School Crossing Study

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General

School Crossing Studies are performed in conjunction with development of a school route plan, at locations where local authorities are considering a school crossing, or at existing school crossings. The primary reason for a school crossing study is to gain an understanding of the need for traffic control at a proposed or existing crossing. The analysis of the need for some form of special protection for a school crossing depends on the following two assumptions:

1. When the delay time between adequate gaps becomes excessive, children may become impatient and endanger themselves by attempting to cross the street during an inadequate gap.
2. The delay time between adequate gaps may be considered excessive when the number of adequate gaps in the traffic stream, during the period the children are using the crosswalk, is less than the number of minutes in that same period of time.

A Gap Study is performed to determine whether there are enough available gaps in traffic passing the crossing location that are of adequate length to permit school children to cross the street. In this context a gap is defined as the time that elapses from when the rear of a vehicle passes a point on a roadway until the front of the next arriving vehicle (from either direction) passes the same point. Gaps are normally expressed in units of seconds.

Gap Study

Gap Studies consist of determining the number of rows in the predominant (85^{th} percentile) pedestrian group size, determining the length of a minimum adequate gap, measuring the number and size of gaps in the traffic stream, and determining the sufficiency of adequate gaps. The survey begins upon arrival of the first child and ends when the last one has crossed the street.

The field survey portion of the study must be done under normal conditions involving the weather, school schedule, nearby traffic generator schedule, etc. For instance, if a nearby high school is not in session, or is not on its regular schedule, the survey will be influenced. Bicyclists are counted as pedestrians if they cross in the crosswalk. Vehicles turning onto the street that is being surveyed are not included if they enter the street from an adjacent side-street stop condition. They are excluded because they are expected to yield to pedestrians after stopping and not interfere with pedestrian gaps. Only school-age pedestrians are included in the study.

The observer must be strategically positioned so as to be able to see precisely when vehicles from each direction pass a certain point at or near the crosswalk, while at the same time being able to see children approaching the crossing. The observer's location and actions must not distract motorists or influence their behavior. The observer must arrive at the study site early enough to evaluate conditions, choose a location from which to gather the data, and practice the study technique long enough to be comfortable in the knowledge that the gathered data will be accurate.

If a roll out stop sign is in use at the site to be studied, some alternative procedure that will maintain the safety of the crossing and still obtain good data must be used. Probably the best solution is to measure the gap sizes immediately before the roll out signs are put in place and immediately after their removal from the street. It may be possible to have the city refrain from placing the roll out stop signs until the first child is near the crossing, and remove them as soon as possible after the normal school crossing time. A drawback to this system is that the children will not gather into groups to wait for adequate gaps so the only groups will be those that gather to walk together.

Determining Predominant Group Size

Groups of pedestrians waiting to cross a roadway will generally arrange themselves in multiple rows of various widths. When the group starts to cross, they enter the roadway with approximately two seconds of headway between rows. At typical locations in most Iowa cities the group sizes will be small and each row will contain one or two pedestrians.

The observer should count the children as they gather into groups to wait for a gap in the traffic stream and record the sizes of the groups on Form 1, Pedestrian Group Size Survey. The number of students in each group should be recorded on the appropriate line based on the size of the group. The number of rows to be used in the determination of adequate gap size is found on the line that includes the 85th percentile group. It is important to record the number of children because the school crossing signal warrant in the MUTCD includes a requirement of a minimum of 20 students during the highest crossing hour.

The group size column assumes rows of two but may be modified by the observer since row widths may vary depending on the size of the groups, width of the storage area and width of the crosswalk.

Determining Minimum Adequate Gap

The minimum adequate gap is defined as the time (in seconds) for a group of children to perceive and react to the traffic situation and cross the roadway from a point of safety on one side to a point of safety on the other. This minimum safe crossing time (gap in traffic) is a function of crossing distance, walking speed, predominant (85th percentile) number of rows in the group, time headway between rows, and the group startup time. This relationship is shown in the following equation:

$$G = \frac{W}{S} + (N-1)H + R$$

where

G = minimum safe gap in traffic, seconds
W = crossing distance, feet
S = walking speed, ft/sec. - assumed value is 3.5 ft/sec
N = predominant number of rows
H = time headway between rows, seconds – assumed value is 2 seconds
R = pedestrian startup time, seconds – assumed value is 3 seconds

The result is rounded to the nearest second. If the roadway is divided such that the median provides a safe haven for the school crossing, a minimum adequate gap will be determined for each half of the crossing.

