2	0
	4:00-5:00	1047	57	227	201	9	0

This also explains the sudden increase in public utility vehicle intensities during the morning and afternoon rush hours, as more people need to travel to and from their workplaces and schools, specifically those professionals and students in the study area (Hizon, 2016). The researchers also found out that different trip characteristics and trip decisions affect the flow of vehicular intensity. The collected vehicular intensity suggests that there are more tricycles in Node B, and more jeepneys in Node A. This is due to the significant locations and road sections that are connected to these nodes: Node A is connected to larger road sections leading to Calauan, Alamnos and Calamba City, thus the presence of long distance vehicles such as jeepneys; Node B, on the other hand, is at the center of the CBD and is relatively near to special locations such as the wet market, church and the mall, which in turn, increases the demand for short distance vehicles such as tricycles.

In total, the highest vehicular intensity in Node A was observed on a Friday (1600 units) at 7:00-8:00 AM, and lowest during a Thursday (1306 units) of the same time. The highest total intensity in Node B was collected during a Thursday (2033 units) 7:00-8:00 AM, and the lowest during a Saturday (1541 units) at 4:00 to 5:00 PM; while the highest collected intensity in Node C is collected during a Thursday (1673 units) at 4:00 to 5:00 PM and the lowest (1405 units) on a Friday at 7:00-8:00 AM. The highest and lowest intensities in Node A was both observed during a rush hour, which contradicts the assumption made in the study. This can be explained through different adaptive capacities by the road users such as going to work early, waking up and travelling early, and walking to their respective workplaces (Hizon, 2016).

Another possible explanation was the conventional rush hours of 7:00-8:00 AM and 4:00-5:00 PM may not necessarily hold true in the study site. The same observation can be seen in Node B wherein the highest intensity was recorded on a weekday morning rush hour, while the lowest on a weekend afternoon rush hour. The results showed that the number of vehicles differ even during rush hours, depending on the day itself. This is due to the travel demand in the area. Some of the establishments are closed during weekends, which lessens the population's transport demand. Finally, Node C has its highest intensity recorded on an afternoon rush hour, and its lowest intensity during a morning rush hour. The same situation can be seen in Node A, where the lowest traffic intensity was recorded during a morning rush hour. The difference in the traffic intensities reflects the difference in the travel demand of the commuting public. The demand for short distance travels was one of the main reasons why there were increases in the number of vehicles during peak hours. The results also showed that even during peak hours, the number of the vehicles may not be as many as during other peak hours. This may be a result of the adaptive strategies of the employees in the area, or the sudden decrease in demand due to other factors.

3.2. Volume Capacity Ratio and Level of Service

Volume capacity ratio analyzes the level of traffic congestion in an area on a specific time. In this study, it was done through the collection of vehicular intensity, passenger car units, and road capacities. The corresponding outputs were then converted to their LOS values, following the DPWH standards.

The results show that in Node A, most of the passenger car unit (PCU) equivalents lies far below the capacity of the road network, with the exception of the collected PCU during a Friday 7:00-8:00 AM. Most are in the range of 0.596-0.66 VCR which are equivalent to a level "C" LOS. This means that more often, the flow of traffic is at "moderate level" and is not congested, with the possible increase in vehicular intensity and decrease in speed as seen in the Friday 7:00-8:00 AM collection that exhibited a Level "D" or a "Moderate to Heavy Traffic situation". The possible reason for these results were the presence of working stoplights and active traffic enforcers in the area. It can also be deduced that tricycles, which often cause traffic in the city, was seldom in number in Node A.

On the other hand, Node B exhibited a Level "E" LOS or a heavy traffic situation during the weekdays, with the VCR range of 1.01-1.29. Furthermore, a Level "C" or a moderate traffic level was observed during the weekend collection in the area. The changes in the traffic situation in Node B can be explained by the presence of tricycles in the area. It can be seen from the vehicular intensity section of this paper, that there are more tricycles in this area compared to the other two nodes. Furthermore, many of the road sections in the area are used as tricycle and jeepney terminals, which uses up space that is supposed to be used for mobility purposes. Another reason is that Node B is at the center of the CBD, which is where most of the population's activities are situated in; thus, the increase in transport demand.

