How Long Should a Safe Pedestrian Clearance Interval Be?

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In 1981, the City of Lakewood, Colorado decided to upgrade its outdated signal master controller. Funds were programmed in 1982 and as a result of the selection process, based on a number of different proposals from various manufacturers, the City purchased a Multisonics VMS 220 computerized traffic control system in 1983.

Peak-hour turning movement and 24-hour approach counts were taken at signalized intersections to determine the timing plans that were to be entered into the signal master data files. This formation is required to determine optimal progression on major and collector streets. A Passer II—80 Program on an IBM Personal Computer was initially used to optimize progression. More recently, the micro version of Transyt 7F, which uses simulation techniques, has been found to be more effective.

As intersections were connected to the VMS 220, intersection-control equipment was upgraded to allow the new master to be more effective in reducing vehicle delay and improving arterial progression and pedestrian safety. The upgrade included installation of new controllers, improved vehicle detection, and the expanded provision of pedestrian detectors.

Purpose

The calculation of a total pedestrian phase time (P) is a critical factor in the determination of minimum cycle lengths, and City of Lakewood staff had to address this when developing new timing plans for signalized intersections being connected to the VMS 220. Several issues became apparent in researching the application of pedestrian clearance intervals. The most significant problem is the lack of consistency in the many published methods of calculating such intervals. Research indicates that there are currently at least seven published methods of calculating pedestrian clearance times that are all probably in current use in the United States. The purpose of this article is to discuss the assumptions behind each of these differences and the effects of these assumptions on pedestrian clearance intervals, signal cycle lengths, and the level of service at signalized intersections. The level of service is critically affected when a traffic engineer is faced with the problem of reconciling 1) the needs of minimum side street green times, 2) optimization of main street progression through the availability of flexible time plans via a computerized signal master controller, and 3) the provision of safe pedestrian clearances.

Effect on Cycle Lengths

To determine minimum cycle lengths for coordinated timing plans for a particular intersection or group of intersections, the method of calculation of pedestrian clearance intervals (i.e., the flashing don't walk [FDW] interval) is very important. This is because whenever pedestrians are present, the minimum green for each phase is normally set by pedestrian crossing requirements. The phase time should provide sufficient walking time for a pedestrian to clear the conflict zone before the release of opposing vehicles.

For fixed time controllers, the minimum green time may be set by a practical vehicle operational minimum, comprising the green time (G) + the amber vehicle change interval (Y) + all red (R). If pedestrian requirements exceed the needs of vehicles, the overall cycle length has to be based on the needs of the pedestrian. With actuated control units and a single vehicle on an approach, the green interval could be as little as 2 or 3 seconds if the control unit is operated with a red rest for the minor street approaches unless pedestrian actuation is not provided. If that is the case, the minimum cycle length has to be based on the needs of pedestrians as with fixed time controllers. If pedestrian actuation is provided and pedestrians are present (depending on the method of calculating pedestrian change intervals that is selected) the minimum side street green time could be greater than 15 seconds depending on the street width. Setting side street green time based on meeting the pedestrians' needs can lengthen the overall cycle dramatically. Consequently, selecting a method of calculating pedestrian clearance intervals that does not compromise pedestrian safety while minimizing effects on phase times and cycle lengths becomes critically important.

Factors in the Application of Pedestrian Clearance Intervals (P)

We determined that the lack of consistency in calculating pedestrian phases was due to the several different factors listed below:

1. Pedestrian walking speed (V_p) assumptions;
2. Length of the initial walk interval (W);
3. Consideration of the vehicle change interval (both amber [Y] and all red [R]) as part of the time provided for pedestrian clearance;
4. Exact definition of the walking distance at the intersection (D); and
5. Method used to calculate the pedestrian clearance interval (flashing don't walk [FDW]).

1. Pedestrian Walking Speed (V_p)

The Manual on Uniform Traffic Control Devices (MUTCD) cites an assumed normal walking speed of 4 feet per second.[1] Research has verified that one-third of all pedestrians cross streets at a rate slower than 4 feet per second and 15 percent walk at or below 3.5 feet per second.[2] We researched Colorado state law and the Uniform Vehicle Code but found no information relevant to this discussion. Pedestrians have the legal right to complete their crossing once they have lawfully begun crossing.

