NJDOT REPORT NO. 75-006-7712

NOT FOR PUBLICATION

PEDESTRIAN GRADE SEPARATION LOCATIONS - A PRIORITY RANKING SYSTEM

VOLUME I

FINAL REPORT

BY

THOMAS BATZ, JOHN POWERS, JOHN MANRODT,
AND RICHARD HOLLINGER

PREPARED BY

NEW JERSEY DEPARTMENT OF TRANSPORTATION
DIVISION OF RESEARCH AND DEVELOPMENT
BUREAU OF OPERATIONS RESEARCH

DECEMBER 1975

ACKNOWLEDGEMENT

The authors wish to express their appreciation for the assistance given them in this project by Frank Parker, Chief Engineer Design, the Bureau of Traffic Engineering, the Bureau of Surface Design, Eugene F. Reilly, Joseph Santacroce, and Allen Toole of the New Jersey Department of Transportation.

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No	2 Government Accession No	3 Recipient's Catalog No

4 Title and Subtitle	5 Report Date
Pedestrian Grade Separation Locations - A Priority Ranking System	December 1975
	6 Performing Organization Code
7 Author(s)	8 Performing Organization Report No
T. Batz, J. Powers, J. Manrodt, and R. Hollinger	75-006-7712
9 Performing Organization Name and Address	10 Work Unit No
New Jersey Department of Transportation Bureau of Operations Research Division of Research and Development 1035 Parkway Avenue, Trenton, NJ 08625	11 Contract or Grant No
12 Sponsoring Agency Name and Address	13 Type of Report and Period Covered
Same as 9	Final Report
	14 Sponsoring Agency Code

15 Supplementary Notes

None

16 Abstract

This report describes the development of a priority ranking system for locations where the installation of a pedestrian grade separation is proposed. The system considers two categories of locations; i.e. where pedestrian activity is possible and where pedestrian activity is not possible.

The system is based on subjective weights applied to parameters which are measured in the field. There are five parameters for locations where pedestrian activity is possible. These are pedestrian-vehicle volume, sight distance or pedestrian crossing, school crossing, distance to alternate crossing, and judgement. There are three parameters for locations where pedestrian activity is not possible. These are trip generation, distance to alternate crossing, and judgement. The procedure permits locations to be evaluated in a consistent manner and allows the expenditure of limited construction funds in the most technically, efficient manner.

Computer programs have been developed for performing the necessary mathematical operations to give the final listing in priority ranking. A manual method utilizing graphs has also been developed.

17 Key Words	18. Distribution Statement
Pedestrian overpasses, pedestrians, priority ranking system, pedestrian grade separation locations, warrants, pedestrian underpasses	

19 Security Classif (of this report)	20 Security Classif (of this page)	21. No of Pages	22 Price
Unclassified	Unclassified		

Form DOT F 1700.7 (8-69)

TABLE OF CONTENTS

List of Tables

R & D IMPLEMENTATION DATA SHEET

PART A

NOTE - The receiving office will code card Col. 3 thru 7, and 17 thru 25.

REPORTING STATE New Jersey

1 2	3	4 6	7	8	9 16	17 23	24	25	26 31	32 37	38 43
State	Yr	Id. Num.	UD	Cd	State Project Number	FCP Code	AP	Fnd	Proj. Start Date (Mo Day Yr)	Proj. Compl. Date (Mo Day Yr)	Date This Report (Mo Day Yr)
2 8				A	7 7 1 2				0 1 7 3	1 1 7 5	1 1 7 5

PART B

44 47
STUDY COST To Date ($1000's)
2 3

48	49	50	51	52	53	54
IS	IO	IP	IA	TA	RU	NI
2	1	3	2			

IMPLEMENTATION STATUS = (IS) in Col. 48
1 Implemented (ing) - Code Col. 49 & 52
2 Implementable - Code Col. 49, 50, & 51
3 No implementation planned - Code Col. 53 or 54

IMPLEMENTABLE BY OTHERS = (IO) in Col. 49
1 By most other states
2 Some other states
3 No other states
4 Other (Explain)

IMPLEMENTATION PLANS = (IP) in Col. 50
1 Will be implemented or underway in next 12 months
2 Will be implemented or underway in next 24 months
3 Implementation is planned, subject to action noted, in Col. 51

IMPLEMENTATION ACTION NEEDED = (IA) in Col. 51
1 Equipment changes or modifications needed
2 Administrative decision required
3 Need new or revised procedures, guidelines, manual, &/or standards or specifications
4 Training aids need to be prepared
5 Other (Explain)

NOT IMPLEMENTABLE = (NI) in Col. 54
1 Negative findings
2 Confirms present practice
3 Additional evaluation or study needed
4 Findings too complex
5 " impractical
6 " inconclusive
7 " unreliable
8 Other (Explain)

RESULTS POTENTIALLY USEFUL = (RU) in Col. 53
1 A phase, or one of a group of studies
2 Points up need for further research
3 Findings are theoretical in nature
4 Exploratory
5 Findings valuable in decision making
6 Other (Explain

TRAINING AIDS USED, PLANNED OR NEEDED = (TA) in Col. 52
1 Workshops
2 Movies
3 Slides
4 Other
5 None used, but some are needed (Explain)

PART C

55 56	57 62	63 64	65	66 67	68 69	70 73	74 77	78 79	80
Rep. State	Benefit End Date (Mo Day Yr)	Num. Mo.	SB	Accid. Prev.	Lives Saved	Cash $ Saved	User $ Saved	Ben/C	Yes No
2 8			3						1

State Reporting Implement.

