GRAND RIVER AVENUE (M-43) PEDESTRIAN STUDY

FINAL REPORT

PREPARED FOR
THE MICHIGAN DEPARTMENT OF TRANSPORTATION

BY

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DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
MICHIGAN STATE UNIVERSITY

April 30, 1999

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EXECUTIVE SUMMARY

GRAND RIVER AVENUE (M-43) PEDESTRIAN STUDY

By

Virginia P. Sisiopiku, Ph.D. and Darcin Akin, M.S.

This study analyzed pedestrian crossing patterns and preferences in order to evaluate pedestrian crossing options, explain pedestrian behaviours and attitudes and assess pedestrian quality of service.

The test bed used for the analysis was Grand River Avenue in E. Lansing, Michigan. This location offers a variety of pedestrian crossing options such as marked and unmarked midblock crosswalks, signalized and unsignalized intersection crosswalks, and special features such as physical barriers, median shelters, pavement markings etc.

An extensive data collection and reduction effort was undertaken for the collection of pedestrian movement data under vehicular peak- and off-peak traffic conditions. A data collection procedure was developed based on which a system of cameras was used to capture all pedestrian movements within the study section at each 30-min data collection session. In addition to pedestrian crossing volumes and locations, information related to site geometry, traffic control, right- and left-turning vehicle volumes, and pedestrian crossing times were gathered. Finally, perceptual data were collected and analyzed using a questionnaire survey that was distributed to users of the study facility.

The data described above were used to:

1. Evaluate the effectiveness of various new treatments on Grand River Avenue (including various types of crosswalks and special features) based on pedestrian compliance and user satisfaction.
2. Validate existing methods for estimation of pedestrian crossing times and based on measured pedestrian crossing times to:
   a. determine pedestrian LOS at signalized study intersections, and

b. test appropriateness of pedestrian signal settings.

3. Examine the interactions between turning vehicles and pedestrians crossing at signalized locations and determine potential turning-vehicle pedestrian conflicts. The latter can be used to identify problematic intersections i.e., locations that impose a high risk to pedestrian crossing and may need improvements.

Pedestrian crossing options were evaluated with respect to pedestrian crossing compliance. The results from the analysis indicate a strong correlation between the existance of positive type of control and pedestrian compliance to the crossing location. The highest pedestrian compliance to the crossing location was observed at signalized intersection crosswalks (average Pedestrian Spatial Compliance Rate = 83.13%), followed by marked midblock crosswalks (71.19%), unsignalized intersection crosswalks (67.45%) and unmarked midblock crosswalks (64.23%).

The overall pedestrian compliance (spatial and timewise) rate at signalized intersections (i.e., compliance to both crossing location and signal indication) was low, with an average value of only 42.98%. Average timewise pedestrian compliance rate at signalized intersection crosswalks is 50.63%. This indicates that signal phasing plans at signalized intersections and signal progression along the corridor may need to be modified to encourage pedestrian compliance to the pedestrian signal indication while maintaining pedestrian safe crossing conditions.

It was also found that shelters on the median have no effect on pedestrian crossing compliance. Therefore, the use of shelters as means to increase pedestrian crossing safety is not warranted.

The analysis of questionnaire surveys provided important insight on attitudes and preferences of pedestrians using the study site. The results from the survey analysis support the notion that properly marked pedestrian facilities encourage users to cross at designated crossing locations.

Among various crossing options studied, the marked midblock crosswalks are perceived most favorably by pedestrian users. Signalized intersections help channelize pedestrian traffic, but fail to persuade pedestrians to comply with the signal indication, particularly under low traffic demand conditions. These conclusions are in agreement

with actual behaviors observed during the pedestrian movement study. This fact is very encouraging as it increases the confidence in using perceptual data collected in this survey for evaluation of various pedestrian treatments and development of recommendations for improvements.

It was also evident from the survey analysis that the crosswalk location, relative to the origin and destination of the pedestrian, was the most influential decision factor for crossing at a designated crossing location. This indicates that proper selection of the position of a crosswalk with respect to land uses, which generate or attract pedestrian traffic, has the potential to improve the rate of pedestrian compliance significantly. Proper traffic control can further encourage pedestrian crossings at designated locations and ensure safe and efficient travel for all users.

Analysis of pedestrian crossing times at signalized intersections allowed for the evaluation of quality of pedestrian operations on the basis of Level of Service (LOS). It was found that all intersections, with the exception of Division, operate at a reasonable pedestrian Level of Service of B or better. The latter operates at a LOS C under non-peak vehicle traffic conditions.

Moreover, measured pedestrian crossing time data were used to check if currently used signal settings at study intersections meet minimum green and flashing red requirements for pedestrians. It was found that currently used signal settings comply with minimum requirements at all signalized intersection locations except Collingwood, where a minor adjustment of green time was recommended.

Also, existing methodologies for pedestrian crossing time estimation were validated and compared. The analysis indicates that existing methodologies overestimate pedestrian crossing times, thus refinement of such methodologies is needed to account for actual conditions.

Finally, the interactions between right- and left- turning vehicle traffic and pedestrians were examined and modeled using regression analysis techniques. The models developed for estimation of potential right- and left turn vehicle-pedestrian conflicts yielded very satisfactory results.

Moreover, the total number of potential turning vehicle/pedestrian conflicts was used to rate signalized intersection crosswalks based on their potential for turning

vehicle-pedestrian collisions. The Division Street intersection was rated as the one with the highest potential risk for such types of collisions. Recommendations for reduction of turning vehicle-pedestrian conflicts were offered including options such as early or late release pedestrian signal timing or exclusive pedestrian signal timing.

INTRODUCTION

The Michigan Department of Transportation (MDOT) was desirous of gaining insight into the compliance of pedestrians crossing at locations under various crosswalk designs and pedestrian treatments. The Department of Civil and Environmental Engineering at Michigan State University (MSU) was contracted to conduct the study. The information obtained from the analysis of pedestrian patterns and behaviors is expected to serve as a guide for future pedestrian planning projects through the identification of treatments that are likely to work.

Grand River Avenue in East Lansing offers an appropriate environment for evaluation of various pedestrian crossing options. Grand River Avenue is an east-west corridor at the boundary of the MSU campus and the East Lansing community business district (CBD). Storeowners in the business district have long recognized the importance of the "pedestrian market." Moreover, the location of student rental housing, sorority and fraternity houses to the north of the corridor, and MSU facilities to the south, insures a high volume of pedestrian traffic through the district on a year-round basis.

Recent renovations along the Grand River Avenue (from Abbott to Bogue streets) aimed at improving traffic flow, increasing safety of pedestrian movements, and enhancing the aesthetics of the corridor. Improvements related to the facilitation of pedestrian movements included the following:

- designating and painting of midblock and intersection crosswalks,
- redesigning of vehicle and pedestrian signalization at the intersections,
- installation of pedestrian plazas,
- brick paving of crosswalk locations at the median and curbs, and
- utilization of physical barriers (through landscaping).

The main purpose of the subject study is to evaluate the degree of utilization of the recently renovated crosswalks on the Grand River Avenue, East Lansing downtown, by pedestrians. In this context, the following objectives are determined:

1. Evaluation of the effectiveness of various new treatments on Grand River Avenue, including intersection and midblock pedestrian crosswalks, physical barriers, shelters at the median etc.;

2. Validation of existing methods to determine pedestrian crossing times using field data from Grand River Avenue crosswalks; and
3. Examination of the effects of turning vehicles on individual pedestrians and platoon of pedestrians.

Objective 1 is viewed as the major objective of the study. It is addressed through the analysis of pedestrian movement data and pedestrian perceptual data. Accomplishment of this objective will provide an insight on pedestrian compliance and ways to improve it. Furthermore, the assessment of various pedestrian treatments will pinpoint solutions that have a better potential to work, when implemented in different locations with similar characteristics in terms of physical and traffic conditions, and pedestrian attitudes.

Conclusions drawn from the analysis of objectives 2 and 3 can enhance the reader's understanding on theories and practices used to accommodate pedestrian needs and can suggest ways to improve them. Moreover, analysis related to objectives 2, and 3 will assist in the estimation of pedestrian Level of Service at signalized study intersections and assessment of the effectiveness of currently used signal settings to meet minimum pedestrian crossing requirements.

The study is organized in chapters by objective. Chapter 1 presents in detail the methodology used and the results obtained from the evaluation of pedestrian treatments along Grand River Avenue. In Part A of Chapter 1, direct observation of pedestrian movements on Grand River Avenue is analyzed. In Part B, pedestrians' perceptions toward various treatments on Grand River Avenue are studied. Chapter 2 describes and compares methodologies for determining pedestrian crossing times and applies such concepts in order to determine pedestrian LOS at signalized crosswalks. Finally, Chapter 3 addresses issues related to the effect of turning vehicles on pedestrian traffic.

Chapter 1

EVALUATION OF PEDESTRIAN CROSSING OPTIONS

DESCRIPTION OF STUDY SITE

The effectiveness of various pedestrian crosswalk types to serve pedestrian needs and preferences was studied in detail using field data from Grand River Avenue in East Lansing, Michigan. The study site extends from Abbott to Bogue Street for approximately 1 km (0.63 mi.). Eastbound vehicular traffic is served by two lanes and westbound by three. Bus service is provided on both directions. Pedestrian crossing lengths vary from 27.8 to 35.9 m (91.2 to 117.8 ft). To facilitate study purposes, the study site is divided in two sections. Figure 1.1 shows a schematic of the study site by section.

The study site offers an appropriate environment for evaluation of various pedestrian crossing treatments. Such treatments include:

1. marked midblock crosswalks,
2. unmarked midblock crosswalks,
3. signalized intersection crosswalks,
4. unsignalized intersection crosswalks,
5. median shelters at crosswalk locations, and physical barriers.

Marked midblock crosswalks are located in the midblock (between two consecutive intersections). They are striped, paved with red-colored bricks at the median and curbs, and have warning signs posted. The warning signs display the message "Cross only when traffic clears". There are four marked midblock crosswalk locations within the study area, two of which have shelters at the median. Unmarked midblock crosswalks, on the other hand, have red-color brick pavement at the median but lack strips and signs. Two unmarked midblock crosswalks exist within the study area. Both are located to the east of Division Street, after a marked midblock crosswalk.

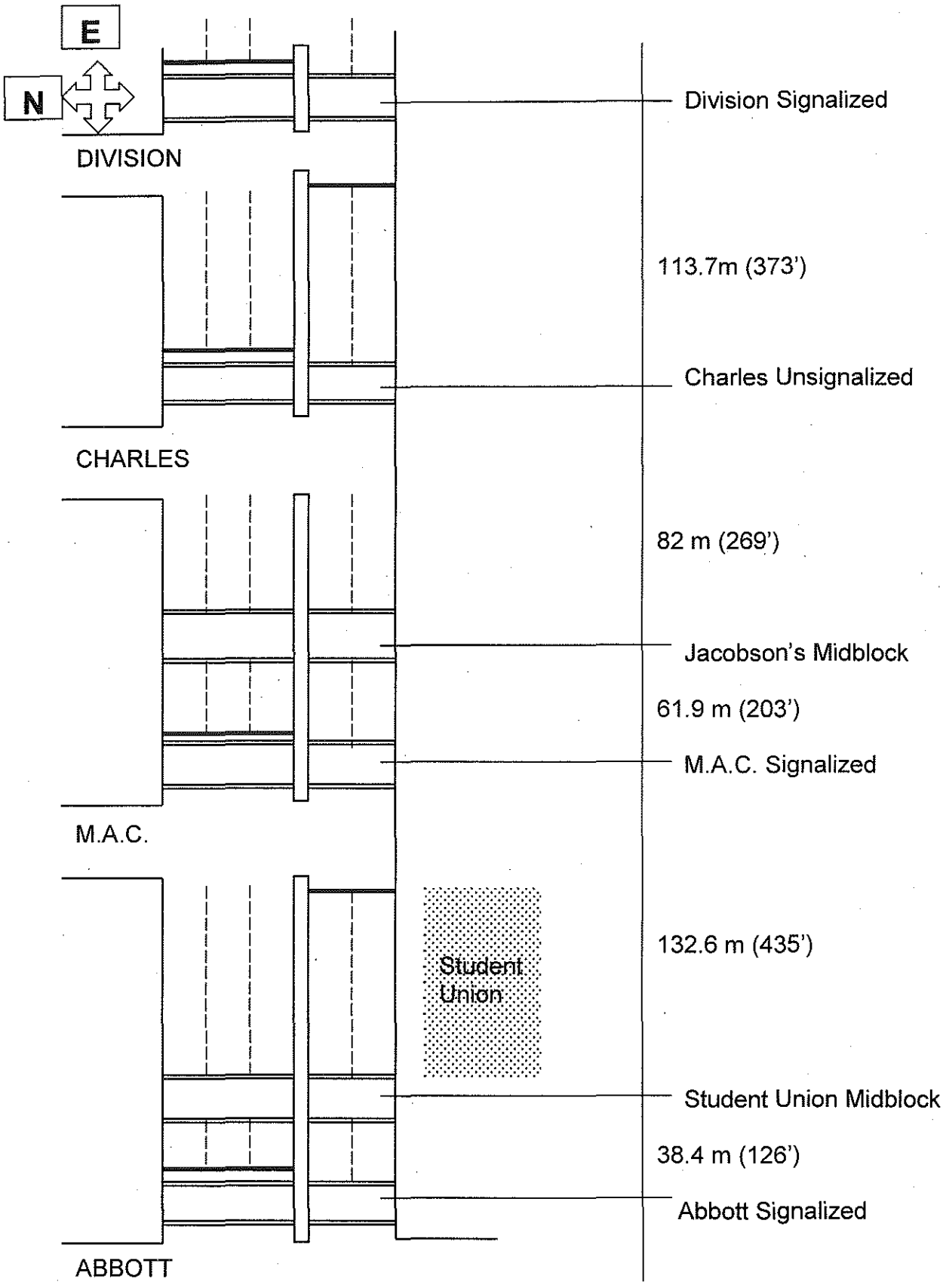

Figure 1.1.a. A schematic of Section 1 (not to scale)

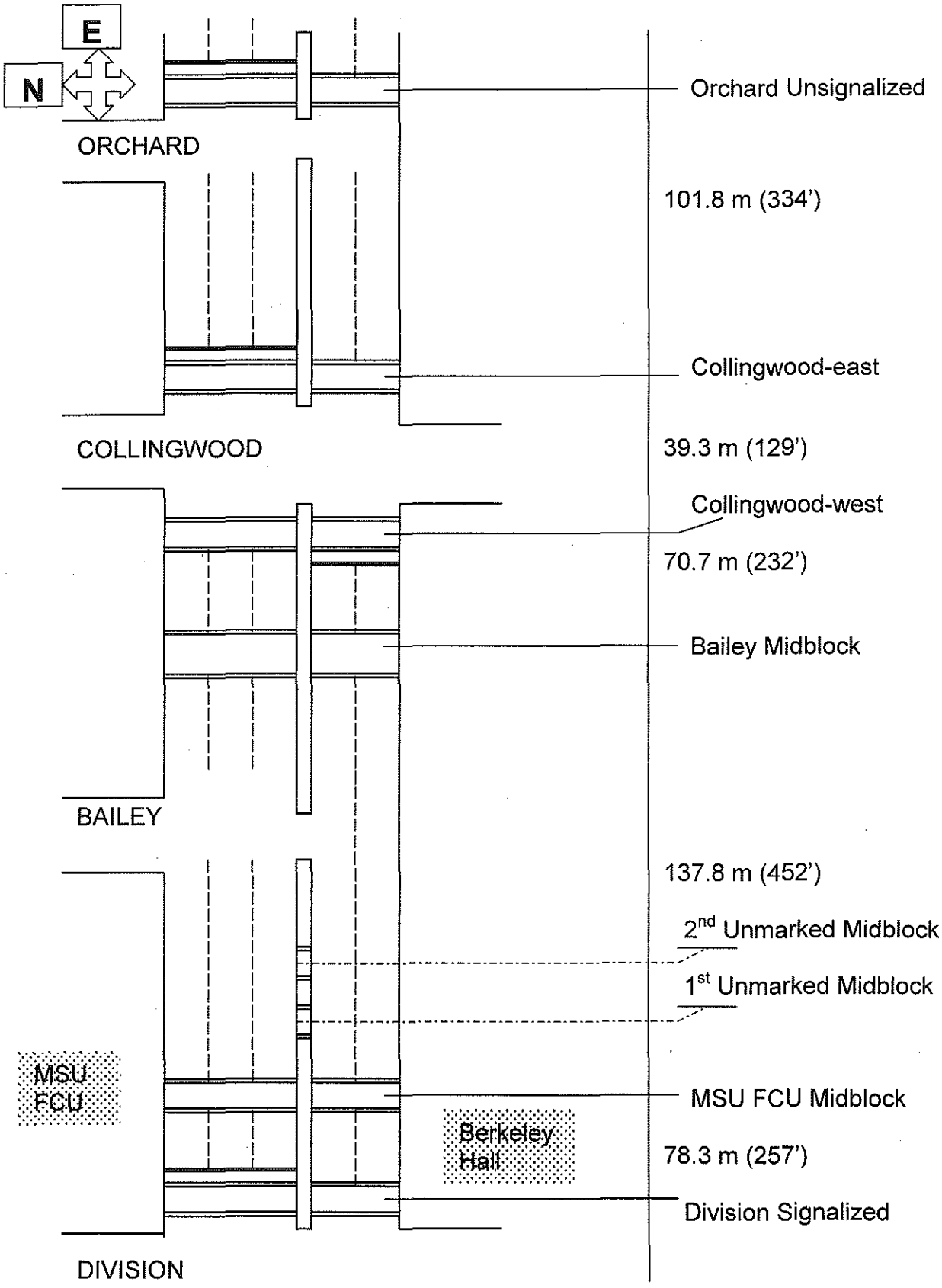

Figure 1.1.b. A schematic of Section 2 (not to scale)

Four signalized intersections with crosswalks are located within the study site. Three of these intersections have a crosswalk at one side (east side) and one intersection provides a crosswalk at both sides. With respect to signal phasing, westbound vehicle traffic receives a red indication 5-6 sec earlier than eastbound at three of the signalized intersections (Abbott, Division and Collingwood St). The purpose of this arrangement is to allow left-turning vehicles on the eastbound to exit Grand River and enter the cross streets. During the 5-6 sec period in which westbound traffic is stopped and eastbound traffic is moving, the pedestrian signal remains red. However, one should keep in mind that pedestrians traveling southbound can safely cross the westbound portion of the roadway (since westbound traffic is stopped), despite the red indication of pedestrian signal.

Finally, two crosswalks are located at unsignalized intersections. In summary, the study crosswalks can be stratified as follows:

1. Signalized intersection crosswalks with one-side pedestrian crossing (Abbott, M.A.C., and Division Streets);
2. Signalized intersection crosswalk with two-side pedestrian crossings (Collingwood Street);
3. Unsignalized intersection crosswalks (Charles and Orchard Streets);
4. Midblock crosswalks with shelter (Student Union, MSU Federal Credit Union);
5. Midblock crosswalks without shelter (Jacobson's, and Bailey Street); and
6. Unmarked midblock crosswalks (east of Berkley Hall).

Part A: STUDY OF PEDESTRIAN ATTITUDES

DATA COLLECTION

Introduction

Pedestrian attitudes were studied through the analysis of field data collected from direct observation of pedestrian crossing activity. Data collection was performed using video cameras set up at selected locations along the study site. Data collection sessions were conducted when a reasonable pedestrian volume was present (about 40-50 ped/hr at major signalized intersection crosswalks).

Pedestrian movements were observed and recorded during morning vehicular off-peak hours and afternoon peak-hours. Data were collected mostly over weekdays. Weekend data collection was limited to Saturdays since most of the stores in East Lansing downtown are not open on Sundays. Data collection was performed during months that the Michigan State University was in session (Spring, 1998). Moreover, football home-game weekends and major holidays were excluded. Data collection was performed under various weather conditions (sunny, cloudy, snow sprinklers, cold, warm, and hot). No data were collected under rain conditions in order to protect the video recording equipment from damages.

Methodology

Eight video cameras were simultaneously used to record pedestrian movements. Video cameras were located consecutively at both sides of Grand River Avenue on the sidewalks along the study section in order to cover the entire study area. An example illustrating typical camera positions is shown in Figure 1.2.

The recording areas of consecutive cameras were overlapped to ensure that all pedestrians in the study section were captured. Pedestrian movements were recorded over 30-min sessions at each camera location. Then, cameras were moved to another location. In order to collect 30-min pedestrian activity data along the entire study site the system of the 8 cameras had to be repositioned at least four times. This required a total 16 to 18 hours in the field for filming alone, without considering the time involved to move the equipment from place to place, and set it up properly.

Although the data collection process was a tedious and labor intensive one, it was very rewarding as it allowed for detection of all pedestrian movements that occurred during the data collection session. Not only information about the pedestrian crossing location became available but additional information about conditions during crossing

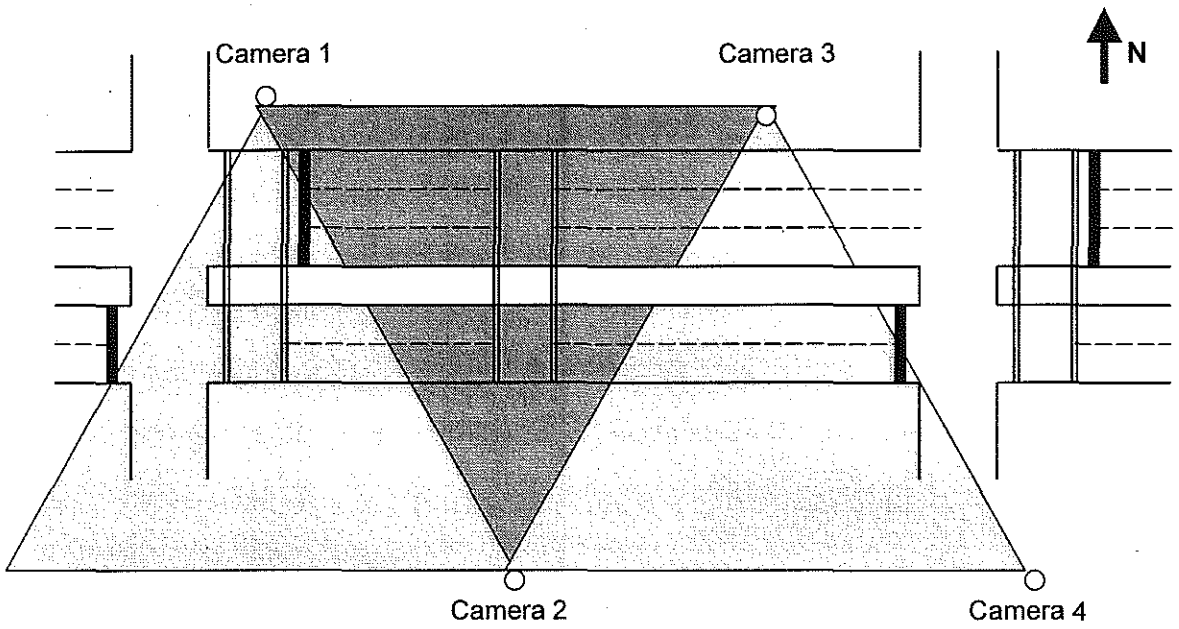

Figure 1.2. Positions of cameras located on the sidewalks along the Grand River Avenue

(such as signal indication, presence of other pedestrians, etc) were obtained through careful processing of the video tape in the office.

Study Sections

To increase the efficiency of the data collection, the entire study site was divided into two sections. Section 1 extended from Abbott Street to Division Street, while section 2 covered the distance between Division and Bogue Streets. The data collection crew videotaped one section at a time moving the equipment at the end of each 30 min session, as described above. Several visits were performed to each section during weekdays and Saturdays. Section 1 included the following crosswalks:

1. Abbott St X-intersection signalized crosswalk (located at the east side of the intersection);
2. MSU Student Union midblock crosswalk (with shelter);
3. M.A.C. Ave T-intersection (w/o south leg) signalized crosswalk (at the east side of the intersection);
4. Midblock crosswalk (w/o shelter) in front of Jacobson's, and
5. Charles St T-intersection (w/o south leg) unsignalized crosswalk (at the east side of the intersection).

Section 2 included the following crosswalks:

1. Division St T-intersection (w/o south leg) signalized crosswalk (at east side of the intersection),
2. Midblock crosswalk (w/shelter) in front of MSU Federal Credit Union,
3. Two unmarked (non-striped) midblock crosswalks east of Berkeley Hall,
4. Midblock crosswalk (w/o shelter) east of Bailey St,
5. Collingwood X-intersection signalized crosswalks (at both sides of the intersection), and
6. Orchard St T-intersection unsignalized crosswalk.

There was no crosswalk at Bogue Street intersection during the data collection. A pedestrian activated signal with a marked crosswalk was installed in December 1998.

Data Collection Dates and Times

Pedestrian movement data were collected between February and May 1998. Tables 1.1 and 1.2 summarize the dates and times of data collection sessions for sections 1 and 2, respectively, as well as traffic and weather conditions present during data collection.

DATA REDUCTION

The data reduction was performed off-site in the transportation laboratory of the Civil and Environmental Engineering Department. Videotapes were watched real time and necessary data were extracted.

Table 1.1. Data collection sessions at Section 1 (From Abbott to Division Streets)

Session No	Date	Day	Time	Weather	Temperature
1	2/10/98	Tuesday	AM off-peak	Warm	Low 40s
2	2/14/98	Saturday	Weekend	Cold, partly cloudy	High 30s
3	2/19/98	Thursday	PM peak	Cold, cloudy	Mid 30s
4	2/23/98	Monday	PM peak	Cold, partly sunny	Mid 30s
5	2/25/98	Wednesday	PM peak	Warm, sunny	High 40s
6	2/26/98	Thursday	AM off-peak	Warm, sunny	High 40s
7	5/27/98	Wednesday	AM off-peak	Sunny	Mid 80s
8	5/28/98	Thursday	PM peak	Sunny	Mid 70s

Table 1.2. Data collection sessions at Section 2 (From Division to Bogue Streets)

Session No	Date	Day	Time	Weather	Temperature
1	4/17/98	Friday	PM peak	Partly cloudy	High 50s
2	4/20/98	Monday	PM peak	Partly cloudy	Low 60s
3	4/23/98	Thursday	AM off-peak	Sunny	Low 70s
4	4/24/98	Friday	PM peak	Sunny	High 60s
5	4/28/98	Tuesday	AM off-peak	Sunny	Low 60s
6	4/30/98	Thursday	AM off-peak	Cloudy	High 60s
7	9/19/98	Saturday	Weekend	Sunny	Low 80s

The analysis was based on the assumption that each crosswalk has an influence area within which it attracts pedestrian users. In order to determine the crosswalk influence area of each study crosswalk, the distance between each pair of consecutive crosswalks was divided in two equal lengths by an imaginary dividing line. As a result, each crosswalk was located between two consecutive dividing lines with the dividing lines serving as the boundaries of the crosswalk influence area. The area between the two dividing lines is the so-called crosswalk influence area.

Figure 1.3 demonstrates an example of a crosswalk influence area determination for crosswalk *i*. The distance between crosswalk *i* and crosswalk *i-1* is L_{i-1}. The distance between crosswalk *i* and crosswalk *i+1* is L_{i+1}. The crosswalk influence area (CIA_i) for the crosswalk *i* is the sum of $L_{i-1}/2$ and $L_{i+1}/2$. The extend of a crosswalk influence area is expressed mathematically by Equation 1.1.

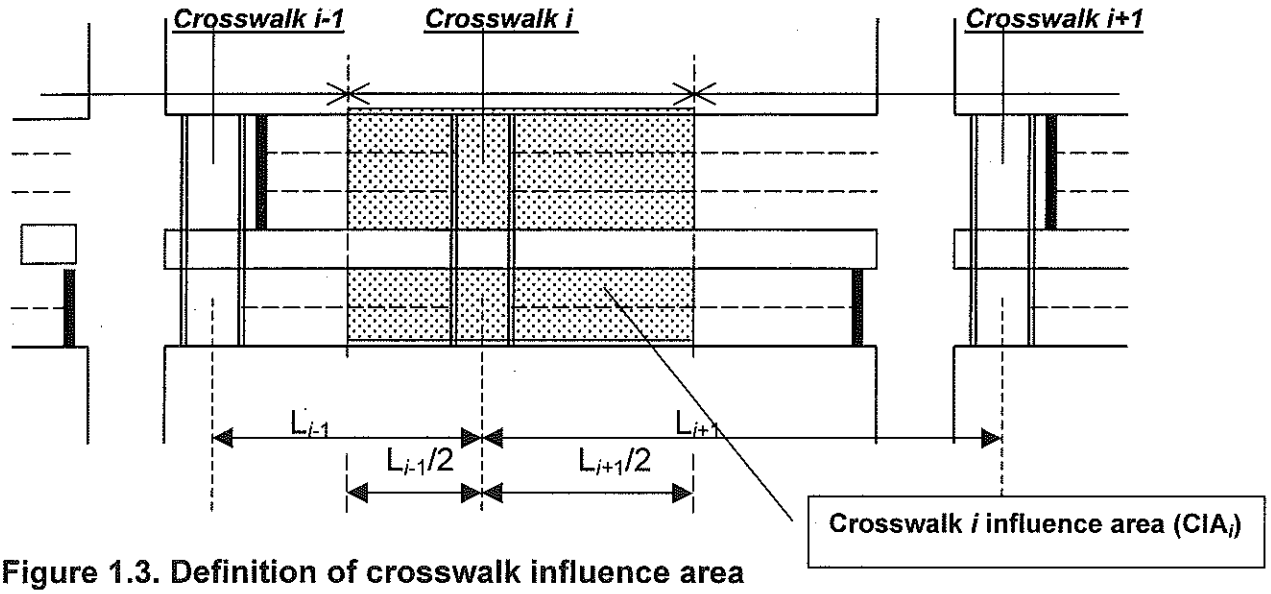

Figure 1.3. Definition of crosswalk influence area

$$CIA_i = \frac{L_{i-1} + L_{i+1}}{2} \quad \text{.....} Eq.1.1$$

where

CIA_i = crosswalk influence area,

L_{i-1} = distance between crosswalks *i*-1 and *i*,

L_{i+1}=distance between crosswalks *i* and *i*+1, and

crosswalks *i*-1, *i*, and *i*+1 are consecutive crosswalks.

The following data were recorded for the pedestrian movement analysis.

Number of pedestrians who:

- cross on the crosswalk during the green indication of pedestrian signal (regular users),
- cross partially on the crosswalk (partial jaywalkers),

- do not cross within 50 ft (15 m) of the crosswalk (jaywalkers).
- cross the signalized crosswalk during the red indication (sneakers),
- cross a portion of the signalized crosswalk during the red indication (partial sneakers),
- cross from curb to the median of a signalized crosswalk during flashing red (late starters), and
- total number of pedestrians within the crosswalk influence area. Special efforts were made to avoid double counting of pedestrians that started their crossing within the field of view of one camera and completed it within the field of the next camera(s).

While watching each tape separately, for each pedestrian a record of the time when he/she appeared on the screen and a significant characteristic of him/her such as wearing red t-shirt or blue jacket, etc were kept. Using such info, pedestrians that appeared on more than one tape in the crosswalk influence area were not counted more than once. Data summary forms were developed to report summary data and calculate pedestrian compliance rates. An example of such forms is given in Figure 1.4, while the complete set of forms is provided in Appendix A.

DATA ANALYSIS

A measure was developed as part of this study in order to enable comparison of various crossing options and assessment of their effectiveness. This measure was termed "Pedestrian Compliance Rate" (PCR_L) and is defined as the ratio of the number of pedestrians who comply to the crossing location over the total number of pedestrians in the crosswalk influence area. Pedestrians who comply with crossing location *i* (denoted as P_L^i) are those that cross within 15 m (50 ft) from the centerline of crosswalk *i* (see Figure 1.5). Equation 1.2 gives the definition of pedestrian compliance rate for midblock, unsignalized intersections, and signalized intersections when compliance to the signal indication is omitted.

Gd River Ave Crosswalks (Abbot - Division Sts)

DATA SUMMARY

Date: 2/23/98 Time: 2:46 pm Data Summary: 01

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

1- Marked Midblock Crosswalk w/ shelter (in front of the MSU Student Union)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	45	5	4	54

Jaywalkers from west side of the crosswalk = 0 peds in 30 min

Jaywalkers from east side of the crosswalk = 2 peds in 30 min

Total pedestrians in the crosswalk area = 54 + 0 + 2 = 56 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on x-walk}}{\textit{total peds in the crosswalk area}} = \frac{45}{56} = 80.4\%$$

Total pedestrian volume in the crosswalk area = 56 * 2 = 112 peds / hr

2- 1st Unmarked Midblock Crosswalk w/o shelter (in front of SPLASH)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	23	0	10	33

Jaywalkers from west side of the crosswalk = 3 peds in 30 min

Jaywalkers from east side of the crosswalk = 0 peds in 30 min

Total pedestrians in the crosswalk area = 33 + 3 + 0 = 36 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on x-walk}}{\textit{total peds in the crosswalk area}} = \frac{23}{36} = 63.9\%$$

Total pedestrian volume in the crosswalk area = 36 * 2 = 72 peds / hr

Figure 1.4. Sample data summary sheets for each type of crosswalk

Gd River Ave Crosswalks (Abbot - Division Sts)

DATA SUMMARY

Date: 2/23/98 Time: 2:46 pm Data Summary: 01

3- Clark St. Unsignalized Intersection Crosswalk

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	29	10	1	40

Jaywalkers from west side of the crosswalk = 6 peds in 30 min

Jaywalkers from east side of the crosswalk = 7 peds in 30 min

Total pedestrians in the crosswalk area = 40 + 6 + 7 = 53 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on x-walk}}{\textit{total peds in the crosswalk area}} = \frac{29}{53} = 54.7\%$$

Total pedestrian volume in the crosswalk area = 53 * 2 = 106 peds / hr

4- Abbot St. Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	47	2	0	11	49
PS (VR)	14	1	0	2	15
S	32	2	2	3	36
LS	9	1	0	1	10
Total	102	6	2	17	110

RU: Regular users S: Sneakers

PS (VS): Partial sneakers (vehicles stopped) LS: Late starters

PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 5 peds in 30 min

Jaywalkers from east side of the crosswalk = 3 peds in 30 min

Total pedestrians in the crosswalk area = 110 + 5 + 3 = 118 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RU + no of PS(VS) on x-walk}}{\textit{total peds in the crosswalk area}} = \frac{47}{118} = 39.8\%$$

Total pedestrian volume in the crosswalk area = 118 * 2 = 236 peds / hr

Figure 1.4. Sample data summary sheets for each type of crosswalk (continued)

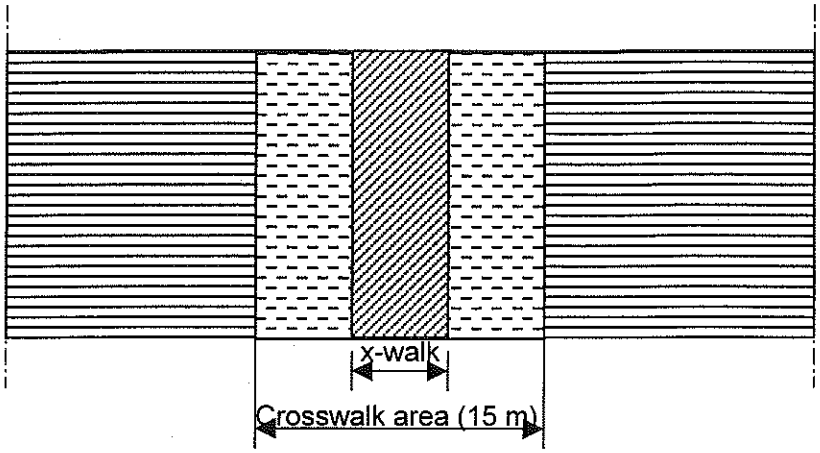

Figure 1.5. Crosswalk area

$$PCR_L^i = \frac{P_L^i}{P_{CIA}^i} \quad \text{.....Eq.1.2}$$

where

PCR_L^i = pedestrian compliance rate at crosswalk *i*,

P_L^i = number of pedestrians who comply to crossing location, and

P_{CIA}^i = total number of pedestrians in the crosswalk influence area (CIA) of crosswalk *i*.

The definition of pedestrian compliance rate given above measures the degree of pedestrian compliance with respect to the crossing location. Thus it is proper to use at midblock crosswalks, unsignalized intersections, and signalized intersection when calculation of compliance to the crossing location is desired. It should be noted, however, that at signalized intersections pedestrian compliance shall be linked to two elements:

a. compliance to the crossing location (within 15 m of the crosswalk); and
b. compliance to the traffic signal (during the green indication of pedestrian signal).

Therefore, another measure has been proposed to calculate the overal pedestrian compliance rate at signalized intersections. Overall pedestrian compliance, PCR_{LT}^i, is defined as the ratio of the number of pedestrians who comply with both crossing location and pedestrian signal indication, (P_{LT}^i), over the total number of pedestrians within the crosswalk influence area (P_{CIA}^i). Equation 1.3 gives the definition of overall pedestrian compliance rate for signalized intersections.

$$PCR_{LT}^{i} = \frac{P_{LT}^{i}}{P_{CIA}^{i}} \quad \text{.....} Eq.1.3$$

where

PCR_{LT}^{i} = overall pedestrian compliance rate at crosswalk *i* at signalized intersection,

P_{LT}^{i} = the number of pedestrians who comply to both crossing location (see Figure 1.6) and signal indication, and

P_{CIA}^{i} = total number of pedestrians in the crosswalk influence area (CIA) of crosswalk *i*.