Table 3. Volume Capacity Ratio and LOS of the three study sites

Day	Time	VCR	LOS
Node A: Manuel L Quezon-Colago Avenue Intersection			
Thursday	7:00-8:00	0.644	C
	10:00-11:00	0.66	C
	4:00-5:00	0.61	C
Friday	7:00-8:00	0.755	D
	10:00-11:00	0.641	C
	4:00-5:00	0.604	C
Saturday	7:00-8:00	0.647	C
	10:00-11:00	0.639	C
	4:00-5:00	0.596	C
Node B: Hermanos Belen St.-M.Paulino St. Intersection			
Thursday	7:00-8:00	1.29	E
	10:00-11:00	1.082	E
	4:00-5:00	1.076	E
Friday	7:00-8:00	1.117	E
	10:00-11:00	1.125	E
	4:00-5:00	1.01	E
Saturday	7:00-8:00	0.687	C
	10:00-11:00	0.674	C
	4:00-5:00	0.669	C
Node C: M.Paulino St.-M.Leonor St. Intersection			
Thursday	7:00-8:00	0.94	E
	10:00-11:00	0.93	E
	4:00-5:00	1.049	E
Friday	7:00-8:00	0.896	E
	10:00-11:00	0.97	E
	4:00-5:00	0.929	E
Saturday	7:00-8:00	0.94	E
	10:00-11:00	1.002	E
	4:00-5:00	0.949	E

The results also show that for Node C, the LOS is at Level E or "Heavy Traffic". The VCR of Node C ranges from 0.896 to 1.049. This means that there is a heavy level of traffic congestion. The reason behind this is that Node C served as a catchment area for vehicles travelling from the CBD area to Makarhila Highway.

3.3. Travel Time Index

The observed trend in Node A showed that congestion affects the travel time. Table 4 shows that there was a difference of at least thirty (30) seconds, and, at most, 1 minute in the flow of traffic due to congestion.

Comparing the traffic intensity and volume capacity ratio, moderate traffic can be inferred. However, the travel time suggested that road users take longer time to move from one point to another. The difference in travel time is due to the management of traffic flow in the area. The stoplights and the traffic enforcers control the traffic flow for a longer time span in order for the traffic flow to move freely. The travel time in the Node B, on the other hand, has a difference of at least five (5) seconds and thirty (30) seconds at most. There is a major slowdown of traffic in the area during 10:00-11:00 am. This is because the activities in the area peak at this schedule. Another reason is that all of the vehicles from J.P.Rizal and Hermanos Belen Street use the road network in order to travel to M.Paulino Street to get to the wet market, which can be easily accessed through this node.

Table 4 Travel Time Index of the Three Study Sites

Day	Time	Average Free Flowing Time (Sec)	Congested Traffic Flow Time Per Transport Mode (Sec)		
			Tricycle	Jeepney	Cars
Node A: M.L.Quezon-Colago Avenue Intersection					
Thursday	07:00-08:00	11	40	47	35
	10:00-11:00	11	58	52	44
	04:00-05:00	11	56	50	57
Friday	07:00-08:00	11.67	39	21	32
	10:00-11:00	11.67	47	45	81
	04:00-05:00	11.67	59	75	71
Saturday	07:00-08:00	8.33	71	41	39
	10:00-11:00	8.33	36	77	56
	04:00-05:00	8.33	63	42	43
Node B: Hermanos Belen St.-M.Paulino St. Intersection					
Thursday	07:00-08:00	12.22	17	16	19
	10:00-11:00	12.22	50	51	37
	04:00-05:00	12.22	48	47	41
Friday	07:00-08:00	11.16	11	14	10
	10:00-11:00	11.16	52	37	43
	04:00-05:00	11.16	40	39	64
Saturday	07:00-08:00	9	16	26	16
	10:00-11:00	9	39	31	44
	04:00-05:00	9	40	45	53
Node C: Marcos Paulino St.- Miguel Leonor St. Intersection					
Thursday	07:00-08:00	8.33	11	11	11
	10:00-11:00	8.33	10	14	16
	04:00-05:00	8.33	19	13	14
Friday	07:000-8:00	10.67	9	15	9
	10:00-11:00	10.67	11	13	10
	04:00-05:00	10.67	31	37	36
Saturday	07:00-08:00	11.83	8	10	8
	10:00-11:00	11.83	8	7	7
	04:00-05:00	11.83	99	104.00	92.00