TIME PERIOD OF SAVINGS & BENEFITS
Period ending date - Col's. 57 - 62
Total period in months - Col's. 63 & 64

TYPE OF SAVINGS OR BENEFITS = (SB) in Col. 65
1 Cash savings to agency
2 Highway user savings (monetary)
3 Savings probable but difficult to assess
4 Improved safety or convenience
5 Improved aesthetics, environmental aspects

For combination benefits, see manual for codes.

DID RESEARCH PAY OFF - Col. 80
If no estimate is possible, do you feel that benefits substantially exceeded the cost? Enter code, Yes = 1, No = 2

BENEFIT/COST RATIO (For reporting period)
Enter in Col's. 78 & 79, to nearest unit $, the benefits per research dollar invested

BEST EST. OF $ SAVINGS THRU IMPLEMENTATION
Enter agency savings ($1000) in Col's 70 - 73
Enter user savings ($1000) in Col's 74 - 77

ESTIMATED No. of ACCIDENTS PREVENTED & No. of LIVES SAVED
No. of Accidents in Col's 66 & 67
No. of Lives saved in Col's 68 & 69

8	9 80
Card	R & D Study Title
B	PEDESTRIAN GRADE SEPARATION LOCATIONS - A PRIORITY RANKING SYSTEM
C	
D	

NOTE - Type no more than 72 characters (Elite) per line including all spaces and punctuation. Use ALL CAPS

NOTE - Type no more than 72 characters (Elite) per line, including all spaces and punctuation. Use all CAPS

8	9 80
Card	Study Objectives
G	DEVELOPMENT OF WARRANTS FOR PEDESTRIAN GRADE SEPARATIONS WHICH
H	CAN BE USED TO EVALUATE LOCATIONS WHERE PEDESTRIAN GRADE
I	SEPARATIONS ARE REQUESTED.
J	

8	9 80
Card	Study Findings
M	A PRIORITY RANKING SYSTEM WAS DEVELOPED FOR LOCATIONS WHERE A
N	PEDESTRIAN GRADE SEPARATION IS PROPOSED. THE SYSTEM GROUPS ALL
O	LOCATIONS INTO TWO GROUPS, ONE WHERE PEDESTRIAN ACTIVITY IS POSSIBLE
P	AND ONE WHERE IT IS NOT POSSIBLE. THE SYSTEM IS BASED ON SUBJECTIVE
Q	WEIGHTS APPLIED TO PARAMETERS WHICH WERE DETERMINED TO SHOW THE NEED
R	FOR A PEDESTRIAN GRADE SEPARATION AND CAN BE MEASURED IN THE FIELD.

8	9 80
Card	Implementation - How Done
V	INCLUDED IN THE REPORT IS A DATA COLLECTION PROCEDURE WHICH EXPLAINS
W	HOW THE COLLECTION OF ALL FIELD DATA SHOULD BE DONE. A MANUAL
X	METHOD FOR DETERMINING THE FINAL SCORE FOR THE PRIORITY RANKING
Y	SYSTEM IS SHOWN AND EXPLAINED. COMPUTER PROGRAMS WHICH WERE DE-
Z	VELOPED SO THAT THE DATA COULD BE EASILY AND CONVENIENTLY PROCESSED,
Ø	ARE SHOWN AND EXPLAINED. THE ULTIMATE OUTPUT OF THESE PROGRAMS IS
1	THE PRIORITY RANKING LIST FOR LOCATIONS WHERE PEDESTRIAN GRADE
2	SEPARATIONS WERE INVESTIGATED.
3	

Indicate who to contact for any followup information.

Mr. Thomas Batz	Mr. Richard Hollinger
Name	Name

I. SUMMARY

Pedestrian grade separations are a means of reducing conflicts between vehicular and pedestrian traffic, thus increasing the efficiency and safety of the transportation system. While some attempts at using economic analysis to justify the construction of pedestrian facilities have been tried, a systematic approach has generally been lacking.

This paper proposes an approach which rates alternate sites and lists them in a priority order. This priority ranking system requires a minimum number of measurements and gives a uniform system for comparison of sites. Recommended locations are divided into two categories: one where pedestrian activity exists, e.g. where pedestrians are observed crossing at grade on the roadway, and the other where pedestrian activity is not possible, e.g. controlled access roadway.

The parameters included in the ranking system were chosen after aspects of existing and proposed pedestrian grade separation locations were observed. The respective importance of each of these parameters, relative to the others, was subjectively determined and a weighting factor was used to give the desired relationships.

It is the feeling of the authors that this system presents a workable method of evaluating pertinent field data for locations where a pedestrian grade separation is under consideration.

