953

DESIGN GUIDELINES FOR RAISED AND TRAVERSABLE MEDIANS IN URBAN AREAS

by

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Research Scientist

(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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954

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955

FOREWORD

This report is a result of a study conducted by the Virginia Highway and Transportation Research Council at the request of the Virginia Department of Highways and Transportation. The study was initiated and conducted by Martin R. Parker. Because Mr. Parker left the Research Council before the end of the project, the final report was not completed until recently.

The companion report, "Methodology for Selecting Urban Median Treatments: A User's Manual", was developed for those who are mainly concerned with the application of the guidelines described herein.

The research was performed under the general guidance and advice of the Research Task Force on Urban Median Design consisting of

- R. E. Atherton, Chairman, Location & Design Engineer, VDH&T
- R. L. Perry, Assistant Transportation Planning Engineer, VDH&T
- F. F. Small, Traffic Engineer, VDH&T
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956

857

TABLE OF CONTENTS

The AASHTO policy briefly describes the design and functional features of urban medians, but it does not include a set of criteria or guidelines to assist the planner or designer in selecting the appropriate median treatment for a given highway section. Without a national policy for selecting median design, the Virginia Department of Highways and Transportation has adopted the use of raised medians with barrier curbs on all urban, multilane projects except in rare cases, when a traversable median is used. The absence of guidelines has led planners, designers, and traffic engineers to question the median designs selected for some projects. There are considerable differences in judgement among these people concerning the appropriate median treatment for a given set of conditions. Median designs have also generated criticism from the motoring public, property owners, and businessmen. There is a need to develop a rational basis for selecting a median treatment that includes quantitative as well as qualitative input.

PURPOSE AND SCOPE

The purpose of the study was to develop guidelines for use in selecting median treatments for nonlimited access, urban and suburban highway projects. Although raised and traversable medians have been used for a number of years, there is little quantitative information that can be used along with engineering judgement and experience to formulate a rational basis for selecting median designs. The specific objectives of the research were to --

1. examine the process currently used to select median treatments on urban and suburban projects in Virginia and other states;

2. determine traffic, land use, and other characteristics that are best served by a raised median and the characteristics that favor a traversable median;

3. investigate the accident histories of medians on urban and suburban projects; and

4. provide guidelines that can be used to select median treatments for specific roadway and traffic conditions.

ABSTRACT

Major urban and suburban streets must provide a high level of service for through traffic as well as access to abutting properties. To an extent, the provisions of traffic service and the accommodation of access needs are conflicting functions that are affected through different treatments of the median. The regulation of left-turn traffic through the utilization of alternate median controls is a primary method of expediting through traffic and providing adequate access to adjacent development.

Although several investigators have examined the merits of raised medians with barrier curbs and traversable or continuous two-way, left-turn median lanes, guidelines for selecting the treatment best suited for particular roadway and traffic conditions have not been fully developed. The absence of guidelines has led to considerable differences in opinion among planners, designers, and traffic engineers concerning the selection of an appropriate median treatment. Often the design chosen has generated criticism from the motoring public, property owners, and businessmen. An inappropriate design can also lead to safety and operational problems as well as the ineffective use of highway revenue.

The scope of the research reported here included a literature review, a questionnaire survey of design engineers in major U. S. cities and state departments of transportation, and the collection of traffic, land use, and accident data covering a three-year period for 50 urban and suburban roadways in Virginia. Data were also collected on four-lane undivided sites to provide a basis for examining the effects of alternative median controls.

Analysis of variance and multiple linear regression techniques were employed to identify and quantify the safety and operational impacts of alternative median treatments. Based on the results of the analysis and on the information obtained from the survey of current practices, a set of guidelines was developed for selecting appropriate median controls. The guidelines are intended to assist in the choice of a specific median design by providing an assessment of the impacts of the various treatments under existing as well as future land use, traffic, and operational conditions. The guidelines include quantitative as well as subjective factors which provide a rational basis for aiding the decision maker in selecting a particular design.

960

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INTRODUCTION

The primary functions of medians on nonlimited access, major urban highways are to (1) separate opposing traffic streams, (2) provide a recovery area for out-of-control vehicles and a storage area for disabled vehicles, (3) increase capacity and safety by providing speed change and storage lanes for left-turning and U-turning vehicles, (4) provide a refuge space for pedestrians, and (5) minimize headlight glare from opposing traffic.(1,2) Medians may also be used as storage space for snow removed from the roadway, as an area for the installation of structural appurtenances, as space for expansion of a facility, or for the accommodation of other transportation modes.(2) The safety and operational benefits of providing medians on multilane facilities have been extensively documented.(2,3,4,5,6,7,8,9,10)

Generally, two types of median treatments, i.e., raised and traversable, are used to separate opposing lanes of traffic on urban streets. Raised medians with barrier curbs prevent left turns and U-turns across the median except at median openings. Flush or traversable medians are used in areas where there are numerous commercial and private driveways to allow motorists to make left turns at any point along the roadway instead of making U-turns at crossovers. One of the most popular traversable median designs is the continuous two-way, left-turn lane, which provides storage space in the median lane for motorists making left turns from either direction of travel.

As a matter of long-standing policy, the American Association of State Highway and Transportation Officials (AASHTO) suggests that "A raised median is generally more suitable for arterial streets."(1) However, in recognition of various land uses and access needs, the AASHTO policy further indicates the "Sometimes it is desirable to provide a continuous left-turn lane in lieu of a median." With the continuing need to increase the efficiency of existing transportation facilities, traversable medians are receiving increased attention because they are usually a relatively economical means of improving capacity and safety.(11)

select median treatments for specific geometric and traffic flow conditions.

The literature search was initiated through the Highway Research Information Service.* References described in some of the articles and reports provided additional information. Respondents to the questionnaire survey offered other published and unpublished documents. The progress of ongoing and recently completed projects was also monitored. The information gleaned from the literature was summarized and is presented in the ANALYSIS section of this report.

Questionnaire Survey of Cities and States

As city and state transportation engineers have used medians on major urban and suburban roadways for a number of years, it was felt that a review of their experience and the methods they use to select a median treatment would provide guidance for formulating design guidelines. To obtain this information, the questionnaire and accompanying cover letter shown in Appendix A were developed and sent to design engineers in 104 cities with a population of 100,000 persons or more and to engineers in the 50 state departments of transportation and Puerto Rico. The officials were requested to outline their policy or guidelines for selecting median treatments, give their opinion of the conditions under which they would use a raised or traversable median, describe their experience with median treatments, and identify ongoing or recently completed studies on median treatments. Space was provided on the questionnaire for general comments.

Responses were received from 47 officials in 46 states (90% return rate). Puerto Rico, along with the states of Maine, Mississippi, West Virginia, and Wyoming, did not respond. Of the 104 cities surveyed, 66 city officials (63% return rate) in 36 states returned the questionnaire. A list of cities that responded is given in Appendix B.

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*A service of the Transportation Research Board, National Academy of Sciences, 2101 Constitution Avenue, N.W., Washington, D. C. 20418.

The research included the following tasks.

1. A review of relevant literature.

2. A questionnaire survey of median selection practices used by design engineers in major cities and state departments of transportation.

3. Field studies to collect data on traffic, land use, and other features of urban and suburban projects throughout the state.

4. The compilation and analysis of accident data for the projects on which field data were collected.

5. The development of estimates of the safety and traffic impacts of alternative median treatments.

6. The development of guidelines for selecting median treatments.

The study was limited to the collection of data for four-lane facilities having a median width sufficient to store left-turning vehicles. To provide a basis against which the results of the traffic and accident analyses could be compared, data were collected for four-lane undivided facilities.

The study was also limited to collecting data on nonlimited access highways. The results, consequently, are not applicable to urban freeway projects or other facilities with limited or partial access controls.

RESEARCH APPROACH

The methodology outlined in the study working plan was approved by the project task force in August 1977.(12) The data sources and major elements of the research approach are described below.

Literature Review

A review of the literature was conducted to examine reported safety and operational impacts of raised and traversable medians. The search also included the identification of methods used to

964

TABLE OF CONTENTS (Continued)

The responses were checked for completeness, and the data were keypunched and tabulated by computer utilizing software available in the Statistical Package for the Social Sciences. (13)

Field Studies

The purpose of the field studies was to determine the impact of medians on traffic operations, highway safety, and land use and to obtain data that could be used to develop guidelines for selecting a median treatment for a given situation.

Study Approach

Field data were collected at sites on four-lane highways with raised and traversable medians. Data were also collected for four-lane undivided highways to provide a basis for comparison. After the data were tabulated, analysis of variance and multiple linear regression techniques were employed to examine differences and to develop relationships between variables for the three treatments. The results of the analyses were compared to findings reported by other investigators.

Study Sites

Data were collected at 50 sites in urban and suburban areas throughout the state. Although the sites were selected at random, they were chosen to represent a wide range of traffic and pedestrian volumes; geometrical features, i.e., curvature and grades, etc.; land uses; and environmental characteristics. The guidelines used to select the sites are given below.

1. All sites had four lanes for through traffic.
2. The facility had been in service for at least 5 years.
3. With some exceptions, the length of the sites was between 0.5 mile and 3.0 miles.
4. Posted speed limits were 45 mph or less (typical of urban and suburban conditions).
5. Sites for each median type had a wide range of traffic volumes and land use characteristics.