If the crossing is on a street with an urban cross section the crossing distance is normally measured from one curb to the other, even when it is in the return area, as it cannot be expected that the children will stand in the gutter while waiting for an adequate gap. If the crossing is on a street with a rural cross section the children will stand on the shoulder at what they perceive to be a safe distance from the edge of the pavement. The walking distance for a rural street can best be determined by observation of the children and by the observer exercising good judgment based on site conditions involving width of shoulder, speed of traffic, etc.

The minimum adequate gap equation can be filled out on Form 1, Pedestrian Group Size Survey, to determine the minimum adequate gap. The minimum adequate gap may also be found directly by

using Table 1, Minimum Adequate Gap Times for School Crossing, after determining the predominant number of rows from the table on Form 1, Pedestrian Group Size Survey.

Table 1

Minimum Adequate Gap Times for School Crossing (G) in seconds

Crossing Width (W) ft.	Predominant Number of Rows (N)							
	1	2	3	4	5	6	7	8
16-19	8	10	12	14	16	18	20	22
20-22	9	11	13	15	17	19	21	23
23-26	10	12	14	16	18	20	22	24
27-29	11	13	15	17	19	21	23	25
30-33	12	14	16	18	20	22	24	26
34-36	13	15	17	19	21	23	25	27
37-40	14	16	18	20	22	24	26	28
41-43	15	17	19	21	23	25	27	29
44-47	16	18	20	22	24	26	28	30
48-50	17	19	21	23	25	27	29	31
51-54	18	20	22	24	26	28	30	32
55-57	19	21	23	25	27	29	31	33
58-61	20	22	24	26	28	30	32	34
62-64	21	23	25	27	29	31	33	35
65-68	22	24	26	28	30	32	34	36
69-71	23	25	27	29	31	33	35	37

Measuring Gap Sizes

The actual gap sizes in the traffic can be measured with a stopwatch and the times of the gaps entered directly on Form 2, Gap Size Survey. The form is also designed so the observer can use a digital watch or a sweep second hand watch and enter the hour, minute and second that each vehicle passes the observation point. Then the length of each gap greater than the minimum is calculated and entered. Gaps may also be measured using electronic count boards or other available equipment. Only the gaps that are equal to or exceed the minimum adequate gap are of interest so it is not necessary to record every gap. The actual minimum adequate gap will not be known, however, if the predominant group size study has not been completed. The observer will then have to use a conservative estimate of the minimum adequate gap to decide the minimum gap that must be recorded. In most cases this should be the value for (G) found in Table 1 where (N) = 1. The gaps that are less than the minimum adequate gap determined by the predominant group size study can be discarded.

Determining Sufficiency of Adequate Gaps

To evaluate the study results the number of effective gaps is compared to the number of minutes during the period when the children are using the crossing. Form 3, Determining Sufficiency of Adequate Gaps, is used for the evaluation. All the gaps that are equal to or greater than the minimum adequate gap are totaled (D) and divided by the minimum adequate gap (G) to obtain the effective number of gaps (E). This is then compared to the number of minutes during the period of time when the children were using the crossing (T).

Some form of special traffic control should be considered if the effective number of minimum adequate gaps (E) is less than the number of minutes in the period when the children were using the crossing (T).

Traffic Control Considerations

If the Gap Study analysis indicates the need for some form of special protection the three most viable forms of protection in Iowa are:

1. Adult crossing guards
2. Roll out stop signs
3. Traffic control signals

There is no minimum number of school children for consideration of adult crossing guards or roll out stop signs but there is a minimum of 20 students during the highest crossing hour for consideration of traffic signals.

Recommendations for study and use of adult crossing guards and traffic control signals, as well as school route planning and other considerations, are found in Part 7 of the Manual on Uniform Traffic Control Devices (MUTCD) and in the publication, School Trip Safety Guidelines, available from the Institute of Transportation Engineers, 1099 14th Street, NW, Suite 300 West, Washington, DC 20005-3438.

For use of traffic control signals the provisions of Section 4C.06 of the MUTCD must be followed.

Roll Out Stop Signs

Portable or part-time stop signs may be used for school crosswalks as noted in Administrative Rule 761.130.1(1). Also, Iowa Code Section 321.249 permits cities and counties to establish school zones and provide for the stopping of all approaching motor vehicles by using movable stop signs placed in the streets. The procedure for authorization of the signs to be placed on a primary highway or primary highway extension is for the city or county to submit an Application For Approval of A Traffic Control Device. If a school is involved in placing and removing the sign, then the school may make the application, which must be approved by the city or county prior to Iowa DOT approval.

The roll out stop sign is a standard 30-inch sign mounted at a height of 4½ feet above the pavement or border.