The parameters used to warrant the need for a pedestrian grade separation at a site where pedestrian activity exists are:

1. The relationship between vehicular and pedestrian volumes with a peak hour average delay factor applied;
2. The amount of pedestrian crossing time needed compared to the maximum green and yellow time available to pedestrians

for a signalized site or the actual sight distance compared to the desirable sight distance for a non-signalized site;

3. The number of school children;
4. The distance to the nearest alternate crossing considering the type of protection at the alternate crossing; and
5. A judgement value.

The parameters used to warrant the need for a pedestrian grade separation at a site where pedestrian activity is not possible are:

1. Pedestrian trip generation;
2. Distance to nearest alternate crossing considering the type of protection at the alternate crossing; and
3. A judgement value.

Appendix A contains a complete description of data collection required for this system, while Appendix B explains how to rank pedestrian grade separation locations. These Appendices can be used separately as a User's Manual for the system.

Three computer programs were developed for this study. The first program computes peak hour pedestrian delay at signalized intersections from field data. The second program computes the priority ranking score for each site from the field and delay data, while the last program formats and outputs the scores in their priority ranking. These programs are described in Appendix C. Appendices D, E, and F are listings of the three computer programs. Appendices A to F may be found in Volume II of this report.

II. INTRODUCTION AND BACKGROUND

Studies on the development of warrants for pedestrian grade separations have been very limted. As discussed by ITE Committee 4E-A in a 1972 report[13], installation of such separations offers some advantages:

1. The construction imposes no new restrictions to the motorists, in fact, it may relieve some restrictions;
2. It eliminates the vehicular-pedestrian conflicts rather than alternating the right-of-way between the two road users; and
3. A decrease in accidents normally will result from a reduction of conflicts.

On the other hand, the installation of a grade separated facility is costly. Unless certain minimum conditions exist and necessary restrictions can effectively be imposed on pedestrians, the facility might be less than a desirable investment.

Previous attempts at determining the need for pedestrian grade separations have dealt with trying to assess the economic worth of a fatal pedestrian accident. This variable and relatively rare occurrence is difficult to predict and tends to carry a disproportionate weight in any economical determination. Factors such as vehicular and pedestrian delay are generally used as benefits to amortize against the cost of implementation. The cost for vehicle delay is a defined quantity; however, the value for the pedestrian's time is very difficult to assess. This problem is more acute when the majority of pedestrians are of school age. Thus, the determination of relative need for a pedestrian separation using the economic approach cannot be reliably accomplished to allow direct comparison to initial construction cost.

Another method would be the rating of alternate sites and listing them on a priority basis. This method could be accomplished by selecting parameters that affect pedestrian-vehicle movement.

Each of these selected parameters would be given a "weight." All sites being considered for a pedestrian separation would then be rated by the traffic engineer on the basis on the "weighted" parameters. A priority listing of sites would be made from the point scores for each site. This method is not without some disadvantages; the most significant being that weights or values must be given to such intangible items as the type of pedestrian, etc. Extreme care must be taken in the initial selection so that these intangibles are identified and agreed upon by all interested parties.

With our present highway system composed of controlled and non-controlled access roads, there exists considerable differences in the need for pedestrian separation from one location to another. Generally, on the controlled access roadway, no crossing is allowed at grade; consequently, no conflict exists with main line vehicles. Thus, it becomes a question of convenience to the pedestrian requiring access to the other side. The principles, then, that should be followed as stated in the "Policy on Arterial Highways[44]" published by the American Association of State Highway Officials are:

> "Spacing of pedestrian crossings (both sidewalks on separation structures and separate pedestrian overpasses) depends upon the needs of pedestrians and the type of adjacent development. In retail business districts, crossings every block frequently are necessary. In intermediate areas, between business and residential areas, crossings at every other cross street or farther apart may be adequate. In outlying areas, pedestrian crossings at greater intervals usually are satisfactory. Locations are likely to be determined more by individual needs than by any general criteria. Pedestrian walks over freeways often are required in the vicinity of schools, factories, shopping centers, parks, playgrounds, or other places of public assembly."

The primary factors to be considered on a non-controlled facility seem to be the vehicular and pedestrian volumes. However, if warrants were based on these two parameters, a pedestrian separation may be justified on every downtown intersection. Thus, additional criteria should be considered in determining the appropriate parameters; these include:

1. Other traffic controls in the vicinity;
2. Geometric characteristics; and
3. Inconvenience to pedestrians in crossing and their acceptance of it.

After reviewing the possible methods of evaluating locations for pedestrian grade separated facilities, a decision was made to develop a priority ranking procedure. While the subjective nature of such a procedure may cause difficulty in developing the weighting factors, it was felt that the probability of success was better than attempting to develop an economic procedure.

III. PROCEDURE

The procedure used to determine and select the applicable parameters consisted mainly of reviewing other studies and reports, along with meetings with traffic and operations personnel.

The initial attempt was to develop a list of parameters that could be used on all types of road facilities. The informational report in the October 1972 issue of Traffic Engineering on "Pedestrian Overcrossings[13]" listed certain conditions and parameters used by the Seattle[10] Engineering Department in their priority pedestrian overpass study. Some of the parameters listed include:

1. Average weekday vehicle and pedestrian volumes;
2. Number of pedestrian accidents;

3. Whether location is signalized;
4. Street geometrics; and
5. Vision and miscellaneous factors.

The above parameters were applied by Seattle to selected locations without regard to type of roadway. In general, all the locations were of the non-controlled access type.

