of useful data was collected on the characteristics of pedestrians and the nature of pedestrian exposure. Only a small fraction of the large data base has been presented here.

The data on pedestrian characteristics provide an indication of what people are doing, where they are doing it, when they are doing it, as well as the kind of people that make up the population of pedestrians. This information is valuable in developing a walking environment designed for the needs and characteristics of the pedestrian population.

The data on pedestrian exposure measures provide an indication of the nature of various kinds of pedestrian-vehicle interactions. By examining areas and locations where pedestrian exposure to vehicular traffic is most frequent, the efficiency and safety of the pedestrian environment can be improved.

The data on relative hazard provide an indication of the risk associated with various roadway, intersection, vehicle, and pedestrian characteristics. This information identifies those places and persons most likely to have a pedestrian accident, based on exposure. This provides an effective way to target locations for safety improvements.

The hazard scores for the various accident types provide an indication of the relative hazard associated with accident-precipitating pedestrian activities. This information can be effectively used to target pedestrian safety countermeasures.

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Midblock Crosswalks: A User Compliance and Preference Study

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ABSTRACT

This study documents the impact of traffic control present at marked midblock crosswalks (MBCs) in an urban area on user compliance and preference. The behavior study indicates that pedestrian compliance is independent of traffic control at MBCs whereas motorist compliance is highest under signalized control. Conflicts between pedestrians and vehicles are more frequent at the unsignalized MBC. The preference study indicates that users perceive the unsignalized MBC to be unsafe, although the same crosswalks are rated highest in crossing convenience. Finally, motorists surveyed indicated that overhead devices (signs, flashing lights) provide effective advance warning of MBCs for approaching traffic.

The competition for urban street space between pedestrian and vehicular traffic (moving or stationary) has been a long-standing problem facing transportation engineers and planners in many U.S. cities. Nonintersection or midblock crosswalks (MBCs) have often been introduced to accommodate natural pedestrian flows at such locations. However, some of the installations have sprung up as a result of community action, business pressure, or political considerations rather than engineering judgment.

Although considerable research has been undertaken on the general problem of pedestrian safety, aspects unique to the MBC have yet to be thoroughly investigated, especially for the marked but unsignalized MBC. Foremost among these problems are the following:

1. Pedestrian crossings at midblock locations are generally unexpected by the motorist [Manual on

Uniform Traffic Control Devices (MUTCD), Sec. 3B-5 (1)]. This problem is further compounded by the occurrence of higher midblock travel speeds and sight distance restrictions due to curb parking.

2. Conflicting interpretations exist between pedestrians and motorists as to who has the right-of-way at any given time, provided that there is no specific guidance from traffic control (e.g., signals, stop signs). Existing legislation often adds to the ambiguity by giving pedestrians the right-of-way at unsignalized crosswalks while prohibiting them from leaving the curb when there is a danger of collision with oncoming vehicles. For example, the Ohio Revised Code, Sec. 4511-46 (1978), which applied to the sites included in this study, defines pedestrian rights at the MBC as follows:

a. Pedestrian on crosswalk has right-of-way (Ohio Rev. Code Ann., Sec. 4511-46, 1978):

> (A) When traffic control signals are not in place or not in operation the driver of a vehicle...shall yield the right-of-way, slowing down or stopping if need be to so yield, to a pedestrian crossing the roadway within a crosswalk when the pedestrian is upon the half of the roadway upon which the vehicle is traveling or when the pedestrian is approaching so closely from the opposite half of the roadway as to be in danger.
> (B) No pedestrian shall suddenly leave a curb or other place of safety and walk or run into the path of a vehicle...which is so close as to constitute an immediate hazard.
> (D) Whenever any vehicle...is stopped at a marked crosswalk...to permit a pedestrian to cross the roadway, the driver of any other vehicle...shall not overtake and pass the stopped vehicle.

b. Right-of-way yielded by pedestrian (Ohio Rev. Code Ann., Sec. 4511-48, 1978):

> (A) Every pedestrian crossing a roadway at any point other than within a marked crosswalk or within an unmarked crosswalk at an intersection shall yield the right-of-way to all vehicles.
> (C) Between adjacent intersections at which traffic control signals are in operation, pedestrians shall not cross at any place except in a marked crosswalk.
> (E) [This section does not relieve the operator of a vehicle]...from exercising due care to avoid colliding with any pedestrian upon any roadway.