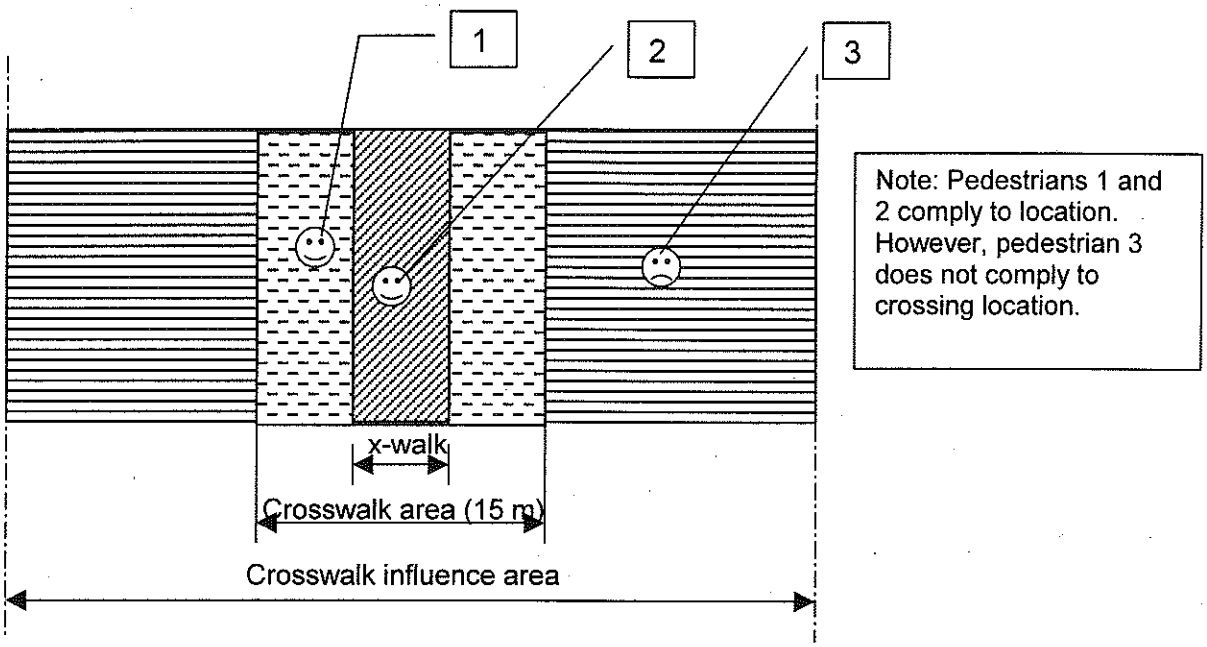

Figure 1.6. Pedestrian compliance to crossing location

RESULTS

Equations 1.2 and 1.3 were used to obtain pedestrian compliance rates for each crosswalk location and each data collection session. Average pedestrian compliance rates by location were then calculated for every crosswalk location by averaging pedestrian compliance rates at the location over all data collection sessions. Moreover, average pedestrian compliance rates by crosswalk type were calculated. Four

crosswalk types were considered, i.e. marked midblock, unmarked midblock, unsignalized intersection, and signalized intersection crosswalks. The average pedestrian compliance rates by crosswalk type were found by averaging pedestrian compliance rates from all locations belonging to the selected crosswalk type. This allowed comparison of the performance of a crosswalk type to the performance of other crosswalk types.

The results are organized by crosswalk type. Descriptive statistics of pedestrian compliance rates were obtained and are presented and discussed in detail in the following paragraphs. Such statistics include: Number of sessions at each location, range of pedestrian compliance rates obtained for the location (i.e., min and max PCR), average pedestrian compliance rate at location over all sessions (mean PCR), and standard deviation of the mean. Also, average pedestrian compliance rates by section were obtained and reported by averaging pedestrian compliance rates over all locations belonging to a crosswalk type under study and located within the study section. Finally, average pedestrian compliance rates for the entire study site were calculated.

Marked Midblock Crosswalks

Equation 1.2 was applied to calculated pedestrian compliance rates for all four marked midblock crosswalks in the study site for each data collection session. The results are summarized in Figure 1.7. As Figure 1.7 shows, pedestrian compliance rates at the midblock crosswalks varied overall between 44.8% and 90.9% with an average of 71.2%.

Figure 1.8 gives an example of pedestrian compliance rate variation at the marked midblock crosswalk in front of the MSU Student Union. Similar graphs for all other marked midblock crosswalk locations are provided in Appendix B. Descriptive statistics of pedestrian compliance rates at all study marked midblock crosswalks are provided in Table 1.3. Based on this table, the average pedestrian compliance rate at study Section 2 is 21.6% higher than that observed at study Section 1. A *t*-test was performed to test if the difference between the compliance rates at the two sections is

statistically significant. The *t*-value and the significance level obtained were 3.248 and 0.008, respectively. Therefore, the difference is statistically significant since 0.008 is smaller than 0.05 at the confidence level of 95%.

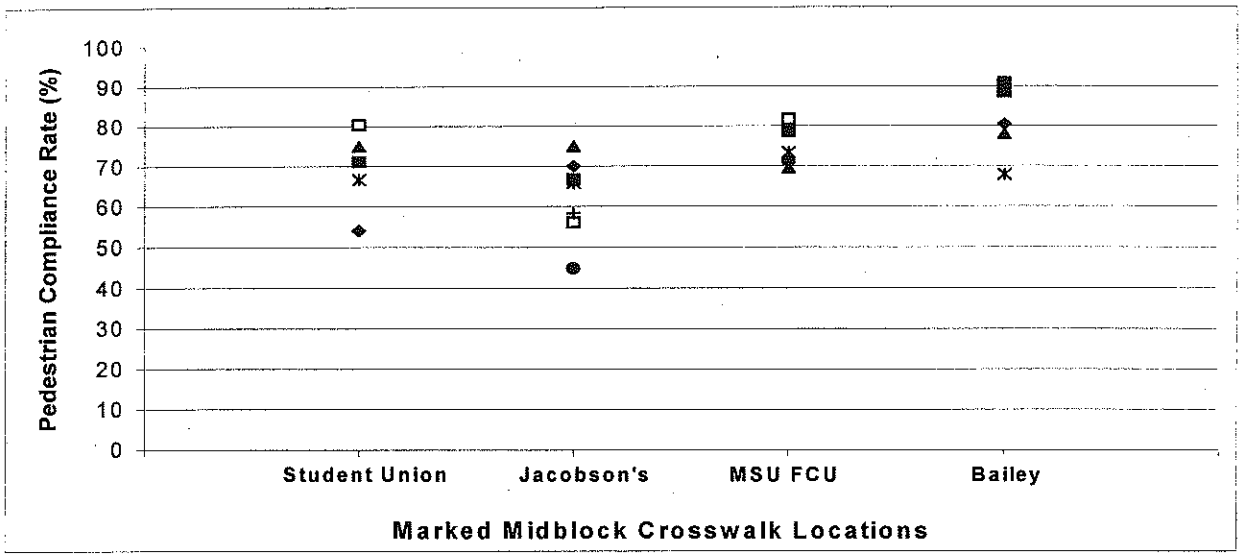

Figure 1.7. Pedestrian compliance rates of all marked midblock crosswalks-All data collection sessions

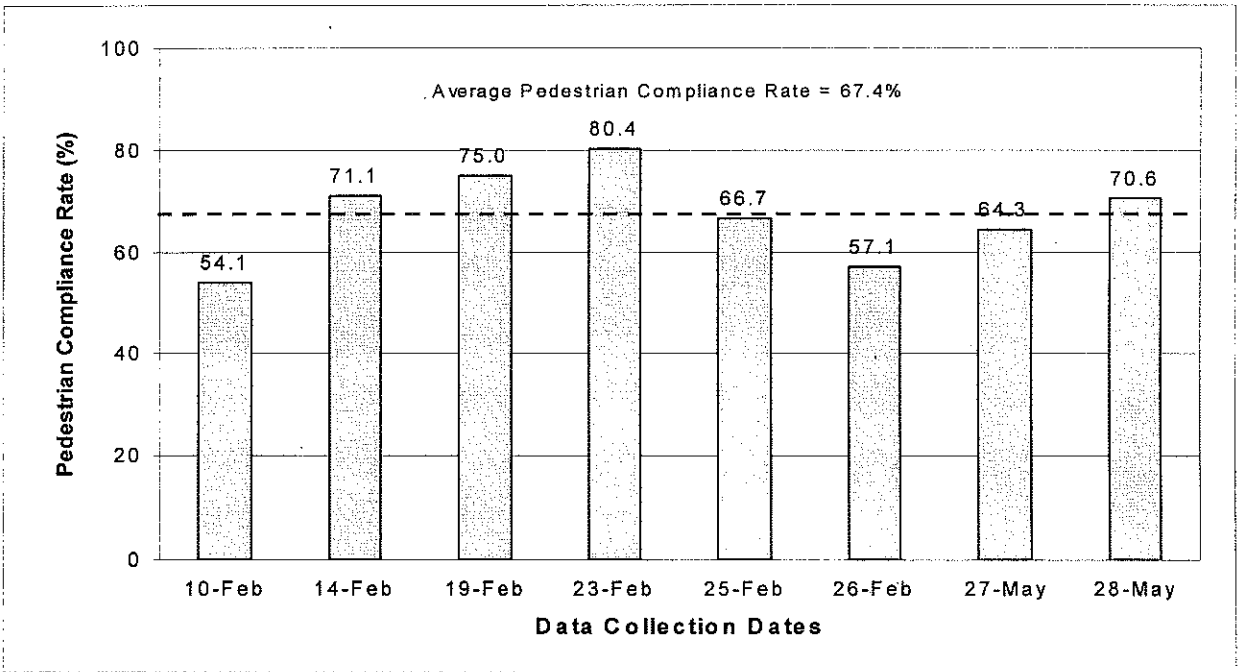

Figure 1.8. Pedestrian compliance rates-MSU Student Union marked midblock crosswalk

Table 1.3. Descriptive statistics of pedestrian compliance rates at all marked midblock crosswalks

Study Section	Crosswalks	No of sessions	PCR			Std. Deviation	Mean PCR for Section
			Min	Max	Mean		
1	Student Union	8	54.10	80.40	67.41	8.8137	65.16
	Jacobson's	8	44.80	75.00	62.90	9.4862	
2	Berkeley Hall	6	69.40	81.60	75.75	5.1259	79.23
	Bailey St	6	67.80	90.90	82.70	9.1128	
	Total:	28				Overall mean:	71.19

Unmarked Midblock Crosswalks

Pedestrian compliance rates for the two unmarked midblock crosswalks in the study section were calculated for each data collection session using Equation 1.2. The first unmarked crosswalk is located east of Berkeley Hall and the second unmarked crosswalk is just to the east of the first one. The results are displayed in Figure 1.9.

Pedestrian compliance rates at the unmarked midblock crosswalks varied overall between 58.3% and 69.0% with an average of 64.2%. Figure 1.10 gives an example of

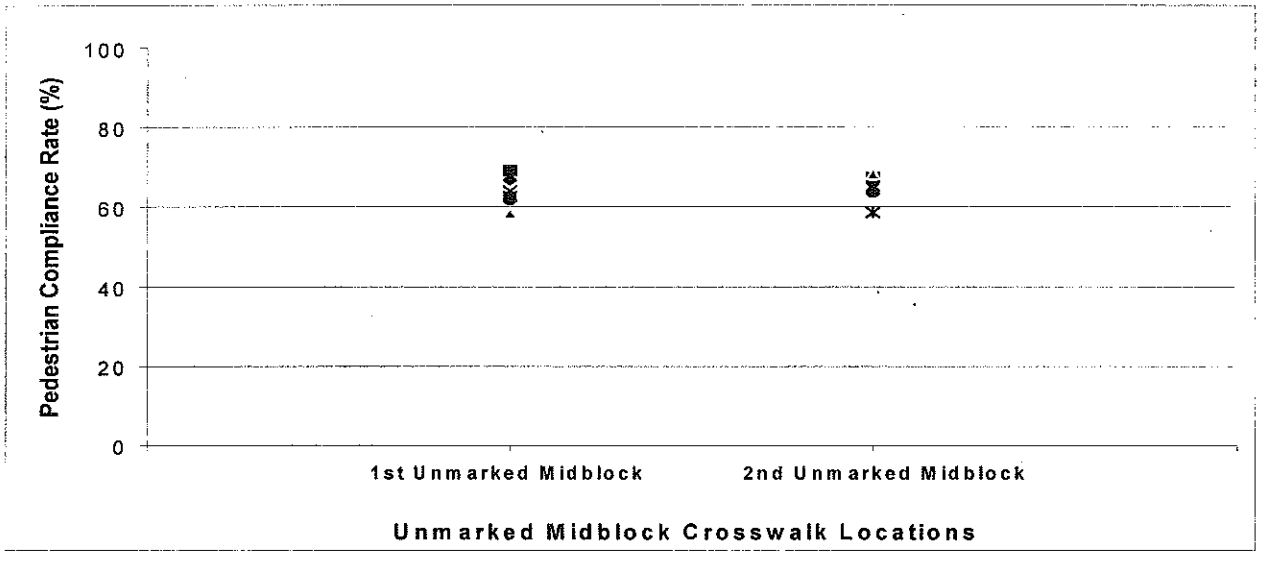

Figure 1.9. Pedestrian compliance rates of all unmarked midblock crosswalks-All data collection sessions

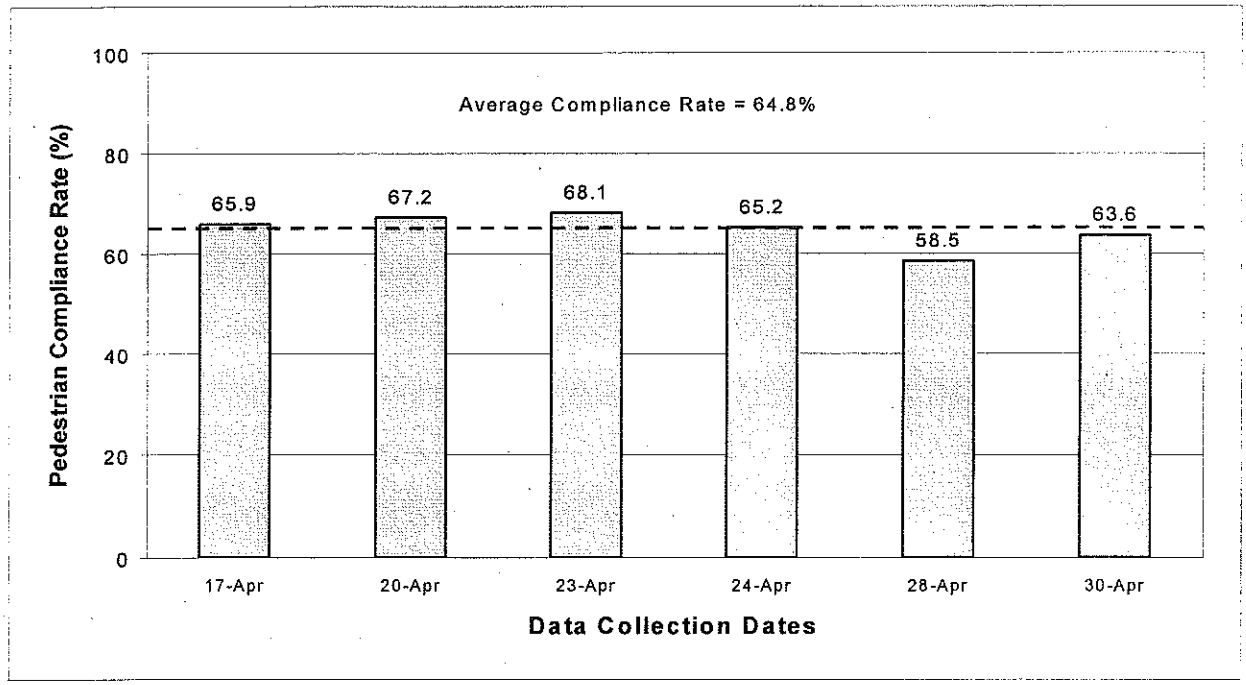

Figure 1.10. Pedestrian compliance rates-2nd unmarked midblock crosswalk

pedestrian compliance rate variation at the second unmarked midblock crosswalk. A similar graph for the first unmarked midblock crosswalk is provided in Appendix C.

Descriptive statistics of pedestrian compliance rates at both unmarked midblock crosswalks in the study site are provided in Table 1.4. The difference between the average values of the compliance rates at the two crosswalks is not statistically significant (*t*-value = -0.538, and the significance level = 0.614 > 0.05).

Table 1.4. Descriptive statistics of pedestrian compliance rates at all unmarked midblock crosswalks

Study Section	Crosswalks	No of sessions	PCR			Std. Deviation	Mean PCR for Section
			Min	Max	Mean		
2	Unmarked 1	6	58.30	69.00	63.70	3.777	64.23
	Unmarked 2	6	58.50	68.10	64.75	3.439	
	Total:	12				Overall mean:	64.23

Unsignalized Intersections Crosswalks

Pedestrian compliance rates for both unsignalized intersection crosswalks were calculated for each data collection session based on Equation 1.2. Each study section had only one unsignalized intersection crosswalk. The results obtained from the analysis are displayed in Figure 1.11. Overall, pedestrian compliance rates at unsignalized intersection crosswalks varied from 55.6% to 78.0% with an average of 67.5%. Figure 1.12 offers an example of the pedestrian compliance rate variation at the Charles Steet unsignalized intersection crosswalk. A similar graph for the Orchard Street crosswalk location is provided in Appendix D.

Table 1.5 shows the descriptive statistics of pedestrian compliance rates at the unsignalized intersection crosswalks. The difference between the average values of the pedestrian compliance rates at the two unsignalized intersection crosswalks is not statistically significant (*t*-value = -0.177, and the significance level = 0.867 > 0.05).

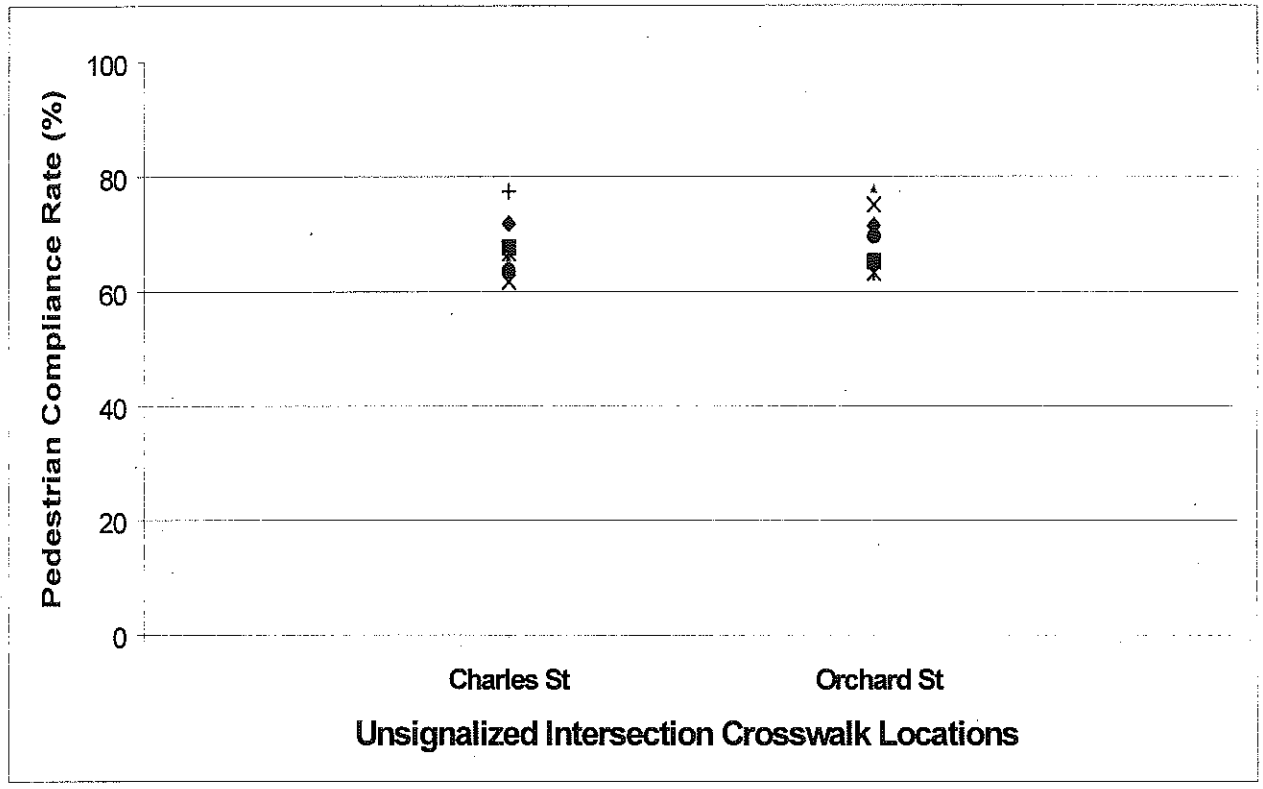

Figure 1.11. Pedestrian compliance rates of all unsignalized intersection crosswalks-All data collection sessions

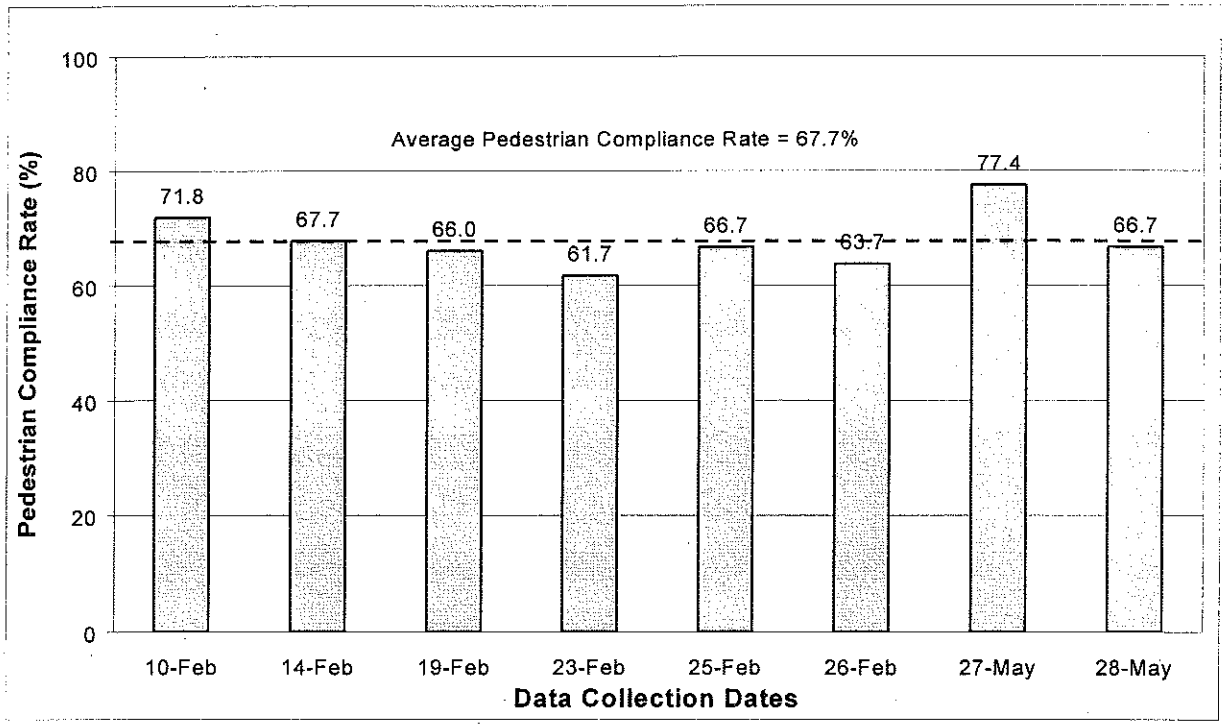

Figure 1.12. Pedestrian compliance rates-Charles St unsignalized intersection crosswalk

Table 1.5. Descriptive statistics of pedestrian compliance rates at all unsignalized intersection crosswalks

Study Section	Crosswalks	No of sessions	PCR			Std. Deviation	Mean PCR for Section
			Min	Max	Mean		
1	Charles St	8	61.70	77.40	67.71	4.896	67.71
2	Orchard St	6	55.60	78.00	67.10	8.599	67.10
	Total:	14			Overall mean:		67.45

Signalized Intersection Crosswalks

Pedestrian compliance rates for all five signalized intersection crosswalks in the study site were calculated for each data collection session using two different methods. First, Equation 1.2 was applied and pedestrian compliance rates to the crossing location were calculated. Then Equation 1.3 was used to obtain overall pedestrian compliance rates,

which reflected pedestrian compliance to the crossing location and traffic signal indication simultaneously. The results are summarized next.

Pedestrian Compliance Rates at Signalized Intersections

As Figure 1.13 shows, pedestrian compliance rates to crossing location at signalized intersection crosswalks varied from 68.4% and 98.2% with an average of 83.1%. Note that these figures explain pedestrian compliance to the crossing location only, without considering compliance to the pedestrian signal indication.

Figure 1.14 gives an example of pedestrian compliance rate variation at the Abbott St signalized intersection crosswalk. Similar graphs for all other signalized intersection crosswalk locations are provided in Appendix E.

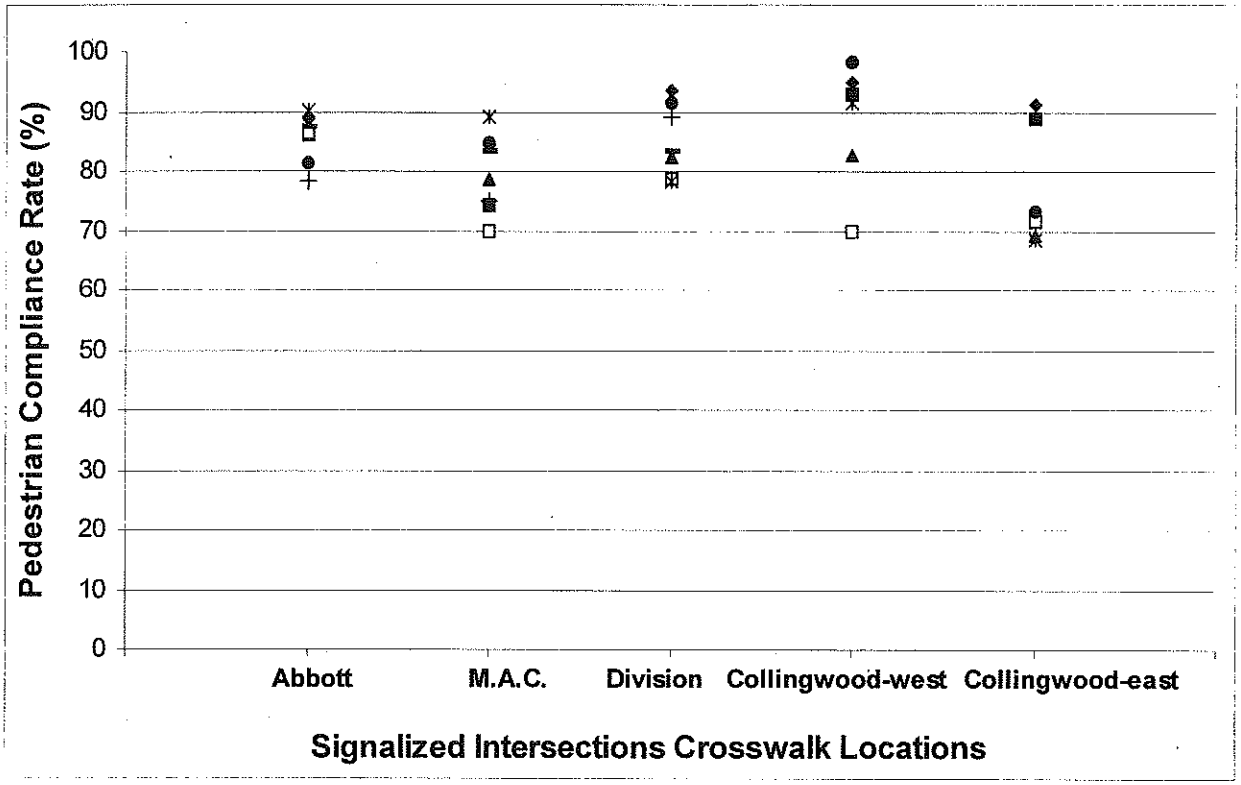

Figure 1.13. Pedestrian compliance rates of all signalized intersection crosswalks- All data collection sessions (compliance to location only)

Descriptive statistics of pedestrian compliance rates at all study signalized intersection crosswalks are summarized in Table 1.6. As shown there, the average compliance rate at study section 2 is 0.75% higher than that at study Section 1. The *T*-

value and the significance level obtained are –1.666 and 0.117, respectively. Therefore, the difference is not statistically significant since 0.117 is higher than 0.05 at the confidence level of 95%.

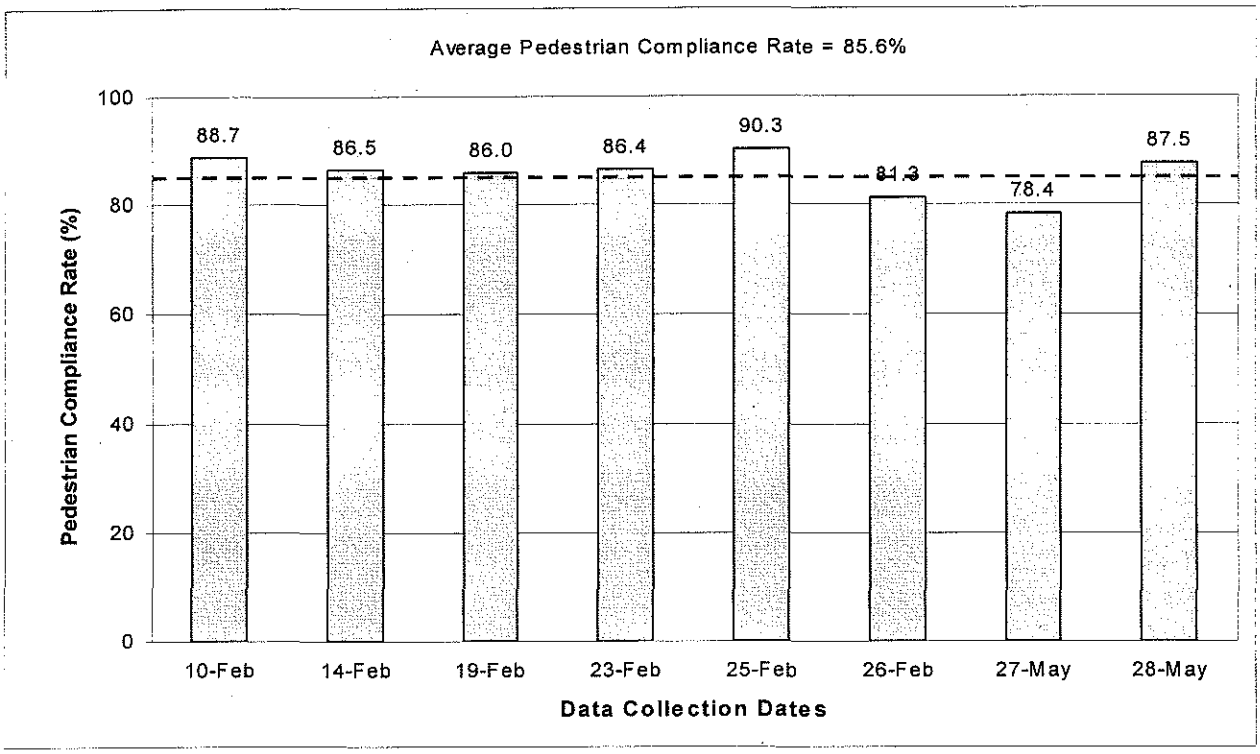

Figure 1.14. Pedestrian compliance rates-Abbott St signalized intersection crosswalk (compliance to location only)

Table 1.6. Descriptive statistics of compliance rates at all signalized intersection crosswalks (compliance to location)

Study Section	Crosswalks	No of sessions	PCR			Std. Deviation	Mean PCR for Sections
			Min	Max	Mean		
1	Abbott	8	78.40	90.30	85.64	3.914	82.78
	M.A.C.	8	69.90	89.10	79.93	6.497	
2	Division	8	78.20	93.60	84.41	6.213	83.40
	Collingwood-west	6	70.00	98.20	88.38	10.380	
	Collingwood-east	6	68.40	91.20	77.07	10.228	
	Total:	36			Overall mean:		83.13

Overall Pedestrian Compliance Rates at Signalized Intersections

Overall pedestrian compliance rates at all signalized intersection crosswalks were also estimated using Equation 1.3. Such rates give useful information about the overall compliance of pedestrians at signalized intersections with respect to crossing location and signal indication.

As Figure 1.15 shows the overall pedestrian compliance rates at all signalized intersection crosswalks varied from 20.5% and 60.7% with an average of 43.0%. An example of overall pedestrian compliance rate variation at the Collingwood east signalized intersection crosswalk is given in Figure 1.16. Similar graphs for all other signalized intersection crosswalk locations are provided in Appendix F.

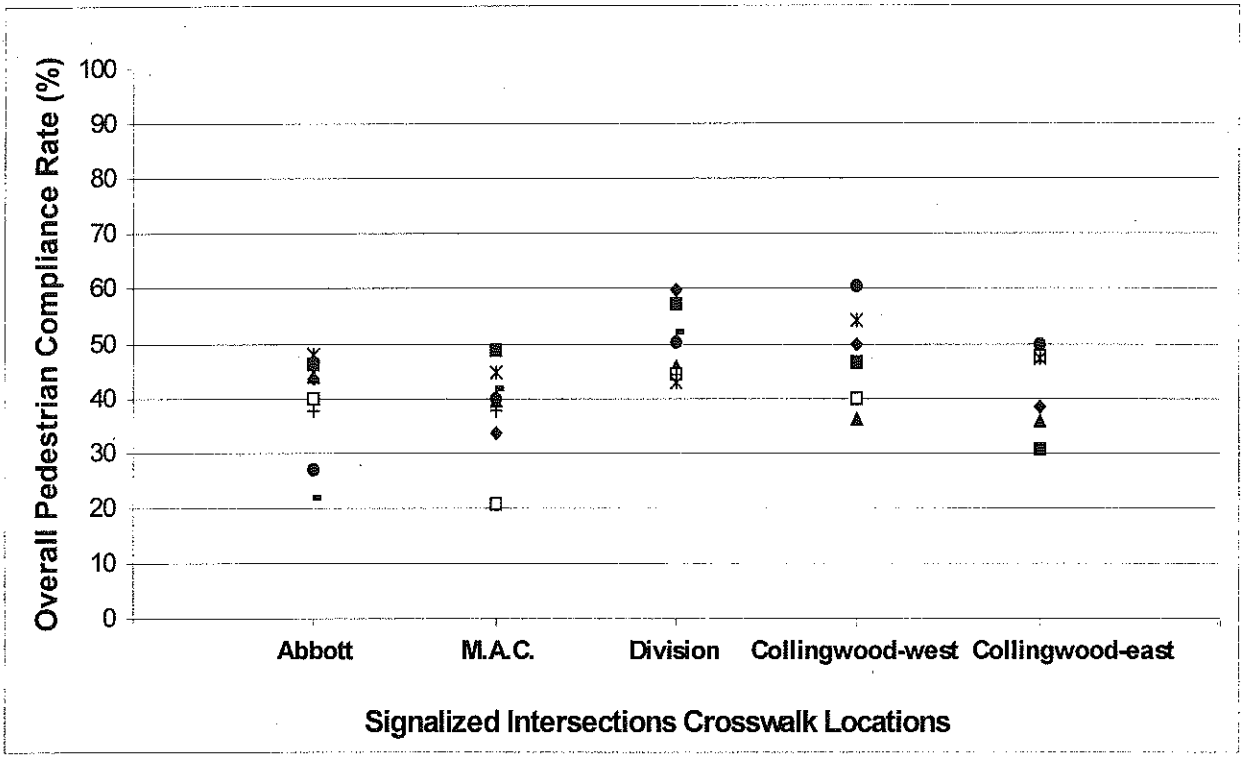

Figure 1.15. Overall pedestrian compliance rates of all signalized intersection crosswalks-All data collection sessions

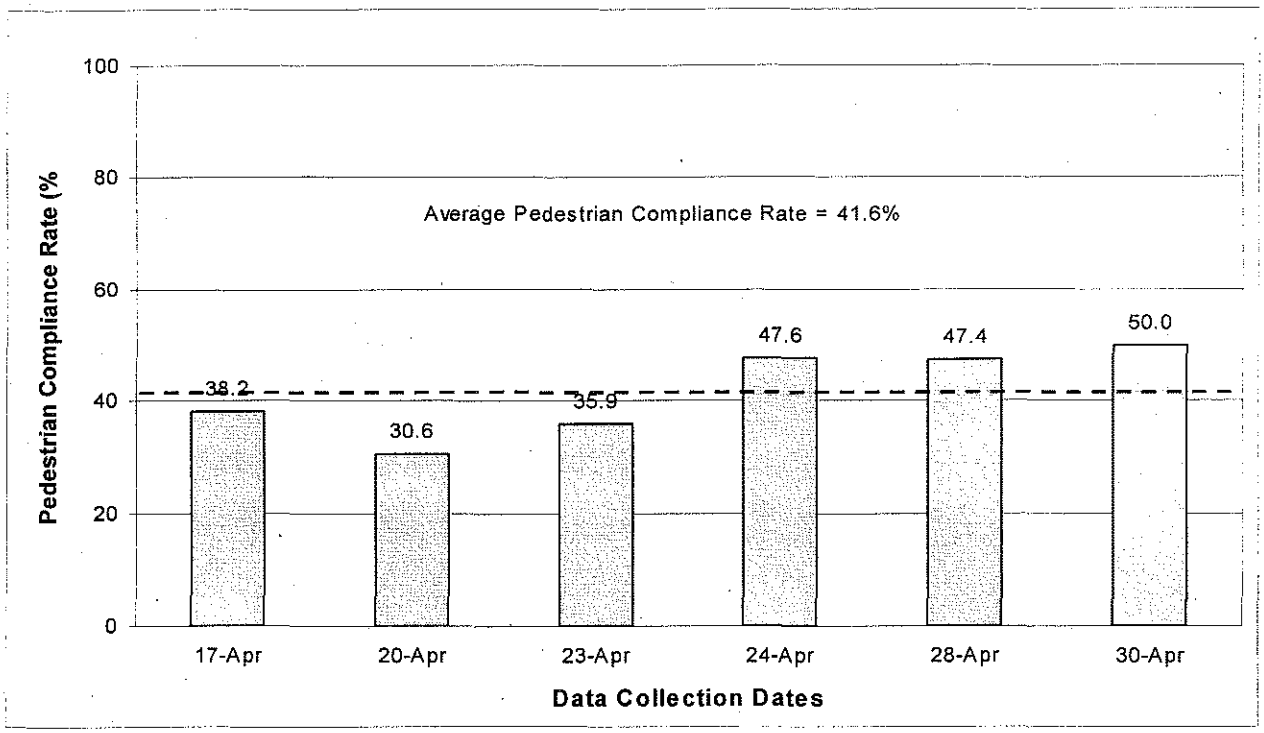

Figure 1.16. Overall pedestrian compliance rates-Collingwood-east signalized intersection crosswalk

Table 1.7 presents descriptive statistics of overall pedestrian compliance rates at signalized intersection crosswalks. According to Table 1.7, the average overall pedestrian compliance rate at study Section 2 is 21.7% higher than the value obtained for study Section 1. A *T*-test was performed to test if the difference between the two sections is statistically significant. The *T*-value and the significance level obtained were -2.993 and 0.009, respectively. Therefore, the difference is statistically significant since 0.009 is smaller than 0.05 at the confidence level of 95%.

