Impact of Road Infrastructure Improvements along Commonwealth Avenue, Quezon City

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Abstract

Commonwealth Avenue is located in the city of Quezon - which has the highest population in Metro Manila; it is also part of Radial Road-7 which connects the province of Bulacan to the metropolis. With that being said, the Avenue should be able to cater to large volume of vehicles. This prompted the several development of the highway over time: the installation of flyover in Tandang Sora to avoid the delay caused by traffic signal and nuisance of transit vehicles, and an underpass from Batasan going Philcoa was also constructed to serve the purpose of convenience to the motorists by not needing to cross multiple lanes in reaching U-Turns. Such traffic and safety problems of these areas presented the closest situation to study areas: Regalado Avenue and University Highway (Diliman) – Philcoa, respectively which is also part of Commonwealth Avenue. Thus it had led the researchers to assess if the impact of building a flyover to the study areas would affect the travel behavior of the vehicles on a Metro Manila. To determine the changes in speed, time travel, cost saving, time savings and environmental impact; network simulation software – EMME3 was used. The approached applied was Transport Co-Benefits.

1. Introduction

Commonwealth Avenue is a 12.4 km highway that has the most number of road lanes – varying from 3 to 9 lanes in each direction, in the Philippines. It stretches from Quezon City Memorial Circle to Quirino Highway (Quezon City Government). See Fig. 1.

The avenue is a passage to the largest population in National Capital Region (NCR) which is Quezon City having 2,679,450 as of 2007. It is also part of Radial Road-7 which links Bulacan to metropolis; it having the highest population of Region III in 2007 according to the National Statistics Office.

Fig. 1 The Location map of Commonwealth Avenue, Quezon City

With the condition of highway, having uneven distribution of number of lanes in different portions of the avenue, causing sudden decrease or increase number of lanes, and a route to large population; different problem arises in traffic and safety of motorists, one of which is the route of jeepney coming from University Avenue – Diliman going Westbound. To travel to its destination, jeepneys will have to go eastbound (Philcoa – Mindanao) first and reach the nearest U-turn. This requires the driver to a state of higher alertness since they will have to swerve the nine lanes to reach U-Turn area; the route also leads to more travel time. Another problem is the traffic jam built along Regalado Highway due to its location, it being near a commercial area which is North Fairview Centermall and is also near school zone. In addition, the presence of stoplight and reduced number of lanes (which is only 3-4 lanes) had helped increase congestion. To improve the problem area, road infrastructure were introduced: a one-way flyover in University Avenue going to Philcoa Westbound and a two-way flyover in Regalado Avenue. The effect of these flyovers was assessed by using Co-Benefits approach and the change of speed and travel time of vehicles in the entire Metro Manila, the Commonwealth Avenue and the area of constructed flyover.

2. Literature Review

It was stated by Kanellaidis in reference with Lamm, in their propose safety module that there are three safety requirements for section of the highway: The harmonization between the design speed and operating speed, provision of dynamic safety of driving and consistency in the alignment. Consistency is the closest factor to human behaviour. Lack of consistency would mean an increase in the workload of the driver. As mentioned by Kanellaidis traffic flow, density of roadside signs and the use of in-vehicle telematics equipment are another factor that adds to driver workload. According to Krammes driver basic expectation is to be able to operate their vehicle safely at uniform speed and uniform mental effort (workload) US Federal Highway Administration determine geometric elements and features that consistency of design and expectancy, these are intersection, lane drops, vertical and horizontal curvature. For this study, relationship between design speed as well as operating is considered for along the stretch of Commonwealth Avenue. It is important to know the design speed of the highway and the operating speed of the motorist. Both require parallelism to be able to have a smooth operational flow.

According to Goyal et. Al., the effect of installation of flyover will have a positive effect on environment by reducing gas emission in the area. The study of the proposed flyover in Regalado Avenue segment tries not only to bring improvement in traffic flow but also assess the impact on the environment by quantifying the gas emission of vehicles before and after the design by the use of co – benefit approach. Through this measure, it will be helpful to know if the proposed flyover on the area is effective or not.

It was found that though many accidents were found to be from EDSA, the fatalities were found to be highest in Commonwealth Avenue for 2006. The reason why this is so is explored in the context of Libres et al. in 2008 where they stressed and was also supported in their study that it was mostly due to driver error. This was also supported by Green et al. of 2004, that studies outside country of Philippines, numerous have been found that reason for accidents were due to driver errors. It was seen that the reasons for the accidents were mainly due to speeding followed by overtaking then inattentiveness of the driver.