As shown, the pedestrian and driver responsibilities in midblock crossings are not specifically delineated. Pedestrians are not supposed to leave a curb and walk or run into the path of a vehicle that is so close as to constitute an immediate hazard. Drivers are supposed to yield to pedestrians crossing within a crosswalk when the pedestrian is on the half of the roadway on which the vehicle is approaching. Thus, no specific suggestions are afforded regarding a minimum pedestrian-vehicle separation before right-of-way preferences are reversed. This is not altogether surprising given the wide variations in gap (or risk) acceptance characteristics among pedestrians.

Although some of these concerns may be addressed by installing a midblock signal, it is unlikely under current MUTCD warrants that many sites would qualify for such action. In a recent survey of 422 signalized intersections in Chicago and Washington conducted by Zegeer (2), only 8 percent met the minimum pedestrian warrant (warrant 3), whereas 84 percent met the minimum vehicular volume warrant (warrant 1). In addition, the high capital costs incurred for signal installation (especially within interconnected signal systems), the uncertainty on the part of the traffic engineer of improved safety performance, and the inevitable increase in delays to both motorists and pedestrians tend to diminish the perceived benefits of the alternative.

Some of these issues are addressed by focusing on the safety aspects of the MBC relative to the level of traffic control adopted at the crossing facility. The following tasks are addressed:

1. A review of safety literature pertaining to the MBC and nonintersection crossings in general,
2. Documentation of a limited field compliance study of pedestrians and motorists to MBC traffic control in an urban area, and
3. Documentation of motorist and pedestrian attitudes and preferences regarding the operation of the MBC.

REVIEW OF SAFETY STUDIES

Nonintersection accidents involving a pedestrian and a vehicle traveling straight ahead account for the largest percentage of vehicle-related fatalities in U.S. urban areas (3). The degree of nonintersection pedestrian accident involvement is related significantly to age group; pedestrians under the age of 14 are more likely to be involved in accidents at these locations.

A comprehensive accident study of 6,000 pedestrian accidents conducted by Knoblauch (4) identified pedestrian actions that are concomitant with accident occurrence for the purpose of developing multidisciplinary countermeasures for each type of behavior (5). Midblock actions including pedestrian dart-outs and dashes were involved in almost 40 percent of the pedestrian accident samples in the study.

The impact of traffic control on accident frequency and severity at the MBC was studied by Inwood and Grayson (6) at zebra (unsignalized) and pelican (pedestrian-actuated signal) crossings in England. Pedestrian accident rates were found to be not statistically significant among crosswalk types although vehicle accident rates were lower at the pelicans. A similar study by Crompton (7) analyzed 31 streets in Greater London from 1972 through 1977. Pedestrian accidents per 1,000 crossings per hour were derived for zebra, pelican, and signalized intersection crossings, among other types. Zebras performed best at a rate of 1.2, whereas pelicans and intersection crossings exhibited accident rates of 1.8 and 3.0, respectively. Similar to Inwood's findings, however, no significant difference was found between accident rates at zebras and those at pelicans.

Data compiled by Rayner (8) provided a unique opportunity for monitoring the safety performance of zebra crossings that were later converted to pelicans, with some being relocated for signal hardware requirements. It was found that at pelicans relocated within 50 ft of the original zebras (30 sites), pedestrian accidents dropped by 28 percent at the crossing but increased by 133 percent within 150 ft from the crossing. It was postulated that as the crosswalks became safer for crossing, they also became less convenient from a delay standpoint. Thus more pedestrians chose to cross between gaps in the traffic, which increased the potential (and indeed actual) conflict with oncoming traffic. Similar to Inwood's findings, vehicle accidents dropped by 20 percent at the new pelican crossings. Because only eight sites were relocated 50 ft or more, no attempt was made to draw statistical inferences from their accident records.

Supplemental traffic control devices such as special reflectorized signs, floodlights, and special illumination techniques were also found to be generally effective in reducing nighttime accidents at pedestrian crosswalks (9-11). However, when sound engineering design is coupled with effective legislative, educational, and enforcement programs, drastic reductions in pedestrian accidents can be achieved, such as those observed in the Toronto Pedestrian Crossover Program (12).

Many studies have resorted to proxy safety indicators in assessing traffic control effectiveness at pedestrian crossings. This is in part because of an increasing need for quick-response techniques that do not rely on long-term accident experience. Cynecki (13), for example, has developed a conflict-analysis technique for pedestrian crossings, and other studies have selected user compliance as the barometer for crosswalk safety (7,14-18). Although the use of proxy variables has been challenged on the grounds that no firm correlation between compliance and accident has yet been established (19), it appears that in the short term, proxy variables can provide a quick, albeit imperfect, tool for the identification of problem crossings in urban areas and the subsequent implementation of needed countermeasures to alleviate some of these problems.