6. The sites included signalized and nonsignalized intersections.

Data Collection

Data were collected by two observers utilizing photographic and manual techniques. The observers used a super 8-mm movie camera and drove through the sites to film the geometrical, environmental, and land use characteristics. Films were taken for both directions of travel. Variables obtained from the film records include number of driveways, signalized and nonsignalized intersections, number of crossovers, speed limits, type of development, pavement marking patterns, and signing characteristics of the site. In addition, aerial photographs were obtained for each site and used to supplement the movie documentation of street patterns, depth of area development, etc. Occasionally, 35-mm slides were taken to depict typical roadway conditions or to illustrate a unique finding.

After the observers had driven through the site and completed the filming, they selected a typical section of the project, usually between 400 and 2,000 feet in length, to observe traffic operations and collect data on traffic volumes and driver maneuvers. The data included through volumes for each direction of travel, the number of left turns from the main street onto adjacent streets and driveways, the number of left turns from adjacent streets and driveways onto the main street, and unusual or illegal maneuvers related to the median. Also, a stopwatch was used to measure the delay time for vehicles turning left from the main street onto adjacent streets. The delay time included only the time the vehicle was stopped on the roadway waiting for an acceptable gap in the traffic stream; it did not include deceleration or acceleration time needed for initially stopping or completing the turn. The operational data were collected at mid-block points and the section did not include a signalized intersection.

The field observations were made for two 15-minute periods at each site. The data were collected on Mondays through Fridays between 8:00 a.m. and 6:00 p.m. Most of the observations were made when the pavement was dry; however, due to time limitations, some were made during light rain.

Data Reduction

After the data were collected for a site, the forms were examined for errors and filed for analysis. After the movie film and the aerial photographs were obtained for a site, they were reviewed and data were summarized and keypunched for analysis.

Accident Studies

To examine the safety characteristics of highway medians, copies of accident reports for calendar years 1975, 1976, and 1977 were obtained for each site included in the field studies.

As the accident data were received, each report was reviewed and the data coded and keypunched for computer analysis. The data from the summaries for each study site were arrayed in various tables to facilitate statistical analysis. Analyses of the data included comparisons of severity, median-related accidents, and types of accidents.

Evaluation of Median Treatments

One of the major efforts of the study was to develop a simple procedure that could be used to estimate the safety and operational impacts of alternative median designs for a given set of highway and land use conditions. Multiple linear regression analysis was used to develop equations that can be used to estimate the effect of the median treatment on accidents and vehicular delay.

Development of Guidelines

After the study data were analyzed, guidelines for selecting alternative median treatments were developed. The guidelines were carefully examined and tested by the project task force to assure that they (1) could be easily understood and used, (2) would provide realistic solutions to median design problems, and (3) would be accepted by the Department for implementation.

ANALYSIS

A synthesis of the information developed and the results of the data analyzed is presented in the succeeding subsections.

Literature Review

The purpose of the literature review was to examine the safety and traffic impacts of highway medians and to investigate the procedures being used to select a median treatment for given site characteristics. A great number of reports concerning medians have been published; however, many of these apply to freeways and other limited access highways. In others, it is difficult to determine the validity of the conclusions because of limiting factors that influenced the investigation, such as (1) only one or two sites were selected for study, (2) the study periods were too short, (3) the data base was too small to permit drawing general conclusions, or (4) there was insufficient information concerning the study procedures. As a consequence, the results of some of the investigations are contradictory or inconclusive.

Nevertheless, the literature does identify some of the pertinent advantages and disadvantages of median designs and some of the primary factors that must be considered when developing guidelines. Because the scope of the study was limited to medians between 10 and 20 feet wide, the principal focus of the literature review was on studies of urban roadways with narrow medians. A summary of the pertinent findings is given below.

Impacts of Highway Medians

Although the origin of the concept of using a median to separate opposing traffic flows could not be found, it is conceivable that the first divided roadway was constructed long before the invention of the automobile. Because of the increasing popularity of auto travel, the practice of dividing roads became widespread in the 1930's after it was discovered that widening pavements did not provide safer travel. (2) A realization of the safety aspects of medians led engineers to experiment with an assortment of designs ranging from a narrow painted strip to wide medians separating the roadways. Because merely dividing the roadway did not prevent all head-on collisions, concave steel barriers and guardrails were placed in the median on some highways in the 1930's. (2) Concrete median barriers were first installed on projects in Louisiana and California in the early 1940's. (14)

The search for optimal median treatments is not over and will probably continue for many years. In recent years, attitudes concerning environmental issues, energy conservation, social problems, and taxation have changed considerably. These broad issues have a direct impact on highway design. It is no longer acceptable to view roadway improvements in terms of one or two measures such as safety or capacity, as it is necessary to consider the impact of an improvement on its environs. Unfortunately, most of the research on medians has been concerned with only their safety aspects; however, some information is available for non-safety-related impacts. A state-of-the-art summary of the impacts of raised and traversable medians is given below.

Raised Medians With Barrier Curbs

Curbs were first used on medians to discourage deliberate crossings of the median and to minimize inadvertent encroachments.(15) Also, it was believed that curbs along the edge of the median provided good delineation of the roadway alignment.(2) Apparently, this philosophy adopted in the 1930's provided justification for using curbs on urban facilities with medians.

Although there have been numerous studies concerning the safety aspects of various median treatments, there is little available information on raised medians with curbs on nonlimited access, urban highways. In 1961, Billion and Parsons reported on the results of their study of 82 miles of urban divided highways without access controls.(16) Accident records for the years 1955 through 1959 were examined for 34 sections carrying traffic volumes of up to 44,000 vehicles per day. A comparison was made of the accident rates for flush grass medians and those for raised medians with curbs. The results indicated that the flush grass median had the lowest rate for all accidents between intersections and the curbed type median had the highest rate. (The latter had nearly 2½ times the accident ratio of the former.) The data also revealed that for curbed medians without illumination, the night accident rate at intersections was twice that of the day rate; however, on curbed sections with illumination, the night and day rates were the same.

In Los Angeles County, a comparison was made of the accident experiences on 12 pairs of roadways with painted and raised medians over 10 feet wide.(8) Each pair consisted of a painted and raised median of similar length, traffic volume, and adjacent roadside development. The accident rate for the roadways with painted medians was 1.81 per million vehicle miles and that for sections with raised medians was 1.00. Also, 47 accidents occurred at driveways on the raised median sections.

In 1964, Wooton et al. studied the impact of a raised median on accidents, traffic operations, and economic activity.(3) The studies were conducted on improvement projects in a small, a medium-size, and a large city in Texas. Comparisons were made of before conditions (two-lane roadway) with after conditions (four-lane roadway with a raised curbed median). The accident analysis indicated that the median eliminated head-on collisions and significantly reduced rear-end accidents. There were increases, however, in improper lane changes and fixed object accidents. Operational studies indicated that a large number of irregular maneuvers were reduced, but that a large number of U-turns at adjacent crossovers were generated. In some cases, the median was not wide enough to permit most drivers to make a legal U-turn. The improvements in the three cities attracted new businesses immediately after they were completed; however, there was a 10% reduction in customer traffic in the after period. Because of the high number of U-turn movements created by the installation of medians in sections with considerable business activity, the researchers recommended that "very careful consideration be given to a traversable type median which would permit mid-block turns and thus eliminate the need for U-turns."(3)

In 1970, Leong examined the immediate and long-range effects of narrow median strips on accidents.(5) The study was conducted on 21 sections of urban arterial highways where raised concrete medians varying in width from 3 to 15 feet were installed. The results of the analysis indicated that there was a significant decrease in accident rates at signalized intersections; however, there was an increase in fixed-object and sideswipe accidents at mid-block locations.

Garner examined accident histories of different median types on rural highways in Kentucky in 1970.(17) The findings indicated that raised medians provide an unsuitable recovery area for vehicles on rural highways, which prompted Garner to suggest that "the use of curbed raised medians in urban areas should be reexamined as the deficiencies of raised medians apparent in this study may be applicable."(17)

Several researchers have examined the differences in accident rates between four-lane highways with raised curbed medians and four-lane roadways with a painted median lane. Frick documented a case study of two improvements in the city of Springfield, Illinois, in 1968.(18) Traffic volumes and speed limits were similar; however, there were more access points on the section with the median lane than on the curbed median section. The results of a two-year accident study revealed that the site with the median lane had an accident rate 2.65 times greater than that of the raised median section (1,143 accidents per million vehicle miles compared to a rate of 434). Although the study was limited in scope, the author recommended the installation of curbed medians in lieu of a painted median lane.

Babcock and Foyle performed a study of urban median treatments in North Carolina cities.(10) The study included 15 sections (32.4 miles) of multilane highways in Raleigh and Fayetteville. The researchers found that roadways with two-way, left-turn lanes had about the same accident rate as divided highways with median openings. They also concluded that a more efficient turning operation occurred on sections with two-way, left-turn median lanes because there was no need for U-turns and because the turning movements were spread over these sections rather than being concentrated at median openings. Also the researchers found no evidence that two-way, left-turn lanes encourage strip development.

A survey of public opinion concerning the use of a raised or a two-way, left-turn lane was conducted in the city of Knoxville, Tennessee.(19) In the survey, questionnaires were distributed to customers, business proprietors, neighborhood residents, and employees of business firms. The questionnaire solicited views on two alternate plans (Plan A - Two-way, left-turn lane and Plan B - raised median) for a local roadway scheduled for reconstruction. The results of the survey indicated that most of the citizens strongly preferred the raised median; however, business owners and operators preferred the two-way, left-turn median lane.