3. Methodology

3.1 Road characteristics

Since the number of lanes for Commonwealth Avenue varies in each segment, the highway was subdivided into several parts to analyze the area further. The length at which the area changes its lanes and the number of lane for that area is encoded.

3.2 Speed and Travel Time Determination

Automobiles were split into four vehicle types: Private vehicles, jeepneys, non-air-conditioned/air-conditioned buses and FXs. For each type, ten trips were travelled going Philcoa – Mindanao and vice versa. The days the trips taken were at random period of weekdays while the time of the trips performed were at usual peak hour. A lap timer was used to get the time of every stop and go of the vehicle in each segment and the time to reach from one reference point to another. Boarding and disembarking of passengers and the nearest street of embark/disembark were also recorded.

The travel time and speed of each segment was determined by equation:

$$\text{Speed} = \frac{\text{distance (km)}}{\text{time(hr)}} \qquad (1)$$

The distance is the distance of each segment and the time is the time it takes for each type of vehicle to reach a certain reference point. The speed therefore is the speed of vehicles within a certain segment area.

3.3 Traffic Count

Volume throughout the stretch of Commonwealth Avenue was estimated to be the same volume entering Philcoa as the video footage of Philcoa was the only accessible video. The video of Philcoa was acquired from MMDA and were segregated into several classifications of vehicle: motorcycle, private vehicle, bus, jeepney, taxi, and truck.

The counting of vehicles was done manually with the use of a counter for a period of 12 hours from 6 a.m. to 6 p.m., with each trial running for 15 minutes. The peak hour was determined by adding four consecutive 15 minute count that would form the highest total volume.

3.4 Emme 3 - Transportation Software Simulation

Travel demand forecasting software - EMME was used to simulate the actual condition of the avenue into a network model. The O-D demand of base year 2011 was attained using the Origin – Destination Demand of MMUTIS 1996. Two models were made – the network having no road infrastructure and another having road infrastructure. These were then compared in base year 2011 and design year 2015 and 2021.

3.5 Co-Benefits approach

Co-benefits approach: Time savings, Vehicle operating costs savings, Environmental Benefits was used to determine the effects whether it had any significant changes if road infrastructure in the study area is constructed. The data for computing the co-benefits was derived from the data generated by EMME 3 software.

4. Result and Discussions

Road characteristics such as estimated length and number of lanes for each segment are shown in Table 1. The segments segregated were each studied to further analyze the area.

Table 1 List of segment and road characteristics

Segment	Estimated Length (km)	Actual no. of lanes
Circle- Philcoa	0.19	9
Philcoa–Shell	0.55	7
Shell–Tandang Sora(TS)	1.43	7 - 9
T.S. – Ever Gotesco	2.2	7 - 8
Ever Gotesco - Batasan	2.23	7 - 8
Batasan – Litex	2.23	6 - 7
Litex – Regalado Avenue	2.23	4 - 7
Regalado Avenue - Regalado Highway	1.49	3 - 5
Regalado Highway - Mindanao Avenue	1.15	3 - 5

From Fig. 2, the average travel speed per type of vehicle per segment had found to vary in each segment. The Batasan – Ever Gotesco segment has the fastest travel speed considering it has the longest length and has the widest segment, because the vehicle on this area has decreased in volume compared to that on the preceding segment. Considering the segment of Shell – Philcoa and FCM – Litex, the travel speed of jeepney and bus is considerably slow that is because although the segment length was reduced, the decreased in the number of lane was a big factor as well as the busy environment on the area.

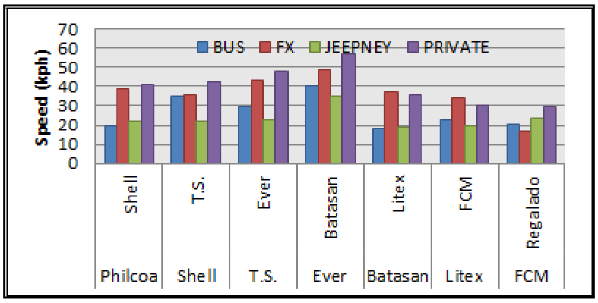


Fig. 2 Average of actual travel speed per segment

Using Emme 3 Network of Metro Manila acquired, a modified version was created to match the present condition of the Commonwealth Avenue and its traffic stream characteristics. About 6924 veh/hr are traveling along the Avenue, while the Peak Hour Factor of public vehicles is 12% and that of the private is 9%. A calibration was then initiated generating the same data obtained from the field experiment and was then projected to the design year 2015 and 2021.