The results obtained in this and the previous section were compared. The comparison shows that compliance to crossing location is very high (average value = 83.13%) when a positive type of control is used such as a signal while the overall pedestrian compliance is low with an average value of just 42.98%. In other words, signalized intersections appear to attract pedestrians as crossing points because they are clearly visibile and strategically located. However, they fail to convince the majority of pedestrian users to cross during green pedestrian indication. One possible explanation for this relates to the presence of low vehicular volumes moving in platoons

Table 1.7. Descriptive statistics of pedestrian compliance rates at all signalized intersection crosswalks

Study Section	Crosswalks	No of sessions	PCR			Std. Deviation	Mean PCR for Section
			Min	Max	Mean		
1	Abbott	8	21.90	47.90	38.50	9.324	38.36
	M.A.C.	8	20.50	48.70	38.21	8.462	
2	Division	8	43.20	59.80	49.56	6.322	46.68
	Collingwood-west	6	36.00	60.70	47.90	9.116	
	Collingwood-east	6	30.60	50.00	41.62	7.813	
Total:		30	Overall mean:				42.98

with long gaps between them. These conditions offer pedestrians the motive and the opportunity to cross safely during a pedestrian red indications. Pedestrian non-compliance to the signal indication may also be linked to improper signal phasing designs. An in depth analysis of these issues is beyond the scope of the subject study.

Effect of Markings to Pedestrian Compliance

The effect of crosswalk markings on pedestrian compliance at midblocks was assessed through statistical comparisons between the pedestrian compliance rates at marked and unmarked midblock crosswalks in Section 2.

As Table 1.8 demonstrates, the presence of markings at the crosswalks makes a difference (pedestrian compliance rate of 79.2% at marked versus 64.2% at unmarked midblock crosswalks, or 23.4% higher at marked locations). This observation was confirmed through statistical tests which showed that the difference between the average values of the pedestrian compliance rates at the two types of crosswalks is statistically significant (*t*-value = 7.999, and the significance level = 0.000 <0.05).

Table 1.8. Descriptive statistics of compliance rates at all marked and unmarked midblock crosswalks

Study Section	Crosswalks	No of sessions	PCR			Std. Deviation
			Min	Max	Mean	
2	Marked	12	67.80	90.90	79.23	7.929
	Unmarked	12	58.30	69.00	64.23	3.487
Total:		24				

Effect of Median Shelters to Pedestrian Compliance

The MSU Student Union and Berkeley Hall midblock crosswalks have a shelter located at the median while the other marked midblock crosswalk locations do not. In addition to improvements in aesthetics, such structures may increase the visibility of the midblock crosswalk location for both the drivers and the pedestrians. The effect of shelters on pedestrian compliance to crossing location was evaluated.

The results from the descriptive analysis of pedestrian compliance rates for both types of crosswalks (i.e., with or without shelter) are given in Table 1.9. The difference between the average values of the compliance rates at the two types of crosswalks is not statistically significant (t-value = -0.126, and the significance level = 0.902 > 0.05). Therefore, there is no evidence that shelters have any effect on pedestrian compliance rates and thus their use may be justified only as part of aesthetic improvements to a corridor.

Table 1.9. Descriptive statistics of compliance rates at all midblock crosswalks with and without shelter

Crosswalks	No of sessions	PCR			Std. Deviation
		Min	Max	Mean	
With shelter	14	54.10	81.60	70.99	8.383
Without shelter	14	44.80	90.90	71.39	13.557
Total:	28				

Effect of Pedestrian Signal Presence on Pedestrian Compliance

The effect of the existence of pedestrian signal at the intersection crosswalks was also studied. The signalized intersection crosswalks include Abbott and M.A.C. in Section 1 and Division and Collingwood in Section 2. The unsignalized intersection crosswalks are Charles and Orchard in Sections 1 and 2 respectively.

The descriptive analysis of pedestrian compliance rates for both types of crosswalks are given in Table 1.10. The difference between the average values of the compliance rates at the two types of crosswalks is statistically significant (*t*-value = 8.744, and the significance level = 0.000 < 0.05). Therefore, the existence of pedestrian signal has a significant effect on the pedestrian compliance rates at intersection crosswalks.

Table 1.10. Descriptive statistics of compliance rates at all signalized and unsignalized intersection crosswalks

Crosswalks	No of sessions	PCR			Std. Deviation
		Min	Max	Mean	
Signalized	36	68.40	98.20	83.13	8.047
Unsignalized	14	55.60	78.00	67.45	6.318
Total:	50				

Table 1.11 summarizes the results from the analysis of pedestrian compliance at crosswalk crossings along the Grand River Avenue.

SUMMARY AND CONCLUSIONS

In Part A of Chapter 1, the effectiveness of various crossing options was assessed through the study of pedestrian crossing activity along the corridor. Comparisons were performed on the basis of pedestrian compliance. The main conclusions from this analysis are as follows:

- Positive type of control affects pedestrian compliance to the crossing location. The highest pedestrian compliance rates were observed at signalized intersection

Table 1.11. Descriptive statistics of pedestrian compliance rates

Pedestrian Compliance Rates, PCR_L (based on compliance crossing location)					
Crosswalks	No of Sessions	Mean PCR	Std. Error	Std. Dev.	95% Conf. Interval
Marked midblock	28	71.19	2.091	11.062	66.896 – 75.475
Unmarked midblock	12	64.23	1.007	3.487	62.009 – 66.441
Unsignalized	14	67.45	1.721	6.438	63.733 – 71.167
Signalized	36	83.13	1.341	8.047	80.402 – 85.848
Pedestrian Compliance Rates, PCR_{LT} (based on compliance to crossing location and signal indication)					
Signalized	36	42.98	1.532	9.190	39.871 – 46.090

crosswalks (average PCR = 83.13%), followed by marked midblock crosswalks (71.19%), and unsignalized intersection crosswalks (67.45%). Unmarked midblock crosswalks registered the lowest pedestrian compliance rate of 64.23%.

- Pedestrian compliance to the crossing location was greater at midblock crosswalks than unsignalized intersections. Thus marked midblock crosswalks should be used with confidence, where warranted, since a large majority of pedestrians appear to recognize them and use them properly.
- While markings and signals increase pedestrian compliance to crossing location, shelters on the median have no effect on compliance. Therefore, the use of shelters as means to increase pedestrian crossing safety is not warranted.

- Overall pedestrian compliance rate at signalized intersections (when compliance to crossing location and signal indication are considered simultaneously) is low (with an average value of only 42.98%). This indicates that the majority of pedestrians crossing at signalized intesections disobey the pedestrian signal indication. Signal phasing plans at each signalized intersection and signal progression along the corridor may need to be properly adjusted to ensure pedestrian safety and encourage pedestrian compliance to the pedestrian signal indication.

Part B: STUDY OF PEDESTRIAN PERCEPTIONS

The main focus of this part of the study is the analysis of users' perceptions toward various pedestrian treatments, including signalized and unsignalized intersection crosswalks, midblock crosswalks, physical barriers and more. Crossing preferences and habits of pedestrians were also studied to determine current practices and explain the reasoning behind their choices.

Users' perceptions should be taken into account when the operation of pedestrian facilities is evaluated. Pedestrians should be offered the opportunity to identify treatments that create a safe and/or desirable crossing environment and options that increase their likelihood to use pedestrian designated facilities properly. The latter is crucial toward the improvement of pedestrian safety. When pedestrians use sidewalks and cross at designated locations, the separation of pedestrians and vehicles increases and vehicle/pedestrian conflicts are minimized.

LITERATURE REVIEW

Although considerable research has been undertaken on the general problem of pedestrian safety, limited studies on pedestrians' perceptions and preferences are reported in the literature. Among them, the research of Tanaboriboon and Jing (1) studied attitudes of pedestrians in China toward sufficiency of crossing facilities and willingness to use the facilities. The study compared signalized intersection pedestrian crossings to overpass and underpass crossings and concluded that users prefer signalized crossings than overpass or underpass crossings.

Rouphail (2) performed a user compliance and preference study on marked midblock crosswalks in downtown Columbus. The preference study indicated that users perceive the unsignalized marked midblock crosswalk to be unsafe. However, the same crosswalks are rated highest in crossing convenience.

The studies described above give valuable information about pedestrian perceptions but focus on one type of crossing at a time (signalized intersection crossings only in (1) and marked midblock crosswalks in (2)). Thus a need has been identified to assess the effectiveness of a variety of common types of pedestrian

treatments based on users' perceptions and crossing preferences. The procedure followed for data collection and analysis and the results obtained are discussed in the following sections.

STUDY PROCEDURES

Survey Design

Two important considerations were needed in order to conduct the survey of users (3):

a. development of a survey instrument; and
b. selection of an appropriate study group.

The development of the survey instrument met the following criteria:

- statement of study purpose and importance of participation;
- clear definition of questions;
- reasonable length;
- lack of personal or potentially offensive questions;
- format appropriate for distribution via E-mail; and
- format appropriate for easy data coding.

The questions contained in the questionnaire covered the following areas of interest:

a. users' profile (age group, gender, and frequency of use of the facility);
b. users' crossing patterns (crossing location, conditions, compliance);
c. factors that affect pedestrian crossing choices (presence of certain types of control, user priorities); and
d. users' perceptions with respect to right-of-way and safety.

The survey questionnaire was pre-tested to identify any unclear questions. The survey form included a total of eight (8) questions with several questions soliciting more than one answer. The questionnaire took approximately 2-3 minutes to complete by pedestrians.

The selection of the study group took under consideration the following criteria:

- familiarity with the study site;
- actual use of the site for pedestrian trips;

- reasonable mix of socioeconomic characteristics (such as age, sex, race, income), and
- willingness to participate.

The selected study group consisted primarily of undergraduate and graduate students, staff and faculty at Michigan State University, which compose the majority of pedestrian population using the facility. First, in vivo surveys were conducted from survey staff that randomly approached pedestrians at the site location. 52 pedestrians were approached and asked for their assistance in completing the survey, 22 out of which agreed to participate. Although the acceptance rate was good (42.3%) this data collection approach was found to be time consuming and costly. Thus a decision was made to distribute the survey instrument electronically instead.

The survey was distributed to e-mail recipients selected randomly via the MSU computer network. The selection was made by assigning a serial number to each and every one of the e-mail addresses in the computer network (50,000 total). Then 5,000 e-mail addresses were selected for survey distribution using a random number generator. The return rate was 17.1%. Given that the typical return rate of mail in surveys reported in the literature is 5-30% the return rate of the subject survey was deemed acceptable. A total of 897 completed questionnaires were received and reviewed.

Data Reduction

Returned questionnaires were first screened to assess their completeness and ensure their uniqueness. During this process, duplicate copies and forms with several unanswered questions were eliminated. Eligible questionnaires were assigned a serial number. This allowed for future tracking of selected surveys to check for coding errors.

After eliminating duplicate and incomplete survey forms a total of 871 questionnaires remained. A decision was made to analyze responses from daily and occasional users only. Another 166 questionnaires were excluded from the study because they expressed opinions of non-users and, thus, could introduce some bias to the results. A total of 711 questionnaires were used in the analysis. The sample size was deemed adequate to provide a fairly accurate picture of the users' crossing habits, observations and perceptions toward the pedestrian facilities in the test site.

The Statistical Package for the Social Sciences (SPSS) program was used to create a file containing the responses from each questionnaire. This package has the capability to perform statistical analysis as well as produce graphs and data summaries. Each survey was coded to a single raw and a serial number was assigned in order to track it later, if necessary. There were 22 fields per questionnaire and 45 sec to 1 min per survey were required to complete a typical data entry. The full survey is shown in Figure 1.17. The next section summarizes the results from the data analysis.

ANALYSIS OF SURVEY RESULTS

Out of the 711 pedestrians studied, 255 (36%) pedestrians used the study site "daily" and the rest (456 pedestrians, or 64%) was classified as "occasional users." The percentage of respondents 21 years or younger was 32.7%, between 21 and 55 years of age was 61.6%, and the remaining 5.7% was over 55 years of age. The fairly normal age distribution is an indication of a representative and properly diverse sample population. Given the fact that the study population primarily belongs to a university community, age distribution may be closely related to other socioeconomic factors such as occupation and income.

Users' Crossing Patterns

The location at which pedestrians select to cross a road, the conditions under which they decide to cross and their compliance with pedestrian traffic control are important factors both from safety and operation perspectives.

As Figure 1.18 shows, the majority of pedestrians surveyed (59%) said that they typically cross at designated locations (24% at signalized crosswalks, 31% at unsignalized and midblock crosswalks, and 4% at crosswalks of any type). The remaining 41% replied that they typically cross at any convenient location.

Figure 1.19 depicts typical crossing conditions for respondents. 61 percent of the respondents admitted to cross when they perceive that an acceptable gap in vehicle traffic exists. On the other hand, 35% said they cross only when all traffic has cleared

Figure 1.17. Grand River Avenue Pedestrian Survey

1. How often do you cross on Grand River Ave between Abbot and Bogue St. on foot? (Please mark your answer by X).
____ 1. Daily ____ 2. Occasionally ____ 3. Almost never

2. Where do you typically cross on Grand River Ave?
____ 1- on designated signalized crosswalks
____ 2- on designated midblock and unsignalized crosswalks
____ 3- at any convenient location

3. When do you typically cross on Grand River Ave?
____ 1- only when pedestrian traffic light is green
____ 2- when traffic clears completely
____ 3- whenever I feel that I can cross with little interference with automobile traffic

4. How often do you cross at a non-designated crosswalk?
____ 1- never ____ 2- rarely ____ 3- sometimes ____ 4- often ____ 5- almost always

5. If you choose to cross at a non-designated crosswalk, what is the main reason?
____ 1- convenience ____ 2- to save time ____ 3- traffic is light, there is no risk

6. In you opinion, when should vehicles yield to pedestrians?
____ 1- always ____ 2- at designated crosswalks ____ 3- never, vehicles should have priority

7. Are the following statements true for Grand River Ave.?

1	2	
Y__	N__	a- motorists typically yield to pedestrians at designated crosswalks
Y__	N__	b- left-turning vehicles typically yield to pedestrians during pedestrian green
Y__	N__	c- pedestrians typically cross at designated locations
Y__	N__	d- bicycles do not pose a safety risk to pedestrians at designated crosswalks

8. Do the following influence your decision to cross at a certain location?

1	2	
Y__	N__	1- existence of pedestrian signal
Y__	N__	2- presence of a midblock crosswalk
Y__	N__	3- red color brick pavement
Y__	N__	4- shelter over a midblock crosswalk
Y__	N__	5- "cross only when traffic clears" sign
Y__	N__	6- presence of other pedestrians that attempt to cross
Y__	N__	7- distance to the desired location
Y__	N__	8- vegetation or barriers on median

9. How often are you willing to divert from your path in order to cross at a designated crosswalk?
____ 1- always ____ 2- often ____ 3- sometimes ____ 4- rarely ____ 5- never

10. What is your age group?
____ 1- less than 21 yrs ____ 2- 22-55 yrs ____ 3-over 55 yrs

11. What is your gender?
____ 1- male ____ 2- female

12. Do you perceive Grand River Ave between Abbott and Bogue St as a safe corridor for pedestrians?
____ 1- Yes ____ 2- No

13. If your answer in Q. 12 is No, what is the major problem from your point of view?

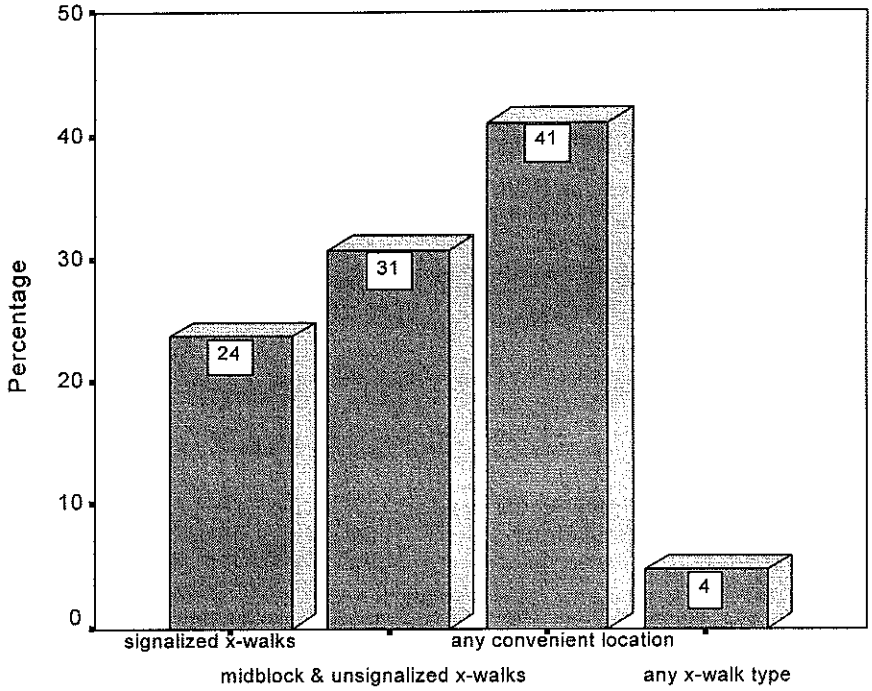

Figure 1.18. Typical pedestrian crossing locations

completely, and a mere 4% was willing to wait for a green pedestrian light indication in order to cross.

Pedestrians were also asked about the frequency of crossing at non-designated locations. Figure 1.20 summarizes the responses obtained. A 29% of the users replied that they rarely (or never) cross at a non-designated crosswalk. Approximately a quarter of the respondents said that they often or almost always jaywalk. 46% of the respondents appeared not having a predetermined crossing preference on the use of designated facilities in order to cross. These results are in reasonable agreement with the responses regarding preferred crossing location presented above and the users' willingness to divert from their path in order to cross at a designated location. A 38% of users replied that are willing to divert, 20% refused to do so, and 42% said that they would sometimes divert from their path in order to use a crosswalk.

It is also interesting to note that occasional users appear to be more conservative in their crossing choices. For example, only 18% of occasional users admit to cross frequently at non-designated locations compared to 34% of daily users. This leads to the conclusion that when pedestrian facilities are designed for primary use by commuters more intensive efforts should be made in order to discourage pedestrians

from crossing at non-designated location. Such behavior may pose a risk for the personal safety of pedestrians and create undesirable disruptions of traffic flow.

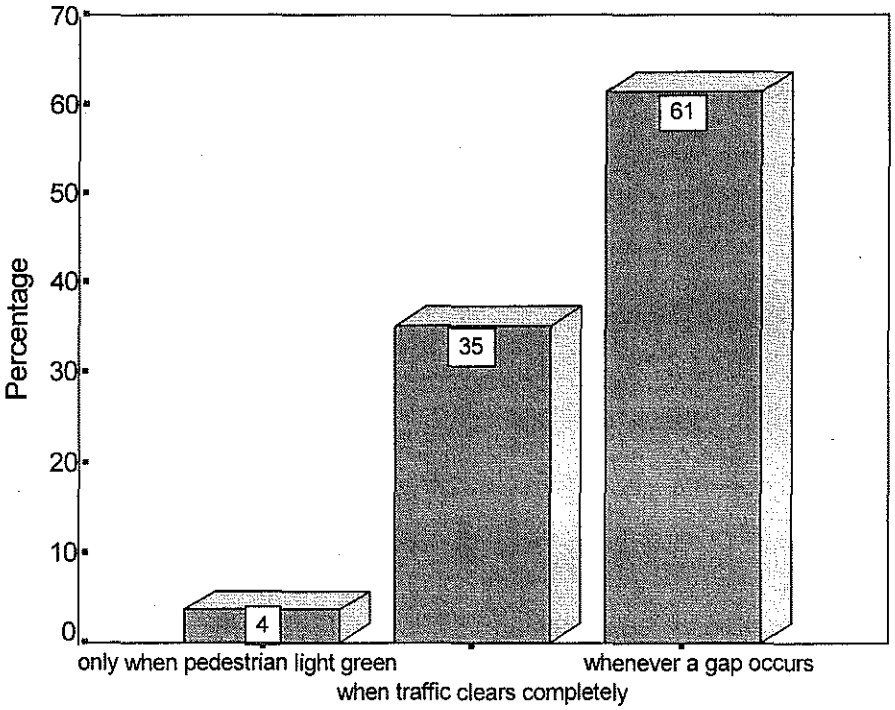

Figure 1.19. Typical pedestrian crossing conditions

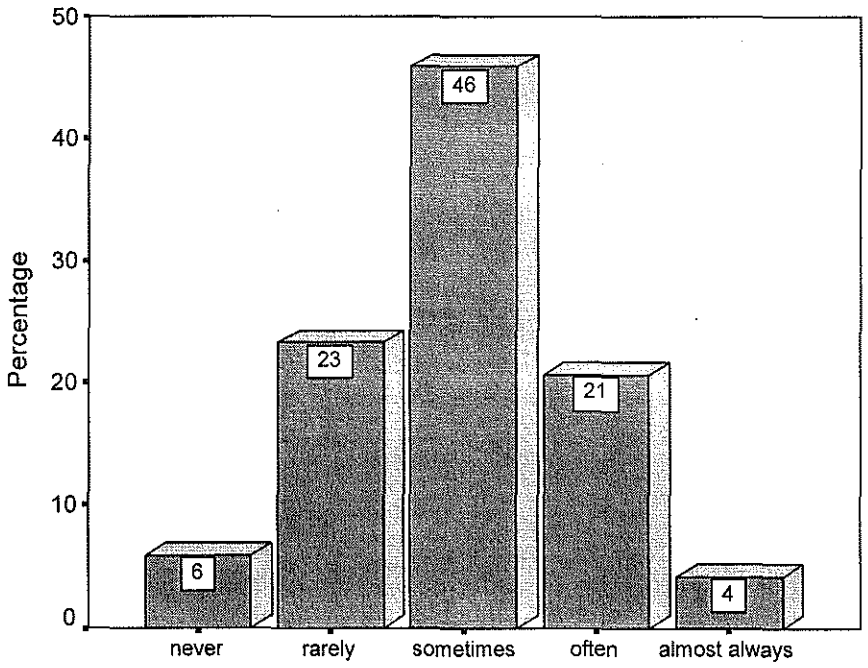

Figure 1.20. Frequency of crossing at a non-designated crosswalk

Assessment of Factors Affecting Pedestrian Crossing Choices

Pedestrians were asked to state the main reason based on which they make a decision to cross at a non-designated crosswalk location. The answers to this question were indented to assess the users' priorities. Convenience is the number one priority sited by users (42%) while time savings was of major importance to 27% of the respondents. Interestingly enough, 30% responded that they do not perceive any major risk crossing the facility at any convenient location since traffic is light enough to allow for safe crossing. These results are summarized in Figure 1.21.

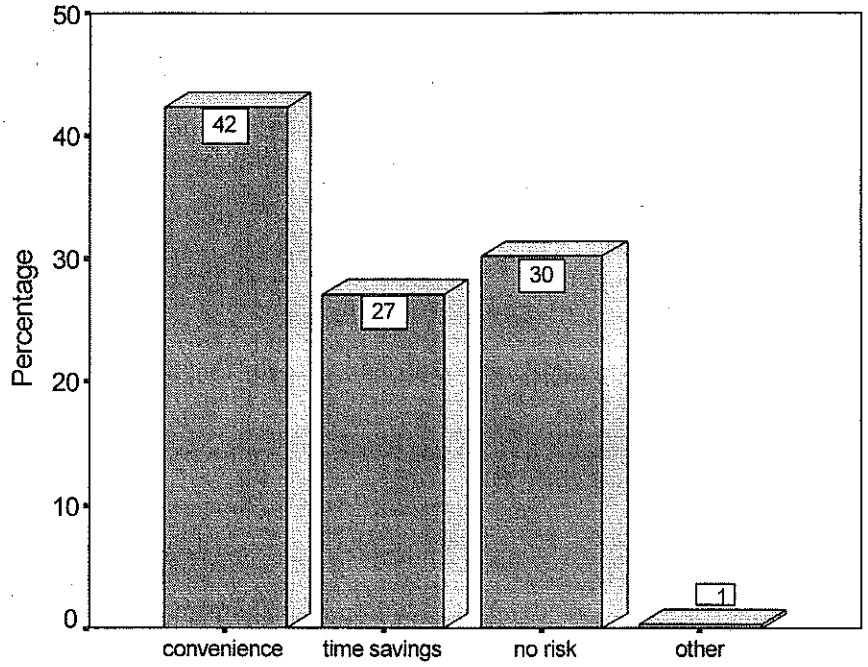

Figure 1.21. Main reasons to cross at a non-designated crosswalk

The effect of the presence of certain types of control on the decision of pedestrians to use pedestrian facilities properly (or not) is of major importance to traffic engineers in designing such facilities. Thus, the subjects were asked a series of yes-or-no questions about treatments that influence their decision to cross at a certain location. Such treatments included existence of pedestrian signal, presence of midblock crosswalk, red color brick pavement or shelter on the median at midblock crosswalk

locations, vegetation or barriers on the median, and the location of the crosswalk relative to the desired destination.

The results indicate that the distance of the crosswalk to a desired destination is a major crossing choice determinant for the vast majority of pedestrians surveyed (90% of total), as is the presence of a midblock crosswalk and/or a pedestrian traffic light for 83% and 74% of survey respondents respectively (Figures 1.22 to 1.24). Vegetation and barriers influenced the decision to cross of a relatively significant number of pedestrians surveyed (65%). On the other hand, respondents had mixed opinions about shelters and red brick paving. Only 35% said that shelters positioned in the median influenced their decision to cross and 58% favored colored paving. Overall, these types of treatments may help pedestrians locate a crosswalk but appear not to have an important influence on their decision to cross at a certain location.

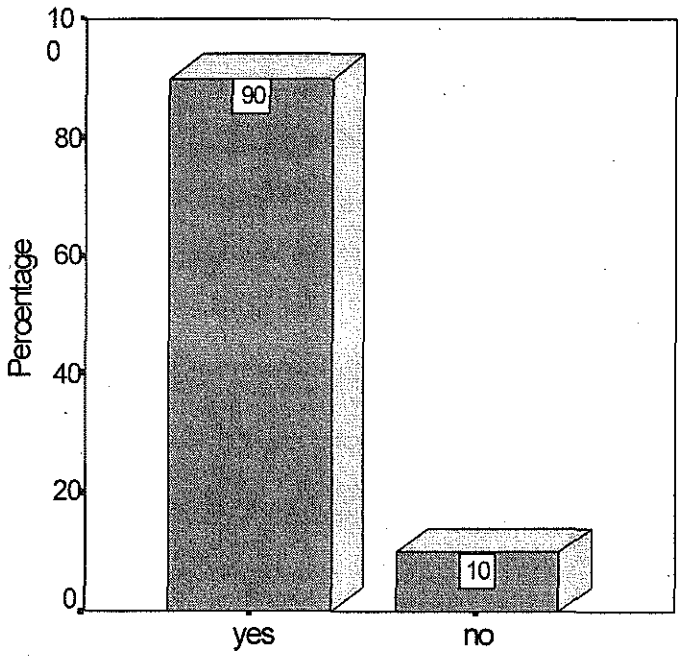

Figure 1.22. Distance to a desired location influences pedestrians' decision to cross at a certain location

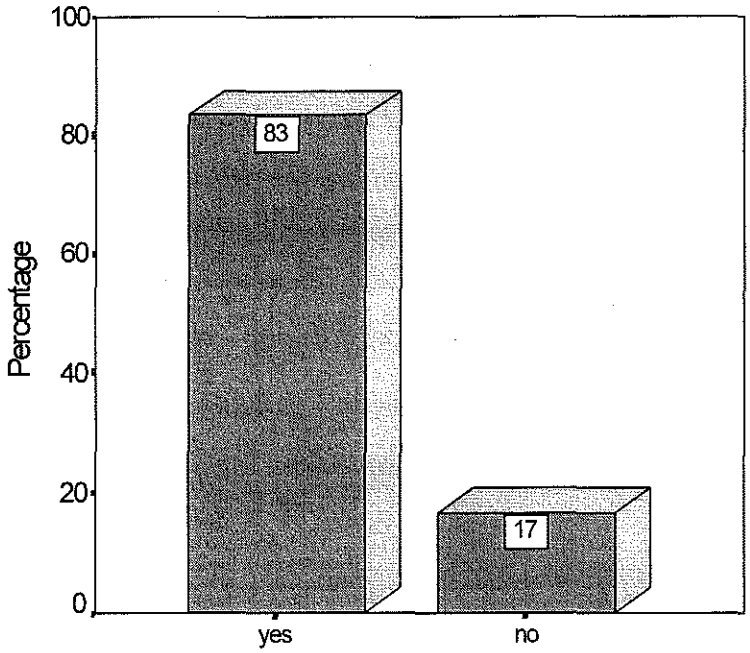

Figure 1.23. Presence of a midblock crosswalk influences pedestrians' decision to cross at a certain location

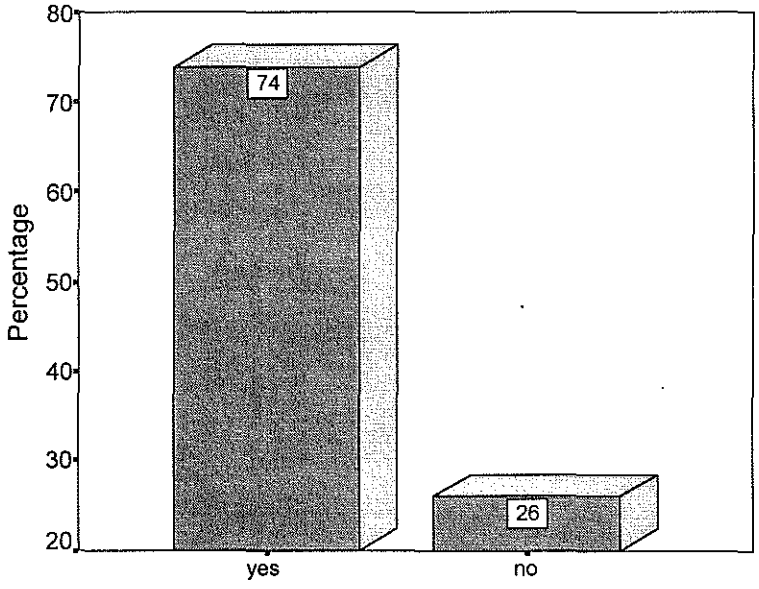

Figure 1.24. Existence of a pedestrian signal influences pedestrians' decision to cross at a certain location

Furthermore, statistical tests were performed to study if there is any significant difference between responses obtained from responders in different age groups or gender classification. The results from the analysis are summarized in Table 1.12. In summary, it was found that differences in the responses obtained by age classification and gender are not statistically significant at the 95% confidence level. Thus the use of aggregate results appears appropriate. The only exception occurred to the question about the effect of the distance to the desired location on the decision of an individual to cross. 92% and 90% of respondents in the age group below 21 and between 21 and 55 years of age responded positively, while 74% of elderly gave a positive response to this question. The analysis indicated that the response of elderly pedestrians to this

Table 1.12. Effect of age and gender on survey responses

Most influential factors	Age Group			Gender		
	Chi-square	Significance level	Comment (95% CL)*	Chi-square	Significance level	Comment (95% CL)*
Distance to destination	10.780	0.005	0.005<0.05 differences statistically significant	0.892	0.345	0.345>0.05 differences statistically not significant
Midblock crosswalk presence	4.550	0.103	0.103>0.05 differences statistically not significant	0.433	0.510	0.510>0.05 differences statistically not significant
Pedestrian signal presence	1.223	0.542	0.542>0.05 differences statistically not significant	1.799	0.180	0.180>0.05 differences statistically not significant

*: Confidence Level

question was statistically different from the other two study groups at the 95th confidence level (significance level 0.005<0.05).

Pedestrians' perceptions were cross-checked using actual pedestrian movement data that were collected in the field prior and during the time the survey was distributed to potential respondents. These data were presented and analyzed earlier (see Part A).

Several conclusions can be drawn from the comparison of survey and movement analysis results. First, there is a relatively good agreement between the responses of users and their actual behavior in terms of their crossing choices. This observation is very encouraging because it shows that the survey analysis results can be trusted and that respondents, in general, answered the questions honestly and in good faith.

Second, both survey and movement data indicated that signalized intersections and marked midblock crosswalks are very effective in directing pedestrians to cross at designated locations. However, a large number of pedestrians who select to cross at signalized crosswalks tend to disobey the pedestrian signal indication in an effort to decrease their delay. A detailed analysis of pedestrian delay at signalized intersections is an interesting subject to be studied in the future.

Finally, with respect to the distance between the crosswalk location and the desired destination, it is clear that traffic engineers should pay extra attention to land uses that may generate increased needs for pedestrian movement and consider these needs when making decisions on placement of pedestrian crosswalks at certain locations.

Users' Perceptions with Respect to Right-of-Way and Safety

A number of questions were asked in order to assess the perceived level of safety and users opinions regarding right-of-way. It was found that a 45% of pedestrians using the study site believe that drivers typically yield to pedestrians in designated locations, especially at midblock crossings when stopped queues could otherwise occupy the crosswalk.

It should be noted that, except from the pavement markings, motorists do not see any positive type of control indicating that pedestrians should be offered priority. Interestingly, when they were asked, "when should motorists yield to pedestrians?", the majority (61%) of respondents answered that this should happen only at designated crosswalks. 31% felt that pedestrians should always have priority over motorized traffic,

and 7% responded that vehicles should always receive the right-of-way. Pedestrian replies show that the majority of users understand the purpose of streets with mixed traffic and are willing to compromise in order to help create a fair and safe travel environment for all users.

With respect to turning vehicular traffic, half of the respondents complained that turning vehicles do not respect pedestrians that attempt to cross at signalized intersections during green. This has been, also, verified by field observations. In most cases pedestrians and right- or left-turning vehicles share the same green phase with pedestrians. This situation is cited as a reason for pedestrians choosing to cross the road at locations other than signalized intersection crosswalks during green. This is an important finding that demonstrates the important role of proper signal timing settings toward the improvement of safety and efficiency.

Moreover, only 35% of the users said that a pedestrian sign displaying the message "Cross only when traffic clears" made a difference in their decision to cross. Analysis of respondents' comments further indicates that this sign often confused or frustrated pedestrians that have selected to cross at a designated crosswalk under the impression that they can have the right-of-way.

As pedestrians often compete with bicycles for the same space, the subjects were also asked to provide their input regarding safety issues that may result from this type of interaction. 59% of the users were not concerned with the interaction between pedestrians and bicycles and did not perceive bicycles as a safety risk factor to pedestrians that cross at designated locations.

Finally, over two thirds of the respondents (68%) agreed that the study site is a safe corridor for pedestrians to use. This response is a sign of approval of the facility for pedestrian use and an indication that pedestrians appreciated the recent improvements along the study corridor and enjoy using it for short trips.

SUMMARY AND CONCLUSIONS

Part B of Chapter 1 describes the procedure used to obtain information on pedestrian users' habits and perception, and summarizes the results from the survey analysis. The analysis of questionnaire surveys provided important insight on attitudes and preferences of pedestrians using the study site. The following conclusions can be drawn:

- Properly marked pedestrian facilities encourage users to cross at a certain location. More specifically, marked midblock crosswalk is found to be a very influential pedestrian facility. This is also supported by actual movement data analysis.
- Signalized intersections with crosswalks help channelize pedestrian traffic; however, prove to be unable to persuade pedestrians to comply with the signal indication, particularly under low traffic demand conditions. Both the actual movement and the survey data support this conclusion.
- The most influential factor cited by pedestrians in making a decision to cross at a designated location is the distance of the crosswalk to the desired destination. Also, added convenience was rated as the number one factor for jaywalking. These results indicate that proper selection of the position of a crosswalk with respect to land uses that generate or attract pedestrian traffic has the potential to improve the rate of pedestrian compliance significantly.
- Pedestrians disapproved of the use of the pedestrian warning sign at midblock crosswalks, as they believed it conveyed a confusing message. Although such signs may not be popular among pedestrians they often have a safety value while used as means of positive enforcement. Additional crash and conflict analysis is recommended to clearly assess the value of these signs and provide warrants for their use.
- The vast majority of turning vehicles fail to give priority to pedestrians during the pedestrian green phase. This increases the chances that pedestrians will not select to cross at signalized crosswalks during green, if they have a crossing alternative that reduces their delays and provides safer crossing conditions. To improve the situation, leading pedestrian intervals may need to be considered when significant turning vehicular and/or pedestrian crossing volumes exist. Leading pedestrian

intervals are expected to assist in reducing the number of conflicting movements with a potential to improve safety as well as pedestrian crossing compliance. Significant enhancement of pedestrian traffic flow may be possible through signal coordination (4).