USER COMPLIANCE STUDY

This study was conducted in Columbus, Ohio, and included a total of 10 MBCs, located in the downtown area. Existing traffic control at the MBC consisted of

1. Three signalized MBCs (all on one-way streets);
2. Seven unsignalized MBCs (all on one-way streets), four of which had side-mounted crosswalk signs; and
3. The unprotected approach width (i.e., street width minus width of parking lane or lanes), which ranged from 38 to 62 ft.

Parameter Identification and Data Collection

The basic premise of the study was that effective traffic control at the MBC promotes higher user compliance and lower conflict opportunities between pedestrians and vehicles. The following variables were measured at each site:

1. The number of pedestrian violations at signalized crosswalks was recorded for crossings outside the MBC (halfway between the MBC and adjacent crosswalks on either side) or against the pedestrian signal indication. At the unsignalized MBC, pedestrian violations included crossings outside the crosswalk area and crossings initiated when no adequate vehicular gaps (in the observer's judgment) existed.
2. Number of motorist violations included vehicles illegally parked in the vicinity of the crosswalks or those stopped on the marked crosswalk. Moving violations included motorists crossing against signal indication at signalized MBCs or those failing to stop or slow for pedestrians already crossing at an unsignalized MBC.
3. For number of pedestrian-vehicle conflicts, because no turning conflicts occur at the MBC, only sudden braking or swerving to avoid collision with a pedestrian was considered in this study.
4. The number of vehicle-vehicle conflicts was similar to the previous category; these included rear-end conflicts when the lead vehicle is stopped for a pedestrian on the MBC or sudden swerves when the following vehicle passes a stopped vehicle on the crosswalk (multiple threat).

In addition, control variables such as pedestrian and vehicle volumes were recorded at each site. A total data-collection effort of 20 hr yielded more than 3,000 pedestrian and 17,000 vehicle observations in the course of the study. Manual counting techniques with three observers were used to gather the data at all sites.

Results

Table 1 gives a summary of site characteristics for the user compliance study. Pedestrian volumes ranged from 153 to 261 pedestrians per hour per site and vehicle volumes from 880 to 1,325 vehicles per hour per site. Following is a summary of the results obtained.

TABLE 1 Relevant Site Characteristics for User Compliance Study

		Unsignalized MBC	
Parameter	Signalized MBC	Signs Present	No Signs
No. of sites[a]	3	4	3
Avg approach width (ft)	45	51	43
Total pedestrian[b] flow observed	1,306	1,153	761
Total vehicle[b] flow observed	6,623	5,941	4,401
Avg pedestrian volume per hour per site	261	173	153
Avg vehicle volume per hour per site	1,325	1,188	880

[a]Only one-way streets are included in this analysis.
[b]Based on ten 10-min observations at each site.

Pedestrian Violations

A chi-square test for independence at the 5 percent significance level indicated that for the given sample of MBCs, there were no significant differences in pedestrian violation percentages among the three categories of MBCs shown in Table 2. The results did not change when unsignalized MBCs were grouped into one category.

TABLE 2 Pedestrian Violations Versus MBC Control

MBC Control	No. of Pedestrian Violations	No. of Pedestrian Compliances	Total Pedestrian Flow
Signalized	191 (190)[a]	1,115 (1,116)	1,306
Unsignalized			
WS	157 (167)	996 (985)	1,153
WOS	120 (111)	641 (650)	761
All sites	468[b]	2,752	3,220

Note: WS = with signs present; WOS = without signs.
[a]Values in parentheses are the expected frequencies (rounded) under the null hypothesis.
[b]Breakdown of total violations (468): crossing against signal, 129; crossing in inadequate gap, 26; crossing outside MBC, 313.

Motorist Violations

Table 3 summarizes the results for this variable. Two observations were made. First, the magnitude of motorist violations appears to be minimal when compared with those of pedestrians (0.52 percent versus 15 percent overall). The chi-square analysis at 5 percent also revealed that motorist violations were indeed reflective of type of MBC crosswalk. Signalized crosswalks exhibited the lowest percentage of violations, 0.4 percent.

