Evaluation of Pedestrian Facility along Six Signalized Intersections in Cagayan de Oro City

Simon GO [a], Jefferson VALLENTE [b], Anabel ABUZO [c]

[a] *Research Assistant, Civil Engineering Department, Xavier University – Ateneo de Cagayan, Cagayan de Oro City, 9000, Philippines*
[b] *Assistant Instructor, Civil Engineering Department, Xavier University – Ateneo de Cagayan, Cagayan de Oro City, 9000, Philippines*
[c] *Associate Professor, Civil Engineering Department, Xavier University – Ateneo de Cagayan, Cagayan de Oro City, 9000, Philippines*
[a] *E-mail: simooon_go@yahoo.com*
[b] *E-mail: jvallente@xu.edu.ph*
[c] *E-mail: aabuzo@xu.edu.ph*

Abstract: Progress in emerging countries have coupling effects of increased mobility but often improvements in pedestrian facilities are neglected. Such is the case in the Philippines especially in Cagayan de Oro city with “high” urban development in the past 10 years. In this study facilities were assessed through a Level of Service (LOS), pedestrian traffic volume, and walkability through the Asian walkability index. Altogether, these determine the pedestrian flow, space, speed, and volume-capacity. The results show that in all areas a “low” rating is observed for walkability and with almost all (83%) with “very poor” LOS. Also, 93% of the sidewalks and 62% of the crosswalk have LOS from D to F. Generally, most intersections lack facilities like lighting, traffic light, pavement markings and ramps. Furthermore, facilities were improperly designed for the “high” pedestrian volume.

Keywords: Pedestrian, Level of Service, Walkability, Asia, Intersections

1. INTRODUCTION

Access and mobility of pedestrian requires efficient and effective facilities that advance the need of the general public in the built environment. Promotion of pedestrian-friendly facilities encourage walking and other non-motorized modes that creates a healthier environment for people to live in a well-balance and sustainable setting.

The availability of pedestrian-friendly facilities such as sidewalks, trails, curbs, ramps, promote pedestrian travel by walking, cycling and other non-motorized modes. These facility further allow pedestrian travel to change as the means and options to travel becomes more broadened. Consequently, the viability of these facilities depends on pedestrian demand and response. In particular, pedestrian response to facilities that expose them to variable risks and pose threats to their safety would generally make pedestrian e.g. the elderly, person with disability etc. wary and cautious in traveling. Walking as a mode to travel will therefore require pedestrian facility with a quality level of public accepatbility.

Recent findings in many Asian cities, shows a rapid increase in motorization combined with limited attention to pedestrian and public transport facilities which inadvertently results in decreased overall pedestrian mode share (Fabian, Gota, Mejia, Leather, and Center, 2010). In the local Philippine scale, such as in Cagayan de Oro City, some people prefer walking for short trips to their destinations. Also, it has been observed that pedestrians either walk across or alongside the road and not on the allocated pedestrian areas which pose risk to the impending dangers from nearby motorist. Road hazard according to the Department of Transportation and Communications (DOTC) revealed that accident in 2013 statistics increase by almost 14.6% each year. Therefore, there is a need to assess pedestrian facilities particularly along high density intersections with pedestrian crosswalk and sidewalks.

The quantifiable measurements of the level of service (LOS) and walkability of pedestrian facilities in intersections are studied in this research. The outcome of this study hopes to contribute in assessing the safety of pedestrians in signalized intersections in Cagayan de Oro. It has been observed that signalized intersections in Cagayan de Oro City lack existing facilities for pedestrian use as shown by studies made by Vallente et.al (2015) in public school zones and Añana et.al (2015) in the main Cogon market area. Poorly designed and maintained facilities can be an unfortunate waste of funds and resources and a hindrance to community vitality in general.

The most common method of qualitatively analyzing pedestrian facilities is through the level of service (LOS), which measures the effectiveness of facilities such as sidewalks, crosswalks or roads through a rating scale. The former produces a measurement which can be complemented with another method developed through the walkability index (WI). The WI is developed by the Asian Development Bank for Asian cities which could give recommendations related to connectivity and quality of walkways, footpaths, or sidewalks in cities (Leather, Fabian, Gota, and Mejia, 2011). Level of service (LOS) is a qualitative measure used to relate the quality of pedestrian facilities. Level of service ensures that pedestrian facilities are balanced with vehicular facilities and other land uses. Walkability is to determine the extent to which the built environment is friendly to the presence of people in the area. It is to describe and measure the connectivity of crosswalks and sideways with respect to the nine parameters defined in the Asian walkability index. Pedestrian safety is also important since analysis of pedestrian/motor vehicle collisions can help establish engineering, education, and enforcement solutions.