However, after an analysis of the conditions at existing pedestrian overpasses and of hypothetical test locations selected to cover the various types of facilities found in our State highway system, it became apparent that different locations required different approaches to the problem. In general, locations may be separated into two categories depending on whether or not pedestrian activity is possible.

LOCATION CATEGORIES

The first category includes locations where pedestrians cross the roadway at grade. This category is further divided by the form of protection afforded pedestrians. The need for pedestrian grade separation at signalized locations is determined from:

1. The relationship between vehicle and pedestrian volumes with a peak hour average delay factor applied;
2. The amount of pedestrian crossing time needed in addition to a minimum initial interval of seven seconds,[41] as compared to the maximum green and yellow time available to pedestrians;
3. The number of school children;
4. The distance to the nearest alternate crossing taking into account the type of protection at the alternate crossing; and
5. Judgement.

At non-signalized locations, the second parameter is changed to reflect the difference in characteristics which affect the need for a grade separation. Instead of signal timing, the relationship between the actual sight distance and the desirable sight distance, as determined from the roadway width and the posted speed, is used.

Locations where a need for crossing exists but for some reason pedestrians are prevented from doing so fall into the category of "pedestrian activity not possible." These locations include all controlled access roadways where grade crossing is prohibited and certain non-controlled access sites where, due to some condition such as a center barrier, pedestrians are unable to cross. At these locations, the rationale used was to evaluate the extent of the desire to cross and the degree of inconvenience caused by walking to the nearest alternate crossing location.

The actual parameters used are:

1. Pedestrian trip generation;
2. Distance to nearest alternate crossing taking into account the type of protection at the alternate crossing; and
3. Judgement.

Once the parameters, which met our basic requirements, were specified for each category, a scheme for weighting them was developed. The relative weights were chosen on the basis of a percentage of the total possible score for any site.

Two hundred points was chosen as the total possible score for a site regardless of category. A large maximum score seemed appropriate since the parameters were chosen to reflect as wide a variation of characteristics as possible. Also, lower weighted parameter scores could be kept to whole number values more often than if one hundred points was used.

The weights chosen for each parameter are intended to reflect their relative importance to the need for a grade separation. Table 1 summarizes the maximum weights given each parameter.

TABLE 1

Pedestrian Activity Possible		Pedestrian Activity Not Possible	
Parameter	Weight	Parameter	Weight
Pedestrian and vehicle volume	40%	Trip generation	35%
Actual sight distance/ desirable sight distance or maximum vehicle green and yellow	25%	Distance to alternate crossing	35%
		Judgement	30%
School crossing	15%	Safety at alternate crossing	2.5%
Distance to alternate crossing	15%	Surplus trip generation	10.0%
Judgement	5%	Uniqueness of location	17.5%

The major difference between the two categories is that scores for the "pedestrian activity possible" category are awarded on the basis of existing conditions while awarded scores for the "pedestrian activity not possible" category rely on a prediction of demand. For this reason, it is felt that judgement must carry a significant portion of the weight for the pedestrian activity not possible category. This is to account for the many unique characteristics of a specific location which may affect the use of a pedestrian facility but which are not considered in the simplified demand model.

Whenever possible, proven procedures were applied in determining the relationships of variables within each parameter. In the absence of such procedures, a consistent application of subjective theories was used. All figures referred to in the following section may be found in Volume II - Appendix B of this report.

LOCATIONS WHERE PEDESTRIAN ACTIVITY IS POSSIBLE

Pedestrian and Vehicle Volume

The Seattle report[10] included a set of curves representing the pedestrian-vehicle conflict which proved to be relatable to delay.

It was felt that the curves could be improved to better reflect delay at both signalized and unsignalized locations by taking the peak hour conditions into account. By applying a linear adjustment based on the average pedestrian delay during the peak hour, the score from Figure B-1 can be increased or decreased. This adjustment is made by using a multiplication factor ranging from zero to two. One cycle or sixty seconds of delay was considered to be acceptable and not require an increase in the base score[21] from B-1. In addition, less than one cycle or sixty seconds of delay was considered to be reason for decreasing the score. Figures B-2 and B-3 show these relationships.

Sight Distance or Pedestrian Crossing

Physical characteristics were related by using the roadway width, speed limit, and actual sight distance, when the location is unsignalized, or by using the roadway width and crossing time allotted to the pedestrian when the location is signalized, as shown in Figures B-4, B-5, and B-6.

A walking speed of four feet per second was used as an average[6]. For unsignalized locations, the roadway width in feet is divided by four feet per second to determine the time required to cross the roadway. Using this time and the vehicular speed limit, a desirable sight distance is determined. Figure B-4 can be used to perform the calculation. When the desirable sight distance is equal to the actual sight distance, a pedestrian could step off the curb at the same time an approaching vehicle just comes into view and could reach the opposite curb safely. On this basis, actual sight distances of between one and two times the desirable sight distance are awarded from ten to zero points, thus giving some additional benefit to those locations with greater sight distance. When the actual sight distance is one-half the desirable sight distance or less, the maximum score, or fifty points, is awarded. This is shown in Figure B-5.