Node C has a difference of twenty (20) seconds travel time. Although, there was a recorded difference of at least eighty one (81) seconds (Table 4). The VCR and LOS of the node show a ‘‘moderate to heavy’’ level of traffic congestion. The travel time suggests otherwise, and showed a shorter time to travel from one point to another. The difference can be explained through road sections that are connected to the intersection of Node C. It is connected to larger road sections such as Maharlika Highway and M.Paulino Street-Calihan Road. This explains the shorter time of travel despite the level of congestion by its VCR and LOS. The sudden increase in the travel time, on the other hand, may be due to some road blockage or congestion on the Maharlika Highway or M.Paulino Street-Calihan Road.

4. Conclusion

In conclusion, there is a presence of traffic congestion in San Pablo City-Central Business Distrcit, specifically on the three study sites (Manuel L. Quezon-Colago Cipriano Avenue Intersection, Hermanos Belen St.-M.Paulino St. Intersection and M.Paulino-M.Leonor St. Intersection). The study also concludes that the use of quantitave (VCR) and qualitative (LOS and TTI) parameters provide a holistic approach on the measurement of traffic congestion. It was also found out that the review of transport policies and its proper implementation, as well as the construction of parking areas and terminals, can help reduce the intensitiy of traffic congestion.

5. References

Bertini, R.L. 2006. You are the Traffic Jam: An Examination of Congestion Measures [CD]. In 85th Annual Meeting of the Transportation Research Board. 17 p. (Cited from Matthew and Rao’s Introduction to Transportation Engineering)

Ca, Primitivo Ph.D,. n.d, Transport Planning and Traffic Management, unpublished

DPWH,.2013, Clarification and Definition on the Difference Between Widening and Paving of Shoulders, Republic of the Philippines: Department of Public Works and Highways

Hizon, K., 2016. Traffic Congestion Analysis of Selected Transport Nodes in San Pablo City-Central Business District, Laguna. University of the Philippines, Los Banos.

Kresl, P and Singh, B, 2012. Urban Competetiveness and US Metropolitan Centres, Urban Studies, 49 (2). 239-254

Litman, Todd, 2009. Transportation Cost Benefit and Analysis: Techniques, Estimates and Implications, Victoria Transport Institute, www.vtpi.org

Litman,Todd,2015f, Transport Costs and Benefit Analysis II: Noise Costs, Victoria Transport Policy Institute.

Malacañan Palace, 2014. Executive Order No. 172 s. 2014,http://www.gov.ph/2014/09/13/executive-order-no-172-s-2014/

Ni, P., 2012. The Global Urban Competetiveness Report-2011. Edward Elgar Publishing.

Organisation for Economic Co-operation and Development (OECD), 2007, Managing Urban Traffic Congestion: Summary Document, European Conference of Ministers of Transport.

Rao, Matthew and Rao, Kaalaga,. 2012, Measuring Urban Traffic Congestion: A Review, International Journal for Traffic and Transport Engineering p. 286-305.

Regidor, Jose F., 2012, Revisiting the Costs of Traffic Congestion in Metro Manila and their implications, National Center for Transport Studies, University of the Philippines Diliman

Rijn John van, 2004, Road Capacities, Indevelopment.

Scheiner, Joachim PD Dr,. 2012, Transport Planning in Developing Countries: Part I-Basic Concepts, Department of Transport Planning Technische Universität Dortmund, unpublished

Varaiya, 2001. Freeway Performance Measurement System: Final Report. (Cited from Matthew and Rao’s Introduction to Transportation Engineering)