A new network was created introducing the proposed improvement on the studied area where problems are perceived. An underpass was constructed from the University Avenue going west bound of Philcoa to prevent using the U-turn as a route to reach the west bound side. This idea was replicated from the same highway on the Batasan segment where an underpass was built to serve as way to avoid traveling multiple lanes and pass the nearest U-turn just to reach the westbound side. An underpass was also created along the Litex – Regalado Avenue to avoid the delay caused by the traffic signal and the pedestrians. The new design can be seen in Fig. 3.

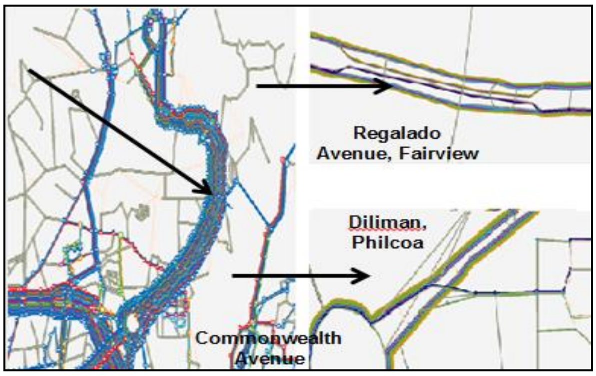


Fig. 3 Design of Metro Manila on network Emme 3

Comparisons of travel speed and travel time of base year 2011 for the actual scenario and network model were tabulated on Table 2. These were important factors as they determine if the results of the calibration was comparable, or realistic, to the actual flow on the avenue. The VDF equation was adjusted to formulate Table 2.

Table 2 Summary of travel time and travel speed on Commonwealth Avenue

Travel Time (min)			
Base Year	Actual Scenario	Network Model	% Error
2011	23.41	25.75	10.00%
Travel Speed (kph)			
Base Year	Actual Scenario	Network Model	% Error
2011	29.63	31.31	5.67%

The percentage error of travel time and speed of the network model from the actual scenario were presented in Table 5.11. The was found to be approximately 10% for travel time and a 5.67% for travel speed, the reasons lies in the complexity of calibrating the results in Emme network. Although speed had increased, time travel for the network model had also took longer than travel time for the actual scenario. The network model length was just an estimate from Emme 3 and not directly the length of the actual Commonwealth Avenue.

4.1 Macroscopic Effect

The reduced emission was calculated by means of a bottom up approach which was dependent to vehicle type and speed to determine the emission factor on each segment. The emission factor came from Bangkok that was developed in the "Study to promote CDM Projects in Transport Sector in order to Resolve Global Environment Problem" On the other hand, volume and speed to be used for the calculation was obtained from software EMME results.

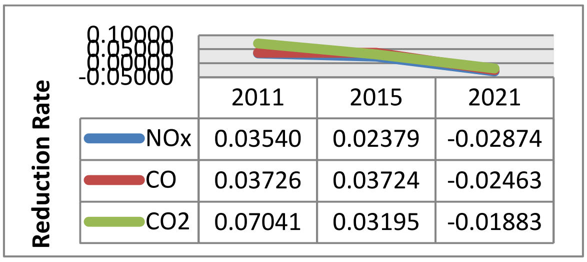


Fig. 5 Emission reductions in macroscopic scale

The design having road infrastructures resulted to a minimal reduction of NOx, CO, and CO2 emissions for the entire Metro Manila for year 2011 and 2015 as can be seen in Figure 5.17. But, the reduction rate decrease as years pass that eventually turns into a disadvantage by year 2021. The rate of emission by year 2021 would have resulted to an increase emission in the area.

4.1.1 Co – Benefit Analysis on Macroscopic Design

The trip characteristics for Metro Manila presented on Table 5.3 were based from the MMUTIS, 1996. The value of time for the study includes the projections for 2005 and 2015. The growth rate used as multiplier for the value of time and the value of vehicle operating cost for 2011 and 2021 were forecasted using the given values from the MMUTIS.

Table 3 Value of time of urban transport users (MMUTIS, 1996)

	Year				
	1996	2005	2011	2015	2021
Private Mode	74.4	101.2	116.81	123.5	142.85
Public Mode	60	81.6	94.2	99.6	115.2
Growth Rate 1996 = 1.00	1	1.36	1.57	1.66	1.92

Using the equation from Mainstreaming Transport Co-benefits Approach (2011) the values of time and values of vehicle cost were forecasted from the values found in MMUTIS 1996. The positive values of difference signify the benefits to be gained while negative values signify detriment. The percent difference is the percentage in which the original cost was reduced after the changes were made.