As discussed by the Highway Capacity Manual (HCM) (Transportation Research Board, 2010), two components in its level of service calculation: a quantitative measure of pedestrian flow rate and a table that helps planners derive an LOS grade from that flow rate. The HCM's pedestrian LOS grade is designed to be an objective measure of congestion on a pedestrian facility. The pedestrian flow rate optimizes the "effective walkway width" which in contrast to buffer zones is used for the main purpose of pedestrian flow (McShane, Roess, and Prassas, 1998). Buffer zones are areas within a given walkway that are not used for any means of pedestrian travel.

Walkability provides a qualitative analysis of the walking conditions including safety, security, and convenience of the pedestrian environment. It consists of a field walkability survey to assess pedestrian facilities with the use of the Asian Walkability index. It consists of nine parameters namely, Walking Path Modal Conflict, Availability of Walking Paths, Availability of Crossings, Grade Crossing Safety, Motorist Behaviour, Amenities, Disability Infrastructure, Obstructions, and Security from Crime (Table 1). These parameters are then measured per area of survey and a total walkability score is acquired for the area surveyed with the corresponding weights applicable in an area.

Sidewalk grade (height) helps in separating the sidewalk from the roadway and helps warn motorist the proper distance needed to be separated from the sidewalk. Alternate sidewalk grade should be paired with curb ramps that provide access between the sidewalk and roadway for people using wheelchairs, strollers, walkers, crutches, handcarts, bicycles, and also for pedestrians with mobility impairments who have trouble stepping up and down high curbs.

High visibility crosswalks aim to increase awareness of pedestrians at intersections by using highly visible marking patterns. High visibility crosswalks installed in New York City have a series of longitudinal white stripes that are constructed from thermoplastic materials. The possible problems with crosswalks generally is that motorists may be less alert to pedestrians crossing at other locations and pedestrians at crosswalks may less alert to potentially conflicting vehicle traffic (Chen, Chen, and Ewing, 2011)

Marked crosswalks indicate optimal or preferred locations for pedestrians to cross and help designate right-of-way for motorists to yield to pedestrians. Marked crosswalks warn motorists to expect pedestrian crossings and indicate preferred crossing locations. Pedestrians are sensitive to out-of-the-way travel, and reasonable accommodation should be made to make crossings both convenient and safe at locations with adequate visibility.

People will always walk. Therefore, pedestrian facilities should be provided. In 2010, Cagayan de Oro City's number of registered vehicles increased by almost fifty percent in five years (Land Transportation Office Region X, 2010). Due to rapid motorization of the city, non-motorized modes of travel such as walking have been given less attention. This study aims to assess and improve existing pedestrian facilities in six (6) signalized intersections in the city. By assessing the level of service, walkability rating, and the effective walkway widths, we aim to provide an appropriate design of pedestrian facilities in the given intersections.

Huge investments are directed to building infrastructures for motorized modes of travel. Increased urban sprawl in Asian cities improved economic conditions and neglect of pedestrian facilities have all led to increase in the number of motorized vehicles, which have resulted in our cities with high levels of pollution, congestion, road accidents, social inequality, poor mobility, and deterioration of quality of life (Fabian et al., 2010). This study would emphasize the conditions of existing facilities and would raise the awareness of the public the need for improvements of these facilities. Considering all this discussions the research aims to assess and design the pedestrian facilities along the six signalized intersections in Cagayan de Oro city through Walkability, Level of Service and propose design options of pedestrian facilities.