- Careful design of signal phasing plans and proper installation of signs can greatly help to improve travel conditions for pedestrians and turning motorists alike. Furthermore, it is recommended that additional surveys be conducted to examine differences between drivers and pedestrians regarding right of way at intersections.
- It should be noted that although user preferences are important, they might not correlate highly with safety considerations. It is recommended that additional analysis be performed to examine the relationship between safety and pedestrian acceptance in future research.

Chapter 2

MEASUREMENT, ESTIMATION, AND APPLICATIONS OF PEDESTRIAN CROSSING TIMES AT SIGNALIZED INTERSECTIONS

Pedestrian crossing times are used in the determination of pedestrian level of service (LOS) of signalized intersection crosswalks. The main measure of effectiveness used in the U.S. to define pedestrian level of service at signalized crosswalks is the average pedestrian space (5). This is a function of pedestrian crossing time and other parameters including crosswalk width, pedestrian crossing length, pedestrian volumes, length of pedestrian green signal indication, and behavioral characteristics. Moreover, pedestrian crossing times can assist in proper selection of pedestrian signal timing settings.

A variety of methodologies have been developed for determining pedestrian crossing times at signalized intersections. As described in objective 2 of this study, a need has been identified to validate such methodologies with field data and discuss their strengths and limitations for application.

First, a review of existing methodologies is offered. Then, field data collected on Grand River Ave (M-43) between Abbott and Bogue St. are used to validate these methodologies under off-peak and peak vehicle traffic conditions. Statistical tests are performed to test the performance of each study methodology. Summary results are presented and interpreted, along with recommendations for model improvements. Finally, measured pedestrian crossing times are used to evaluate operations at study intersections with respect to pedestrian LOS and proper pedestrian signal timing setting.

LEVEL OF SERVICE AT SIGNALIZED CROSSWALKS

The "Pedestrians" Chapter of the 1994 Highway Capacity Manual (Chapter 13) uses the average space per pedestrian criterion for pedestrian crosswalk level of service estimation (5). The average space per pedestrian, M_c, is defined as

$$M_c = TS/(V * T) \quad \text{.....Eq.2.1}$$

where

M_c = average space per pedestrian (m^2/ped);

TS = crosswalk time-space available to pedestrians during one cycle length (m^2-sec/cycle);

V = total incoming and outgoing pedestrians volume (ped/cycle), and

T = pedestrian crossing time (sec).

The crosswalk time-space, TS, available to pedestrians is calculated as

$$TS = W * L * G \quad \text{.....Eq.2.2}$$

where

W = crosswalk width (m),

L = pedestrian crossing distance (m),

G= walk interval (sec), and other variables as previously defined.

The walk interval, G, is typically the sum of the pedestrian green and flashing red intervals reduced by 3 sec to account for start up delays due to pedestrian perception-reaction. A two-dimensional time-space diagram illustrating the approach described above is shown in Figure 2.1.

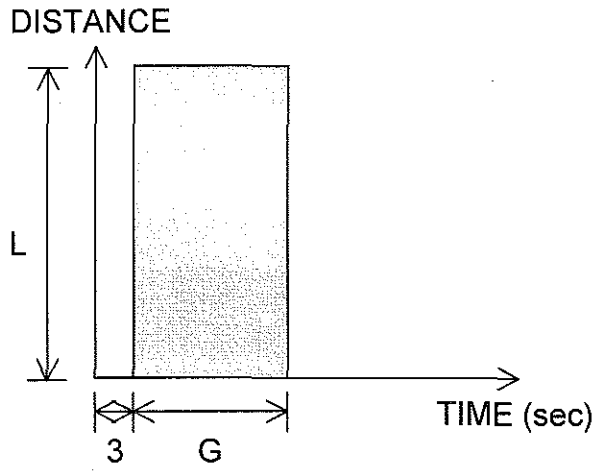

Figure 2.1. Time-space diagram for HCM approach (6)

If pedestrian crossing volumes and the required pedestrian crossing time are known, then the crosswalk level of service can be determined. In the following, methodologies for estimating the required pedestrian crossing time are reviewed and evaluated.

PEDESTRIAN CROSSING TIMES-REVIEW OF EXISTING METHODOLOGIES

1994 Highway Capacity Manual Models

Literature review indicates that the 1994 U.S. Highway Capacity Manual (HCM) utilizes two formulas to calculate pedestrian crossing times. Chapter 13 of the 1994 HCM is devoted to pedestrian issues and proposes Equation 2.3 for pedestrian crossing time, *T*, calculation at signalized crosswalks (5):

$$T = L/u \quad \text{.....Eq.2.3}$$

where

T = pedestrian crossing time (sec),

L = pedestrian crossing distance (m), and

u = pedestrian crossing speed (proposed default value=1.37 m/sec or 4.5 ft/sec).

On the other hand, Chapter 9 of the 1994 HCM (which analyzes signalized intersections) defines the minimum crossing time for meeting pedestrian requirements, *T*, as (5):

$$T = D + (L/u) \quad \text{.....Eq.2.4}$$

where

T = pedestrian crossing time (sec),

D = pedestrian initial start-up delay (sec),

L = pedestrian crossing distance (m), and

u = pedestrian crossing speed (proposed default value=1.22 m/sec or 4.0 ft/sec).

Figure 2.2 shows a time-space diagram for a single pedestrian crossing movement based on the formulation presented in Equation 2.4.

There are two differences between the two formulations proposed in the 1994 HCM for crossing time estimation. First, pedestrian initial start-up delay is ignored in Chapter 13 but accounted for in Chapter 9 and second, the definition of pedestrian crossing speed used differs from one methodology to the other.

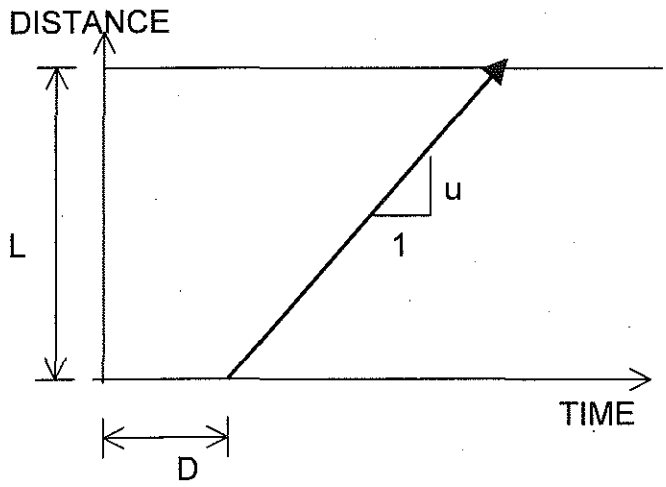

Figure 2.2. Time-space diagram for a single pedestrian (6)

The pedestrian initial start-up delay, *D*, refers to the time it takes the pedestrian to step off curb and enter crosswalk after a pedestrian signal indication becomes green. The proposed default value in Chapter 9 of the 1994 HCM is 7 sec, while Chapter 13 ignores this variable (*D*=0).

Moreover, Chapter 13 uses the average pedestrian walking speed as the recommended pedestrian crossing speed, *u*, with a default value of 1.37 m/sec (4.5 fps). Chapter 9, on the other hand, assumes as pedestrian crossing speed, *u*, the 15^{th}-percentile walking speed of pedestrians with a recommended default value of 1.22 m/sec (4.0 ft/sec). This modification is intended to accommodate crossing pedestrians who walk at speeds lower than the average.

Overall, the formulation offered in Chapter 9 (Equation 2.2) is more conservative than the one used in Chapter 13, while Chapter 9 formula appears to address pedestrian crossing needs in a more realistic manner.

The MUTCD Model

The Manual on Uniform Traffic Control Devices (MUTCD) proposes an equation in a format identical to Equation 2.4, with the exception that the start-up delay, *D*, varies from 4 to 7 sec (7).

The Pignataro Model

Pignataro (8) used a model identical to Equation 2.4, and recommended modifications to the range of values of the pedestrian initial start-up delay, *D*, and the pedestrian crossing speed, *u*. He proposed a *D* value equal to or greater than 5 sec, and *u* values in the range of 1.07 to 1.22 m/sec. The proposed crossing speeds in Pignataro's approach consider crossing needs of users with restricted crossing abilities such as children and the elderly.

Discussion:

All three methodologies presented above model pedestrian crossing time for individual pedestrians without any consideration for pedestrian platoons. As Virkler et.al (6) indicate, the crossing time, *T*, in the above models shall be sufficient if only a small number of pedestrians use the crosswalk during a given phase. However, in the presence of pedestrian platoons, time *D* may not be sufficient for everyone to leave the curb, and the crosswalk may not be cleared of pedestrians in time *T*.

The ITE Model

The Institute of Traffic Engineers (ITE) School Crossing Guideline (9) describes a methodology for pedestrian crossing time calculation that considers platoon presence in one direction. Pedestrian crossing time, *T*, is described as follows:

$$T = D + L/u + 2[(N/5) - 1] \quad \text{.....Eq.2.5}$$

where

N = number of pedestrians in a platoon of pedestrian crossing during an interval, and all other variables as defined above. It is assumed that pedestrians walk in rows, five abreast, with a 2-sec headway between rows. Recommended D and u values in the ITE model are 5 sec and 1.22 m/sec respectively. Figure 2.3 shows the time-space diagram for this model.

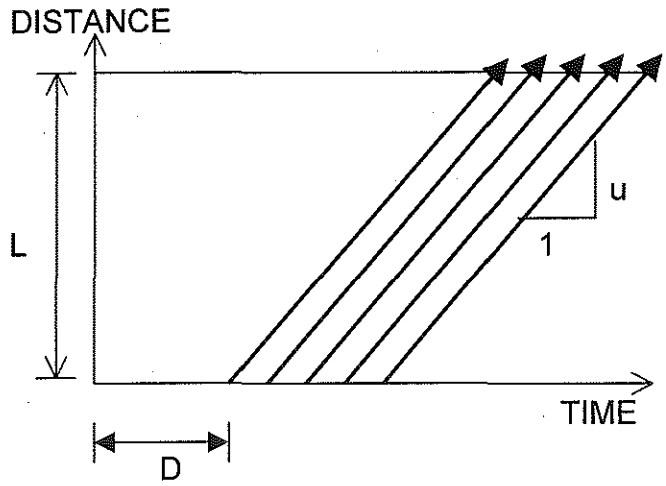

Figure 2.3. Time-space diagram for a one-way platoon (6)

The Virkler and Guell Model

Virkler and Guell (6) generalized the concept proposed in the ITE model. Their model considered also the presence of a one-way platoon and is formulated as follows:

$$T = D + L/u + x(N/W) \quad \text{.....Eq.2.6}$$

where

x = average pedestrian headway (sec/ped/m of crosswalk width), and

W = crosswalk width (m), and all other variables as defined earlier.

Figure 2.3 also applies to this equation. The first term of Equation 2.6 refers to perception-reaction time required by pedestrians to start crossing. The second term represents the time needed by a single pedestrian to cross when moving with speed equal to *u* and the third term is an adjustment to account for platoon presence. A start-up delay of 3 sec with u=1.27 m/sec, and x=2.61 sec/pedestrian/m can be used as default values.

Discussion:

Although Equations 2.5 and 2.6 recognize pedestrian platoon existence and consider platoon size, they both assume that platoons are formed at one crossing direction only. In reality, it is quite common that two opposite-direction platoons are formed which meet in the crosswalk during time *T*. If platoon sizes are relatively large, and/or the crosswalk width (*W*) is small then conflicts between the two platoons are expected which will result in an increase of pedestrian crossing time, *T*.

Last but not least, none of the methodologies currently in existence accounts for the effects of turning vehicles during the pedestrian crossing phase. Improved methodologies need to be developed to address such issues in the future.

VALIDATION OF EXISTING METHODOLOGIES

Description of Field Data

Field data were collected on all five signalized intersection crosswalks in the study site. These include geometric characteristics of signalized intersection crosswalks, pedestrian movement data, and signal timings.

Table 2.1 summarizes descriptive characteristics of the study crosswalks such as location identification, pedestrian crossing distance, and crosswalk width. Signal timings at all study crosswalks are presented in Table 2.2.

Pedestrian movement data were also collected on a cycle-by-cycle basis including pedestrian volumes and crossing times. Average pedestrian volumes were then obtained by averaging the cycle-by-cycle data obtained over the total number of cycles observed. Average pedestrian volume data under peak- and off-peak vehicle traffic conditions are summarized in Table 2.3.

Table 2.1. Descriptive characteristics of signalized intersection crosswalks

Crosswalks	Crossing Length (m)	Crosswalk Width (m)
Abbott St	35.19	3.43
M.A.C.	27.79	3.25
Division	27.84	2.71
Collingwood-west	31.92	3.20
Collingwood-east	35.89	3.53

Table 2.2. Signal timings at the signalized intersection crosswalks*

Intersections	Pedestrian Green time (sec)	Pedestrian Flashing red (sec)	Pedestrian Solid red (sec)	Cycle length (sec)
Abbott	23	13	54	90 off-peak
	23	13	64	100 am-peak
	23	13	64	100 pm-peak
M.A.C.	21	10	59	90 off-peak
	25	10	65	100 am-peak
	25	10	65	100 pm-peak
Division	20	10	60	90 off-peak
	21	10	59	100 am-peak
	22	10	58	100 pm-peak
Collingwood	23	14	53	90 off-peak
	23	14	63	100 am-peak
	23	14	63	100 pm-peak

*: Data obtained from MDOT Traffic and Safety Section

Table 2.3. Average pedestrian volume data at signalized intersection crosswalks

Crosswalks	Average pedestrian volume per cycle, V (ped/cycle)	
	During peak-vehicular traffic	During off-peak vehicular traffic
Abbott St	4.8	2.6
M.A.C.	2.8	6.4
Division	7.9	15.7
Collingwood-west	1.3	1.5
Collingwood-east	1.6	1.2

Pedestrian crossing times for each signalized intersection were measured on a cycle-by-cycle basis through observation of the behavior of a typical pedestrian crossing at the intersection during the cycle. A typical pedestrian is defined as one that is waiting for the pedestrian green indication at the curbside and starts crossing after the pedestrian signal turns green. Pedestrian crossing time for the typical pedestrian is measured from the instant pedestrian signal turns green to the instant the pedestrian reaches the opposite curbside. Average pedestrian crossing times for each crossing location are obtained by averaging the cycle-by-cycle pedestrian crossing times (over the total number of cycles observed). The summary results are displayed in Table 2.4.

Table 2.4. Average measured pedestrian crossing times at signalized crosswalks

Crosswalks	Average measured pedestrian crossing times, T (sec)		
	During peak vehicular traffic	During off-peak vehicular traffic	Overall
Abbott St	21.2	20.5	21.6
M.A.C.	17.4	18.3	17.5
Division	19.6	19.0	19.2
Collingwood-west	19.9	19.8	19.9
Collingwood-east	23.2	23.6	23.3

Data Analysis Procedure

In this section, the various models proposed for pedestrian crossing time estimation are validated using the measured pedestrian crossing time data presented in Table 2.4.

First, pedestrian crossing times are calculated for each signalized intersection using the five alternative methodologies described in the literature review and characteristics of the intersection crosswalks provided in Table 2.1. Then, the results obtained by each model for each signalized intersection are compared to the measured pedestrian crossing times as shown in Table 2.4. Statistical tests are performed to determine if the two pedestrian crossing time values (predicted and measured) are

statistically the same. Moreover, the results obtained for all intersections when testing the same model are checked for consistency.

Based on the results from the statistical analysis described above, assessment of the effectiveness of a given model to predict pedestrian crossing time accurately becomes possible.

Results

Model Validation

Pedestrian crossing times were calculated for all study intersections for the following proposed methodologies:

- HCM, Chapter 13
- HCM, Chapter 9
- MUTCD Model
- Pignataro Model
- ITE Model, and
- Virkler and Guell Model.

The formulations and assumptions involved in each methodology were presented in detail earlier in this chapter. The Pignataro methodology yields two pedestrian crossing time values, the larger of which refers to pedestrian crossing requirements of elderly pedestrians. The average of the two proposed values was used for comparison purposes.

The ITE and Virkler and Guell models require specification of the maximum pedestrian platoon size, *N* (one-directional platoon). The observed maximum pedestrian platoon sizes on signalized intersection crosswalks varied between 10 and 15 pedestrians. Maximum platoon size of 10 pedestrians was selected for all study intersections with the exception of Division Street where an *N* value of 15 pedestrians deemed more appropriate (due to heavy pedestrian traffic conditions). Default values of u=1.27 m/sec and x=2.61 sec/ped/m of crosswalk width where used in Virkler and Guell model. These values correspond to LOS of B conditions. The results obtained are presented in Table 2.5.

Table 2.5. Validation of methodologies for pedestrian crossing time estimation

Model		Crosswalk	Estimated Pedestrian Crossing Time (sec)	Measured Pedestrian Crossing Time (sec)	Difference (sec)	Difference Statistically Significant ?
HCM	Chp 13	Abbott	26	21.6	4.4	yes
	Chp 9	Abbott	36	21.6	14.4	yes
MUTCD Model		Abbott	36	21.6	14.4	yes
Pignataro Model		Abbott	36 - 40+	21.6	16.4	yes
ITE Model		Abbott	35	21.6	13.4	yes
Virkler & Guell		Abbott	36	21.6	14.4	yes
HCM	Chp 13	M.A.C.	21	17.5	3.5	yes
	Chp 9	M.A.C.	30	17.5	12.5	yes
MUTCD Model		M.A.C.	30	17.5	12.5	yes
Pignataro Model		M.A.C.	30 -33+	17.5	14.0	yes
ITE Model		M.A.C.	29	17.5	11.5	yes
Virkler & Guell		M.A.C.	31	17.5	13.5	yes
HCM	Chp 13	Division	21	19.2	1.8	yes
	Chp 9	Division	30	19.2	10.8	yes
MUTCD Model		Division	30	19.2	10.8	yes
Pignataro Model		Division	30 - 33+	19.2	12.3	yes
ITE Model		Division	30	19.2	10.8	yes
Virkler & Guell		Division	39	19.2	19.8	yes
HCM	Chp 13	Collingwood	27	23.3++	3.7	yes
	Chp 9	Collingwood	37	23.3	13.7	yes
MUTCD Model		Collingwood	37	23.3	13.7	yes
Pignataro Model		Collingwood	37 - 41+	23.3	15.7	yes
ITE Model		Collingwood	36	23.3	12.7	yes
Virkler & Guell		Collingwood	37	23.3	13.7	yes

+: Statistical comparisons are based on the average of these two values.

++: Average pedestrian crossing time on the east side crosswalk (19.9 sec on the west side)

The overall average measured pedestrian crossing time is used to perform the comparisons on an intersection-by-intersection basis. As table 2.4 shows, Collingwood Rd has two crosswalks. The east crosswalk has an average measured pedestrian crossing time of 23.3 sec (19.9 for the west). The higher of the two values (i.e., 23.3 sec) is used for comparison.

t-tests were performed to determine whether the differences between the measured and the estimated average pedestrian crossing times are significant. With no exceptions, the differences between measured and estimated T (crossing time) were found statistically significant at the 0.05 significance level. The analysis shows that all methodologies tested overestimate pedestrian crossing time, with the HCM (Chapter 13) methodology showing the closest fit. These results were consistent across all intersections when a particular model was evaluated, and across all alternative models, when a particular intersection was studied.

Several reasons can be cited in an attempt to describe the discrepancies between measured and estimated pedestrian crossing time values.

a. The default values (start-up delay and walking speed) used in the existing methods for pedestrian crossing time estimation might be improper to actual characteristics of pedestrians using the study facilities. Indeed, field observations indicate that the start up delay due to perception-reaction time varies between 2 and 3 sec. The different models propose values in the range of 3-7 sec. In addition, it is observed that pedestrians' walking speed is higher than the suggested walking speed in the models (observed speed varied between 1.42 and 1.65 m/sec).
b. Important variables may be missing from existing formulations. As a result, site specific characteristics that may impact pedestrian crossing time at signalized intersections are not represented properly. For example, presence of turning vehicles that share the same right-of-way with pedestrian traffic, two-directional crossing platoons, available crosswalk width, perceptual and kinetic characteristics of pedestrian users, weather conditions etc. may have an important effect on pedestrian crossing times at certain locations.

The findings from this analysis clearly demonstrate the need for further testing and refinement of existing methodologies for pedestrian crossing time calculation in order to reflect more accurately actual conditions.

Pedestrian crossing times can be used to:

a. provide information on proper signal timing of pedestrian signals, and
b. determine pedestrian LOS of signalized intersection crosswalks.

The results from these analyses are presented next.

Evaluation of signal settings

Measured pedestrian crossing times were used to evaluate existing signal settings during peak- and non-peak vehicle traffic conditions. The duration of existing pedestrian green and flashing red signals was tested against minimum pedestrian crossing time criteria.

Selection of pedestrian green time that allows for safe and comfortable crossing requires minimum pedestrian green equal to the average pedestrian crossing time for individuals as well as platoons of pedestrians. Table 2.6 summarizes the results from the evaluation of the length of pedestrian green time interval at the signalized intersections.

Table 2.6. Evaluation of the length of existing pedestrian green time interval

Intersections	Peak Conditions		Non-Peak Conditions	
	Pedestrian crossing time (sec)	Pedestrian green time (sec)	Pedestrian crossing time (sec)	Pedestrian green time (sec)
Abbott	21.2	23	20.5	23
M.A.C.	17.4	21	18.3	25
Division	19.6	20	19.0	21
Collingwood -W	19.9	23	19.8	23
Collingwood- E	23.2	23	23.6	23

As Table 2.6 demonstrates, under both vehicular peak and non-peak conditions, the intersections at Abbott, M.A.C., and Division Streets provide pedestrian green time greater than the average pedestrian crossing time measured in the field. The intersection at Collingwood provides slightly less green time than that required for pedestrian crossing at the east side of the intersection.

In fact, the existing flashing red time may allow pedestrians that started crossing in green to complete their crossing maneuver safely. However, it is desirable to provide pedestrian green indication at least equal to the average pedestrian crossing time. Thus it is recommended that the signal timing be adjusted to provide for pedestrian green time equal to 24 sec under both peak- and non-peak traffic conditions.

Pedestrian flashing red intervals should allow pedestrians who begin crossing at the start of flashing red to reach a refuge point by the time the red indication is displayed. The median is considered as the refuge point for divided facilities and the opposite curb for undivided ones.

To test if minimum pedestrian flashing red requirements are currently met, the available pedestrian flashing red time was compared to the time required for pedestrians to cross from curb to median. The latter was calculated by multiplying the measured pedestrian crossing time by the ratio of the distance between curb and median over the total crosswalk length. As the distances between the median and the north- and south side curbs were typically not the same, the longer of the two was considered. The results from the comparison are displayed in Table 2.7. It was found that, the flashing red intervals currently used meet the minimum flashing red interval criteria for pedestrian crossing needs at these locations.

LOS Estimation

The pedestrian level of service at all signalized crosswalks was estimated using the procedure proposed by the 1994 HCM (Chapter 13) and summarized in the beginning of this chapter. The LOS estimation is based on average space per pedestrian, M_c. The latter is a function of the available time-space for pedestrians, *TS*, the pedestrian

Table 2.7. Evaluation of the length of existing flashing red time interval

Intersections	Peak Conditions		Non-Peak Conditions	
	Pedestrian crossing time to median (sec)	Pedestrian flashing red time (sec)	Pedestrian crossing time to median (sec)	Pedestrian flashing red time (sec)
Abbott	9.0	13	8.7	13
M.A.C.	7.4	10	7.8	10
Division	8.0	10	7.8	10
Collingwood -W	8.2	14	8.2	14
Collingwood- E	11.2	14	11.4	14

crossing volume per cycle, V, and pedestrian crossing times, T. The 95th percentile pedestrian crossing volume per cycle was used, instead of the average pedestrian crossing volume per cycle, since the variance of pedestrian volume from cycle-to-cycle was high. Measured pedestrian crossing time data were used and the walk time, G, involved in the estimation of TS was taken as the sum of the pedestrian green and flashing red intervals reduced by 3 sec to account for start up delays due to pedestrian perception-reaction.

Table 2.8 illustrates the pedestrian level of service estimation procedure and results obtained for peak vehicular traffic conditions. Examination of Table 2.8 indicates that all study signalized intersections operate at an acceptable pedestrian level of service during peak traffic conditions (LOS of B or better). The high quality of service offered to pedestrians at the study intersections may explain the high crossing compliance rate at such locations reported in Chapter 1. On the other hand, if a facility offers poor level of service to pedestrians, it is very likely that pedestrians will attempt to optimize their crossing by themselves. They typically do so by crossing at a different location (designated for crossing or not) or at the same location but at a different time (i.e., during pedestrian red indication if vehicle traffic gaps allow for crossing).

Table 2.8. Pedestrian level of service estimation – vehicular peak conditions

Intersection	TS (m^2-sec)	M_c (m^2/ped)	LOS
Abbott	3983	15.0	A
M.A.C.	2890	26.0	A
Division	2112	5.4	B
Collingwood-W	3473	53.7	A
Collingwood-E	4308	28.6	A

Pedestrian levels of service for non-peak conditions are shown in Table 2.9. Under non-peak traffic conditions, Abbott and Collingwood Street intersection crosswalks operate at a pedestrian level of service A, while M.A.C. and Division intersection crosswalks operate at LOS of B and C, respectively. It is recommended that Division intersection crosswalk be examined in more detail in a future study to determine potential actions for improvement of operations both for vehicle and pedestrian users.

Table 2.9. Pedestrian level of service estimation – vehicular non-peak conditions

Intersection	TS (m^2-sec)	M_c (m^2/ped)	LOS
Abbott	3983	.38.5	A
M.A.C.	2529	11.1	B
Division	2037	3.4	C
Collingwood-W	3473	43.8	A
Collingwood-E	4308	45.6	A

SUMMARY AND CONCLUSIONS

In this chapter, pedestrian crossing times at signalized intersections were studied in detail. First, existing methodologies for the estimation of pedestrian crossing times were reviewed and summarized, and their limitations were discussed. Then these methodologies were validated using measured pedestrian crossing times. The data were collected at all four signalized intersections within the study area under peak and non-peak vehicular traffic conditions. Moreover, measured pedestrian crossing time data were used to check if currently used signal settings at the study intersections meet minimum green and flashing red requirements for pedestrians. Finally, measured pedestrian crossing times were used to assess the pedestrian LOS at all study intersections. The following conclusions were reached:

- Pedestrian crossing time is a key measure to the evaluation of signal settings and the assessment of operational efficiency at signalized intersections from the perspective of pedestrian users.
- Existing methodologies for pedestrian crossing time estimation systematically overpredict pedestrian crossing times. Refinement of such methodologies so that they represent actual conditions in a more realistic manner is recommended.
- Pedestrian crossing times can assist proper selection of signal settings including pedestrian green and flashing red interval lengths.
- To meet the minimum pedestrian green time criterion, pedestrian green time at Collingwood shall be increase from 23 to 24 sec under both vehicle peak and non-peak conditions.
- The minimum pedestrian flashing red time criterion is met at all locations, so no adjustments are needed to pedestrian flashing red time under either vehicle peak and non-peak conditions.
- All signalized intersections in the study area, except Division street, operate at an acceptable pedestrian level of service (B or better) during both vehicular peak and non-peak conditions. Division operates under pedestrian LOS C during vehicle non-peak conditions. Note that peak pedestrian traffic conditions were met during non-peak vehicle traffic periods. It is recommended that a study be undertaken to

examine pedestrian and vehicular needs at this location in detail and determine actions that can improve operational efficiency for both drivers and pedestrian users.

Chapter 3

PEDESTRIAN AND TURNING VEHICLES INTERACTIONS AT SIGNALIZED INTERSECTION CROSSWALKS

It is a common practice for pedestrians to share the right-of-way with turning vehicles. At signalized intersections, right- and/or left-turning vehicles are often allowed to perform their maneuvers during the pedestrian green signal indication. This creates conflicts between pedestrians and vehicles that may introduce delays to pedestrians, turning vehicles, or both, as well as increase the likelihood for a crash to occur. On the other hand, reduction of pedestrian-vehicle conflicts through the application of proper traffic-control measures (e.g., exclusive phases for pedestrians) is expected to decrease the overall operational efficiency of the signalized intersection. Thus, a trade-off exists between providing pedestrian safety and crossing convenience, and generating operational efficiency.

This chapter examines the interactions between turning vehicles and pedestrians crossing at signalized locations as described in objective 3 of this study. Field data collected at four signalized intersection crosswalk locations along Grand River Avenue are used for this purpose. First, conflicts observed as a result of turning vehicle-pedestrian interactions were counted. Then, regression analysis was performed to develop relationships between measured conflicts and pedestrian and vehicle volumes.

The results from this analysis were used in order to classify intersections with respect to the risk they impose to pedestrian movements. Furthermore, the correlation between pedestrian-vehicle conflicts and crashes can be examined to further assess safety at a crossing location and determine the need for geometric and/or signal timing improvements. Such analysis is beyond the scope of the subject research and is recommended for further study in the future.

BACKGROUND

Literature review indicates that vehicle left-turns are approximately four times more dangerous to pedestrians than through movements (10, 11). Almuina (12) examined

crashes involving left-turning vehicles and pedestrians at signalized intersections for a three-year period and reported that approximately 32 percent of pedestrian crashes at signalized intersections occurred with left-turning vehicles. Sisiopiku and Akin (1) analyzed pedestrian perceptual and movement data and concluded that pedestrian and turning vehicle conflicts increase the likelihood that pedestrian users will cross the road improperly to avoid such conflicts. Improper crossing refers to crossing during pedestrian red, or at a non-designated location.

A traffic conflict occurs when the paths of two movements that are competing for the same space cross each other. Traffic conflict areas have an increased potential for collisions. There are two types of traffic conflicts, namely (13):

a. evasive actions of road users, and
b. traffic violations.

The first type refers to a situation where one or both parties take evasive action to avoid collision that is imminent. Evasive actions of drivers or bicyclists are evidenced by braking or weaving. Evasive actions of pedestrians are evidenced by significant increase of walking speed, running, or waiting for vehicles or bicyclists to clear prior to crossing a roadway or a section of it. On the other hand, traffic violations are defined as the violations of pedestrian right-of-way by vehicles if the right-of-way of pedestrians over vehicles is clearly indicated by posted signs.

Actual pedestrian-vehicle conflicts are defined by Davis et. al. (14) as situations where the projected path of a turning vehicle and a pedestrian cross and either the pedestrian or the vehicle, or both, must change direction and/or speed to avoid a collision. This definition is appropriate to use when examining the relationship between conflicts and crashes, because actual conflict points are potential vehicle-to-pedestrian crash locations.

In order to analyze the impact of pedestrian-vehicle interactions on operations, consideration of potential (not actual) pedestrian-vehicle conflicts appears more appropriate. In the next paragraphs, potential pedestrian-vehicle conflicts are defined and measured at four signalized intersections on Grand River Avenue. Due to differences in space requirements and right-of-way, potential conflicts between a.

pedestrians and right-turning vehicles, and b. pedestrians and left-turning vehicles were analyzed separately.

DEFINITION OF POTENTIAL CONFLICTS

A potential pedestrian-turning vehicle conflict is defined as a situation in which the paths of a turning vehicle and a pedestrian cross and both pedestrian and vehicle are present simultaneously within the conflict area. The conflict area is clearly defined in Figures 3.1 and 3.2 for right- and left-turning vehicle conflicts to pedestrians, respectively.

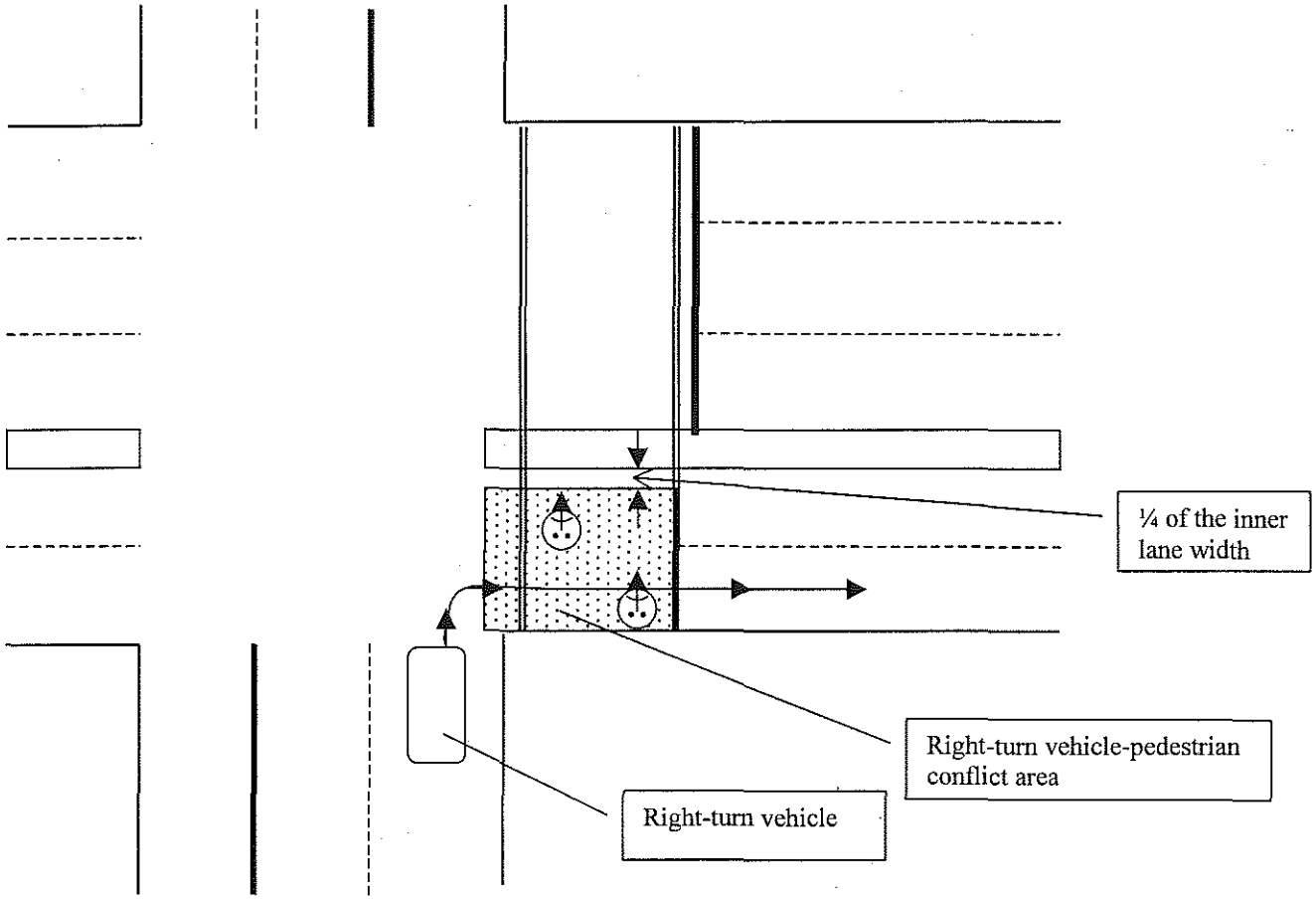

Figure 3.1. Right-turn vehicle and pedestrian conflict area on a crosswalk

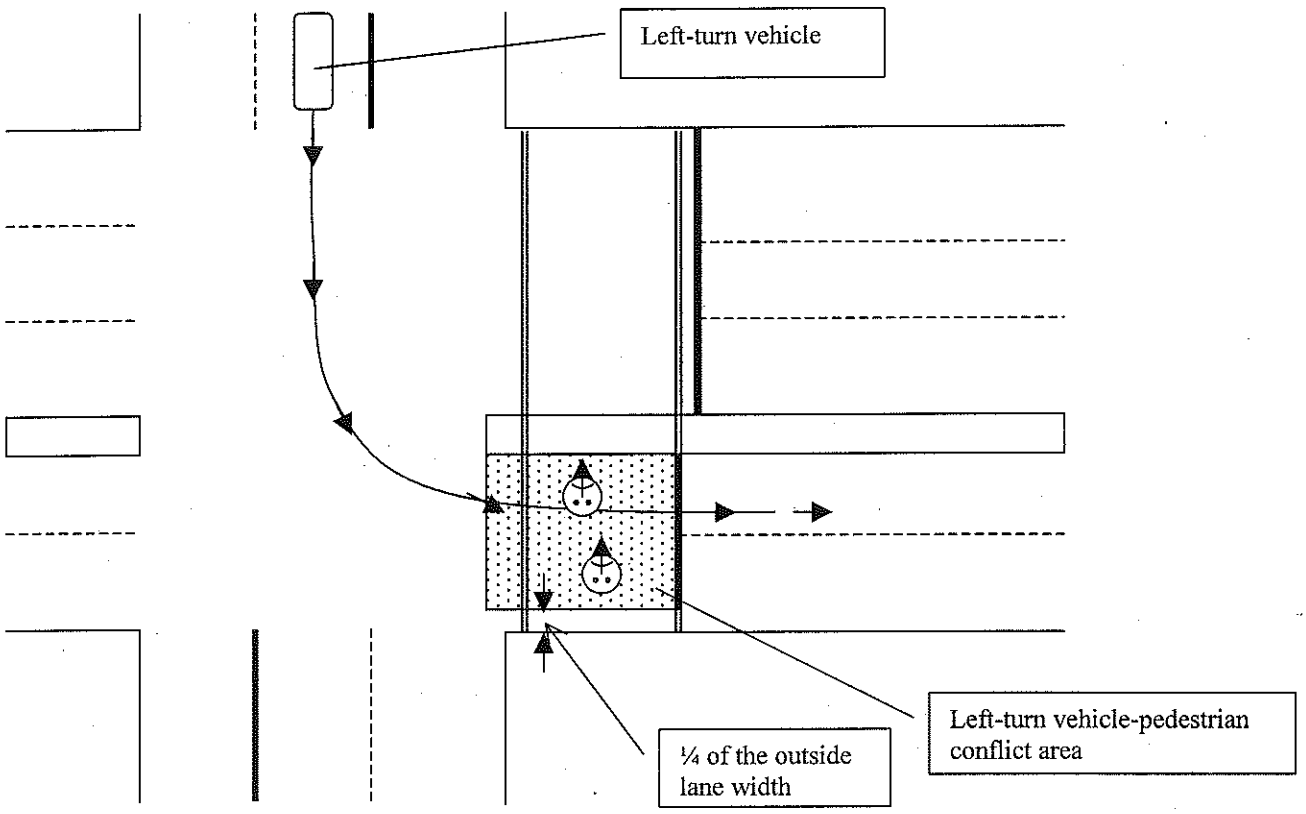

Figure 3.2. Left-turn vehicle and pedestrian conflict area on a crosswalk

DATA COLLECTION

Potential turning vehicle-pedestrian conflicts were counted over 30-min periods and then converted to potential conflicts per hour for each signalized intersection crosswalk within the study site. Note that at the signalized intersection of M.A.C. Avenue, no pedestrian conflicts with turning vehicles exist because the crosswalk is located at the east-side of the intersection. The Abbott Street intersection crosswalk poses both left- and right-turn vehicle conflicts to pedestrians. The crosswalk at Division Street has only left-turn vehicle-pedestrian conflicts since the intersection does not have a south leg. The Collingwood-west intersection crosswalk poses both left- and right-turn vehicle-pedestrian conflicts to pedestrians. At the Collingwood-east intersection crosswalk, left-turn vehicles are not allowed and, thus, only right-turn vehicle-pedestrian conflicts were counted.