The roll out stop sign should be placed at centerline on each side of the intersection or mid-block marked crosswalk. If used on a four-lane street, an additional sign should be placed on the border. The one on the border may be articulated rather than movable, so as to face side street traffic when the roll out sign is not in use on the street. Adult crossing guards may be used in conjunction with roll out stop signs.

Location Assessment

Sight Distance

Sight distance for a school child or group of children at a crossing must be adequate for an approaching vehicle to be seen soon enough that the street can be crossed before the vehicle arrives at the crossing. A study is performed to determine if adequate sight distance exists for the children that use the crossing. The time required for the group to cross the street is arrived at as discussed in the section on Determining Minimum Adequate Gap (G). The sight distance (SD) required for that amount of time will depend on the speed of the vehicle as shown in the following equation:

$$SD = (S)(G)\frac{5280}{3600}$$

where

SD = Required Sight Distance, feet
S = Speed, miles per hour
G = Minimum Adequate Gap, seconds

As an example, a minimum adequate gap time of 15 seconds on a street with a 45 mph speed limit would require a minimum sight distance of 990 feet.

Assumptions appropriate for the study are:

- The location of the child relative to the street is the point of safety used to determine the minimum adequate gap.
- For a grade school crossing, the height of eye of the child is 3.5 feet, which is based on a five-year-old being 44 inches tall.
- For a middle school or high school crossing, the height of eye of the child is 4.5 feet, which is based on an eleven-year-old being 57 inches tall.
- The height of the approaching vehicle is 3.5 feet.
- The lateral location of the approaching vehicle is the center of the near lane for each direction of travel.
- The speed of approaching traffic is five miles per hour over the posted speed limit unless a recent speed study or other factors indicate that another speed should be used.

If the required sight distance is not available the crossing should be relocated. If this is not practical then some form of traffic control is indicated, even if there would otherwise be a sufficient number of adequate gaps in the traffic stream.

Crosswalk Signing and Marking

The school crosswalk must be signed and marked as provided in Part 7 of the MUTCD. The Iowa Dept. of Transportation will provide and install the School Advance Warning Assembly and School Crosswalk Warning Assembly on primary highways or primary highway extensions. The City is responsible for providing the pavement markings for the crosswalk. Word and symbol markings shall be white. They shall read up in the direction of travel and consist of the word “SCHOOL” and the word “X-ING”. The longitudinal space between the two words shall be four times greater than the letter height. The distance from the word “X-ING” to the crossing shall be at least four times the height of the word for low speed roads but not more than ten times the height of the word under any conditions. These markings are elongated as shown in Section 3B-2 of the Traffic and Safety Manual and shall be placed by template on the pavement. Word messages shall be no more than one lane width, except the word “SCHOOL” may extend across two lanes.

Other Factors

The entire street in the vicinity of a proposed or existing school crossing should be reviewed and appropriate improvements made to contribute to the safety of the crossing area. One of the first considerations should be whether or not the proposed crossing is on a school route in the plan for that school. Prior to being signed and marked as a school crossing, regardless of the type of control being used, it should be officially designated by the City or County as a school crossing. Existing signing in the vicinity should be reviewed as suggested in Section 7J-1 of the Traffic and Safety Manual to make sure that proper signs are in place and at the proper height, lateral clearance and longitudinal spacing, especially signs relative to the school and/or school crossing. Appropriate pavement markings should be in place and in good condition. The existence of sidewalks for the use of school children is important for their access to the crossing. The influence of commercial land use should be evaluated and adverse effects mitigated as much as possible. Nearby traffic control such as all-way stop and traffic signals should be taken into consideration with regard to their influence on school crossing evaluations. The speed limit, prevailing speed, vehicular traffic volume and crash history may all contribute to the evaluation.

Form 1

Pedestrian Group Size Survey

Date_____ Location _____

End of Survey Nearest Min._____ Crosswalk Across _____

Begin Survey Nearest Min._____ Crossing Width (W) _____ Ft.

Total Survey Time Minutes (T)_____ Observer _____

Minimum Adequate Gap Time (G)_____

(W) = Distance from a point of safety on one side of the street to a point of safety on the other side

T = Length of survey in minutes (time of last crossing – time of first crossing)

F = Number of groups of students using crossing

C = Cumulative number of groups

	Number of Groups				
Group Size	**Number of Students in Each Group**	**Count of Groups**	**Cumulative Number of Groups (C)**	**Cumulative Percentile C/F**	**Number of Rows (N)**
1 or 2					1
3 – 4					2
5 – 6					3
7 – 8					4
9 – 10					5
11 – 12					6
13 – 14					7
15 - 16					8

Total Students_____

Total_____ Groups, F

The number of rows (N) to be used in the determination of minimum adequate gap (G) is found on the line that includes the 85th percentile group size.