Table 1. Walkability survey parameters

	Description
1. Walking Path Modal Conflict	The extent of conflict between pedestrians and other modes on the road, such as bicycles, motorcycles and cars
2. Availability of Walking Paths	The need, availability and condition of walking paths. This parameter is amended from the parameter "Maintenance and Cleanliness" in the Global Walkability Index
3. Availability of Crossings	The availability and length of crossings to describe whether pedestrians tend to jaywalk when there are no crossings or when crossings are too far apart
4. Grade Crossing Safety	The exposure to other modes when crossing roads, time spent waiting and crossing the street and the amount of time given to pedestrians to cross intersections with signals
5. Motorist Behavior	The behavior of motorists towards pedestrians as an indication of the kind of pedestrian environment
6. Amenities	The availability of pedestrian amenities, such as benches, street lights, public toilets, and trees, which greatly enhance the attractiveness and convenience of the pedestrian environment, and in turn, the surrounding area
7. Disability Infrastructure	The availability of, positioning of and maintenance of infrastructure for the disabled
8. Obstructions	The presence of permanent and temporary obstructions on pedestrian pathways. These ultimately affect the effective width of the pedestrian pathway and may cause inconvenience to pedestrians
9. Security from Crime	The general feeling of security from crime on a certain stretch of road

This study is conducted in six major signalized intersections in Cagayan de Oro City which is primarily concerned in the walkability, level of service of the pedestrian facilities and pedestrian safety of the six signalized intersections. The number of intersection chosen were limited six due to the time frame of the research duration. Pedestrian Facilities would include sidewalks, crosswalk, signal lights, markings, buffer zones, ramps and utilities like lightings, benches, arboriculture, and shelters. Level of service (LOS) is to be analyzed with respect to the pedestrian facilities indicated in the study. Walkability of intersections is limited to the nine perimeters defined in the Asian walkability index shown in Table 1. Pedestrian safety has many factors however the study is only limited to pedestrian facility engineering design standards and specifications that contribute to safety. This study will only focus on sidewalk buffer zones, grade (height) and curb ramps, and pedestrian crosswalk markings for assessment of pedestrian safety.

2. REVIEW OF RELATED LITERATURE

2.1 Pedestrian LOS

Roads allow in-and-out land access to desired destinations possible but along with the varied modes of travel (e.g. walking, car, motorcycle, bicycle, and bus) comes satisfying the need to safety and quality of the road environment for all its users (Refaat and Kafafy, 2014). Conversely, the recent popularity and rise in the number of motorized transport resulted to the inadequacy of pedestrian and public transport facilities which caused an increase in pedestrian fatalities and accidents, and heavy exposure of pedestrians to air pollution (Leather et al., 2011); therefore making pedestrians as the most vulnerable road user (Iasmin, Kojima, Kubota, 2015).

This situation then paved way to the creation of the concept of pedestrian LOS. Since the discovery of the concept, various reserchers have developed different criteria and methods to evaluate pedestrian LOS (Abdul Ghani, Shimizu, and Mokhtar, 2015).

Focusing on creating safe urban intersections and sidewalks for pedestrians, both Sarkar (1993) and Khisty (1994) had developed a qualitative model with attrativeness, comfort, convenience, continuity, security, safety and system coherence, and safety as the main criteria for pedestrian LOS. Only that Khisty (1994)'s included system continuity as a part of her the criteria and conducted the study from the user's point of view.

On the other hand, Dixon (1996) and Nelson and Zaly Shah (2010) made use of a point system to assess road conditions. Dixon (1996)'s model was characterized by assigning randomly weighted points for each indicator. His indicators include provision of basic facilities, path conflicts, amenities, motor vehicle LOS, maintenece problems, and provision for multiple modes. Adapting some elements of evaluation from Dixon (1996), Nelson and Zaly Shah (2010) developed their model to included amenities, maintenance, pedestrian paths, conflicts, pavement material, security perception, comfort, and traffic volume in the adjusted car lane.

Studies such as Asadi-Shekari and Zaly Shah (2011) and Asadi-Shekari and Zaly Shah (2013) made further efforts to consider micro level infrustructure and facility details (e.g. ramps, toilet, signal, bench and seating area, and drinking fountain) to incorporate into their models. Asadi-Shekari and Zaly Shah (2011)'s proposed practical evaluation method of complete streets was called a general pedestrial LOS while Asadi-Shekari and Zaly Shah (2013)'s latest method was called disabled pedestrian LOS because the new method considered the needs of disabled people in opose to the latter which considered only normal people.