Table 3.1 summarizes the potential right-turn vehicle-pedestrian conflicts observed at the study signalized intersection crosswalks. As Table 3.1 indicates, the signalized intersection crosswalk at Abbott Street has the highest average potential right-turn vehicle-pedestrian conflict rate per hour (41 potential conflicts/hr) followed by the Collingwood-east crosswalk (24 potential conflicts/hr).

Table 3.1. Potential right-turn conflicts on study intersection crosswalks

Crosswalks	Average right-turn volume (veh/hour)	Average pedestrian volume (ped/hour)	Average right-turn potential conflicts (conflicts/ hour)
Abbott St	40	154	41
Division St	N/A	323	N/A
Collingwood-west	20	50	5
Collingwood-east	151	56	24

N/A: not applicable

Table 3.2 summarizes the left-turn potential pedestrian-vehicle conflicts observed at the study signalized intersection crosswalks. As shown, the crosswalk at Division Street has the highest average left-turn potential pedestrian-vehicle conflict rate. Note that this intersection serves also the highest left-turning vehicle and pedestrian crossing volumes among all signalized intersections studied.

Table 3.2. Potential left-turn conflicts on study intersection crosswalks

Crosswalks	Average left-turn volume (veh/hour)	Average pedestrian volume (ped/hour)	Average left-turn potential conflicts (ped/ hour)
Abbott St	54	154	11
Division St	154	323	159
Collingwood-west	104	50	42
Collingwood-east	N/A	56	N/A

N/A: not applicable

Also according to Table 3.2, a very low left-turn conflict rate was observed at the Abbott Street crosswalk. This can be explained by the low left-turn vehicle volume (54 vph) as well as the fact that left turning vehicles there are given a permissive phase. Due to the lack of exclusive right of way, left-turning vehicles conflict first with northbound through traffic and then with pedestrian traffic at the crosswalk. As a result, many pedestrians can be safely cleared from the conflict area while left-turning vehicles wait for northbound traffic to clear, prior to entering the conflict area at the crosswalk. The same situation occurs at the Collingwood-west intersection crosswalk. However, at this crosswalk, left-turn traffic from Collingwood Street onto Grand River Ave is not opposed by a heavy southbound through volume.

In Table 3.3 the study intersections are ordered based on the total potential turning vehicle-pedestrian conflicts per hour. Such classification assists in identifying intersections with a greater risk for pedestrian-turning vehicle collisions and setting priorities for potential improvements.

Table 3.3. Classification of intersections based on total potential turning vehicle-pedestrian conflicts

Intersection	Total potential turning-vehicle-pedestrian conflicts (per hour)	Priority for consideration for action
Division	159	1
Abbott	52	2
Collingwood-west	47	3
Collingwood-east	24	4

According to Table 3.3, the intersection at Division Street is clearly the one with the greatest potential for turning vehicle-pedestrian collisions on the basis of the total potential conflict rate. To improve the situation, early or late release or exclusive pedestrian signal timing can be used, to replace the concurrent signal timing currently in effect. Early or late release pedestrian signal timing will assist in reducing the number of conflicts between pedestrians and turning traffic with expected positive implications on pedestrian safety and pedestrian crossing compliance.

ANALYSIS AND RESULTS

The collection of turning vehicle-pedestrian conflict data in the field was a tedious and time-consuming process. The following paragraphs present the results from an effort to estimate potential conflicts based on turning vehicle and pedestrian volumes. Regression analysis techniques were employed to model the relationship between potential turning vehicle-pedestrian conflicts and turning vehicle and pedestrian volumes. The results are presented next by turning movement type (i.e., right- or left-turning movement).

Modeling Right-turn Vehicle-Pedestrian Conflicts

Figure 3.3 presents a plot of potential right-turn vehicle-pedestrian conflicts (per hour) versus right-turn vehicle volumes. Figure 3.4 depicts the correlation between right-turn vehicle-pedestrian potential conflict rate and pedestrian volume. Observation of the two plots shows a potential correlation between right-turn vehicle and pedestrian conflicts and their volumes. This correlation was modeled using regression analysis.

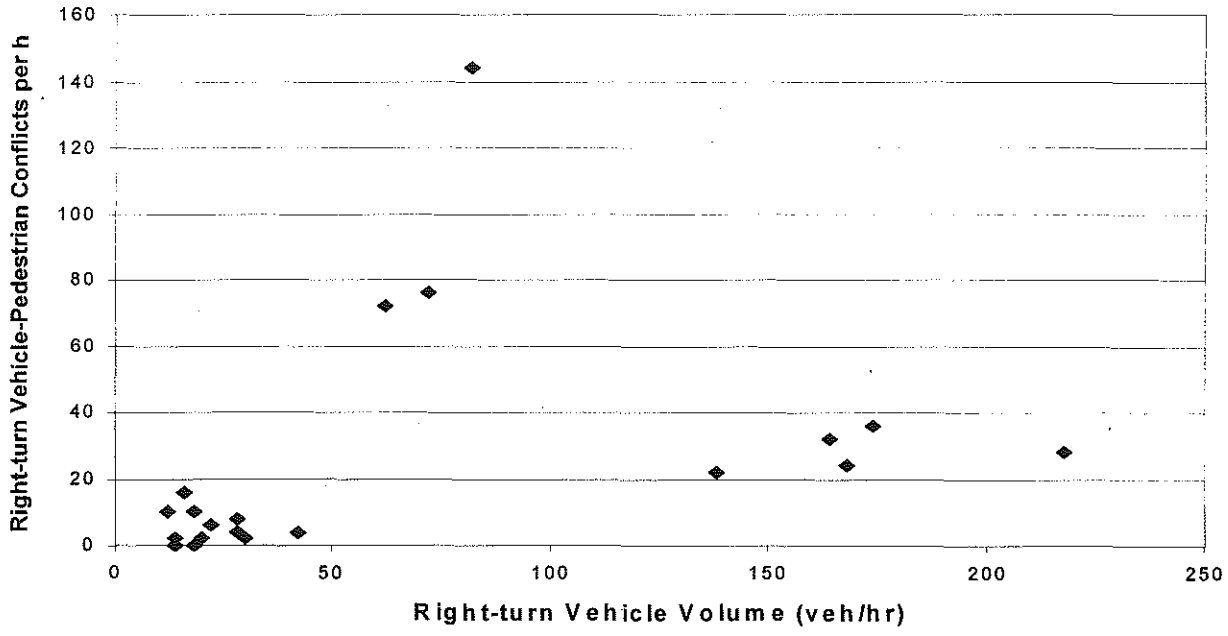

Figure 3.3. Relationship between right-turn vehicle-pedestrian conflicts and right-turn vehicle volume at signalized intersection crosswalks

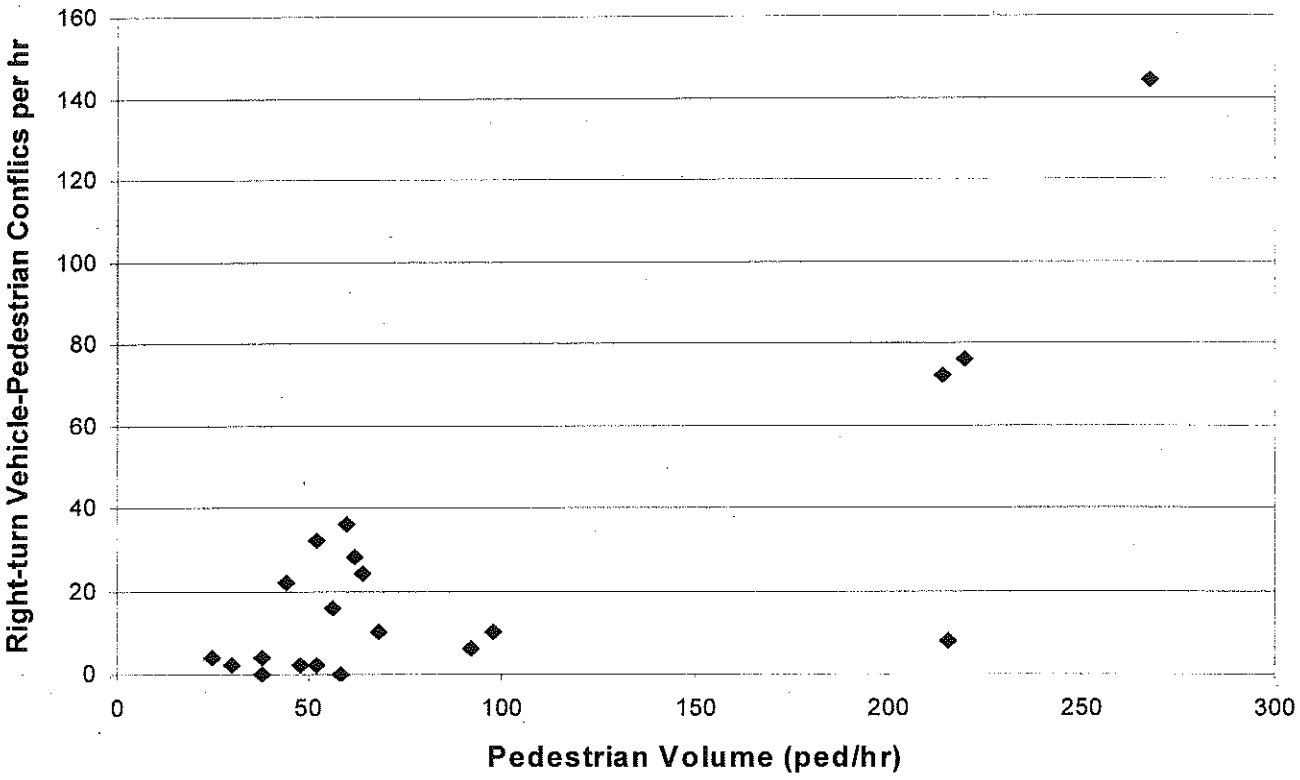

Figure 3.4. Relationship between right-turn vehicle-pedestrian conflicts and pedestrian volume at signalized intersection crosswalks

Several experiments with alternative model formulations were performed in search for a model that is reasonable, in terms of fit, and intuitively correct. A linear regression model of the form Y=a+b*X1+c*X2 was considered first, with the dependent variable, Y, being the potential pedestrian turning vehicle conflict rate, X1 the right turn vehicle volume, X2 the pedestrian volume, and a, b, c regression parameters. This model was soon abandoned as it fails to accurately model situations under which either vehicles or pedestrians, or both are absent. Under these conditions, the model shall predict zero potential conflicts. Thus an alternative linear model formulation was proposed and tested as shown in equation 3.1.

$$RTVPC = A*(RTVV*PV) \quad \text{.....Eq.3.1}$$

where

RTVPC = right-turn vehicle-pedestrian conflicts,

RTVV = right-turn vehicle volume,

PV = pedestrian volume, and

A = regression coefficient.

The regression analysis yielded an A value equal to 4.641 *10 $^{-3}$ resulting in the following model: -

$$RTVPC = 4.641 * 10^{-3} * (RTVV * PV) \quad \text{.....Eq.3.2}$$

The linear regression analysis results are presented in detail in Table 3.4. As shown, the R^2 value for the model above was 0.872 and the significance level of the model is less than 0.0005. Overall the model appears to predict reasonably well potential right-turn vehicle and pedestrian conflicts when right turn vehicle and pedestrian volumes are known. This is confirmed by Figure 3.5, which shows the plot of measured data, and the model estimates based on Equation 3.2.

Table 3.4. Linear regression analysis results for the RTVPC model

Model		Sum of Squares	df	Mean Square	F	Significance
1	Regression	31882.590	1	31882.590	136.326	0.000
	Residual	4677.410	20	233.871		
	Total	36560.000	21			

Unstandardized Coefficients		Standardized Coefficients	t	Significance	95% Confidence Interval for coefficients	
B	Std. Error	B			Lower bound	Upper bound
4.641E-03	0.000	0.934	11.676	0.000	0.004	0.005

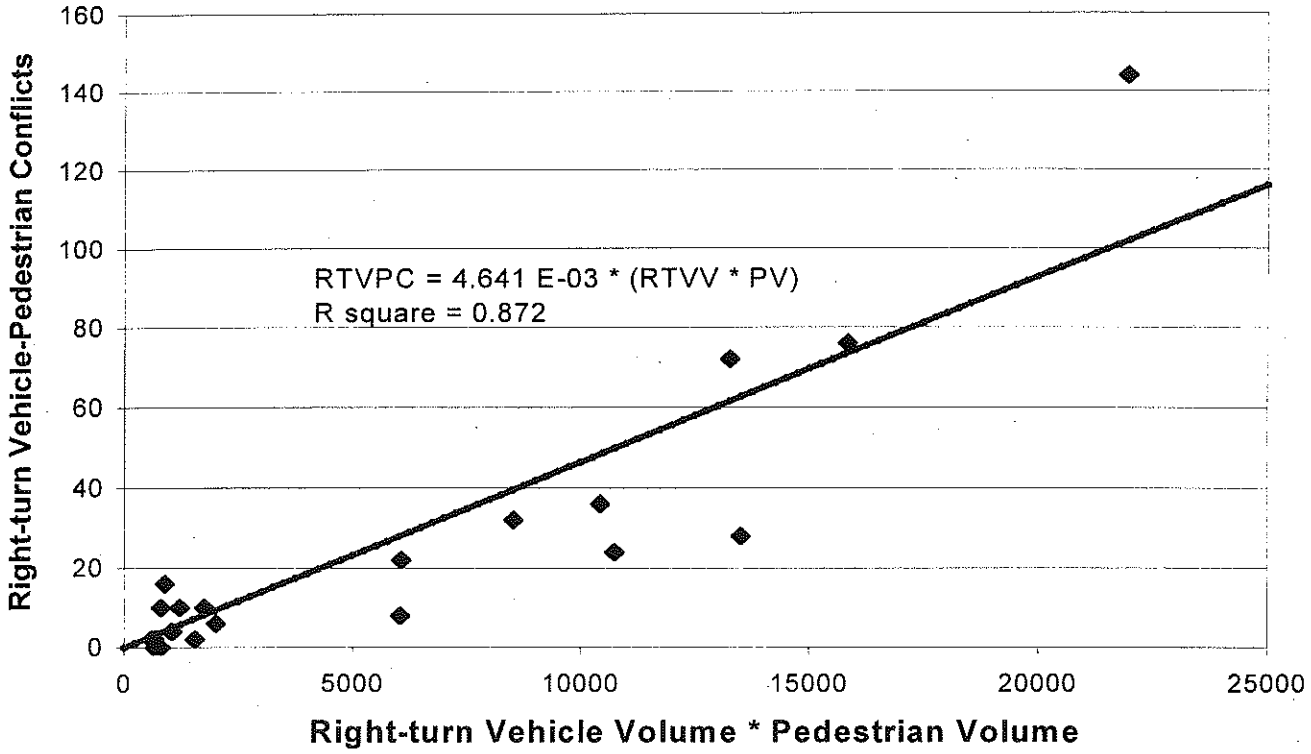

Figure 3.5. Relationship between right-turn vehicle-pedestrian conflicts and right-turn vehicle and pedestrian volumes at signalized intersection crosswalks

Modeling Left-turn Vehicle-Pedestrian Conflicts

Figure 3.6 presents a plot of the potential left-turn vehicle-pedestrian conflicts (per hour) versus left-turn vehicle volumes. Figure 3.7 shows the correlation between left-turn vehicle-pedestrian potential conflict rate and pedestrian volume.

Observation of the two plots shows a good correlation between left-turn vehicle and pedestrian conflicts and their volumes. Since, again, the model has to predict no conflicts when either turning vehicles, or pedestrians, or both are not present, a model formulation similar to the one suggested for right-turn vehicle pedestrian conflict estimation is used. This formulation is shown in equation 3.3.

$$LTVPC = B * (LTVV * PV) \quad \text{.....Eq.3.3}$$

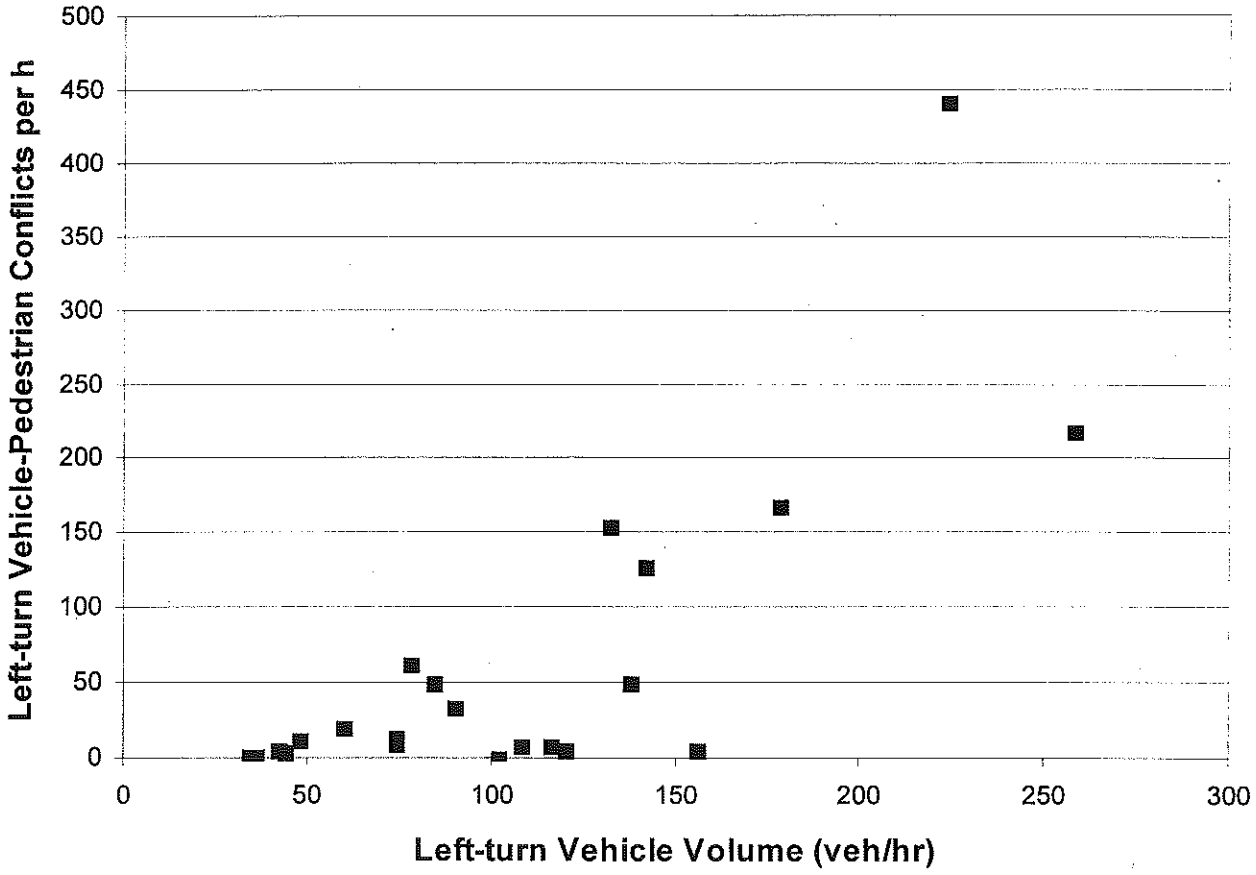

Figure 3.6. Relationship between left-turn vehicle-pedestrian conflicts and left-turn vehicle volume at signalized intersection crosswalks

where

LTVPC = left-turn vehicle-pedestrian conflict,

LTVV = left-turn vehicle volume,

PV = pedestrian volume, and

B = regression coefficient.

The linear regression analysis yielded the following model:

$$LTVPC = 2.444 * 10^{-3} * (LTVV * PV) \quad \text{.....Eq.3.4}$$

Summary results from the linear regression analysis are presented in Table 3.5. The R^2 value is 0.945 and the significance level of the model is less than 0.0005.

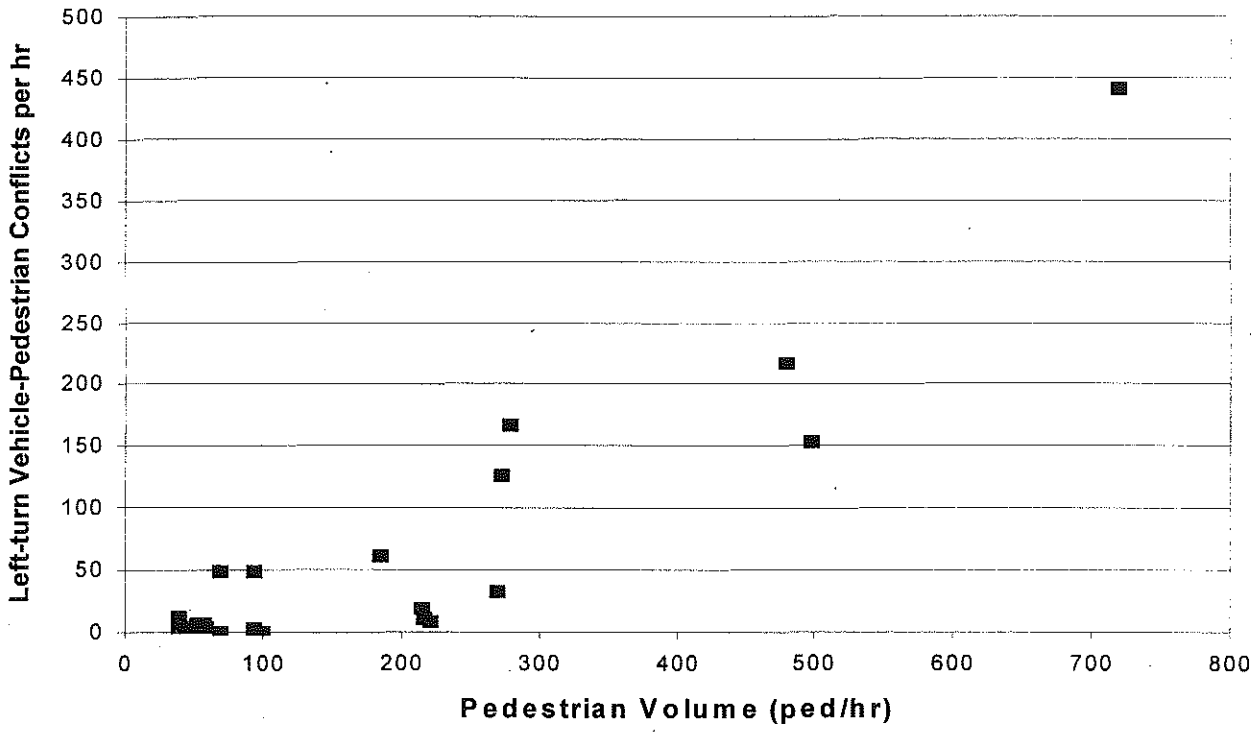

Figure 3.7. Relationship between left-turn vehicle-pedestrian conflicts and pedestrian volume at signalized intersection crosswalks

Table 3.5. Linear regression analysis results for the LTVPC model

Model		Sum of Squares	df	Mean Square	F	Significance
1	Regression	304677.028	1	304677.028	362.814	0.000
	Residual	17634.972	21	839.761		
	Total	322312.000	22			

Unstandardized Coefficients		Standardized Coefficients	t	Significance	95% Confidence Interval for coefficients	
B	Std. Error	B			Lower bound	Upper bound
2.444E-03	0.000	0.972	19.048	0.000	0.002	0.003

Figure 3.8 shows the plot of the data and the model estimates resulting from application of Equation 3.4. Both the high R^2 value obtained and the very good fit of the model to the data as shown in Figure 3.8 indicate that Equation 3.4 can predict with reasonable accuracy potential left-turn vehicle and pedestrian conflicts when left turn vehicle and pedestrian volumes are known.

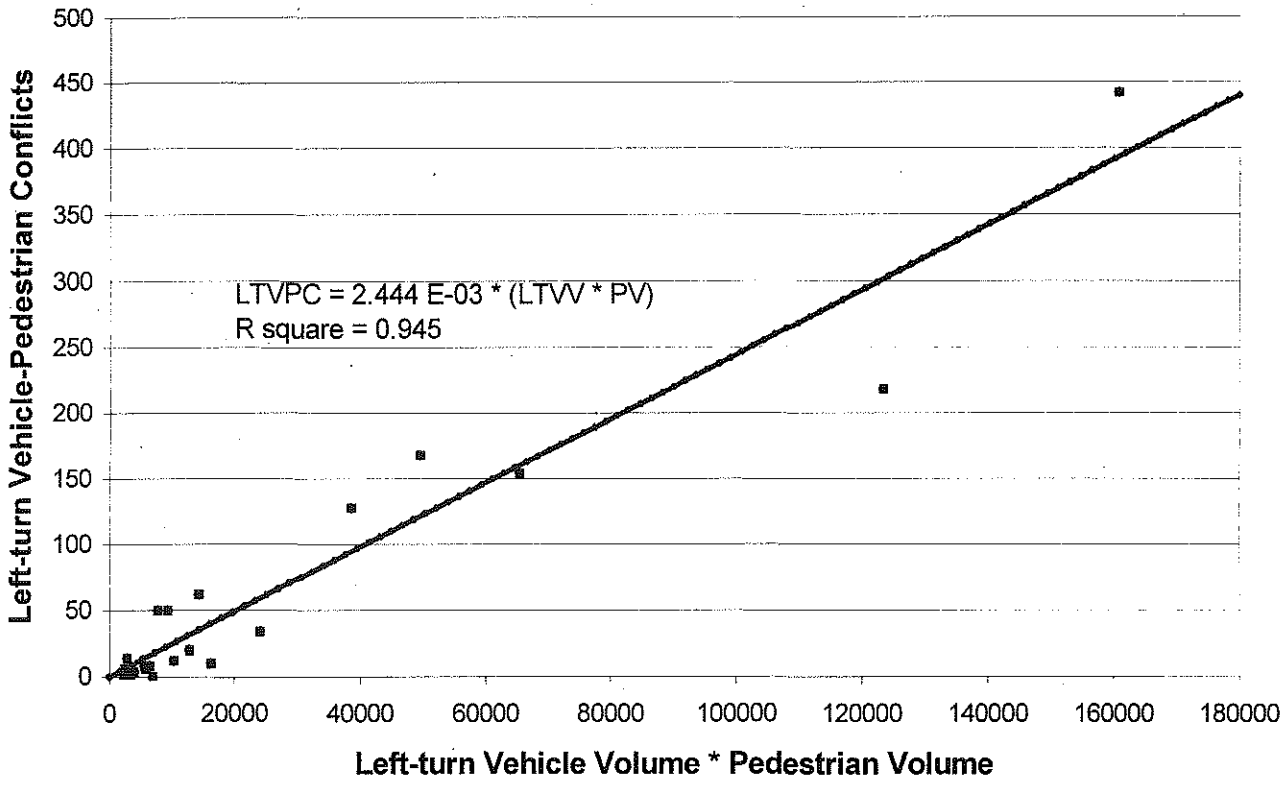

Figure 3.8. Relationship between left-turn vehicle-pedestrian conflicts and left-turn vehicle and pedestrian volumes at signalized intersection crosswalks

SUMMARY AND CONCLUSIONS

In this chapter, pedestrian and turning vehicle interactions at signalized intersection crosswalks were studied in detail. First, potential right- and left-turn vehicle-pedestrian conflicts at signalized intersection were defined and measured at qualifying locations within the study area. The total number of potential turning vehicle/pedestrian conflicts observed was used to classify the study intersections with respect to the need for improvements. Potential conflict estimation models were developed and discussed.

The proposed models can be used to estimate potential right- or left- turning vehicle and pedestrian conflicts when turning vehicle and pedestrian volumes are available.

The following conclusions were reached from the results of the analysis described above:

- The estimation of potential right- and left-turn vehicle-pedestrian conflicts is possible through the application of linear regression models developed in this study and described in Equations 3.2 and 3.4.
- The relationship between left-turn vehicle-pedestrian conflicts, and pedestrian and left-turn vehicle volumes appears stronger than the one between right-turn vehicle-pedestrians conflicts, and pedestrian and right-turn vehicle volumes.
- Among all intersections studied, the Division Street one carries the highest left-turning vehicle and pedestrian volumes and shows the greatest potential for turning vehicle-pedestrian collisions. The Abbott Street crosswalk is the one with the highest potential right-turning vehicle and pedestrian conflicts.
- Early or late release pedestrian signal timing can assist toward turning vehicle-pedestrian conflict reduction and increase pedestrian safety and crossing convenience.
- Although the models that proposed in this chapter give very reasonable results, additional testing of the models is recommended to confirm their validity and applicability under different settings.

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APPENDICES

APPENDIX A: Summaries of Pedestrian Movement Data

TERMINOLOGY AND ABBREVIATIONS

PS (VS): **Partial sneakers** (at signalized intersections under lead/lag vehicle phasing only). Pedestrians who cross from curbside to the median during red pedestrian signal indication while vehicles in this direction are stopped and complete their crossing (from median to opposite curbside) during green pedestrian signal indication.

PS (VR): **Partial sneakers, risk takers** (at signalized intersections only). Pedestrians who cross a portion of the roadway width during the red pedestrian signal indication while vehicles in both directions are in motion.

RU: **Regular users** (at signalized intersections only). Pedestrians who comply with location and crossing time restrictions and cross at the crosswalk location during the green indication of pedestrian signal.

Jaywalkers: Pedestrians who cross outside the crosswalk area (see figures 1.5 and 1.6).

Partial Jaywalkers: Pedestrians whose paths are partially within the crosswalk area.

S: **Sneakers** (at signalized intersections only). Pedestrians who cross from one curbside to the other entirely during the red pedestrian signal indication.

LS:	**Late starters** (at signalized intersections only). Pedestrians who start to cross the street during flashing red pedestrian signal.
CIA:	**Crosswalk influence area** (see Figure 1.4 and Equation 1.1).
Crosswalk area:	Defined by the crosswalk centerline location ±7.5 m on each side (see Figure 1.5).
PCR_L^i:	Pedestrian compliance rate at crosswalk *i* (see Equation 1.2).
PCR_{LT}^i:	Overall pedestrian compliance rate at signalized crosswalk *i*, i.e., compliance to both crossing location and signal indication (see Equation 1.2).
P_L:	The number of pedestrians who comply with crossing location.
P_{LT}:	The number of pedestrians who comply with crossing location and signal indication.
P_{CIA}:	Total number of pedestrians in the crosswalk influence area.

DATA SUMMARY

Date:2/10/98 Time:10:43 am AM Off-Peak
Low 40Fs, warm

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

1- Abbot St. Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	23	1	0	2	24
PS (VR)	5	0	0	1	5
S	8	1	0	5	9
LS	11	0	0	1	11
Total	47	2	0	9	49

RU: Regular users S: Sneakers
PS (VS): Partial sneakers (vehicles stopped) LS: Late starters
PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 4 peds in 30 min
Jaywalkers from east side of the crosswalk = 0 peds in 30 min
Total pedestrians in the crosswalk area = 49 + 4 + 0 = 53 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{23}{53} = 43.4\%$$

Total pedestrian volume in the crosswalk area = 53 * 2 = 106 peds / hr

2- Marked Midblock Crosswalk w/ shelter (in front of the MSU Student Union)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	20	6	1	27

Jaywalkers from west side of the crosswalk = 0 peds in 30 min
Jaywalkers from east side of the crosswalk = 10 peds in 30 min
Total pedestrians in the crosswalk area = 27 + 0 + 10 = 37 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{20}{37} = 54.1\%$$

Total pedestrian volume in the crosswalk area = 37 * 2 = 74 peds / hr

DATA SUMMARY

Date:2/10/98 Time:10:43 am
Low 40Fs, warm

AM Off-Peak

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

3- M.A.C. Ave. Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	45	2	0	4	47
PS (VR)	38	2	0	4	40
S	19	2	0	1	21
LS	11	1	0	0	12
Total	113	7	0	9	120

RU: Regular users S: Sneakers
PS (VS): Partial sneakers (vehicles stopped) LS: Late starters
PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 7 peds in 30 min
Jaywalkers from east side of the crosswalk = 7 peds in 30 min
Total pedestrians in the crosswalk area = 120 + 7 + 7 = 134 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{45}{134} = 33.6\%$$

Total pedestrian volume in the crosswalk area = 36 * 2 = 72 peds / hr

4- Marked Midblock Crosswalk w/o shelter (in front of Jabobson's)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	21	3	0	24

Jaywalkers from west side of the crosswalk = 3 peds in 30 min
Jaywalkers from east side of the crosswalk = 3 peds in 30 min
Total pedestrians in the crosswalk area = 24 + 3 + 3 = 30 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{21}{30} = 70.0\%$$

Total pedestrian volume in the crosswalk area = 30 * 2 = 60 peds / hr

DATA SUMMARY

Date:2/10/98 Time:10:43 am
Low 40Fs, warm

AM Off-Peak

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

5- Charles St. Unsignalized Intersection Crosswalk

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	79	12	3	94

Jaywalkers from west side of the crosswalk = 12 peds in 30 mins
Jaywalkers from east side of the crosswalk = 4 peds in 30 mins
Total pedestrians in the crosswalk area = 94 + 12 + 4 = 110 peds / hr

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{79}{110} = 71.8\%$$

Total pedestrian volume in the crosswalk area = 110 * 2 = 220 peds / hr

6- Division St. Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	149	3	0	5	152
PS (VR)	26	0	0	0	26
S	34	1	0	2	35
LS	24	2	0	2	26
Total	233	6	0	9	239

RU: Regular users S: Sneakers
PS (VS): Partial sneakers (vehicles stopped) LS: Late starters
PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 3 peds in 30 min
Jaywalkers from east side of the crosswalk = 7 peds in 30 min
Total pedestrians in the crosswalk area = 239 + 3 + 7 = 249 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{149}{249} = 59.8\%$$

Total pedestrian volume in the crosswalk area = 249 * 2 = 598 peds / hr

Gd River Ave Crosswalks (Division - Bogue Sts)

DATA SUMMARY

Date:4/17/98, Fri, 3:29p PM Peak

High 50s, Partly cloudy

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (DIVISION - BOGUE STS)

7- Marked Midblock Crosswalk w/ shelter (in front of the MSU Federal Credit Union)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	95	8	0	103

Jaywalkers from west side of the crosswalk = 9 peds in 30 min

Jaywalkers from east side of the crosswalk = 6 peds in 30 min

Total pedestrians in the crosswalk area = 103 + 9 + 6= 118 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{95}{118} = 80.5\%$$

Total pedestrian volume in the crosswalk area = 118 * 2 = 236 peds / hr

8- 1st Unmarked Midblock Crosswalk w/o shelter (in front of SPLASH)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	28	0	7	35

Jaywalkers from west side of the crosswalk = 2 peds in 30 min

Jaywalkers from east side of the crosswalk = 5 peds in 30 min

Total pedestrians in the crosswalk area = 35 + 2 + 5 = 42 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{28}{42} = 66.7\%$$

Total pedestrian volume in the crosswalk area = 42 * 2 = 84 peds / hr

DATA SUMMARY

Date:4/17/98, Fri, 3:29p PM Peak
High 50s, Partly cloudy

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (DIVISION - BOGUE STS)

9- 2nd Unmarked Midblock Crosswalk w/o shelter (in front of University Pizza)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	27	0	4	31

Jaywalkers from west side of the crosswalk = 6 peds in 30 min
Jaywalkers from east side of the crosswalk = 4 peds in 30 min
Total pedestrians in the crosswalk area = 31 + 6 + 4 = 41 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{27}{41} = 65.9\%$$

Total pedestrian volume in the crosswalk area = 41 * 2 = 82 peds / hr

10- Marked Midblock Crosswalk w/o shelter (in front of Good Time Pizza)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	37	2	0	39

Jaywalkers from west side of the crosswalk = 6 peds in 30 min
Jaywalkers from east side of the crosswalk = 1 peds in 30 min
Total pedestrians in the crosswalk area = 39 + 6 + 1 = 46 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{37}{46} = 80.4\%$$

Total pedestrian volume in the crosswalk area = 46 * 2 = 92 peds / hr

DATA SUMMARY

Date:4/17/98, Fri, 3:29p
High 50s, Partly cloudy

PM Peak

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (DIVISION - BOGUE STS)