Table 5.4 shows the difference in time savings using Co-benefits approach for Metro Manila (Transport Co-Benefits Guidelines). The difference between the model with and without road infrastructures depicts good results for year 2011 and year 2015 but would eventually became costly by year 2021.

Table 4 Comparison of time savings in macroscopic scale

	w/o road infrastructures (PHP/year)	w/ road infrastructures (PHP/year)	Difference (PHP/year)
2011	35,556,604,134,279.40	35,536,886,198,836.00	19,717,935,443.45
2015	56,890,981,964,885.20	56,888,527,182,427.20	2,454,782,458.02
2021	113,388,905,870,121.00	113,398,425,730,378.00	-9,519,860,256.98

Though as can be seen in Figure 6, the flow was found to exhibit a decreasing reaction each year that by year 2021, the cost in time savings would had had shown to be higher. This suggests that the flyover in due time would cost greater expense in the macroscopic aspect. Nonetheless, the rate of flow showed minimal effect for the whole Metro Manila. Also, it was observed that a relationship between vehicle hours travelled and time savings exists, since both are directly associated to the time travel of vehicles. Thus, Figure 5.16 and 5.18 had shown the same behavior for which both displayed positive effect on year 2011 and 2015 and negative results to year 2021.

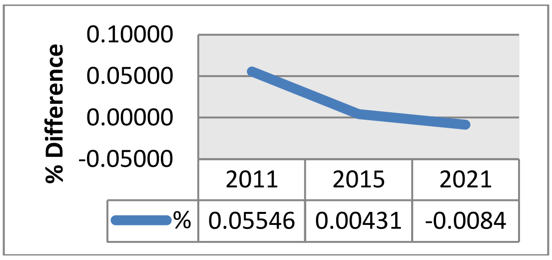


Fig. 6 Time savings percent difference in Macroscopic scale

The cost operating savings for Metro Manila for year 2011 had shown improvement when road infrastructures are installed but as years proceeded, the improvement turns into depreciation. For year 2011 there had been an increase in cost operating savings but soon the flow continues to decline that by year 2021, the result had a cost growth of 0.027%. It was also observed that a relationship also exist for vehicle distance travelled and operating cost savings, since both are affiliated with the length of the link traveled. And therefore both displayed a behavior which showed a positive value for year 2011 and negative results for year 2015 and 2021 as can be seen in Figure 6 and 7.

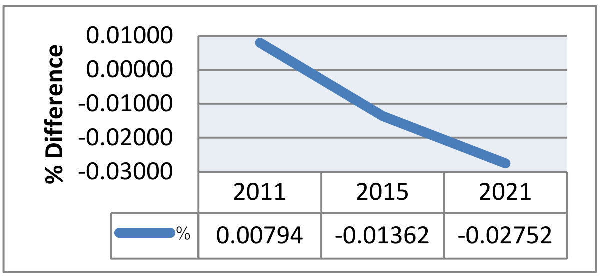


Fig. 7 Cost operating savings percent difference in macroscopic scale

4.2 Mesoscopic scale

The same procedure was done for mesoscopic scale, but mesoscopic level covers the effect of flyovers only on the entire Commonwealth Avenue.

The results of the parameter being measured had provided an idea that the presence of road infrastructure was only slightly felt in the mesoscopic scale, though the improvements had resulted to positive changes to speed, vehicle hour travel and time savings. The addition of flyover on Commonwealth Avenue caused a negative effect on vehicle distance travel, environmental impact and cost operating savings. It can be inferred that the changes were slightly higher for the mesoscopic scale than in the macroscopic scale, the percentage differences for the actual and the modified models depicts a maximum change of approximately 2%, it can be concluded that minimal effects are contributed by the installed road infrastructures on Commonwealth Avenue.

4.3 Microscopic Scale

The microscopic result assessed only the areas where the flyover would be placed. In the case of the study, only UP Diliman - Philcoa and Ragalado Avenue were evaluated.

4.3.1 Analysis of University Avenue (Diliman) – Elliptical Road flyover

The proposed flyover would hail from the University Avenue (Diliman) going to the Elliptical Road as can be seen in Fig. 8. The U-turn slot was to be removed since it would no longer serve its purpose upon the installation of the flyover.