The timing of pedestrian signal indications near facilities that serve segments of the population with slower walking speeds may have to be calculated based on a slower rate than 4 feet per second. Such populations would be crossing near shopping centers, convalescent or rest homes, schools, hospitals, residential areas with large groups of senior citizens, or therapy centers. The use of a slower walking rate can result in less favorable signal cycle green time splits, longer cycle lengths, and increased vehicle delays. Engineering studies and judgment should be exercised for each problem intersection to reconcile the needs of pedestrian safety and vehicular traffic movement.

2. Length of Walk Interval (W)

When separate displays (walk [W] and don't walk [DW]) are used, the *MUTCD* recommends the minimum walk interval to be 4 to 7 seconds.[1] This allows the pedestrian or group of pedestrians ample time to leave the curb before the pedestrian clearance interval commences. A summary of research studies has indicated that when, on average,there are less than 10 pedestrians per cycle per crosswalk, the 4-second interval is usually adequate.[2,8] If groups exceeding 10 pedestrians use a crosswalk for a significant number of cycles, such as in a downtown business district at times of peak pedestrian activity, consideration should be given to longer walk intervals.

3. Inclusion of Vehicle Clearance Intervals as Part of the Time for Pedestrian Clearance

The *MUTCD* mandates that "a Pedestrian clearance interval shall always be provided where pedestrian indications are used. It shall consist of a flashing don't walk (FDW) indication. The duration should be sufficient to allow a pedestrian crossing in the crosswalk to leave the curb and travel to the center of the farthest traveled lane before opposing vehicles receive a green indication."[1] The *MUTCD* does not state whether the vehicle change interval must be included in the pedestrian clearance interval (P).

As will be seen later, some methods of computing pedestrian clearance intervals terminate the flashing don't walk (FDW) and display a steady don't walk (DW) at the onset of the vehicular change interval.[3-6] This is to encourage those pedestrians still in the crosswalk to complete the crossing without delay. The calculations based on these methods include the vehicle change interval (Y) in the pedestrian clearance time. The total pedestrian clearance time (P) comprises the flashing don't walk (FDW) plus the vehicle change interval (Y), which is a steady don't walk (DW) indication to the pedestrian. If the vehicular change includes an all red (R), this would also be included in the pedestrian clearance interval. Note that according to the National Electrical Manufacturer Association (NEMA) specifications, during the indication of walk and pedestrian clearance intervals, a concurrent green vehicle interval must be shown.[7]

Dade County, Florida requested and received a ruling from the Federal Highway Administration concerning the inclusion of vehicle change interval in the pedestrian clearance interval. This ruling states that vehicle change intervals can be considered as being part of the time provided for pedestrian clearance even though the steady don't walk (DW) is displayed during this vehicle change interval.

As will be seen later, the inclusion of the vehicle change interval comprising the amber (Y) and all red (R) clearance