The minimum adequate gap (G) is calculated using the following equation:

$$G = \frac{W}{S} + (N - 1)H + R \qquad G = \frac{\_\_\_}{3.5} + (\_\_\_ - 1)2 + 3$$

where

G = minimum safe gap in traffic, seconds
W = crossing distance, feet
S = walking speed, ft/sec. - assumed value is 3.5 seconds
N = predominant number of rows
H = time headway between rows, seconds – assumed value is 2 seconds
R = pedestrian startup time, seconds – assumed value is 3 seconds

Form 2

Gap Size Survey

Date__________________ Location ____

End of Survey Nearest Min. _______________ Crosswalk Across ___________________________

Begin Survey Nearest Min.________________ Crossing Width (W) _______________________ Ft.

Total Survey Time Minutes (T)_____________Observer ___________________________________

Minimum Adequate Gap Time (G)_______________(from Form 1 or Table 1)

T = Length of survey in Minutes (time of last crossing – time of first crossing)

Hour	Minute	Second	Gap	Hour	Minute	Second	Gap	Hour	Minute	Second	Gap

Form 3

Determining Sufficiency of Adequate Gaps

Date_____ Location _____

End of Survey Nearest Min. _____ Crosswalk Across _____

Begin Survey Nearest Min._____ Crossing Width (W) _____ Ft.

Total Survey Time Min. (T)_____ Observer _____

Minimum Adequate Gap Time (G)_____ (from Form 1 or Table 1)

T = Length of survey in Minutes (time of last crossing – time of first crossing)

D = Total amount of time available in all adequate gaps (seconds)

E = Effective number of gaps in study period

$E = \frac{D}{G}$ = Effective number of minimum adequate gaps (E) _____

Gap Length	Tally	Total Gaps	Total Seconds	Gap Length	Tally	Total Gaps	Total Seconds
10				33			
11				34			
12				35			
13				36			
14				37			
15				38			
16				39			
17				40			
18				41			
19				42			
20				43			
21				44			
22				45			
23				46			
24				47			
25				48			
26				49			
27				50			
28							
29							
30							
31							
32							

D, Sec.

Origin of Method of Determining the Adequacy and Frequency of Gaps for School Crossings

Section 4C.06 of the 2003 MUTCD refers to Section 7A.03, which states that: "A recommended method for determining the frequency and adequacy of gaps in the traffic stream is given in the Institute of Transportation Engineers publication, "School Trip Safety Program Guidelines" (see Section 1A.11)." This publication, however, does not include a recommended method for determining the frequency and adequacy of gaps in the traffic stream. It states on page 7, that: "Detailed procedures for vehicle gap studies and pedestrian group size studies may be found in the *Transportation and Traffic Engineering Handbook*, ITE, 1982 and 1976."

The *Transportation and Traffic Engineering Handbook*, ITE, 1982, on page 538, presents a method of obtaining the percent delay at the crossing, based on the total time of all gaps equal to or greater than the adequate gap time compared to the total survey time, but does not provide information as to how to utilize that information. It refers to the 1972 publication, *A Program for School Crossing Protection*, but only in the context of calculating delay at signalized intersections.

The *Transportation and Traffic Engineering Handbook*, ITE, 1976, presents the same method of obtaining the percent delay at the crossing, and for use of that information it refers to "A Program for School Crossing Protection: a Recommended Practice of the Institute of Traffic Engineers," Traffic Engineering, Vol. 33, No 1 (October 1962), pp. 45-52, 56, 58 and 60 (revised 1971 and reprinted as *A Program for School Crossing Protection*).

The 1972 publication, *A Program for School Crossing Protection*, includes Exhibit No. 2 entitled "Determination of Need for Traffic Control at School Crossings" that graphically presents three parameters - width, number of rows and percent delay. The graph was developed on the basic assumption that the delay time between adequate gaps may be considered excessive when the number of adequate gaps in the traffic stream, during the period the children are using the crosswalk, is less than the number of minutes in that same period of time. The actual percentage of delay time is graphically being compared to the allowable percentage of delay time. If a plotted point is to the right of the appropriate line for number of rows, control is needed.

The Iowa DOT procedure is to sum the total time available in all adequate gaps, as shown in the 1972 publication, *A Program for School Crossing Protection*, but then divide that time by the length of the minimum adequate gap for direct comparison to the total number of minutes of crossing usage. The direct comparison method produces the result without the user having to go through the extra steps of computing delay, plotting it on the graph and reading the result from the graph.

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