The diversity of pedestrian LOS models are mainly caused by setting criteria to adapt to the unique context of the study local. Thus, model results may vary from one local to another (Abdul Ghani et al., 2015). According Regidor (2004), the Philippines is yet to have a comprehensive LOS criteria of its own. However, studies such as Añana et.al (2015) have already begun adapting HCM standards for LOS evaluation in the Philippine context.

2.2 Methodologies on Measuring Walkability

Walking is considered the oldest and most common mode of transport that existed and is considered an integral part of the whole transport system (Leather et al., 2011) so much that a walkable city is a testament to a sustainable, more livable, and environemntally stable city (Osmond, 2005). Moreover, a walkable city is only achieved through the availability of adequate pedestrian facilities(Shamsuddin et al., 2012).

There are several ways and methods to measure walkability. One of which is through the use of a website, "walkscore.com". It is commonly as it is the easiest and cheapest method of measuring walkability available. Walk Score calculates walkability scores based on the location of your house and the nearby facilities. Although studies like Ducan (2013) and (Carr et al., 2011) agree that the web-based tool as fine and economical option that allows its users to understand the level of access to nearby facilities, Leather et al. (2011) points out its lack of qualitative assessment of pedestrian facilities (e.g street width, block length, traffic, and safety). Therefore, when Walk Score is used to measure walakability in Asia cities, the tool will tend to produce high scores because Asian cities are usually characterized with mixed-land use with high area density. Conversely, a high walkability high score obtain in an Asian city, will not mean that the said city is easy to walk in.

Walkability indexes are also another method of measuring walkability. The Global Walkability Index (GWI) made by Krambeck (2006) and was a tool that provided qualitative analysis to rate walking conditions. Specifically, it had a set of components, a structured methodology that compose of variables and indicators to be used for data evaluation and calculation (Yusuf and Waheed, 2015). According to Leather et al. (2011) this index provides a comprehensive understanding of the current walkability of Asian cities as it also identifies areas that require improvement. Because the GWI was considered a good basis to measure the walkability in Asian cities, the Asian Development Bank created a methodology that adapted GWI standards and made alterations to match the conditions of the Asian cities (Fabian et al., 2010).

3. RESEARCH DESIGN

The research started by selecting areas for the study that involves a set of criteria of signalized intersection, proximity of an arterial road, and population of pedestrian users. The research design composes of four (4) phases. First is a data collection involving pedestrian count, crosswalk rate of flow, effective walkway width, and the walkability of the walkway. Second is a survey on pedestrian facilities to assess the lack in facilities that aid pedestrians. Third is a cost-benefit analysis to be use for the recommendations regarding the necessary engineering measures to be applied in the intersections for the improvement of the pedestrians' safety. Forth is a careful observation to determine pedestrians' knowledge of road safety and its' precautions.

3.1 Research Locale

The intersections that will be chosen for the improvement of pedestrian safety are shown in Table 2 and Figure 1. These intersections were selected based from the following three (3) criteria: availability of a signalized intersection, proximity to an arterial road and population of pedestrian.