Fig. 8 University Avenue – Diliman flyover

The installation of the flyover and the removal of the U-turn had resulted to an increased number of vehicles coming from Diliman going to the Elliptical Road as presented in Table 5. For the future design years, it could be observed that the improvements, measured in percentage differences, brought about by the flyover continuously increases. Assuming all the vehicles using the U-turn slots comes from Diliman, the increase in volume can be seen in Figure 9, where the increase amounted to as much as 14% this in turn drawn or attracted more motorists to make use of the Diliman flyover; ultimately serving its purpose to divert traffic directly towards the elliptical roads.

Table 5 Comparison of volume between design via route of U-turn and Diliman flyover

	U-Turn (Veh/Hr)	University Avenue (Diliman) flyover (Veh/Hr)	Difference (Veh/Hr)
2011	706.00	756.00	(50.00)
2015	767.00	857.33	(90.33)
2021	933.00	1,065.33	(132.33)

Figure 10 shows the change in speed of vehicles using the flyover from Diliman to Philcoa. The speed significantly increased in the area which almost reached to twice that of the former speed. Though, the speed continuously to degrade as the years progress as can be observed form Figure 11 that by year 2021 the improvement had decreased to 113%. Still, the speed in the area can be concluded highly improved. The faster speeds in the Diliman flyover can be attributed to smaller nuisances and fewer traffic interruptions along the path, since the installed flyover directly travels to Philcoa with ease. On the other hand the use of U-turn slots causes slower speed, since vehicles need to decrease speed in maneuvering different lanes to employ the U-Turns, resulting not only to slower speeds but also to a more dangerous environment.

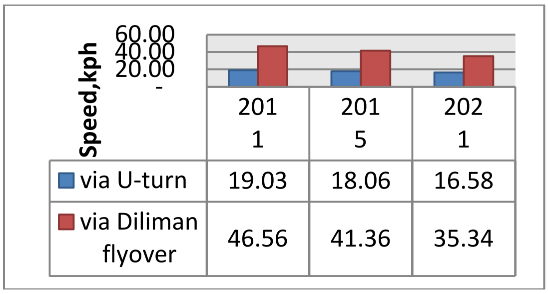


Fig. 10 Comparison of speed between design via route of U-turn and Diliman flyover

By traveling along the proposed flyover in Diliman, half of the time can be saved as opposed to the travel time of vehicles traversing the U-turn slots. This was shown in the Fig. 12 which displays the travel time between the model with and without the proposed flyover.

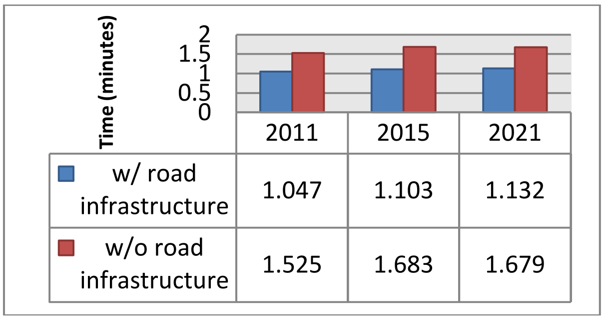


Fig. 12 Percent difference of time travel of vehicles via route of U-turn and Diliman flyover

4.3.2 Analysis on Two- way flyover in Regalado Avenue

The presence of traffic lights on the Regalado Avenue intersection and a number of establishments on the area can be said to be one of the causes of delays in the area. Public vehicles also tend to wait for passegers in the intersection, thus an installation of a two-way flyover in Regalado Avenue was included in the infrastructure improvements which would perhaps reduce the inconvenience, experienced by private vehicles, brought about by the disorderliness of the public vehicles. The overview plan where the Regalado Flyover would be installed can be seen in Fig.13.

Fig. 13 Regalado flyover

On Figure 14 the network with the proposed flyover displayed faster speed than the network without flyover. This was expected to happen since an option to take the proposed flyover which would pass through and over the traffic light without delay was introduced in the new model. Because of the assumed thirty seconds waiting time on the intersection on Regalado Avenue, the time delay resulted to slower speeds for vehicles while those that opt to traverse the flyover have faster speeds by up to 50%. This is beneficial and significant because by traveling the flyover you get to traverse the same area by a substantial faster time. A 50% increase in speed could also translate to a 50% decrease in travel time. The figure shows improvements in terms of increase in speed for the new model as the year approaches 2021. The increase in speed contributed by the flyover would be greater than the base year 2011 and the design year 2015 suggesting that the proposed flyover in Regalado Avenue would be more beneficial in the future.