For signalized locations, the roadway width is again divided by four feet per second. This time is the necessary pedestrian crossing time. The MUTCD[21] indicates that seven seconds is a minimum clearance interval for pedestrians. In order to have a common basis for comparing the needed time to the time allotted by the signal, this seven seconds is added to the pedestrian crossing time. As for unsignalized sites when the values are equal, the score awarded is ten points. When the allotted time is twice that needed, the score awarded is zero points, and when the allotted time is half or less of that needed, the maximum score, or fifty points, is awarded. This is shown in Figure B-6.

School Crossings

School children and the protection afforded them, such as a crossing guard, signal, or school crossing signs, were chosen as the most important pedestrian characteristics. Two approaches exist on how to award points. One theory would allow the maximum score when a location has a school crossing guard on duty and less points when a location has a lesser form of protection. This is based on the fact that a guard on duty indicates a greater need for protection. The other theory does not debate this fact but holds that if a school guard is present the school children have a safer situation than if they were crossing at a location which has a lesser form or no protection afforded them, all other factors being equal. The scores awarded by Figure B-7 reflect the second theory. The actual point limits were chosen on the basis that the five forms of protection would each have a separate maximum number of points. Each of these maximums would be allotted when two hundred school children crossings per day were made at the crossing. Two hundred school children crossings were chosen because few sites are expected to exceed this number on the basis of experience in the field. The maximum points for each form of protection decreases in steps of five points in ascending order of protection from a maximum value of thirty points for no protection to a maximum value of ten points for a guard on duty. The scores were awarded for less than two hundred school children crossings on the basis than in any case, zero school children crossings would receive zero points; half the maximum, or one hundred school children crossings, would receive roughly two-thirds the maximum score; and one-quarter the maximum number, or fifty school children crossings, would receive roughly one-half the maximum score. These relationships were approximated by parabolic curves on Figure B-3. The reasoning is that an increase of fifty school children crossings, from zero to fifty, is about twice as significant as an increase from fifty to one hundred school children crossings, and about three times as significant as an increase from one hundred to one hundred and fifty school children crossings. This reasoning allows the scoring to be more sensitive to small changes in the number of school children crossings when the total number is relatively low and less sensitive to small changes in the number of school children crossings when the total number is relatively large.

Distance to Nearest Alternate Crossing

The distance to an alternate legal (marked) crossing and the form of protection afforded pedestrians at the alternate crossing were chosen as the basis for scoring inconvenience. The inconvenience to the pedestrian is considered to increase as the distance to the alternate crossing increases. However, the likelihood that pedestrians will walk a certain distance decreases rapidly up to about seven hundred and twenty-five feet at which point this "propensity" to walk a distance decreases more gradually[42]. The curve becomes somewhat asymptotic at two thousand feet, since only about eighteen percent of all walking trips are two thousand feet or longer. This relationship is considered to define the inconvenience associated with a walking distance.

The number of pedestrians times the distance to be walked gives a measure of pedestrian delay in terms of pedestrian-feet. Five hundred trips of two thousand feet, or one million pedestrian-feet, was subjectively chosen to deserve a maximum score. Lines of constant pedestrian volumes, varying from twenty-five to two thousand pedestrians, were then plotted on the graph and adjusted by the inconvenience curve to represent a combination of delay and inconvenience.

Three basic types of protection for a crossing were defined. They are: passive (flashing signal, signs only, or crosswalk); active (traffic signal); and a grade separation. An unmarked crossing was not considered to be a legal alternate crossing. Passive protection was considered to deserve the maximum number of points, thirty. Active protection and grade separation were awarded lower maximums, twenty five and twenty points, respectively to account for the protection available. An alternate crossing at a distance of zero feet was considered to be worth zero points unless it offered only passive protection. For this case, the decision was made that it be awarded half the maximum or fifteen points. The theory for this decision was that even if the distance is extremely short for the pedestrian to use an alternate crossing, the score should be significant if the crossing offers him little or no advantage in terms of protection. The point scales increase linearly from the minimum to the maximum points awarded.

Judgement

The use of judgement was determined as the only way to interpret exactly how much score an unusual circumstance should be awarded. When pedestrian activity exists, the chances that an unusual circumstance will not be accounted for in the previous four parameters are greatly reduced. This is because the number of pedestrians is measurable and their characteristics can be related to the existing conditions in most cases. This system attempts to achieve a good balance or optimum condition between accounting for all location conditions and the sensitivity of differences at each location. In order to allow for conditions which the evaluator may feel are not reflected by the previous scoring procedures, the option of using his own judgement in awarding up to ten additional points is present. It is suggested that reasons for awarding these points be explained so that the condition or conditions warranting the points awarded can be easily identified should the evaluation be reviewed and so that different evaluators will give similar ratings.

LOCATIONS WHERE PEDESTRIAN ACTIVITY IS NOT POSSIBLE

Trip Generation

The task of evaluating a site where no pedestrian activity is possible depends heavily on the ability to predict the demand for its use. Planning models exist for predicting auto trips on the assumption that residential density and certain attractions are the reason that most trips are generated. The assumption was made that a relationship between the method of predicting auto trips and pedestrian trips would exist when the predicted distances are short.