In 1974, Olson et al. used the highway vehicle-object simulation model and conducted 18 full-scale crash tests to examine the effects of vehicle behavior on 4- and 6-inch concrete curbs.(20) Concrete curbs of this type are commonly used on urban and suburban roadways to control drainage and separate opposing lanes of traffic. The major conclusion of the research was that 6-inch concrete curbs do not redirect vehicles at speeds above 45 mph with encroachment angles greater than 5°. The results of the tests provide evidence that the curbs used to provide raised medians do not physically prevent vehicles from crossing the median and, in fact, may cause the driver to lose control of the vehicle after striking the curb. Following the research, the Federal Highway Administration policy does not permit the use of curbs on federal-aid roadways where traffic speeds exceed 45 mph. Mountable curbs and full-height curbs which redirect errant vehicles are permitted.

Traversable Medians

One of the most comprehensive literature reviews pertaining to continuous two-way, left-turn median lanes was recently conducted by Nemeth.(9) The pertinent findings of that study are summarized below.

1. Two-way, left-turn lanes are most applicable in areas where there are numerous access points, including areas where there is residential or commercial development.

2. Median lanes are used on arterial streets carrying volumes ranging from 8,000 to 31,000 vehicles per day.

3. Speed limits found on roadways with median turn lanes ranged from 25 to 45 mph.

4. There was considerable lack of uniformity in signing and marking practices related to two-way, left-turn lanes. Standards recommended in the Manual on Uniform Traffic Control Devices should help to encourage uniformity.(21)

5. Continuous two-way, left-turn lanes should not be carried through major intersections.

6. Median turn lanes require less right-of-way than raised medians and can often be constructed within existing right-of-way.

7. Early studies of driver use of median lanes indicated that a significant percentage of motorists used the lane improperly.

8. Most researchers reported significant reductions in rear-end, sideswipe and mid-block, left-turn accidents as a result of installing a continuous two-way, left-turn lane.

9. In every study, head-on collisions have been found to be an uncommon occurrence and of negligible concern.

10. Two-way, left-turn lanes have been successfully used as reversible lanes during peak periods and as exclusive lanes for public transit.

A large number of studies have been conducted in recent years to examine the safety, operational, and economic impacts of continuous two-way, left-turn median lanes. A brief synopsis of the most pertinent findings is presented below.

Sawhill and Neuzil conducted a before and after study in 1963 at three sites in Seattle and found that only 9.4% of the total accidents were related to the use of the continuous median lanes. (7) Head-on accidents in the median lane were found to be negligible and median-related accidents were less severe than non-median-related accidents. The median lane was reported to reduce accidents by 26%, with most of the decrease being attributed to rear-end collisions.

In 1974, Hoffman conducted an evaluation of the safety impacts of installing a continuous two-way, left-turn median lane at four sites in Michigan. (22) Prior to the addition of the median lane, the sites were four-lane undivided roadways. Hoffman examined accident data for a one-year before and one-year after period and reported that total accidents decreased by 33% and injury accidents by 41%.

Burritt and Coppola recently examined the impacts of installing continuous two-way, left-turn median lanes at seven sites in Arizona. (23) A two-year before and two-year after accident period was used in the analysis. The researchers found that total accidents were reduced by 35.9% and reported a benefit-cost ratio of 8.6 for the median treatment.

The operational effectiveness of continuous two-way, left-turn median lanes was examined by Nemeth in 1976 at three sites in Ohio. (9) Traffic speeds, volumes, and traffic conflict data were collected before and after the median treatment was installed. The restriping of a two-lane roadway to provide two through lanes and a median left-turn lane resulted in reducing travel time and vehicle delay and led to an increase in average running speed. Traffic conflicts were reduced by 37%; however, this may be an underestimation of the effect of the treatment on conflicts as main line volumes increased by 2.5%, cross-street volumes by 25%, and left-turn conflicts by 16%. The restriping of a four-lane undivided roadway to allow four through lanes and a left-turn median lane resulted in a slight increase in running speed and a reduction in traffic conflicts.

In 1978 Babcock and Foyle analyzed accident and operational data on 14 urban roadway sections in two cities in North Carolina. (10) They found that accident rates on five- and seven-lane roadway sections with continuous two-way, left-turn median lanes were similar to accident rates for four- and six-lane divided roadways. The traversable medians were found to be effective in accommodating large traffic volumes.

Walton et al. collected accident data and data on urban highways in 1978 and found that the number of accidents on roadways with continuous two-way, left-turn median lanes were significantly affected by the number of traffic signals per mile, the number of driveways per mile, the city population, and average daily traffic.(24) A regression equation was developed to predict the annual number of accidents per mile for given site-specific conditions on four-lane highways with continuous two-way, left-turn median lanes. The authors also reported that their observations of traffic flow on the sections indicated that pavement markings were more effective than signs in contributing to driver awareness of the median lane.

In 1982, McCoy et al. collected stop and delay data on roadways in Nebraska where continuous two-way, left-turn lanes were installed.(25) Using a computer simulation model, the researchers found that the installation of a median lane improved the efficiency of traffic operations for a wide range of traffic volumes, left-turn demands, and driveway densities.

Although most of the literature examined for traversable medians was related to studies on continuous two-way, left-turn median lanes, several investigations examined the use of other painted median types. For example, in 1966 Thomas conducted a one-year before and one-year after study of a four-mile roadway in Denver where continuous alternating left-turn lanes were painted in the median.(26) Thomas found that total accidents decreased by 20%, injuries by 22%, and rear-end accidents by 52%.

Procedures for Selecting Median Treatments

In view of the various median treatments that existed in 1956, Billion noted that "there is quite a difference of opinion among highway engineers regarding the relative merits and effectiveness of the different types and widths of median dividers."(27) Unfortunately, this difference of opinion exists today. Although researchers have identified some of the primary aspects of median design, many questions remain. Much of the controversy is related to the difficulty encountered when one attempts to collect data and relate them to a particular set of site conditions.

The need for developing guidelines for selecting appropriate median treatments has been clearly recognized in recent years. Some progress has been made, but specific recommendations are yet to be developed. Nemeth had developed guidelines for using two-way, left-turn lanes; however, only general considerations are outlined in his report.(9) Babcock recently examined the effects of various median treatments but only presented the findings with the feeling that additional information on medians would be useful in selecting median alternatives.(10)

During the past 20 years, the Institute of Transportation Engineers has published several committee reports concerning warrants and design standards for continuous two-way, left-turn median lanes.(28,29,30) These reports provide information concerning factors to be considered in using a traversable median treatment, but the guidelines do not provide quantitative data that can be used to select between a raised and a traversable design.

Perhaps the best guide available for selecting alternative median treatments is included in a report prepared by Azzeh et al.(31) In that report a cost-benefit framework is developed as a basis for selecting a median treatment that is cost-effective and operationally appropriate for a given highway. However, the results are limited by the fact that the accident and delay reduction estimates are based on assumptions that may not be entirely supported by research. Also, when alternative treatments are being evaluated it is necessary to consider factors that are not amenable to economic analysis, such as flexibility of design and future access needs.

Questionnaire Survey of Median Design Practices

The experience of city and state design engineers with alternative median treatments was examined and the results are given in Appendix C. Many of the respondents offered additional comments related to median designs and a summary of their remarks is given in Appendix D. An overview of the survey results is outlined below.

1. Raised medians are used on approximately one-half of the four-lane divided mileage in urban areas, and traversable medians with left-turn lanes are employed on one-fourth of the routes. However, there is considerable variation in the results as some agencies use only a raised median and others make exclusive use of a traversable median.

2. One-third of the respondents indicated that they had a set of guidelines for selecting an alternative median

treatment. Many of the guidelines consisted of cross-sectional designs and were not related to procedures that could be used to select alternative designs. The design guidelines for Utah and Washington are presented in Appendix E.

3. Experience and engineering judgment were cited as principal bases for choosing an appropriate median treatment. Public and political input also appear to be considered in the design selection.

4. Analysis of responses to question 5 of the survey indicates that design engineers preferred raised medians under the following conditions.

   (a) Traffic volumes greater than 25,000 ADT.

   (b) Speeds greater than 50 mph.

   (c) Areas with heavy commercial and industrial development and where land is prime for development.

   (d) Where there is a heavy demand for mid-block left turns.

   (e) In areas where there are heavy and moderate pedestrian activities.

   (f) On roadways with limited sight distance.

   (g) Where there are 6 or more through lanes.

5. Traversable medians were preferred under the following conditions.

   (a) Traffic volumes of all volume levels.

   (b) Speeds less than 50 mph.

   (c) Areas with commercial development.

   (d) Areas with moderate and heavy demands for mid-block left turns.

6. The majority of respondents felt that raised medians created access problems.

7. The majority of engineers also felt that public, business, and political response to raised medians was adverse.

8. Most of the respondents felt that the installation of raised medians would have a beneficial effect on accidents; however, 15 state and 3 city officials suggested that accidents would increase.

9. Few pedestrian and operational problems with raised medians were cited; however, the officials felt that U-turning and wrong-way driving to reach crossovers caused some problems.

10. Maintenance problems with raised medians included mowing, snow removal, and additional costs. The only construction problems cited were that raised medians caused traffic and drainage problems and were more expensive to build.

11. The majority of respondents felt that traversable medians caused few problems. There was some concern for providing pedestrians a refuge space in the median, and 15 state design engineers felt that accidents increased when traversable medians were used.