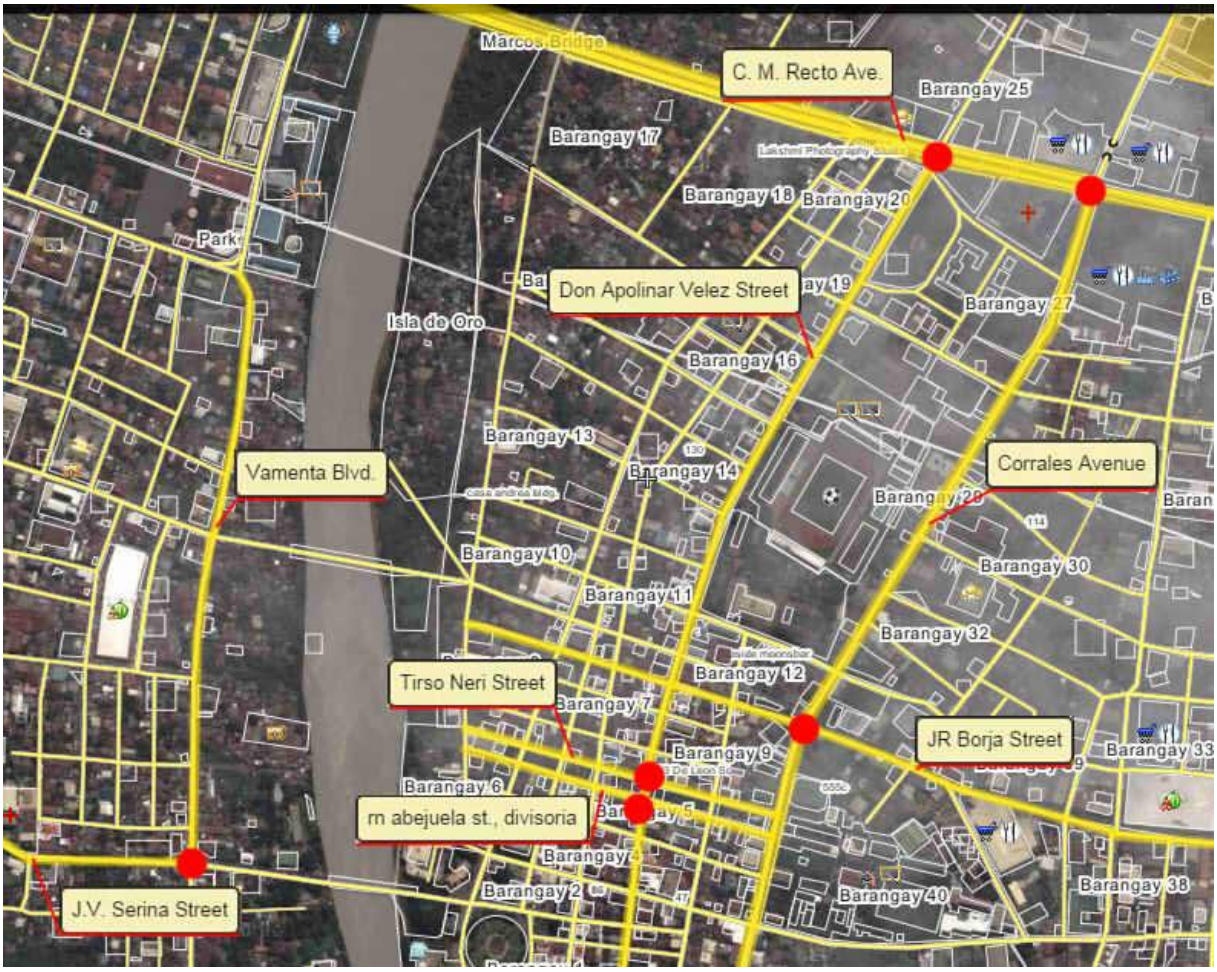

Figure 1. Locations of six intersections in the study area. “Map data ©2015 Google”

Availability of a signalized intersection means that there would be some traffic light or RTA personnel that would be controlling the flow of traffic. Proximity to an arterial road means that the intersection is located where there is an arterial road connected. Population of pedestrian is determined by ocular and previous data basis to know if the intersection has dense population.

Table 2. Intersection name and its classifications

	Road Classification
1. Don Apolinar Velez St. and R.N. Abejuela St	Urban Minor Arterial
2. C.M. Recto and Corrales Ave Ext.	Urban Major Arterial
3. Corrales Ave. and J. R. Borja St.	Urban Minor Arterial
4. J. Seriña St. and Vamenta Blvd.	Urban Minor Arterial
5. C.M. Recto, Don A. Velez St. and J. Pacana St.	Urban Major Arterial
6. Don A.Velez St. and Tirso Neri St.	Urban Minor Arterial

4. METHODOLOGY

Survey and computations for walkability were adapted from Asian Walkability Index (AWI) with the same parameters from Vallente et.al. (2014) and LOS ratings from Añana et.al. (2014). The pedestrian volume count study used to determine the volume of pedestrians crossing the streets at signalized or non-signalized intersections. The pedestrian is classified according to the direction of movement. The pedestrian volume sheet includes the number movement of pedestrians at the corners of the intersections, the time of conducted survey, and distance of the crosswalk. The summary of pedestrian movements includes the summary of the movements of the pedestrian with the specific time of survey. The crosswalk rate of flow was used to determine the volume of pedestrian using the crosswalk at a given time but since pedestrian flow may vary in time increments, counts are summarize in signal cycle. The researchers will survey on the volume of pedestrian in proportion to the cycle length.