A one-quarter mile radius circle was chosen as a reasonable limit for which this assumption would hold. The proposed pedestrian grade separation would be located at the center of this circle. The roadway to be crossed is used to separate the circle into two zones, each of which could generate trips to the opposite zone. Two trips per day per household was expected to be the maximum number of trips which could be generated. Four major trip attractors were defined and each was assigned a percentage of the two trips each household is likely to produce to that attractor. Scoring is awarded on the basis of one point for every ten trips per day generated up to 700 pedestrian trips.

Distance to Nearest Alternate Crossing

The technique for evaluating the distance to the alternate crossing and the protection afforded there is identical to the method used for the previous category. However, scores for the distance to the alternate crossing were adjusted to reflect the weighting assigned to this parameter within this category. For passive protection, the maximum score is increased to seventy points and the minimum is held at one-half the maximum or thirty-five points. Active protection and grade separations were awarded a lower maximum score, sixty and fifty points, respectively. Their minimums were held at zero as for pedestrian activity possible locations.

Judgement

When pedestrian activity is not possible, the evaluation of a location must rely heavily on a subjective analysis because of the many variables which are not considered in the model. As indicated in Table 1, judgement carries a weight of thirty percent, or sixty points of two hundred possible points, when pedestrian activity is not possible. A maximum of five additional points was allowed to account for the possibility that in getting to or once at an alternate crossing, a pedestrian may be subjected to less than desirable conditions. A lack of sidewalks at a bridge overpass or underpass or the necessity of crossing another roadway at grade to gain access to the alternate crossing is considered to be less than desirable. Generated trips in excess of seven hundred were also considered to be worth up to an additional twenty points.

The remaining thirty-five possible points were chosen to be awarded solely on the judgement of the evaluator if he feels that there is something unique at this location. The scoring system for locations without pedestrian activity is based on a significantly smaller sample of measurable data and, therefore, is in itself more subjective. For this reason, the theory is that conditions not reflected by previous scoring should carry a more significant portion of the total score. As before, it is suggested that the reasons for awarding these points be explained so that the condition or conditions warranting the points awarded can be easily identified should the evaluation be reviewed.

IV. RESULTS

After making the decision of which parameters best determined the need for a pedestrian grade separation, an easy and convenient way to process this data was needed. Three computer programs were written to perform this task.

The first program, COMDEL, computes the average pedestrian delay per signal cycle for a signalized site. This, along with the remaining field data, is then inputted to the second program, PEDOP1, which computes the scores for each parameter and a total. The third computer program, PEDOP2, formats these scores for easy reference. This program can output the data in two ways. One option is a priority ranking list for all sites, while the other is only the output for a particular site showing its ranking. The computer method and the program listings comprise Appendices C through F in Volume II of this report.

The final output of the programs is two priority ranking listings, one for sites where pedestrian activity exists and one for sites where pedestrian activity is not possible, which show where the need for a pedestrian grade separation is the greatest. It must be emphasized that the point scores of the two different listings are not comparable.

V. DISCUSSION

Four generalizations were made to account for unusual occurrences. The first was for a site which had a signal that could be activated by pedestrians only. The average pedestrian delay that would have been calculated for such a location, using the COMDEL computer program, would have been much larger than the actual delay. The delay calculated by COMDEL assumes an arrival distribution such that a value of one-half the red time will represent the average waiting time for pedestrians arriving during the red time. This value will be much larger than the actual delay in this case, which would be only that portion of the red time from pedestrian activation to the signal turning green. This would cause an erroneous point score for the site. Such error would not occur with the sampling technique which is used to measure pedestrian delay at non-signalized locations. Therefore, such a site was evaluated as a non-signalized location, thus acquiring a more accurate average pedestrian delay.

The next generalization was the determination of exactly what day and/or time to perform the required field studies. It was decided that this study should be done when the peak pedestrian trip generator is functioning. For example, if the peak pedestrian trip generator is a church, the actual field studies should be performed on a Sunday when the church is holding its services.

However, it must be remembered that a pedestrian count obtained on a specific day of the week is only a representative sample if it can be compared to other sites' pedestrian counts within the same pedestrian activity category. The engineer must determine a common unit of comparison for all sites. If the pedestrian count for a site does not represent an "average day of the week" condition, the count should be adjusted. Taking the church for example, the collected pedestrian count would probably not be a representative sample. Therefore, the count could be divided by five days to obtain an "average day of the week" count which would then be in a comparable form.

From this analysis, a general formula could be used for each site's pedestrian count. Each pedestrian count would be multiplied by the number of days a week this measured activity is expected to occur. Then by dividing by five days, and "average day of the week" count for each site would be obtained.

The third generalization concerned the delay study at a site where a school crossing exists. Because of this crossing, a location may have seasonal pedestrian peak hours, one for the school months and one for the non-school months. It was decided that if this incidence occurred, a pedestrian delay study should be done for both pedestrian peak hours and the larger average pedestrian delay used in the study.