12. Nearly 75% of the state and 61% of the city engineers described conditions where raised medians should not be used. A summary of these conditions is given in Tables 1 and 2. The primary condition cited for not using a raised median was a high degree of development with numerous access needs.

13. As shown in Tables 3 and 4, the major locations cited where a traversable median should not be used were ones with high traffic volumes and high speeds.

14. Over 74% of the state design engineers reported that they were designing more projects with traversable medians than they did a few years ago. Less than 40% of the city engineers were using more traversable medians.

15. Generally, access to both directions of travel was not a compensable item in most states and cities; however, some of the respondents indicated that access was becoming a more important issue.

Table 1

Conditions Where State DOTs Suggest a Raised Median Should Not Be Used

No. Responses	Condition
16	Highly developed areas with numerous access needs
7	Hazardous, as the curb prevents evasive maneuvers
4	Areas where U-turn activity is not acceptable
4	Roadways with high speeds
3	Areas with poor street circulation
3	Roadways with narrow medians
2	Low volume areas
2	Heavy snow areas
1	Roadways with low speeds
1	Adds to cost of project
1	On two-lane highways

Table 2

Conditions Where City DOTs Suggest a Raised Median Should Not Be Used

No. Responses	Condition
15	Heavy strips of industrial development
8	Limited access
7	Right-of-way not available — cost prohibitive
7	High volume
4	Unlimited access
3	High speeds
3	Long blocks
2	Residential areas
2	No frontage roads
2	Low volume
1	Public opposition
1	Added cost of construction
1	Poor sight distance
1	In front of emergency entrance

Table 3

Conditions Where State DOTs Suggest a Traversable Median Should Not Be Used

No. Responses	Condition
14	Roadways with high speeds
14	Roadways with high volumes
9	Areas where access should be controlled
6	Approaches to intersections with high left-turning volumes
3	Areas with little left-turn demand
3	Areas with high volume of pedestrian movements
3	Roadways with six or more lanes
2	Roadways with limited sight distance
1	Areas where vehicle speeds are uncontrolled
1	Limited access highways
1	Roads with a history of head-on accidents

Table 4

Conditions Where City DOTs Suggest a Traversable Median Should Not Be Used

No. Responses	Comments
13	Heavy volume
12	High speed
6	Heavy turning activity
5	Six-lane highways
5	Developing areas
4	Short sight distance
3	High accident rate
2	Major intersections
2	Light commercial development
1	Pedestrian safety
1	Clustered business driveways
1	Experience showing raised is better
1	Limited access
1	Narrow road width
1	Less than a 4-lane highway

Results of Field Studies

To estimate the safety and operational impacts of alternative median treatments, data were collected at 50 sites located in 31 urban and suburban areas in Virginia. The types of median treatments studied are shown in Table 5. A summary of the characteristics of each study site is given in Appendix F.

As the primary objective of the study was to develop a practical set of guidelines that can be used to aid in the selection of a median treatment for site-specific conditions, only easy-to-measure variables were considered. This requirement not only enhances adoption of the results by reducing the amount of data needed, but simplifies the task of obtaining data for projects in the design stage.

A list of field data variables is given in Table 6. To compare the variables, the data were normalized, i.e., expressed in terms of intersections per mile, driveways per mile, etc.

Table 5

Median Treatments Studied

Median Treatment	Number of Locations	Length, Miles
Raised (6-in. curbs)	19	28.22
Traversable		
Two-way left-turn lane	13	12.24
Alternating left-turn lane	3	2.06
Continuous left-turn lanes	1	0.87
Undivided	14	16.59
Total	50	59.98

Table 6

Field Data Collection Variables

1. Average daily traffic
2. Main line volume, in vehicles per hour, recorded during the field studies
3. Average number of left turns per hour
4. Average mid-block, left-turn delay per vehicle
5. Number of signalized intersections per mile
6. Number of public streets per mile. (A four-way intersection would be counted as two streets whereas a tee intersection has only one street approach. The number of approach legs at signalized intersections should also be included.)
7. Number of driveways per mile (includes all intersections except public streets)

Table 6 (continued)

8. Median openings per mile (applies only to raised median projects)

9. Area population

A summary of the data collected for each median treatment is given in Table 7. As shown in Table 7, there were no significant differences in the three median treatments for each of the variables studied, except that the number of driveways per mile were significantly higher for the traversable sites. This finding may be attributable to the current practice of installing traversable medians in areas of heavy roadside development.

Table 7

Comparison of Field Data for Median Treatments

Category	Average Value Raised	Traversable	Undivided	Significant Differences, $\alpha = 0.05$
Number of sites	19	17	14	
Average daily traffic	18,424	20,489	17,296	None
Main line volume, vph	681	704	586	None
Left turns per mile, per hour	424	445	580	None
Mid-block, left-turn delay, seconds per vehicle	7.62	6.02	5.15	None
Traffic signals per mile	1.93	2.88	2.76	None
Public streets per mile	12.18	11.97	13.16	None
Driveways per mile	47.11	74.32	65.11	More driveways on traversable sections
Crossovers per mile	10.17	--	--	--

The field investigations also led to the following conclusions.

1. The major problem observed at raised median sites was U-turns at adjacent crossovers, especially at sites with curb and gutter. As a result of restricting left turns to specific points along the highway, mid-block, left-turn delays were generally higher than delays recorded for other median treatments.

2. Very few operational problems were observed at traversable sites. Driver understanding of the proper use of the median lane was exceptionally good. A variety of pavement markings, arrows, and signs were found at traversable sites, and many of these traffic control devices did not conform to the standards outlined in the MUTCD. Traversable sections should be marked in a uniform manner as suggested in the MUTCD.

3. Contrary to expectations, the mid-block, left-turn delay at undivided sections was less than the delay recorded at locations where median storage lanes were provided. Motorists apparently recognized the danger of stopping in the through lane and attempted to minimize the danger by accepting shorter gaps in the opposing traffic stream.

Results of Accident Studies

To examine the safety characteristics of medians, accident data were obtained for each project selected for study. For most sites the accident period included the years 1975, 1976, and 1977; however, for some sites only 1977 data were available. Over 5,500 accident reports were analyzed for the 50 study sites.

A summary of the results of the data collected for each median treatment is given in Table 8 and a summary of the accident data for each site is presented in Appendix G.

Although the mean accident rates were higher for traversable and undivided sites, the mean rate was not significantly different from that for the raised median locations. The most important difference is that the severity rate, i.e. number of persons killed and injured on undivided roadways, is approximately twice that found for raised and traversable sites.

Table 8

Accident Data Summary

Category	Average Value			Significant Differences
	Raised	Traversable	Undivided	
Number of sites	19	17	14	
Accident rate per 100 million vehicle miles	442	611	679	None
Annual number of accidents per mile	29.45	48.32	41.53	None
Severity rate	136	147	242	Undivided greater
Mid-block, left-turn accidents, in percent	6.68	17.85	16.56	Raised lower
Median-related accidents, in percent	46.88	48.50	52.09	Undivided greater
Not-median-related accidents, in percent	53.12	51.50	47.91	Raised greater
Accidents at signalized intersections, in percent	32.00	40.81	35.50	Traversable greater
Accidents between intersections, in percent	29.74	43.43	37.44	Traversable greater

The frequency of mid-block, left-turn accidents is significantly lower for raised median sections, probably because crossings of the median are restricted. Traversable sections have a greater frequency of accidents between intersections; however, there is a trade-off in location as raised median sections had a greater number of accidents at nonsignalized street intersections. A summary of the data by type of accident is given in Table 9.

Table 9

Type of Collision

Category	Percent of Collisions			Significant Differences, $\alpha = 0.05$
	Raised	Traversable	Undivided	
Rear-end	37.48	35.69	34.67	None
Angle	38.70	42.63	39.98	Trav. greater
Sideswipe	8.62	11.90	11.75	Raised lower
Head-on	1.05	0.98	1.97	Undiv. greater
Pedestrian	0.94	1.65	1.61	None
Bicycle	1.00	0.80	0.48	None
Fixed-object	10.45	5.12	8.53	Raised greater
Miscellaneous	1.77	1.25	1.01	None
U-turn accidents	1.27	0.15	0.36	Raised greater

As shown in Table 9, there was a greater frequency of angle and sideswipe accidents on traversable median sections; however, this was offset by a greater percentage of fixed-object accidents on raised sections. One suggested disadvantage of the traversable section is that it creates a potential for head-on collisions; however, as noted in Table 9, the accident data indicate that head-on collisions on traversable sections are infrequent. The potential for accidents caused by motorists making U-turns at crossovers is reflected in the data, as raised sections had significantly more U-turn type accidents than the other median types.

Another finding was that more motorists were involved in accidents at speeds below 30 mph on the traversable sections; however, raised median sites had more accidents at speeds above 30 mph.

In addition to the comparisons of accident frequencies and rates, the analysis of variance was used to examine differences between mean accident rates for several traffic and geometrical characteristics. A summary of the significant findings is given below.

Shown in Table 10 are the number of accidents per mile on each median type divided according to the posted speed limit; i.e., below 40 mph and above 40 mph. The results of the analysis indicate that there were more accidents on traversable sections; however, for each median type, as the speed limit increased, the number of accidents per mile significantly decreased.

Table 11 shows the number of accidents per mile arrayed by left turns and signals per mile. The analysis indicates that, again, traversable sections had a greater number of accidents per mile; however, for each median treatment, as the signals per mile and left turns increased, the number of accidents increased. As might be expected, increases in traffic volume were also found to increase the accident rate, but this effect was independent of the type of median treatment.