11- Collingwood St. West-Side Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	10	0	0	4	10
PS (VR)	1	0	0	0	1
S	3	0	0	2	3
LS	5	0	0	0	5
Total	19	0	0	6	19

RU: Regular users S: Sneakers
PS (VS): Partial sneakers (vehicles stopped) LS: Late starters
PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 1 peds in 30 min
Jaywalkers from east side of the crosswalk = 0 peds in 30 min
Total pedestrians in the crosswalk area = 19 + 1 + 0 = 20 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{10}{20} = 50.0\%$$

Total pedestrian volume in the crosswalk area = 20 * 2 = 40 peds / hr

12- Collingwood St. East-Side Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	13	0	0	3	13
PS (VR)	13	0	0	1	13
S	0	0	0	1	0
LS	5	0	0	1	5
Total	31	0	0	6	31

RU: Regular users S: Sneakers
PS (VS): Partial sneakers (vehicles stopped) LS: Late starters
PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 0 peds in 30 min
Jaywalkers from east side of the crosswalk = 3 peds in 30 min
Total pedestrians in the crosswalk area = 31 + 0 + 3 = 34 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{13}{34} = 38.2\%$$

Total pedestrian volume in the crosswalk area = 34 * 2 = 68 peds / hr

DATA SUMMARY

Date:4/17/98, Fri, 3:29p PM Peak
High 50s, Partly cloudy

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (DIVISION - BOGUE STS)

13- Orchard St. Unsignalized Intersection Crosswalk

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	10	4	0	14

Jaywalkers from west side of the crosswalk = 2 peds in 30 min

Jaywalkers from east side of the crosswalk = 2 peds in 30 min

Total pedestrians in the crosswalk area = 10 + 2 + 2 = 14 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{10}{14} = 71.4\%$$

Total pedestrian volume in the crosswalk area = 14 * 2 = 28 peds / hr

Gd River Ave Crosswalks (Abbott - Bogue Sts)

DATA SUMMARY

Date:2/14/98 Time:12:44pm-Sat Weekend

Mid to high 30s, cold, partly cloudy

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

1- Abbot St. Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	24	0	0	12	24
PS (VR)	5	1	0	2	6
S	7	1	0	3	8
LS	9	2	1	0	12
Total	45	4	1	17	50

RU: Regular users S: Sneakers
PS (VS): Partial sneakers (vehicles stopped) LS: Late starters
PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 2 peds in 30 min

Jaywalkers from east side of the crosswalk = 0 peds in 30 min

Total pedestrians in the crosswalk area = 50 + 2 + 0 = 52 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{24}{52} = 46.2\%$$

Total pedestrian volume in the crosswalk area = 52 * 2 = 104 peds / hr

2- Marked Midblock Crosswalk w/ shelter (in front of the MSU Student Union)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	32	10	1	43

Jaywalkers from west side of the crosswalk = 0 peds in 30 min

Jaywalkers from east side of the crosswalk = 2 peds in 30 min

Total pedestrians in the crosswalk area = 43 + 0 + 2 = 45 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{32}{45} = 71.1\%$$

Total pedestrian volume in the crosswalk area = 45 * 2 = 90 peds / hr

DATA SUMMARY

Date:2/14/98 Time:12:44pm-Sat Weekend

Mid to high 30s, cold, partly cloudy

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

3- M.A.C. Ave. Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	19	2	0	2	21
PS (VR)	9	1	0	0	10
S	0	0	0	0	0
LS	1	0	0	1	1
Total	29	3	0	3	32

RU: Regular users S: Sneakers

PS (VS): Partial sneakers (vehicles stopped) LS: Late starters

PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 5 peds in 30 min

Jaywalkers from east side of the crosswalk = 2 peds in 30 min

Total pedestrians in the crosswalk area = 32 + 5 + 2 = 39 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{19}{39} = 48.7\%$$

Total pedestrian volume in the crosswalk area = 39 * 2 = 78 peds / hr

4- Marked Midblock Crosswalk w/o shelter (in front of Jabobson's)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	10	1	0	11

Jaywalkers from west side of the crosswalk = 2 peds in 30 min

Jaywalkers from east side of the crosswalk = 2 peds in 30 min

Total pedestrians in the crosswalk area = 11 + 2 + 2 = 15 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{10}{15} = 66.7\%$$

Total pedestrian volume in the crosswalk area = 15 * 2 = 30 peds / hr

Gd River Ave Crosswalks (Abbott - Bogue Sts)

DATA SUMMARY

Date:2/14/98 Time:12:44pm-Sat Weekend

Mid to high 30s, cold, partly cloudy

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

5- Charles St. Unsignalized Intersection Crosswalk

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	21	2	0	23

Jaywalkers from west side of the crosswalk = 3 peds in 30 min

Jaywalkers from east side of the crosswalk = 5 peds in 30 min

Total pedestrians in the crosswalk area = 23 + 3 + 5 = 31 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{21}{31} = 67.7\%$$

Total pedestrian volume in the crosswalk area = 31 * 2 = 62 peds / hr

6- Division St. Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	24	1	0	2	25
PS (VR)	2	0	0	0	2
S	3	0	0	2	3
LS	4	0	0	3	4
Total	33	1	0	7	34

RU: Regular users S: Sneakers

PS (VS): Partial sneakers (vehicles stopped) LS: Late starters

PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 1 peds in 30 min

Jaywalkers from east side of the crosswalk = 7 peds in 30 min

Total pedestrians in the crosswalk area = 34 + 1 + 7 = 42 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{24}{42} = 57.1\%$$

Total pedestrian volume in the crosswalk area = 42 * 2 = 84 peds / hr

Gd River Ave Crosswalks (Division - Bogue Sts)

DATA SUMMARY

Date:4/20/98, Mon, 3:26p PM Peak

Low 60s, Partly cloudy

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (DIVISION - BOGUE STS)

7- Marked Midblock Crosswalk w/ shelter (in front of the MSU Federal Credit Union)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	95	13	1	109

Jaywalkers from west side of the crosswalk = 7 peds in 30 min

Jaywalkers from east side of the crosswalk = 5 peds in 30 min

Total pedestrians in the crosswalk area = 109 + 7 + 5= 121 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{95}{121} = 78.5\%$$

Total pedestrian volume in the crosswalk area = 121 * 2 = 242 peds / hr

8- 1st Unmarked Midblock Crosswalk w/o shelter (in front of SPLASH)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	29	0	9	38

Jaywalkers from west side of the crosswalk = 1 peds in 30 min

Jaywalkers from east side of the crosswalk = 3 peds in 30 min

Total pedestrians in the crosswalk area = 38 + 1 + 3 = 42 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{29}{42} = 69.0\%$$

Total pedestrian volume in the crosswalk area = 42 * 2 = 84 peds / hr

DATA SUMMARY

Date:4/20/98, Mon, 3:26p PM Peak
Low 60s, Partly cloudy

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (DIVISION - BOGUE STS)

9- 2nd Unmarked Midblock Crosswalk w/o shelter (in front of University Pizza)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	45	0	13	58

Jaywalkers from west side of the crosswalk = 6 peds in 30 min
Jaywalkers from east side of the crosswalk = 3 peds in 30 min
Total pedestrians in the crosswalk area = 58 + 6 + 3 = 67 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{45}{67} = 67.2\%$$

Total pedestrian volume in the crosswalk area = 67 * 2 = 134 peds / hr

10- Marked Midblock Crosswalk w/o shelter (in front of Good Time Pizza)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	46	3	0	49

Jaywalkers from west side of the crosswalk = 3 peds in 30 min
Jaywalkers from east side of the crosswalk = 0 peds in 30 min
Total pedestrians in the crosswalk area = 49 + 3 + 0 = 52 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{46}{52} = 88.5\%$$

Total pedestrian volume in the crosswalk area = 52 * 2 = 104 peds / hr

DATA SUMMARY

Date:4/20/98, Mon, 3:26p PM Peak
Low 60s, Partly cloudy

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (DIVISION - BOGUE STS)

11- Collingwood St. West-Side Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	13	0	0	4	13
PS (VR)	8	0	0	4	8
S	4	0	0	4	4
LS	1	0	0	0	1
Total	26	0	0	12	26

RU: Regular users S: Sneakers
PS (VS): Partial sneakers (vehicles stopped) LS: Late starters
PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 2 peds in 30 min
Jaywalkers from east side of the crosswalk = 0 peds in 30 min
Total pedestrians in the crosswalk area = 26 + 2 + 0 = 28 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{13}{28} = 46.4\%$$

Total pedestrian volume in the crosswalk area = 28 * 2 = 56 peds / hr

12- Collingwood St. East-Side Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	11	0	0	4	11
PS (VR)	12	0	0	4	12
S	6	0	0	0	6
LS	3	0	0	1	3
Total	32	0	0	9	32

RU: Regular users S: Sneakers
PS (VS): Partial sneakers (vehicles stopped) LS: Late starters
PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 0 peds in 30 min
Jaywalkers from east side of the crosswalk = 4 peds in 30 min
Total pedestrians in the crosswalk area = 32 + 0 + 4 = 36 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{11}{36} = 30.6\%$$

Total pedestrian volume in the crosswalk area = 36 * 2 = 72 peds / hr

DATA SUMMARY

Date:4/20/98, Mon, 3:26p
Low 60s, Partly cloudy

PM Peak

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (DIVISION - BOGUE STS)

13- Orchard St. Unsignalized Intersection Crosswalk

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	30	6	0	36

Jaywalkers from west side of the crosswalk = 3 peds in 30 min

Jaywalkers from east side of the crosswalk = 7 peds in 30 min

Total pedestrians in the crosswalk area = 36 + 3 + 7 = 46 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{30}{46} = 65.2\%$$

Total pedestrian volume in the crosswalk area = 46 * 2 = 92 peds / hr

DATA SUMMARY

Date:2/19/98 Time: 2:33 pm PM Peak

35 F, cool, cloudy

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

1- Abbot St. Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	50	2	1	4	53
PS (VR)	15	0	0	1	15
S	19	6	0	4	25
LS	14	0	0	2	14
Total	98	8	1	11	107

RU: Regular users S: Sneakers
PS (VS): Partial sneakers (vehicles stopped) LS: Late starters
PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 6 peds in 30 min
Jaywalkers from east side of the crosswalk = 1 peds in 30 min
Total pedestrians in the crosswalk area = 107 + 6 + 1 = 114 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\text{no of RUs + no PS(VS)s on-crosswalk}}{\text{total peds in the crosswalk area}} = \frac{50}{114} = 43.9\%$$

Total pedestrian volume in the crosswalk area = 114 * 2 = 228 peds / hr

2- Marked Midblock Crosswalk w/ shelter (in front of the MSU Student Union)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	45	5	1	51

Jaywalkers from west side of the crosswalk = 1 peds in 30 min
Jaywalkers from east side of the crosswalk = 8 peds in 30 min
Total pedestrians in the crosswalk area = 51 + 1 + 8 = 60 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\text{no of Pedestrians on-crosswalk}}{\text{total peds in the crosswalk area}} = \frac{45}{60} = 75.0\%$$

Total pedestrian volume in the crosswalk area = 60 * 2 = 120 peds / hr

DATA SUMMARY

Date:2/19/98 Time: 2:33 pm PM Peak
35 F, cool, cloudy

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

3- M.A.C. Ave. Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	22	0	0	4	22
PS (VR)	8	1	0	1	9
S	7	0	0	2	7
LS	7	0	0	0	7
Total	44	1	0	7	45

RU: Regular users S: Sneakers
PS (VS): Partial sneakers (vehicles stopped) LS: Late starters
PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 10 peds in 30 min
Jaywalkers from east side of the crosswalk = 1 peds in 30 min
Total pedestrians in the crosswalk area = 45 + 10 + 1 = 56 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\text{no of RUs + no PS(VS)s on-crosswalk}}{\text{total peds in the crosswalk area}} = \frac{22}{56} = 39.3\%$$

Total pedestrian volume in the crosswalk area = 56 * 2 = 112 peds / hr

4- Marked Midblock Crosswalk w/o shelter (in front of Jabobson's)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	15	1	0	16

Jaywalkers from west side of the crosswalk = 1 peds in 30 min
Jaywalkers from east side of the crosswalk = 3 peds in 30 min
Total pedestrians in the crosswalk area = 16 + 1 + 3 = 20 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\text{no of Pedestrians on-crosswalk}}{\text{total peds in the crosswalk area}} = \frac{15}{20} = 75.0\%$$

Total pedestrian volume in the crosswalk area = 20 * 2 = 40 peds / hr

Gd River Ave Crosswalks (Abbott - Bogue Sts)

DATA SUMMARY

Date:2/19/98 Time: 2:33 pm PM Peak

35 F, cool, cloudy

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

5- Charles St. Unsignalized Intersection Crosswalk

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	35	5	0	40

Jaywalkers from west side of the crosswalk = 6 peds in 30 min

Jaywalkers from east side of the crosswalk = 7 peds in 30 min

Total pedestrians in the crosswalk area = 40 + 6 + 7 = 53 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{35}{53} = 66.0\%$$

Total pedestrian volume in the crosswalk area = 53 * 2 = 106 peds / hr

6- Division St. Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	70	1	1	6	72
PS (VR)	18	0	1	0	19
S	23	4	1	2	28
LS	15	2	0	2	17
Total	126	7	3	10	136

RU: Regular users S: Sneakers

PS (VS): Partial sneakers (vehicles stopped) LS: Late starters

PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 4 peds in 30 min

Jaywalkers from east side of the crosswalk = 13 peds in 30 min

Total pedestrians in the crosswalk area = 136 + 4 + 13 = 153 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{70}{153} = 45.8\%$$

Total pedestrian volume in the crosswalk area = 153 * 2 = 306 peds / hr

DATA SUMMARY

Date:4/23/98, Thu, 11:02a
Low 70s, Sunny

AM Off-Peak

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

7- Marked Midblock Crosswalk w/ shelter (in front of the MSU Federal Credit Union)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	59	13	1	73

Jaywalkers from west side of the crosswalk = 5 peds in 30 min
Jaywalkers from east side of the crosswalk = 7 peds in 30 min
Total pedestrians in the crosswalk area = 73 + 5 + 7= 85 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{59}{85} = 69.4\%$$

Total pedestrian volume in the crosswalk area = 85 * 2 = 170 peds / hr

8- 1st Unmarked Midblock Crosswalk w/o shelter (in front of SPLASH)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	42	0	27	69

Jaywalkers from west side of the crosswalk = 3 peds in 30 min
Jaywalkers from east side of the crosswalk = 0 peds in 30 min
Total pedestrians in the crosswalk area = 69 + 3 + 0 = 72 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{42}{72} = 58.3\%$$

Total pedestrian volume in the crosswalk area = 72 * 2 = 144 peds / hr

DATA SUMMARY

Date:4/23/98, Thu, 11:02a AM Off-Peak
Low 70s, Sunny

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

9- 2nd Unmarked Midblock Crosswalk w/o shelter (in front of University Pizza)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	47	0	18	65

Jaywalkers from west side of the crosswalk = 0 peds in 30 min
Jaywalkers from east side of the crosswalk = 4 peds in 30 min
Total pedestrians in the crosswalk area = 65 + 0 + 4 = 69 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{47}{69} = 68.1\%$$

Total pedestrian volume in the crosswalk area = 69 * 2 = 138 peds / hr

10- Marked Midblock Crosswalk w/o shelter (in front of Good Time Pizza)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	74	7	1	82

Jaywalkers from west side of the crosswalk = 10 peds in 30 min
Jaywalkers from east side of the crosswalk = 3 peds in 30 min
Total pedestrians in the crosswalk area = 82 + 10 + 3 = 95 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{74}{95} = 77.9\%$$

Total pedestrian volume in the crosswalk area = 95 * 2 = 190 peds / hr

DATA SUMMARY

Date:4/23/98, Thu, 11:02a AM Off-Peak
Low 70s, Sunny

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

11- Collingwood St. West-Side Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	9	0	0	4	9
PS (VR)	4	0	0	0	4
S	6	0	0	5	6
LS	5	0	0	2	5
Total	24	0	0	11	24

RU: Regular users S: Sneakers
PS (VS): Partial sneakers (vehicles stopped) LS: Late starters
PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 1 peds in 30 min
Jaywalkers from east side of the crosswalk = 0 peds in 30 min
Total pedestrians in the crosswalk area = 24 + 1 + 0 = 25 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\text{no of RUs + no PS(VS)s on-crosswalk}}{\text{total peds in the crosswalk area}} = \frac{9}{25} = 36.0\%$$

Total pedestrian volume in the crosswalk area = 25 * 2 = 50 peds / hr

12- Collingwood St. East-Side Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	14	0	0	4	14
PS (VR)	7	0	0	1	7
S	5	2	1	1	8
LS	1	0	0	0	1
Total	27	2	1	6	30

RU: Regular users S: Sneakers
PS (VS): Partial sneakers (vehicles stopped) LS: Late starters
PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 0 peds in 30 min
Jaywalkers from east side of the crosswalk = 9 peds in 30 min
Total pedestrians in the crosswalk area = 30 + 0 + 9 = 39 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\text{no of RUs + no PS(VS)s on-crosswalk}}{\text{total peds in the crosswalk area}} = \frac{14}{39} = 35.9\%$$

Total pedestrian volume in the crosswalk area = 39 * 2 = 78 peds / hr

DATA SUMMARY

Date:4/23/98, Thu, 11:02a
Low 70s, Sunny

AM Off-Peak

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

13- Orchard St. Unsignalized Intersection Crosswalk

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	64	10	1	75

Jaywalkers from west side of the crosswalk = 5 peds in 30 min
Jaywalkers from east side of the crosswalk = 2 peds in 30 min
Total pedestrians in the crosswalk area = 75 + 5 + 2 = 82 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{64}{82} = 78.0\%$$

Total pedestrian volume in the crosswalk area = 78 * 2 = 156 peds / hr

Gd River Ave Crosswalks (Abbott - Division Sts)

DATA SUMMARY

Date:2/23/98, Mon, 2:46p PM Peak

35 F, cold, partly sunny

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

1- Abbot St. Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	47	2	0	11	49
PS (VR)	14	1	0	2	15
S	32	2	2	3	36
LS	9	1	0	1	10
Total	102	6	2	17	110

RU: Regular users S: Sneakers
PS (VS): Partial sneakers (vehicles stopped) LS: Late starters
PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 5 peds in 30 min
Jaywalkers from east side of the crosswalk = 3 peds in 30 min
Total pedestrians in the crosswalk area = 110 + 5 + 3 = 118 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{47}{118} = 39.8\%$$

Total pedestrian volume in the crosswalk area = 118 * 2 = 236 peds / hr

2- Marked Midblock Crosswalk w/ shelter (in front of the MSU Student Union)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	45	5	4	54

Jaywalkers from west side of the crosswalk = 0 peds in 30 min
Jaywalkers from east side of the crosswalk = 2 peds in 30 min
Total pedestrians in the crosswalk area = 54 + 0 + 2 = 56 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{45}{56} = 80.4\%$$

Total pedestrian volume in the crosswalk area = 56 * 2 = 112 peds / hr

DATA SUMMARY

Date:2/23/98, Mon, 2:46p PM Peak

35 F, cold, partly sunny

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

3- M.A.C. Ave. Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	15	5	1	6	21
PS (VR)	15	1	1	2	17
S	13	3	0	1	16
LS	8	2	0	2	10
Total	51	11	2	11	64

RU: Regular users S: Sneakers
PS (VS): Partial sneakers (vehicles stopped) LS: Late starters
PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 8 peds in 30 min
Jaywalkers from east side of the crosswalk = 1 peds in 30 min
Total pedestrians in the crosswalk area = 64 + 8 + 1 = 73 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{15}{73} = 20.5\%$$

Total pedestrian volume in the crosswalk area = 73 * 2 = 146 peds / hr

4- Marked Midblock Crosswalk w/o shelter (in front of Jabobson's)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	14	4	2	20

Jaywalkers from west side of the crosswalk = 2 peds in 30 min
Jaywalkers from east side of the crosswalk = 3 peds in 30 min
Total pedestrians in the crosswalk area = 20 + 2 + 3 = 25 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{14}{25} = 56.0\%$$

Total pedestrian volume in the crosswalk area = 25 * 2 = 50 peds / hr

DATA SUMMARY

Date:2/23/98, Mon, 2:46p
35 F, cold, partly sunny

PM Peak

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

5- Charles St. Unsignalized Intersection Crosswalk

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	29	10	1	40

Jaywalkers from west side of the crosswalk = 6 peds in 30 min
Jaywalkers from east side of the crosswalk = 7 peds in 30 min
Total pedestrians in the crosswalk area = 40 + 6 + 7 = 53 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{29}{53} = 54.7\%$$

Total pedestrian volume in the crosswalk area = 53 * 2 = 106 peds / hr

6- Division St. Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	70	1	1	4	72
PS (VR)	18	0	0	0	18
S	19	12	1	8	32
LS	17	0	0	1	17
Total	124	13	2	13	139

RU: Regular users
PS (VS): Partial sneakers (vehicles stopped)
PS (VR): Partial sneakers (vehicles running)
S: Sneakers
LS: Late starters

Jaywalkers from west side of the crosswalk = 13 peds in 30 min
Jaywalkers from east side of the crosswalk = 6 peds in 30 min
Total pedestrians in the crosswalk area = 139 + 13 + 6 = 158 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{70}{158} = 44.3\%$$

Total pedestrian volume in the crosswalk area = 158 * 2 = 316 peds / hr

DATA SUMMARY

Date:4/24/98, Fri, 3:26p PM Peak
High 60s, sunny

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

7- Marked Midblock Crosswalk w/ shelter (in front of the MSU Federal Credit Union)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	80	7	1	88

Jaywalkers from west side of the crosswalk = 7 peds in 30 min

Jaywalkers from east side of the crosswalk = 3 peds in 30 min

Total pedestrians in the crosswalk area = 88 + 7 + 3 = 98 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{80}{98} = 81.6\%$$

Total pedestrian volume in the crosswalk area = 98 * 2 = 196 peds / hr

8- 1st Unmarked Midblock Crosswalk w/o shelter (in front of SPLASH)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	23	0	10	33

Jaywalkers from west side of the crosswalk = 3 peds in 30 min

Jaywalkers from east side of the crosswalk = 0 peds in 30 min

Total pedestrians in the crosswalk area = 33 + 3 + 0 = 36 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{23}{36} = 63.9\%$$

Total pedestrian volume in the crosswalk area = 36 * 2 = 72 peds / hr

Gd River Ave Crosswalks (Division - Bogue Sts)

DATA SUMMARY

Date:4/24/98, Fri, 3:26p
High 60s, sunny

PM Peak

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

9- 2nd Unmarked Midblock Crosswalk w/o shelter (in front of University Pizza)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	15	0	3	18

Jaywalkers from west side of the crosswalk = 3 peds in 30 min
Jaywalkers from east side of the crosswalk = 2 peds in 30 min
Total pedestrians in the crosswalk area = 18 + 3 + 2 = 23 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{15}{23} = 65.2\%$$

Total pedestrian volume in the crosswalk area = 23 * 2 = 46 peds / hr

10- Marked Midblock Crosswalk w/o shelter (in front of Good Time Pizza)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	39	0	0	39

Jaywalkers from west side of the crosswalk = 3 peds in 30 min
Jaywalkers from east side of the crosswalk = 1 peds in 30 min
Total pedestrians in the crosswalk area = 39 + 3 + 1 = 43 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{39}{43} = 90.7\%$$

Total pedestrian volume in the crosswalk area = 43 * 2 = 86 peds / hr

DATA SUMMARY

Date:4/24/98, Fri, 3:26p
High 60s, sunny

PM Peak

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

11- Collingwood St. West-Side Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	8	2	0	2	10
PS (VR)	0	0	0	0	0
S	5	0	1	1	6
LS	1	2	0	1	3
Total	14	4	1	4	19

RU: Regular users — S: Sneakers
PS (VS): Partial sneakers (vehicles stopped) — LS: Late starters
PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 1 peds in 30 min
Jaywalkers from east side of the crosswalk = 0 peds in 30 min
Total pedestrians in the crosswalk area = 19 + 1 + 0 = 20 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{8}{20} = 40.0\%$$

Total pedestrian volume in the crosswalk area = 20 * 2 = 40 peds / hr

12- Collingwood St. East-Side Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	10	0	0	5	10
PS (VR)	0	0	0	0	0
S	3	0	0	0	3
LS	2	0	0	0	2
Total	15	0	0	5	15

RU: Regular users — S: Sneakers
PS (VS): Partial sneakers (vehicles stopped) — LS: Late starters
PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 0 peds in 30 min
Jaywalkers from east side of the crosswalk = 6 peds in 30 min
Total pedestrians in the crosswalk area = 15 + 0 + 6 = 21 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{10}{21} = 47.6\%$$

Total pedestrian volume in the crosswalk area = 16 * 2 = 32 peds / hr

DATA SUMMARY

Date:4/24/98, Fri, 3:26p
High 60s, sunny

PM Peak

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

13- Orchard St. Unsignalized Intersection Crosswalk

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	21	0	0	21

Jaywalkers from west side of the crosswalk = 6 peds in 30 min
Jaywalkers from east side of the crosswalk = 1 peds in 30 min
Total pedestrians in the crosswalk area = 21 + 6 + 1 = 28 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{21}{28} = 75.0\%$$

Total pedestrian volume in the crosswalk area = 28 * 2 = 56 peds / hr

Gd River Ave Crosswalks (Abbott - Bogue Sts)

DATA SUMMARY

Date:2/25/98 Time: 2:36 pm PM Peak

High 40s, warm, sunny

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

1- Abbot St. Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	69	0	0	15	69
PS (VR)	21	0	0	0	21
S	24	2	0	8	26
LS	16	2	0	0	18
Total	130	4	0	23	134

RU: Regular users S: Sneakers
PS (VS): Partial sneakers (vehicles stopped) LS: Late starters
PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 9 peds in 30 min

Jaywalkers from east side of the crosswalk = 1 peds in 30 min

Total pedestrians in the crosswalk area = 134 + 9 + 1 = 144 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{69}{144} = 47.9\%$$

Total pedestrian volume in the crosswalk area = 144 * 2 = 288 peds / hr

2- Marked Midblock Crosswalk w/ shelter (in front of the MSU Student Union)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	16	1	1	18

Jaywalkers from west side of the crosswalk = 0 peds in 30 min

Jaywalkers from east side of the crosswalk = 6 peds in 30 min

Total pedestrians in the crosswalk area = 18 + 0 + 6 = 24 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{16}{24} = 66.7\%$$

Total pedestrian volume in the crosswalk area = 24 * 2 = 48 peds / hr

DATA SUMMARY

Date:2/25/98 Time: 2:36 pm PM Peak
High 40s, warm, sunny

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

3- M.A.C. Ave. Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	53	0	2	5	55
PS (VR)	30	0	1	4	31
S	17	0	1	2	18
LS	6	1	0	1	7
Total	106	1	4	12	111

RU: Regular users S: Sneakers
PS (VS): Partial sneakers (vehicles stopped) LS: Late starters
PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 6 peds in 30 min
Jaywalkers from east side of the crosswalk = 2 peds in 30 min
Total pedestrians in the crosswalk area = 111 + 6 + 2 = 119 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{53}{119} = 44.5\%$$

Total pedestrian volume in the crosswalk area = 119 * 2 = 238 peds / hr

4- Marked Midblock Crosswalk w/o shelter (in front of Jabobson's)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	23	2	2	27

Jaywalkers from west side of the crosswalk = 6 peds in 30 min
Jaywalkers from east side of the crosswalk = 2 peds in 30 min
Total pedestrians in the crosswalk area = 27 + 6 + 2 = 35 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{23}{35} = 65.7\%$$

Total pedestrian volume in the crosswalk area = 35 * 2 = 70 peds / hr

DATA SUMMARY

Date:2/25/98 Time: 2:36 pm PM Peak
High 40s, warm, sunny

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

5- Charles St. Unsignalized Intersection Crosswalk

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	32	3	4	39

Jaywalkers from west side of the crosswalk = 1 peds in 30 min
Jaywalkers from east side of the crosswalk = 8 peds in 30 min
Total pedestrians in the crosswalk area = 39 + 1 + 8 = 48 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{32}{48} = 66.7\%$$

Total pedestrian volume in the crosswalk area = 48 * 2 = 96 peds / hr

6- Division St. Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	117	17	2	8	136
PS (VR)	18	2	1	2	21
S	57	8	2	5	67
LS	20	4	0	1	24
Total	212	31	5	16	248

RU: Regular users S: Sneakers
PS (VS): Partial sneakers (vehicles stopped) LS: Late starters
PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 12 peds in 30 min
Jaywalkers from east side of the crosswalk = 11 peds in 30 min
Total pedestrians in the crosswalk area = 248 + 12 + 11 = 271 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{117}{271} = 43.2\%$$

Total pedestrian volume in the crosswalk area = 271 * 2 = 542 peds / hr

DATA SUMMARY

Date:4/28/98, Tue, 10:58a
Low 60s, Sunny

AM Off-Peak

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (DIVISION - BOGUE STS)

7- Marked Midblock Crosswalk w/ shelter (in front of the MSU Federal Credit Union)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	88	8	3	99

Jaywalkers from west side of the crosswalk = 14 peds in 30 min
Jaywalkers from east side of the crosswalk = 7 peds in 30 min
Total pedestrians in the crosswalk area = 99 + 14 + 7= 120 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{88}{120} = 73.3\%$$

Total pedestrian volume in the crosswalk area = 120 * 2 = 240 peds / hr

8- 1st Unmarked Midblock Crosswalk w/o shelter (in front of SPLASH)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	15	0	3	18

Jaywalkers from west side of the crosswalk = 2 peds in 30 min
Jaywalkers from east side of the crosswalk = 4 peds in 30 min
Total pedestrians in the crosswalk area = 18 + 2 + 4 = 24 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{15}{24} = 62.5\%$$

Total pedestrian volume in the crosswalk area = 24 * 2 = 48 peds / hr

Gd River Ave Crosswalks (Division - Bogue Sts)

DATA SUMMARY

Date:4/28/98, Tue, 10:58a
Low 60s, Sunny

AM Off-Peak

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (DIVISION - BOGUE STS)

9- 2nd Unmarked Midblock Crosswalk w/o shelter (in front of University Pizza)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	24	0	10	34

Jaywalkers from west side of the crosswalk = 3 peds in 30 min

Jaywalkers from east side of the crosswalk = 4 peds in 30 min

Total pedestrians in the crosswalk area = 34 + 3 + 4 = 41 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{24}{41} = 58.5\%$$

Total pedestrian volume in the crosswalk area = 41 * 2 = 82 peds / hr

10- Marked Midblock Crosswalk w/o shelter (in front of Good Time Pizza)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	40	8	0	48

Jaywalkers from west side of the crosswalk = 10 peds in 30 min

Jaywalkers from east side of the crosswalk = 1 peds in 30 min

Total pedestrians in the crosswalk area = 48 + 10 + 1 = 59 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{40}{59} = 67.8\%$$

Total pedestrian volume in the crosswalk area = 59 * 2 = 118 peds / hr

DATA SUMMARY

Date:4/28/98, Tue, 10:58a
Low 60s, Sunny

AM Off-Peak

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (DIVISION - BOGUE STS)

11- Collingwood St. West-Side Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	19	1	0	7	20
PS (VR)	3	0	0	1	3
S	5	0	0	5	5
LS	5	1	0	0	6
Total	32	2	0	13	34

RU: Regular users
PS (VS): Partial sneakers (vehicles stopped)
PS (VR): Partial sneakers (vehicles running)
S: Sneakers
LS: Late starters

Jaywalkers from west side of the crosswalk = 1 peds in 30 min
Jaywalkers from east side of the crosswalk = 0 peds in 30 min
Total pedestrians in the crosswalk area = 34 + 1 + 0 = 35 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RU + no PS(VS) on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{19}{35} = 54.3\%$$

Total pedestrian volume in the crosswalk area = 35 * 2 = 70 peds / hr

12- Collingwood St. East-Side Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	18	0	0	2	18
PS (VR)	1	0	0	0	1
S	1	0	0	1	1
LS	6	0	0	0	6
Total	26	0	0	3	26

RU: Regular users
PS (VS): Partial sneakers (vehicles stopped)
PS (VR): Partial sneakers (vehicles running)
S: Sneakers
LS: Late starters

Jaywalkers from west side of the crosswalk = 0 peds in 30 min
Jaywalkers from east side of the crosswalk = 12 peds in 30 min
Total pedestrians in the crosswalk area = 26 + 0 + 12 = 38 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RU + no PS(VS) on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{18}{38} = 47.4\%$$

Total pedestrian volume in the crosswalk area = 38 * 2 = 76 peds / hr

DATA SUMMARY

Date:4/28/98, Tue, 10:58a
Low 60s, Sunny

AM Off-Peak

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (DIVISION - BOGUE STS)

13- Orchard St. Unsignalized Intersection Crosswalk

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	43	10	3	56

Jaywalkers from west side of the crosswalk = 7 peds in 30 min
Jaywalkers from east side of the crosswalk = 5 peds in 30 min
Total pedestrians in the crosswalk area = 56 + 7 + 5 = 68 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{43}{68} = 63.2\%$$

Total pedestrian volume in the crosswalk area = 68 * 2 = 136 peds / hr

DATA SUMMARY

Date:2/26/98 Time:10:35am AM Off-Peak

High 40s, warm, sunny

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

1- Abbot St. Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	13	4	0	1	17
PS (VR)	4	0	0	0	4
S	20	1	1	2	22
LS	2	1	0	0	3
Total	39	6	1	3	46

RU: Regular users S: Sneakers
PS (VS): Partial sneakers (vehicles stopped) LS: Late starters
PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 0 peds in 30 min
Jaywalkers from east side of the crosswalk = 2 peds in 30 min
Total pedestrians in the crosswalk area = 46 + 0 + 2 = 48 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{13}{48} = 27.1\%$$

Total pedestrian volume in the crosswalk area = 48 * 2 = 96 peds / hr

2- Marked Midblock Crosswalk w/ shelter (in front of the MSU Student Union)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	16	5	2	23

Jaywalkers from west side of the crosswalk = 1 peds in 30 min
Jaywalkers from east side of the crosswalk = 4 peds in 30 min
Total pedestrians in the crosswalk area = 19 + 1 + 4 = 24 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{16}{24} = 66.7\%$$

Total pedestrian volume in the crosswalk area = 24 * 2 = 48 peds / hr

DATA SUMMARY

Date:2/26/98 Time:10:35am AM Off-Peak

High 40s, warm, sunny

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

3- M.A.C. Ave. Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	55	3	0	4	58
PS (VR)	34	0	0	5	34
S	21	2	1	3	24
LS	7	1	0	0	8
Total	117	6	1	12	124

RU: Regular users S: Sneakers

PS (VS): Partial sneakers (vehicles stopped) LS: Late starters

PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 8 peds in 30 min

Jaywalkers from east side of the crosswalk = 6 peds in 30 min

Total pedestrians in the crosswalk area = 124+ 8 + 6 = 138 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{55}{138} = 39.9\%$$

Total pedestrian volume in the crosswalk area = 138 * 2 = 276 peds / hr

4- Marked Midblock Crosswalk w/o shelter (in front of Jabobson's)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	13	10	1	24

Jaywalkers from west side of the crosswalk = 2 peds in 30 min

Jaywalkers from east side of the crosswalk = 3 peds in 30 min

Total pedestrians in the crosswalk area = 24 + 2 + 3 = 29 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{13}{29} = 44.8\%$$

Total pedestrian volume in the crosswalk area = 29 * 2 = 58 peds / hr

DATA SUMMARY

Date:2/26/98 Time:10:35am AM Off-Peak

High 40s, warm, sunny

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

5- Charles St. Unsignalized Intersection Crosswalk

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	58	12	2	72

Jaywalkers from west side of the crosswalk = 11 peds in 30 min

Jaywalkers from east side of the crosswalk = 8 peds in 30 min

Total pedestrians in the crosswalk area = 72 + 11 + 8 = 91 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{58}{91} = 63.7\%$$

Total pedestrian volume in the crosswalk area = 91 * 2 = 182 peds / hr

6- Division St. Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	189	7	0	7	196
PS (VR)	69	0	0	2	69
S	51	7	0	5	58
LS	35	0	1	0	36
Total	344	14	1	14	359

RU: Regular users S: Sneakers

PS (VS): Partial sneakers (vehicles stopped) LS: Late starters

PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 10 peds in 30 min

Jaywalkers from east side of the crosswalk = 7 peds in 30 min

Total pedestrians in the crosswalk area = 359 + 10 + 7 = 376 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{189}{376} = 50.3\%$$

Total pedestrian volume in the crosswalk area = 376 * 2 = 752 peds / hr

DATA SUMMARY

Date:4/30/98, Thu, 10:59a AM Off-Peak
High 60s, Cloudy

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (DIVISION - BOGUE STS)

7- Marked Midblock Crosswalk w/ shelter (in front of the MSU Federal Credit Union)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	84	9	3	96

Jaywalkers from west side of the crosswalk = 15peds in 30 min
Jaywalkers from east side of the crosswalk = 9 peds in 30 min
Total pedestrians in the crosswalk area = 96 + 15 + 9= 120 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{84}{120} = 70.0\%$$

Total pedestrian volume in the crosswalk area = 120 * 2 = 240 peds / hr

8- 1st Unmarked Midblock Crosswalk w/o shelter (in front of SPLASH)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	21	0	3	24

Jaywalkers from west side of the crosswalk = 0 peds in 30 min
Jaywalkers from east side of the crosswalk = 10 peds in 30 min
Total pedestrians in the crosswalk area = 24 + 0 + 10 = 34 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{21}{34} = 61.8\%$$

Total pedestrian volume in the crosswalk area = 34 * 2 = 68 peds / hr

DATA SUMMARY

Date:4/30/98, Thu, 10:59a
High 60s, Cloudy

AM Off-Peak

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (DIVISION - BOGUE STS)

9- 2nd Unmarked Midblock Crosswalk w/o shelter (in front of University Pizza)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	21	0	5	26