4.1 Effective Walkway Width and Pedestrian Flow

The effective walkway width is the portion of a walkway that can be used effectively by pedestrians for walking. Several types of obstructions such as buffer zones tend to reduce the effective walkway width which causes pedestrians to move away outside the walkway. The primary performance measure for walkways and sidewalks is space. For the field observation to analyze walkways and sidewalks, a pedestrian unit flow rate is used.

4.2 Walkability Survey

The walkability survey is use to assess the pedestrian infrastructures against the nine parameters of the field walkability. This also gives ratings recorded per parameter of how well these facilities attain safe and walkable surroundings. This study uses a modified Global Walkability Index (GWI) to make it more applicable to the Asian situation. Areas with high pedestrian volume were selected based on preparatory surveys and consultation with local stakeholders. Each of the field surveyors will rate the selected road stretches from 1 to 5 for each parameter (1 being the lowest, 5 being the highest) in each of the area types shown.

The averages for each of the parameters are translated into a rating system from 0 (lowest score) to 100 (highest score). Walkability ratings in the different area types in intersection are derived by taking the average of the individual parameters' averages. Also, a predetermined weighting is used as shown in Table 3. The final walkability ratings are then derived by averaging the walkability ratings in the different area types (Fabian et al., 2010).

Table 3. Weight applied to the different parameters

Parameters	Weights
1. Walking Path Modal Conflict	15
2. Availability of Walking Paths	25
3. Availability of Crossings	10
4. Grade Crossing Safety	10
5. Motorist Behavior	5
6. Amenities	10
7. Disability Infrastructure	10
8. Obstructions	10
9. Security from Crime	5
Total	100

An assessment of pedestrian facilities which includes: sidewalks, trails, curb ramps, traffic calming and control devices, grade separated crossings, wide shoulders and other technology, design features, and strategies intended to encourage pedestrian travel will be done by the researchers to determine if these facilities are present and available area of study

5. RESULTS AND DISCUSSIONS

A summary of the six intersections' walkability (Appendix) which interprets the intersection conditions on how walkable they are for pedestrians. The summary also shows the nine parameters using the Asian Walkability Index in rating the walkability of Asian cities. Figure 2 shows an overlay rating on each of the six intersections' walkability with the nine (9) parameters and there corresponding rating to compare each intersection rating.