Table 10

Annual Number of Accidents Per Mile
by Median Type and Speed Limit

Speed Limit, mph	Raised	Traversable	Undivided
25-35	30.24	73.19	58.50
40+	12.32	42.17	26.28

Table 11

Average Annual Number of Accidents Per Mile by Median Type,
Left Turns, and Signals Per Mile

Total Left Turns/Mile/Hour	Raised		Traversable		Undivided	
	Signals/Mile		Signals/Mile		Signals/Mile	
	0-1.99	2.00+	0-1.99	2.00+	0-1.99	2.00+
0-449	21.25	41.99	17.73	76.69	10.09	41.83
450+	28.62	30.09	42.86	79.02	34.06	72.59

EVALUATION OF MEDIAN TREATMENTS

A multiple linear regression analysis was used to examine the possibility of developing equations that could be used to estimate the impacts of alternative median treatments on accidents and delays. For the accident data, the three dependent variables investigated were the annual number of accidents per mile, the accident rate per 100 million vehicle miles, and the severity rate per 100 million vehicle miles. Delay was expressed in seconds per left turn vehicle. Although total vehicle delay and travel time may have been more appropriate measures for investigation, data on these factors are expensive to collect. Special care was taken in selecting the independent variables because it was felt that unless the input data were easy to collect, the final median selection process would not be beneficial to practicing traffic engineers and designers. Several investigators have developed equations for estimating the frequency of accidents on urban highways, but the results have not been extensively used because of the difficulty in obtaining the necessary input data. (32,33)

Development of Regression Equations

A stepwise multiple regression analysis was employed to develop equations that could be used to estimate the annual number of accidents per mile and mid-block, left-turn delays. The first step was to compute correlation coefficients for each dependent and independent variable. Independent variables which displayed high colinearity were not used in the same equation. The next step was to enter each independent variable and determine if the result significantly increased the multiple coefficient or determination (R^2).* Variables were added until a nonsignificant increase in R^2 was encountered. As a final step, the variables in the accident and delay equations were examined for consistency and, wherever possible, the equations were further modified to reduce the number of input variables.

The best dependent variable for predicting accidents on raised and traversable median sections was the annual number of accidents per mile. The accident and mid-block, left-turn delay regression equations are given in Table 12. The range of values used in developing the equations is given in Table 13. Attempts to predict accident severity were unsuccessful; R^2 values were less than 0.40.

Prediction of Accident and Delay Statistics

The equations shown in Table 12 can be used to predict the accident and delay information for any set of traffic and geometrical features. Only seven items are required for a complete evaluation of alternative median treatments. The equations for undivided highways are provided only for comparative purposes. Irrespective of the results of the accident estimates given by the equation, an undivided section should not be considered because its severity rates are significantly greater than those for both type medians. The equations, however, may be useful in estimating accidents on existing four-lane undivided sections.

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*R^2 is the explained variance; i.e., the variance in the dependent variable that is explained by the independent variables.

Table 12

Regression Equations for Predicting
Annual Accidents Per Mile and
Mid-block, Left-turn Delay

Median Type	Regression Equations	R^2	Standard Error
Raised	$A_R = 8.040\ Sig + 0.00155\ ADT - 0.0228\ Dr - 0.00000926\ Pop - 12.718$	0.73	10.29 acc/mile
	$D_R = -1.362\ Sig + 0.0184\ DHV - 0.205\ Open - 0.0000332\ Pop + 2.937$	0.81	3.37 seconds
Traversable	$A_T = 5.432\ Sig + 0.00173\ ADT + 2.157\ St - 0.0000058\ Pop - 28.797$	0.71	20.77 acc/mile
	$D_T = -0.525\ Sig + 0.0198\ DHV - 0.0676\ Dr - 0.0000214\ Pop + 0.920$	0.75	2.74 seconds
Undivided	$A_u = 3.055\ Sig + 0.00212\ ADT - 0.264\ St + 0.557\ Dr - 36.507$	0.79	13.40 acc/mile
	$D_u = -1.073\ Sig + 0.0142\ DHV + 0.367\ St - 0.0000203\ Pop - 3.177$	0.57	3.01 seconds

Table 13

Range of Independent Variables

Variable	Symbol	Range	
		Minimum	Maximum
Signals per mile	Sig	0.00	6.98
Average daily traffic	ADT	5,460	33,590
Design hourly volume	DHV	138	1,367
Driveways per mile	Dr.	12.42	116.36
Area population	Pop	1,111	286,694
Streets per mile	St	2.61	32.59
Median openings per mile	Open	5.21	16.65

A comparison of the expected numbers of accidents for specific geometrical and traffic conditions for raised and traversable sections is given in Table 14. As expected, the accident frequencies increase as the numbers of signals, streets and driveways, and traffic and population increase for each median treatment. However, as shown in Table 14, a two-way, left-turn lane would be expected to have a low accident frequency when the number of streets per mile is low. This result holds regardless of an increase in signals per mile, average daily traffic, and city population. However, when the number of streets per mile increases to 12, a raised median is preferred, regardless of the number of signals or driveways, or traffic volumes.

Table 14

Estimated Number of Accidents Per Mile for Median Treatments

Signals Per Mile	Streets Per Mile	Driveways Per Mile	10,000 ADT				30,000 ADT			
			50,000 Population		250,000 Population		50,000 Population		250,000 Population	
			Raised	Two-Way	Raised	Two-Way	Raised	Two-Way	Raised	Two-Way
0	5	30	1.64	- 1.00*	- 0.22*	- 2.16*	32.64	33.60	30.78	32.44
	15	60	0.95	20.57	- 0.91*	19.41	31.95	55.17	30.10	54.01
	25	90	0.27	42.14	- 1.59*	40.98	31.27	76.74	29.42	75.58
2	5	30	17.72	9.86	15.86	8.70	48.72	44.46	46.86	43.30
	15	60	17.03	31.43	15.17	30.27	48.04	66.03	46.18	64.87
	25	90	16.35	53.00	14.49	51.84	47.36	87.60	45.50	86.44
4	5	30	33.80	20.73	31.94	19.57	64.30	55.33	62.94	54.17
	15	60	33.11	42.30	31.25	41.14	64.12	76.90	62.26	75.74
	25	90	32.43	63.87	30.57	62.71	63.44	98.47	61.58	97.31
6	5	30	49.88	31.59	48.02	30.43	80.88	66.19	79.02	65.03
	15	60	49.19	53.14	47.33	51.98	80.20	87.74	78.34	86.60
	25	90	48.51	74.71	46.65	73.55	79.52	109.33	77.66	108.17

*Indicates that the expected number of accidents is approximately zero.

Comparison of Accident Results

Walton et al. recently conducted a study of two-way, left-turn lanes in Texas and developed the following regression equation to predict accidents per mile. (24)

$$\text{Accidents/mi.} = 9.20\ \text{Signals/mi.} + 0.491\ \text{Driveways/mi.} + 0.000175\ \text{City Population} + 0.00203\ \text{ADT} - 43.5.$$

The standard error was 33 accidents per mile and the R^2 value was 0.75. Tabulations of the actual accidents per mile for the sites with traversable medians in the present study and the results predicted with the Virginia and Texas equations are given in Table 15. As expected, the Virginia equation yields results which closely approximate the actual data; however, the Texas results are reasonable for most of the sites. The Texas equations overestimate the actual frequencies in all but two cases. Among other possible explanations, one major reason for the difference is that the Texas equation was developed with an accident reporting threshold of $25 for a property damage accident while the Virginia limit was $250.

Table 15

Comparison of Accident Predictions
for Traversable Median Sections

	Actual	Virginia Equation	Average Error	Texas Equation	Average Error
1	6.10	2.36	3.74	22.11	-16.01
7	42.74	37.96	4.78	77.61	-34.87
9	11.43	17.00	- 5.57	14.15	- 2.72
11	39.50	35.40	4.10	62.95	-23.45
13	21.88	56.69	-34.81	105.65	-83.77
14	4.35	- 3.52	7.87	14.86	-10.51
20	11.47	43.43	-31.99	80.99	-69.52
21	21.44	35.37	-13.93	109.16	-87.72
29	91.09	84.28	6.81	123.09	-32.00
30	91.94	54.49	37.45	127.39	-35.45
31	95.00	95.85	- 0.85	145.92	-50.92
32	36.51	38.35	- 1.84	87.26	-50.75
38	91.26	58.79	32.47	76.99	14.27
41	67.65	78.75	-11.10	64.06	3.59
44	85.05	86.63	- 1.58	118.05	-33.00
47	60.92	55.07	5.85	79.30	-18.38
50	43.14	44.06	- 0.92	61.08	-17.94
		Avg. Error =	0.02	Avg. Error =	-32.30

Note: Values are expressed in terms of annual accidents per mile.

Development of Guidelines

The general methodology developed for selecting an appropriate median treatment for a site-specific set of roadway and operational conditions consists of the following steps:

- Data Collection
- Accident Analysis
- Delay Analysis
- Economic Analysis

904

- o Other Considerations
- o Selection of Median Type

Details of the step-by-step procedure for conducting the analysis are given in the companion report entitled "Methodology for Selecting Urban Median Treatments: A User's Manual." In addition to summarizing the advantages and disadvantages of alternative median treatments, the manual provides illustrative examples of the median selection process.