Jaywalkers from west side of the crosswalk = 6 peds in 30 min

Jaywalkers from east side of the crosswalk = 1 peds in 30 min

Total pedestrians in the crosswalk area = 26 + 6 + 1 = 33 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{21}{33} = 63.6\%$$

Total pedestrian volume in the crosswalk area = 33 * 2 = 66 peds / hr

10- Marked Midblock Crosswalk w/o shelter (in front of Good Time Pizza)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	70	2	1	73

Jaywalkers from west side of the crosswalk = 3 peds in 30 min

Jaywalkers from east side of the crosswalk = 1 peds in 30 min

Total pedestrians in the crosswalk area = 73 + 3 + 1 = 77 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{70}{77} = 90.9\%$$

Total pedestrian volume in the crosswalk area = 77 * 2 = 154 peds / hr

DATA SUMMARY

Date:4/30/98, Thu, 10:59a
High 60s, Cloudy

AM Off-Peak

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (DIVISION - BOGUE STS)

11- Collingwood St. West-Side Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	17	0	0	7	17
PS (VR)	4	0	0	3	4
S	5	0	1	5	6
LS	1	0	0	1	1
Total	27	0	1	16	28

RU: Regular users
PS (VS): Partial sneakers (vehicles stopped)
PS (VR): Partial sneakers (vehicles running)
S: Sneakers
LS: Late starters

Jaywalkers from west side of the crosswalk = 0 peds in 30 min
Jaywalkers from east side of the crosswalk = 0 peds in 30 min
Total pedestrians in the crosswalk area = 28 + 0 + 0 = 28 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{17}{28} = 60.7\%$$

Total pedestrian volume in the crosswalk area = 28 * 2 = 56 peds / hr

12- Collingwood St. East-Side Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	15	0	0	2	15
PS (VR)	4	0	0	0	4
S	1	0	0	0	1
LS	2	0	0	0	2
Total	22	0	0	2	22

RU: Regular users
PS (VS): Partial sneakers (vehicles stopped)
PS (VR): Partial sneakers (vehicles running)
S: Sneakers
LS: Late starters

Jaywalkers from west side of the crosswalk = 0 peds in 30 min
Jaywalkers from east side of the crosswalk = 8 peds in 30 min
Total pedestrians in the crosswalk area = 22 + 0 + 8 = 30 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{15}{30} = 50.0\%$$

Total pedestrian volume in the crosswalk area = 30 * 2 = 60 peds / hr

DATA SUMMARY

Date:4/30/98, Thu, 10:59a
High 60s, Cloudy

AM Off-Peak

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (DIVISION - BOGUE STS)

13- Orchard St. Unsignalized Intersection Crosswalk

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	39	6	1	46

Jaywalkers from west side of the crosswalk = 5 peds in 30 min
Jaywalkers from east side of the crosswalk = 5 peds in 30 min
Total pedestrians in the crosswalk area = 46 + 5 + 5 = 56 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{39}{56} = 69.6\%$$

Total pedestrian volume in the crosswalk area = 56 * 2 = 112 peds / hr

DATA SUMMARY

Date:5/27/98 Time: 10:36 am AM Off-Peak
Mid 80Fs, Sunny

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

1- Abbot St. Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	14	1	0	1	15
PS (VR)	5	1	0	0	6
S	8	0	3	3	11
LS	2	0	0	1	2
Total	29	2	3	5	34

RU: Regular users S: Sneakers
PS (VS): Partial sneakers (vehicles stopped) LS: Late starters
PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 1 peds in 30 min
Jaywalkers from east side of the crosswalk = 2 peds in 30 min
Total pedestrians in the crosswalk area = 34 + 1 + 2 = 37 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{14}{37} = 37.8\%$$

Total pedestrian volume in the crosswalk area = 37 * 2 = 74 peds / hr

2- Marked Midblock Crosswalk w/ shelter (in front of the MSU Student Union)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	9	0	2	11

Jaywalkers from west side of the crosswalk = 1 peds in 30 min
Jaywalkers from east side of the crosswalk = 2 peds in 30 min
Total pedestrians in the crosswalk area = 11 + 1 + 2 = 14 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{9}{14} = 64.3\%$$

Total pedestrian volume in the crosswalk area = 14 * 2 = 28 peds / hr

DATA SUMMARY

Date:5/27/98 Time: 10:36 am
Mid 80Fs, Sunny

AM Off-Peak

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

3- M.A.C. Ave. Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	6	0	0	0	6
PS (VR)	0	0	0	0	0
S	5	1	0	2	6
LS	1	0	0	3	1
Total	12	1	0	5	13

RU: Regular users S: Sneakers
PS (VS): Partial sneakers (vehicles stopped) LS: Late starters
PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 3 peds in 30 min
Jaywalkers from east side of the crosswalk = 0 peds in 30 min
Total pedestrians in the crosswalk area = 13 + 3 + 0 = 16 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{6}{16} = 37.5\%$$

Total pedestrian volume in the crosswalk area = 16 * 2 = 32 peds / hr

4- Marked Midblock Crosswalk w/o shelter (in front of Jabobson's)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	16	4	0	20

Jaywalkers from west side of the crosswalk = 2 peds in 30 min
Jaywalkers from east side of the crosswalk = 2 peds in 30 min
Total pedestrians in the crosswalk area = 20 + 2 + 2 = 24 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{16}{24} = 66.7\%$$

Total pedestrian volume in the crosswalk area = 24 * 2 = 48 peds / hr

DATA SUMMARY

Date:5/27/98 Time: 10:36 am
Mid 80Fs, Sunny

AM Off-Peak

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

5- Charles St. Unsignalized Intersection Crosswalk

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	72	4	0	76

Jaywalkers from west side of the crosswalk = 10 peds in 30 min

Jaywalkers from east side of the crosswalk = 7 peds in 30 min

Total pedestrians in the crosswalk area = 76 + 10 + 7 = 93 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{72}{93} = 77.4\%$$

Total pedestrian volume in the crosswalk area = 93 * 2 = 186 peds / hr

6- Division St. Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	45	0	0	7	45
PS (VR)	14	0	0	2	14
S	21	1	0	4	22
LS	11	0	0	0	11
Total	91	1	0	13	92

RU: Regular users S: Sneakers

PS (VS): Partial sneakers (vehicles stopped) LS: Late starters

PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 5 peds in 30 min

Jaywalkers from east side of the crosswalk = 5 peds in 30 min

Total pedestrians in the crosswalk area = 92 + 5 + 5 = 102 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{45}{102} = 44.1\%$$

Total pedestrian volume in the crosswalk area = 102 * 2 = 204 peds / hr

DATA SUMMARY

Date:5/28/98 Time:3:15 pm PM Peak
76 F, sunny

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

1- Abbot St. Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	7	0	0	4	7
PS (VR)	10	1	0	0	11
S	5	0	0	4	5
LS	6	0	0	3	6
Total	28	1	0	11	29

RU: Regular users S: Sneakers
PS (VS): Partial sneakers (vehicles stopped) LS: Late starters
PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 0 peds in 30 min
Jaywalkers from east side of the crosswalk = 3 peds in 30 min
Total pedestrians in the crosswalk area = 29 + 0 + 3 = 32 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{7}{32} = 21.9\%$$

Total pedestrian volume in the crosswalk area = 32 * 2 = 64 peds / hr

2- Marked Midblock Crosswalk w/ shelter (in front of the MSU Student Union)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	12	2	1	15

Jaywalkers from west side of the crosswalk = 1 peds in 30 min
Jaywalkers from east side of the crosswalk = 1 peds in 30 min
Total pedestrians in the crosswalk area = 15 + 1 + 1 = 17 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{12}{17} = 70.6\%$$

Total pedestrian volume in the crosswalk area = 17 * 2 = 34 peds / hr

DATA SUMMARY

Date:5/28/98 Time:3:15 pm PM Peak

76 F, sunny

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

3- M.A.C. Ave. Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	15	0	0	2	15
PS (VR)	7	2	0	0	9
S	2	1	0	3	3
LS	6	0	0	2	6
Total	30	3	0	7	33

RU: Regular users S: Sneakers

PS (VS): Partial sneakers (vehicles stopped) LS: Late starters

PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 2 peds in 30 min

Jaywalkers from east side of the crosswalk = 1 peds in 30 min

Total pedestrians in the crosswalk area = 33 + 2 + 1 = 36 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{15}{36} = 41.7\%$$

Total pedestrian volume in the crosswalk area = 36 * 2 = 72 peds / hr

4- Marked Midblock Crosswalk w/o shelter (in front of Jabobson's)

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	7	1	0	8

Jaywalkers from west side of the crosswalk = 2 peds in 30 min

Jaywalkers from east side of the crosswalk = 2 peds in 30 min

Total pedestrians in the crosswalk area = 8 + 2 + 2 = 12 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{7}{12} = 58.3\%$$

Total pedestrian volume in the crosswalk area = 12 * 2 = 24 peds / hr

DATA SUMMARY

Date:5/28/98 Time:3:15 pm
76 F, sunny

PM Peak

GD RIVER AVE (M-43) PEDESTRIAN CROSSWALKS (ABBOTT - BOGUE STS)

5- Charles St. Unsignalized Intersection Crosswalk

	On-crosswalk	Partial Jaywalkers	Jaywalkers	Total
Pedestrians	12	0	2	14

Jaywalkers from west side of the crosswalk = 2 peds in 30 min
Jaywalkers from east side of the crosswalk = 2 peds in 30 min
Total pedestrians in the crosswalk area = 14 + 2 + 2 = 18 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of Pedestrians on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{12}{18} = 66.7\%$$

Total pedestrian volume in the crosswalk area = 18 * 2 = 36 peds / hr

6- Division St. Signalized Intersection Crosswalk

Signalized	On-crosswalk	Partial Jaywalkers	Jaywalkers	Bikes	Total
RU + PS (VS)	28	0	0	2	28
PS (VR)	7	0	0	0	7
S	6	1	0	2	7
LS	4	0	0	1	4
Total	45	1	0	5	46

RU: Regular users S: Sneakers
PS (VS): Partial sneakers (vehicles stopped) LS: Late starters
PS (VR): Partial sneakers (vehicles running)

Jaywalkers from west side of the crosswalk = 2 peds in 30 min
Jaywalkers from east side of the crosswalk = 6 peds in 30 min
Total pedestrians in the crosswalk area = 46 + 2 + 6 = 54 peds in 30 min

$$\text{Pedestrian compliance} = \frac{\textit{no of RUs + no PS(VS)s on-crosswalk}}{\textit{total peds in the crosswalk area}} = \frac{28}{54} = 51.9\%$$

Total pedestrian volume in the crosswalk area = 54 * 2 = 108 peds / hr

APPENDIX B: Pedestrian Compliance Rates of All Marked Midblock Crosswalks

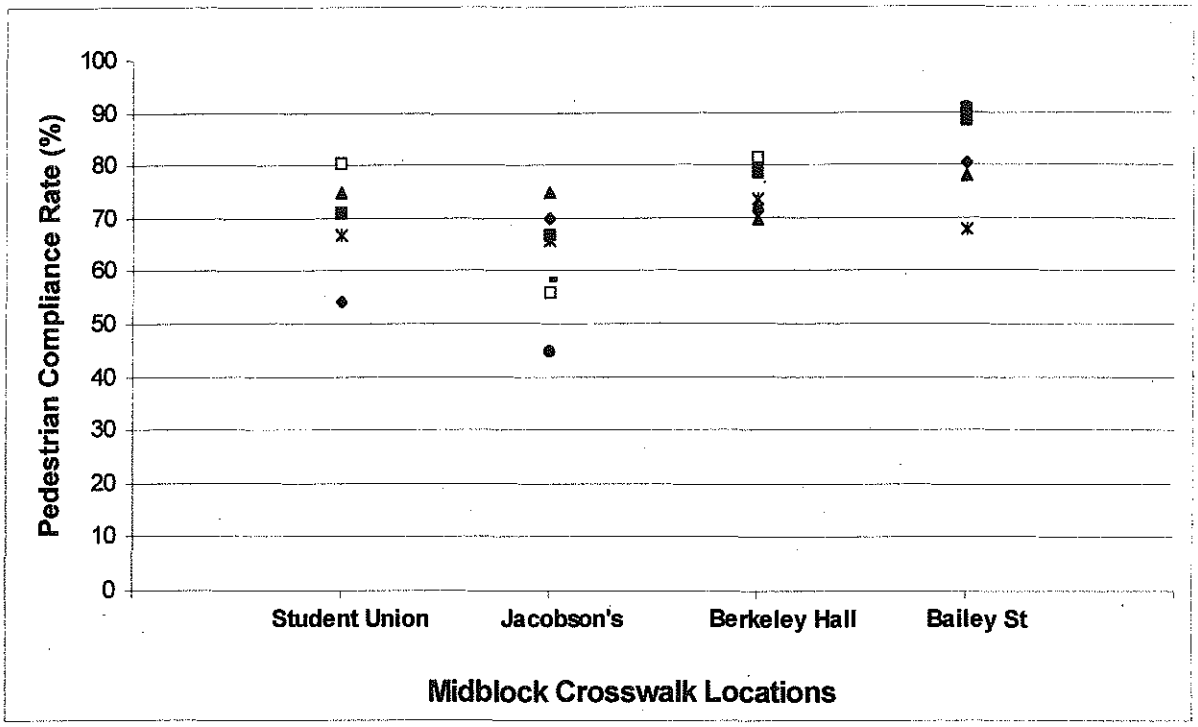

Figure B.1. Pedestrian compliance rates of all marked midblock crosswalks-- All data collection sessions

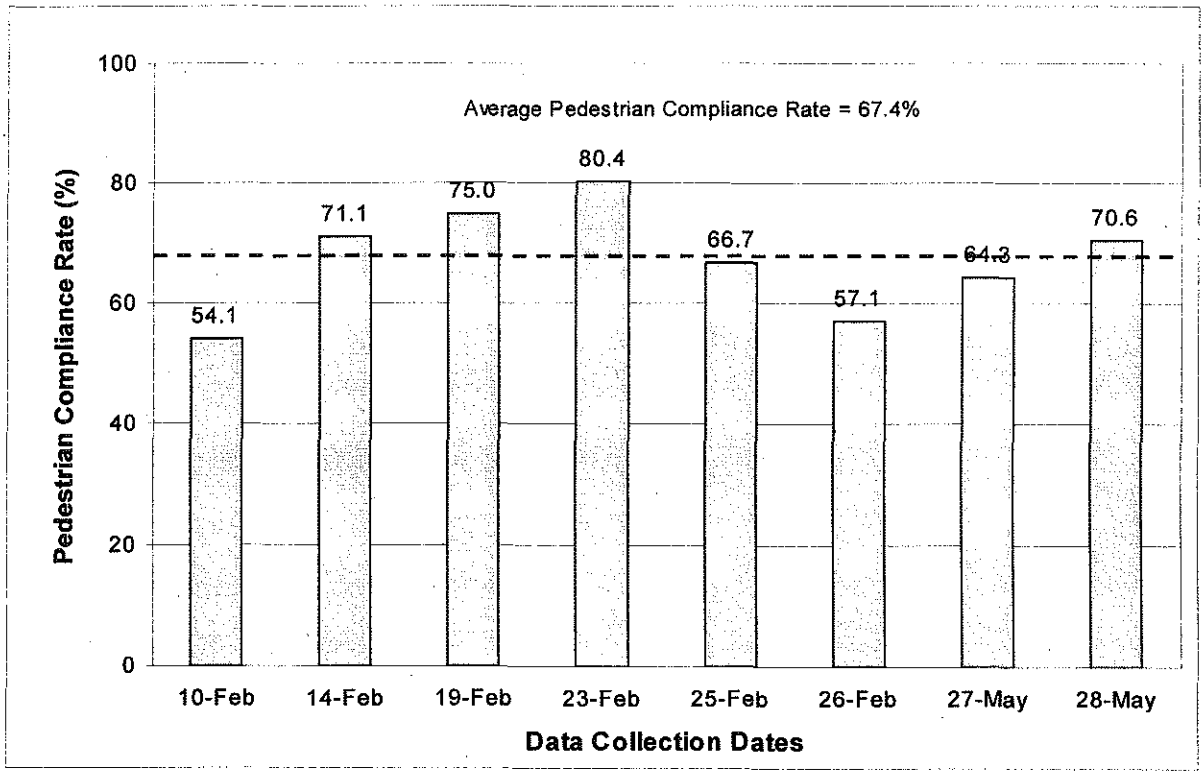

Figure B.2. Pedestrian compliance rates- MSU Student Union marked midblock crosswalk

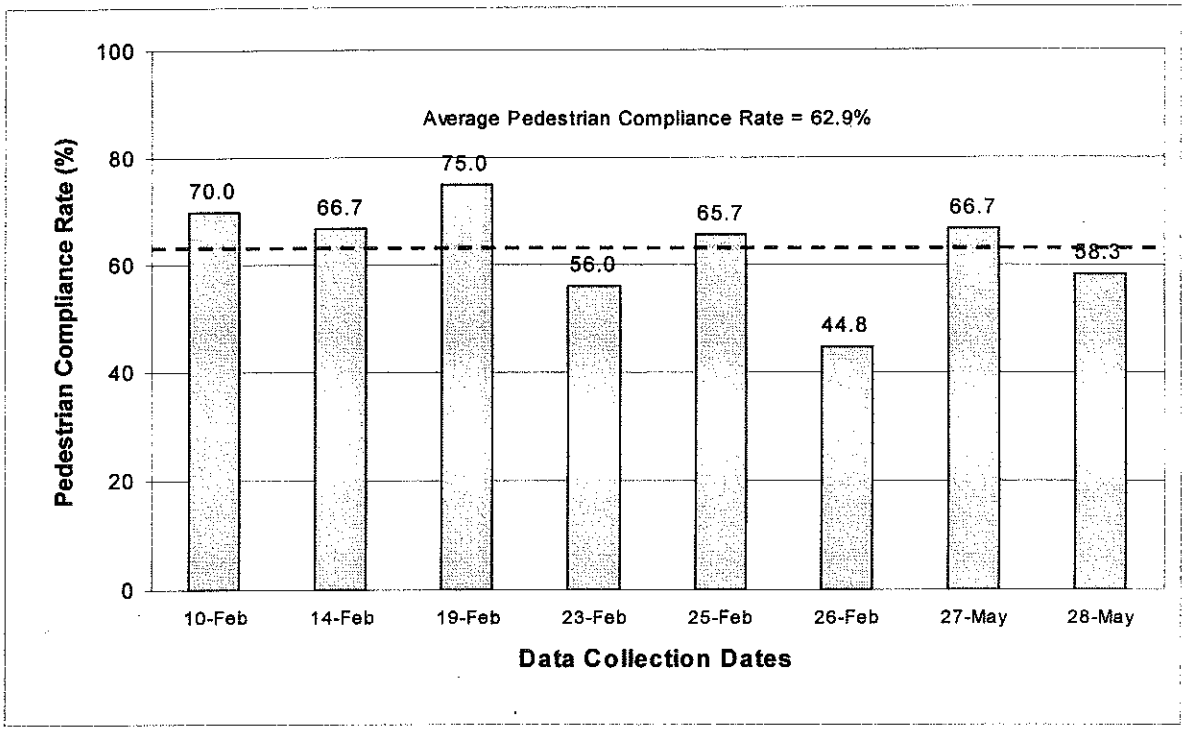

Figure B.3. Pedestrian compliance rates- Jacobson's marked midblock crosswalk

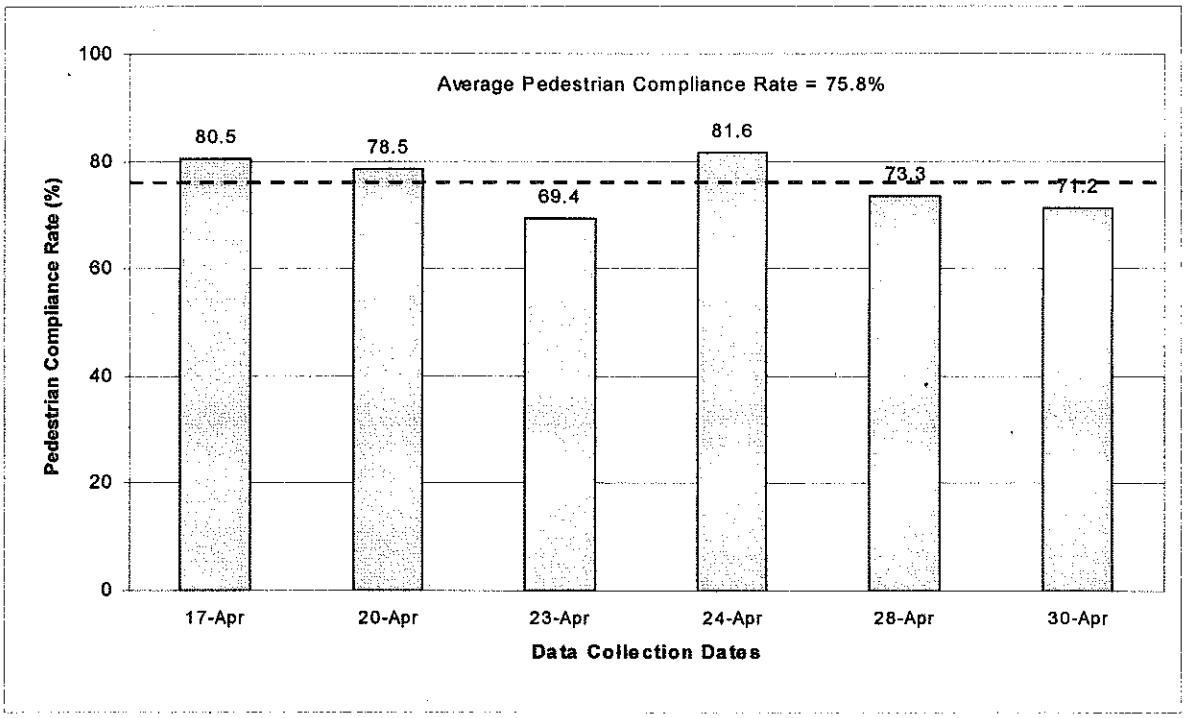

Figure B.4. Pedestrian compliance rates- MSU Federal Credit Union marked midblock crosswalk

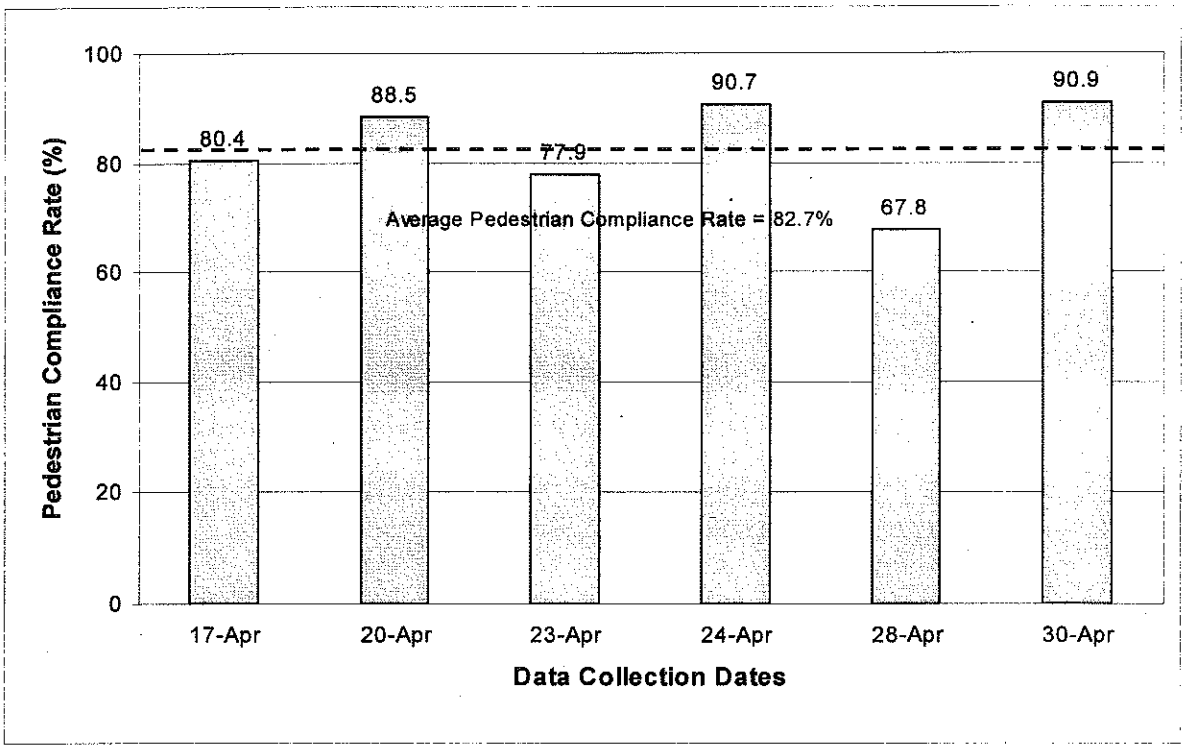

Figure B.5. Pedestrian compliance rates- Bailey Street marked midblock crosswalk

APPENDIX C: Pedestrian Compliance Rates of All Unmarked Midblock Crosswalks

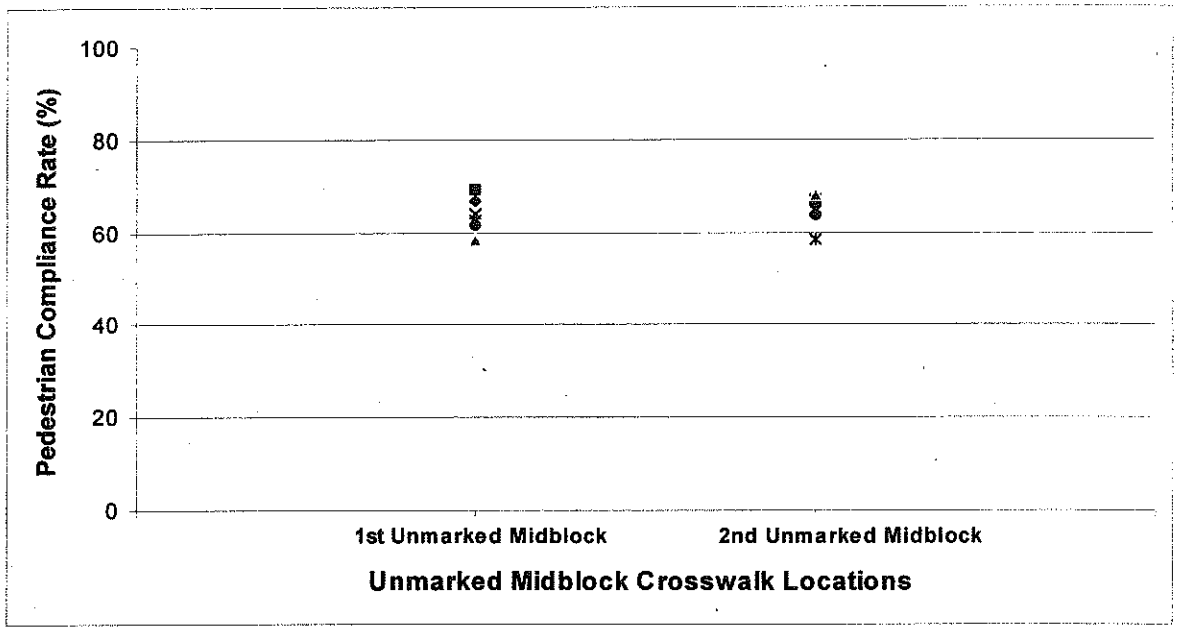

Figure C.1. Pedestrian compliance rates of all unmarked midblock crosswalks-- All data collection sessions

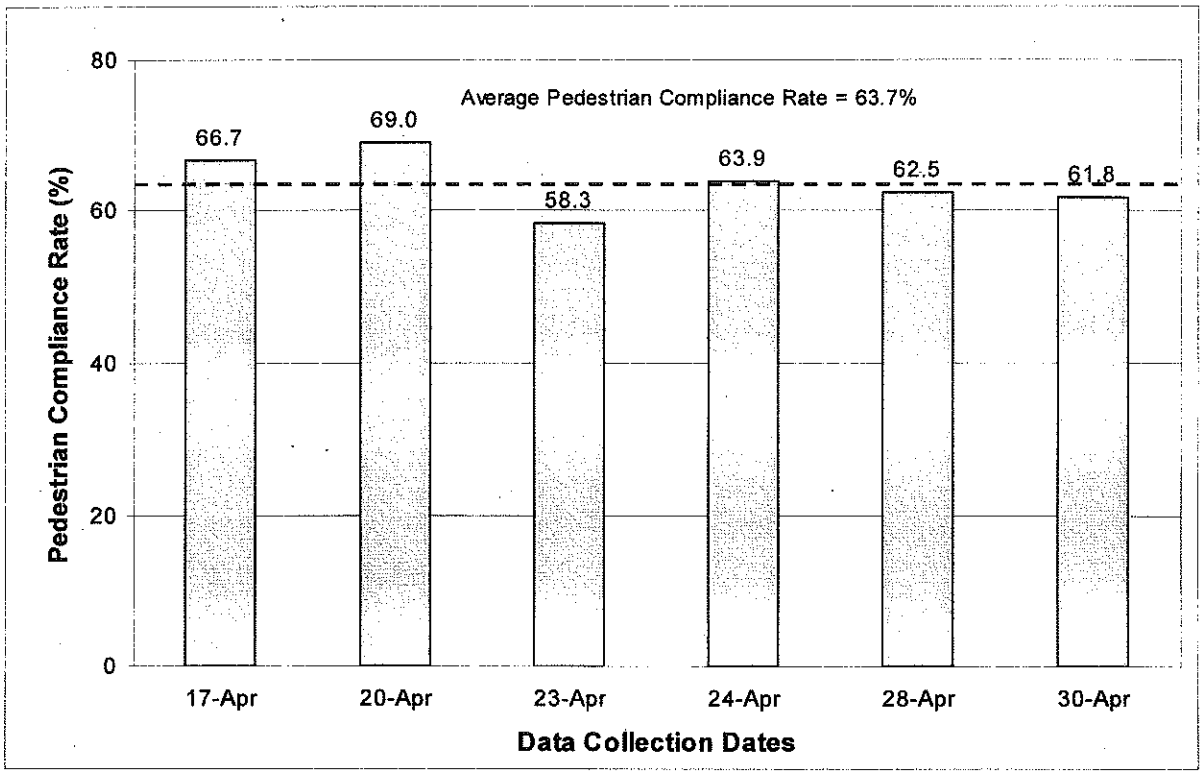

Figure C.2. Pedestrian compliance rates- 1st unmarked midblock crosswalk

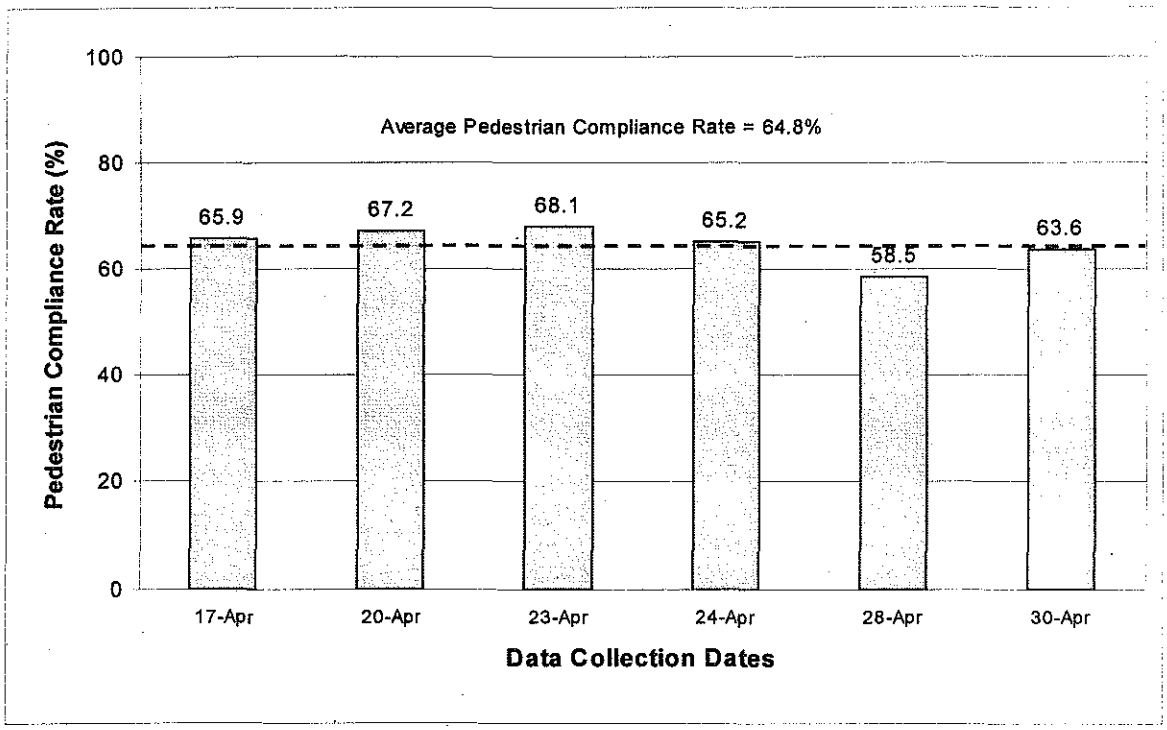

Figure C.3. Pedestrian compliance rates- 2nd unmarked midblock crosswalk

APPENDIX D: Pedestrian Compliance Rates of All Unsignalized Intersection Crosswalks

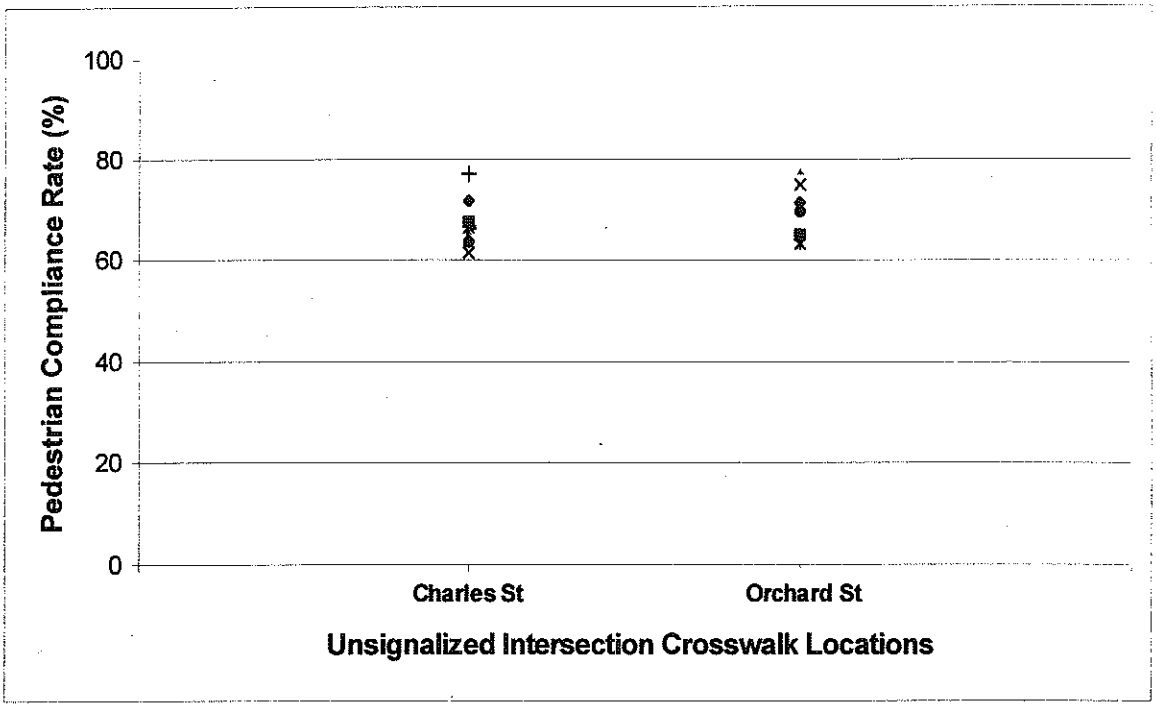

Figure D.1. Pedestrian compliance rates of all unsignalized intersection crosswalks-- All data collection sessions

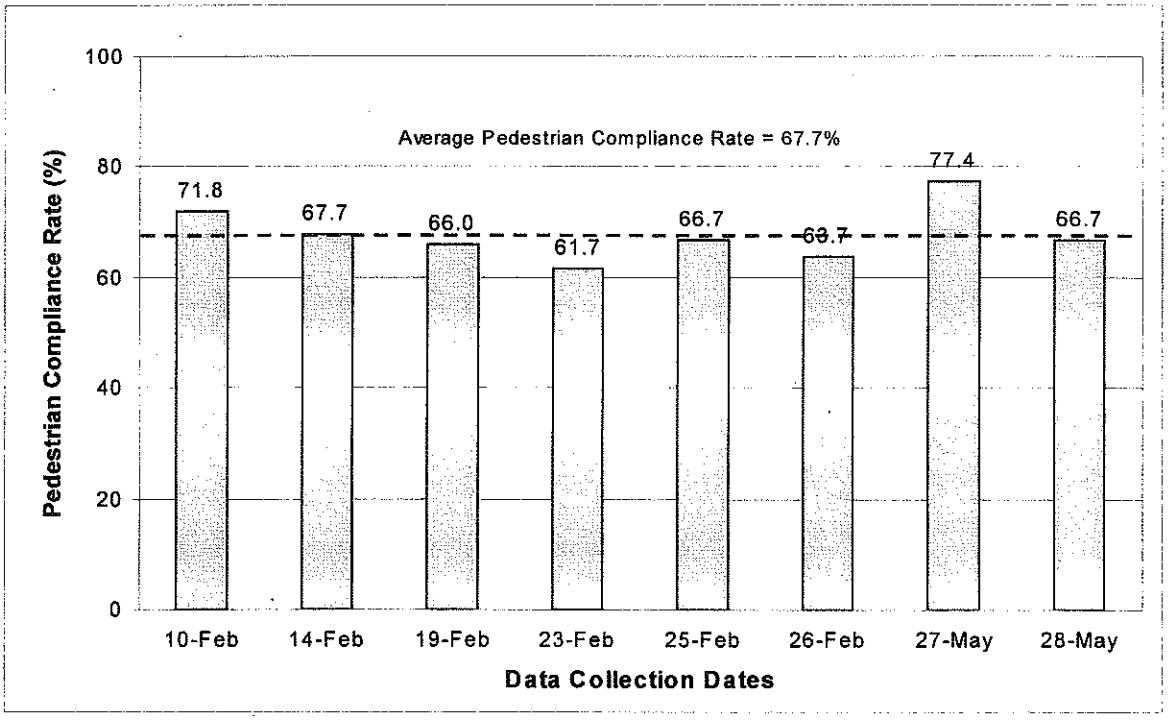

Figure D.2. Pedestrian compliance rates- Charles St unsignalized intersection crosswalk