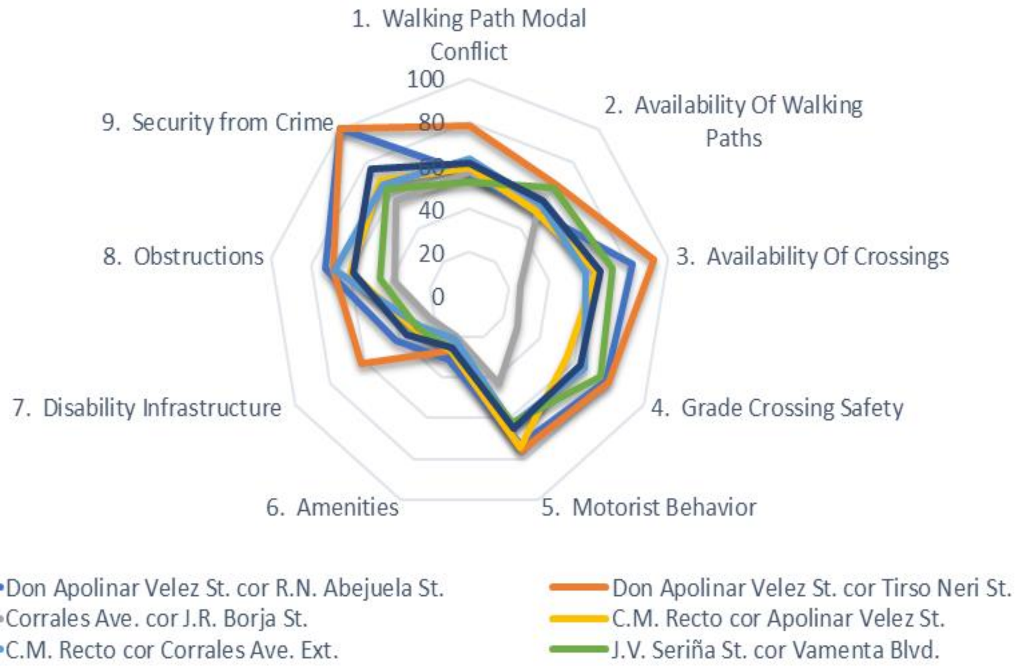

Figure 2. Walkability rating results

The LOS quantifies and measures the effectiveness of the sidewalks and walkways. Four (4) parameters were needed to be assessed namely the pedestrian flow, space module, space and volume-capacity (v/c) ratio to quantify each pedestrian facilities' effectiveness. Pedestrian flow is expressed as the amount of pedestrians passing through an area per minute per meter (ped/min/m). Volume of pedestrians acquired through pedestrian count survey is taken is divided into four 15-minute surveys for each walkway width. The flow rate, space, speed and v/c ratio are computed and each parameters are compared to a LOS scoring from A to F. The summary in Figure3 show the distribution of LOS rating and percentile for each intersections' crosswalks and sidewalk.