As previously outlined, the input data needed for conducting an evaluation of alternative median treatments are variables which are easy to obtain or estimate for a given project. The regression equations are used to provide estimates of the number of accidents and left-turn delay values for each median treatment. It should be noted that the equations can be used to obtain estimates based on existing volumes and geometric conditions as well as estimates of the impacts of future volume and land use conditions.

As a further aid in selecting an appropriate median treatment, an economic analysis of the alternatives should be conducted. Accident reduction values used in the economic analysis can be obtained by comparing existing accident conditions to expected values obtained from the regression equations. Of course, in cases involving the comparison of either a raised or traversable median (i.e., the decision has been made to construct a median and existing conditions are not of interest), the differences in accidents per mile and delay between the median types are used as reduction factors.

No specific method for conducting an economic analysis is suggested as a result of this research. In fact, the decision of whether an economic analysis should be conducted is an option left to the designer or traffic engineer. The major emphasis of this guide is to provide an estimate of the accident and delay characteristics of several median alternatives, thus enabling the designer to select the treatment offering the best safety estimates. If the designer wishes to conduct an economic analysis to further determine which treatment is justified, current Departmental practices should be followed.

If, after calculations of accident statistics and operational delay have been made there is no clear determination or choice of median type, then neither treatment is assumed to have advantages over the other, and either type may be selected for design. Nevertheless, there are several factors that should be considered before the final decision is made. The following guidelines are suggested.

1. If the stopping sight distance is less than the safe distance as computed by AASHTO standards anywhere on the project, a traversable median should never be used on the section, unless the sight distance can be increased above acceptable limits.

2. Raised medians with 6-inch vertical face curbs should not be used on roadway sections where the operating speed exceeds 45 mph; however, raised medians with mountable curbs and a full-height barrier curb are permitted.

3. Generally, raised medians are desirable under the following conditions:

   (a) Access points are limited to major intersections where crossovers can be provided.

   (b) The number of streets per mile is greater than 12.

   (c) Large volumes of pedestrians frequently cross the roadway throughout the section and cannot be confined to crosswalks.

   (d) A grid pattern of intersecting streets permits circuitous flow of traffic without disrupting traffic in residential communities.

4. Generally, traversable medians are desirable under the following conditions:

   (a) The number of streets per mile is less than 12.

   (b) The number of driveways per mile is greater than 50.

   (c) A reversible lane for carrying peak-period traffic is needed in the near future.

5. Generally, the alternating left-turn lanes should be used when access is not needed on one side of the road.

6. Generally, continuous median lanes offer no safety or operational advantages over other median treatments and

should not be selected for implementation due to their right-of-way and construction costs.

The accident and delay data, along with the other considerations outlined above, are intended to aid the designer and traffic engineer in the selection of a median treatment. Experience and judgement should be used in interpreting the results of the analysis. The guidelines provide factual, quantifiable data upon which a decision can be based; however, the guidelines should not be used without a full understanding of current knowledge and limitations of the process. For example, one should never use input values that exceed the range of the independent variables given in Table 13. Similar to other empirical approaches, these guidelines should be reviewed and revised from time to time to ensure their applicability in today's dynamic highway safety and operational environment.

The guidelines do not cover every factor involved in median design. For example, aesthetics of design are often a function of accepted practice in a community and are not necessarily compatible with safety or operational objectives. These factors are difficult, if not impossible, to quantify and are not included in the proposed methodology.

It should be noted that other factors such as posted speed limits are not directly considered in the analysis. The primary reason for this omission is the finding that speed limits per se do not significantly affect the number of accidents or mid-block, left-turn delay on urban and suburban multilane highways. Speed, however, is indirectly considered in the median selection process; e.g., raised medians should not be used on roadways where operating speeds exceed 45 mph. Mountable curbs and full-height barrier curbs which redirect errant vehicles are permitted.

The diversity of opinion regarding the selection of a specific median treatment may never be eliminated because of the variety of factors that can be included in an analysis and personal preferences of some highway engineers. The guidelines offered in this report simply provide additional data that can be used to aid the engineer in making a rational selection.

CONCLUSIONS

Using empirical data, a rational approach for selecting a median treatment for a set of project conditions has been developed. The process is intended to aid the transportation engineer, but the results of the analysis must be interpreted in view of the limitations of the regression equations. The process will be especially useful when considerable differences of opinion exist concerning which median design to use for specific traffic and geometric variables. Perhaps the greatest benefit of the approach lies in giving the engineer the ability to express the expected impacts in terms of accident frequencies and delay times instead of indices, ratios, or other terms not readily understood by the public. Estimates of these impacts should be especially beneficial at public hearings and in other deliberations where the selection of a median treatment is being considered.

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1021

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APPENDIX A

QUESTIONNAIRE SURVEY OF STATE AND CITY ROADWAY DESIGN ENGINEERS

Part A — Transmittal Letter

December 15, 1977 23-7-40

Dear

The Virginia Highway and Transportation Research Council is conducting a study for the purpose of developing guidelines that can be used by designers to select raised and traversable medians for urban highway projects. For the purpose of this research, a traversable median is defined as a continuous left turn median lane(s) where a physical barrier is not used to separate opposing traffic streams.

The scope of the study includes a literature review and an analysis of completed four-lane divided facilities in urban areas of Virginia. To supplement our work here, we will examine median design practices and experiences in urban areas of other states through the use of the attached questionnaire. I would appreciate your cooperation in completing the questionnaire and returning it along with any requested material by February 1, 1978.

Should you not be involved with the design of medians for urban areas, I would appreciate your forwarding the questionnaire to the proper authority. If you have any questions or would like more information concerning the study, please contact Martin R. Parker, Jr. of our office, telephone (804) 977-0290.

Thank you for your cooperation and assistance.

Jack H Dillard

J. H. Dillard, Head
Virginia Highway & Transportation
Research Council

MRPjr/bsm
Attachment

1006

Return Completed Questionnaire To:

Martin R. Parker, Jr., P.E.
Research Engineer
Virginia Highway & Transportation Research Council
Box 3817 University Station
Charlottesville, Virginia 22903

QUESTIONNAIRE SURVEY OF PRACTICES IN DESIGN OF URBAN MEDIANS

1. Jurisdiction ______________ State ______________ Date __________

2. Of the total mileage of four-lane urban divided highways (excluding urban freeways) under your jurisdiction, please estimate the percentage of the mileage for each median type listed below.

   ______% Raised median

   ______% Depressed median

   ______% Narrow traversable median (a median less than 8-feet wide without a physical barrier)

   ______% Traversable median with left turn lane(s) but no physical barrier

   ______% Other (Please specify type) ______________

3. Does your organization have a set of guidelines (or a policy) that is used by your designers to select a median type for an urban project?

   ______yes. If yes, please briefly outline your policy or enclose a copy of your guidelines.

   ____

   ____

   ____

   ______no.

4. If you do not have a set of guidelines, on what basis do you select the type of median to be used? (Check one or more)

   a. ______ A raised or depressed median is always used
   b. ______ Engineering judgement
   c. ______ Experience
   d. ______ Public input
   e. ______ Political input
   f. ______ Other. Please describe ______________

   ____

5. For each of the following conditions, please indicate if you would always, usually, sometimes, rarely, or never use a raised median. If the condition is not considered important in your decision to use a raised median, indicate that it is not a factor. Assume that each criterion is independent of other factors.

Condition	Always	Usually	Sometimes	Rarely	Never	Not a Factor
Traffic Volume						
a. 10,000 ADT or less	___	___	___	___	___	___
b. 10,000 to 25,000 ADT	___	___	___	___	___	___
c. 25,000 ADT or greater	___	___	___	___	___	___
Traffic Speed						
a. 30 mph or less	___	___	___	___	___	___
b. 30 to 40 mph	___	___	___	___	___	___
c. 40 to 50 mph	___	___	___	___	___	___
d. 50 mph or greater	___	___	___	___	___	___
Roadside Development						
a. Light residential	___	___	___	___	___	___
b. Heavy residential	___	___	___	___	___	___
c. Light commercial	___	___	___	___	___	___
d. Heavy commercial	___	___	___	___	___	___
e. Industrial	___	___	___	___	___	___
f. Land prime for development	___	___	___	___	___	___
Intersecting Street Patterns						
a. Interconnecting streets adjacent to main road	___	___	___	___	___	___
b. Streets are not interconnected	___	___	___	___	___	___
Demand for Mid-block Left Turns						
a. Heavy	___	___	___	___	___	___
b. Moderate	___	___	___	___	___	___
c. Light	___	___	___	___	___	___
Pedestrian Crossings						
a. Heavy	___	___	___	___	___	___
b. Moderate	___	___	___	___	___	___
c. Light	___	___	___	___	___	___
Other Considerations						
a. Limited sight distance	___	___	___	___	___	___
b. Six or more through lanes	___	___	___	___	___	___
c. Public request	___	___	___	___	___	___
d. Political request	___	___	___	___	___	___
e. Business request	___	___	___	___	___	___
f. Limited construction funds	___	___	___	___	___	___
g. Limited right-of-way	___	___	___	___	___	___
h. Other. Please specify						
___________	___	___	___	___	___	___
___________	___	___	___	___	___	___

1038

6. For each of the following conditions, please indicate if you would always, usually, sometimes, rarely, or never use a traversable median. If the condition is not considered important in your decision to use a traversable median, indicate that it is not a factor. Assume that each criterion is independent of other factors.