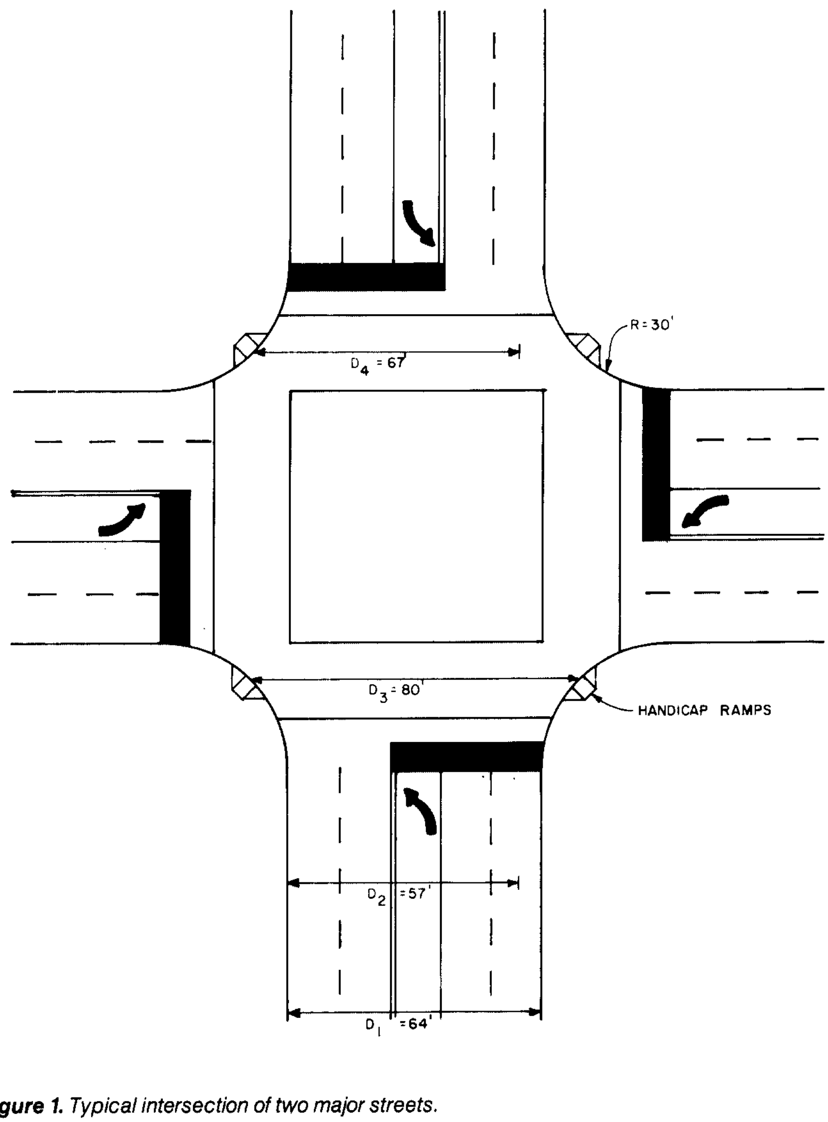

Figure 1. *Typical intersection of two major streets.*

time can have a major effect on the overall pedestrian clearance time and the minimum cycle length at a particular intersection. Numerous methods exist for calculating the amber change interval (Y) (and all red [R] if used). The method selected will in turn affect the total length of the flashing don't walk (FDW) if the vehicle change interval is included.

4. Definition of the Walking Distance (D)

The method used to calculate the distance a pedestrian must travel while crossing an intersection can have a significant effect on the pedestrian clearance interval. Different calculation methods use different definitions. The *MUTCD* states "the duration should be sufficient to allow a pedestrian in the crosswalk to leave the curb and travel to the center of the farthest traveled lane before opposing vehicles receive a green indication (normal walking speed is assumed to be 4 feet per second.)"[1] Note that the geometric layout of an intersection can have a significant effect on the resulting crossing times.

The following definitions of crossing distance have all been used in the calculation of pedestrian clearance times (Figure 1).

a. From the curb face nearest the pedestrian to the curb face on the opposite side of the street. (If there is no curb, the edge of traveled way should be used) (D_1).
b. From the curb face nearest the pedestrian to the center of the farthest traveled lane (D_2).
c. Between the midpoints of the corner curb radii (at the centers of the intersection handicap ramps (D_3).
d. From the center of the corner radius (at the center of the intersection handicap ramp) to the center of the farthest traveled lane (D_4).

The effect of on-street parking on the definition of walking distance has also been studied. Results of study observations indicate that pedestrians do not tend to use the near side parking lanes as a protected area for beginning their crossing.[8] Far side parking lanes should also be considered as traveled lanes unless geometrics or operational constraints preclude pedestrian/vehicle conflicts in the lane. A right-turn lane should be considered as a traveled lane unless a pedestrian refuge island separates the right-turn lane from the throughlanes. Where such an island is provided, the right-turn lane behind the island should not be considered part of the crosswalk for the purpose of calculating pedestrian clearance times as this can easily be crossed by the pedestrian during adequate gaps in right-turn traffic.