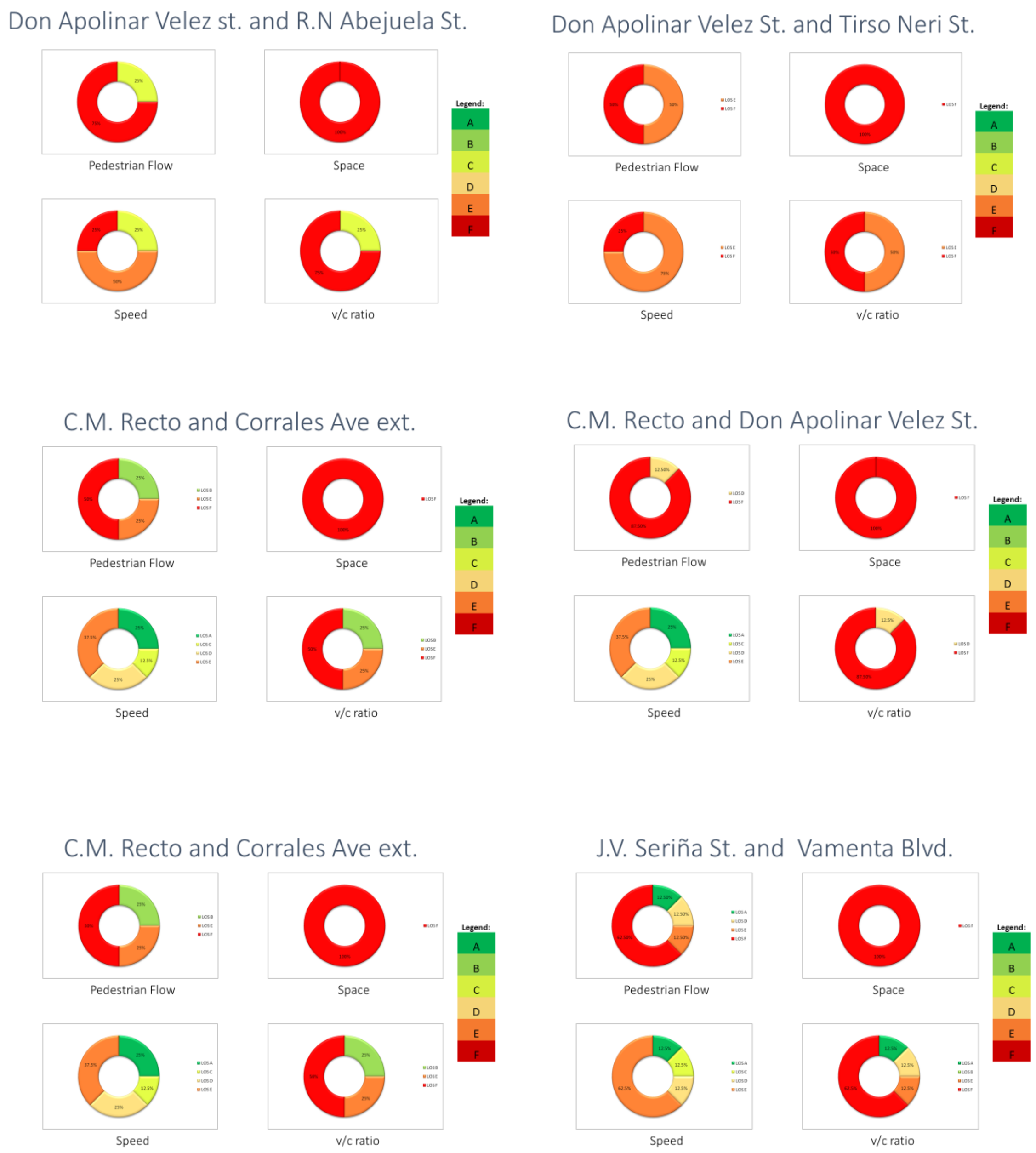

Figure 3. LOS Rating results

From the two methods of analyses results revealed that there are observable poor facility rating in both walkability and LOS evaluation. Taken into consideration the results a pedestrian faciltiy design was prepared to help in improving the intersections' overall effectiveness with proper engineering standards and aesthetic design. The design mainly focus on the intersections' sidewalks, crosswalks, pavement markings, signal lightings, ramps and utilities such as street lights and benches as per Asian standard and HCM recommendations. With respect to the intersections' sidewalk, the research is only limited to the removal and installation of facilities. Any alteration on the sidewalks' width will result to the reduction of the roads width. Table 4 shows the list of suggested strategies for pedestrian facility improvements in the intersections for short-term, mid-term and long-term intervention.

Table 4. Pedestrian Management schemes for the study area

Pedestrian Management Recommendations	Intervension Scheme		
	Short Term	Mid Term	Long Term
Structural Pedestrian Elements			
Install new pedestrian traffic signals			o
Maintain and repair pedestrian traffic signals	o		
Establish dedicated pedestrian and bicyclist street crossing facility			o
Establish fixed barrier delienate to pedestrian and vehicle traffic along curbs and sidewalks			o
Establish sidewalk widening in high density areas			o
Establish speed control measures along crosswalk approach (e.g. speed cushion or bumps, raised crosswalk, rumble stripes,)		o	
Install pedestrian-friendly shelters e.g beches, pedestrian waiting area (loading and unloading of passengers) etc.		o	
Establish pedestrian-friendly ramps for PWD, pregnant women and the elderly		o	
Non-structural Pedestrian Elements			
Clear all non-structural elements that create sidewalk obstruction	o		
Installation of pedestrian-friendly direction and guide signs	o		
Rehabilitate and repaint pedestrian crosswalk	o		
Establish crosswalk widening in mid- and high- density areas	o		
Establish speed control measures along crosswalk approach (e.g. school zones, hospitals, church and public parks)	o		
Reclaim and rehabilitate dilapidated pedestrian curbs and sidewalks		o	

6. CONCLUSIONS

Majority of the six intersections surveyed in this study shows to have a low rating. Per AWI a walkability of 60% is a recommended passing score of which only one intersection in Don A. Velez St. corner R.N. Abejuela St. However, rating all the intersection collectively which represents the walkability as a city scored 52.68% which did not exceed the passing score.

In terms of LOS, the sidewalks of the intersections have very low rating many of which display a grade of LOS “F”. The current design of the intersection’s sidewalks cannot effectively accommodate the volume of pedestrians passing through. Due to the current design, the spaces and speed at which people walk through during peak hours are slow and tightly gapped from each other. Moreover, the volume of pedestrians exceeeds the sidewalks capacity in most of the city’s intersection.

Many of the pedestrian facilities such as pavement markings, ramps, bufferzones and signal lights are either defective, lacking or non-existent at all. These facilities are necessary for pedestrian aid but the intersections in the city lack many as mentioned.

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APPENDIX

Table 5. Walkability Rating of the six study area/streets

	Walkability Ratings							
	weights	A	B	B	D	E	F	City Rating
Walking Path Modal Conflict	15	56	78	57	59	63	52	62
Availability of Walking Paths	25	51	67	54	51	55	65	56
Availability of Crossings	10	82	93	26	64	59	72	64
Grade Crossing Safety	10	78	80	28	56	66	75	59
Motorist Behavior	5	73	76	43	74	63	62	66
Amenities	10	31	27	20	27	21	26	25
Disability Infrastructure	10	42	62	22	31	28	30	36
Obstructions	10	73	69	38	60	68	45	60
Security form Crime	5	100	100	57	69	67	64	77
Walkability Score		61	71	41	53	54	56	55

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