Condition	Always	Usually	Sometimes	Rarely	Never	Not A Factor
Traffic Volume						
a. 10,000 ADT or less						
b. 10,000 to 25,000 ADT						
c. 25,000 ADT or greater						
Traffic Speed						
a. 30 mph or less						
b. 30 to 40 mph						
c. 40 to 50 mph						
d. 50 mph or greater						
Roadside Development						
a. Light residential						
b. Heavy residential						
c. Light commercial						
d. Heavy commercial						
e. Industrial						
f. Land prime for development						
Intersecting Street Patterns						
a. Interconnecting streets adjacent to main road						
b. Streets are not interconnected						
Demand for Mid-block Left Turns						
a. Heavy						
b. Moderate						
c. Light						
Pedestrian Crossings						
a. Heavy						
b. Moderate						
c. Light						
Other Considerations						
a. Limited sight distance						
b. Six or more through lanes						
c. Public request						
d. Political request						
e. Business request						
f. Limited construction funds						
g. Limited right-of-way						
h. Other. Please specify						
______________						
______________						

7. Please describe your experience with raised medians with regard to the following items. For each item, if you are unaware of any problems, indicate none.

a. Access problems ______

b. Public response ______

c. Business response ______

d. Political response ______

e. Traffic accidents ______

f. Pedestrian problems ______

g. Traffic operational problems ______

h. U-turning problems at crossovers ______

i. Wrong-way driving to reach crossovers ______

j. Maintenance problems ______

k. Construction problems ______

l. Other. Please specify. ______

______

______

8. Please describe your experience with traversable medians with regard to the following items. For each item, if you are unaware of any problems, indicate none.

a. Access problems ______

b. Public response ______

c. Business response ______

d. Political response ______

e. Traffic accidents ______

f. Pedestrian problems ______

g. Traffic operational problems ______

h. Improper use of median lane ______

i. Maintenance problems ______

j. Construction problems ______

k. Other. Please specify. ______

______

______

9. Based on your experience, are you aware of any situations where a raised median should not be used?

______yes. Please describe conditions. ______

______

______no.

1010

10. Based on your experience, are you aware of any situations where a traversable median should not be used?

______yes. Please describe conditions. ____________________________________

____

______no.

11. Is your organization designing more projects with traversable medians than it did a few years ago?

______yes. Please list your reasons. ____________________________________

____

______no.

12. When raised medians are used, direct access to both directions of travel from every existing business or residential development is not possible in a number of cases. When direct access to both lanes is restricted, is this access problem a compensable item in your jurisdiction during right-of-way negotiations with property owners?

______yes. Please explain your policy. ____________________________________

____

______no.

13. Are any planned, ongoing, or completed studies being conducted by your organization with regard to either determining the effects of raised or traversable medians or developing guidelines for selecting median type for urban facilities?

______yes. Contact ____________________________________

____

____

Phone
Area Code ( ) ____________________________________

or please include a copy of the report or project status.

______no.

14. Additional comments or observations. ____________________________________

____

____

____

15. Would you like a copy of our final report on this project?

______yes.

______no.

Your name ______________________________

Title ______________________________

Mailing Address ______________________________

____

____

____

Phone Number Area Code (   ) ______________________________

Thank you for your cooperation and assistance. The information you have provided will be tabulated along with data from other jurisdictions and summarized in the final report. If you have any questions or would like more information concerning the study, please contact: Martin R. Parker, Jr., Virginia Highway and Transportation Research Council, Charlottesville, Virginia Telephone (804) 977-0290.

APPENDIX B

CITIES RESPONDING TO THE QUESTIONNAIRE

State/City	Population in 1,000's
ALABAMA	
Mobile	190
ARIZONA	
Phoenix	582
Tucson	263
ARKANSAS	
Little Rock	132
CALIFORNIA	
Fresno	166
Los Angeles	2,816
Oakland	362
Riverside	155
Sacramento	254
San Diego	697
San Jose	446
COLORADO	
Denver	515
FLORIDA	
Dade County (Miami)	1,268
St. Petersburg	216
Tampa	278
GEORGIA	
Columbus	154
HAWAII	
Honolulu	325
ILLINOIS	
Chicago	3,367

State/City	Population in 1,000's
INDIANA	
Indianapolis	745
Fort Wayne	178
Gary	175
KANSAS	
Kansas City	168
Wichita	277
LOUISIANA	
Baton Rouge	166
Shreveport	182
MARYLAND	
Baltimore	906
MASSACHUSETTS	
Boston	641
Springfield	164
MICHIGAN	
Detroit	1,511
Grand Rapids	198
Warren	179
MINNESOTA	
St. Paul	310
MISSOURI	
St. Louis	622
NEBRASKA	
Omaha	347
NEVADA	
Las Vegas	126
NEW HAMPSHIRE	
Manchester	88

State/City	Population in 1,000's
NEW JERSEY	
Newark	382
NEW YORK	
Buffalo	463
New York	7,868
Rochester	296
Syracuse	197
NORTH CAROLINA	
Charlotte	241
OHIO	
Cincinnati	453
Toledo	384
OKLAHOMA	
Oklahoma City	366
OREGON	
Portland	382
PENNSYLVANIA	
Pittsburgh	520
SOUTH DAKOTA	
Sioux Falls	72
TENNESSEE	
Knoxville	175
Nashville	448
TEXAS	
Austin	252
Corpus Christi	205
Dallas	844
El Paso	322
Fort Worth	393
San Antonio	654

State/City	Population in 1,000's
UTAH	
Salt Lake City	176
VERMONT	
Burlington	38
VIRGINIA	
Norfolk	308
Richmond	250
Virginia Beach	172
WASHINGTON	
Seattle	531
Tacoma	155
WISCONSIN	
Madison	173
Milwaukee	717
WYOMING	
Cheyenne	41

APPENDIX C

RESULTS OF QUESTIONNAIRE SURVEY

Part A — Opinions of State Design Engineers

Return Completed Questionnaire To:

Martin R. Parker, Jr., P.E.
Research Engineer
Virginia Highway & Transportation Research Council
Box 3817 University Station
Charlottesville, Virginia 22903

QUESTIONNAIRE SURVEY OF PRACTICES IN DESIGN OF URBAN MEDIANS

1. Jurisdiction 46 STATE DOT State UNITED STATES Date AUGUST 1, 1978

2. Of the total mileage of four-lane urban divided highways (excluding urban freeways) under your jurisdiction, please estimate the percentage of the mileage for each median type listed below.

Average %

38 % Raised median

16 % Depressed median

18 % Narrow traversable median (a median less than 8-feet wide without a physical barrier)

25 % Traversable median with left turn lane(s) but no physical barrier

3 % Other (Please specify type) NEW JERSEY BARRIER, PAINTED CHANNELIZATION

3. Does your organization have a set of guidelines (or a policy) that is used by your designers to select a median type for an urban project?

34.0 yes. If yes, please briefly outline your policy or enclose a copy of your guidelines.

SEE TABLE

66.0 no.

4. If you do not have a set of guidelines, on what basis do you select the type of median to be used? (Check one or more)

a. 4.3 A raised or depressed median is always used

b. 74.5 Engineering judgement

c. 66.0 Experience

d. 61.7 Public input

e. 36.2 Political input

f. 31.9 Other. Please describe DEVELOPMENT ALONG ROADWAY, AVAILABLE RIGHT-OF-WAY, STREET PATTERNS ADJACENT TO ROADWAY, SPEEDS, VOLUMES, WHERE POSITIVE ACCESS CONTROL IS NEEDED USE RAISED MEDIAN, DEMAND FOR MID-BLOCK LEFT TURNS, CONTINUITY OF ADJACENT SECTIONS, AND ACCIDENT PROBLEMS ARE CONSIDERATIONS.

NOTE: Results are expressed as a percentage of the total number of responses.

5. For each of the following conditions, please indicate if you would always, usually, sometimes, rarely, or never use a raised median. If the condition is not considered important in your decision to use a raised median, indicate that it is not a factor. Assume that each criterion is independent of other factors.

Condition	Always	Usually	Sometimes	Rarely	Never	Not a Factor	Not Applicable	No Response
Traffic Volume								
a. 10,000 ADT or less	0	6.4	36.2	25.5	4.3	23.4	0	4.3
b. 10,000 to 25,000 ADT	2.1	19.1	48.9	10.6	0	14.9	0	4.3
c. 25,000 ADT or greater	10.6	31.9	36.2	6.4	0	10.6	0	4.3
Traffic Speed								
a. 30 mph or less	0	10.6	44.7	12.8	8.5	19.1	0	4.3
b. 30 to 40 mph	0	12.8	55.3	12.8	0	14.9	0	4.3
c. 40 to 50 mph	2.1	23.4	40.4	14.9	2.1	12.8	0	4.3
d. 50 mph or greater	8.5	23.4	25.5	12.8	14.9	8.5	0	6.4
Roadside Development								
a. Light residential	0	12.8	42.6	21.3	0	19.1	0	4.3
b. Heavy residential	0	12.8	36.2	27.7	2.1	17.0	0	4.3
c. Light commercial	0	14.9	55.3	10.6	0	14.9	0	4.3
d. Heavy commercial	0	17.0	42.6	21.3	4.3	10.6	0	4.3
e. Industrial	0	21.3	44.7	12.8	4.3	12.8	0	4.3
f. Land prime for development	4.3	17.0	38.3	14.9	6.4	12.8	0	6.4
Intersecting Street Patterns								
a. Interconnecting streets adjacent to main road	0	19.1	48.9	8.5	0	17.0	0	6.4
b. Streets are not interconnected	0	12.8	34.0	19.1	0	25.5	0	8.5
Demand for Mid-block Left Turns								
a. Heavy	2.1	23.4	19.1	38.3	6.4	4.3	0	6.4
b. Moderate	0	14.9	55.3	17.0	2.1	4.3	0	6.4
c. Light	0	21.3	48.9	17.0	0	6.4	0	6.4
Pedestrian Crossings								
a. Heavy	0	25.5	29.8	8.5	2.1	29.8	0	4.3
b. Moderate	0	12.8	34.0	14.9	0	34.0	0	4.3
c. Light	0	2.1	34.0	23.4	2.1	34.0	0	4.3
Other Considerations								
a. Limited sight distance	0	6.4	34.0	23.4	2.1	29.8	0	4.3
b. Six or more through lanes	10.6	36.2	27.7	6.4	0	12.8	0	6.4
c. Public request	0	10.6	51.1	27.7	0	4.3	0	6.4
d. Political request	0	10.6	46.8	25.5	2.1	8.5	0	6.4
e. Business request	0	8.5	46.8	31.9	4.3	2.1	0	6.4
f. Limited construction funds	2.1	4.3	38.3	19.1	2.1	29.8	0	4.3
g. Limited right-of-way	2.1	17.0	44.7	21.3	0	8.5	0	6.4
h. Other. Please specify:								
DRAINAGE, CONTROL ACCESS,	0	6.4	6.4	2.1	0	0	0	85.1
HIGH No. OF ACCIDENTS,	0	2.1	2.1	0	0	0	0	95.7