5. Methods of Calculating Pedestrian Clearance Intervals

The primary purpose of this sectionof the article is to illustrate the different methods of calculating pedestrian clearance times that are currently published and available to the traffic engineering profession. Table 1 summarizes the different methods and provides results of the pedestrian phase calculations based on each method so that the effect of the different methods and their associated assumptions on signal timing can be evaluated.

The calculations in Table 1 are based on the following (Figure 1):

1. An intersection comprising two major streets with a curb face to curb face width of 64′ (D_1); the distance between centers of corner radii (D_3) is 80′.
2. The 30′ corner radii;
3. The 12′ inside lanes and 14′ outside or curb lanes that include a 2′ pan;
4. The vehicular change interval (Y) is 4.0 seconds;
5. All-red change interval (R) of 2.0 seconds.

The amber (Y) and all-red (R) vehicle change intervals are based on a 40 m.p.h. approach speed and calculation methods provided in the *ITE Transportation and Traffic Engineering Handbook*.[3] They were used in conjunction with methods[3-6] that included vehicle change times as part of the pedestrian clearance interval ruled appropriate by the Federal Highway Administration to Dade County, Florida.[4]

Conclusions

The seven techniques in current use produced total pedestrian phase times ranging from 14.75 to 20.75 seconds (Table 1). The effect on signal progression green bands could be significant depending on the method selected. Our recommended method, which is the

Table 1. Methods of Calculating P[a]

Method/Source	Formula for FDW	Sample Intersection FDW Time (S)	Total P[b]	Description D[c]
MUTCD[1]	$FDW = D_4/V_p$	16.75	20.75	D_4
MTSD[2]	$FDW = \frac{D_1}{V_p} - 5$	14.75	18.75	$D_1 - 5$[d]
ITE Handbook[3]	$FDW = \frac{D_3}{V_p} - 4$	16.0	20.0	D_3
Dade County Ruling[4]	$FDW = \frac{D_4}{V_p} - Y - R$	10.75	14.75	D_4
TCDH[5]	$FDW = \frac{D_4}{V_p} - Y$	12.75	16.75	D_4
Georgia Tech.[6]	$FDW = \frac{D_4}{V_p} - Y$	12.75	16.75	D_4
STSCT ITE[9]	$FDW = D_1/V_p$	16.0	20.0	D_1

[a]For data on which these calculations were based, see section on "Various Methods of Calculating Pedestrian Clearance Intervals."

[b]Based on a 4-second interval.

[c]See Figure 1.

[d]This method always assumes a traveled lane to be only 10′ wide.

[c]See Figure 1.

same as the Dade County ruling,[4] yields a value of 14.75 seconds, which was considered reasonable based on our research summarized in this article. (We recognize that some older controllers could not use fractions of a second and the minimum time would be 15 seconds.) We felt that this method minimizes detrimental effects on signal progression green bands but at the same time does not compromise pedestrian safety where pedestrian phases dictate minimum signal cycles length for actuated controllers.

Recommendations

Based on the published information available and calculations based on a typical arterial intersection, we recommend the calculation of pedestrian clearance times that provide safe clearance for pedestrians, minimize adverse effects on signal cycle lengths, and (in conformance with the *MUTCD* and FHWA rulings) are based on the following:

1. A walking speed (V_p) of 4 feet per second, except at intersections where a lower speed should be used (e.g., near housing for the elderly, hospitals, therapy clinics, and schools for the handicapped). The exact speed should be based on an engineering study including field observations.
2. The initial walk (W) should be 4 seconds unless, on average, groups of more than 10 pedestrians per cycle use a particular crosswalk for a significant number of cycles. In such situations this interval should be increased depending on field observations but should not exceed 7 seconds.
3. The vehicle change interval (amber [Y] all red [R]) should be included as part of the time provided for pedestrian clearance in accordance with the FHWA ruling to Dade County, Florida and should be displayed to the pedestrian as a steady don't walk (DW).
4. The walking distance should be defined as that between the center of the corner radii to the center of the farthest lane (D_4), including parking lanes. Right turns can be excluded if a pedestrian refuge island separates the right turn lane from the through lane.
5. The method of computing the total pedestrian phase should be by the following formula:

$$\text{Total pedestrian phase time} = W + \left(\frac{D_4}{V_p} - Y - R\right)$$

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