TABLE 3 Motorist Violations Versus MBC Control

MBC Control	No. of Motorist Violations	No. of Motorist Compliances	Total Vehicle Flow
Signalized	27 (35)[a]	6,596 (6,588)	6,623
Unsignalized			
WS	45 (31)	5,896 (5,910)	5,941
WOS	17 (23)	4,341 (4,378)	4,401
All sites	89[b]	16,876	16,965

Note: WS = with signs present; WOS = without signs.
[a]Values in parentheses are the expected frequencies (rounded) under the null hypothesis.
[b]Breakdown of total violations (89): moving against signal, 15; blocking part or all of MBC, 17; illegally parked in vicinity of MBC, 20; did not slow or stop for pedestrians, 37.

Pedestrian-Vehicle Conflicts

The results summarized in Table 4 indicate that the magnitude of pedestrian-vehicle conflicts is reflective of crosswalk control. Significant differences were found between signalized and unsignalized (pooled in one category) MBCs. Again, signalized locations exhibited lower conflict rates than other types of control.

TABLE 4 Pedestrian-Vehicle Conflicts Versus MBC Control

MBC Control	No. of Pedestrians Involved in Conflicts	No. of Pedestrians Not Involved in Conflicts	Total Pedestrian Flow
Signalized	10 (18)[a]	1,296 (1,288)	1,306
Unsignalized			
WS	20 (16)	1,122 (1,137)	1,153
WOS	14 (10)	747 (751)	761
All sites	44	3,176	3,220

Note: WS = with signs present; WOS = without signs.
[a]Values in parentheses are the expected frequencies (rounded) under the null hypothesis.

Vehicle-Vehicle Conflicts

Only 14 vehicles out of the 17,000 observed were involved in vehicle-vehicle conflicts. Hence no rigorous statistical test was conducted on this sample. Simple conflict ratios were estimated at 0.075 and 0.087 for signalized and unsignalized MBCs, respectively.

Summary

The preceding results have indicated that pedestrian behavior is virtually unaffected by the type of control prevalent at the MBCs at the study sites. However, because of the continuous exposure of pedestrians to moving traffic at the unsignalized locations, the potential for accidents (conflicts in this study) is greater there. There were no observed differences between sites equipped with side-mounted signs and those with pavement marking alone. Midblock signals, albeit imperfect in affecting pedestrian behavior, could be valuable in providing an improved target value for the crossing facility and consequently adequate response time for approaching motorists. This was demonstrated in this study by observing lower motorist violations and pedestrian-vehicle conflicts at the signalized locations.

USER PREFERENCE SURVEY

Eliciting user understanding of and preference for traffic control devices can be a useful tool in planning safer pedestrian facilities. Reiss (20), for example, has used such data to correlate knowledge of traffic control with accident involvement rates. Robertson (14) conducted a pedestrian understanding study of various pedestrian signal indications in an effort to assess the effectiveness of such devices, whereas Crompton (7) aimed at identifying threshold delays that were noticed by pedestrians in a survey.

Survey Design

The scope of the survey was limited to downtown Columbus. Two types of interviews were conducted: a pedestrian survey that was administered at the same sites as the user compliance study and a driver survey that was conducted at major parking generators in the downtown area. A total of approximately 600 complete interviews (more than 90 percent response rate) from both surveys were analyzed in the course of this study.

Pedestrian Survey

There were three objectives in this survey, to identify

1. Users' opinions regarding safety problems associated with the MBC,
2. Users' interpretations of their legal rights and duties at the unsignalized MBC, and
3. Users' preference regarding the level of traffic control to be adopted at the MBC.

Responses from the pedestrian survey were first categorized as those from drivers and those from nondrivers, as shown in Table 5, in order to test whether each group perceived the role of traffic control differently. Statistical tests conducted at the 5 percent level indicated that nondrivers were more likely to respond that the unsignalized MBC is unsafe (77 percent versus 49.8 percent). Responses regarding legal responsibility and crossing preference did not differ significantly between the two groups. Yet one in five respondents indicated that drivers have the right-of-way at the unsignalized MBC. It should be noted, however, that because of the small sample size of nondrivers in the survey (26) these findings should not be extrapolated beyond the population represented in the survey.