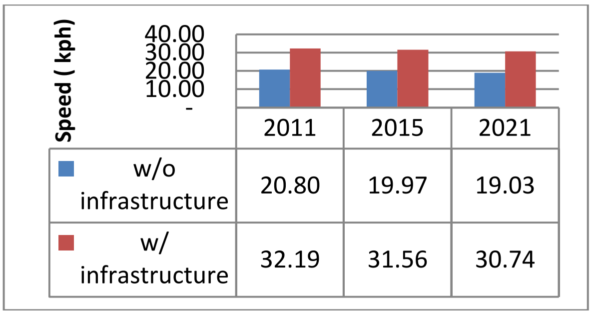


Fig. 14 Comparisons of speed in Regalado Avenue

The vehicle distance traveled along Fairview has increased on the network with infrastructure. As can be seen in Fig. 15, the slope of the line from year 2011 to 2015 is steeper than the line of the year 2015 to 2021. This only suggests that the effectiveness of the improvements, measured with respect to the base year parameters, becomes less every year gradually depreciating due to an increasing number of vehicles.

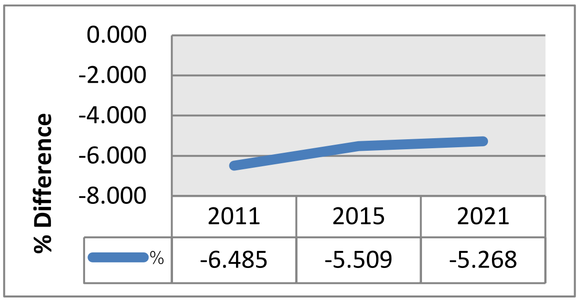


Fig. 15 Vehicle distance travel percent difference in Regalado Avenue

A decreased vehicle hour travel on Fairview area was displayed by the network with the proposed flyover. As the years progressed the difference in vehicle hours traveled increased, which was shown in Table 6. It can also be noticed that the decrease in vehicle hour travel on the network with flyover was approximately 50% of the vehicle hour travel for the original network. Hence this result is effective as it has resulted to a large amount of change in the vehicle distance hour traveled. Moreover, this can also be associated with the higher speed on the flyover, since there was less traffic interference the vehicle would travel faster. As the year reached 2021 the difference in vehicle hours traveled has depreciated It can be the effect of the increased number of vehicle every year that might have affected the traffic flow in the area. This suggests that the proposed flyover would be more beneficial on design year 2015 than 2021 in terms of vehicle hours traveled due to the behavior it displayed.

Table 6 Comparisons of vehicle hour travel on Regalado Avenue

	w/o road infrastructure (Veh-Hr)	w/ road infrastructure (Veh-Hr)	Difference (Veh-Hr)
2011	287.55	72.81	114.74
2015	373.09	220.44	152.65
2021	507.64	297.50	210.14

The comparison of travel time for the actual and model areas of the proposed flyover in Fairview was shown on Fig. 16. The vehicle that would pass the flyover would have a faster travel time than those that travel on the main road. Almost half of the time can be saved when traveling the flyover since there was no delay felt in traversing the flyover as compared to passing the main road having time delays.

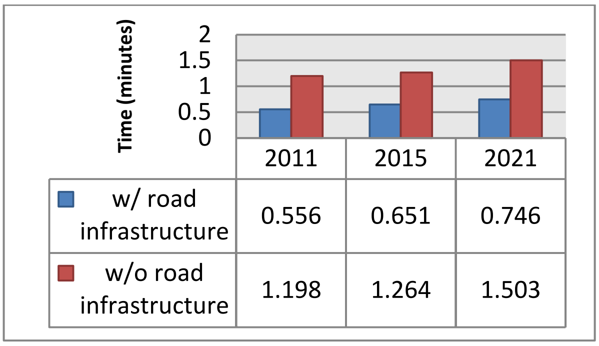


Fig. 16 Travel time on Regalado Avenue

4.3.3 Location of origin and destination of vehicles passing through Regalado Avenue

Figures 17 and 18 presents the distribution of origins and destinations on the Metro Manila network for the year 2011 with the proposed flyover. Green color marking are the volume of the people coming from the areas of origin and the red color marking are the volume of the people going to their destinations. The origin-destination marking were embedded in the zones scattered all over the network.

Figure 5.17 shows that the origins of passenger and motorists would mostly come from the upper part of the network and destination would often be located at the lower part of the network and would mostly be reached at areas of Manila, Makati and Quezon city. This was indicated by the orange high level markings on the zone presented in the network. While majority of travelers that pass through the Regalado flyover going northbound came from Valenzuela and Bulacan.