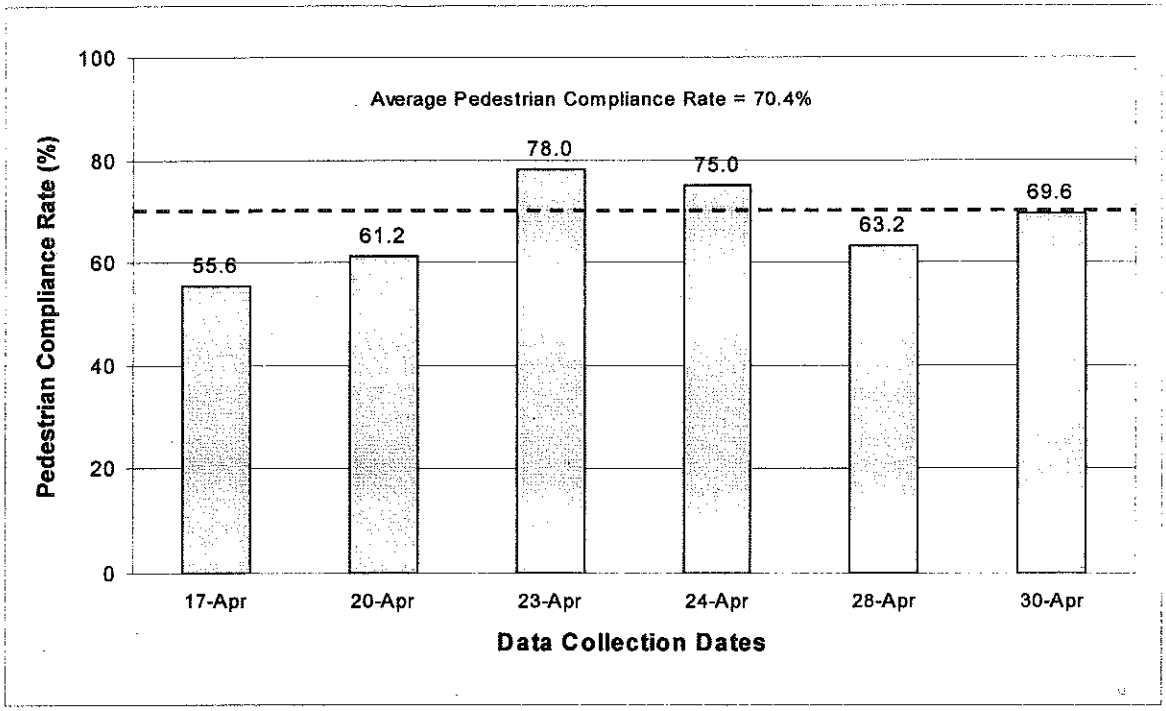

Figure D.3. Pedestrian compliance rates- Orchard St unsignalized intersection crosswalk

APPENDIX E: Pedestrian Compliance Rates of All Signalized Intersection Crosswalks (compliance to location only)

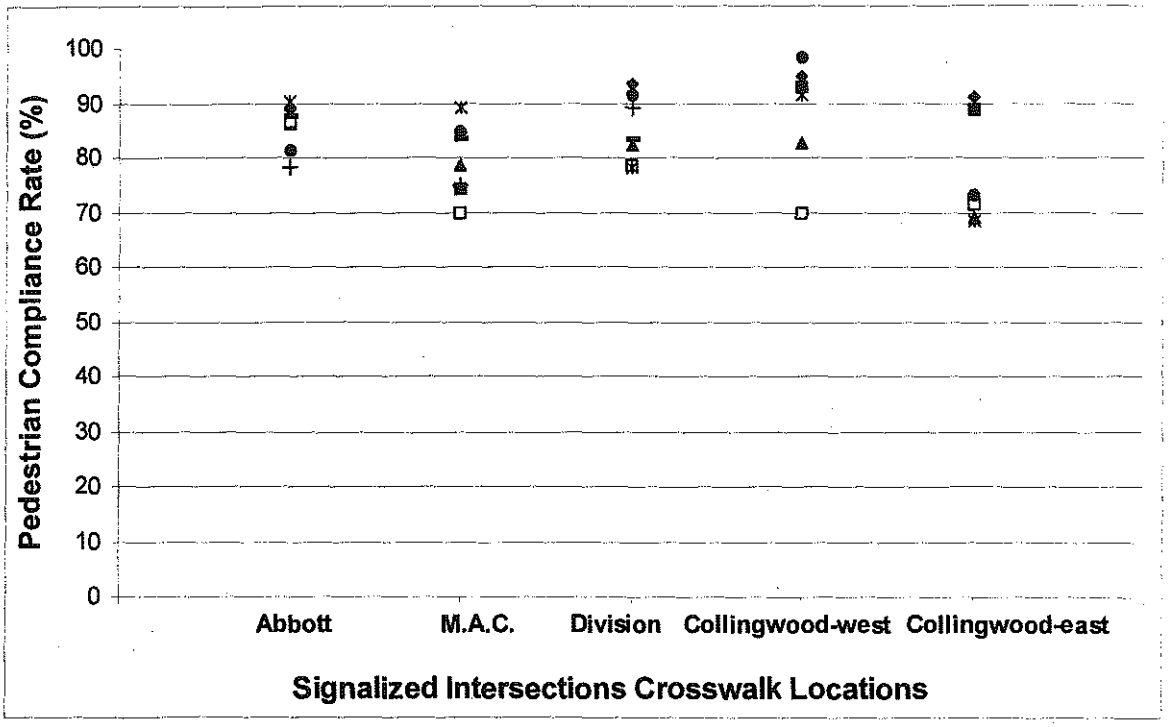

Figure E.1. Pedestrian compliance rates of all signalized intersection crosswalks-- All data collection sessions (compliance to location)

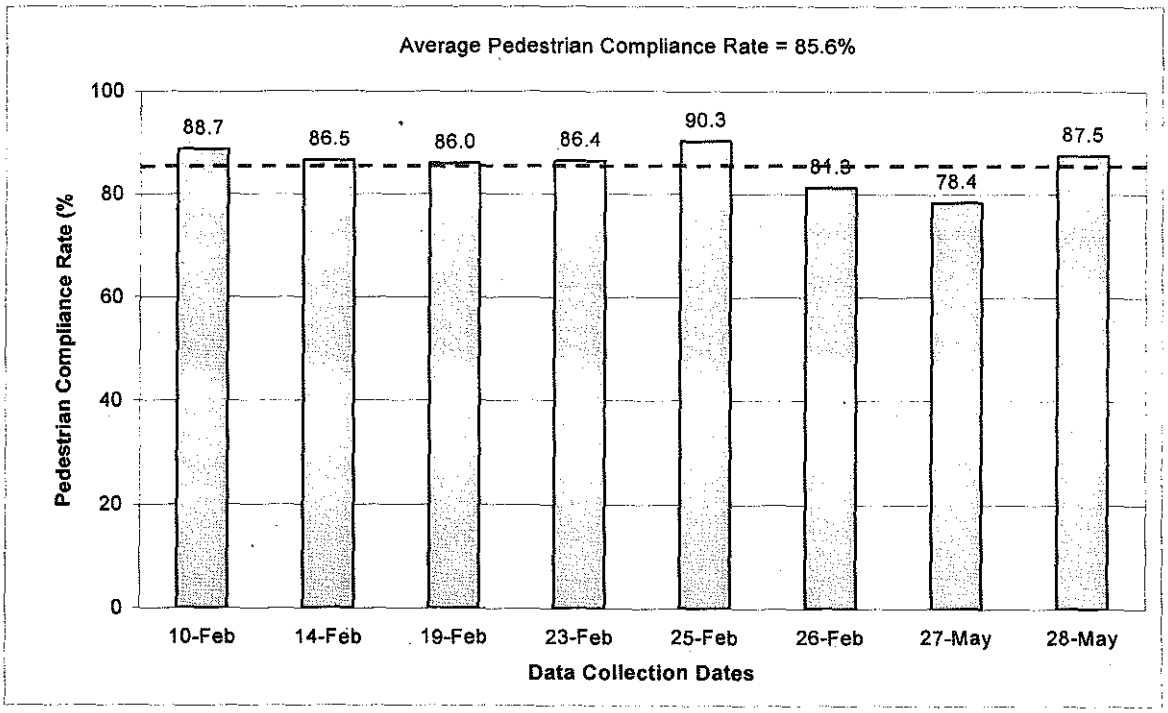

Figure E.2. Pedestrian compliance rates- Abbott St signalized intersection crosswalk (compliance to location)

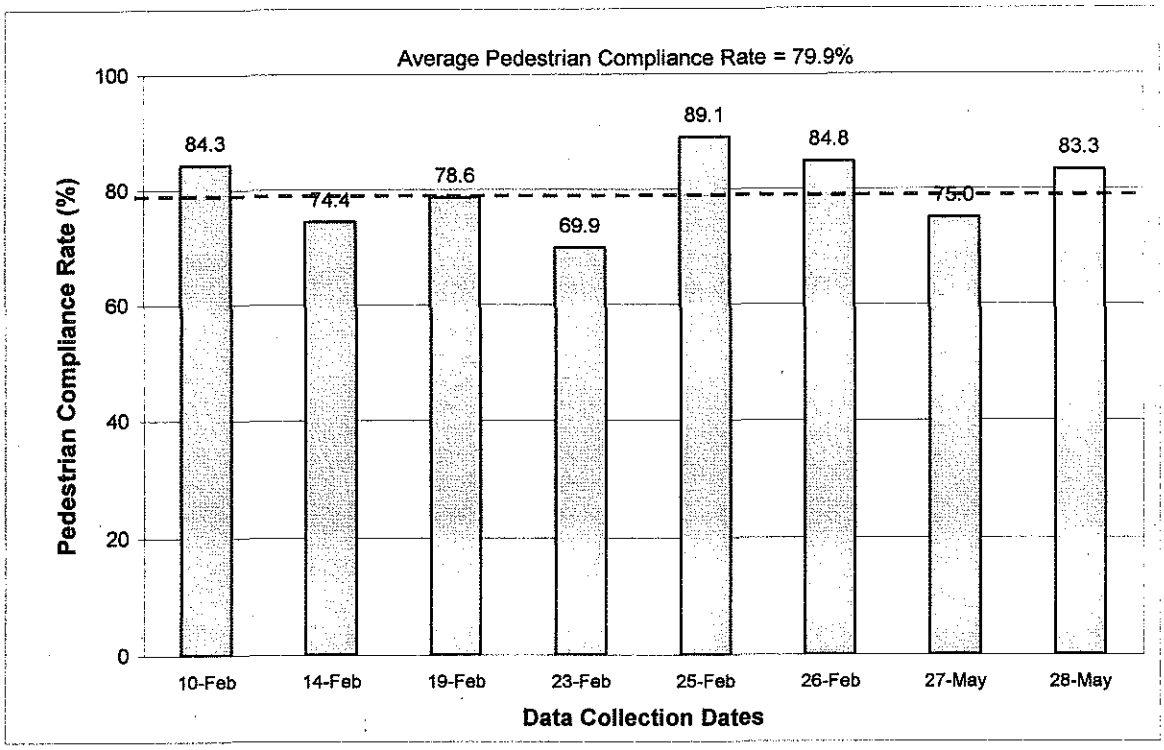

Figure E.3. Pedestrian compliance rates- M.A.C. Ave signalized intersection crosswalk (compliance to location)

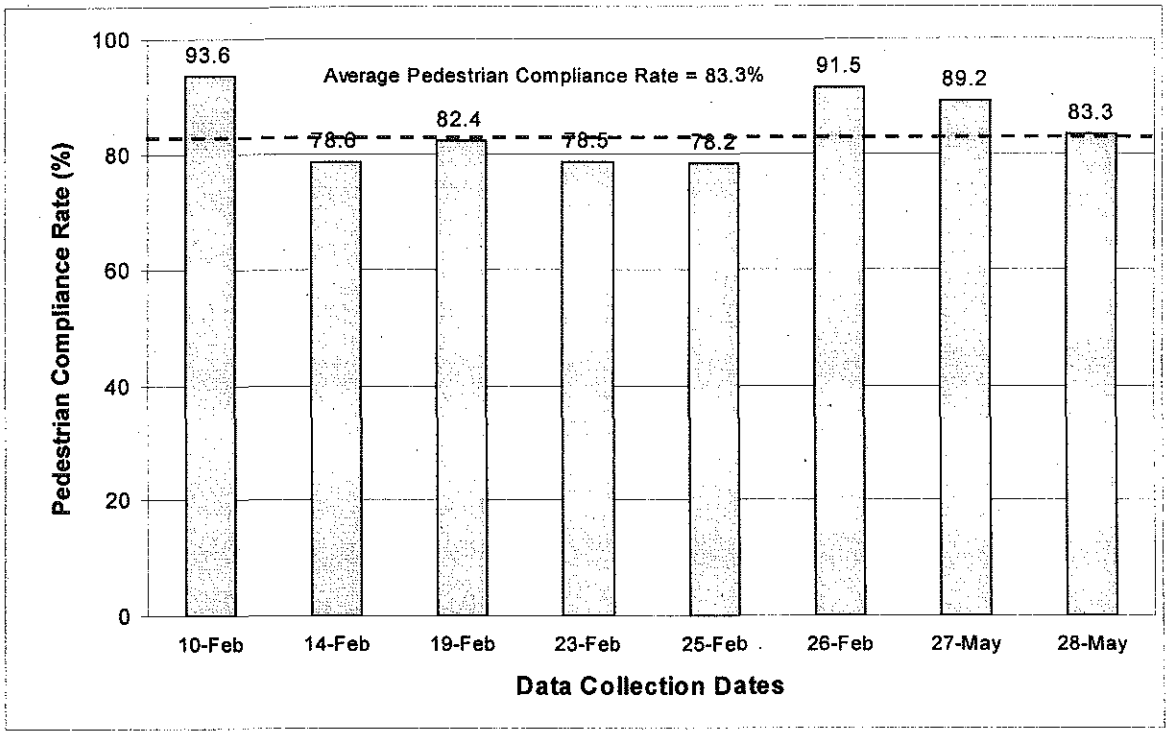

Figure E.4. Pedestrian compliance rates- Division St signalized intersection crosswalk (compliance to location)

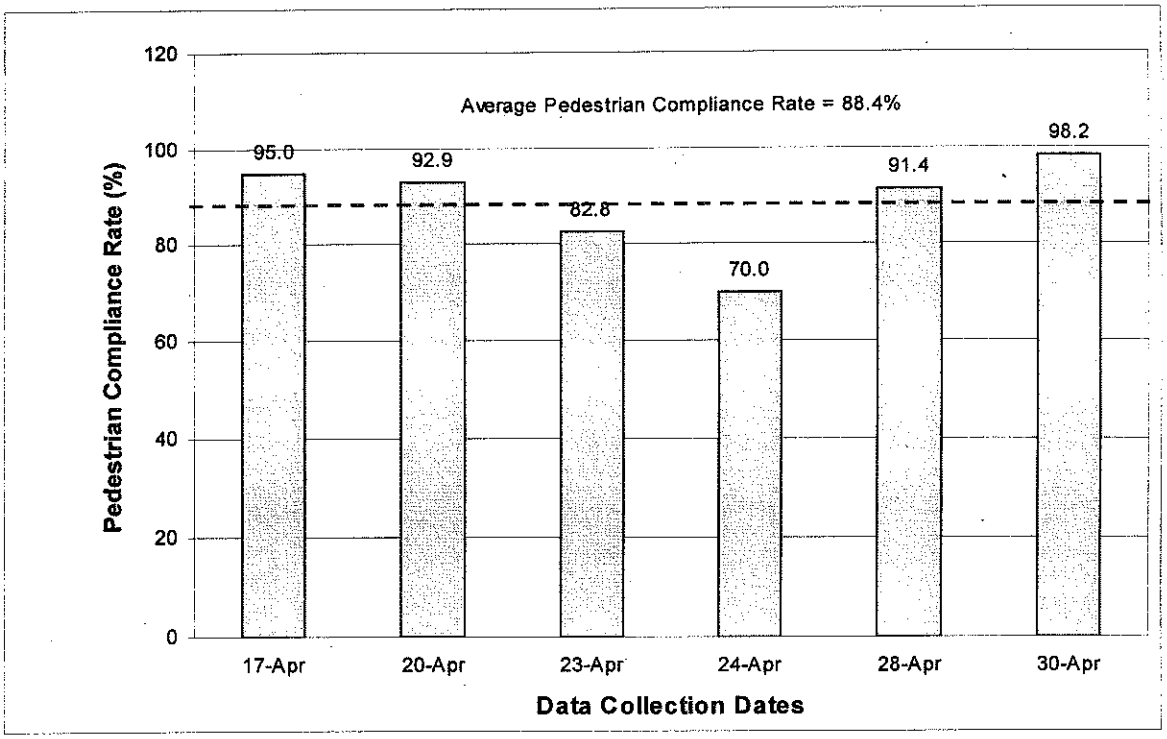

Figure E.5. Pedestrian compliance rates- Collingwood-west St signalized intersection crosswalk (compliance to location)

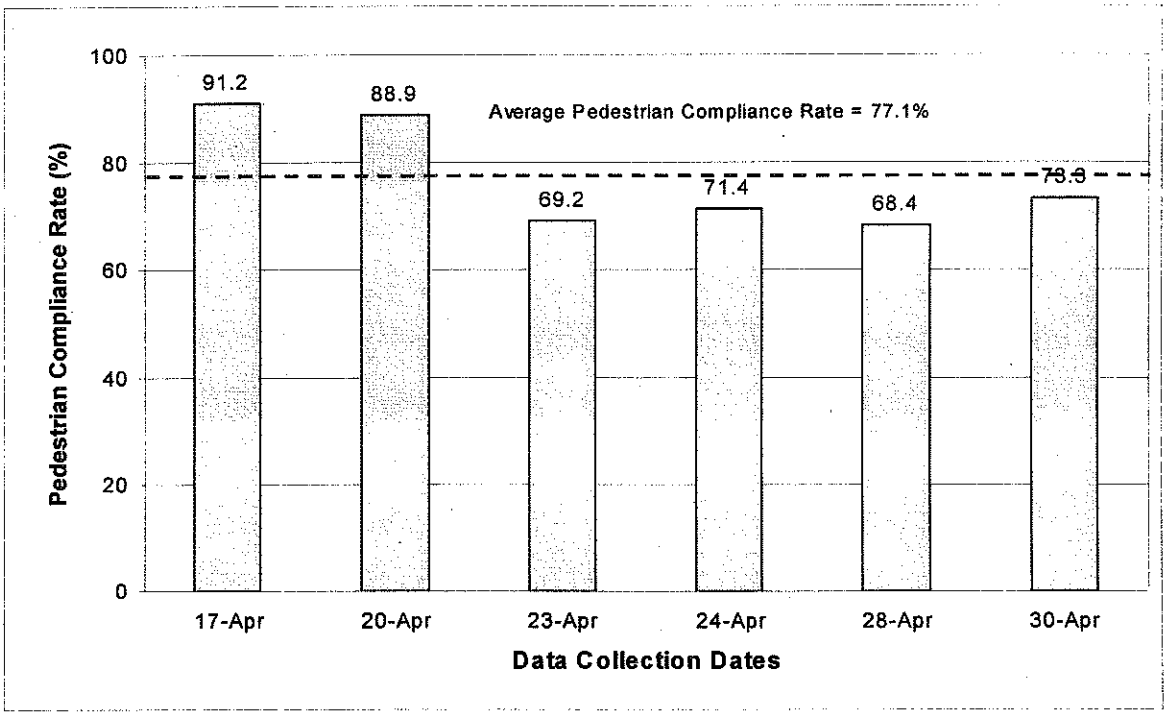

Figure E.6. Pedestrian compliance rates- Collingwood-east St signalized intersection crosswalk (compliance to location)

APPENDIX F: Overall Pedestrian Compliance Rates of All Signalized Intersection Crosswalks

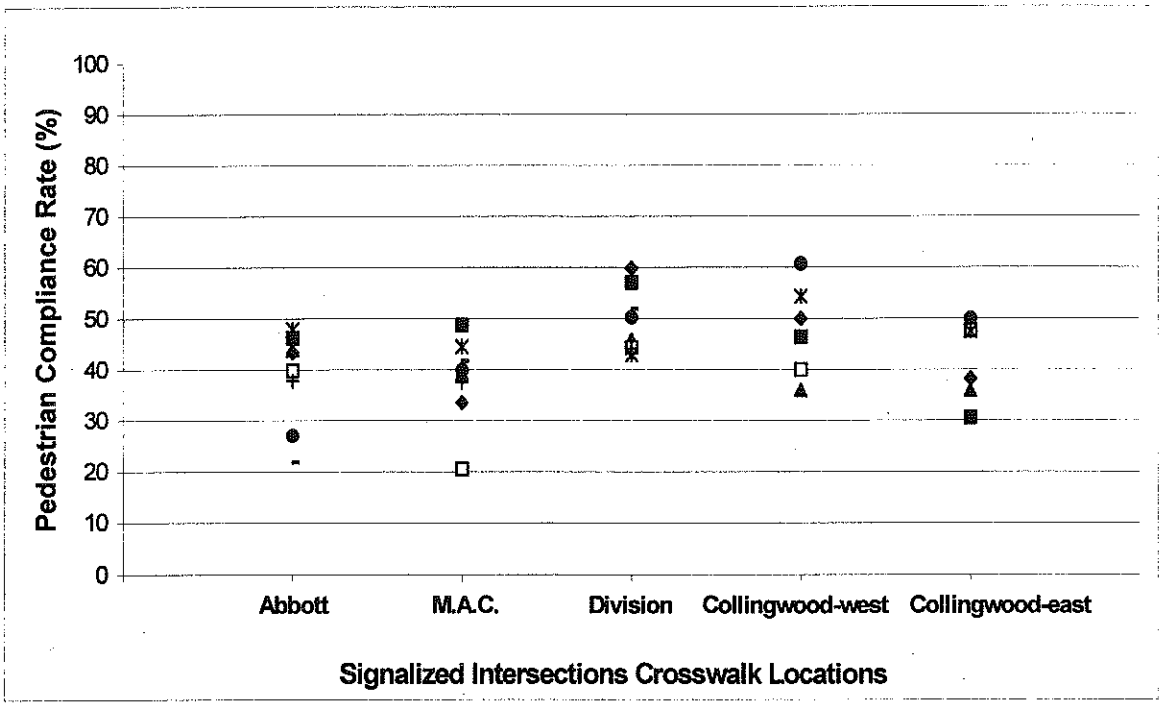

Figure F.1. Pedestrian compliance rates of all signalized intersection crosswalks-- All data collection sessions

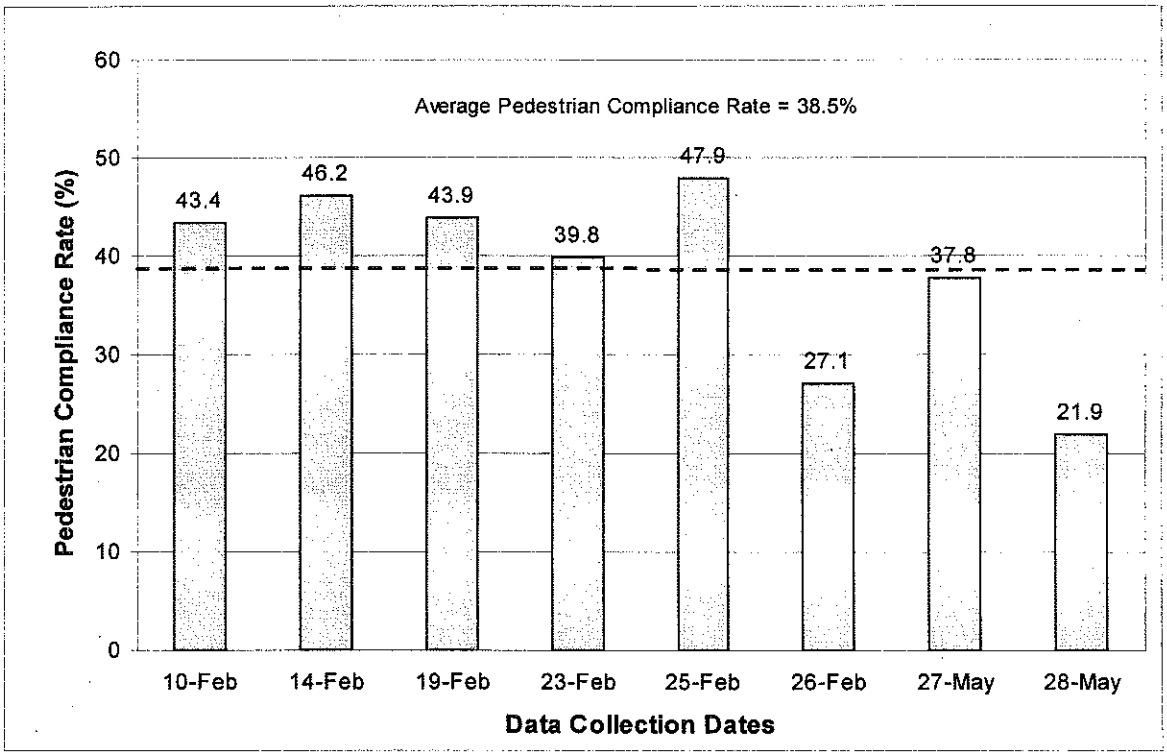

Figure F.2. Pedestrian compliance rates- Abbott St signalized intersection crosswalk

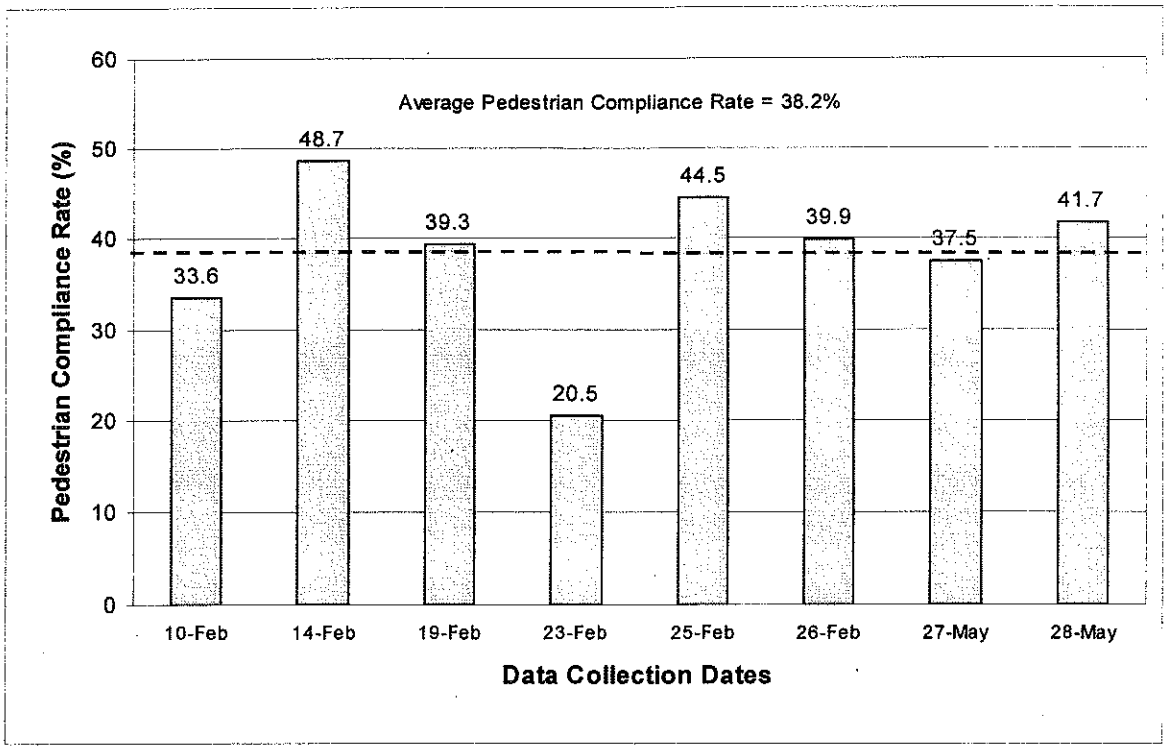

Figure F.3. Pedestrian compliance rates- M.A.C. Ave signalized intersection crosswalk

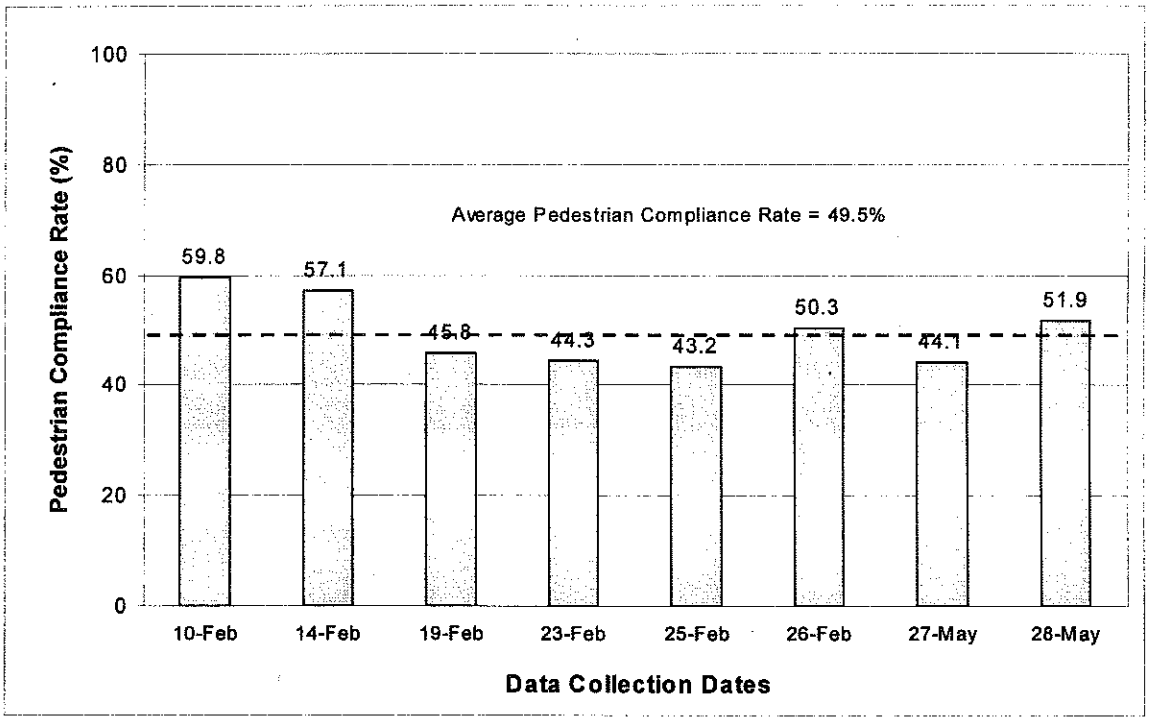

Figure F.4. Pedestrian compliance rates- Division St signalized intersection crosswalk

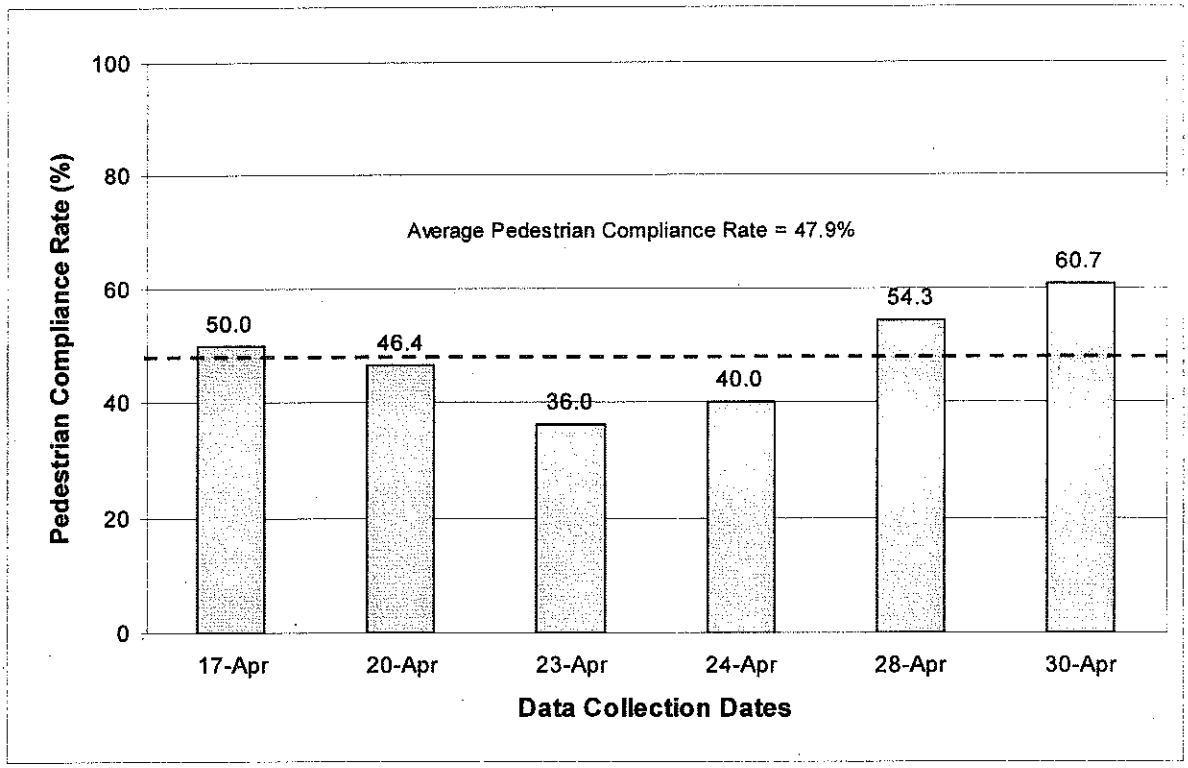

Figure F.5. Pedestrian compliance rates- Collingwood-west St signalized intersection crosswalk

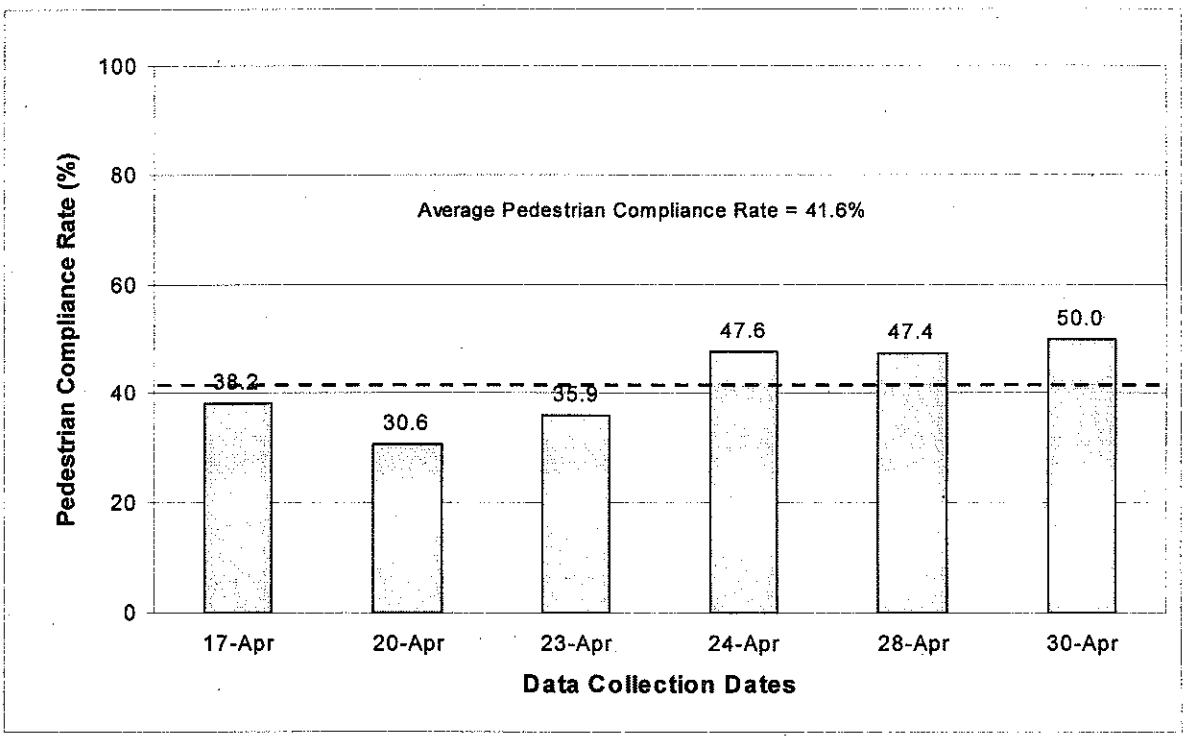

Figure F.6 Pedestrian compliance rates- Collingwood-east St signalized intersection crosswalk