A classification of responses by survey location was also undertaken to test whether the crossing problems at the unsignalized MBC perceived by some users reflect on the selection of crossing location. This was not found to be the case, as shown in Table 6. A chi-square test on the data showed that crossing location and pedestrian opinion regarding the safety of the unsignalized MBC were independent. Preference of crossing type, however, was found to

TABLE 5 Pedestrian Survey: Drivers Versus Nondrivers

		Percentage of Response		
Question	Response	All (N = 298)	Drivers (N = 271)	Nondrivers (N = 26)
Safe when crossing unsignalized MBC? (objective 1)	Very safe	9.9	10.8	0
	Fairly safe	38.3	39.4	23.0
	Not so safe	31.7	31.0	38.5
	Unsafe	20.1	18.8	38.5
Who has the right-of-way at unsignalized MBC? (objective 2)	Pedestrian	78.9	82.2	76.0
	Driver	21.1	17.8	24.0
Which crossing is more convenient? (objective 3)	Corner traffic signal	37.4	37.3	38.5
	Signalized MBC	17.2	16.3	26.9
	Unsignalized MBC	45.4	46.4	34.6

TABLE 6 Pedestrian Survey: Signalized Versus Unsignalized Location

		Percentage of Response		
Question	Response	All (N = 298)	Signalized (N = 88)	Unsignalized (N = 210)
Safe when crossing unsignalized MBC? (objective 1)	Very safe	9.9	14.1	18.1
	Fairly safe	38.3	37.1	38.9
	Not so safe	31.7	33.7	30.8
	Unsafe	20.1	15.1	22.2
Who has the right-of-way at unsignalized MBC? (objective 2)	Pedestrian	78.9	81.2	78.6
	Driver	21.1	18.8	21.4
Which crossing is more convenient? (objective 3)	Corner traffic signal	37.4	37.0	37.6
	Signalized MBC	17.2	21.7	15.3
	Unsignalized MBC	45.4	41.3	47.1

be significantly related to crossing location; users of the unsignalized MBC were more likely to favor this type of crossing.

Driver Survey

The objectives of the driver survey were threefold:

1. To detect whether conflicting interpretations exist between pedestrians and motorists regarding the right-of-way at the unsignalized MBC,
2. To assess the degree of inconvenience perceived by the motorists for stopping at the MBC, and
3. To elicit motorists' preference of traffic control devices to be adopted at the MBC.

A summary of the survey results is given in Table 7.

The problem of conflicting interpretations is not overwhelmingly evident from the survey data. In fact, the proportions of pedestrians and drivers who indicated that pedestrians have the right-of-way are within 5 percent of one another (79 versus 84 percent for pedestrians and drivers, respectively). It should be pointed out, however, that the potential consequences of some pedestrian violations (for example, relinquishing their right-of-way to motorists) are often less hazardous than motorist violations (not stopping or slowing for a pedestrian legally crossing at MBC). Thus because about 20 percent of the drivers surveyed indicated that drivers have the right-of-way at unsignalized MBCs, this must be a source of concern for the traffic engineer and ought to be addressed through some engineering as well as nonengineering means (enforcement, education, etc.).

Approximately one in three drivers surveyed believed that stopping at the MBC was inconvenient. This is quite close to the percentage of pedestrians (who also drove) who preferred to cross at corner traffic signals (37 percent).

When given a choice of warning devices at the

TABLE 7 Driver Survey Results

		Percentage of Response		
Question	Response	All (N = 291)	Group 1[a] (N = 100)	Group 2 (N = 191)
Who has the right-of-way at unsignalized MBC? (objective 1)	Pedestrian	84.1	81.6	85.5
	Driver	15.9	18.4	14.5
Are unsignalized MBCs inconvenient? (objective 2)	Very convenient	11.0	100	—
	Somewhat inconvenient	24.5		—
	Not inconvenient	64.5		100
Preference for advance warning? (objective 3)	Traffic signal	18.1	23.8	15.0
	Warning light	26.4	31.1	23.8
	Overhead sign or flashing light	42.4	43.2	42.0
	Crosswalk markings only	13.1	1.9	19.2

[a]Group 1 = respondents finding unsignalized MBC very or somewhat inconvenient.

MBC, overhead signs or flashing lights were more likely to be stated as the preferred type by the survey respondents (42 percent). The least-liked options were traffic signals (18 percent) and crosswalk markings (13 percent).

Finally, responses were classified into two groups. The first group consisted of respondents who indicated that they were inconvenienced by the presence of an MBC. The remaining responses were allocated to the second group. The objective was to depict whether inconvenience on the part of some respondents was associated with any of the factors included in the survey. A chi-square test on the two groups showed that drivers who did perceive a problem in stopping for pedestrians at the MBC overwhelmingly favored traffic signals over crosswalk markings as a means for advance warning (23.8 versus 1.9 percent). On the other hand, other motorists ranked both alternatives almost equally (15 versus 19 percent). Both groups, however, indicated their first preference to be some type of overhead device.