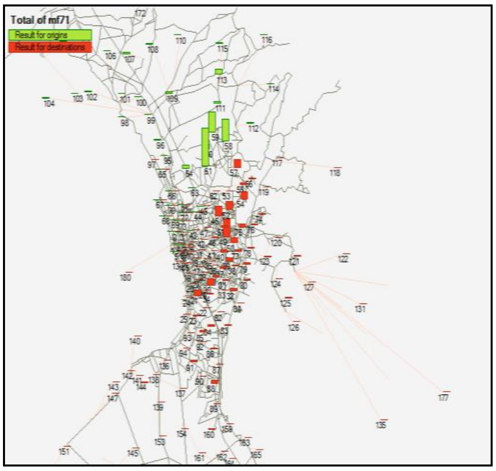


Fig. 17 Origin-Destination that passes through flyover in Regalado Avenue going northbound

On the other hand, Figure 5.41 shows a counter destination of passengers and motorists. A number of the travelers that pass the Regalado flyover going southbound usually came from the area near Quezon City, Makati and Manila. And also, mostly the destination of the motorists and passengers would be Bulacan as indicated in the high level orange marking color shown in the network.

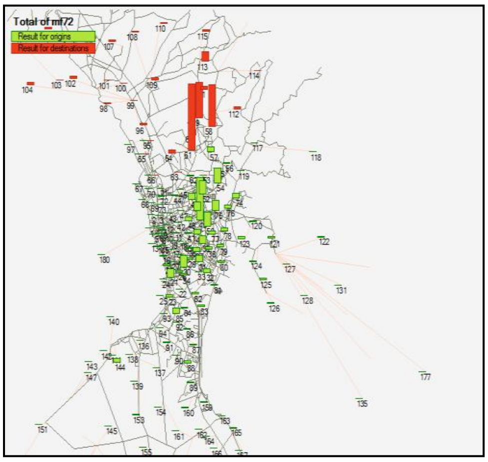
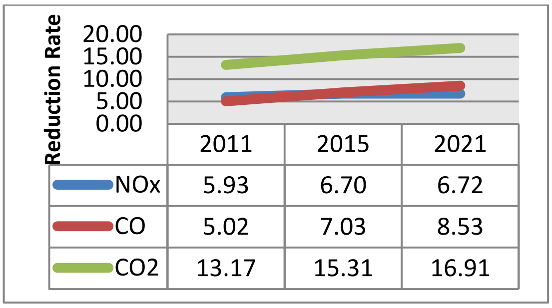


Fig 18 Origin-Destination that passes through flyover in Regalado Avenue going southbound

4.3.4 Analysis of environmental benefits on Regalado Avenue

As can be observed in Figure 5.19, the reduction rates compared to macroscopic and mesoscopic design for the analysis of emission rate had significantly been apparent. The reduced emission for NOx reached a decrease of 6.72% for year 2021, CO reached 8.53%, while CO2 stagnantly doubles CO reduction by reaching 16.91% decrease. Therefore it can be implied that the road infrastructure in the area of installation had brought positive results (See appendix F-1.)

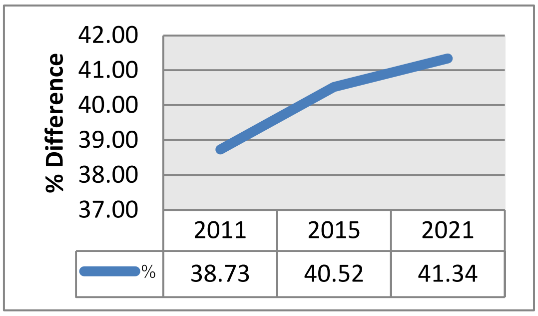


	2011	2015	2021
NOx	5.93	6.70	6.72
CO	5.02	7.03	8.53
CO2	13.17	15.31	16.91

Fig. 19 Emission reduction rate in Regalado Avenue

4.3.5 Co - Benefits Analysis on Regalado Avenue

Time savings in the Regalado area had shown significant reduction; time savings expense observed in Fig. 20 was cut almost by half when road infrastructure was installed in Regalado Avenue. And still, this improvement continues to increase as year goes.



	2011	2015	2021
%	38.73	40.52	41.34

Fig. 20 Time savings percent difference on Regalado Avenue

On the other hand, the operating cost had shown negative results when road infrastructure was installed in the area, the operating cost also increased for the future years. By year 2021, the increase in the operating cost, as can be seen in Figure 21, would reach by 5.03%. Although in comparison with other impact parameters for the flyover in the area, the negative effect of operating costs can still be relieved.