The final generalization had to do with the distance to the alternate crossing if a location was at a signalized intersection. It was decided that fifty feet be used as a minimum, because the signalized intersection would act as the alternate crossing if a pedestrian grade separation were built there.

Six sites located along access controlled roadways at which pedestrian grade separations exist were selected to calibrate the Trip Generation Model within the PEDOP1 computer program to the actual number of pedestrians crossing the overpass. A comprehensive survey was made of each of the six sites so that when pedestrian trips were observed they could be grouped within the five types of pedestrian trip attractors identified in this study. A comparison of the observed trips to the pedestrian trips predicted by the computer model enabled modification in the model to be made until an acceptable calibration was obtained.

Because the actual trip generating characteristics vary considerably from location to location, the model was considered to be calibrated when the ranking of the six sites, which is shown in Table 2 was achieved. Route 3 and Route 29 were accurately predicted as being significantly different from the other four sites.

One of the variables required in the Trip Generation Model is the number of pedestrian trips caused by the presence of a bus stop. Because of the large differences found in characteristics of bus stops, it was decided that a manual estimate of pedestrian trips to the bus stop would be used rather than an internal algorithm.

SITE DESCRIPTION	PEDESTRIAN TRIPS COMPUTED BY PEDOP1 COMPUTER PROGRAM	ADJUSTED ACTUAL PEDESTRIAN TRIPS
Rt. 3, MP 8.8	552	928
Rt. 80, MP 56.5	414	568
Rt. 4, MP 7.9	411	440
Rt. 17, MP 15.5	398	560
Rt. 495, MP 1.2	393	420
Rt. 29, MP 1.9	229	282

TABLE 2: COMPARISON OF TRIP GENERATION MODEL TO ACTUAL NUMBER OF PEDESTRIANS CROSSING THE OVERPASS

It was also determined that each of the other four trip attraction factors, i.e. commercial, school, institutional, and recreational, should only be applied when there are in fact two different types of an attractor in the two zones. For example, if there is a delicatessen in both zones for a site, they would cancel each other and their presence would not be considered in the study. However, if there were a delicatessen in only one of the zones for a site, it would be used for that zone.

Nineteen sites were evaluated using the procedure discussed below during this project. The results of this evaluation can be found in Volume II - Appendix C. Thirteen of these sites were of the type where pedestrian activity exists. Nine of this type were signalized intersections and four were non-signalized intersections. The remaining six sites were on non-access highways (pedestrian activity is not possible) and pedestrian grade separations existed at each site.

The first task performed is to run part of the field data for signalized intersections through the COMDEL computer program which calculated the average pedestrian delay in signal cycles. The average pedestrian delay in seconds for non-signalized sites is found by 15-second intervals. These methods are explained in Volume II - Appendix B. The delay data used for both the signalized and non-signalized sites was collected during the pedestrian peak hour.

The data for all sites is then inputted into the PEDOP1 computer program. This program calculates the point scores for each of the sites.

The output from PEDOP1 is then sorted into a priority ranking list according to the point score and is inputted into the PEDOP2 computer program, which formats the output. For a location where pedestrian activity exists, this output identifies the five individual parameter point scores, the total scores, the four-digit New Jersey county and municipality code, and a site description. For a location where pedestrian activity is not possible, this output identifies the three individual parameter point scores, the total score, the New Jersey county and municipality code, and a site description.

PEDOP2 will output either the priority ranking list with all sites included or the output data and rank for any specific site. A detailed description of the computer programs can be found in Appendix C.

BIBLIOGRAPHY

1. "Determining the Degree of Hazard at School Crossings," Robert D. Dier, Traffic Engineering, January 1955, pgs. 137-139.

2. "Pedestrian Signalization and Control," Walter E. Schwanhausser, Jr., Traffic Engineering, November 1952, pgs. 47-50.

3. "New Approaches to Pedestrian Problems," Olaf Lovemark, Journal of Transport Economics and Policy, January 1972, pgs. 1-9.

4. "A Program for School Crossing Protection," Technical Notes, Traffic Engineering, October 1952, pgs. 45-58.

5. "Pedestrian Travel Rates in Central Business Districts," Lester A. Hoel, Traffic Engineering, January 1968, pgs. 10-13.

6. "Mathematical Determination of Warrants for Pedestrian Crossing," S. A. Massey, Traffic Engineering, September 1962, pgs. 19-21.

7. "Warrants for School Crosswalks," W. Stok, Traffic Engineering, May 1962, pgs. 16-22.

8. "Pedestrian Flow Characteristics," Francis P. D. Navin, And R. J. Wheeler, Traffic Engineering, June 1969, pgs. 30-36.

9. "A Nomograph for Urban Traffic Signal Priorities," F. Houston Wynn, Traffic Engineering, August 1951, pgs. 370-372.

10. "Priority Study Pedestrian Overpasses," Seattle Engineering Department, Traffic and Transportation Division, W. G. Van Gelder, City Traffic Engineer.

11. "The Pedestrian's Role in Traffic Control," Sam Yaksich, Jr., 44th Annual Convention of the Canadian Goods Roads Association, Winnipeg, Manitoba, October 1-5, 1963.