Summary

The results of the user preference survey provided some insight into the perceived safety of the MBC in Columbus. It was found that neither motorists nor pedestrians appeared to favor the signalized MBC, presumably because of the added travel delays to both types of users. Drivers rated the signalized MBC at the lower end of the preference scale, whereas pedestrians favored the unsignalized MBC by a ratio of 2.6 to 1.0 over the signalized MBC.

However, the survey respondents expressed a genuine concern about the safety of the unsignalized MBC. One in two pedestrians surveyed believed that they were unsafe. Nondrivers were even more skeptical (77 percent), perhaps because of their inability to predict driver actions. Drivers were generally tolerant of the MBC but indicated a strong need for effective warning ahead of the crossings. Overhead signs and flashing lights were preferred because side-mounted devices tend to lose their target value in the visual clutter of high-density areas. Finally, a clear majority of the surveyed pedestrians (79 percent) and drivers (84 percent) agree that pedestrians have the right-of-way at the unsignalized MBC. However, because of the general nature of the response, little can be inferred regarding motorist and pedestrian actions in situations where right-of-way priority is not clear-cut. Additional findings of the user compliance and preference studies can be found in the original study report (21).

CONCLUSIONS AND RECOMMENDATIONS

This study has focused on pedestrian and motorist behavior at MBCs in an urban area. Although the scope of the findings is limited to the population under study, many issues were raised pertaining to the safety, operational, and legal aspects of MBCs.

The behavior study indicated that pedestrians are less influenced by type of control than motorists. On the other hand, both groups indicated a preference for the unsignalized MBC, because delays are minimized to all users. Yet concern was expressed over the safety of unsignalized crossings, partly because of inadequate advance warning and uncertainty over right-of-way priority.

Further research is needed to secure a comprehensive view on the operation of marked MBCs. This includes research as follows:

1. To compile nationwide data on existing engineering and nonengineering guidelines for establishing marked MBCs (excluding school crossings) in urban areas. This information is needed to assess the feasibility of a uniform warrant for such installations.
2. To generate a comprehensive MBC accident data base and test for correlations between accident frequency and level of traffic control, including supplemental devices.
3. To link short-term behavioral observations (e.g., compliance, conflicts, attitudes) with long-term accident experience at MBCs. The hypothesis assumed in the study presented in this paper and other referenced work can be tested as a result of this effort.
4. To review existing legislation regarding right-of-way at unsignalized MBCs and to explore means of clarifying and delineating users' responsibilities.

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Pedestrian Crossing-Time Requirements at Intersections

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ABSTRACT

Existing procedures for determining pedestrian crosswalk-time requirements are inadequate because they ignore the number of people crossing. A study of six crossing locations showed that those in large crossing groups walk at fairly uniform headways and uniform speeds. Pedestrian headways are close to 6.7 sec per pedestrian per foot width of walkway and speeds are close to 4.5 ft/sec. A model of crossing time is developed. The inputs are the number crossing, crosswalk length, and crosswalk width.

The time required by pedestrians to cross streets at signalized intersections must be determined to ensure safe and efficient operation of the intersection. Most procedures used today (1-3) treat crossing time as a function of crosswalk length divided by a walking speed. However, crossing time is also a function of the number crossing (4).

Figure 1 shows the times required by groups (herds) of four or more to cross a street in downtown Richmond, Virginia. The ordinate is the time between when the first person in the herd leaves the curb and when the last person reaches the opposite curb. The horizontal lines are the crossing times predicted by dividing the crosswalk length (32 ft) by walking speeds of 3.5 and 4.0 ft/sec (the values usually recommended). The diagonal line is the regression line of best fit. The slope of this line was significantly different from zero at the 1 percent level.

The purpose of this study was to develop an improved design procedure for considering pedestrians in traffic signal timing. Data on crossing times are examined in the next section. A basis for modeling pedestrian crossing times is then developed. This is followed by a recommended design procedure.

METHODOLOGY AND DATA ANALYSIS

Data were collected for 85 herd crossings at 6 crossing locations. Four crossings were in downtown Richmond, Virginia. These crossings were controlled by pedestrian signals, and crosswalk lines were marked on the pavement. A majority of pedestrians were shoppers. The other crossings were near the University of Missouri-Columbia football stadium. These had no crosswalk lines and traffic was controlled by a police officer. The pedestrians were football patrons going to the stadium.

Data Collected

For all the crossings, curb-to-curb distance (L) was measured. For the downtown shoppers, crosswalk width