Table 7 Comparisons of cost operating savings on Regalado Avenue

	w/o road infrastructure (PHP/hr)	w/ road infrastructure (PHP/hr)	Difference (PHP/hr)
2011	740,239.43	785,252.56	-45,013.13
2015	963,127.70	1,013,486.06	-50,358.36
2021	1,425,858.25	1,498,043.21	-72,184.96

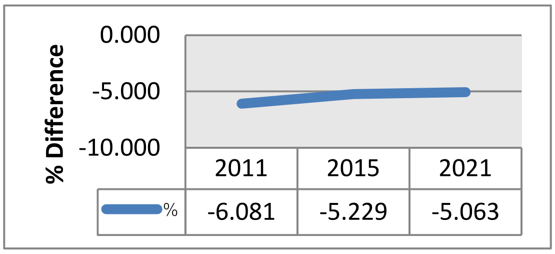


Fig. 21 Cost operating savings percent difference on Regalado Avenue

5. Conclusion

The road infrastructure improvements were observed to have negative effects for the network of Metro Manila in the future. Although all parameters, excluding speed and travel time, are considered to have positive results for a few years after the installation of the infrastructures, these positive changes eventually dissipate, that just by year 2015 the results would have had resulted to a negative impact for the macroscopic scale. Also, majority of the percent differences for the impact parameters of all the design years did not even exceed 0.1%. On the other hand, travel time for vehicles in Metro Manila had been found to save 15 minutes for the base year 2011, but it continues to decrease for the future design years. On year 2021 the saved time for vehicles will be reduced to just 2 minutes. As was stated earlier, even though speed had increased, the increase is very minimal that almost no change would be felt. Thus it could be concluded that although impact parameters had shown to be negative for the last few years, these negative results ends up being so small as to not even reach 0.1%, therefore the effect of the road infrastructure in the macroscopic scale were found to be negligible for base year to end design year.

On the other hand, the improvement brought about by the road infrastructure in the mesoscopic scale had resulted to changes in the percent differences amounting to an approximate of about 1% for all parameters not including speed and travel time. In this case, it had been shown that only travel speed, time, time savings and vehicles hours travelled were the only parameters that manifested positive effects in the area by reducing travel time for approximately 1 minute. Since all the impact parameters are directly affected by time travel of vehicles, therefore it is only expected that the vehicular flow would resemble the same. On the other hand, the rest of the parameters showed negative results but the rate or magnitude of the percent differences eventually improved as the years advance. Overall, it can be concluded that the road infrastructure when assessed on the mesoscopic design scale shows minimal effects for the entire Commonwealth Avenue.

The result in the installation of the University Avenue (Diliman) flyover and the removal of the U-turn slot in the area had resulted to a significant increase in the volume, travel time and especially the speed of vehicles. Travel speed can be improved by up to a 150% increase and can save 1/3 of the time when vehicles employ the U-turn space. On the other hand, volume also increased which only means that motorists were attracted to use the flyover rather than traverse a path towards the U-turn slot. This system also ensures the safety of motorists by not requiring them to traverse multiple lanes to reach the U-turn.

And finally the results upon the installation of the flyover in Regalado Avenue showed significant improvements for all the parameters except for VDT and cost operating savings. As much as 40% improvements in VHT and time savings are observed to be the effect of the proposed infrastructure. Emissions are reduced, having reductions amounting to approximately 6% for NOx, 9% for CO and 15% in CO2. According to Goyal et al. when a flyover is introduced in an area emission would be reduced in the areas since vehicles will less likely to standby in an area thus there will be less accumulation of emissions from vehicles; the findings of the study supported the study of Goyal. On the other hand, the increase of VDT and cost operating savings only approximates to 6%. Thus in comparison with the significant improvements of other impact parameters the positive results outweighs the negative results.

Regarding travel time, the installation of the road infrastructures would reduce the time for standby in specific areas by an approximately half the base time. Also, speed increased for the Regalado Avenue by as much as 64% because the installation of the flyover segregated private vehicles from public vehicles. Since public vehicles tend to go under the flyover to load for passengers faster speeds on the flyover would be experienced since public activity or interruptions are avoided.

Overall, it can be pronounced that the road infrastructures – flyovers for the Regalado Avenue and University Avenue (Diliman) – would show minor improvements, which are almost negligible, on the macroscopic and mesoscopic scale, but would give significant improvements on the designated areas of Philcoa and Regalado Avenue; on a microscopic scale.

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