12. "Pedestrians and Motor Vehicles are Compatible in Today's World," R. L. Moore and S. J. Older, Traffic Engineering, September 1965, pgs. 20-23 and 52-59.

13. "Pedestrian Overcrossings - Criteria and Priorities," ITE Informational Report, Traffic Engineering, October 1972, pgs. 34-39.

14. "Travel Characteristics of Two San Diego Subdivision Developments," Edward M. Hall, HRB Bulletin 203 - Travel Characteristics in Urban Areas.

15. "Factors Affecting Trip Generation of Residential Land-Use Areas," G. B. Sharpe, W. G. Hansen and L. B. Hamner, HRB Bulletin 203.

16. "Transportation Usage Study," Alan M. Voorhees, HRB Bulletin 203.

17. "Pedestrian Protection," Highway Research Record #406, 5 Reports.

18. "Nonadjectival Rating Scales in Human Response Experiments," Ronald A. Hess, Department of Aeronautics, U. S. Naval Postgraduate School, Monterey, California, Human Factors, Vol. 15, No. 3, June 1973, pgs. 275-280.

19. "Pedestrians and Safety," Highway Research Record No. 436, 3 Reports.

20. "The Ability of Elementary and Secondary School Children to Sense Oncoming Car Velocity," S. Salvatore, Injury Control Research Lab, Providence, R. I., pgs. 19-28.

21. Manual on Uniform Traffic Control Devices, 1971, Chapter 4C

22. "Theory and Methods of Scaling," Warren S. Torgerson, J. Wiley and Son, Chapters 4, 5, and 11.

23. "Psychometric Methods," J. Paul Guilford, Chapters 7, 8, 9 and 10.

24. "The Pedestrian," Traffic Engineering Handbook, Third Edition, J. E. Baerwald, Chapter 4, pgs. 108-141.

25. "Traffic Characteristics," Traffic Engineering Handbook, Third Edition, J. E. Baerwald, Chapter 5 - Urban Travel Characteristics, pgs. 194-222.

26. "Designing for Pedestrians, A Level-of-Service Concept," J. J. Fruin, Port of New York and New Jersey Authority, Highway Research Record No. 355.

27. "Pedestrian Travel Demand," B. Pushkarov, J. M. Zupan, Regional Plan Association, New York, Highway Research Record No. 355, pg. 37.

28. "Pedestrian Circulation Systems in Canada," V. S. Pendakur, University of British Columbia, Highway Research Record No. 355.

29. "Pedestrian Way Concepts and Case Studies," H. S. Levinson, Wilbur Smith Associates, Highway Research Record No. 355.

30. "Evaluating the Requirements for a Downtown Circulation System," Robert L. Morris, Senior Transportation Planner, Washington, D. C., Highway Research Board Bulletin No. 347, 1967, pgs. 211-221.

31. "Rating for Pedestrian Overcrossing," Staff Report, Department of Traffic, City of Los Angeles, California.

32. "Pedestrian Crossing Time in Determining Widths of Signalized Traffic Arterials," V. R. Vuchic, Transportation Science, Vol. 1, No. 3, pgs. 224-231.

33. "Factors and Trends in Trip Lengths," A. M. Voorhees and Associates, NCHRP No. 48, 1968.

34. "Social and Economic Factors Affecting Intercity Travel," Vogt, Ivers and Associates, NCHRP No. 70, 1969.

35. "Long Range Urban Traffic Planning," Traffic Engineering Handbook, 1965, J. E. Baerwald, Chapter 18, pgs. 664-723.

36. "Pedestrian Gap-Acceptance," Charles M. DiPietro Southwestern Penn Regional Planning Commission and L. Ellis King, Department of Civil Engineering, West Virginia University, Highway Research Record No. 308, pgs. 80-91.

37. "Use of TOPAZ for Generating Alternate Land-Use Schemes," J. W. Dickey, P. A. Leone and A. R. Schwarte, Virginia Polytechnic Institute and State University, Highway Research Record No. 422, pgs. 39-52.

38. First Quarterly Progress Report for "A Comparison and Feasibility Analysis of Alternative Facilities for Pedestrians and Abutting Property Occupants," U. S. Department of Transportation, Federal Highway Administration, Peat, Marwick, Mitchell and Company, February 15, 1973.

39. <u>Traffic Engineering</u>, Theory and Practice, Chapter 15, "Pedestrian Studies," Louis J. Pignataro, Prentice Hall, Inc., 1973.

40. <u>Highway Capacity Manual</u>, Highway Research Board, Special Report 87, 1965, pgs. 101-104, 288.

41. <u>Manual on Uniform Traffic Control Devices</u>, 1971, Chapter 4D.

42. <u>A Comparison of Costs and Benefits of Facilities for Pedestrians</u>, Peat, Marwick, Mitchell and Company, December 1973.

43. "An Evolving System for the Circulation of People in the Central Area of St. Paul," P. Fausch, D. Hancock, D. Cooper, <u>Traffic Engineering</u>, Vol. 43, No. 11, August 1973, pgs. 69-73.

44. "A Policy on Arterial Highways in Urban Areas," American Association of State Highway Officials, 1957, pgs. 356-357.

45. <u>Manual on Uniform Traffic Control Devices</u>, 1971, Chapter 5A