BETTER TRAFFIC CONTROL SIGNING AND SIGNAL PLACEMENT ON WIDE STREETS, AND SNOW REMOVAL.

6. For each of the following conditions, please indicate if you would always, usually, sometimes, rarely, or never use a traversable median. If the condition is not considered important in your decision to use a traversable median, indicate that it is not a factor. Assume that each criterion is independent of other factors.

Condition	Always	Usually	Sometimes	Rarely	Never	Not A Factor	Not Applicable	No Response
Traffic Volume								
a. 10,000 ADT or less	0	10.6	48.9	14.9	0	17.0	4.3	4.3
b. 10,000 to 25,000 ADT	0	10.6	59.6	10.6	0	10.6	4.3	4.3
c. 25,000 ADT or greater	0	14.9	40.4	19.1	8.5	8.5	4.3	4.3
Traffic Speed								
a. 30 mph or less	2.1	23.4	44.7	6.4	0	17.8	4.3	6.4
b. 30 to 40 mph	0	19.1	57.4	4.3	0	10.6	4.3	4.3
c. 40 to 50 mph	0	10.6	42.6	27.7	0	10.6	4.3	4.3
d. 50 mph or greater	0	2.1	27.7	27.7	23.4	6.4	6.4	6.4
Roadside Development								
a. Light residential	0	14.9	36.2	25.5	2.1	12.8	4.3	4.3
b. Heavy residential	0	25.5	38.3	19.1	0	8.5	4.3	4.3
c. Light commercial	2.1	19.1	59.6	4.3	0	6.4	4.3	4.3
d. Heavy commercial	6.4	21.3	57.4	4.3	0	2.1	4.3	4.3
e. Industrial	2.1	14.9	57.4	12.8	0	4.3	4.3	4.3
f. Land prime for development	2.1	12.8	42.6	23.4	0	10.6	4.3	4.3
Intersecting Street Patterns								
a. Interconnecting streets adjacent to main road	0	6.4	46.8	12.8	0	21.3	4.3	8.5
b. Streets are not interconnected	0	10.6	38.3	14.9	0	23.4	4.3	8.5
Demand for Mid-block Left Turns								
a. Heavy	8.5	44.7	27.7	10.6	0	0	4.3	4.3
b. Moderate	2.1	34.0	53.2	2.1	0	0	4.3	4.3
c. Light	0	27.7	34.0	25.5	2.1	2.1	4.3	4.3
Pedestrian Crossings								
a. Heavy	0	4.3	23.4	27.7	0	36.2	4.3	4.3
b. Moderate	0	4.3	38.3	10.6	0	38.3	4.3	4.3
c. Light	0	12.8	25.5	10.6	0	42.6	4.3	4.3
Other Considerations								
a. Limited sight distance	0	4.3	34.0	23.4	2.1	27.7	4.3	4.3
b. Six or more through lanes	0	8.5	23.4	31.9	17.0	10.6	4.3	4.3
c. Public request	0	10.6	63.8	17.0	0	0	4.3	4.3
d. Political request	2.1	8.5	61.7	17.0	0	2.1	4.3	4.3
e. Business request	2.1	8.5	59.6	17.0	2.1	0	4.3	6.4
f. Limited construction funds	2.1	8.5	48.9	6.4	0	25.5	4.3	4.3
g. Limited right-of-way	2.1	23.4	44.7	12.8	0	8.5	4.3	4.3
h. Other. Please specify								
ACCIDENT PROBLEMS,	0	2.1	0	0	0	0	4.3	93.6
CONTINUITY OF ADJACENT SECTIONS.	0	4.3	0	0	0	0	4.3	91.5

-1000

7. Please describe your experience with raised medians with regard to the following items. For each item, if you are unaware of any problems, indicate none.

   a. Access problems YES (33 STATES), MINIMAL (7 STATES), NONE (5 STATES)
   b. Public response ADVERSE (28 STATES), MIXED (2 STATES), MINIMAL (8), FAVORABLE (6)
   c. Business response ADVERSE (34 STATES), MINIMAL OR NONE (6 STATES), FAVORABLE (6)
   d. Political response ADVERSE (25 STATES), MIXED (6), MINIMAL OR NONE (11) FAVORABLE (8)
   e. Traffic accidents INCREASE (15 STATES), DECREASE (20), NO PROBLEM (10)
   f. Pedestrian problems IMPROVE (14 STATES), NO PROBLEM (27), PROVIDE RAMPS-HANDICAPPED (2)
   g. Traffic operational problems IMPROVES OPERATIONS (8), SOME PROBLEMS (19), NO PROBLEMS (13)
   h. U-turning problems at crossovers U-TURN PROBLEM (22 STATES), NO PROBLEM (21)
   i. Wrong-way driving to reach crossovers SOME PROBLEMS (16), MINOR PROBLEMS (20), NONE (13)
   j. Maintenance problems DURING SNOW (14), MOWING PROBLEMS (7), MORE COSTLY (3), NONE (14)
   k. Construction problems MORE COSTLY (5), TRAFFIC $ DRAINAGE (3), NONE (35)
   l. Other. Please specify. COSTS MORE TO CONSTRUCT (2), RAISED MEDIAN REQUIRES ADDITIONAL TRAVEL TO REACH DESTINATION, POOR VISIBILITY DURING FOG OR RAIN, REQUESTS FOR ADDITIONAL OPENINGS, ADVERSE REACTION FROM FHWA ON HIGH SPEED ROADS, HOLDS SNOW WHICH MELTS ON PAVEMENT, BENEFITS EXCEED PROBLEMS,

8. Please describe your experience with traversable medians with regard to the following items. For each item, if you are unaware of any problems, indicate none.

   a. Access problems IMPROVED (6), SOME PROBLEM (6), NO PROBLEM (28)
   b. Public response FAVORABLE (29), MIXED (2), ADVERSE (3), NONE (8)
   c. Business response FAVORABLE (32), MIXED (2), ADVERSE (3), NONE (6)
   d. Political response FAVORABLE (24), MIXED (5), ADVERSE (1), NONE (11)
   e. Traffic accidents INCREASE (9), DECREASE (6), NONE (12), NO DATA (4)
   f. Pedestrian problems NO PROTECTION (21), MINIMAL (3), NO PROBLEM (17)
   g. Traffic operational problems SOME PROBLEMS (18), (PASSING AND NO CONTROL), NONE (15)
   h. Improper use of median lane SOME PASSING AND IMPROPER TURNS (16), MINIMAL (14), NONE (9)
   i. Maintenance problems COLLECTS SNOW & DIRT (3), NONE OR ROUTINE (29)
   j. Construction problems MINIMAL (3), EASIER THAN RAISED (3), NO PROBLEM (35)
   k. Other. Please specify. LOWER COST, GOOD MARKINGS ARE IMPERATIVE, ALLOWS SPACE FOR EMERGENCY VEHICLES, REFLECTIVE CRACKING AFFECTS LANE OPERATION.

9. Based on your experience, are you aware of any situations where a raised median should not be used?

   74.5 yes. Please describe conditions. SEE TABLE 2

   25.5 no.

   ______ no response.

1021

10. Based on your experience, are you aware of any situations where a traversable median should not be used?

76.6 yes. Please describe conditions. SEE TABLE 4

17.0 no. 4.3 Not applicable 2.1 No response

11. Is your organization designing more projects with traversable medians than it did a few years ago?

74.5 yes. Please list your reasons. COST EFFECTIVE, FEW OPERATIONAL PROBLEMS, IMPROVES ACCESSABILITY, FAVORABLE RESPONSE, LIMITED RIGHT-OF-WAY, ENHANCES SNOW REMOVAL, DEMAND FOR MORE CROSSOVERS ON RAISED MEDIANS, AND GREATER FLEXIBILITY WITH TRAVERSABLE MEDIANS.

25.5 no.

12. When raised medians are used, direct access to both directions of travel from every existing business or residential development is not possible in a number of cases. When direct access to both lanes is restricted, is this access problem a compensable item in your jurisdiction during right-of-way negotiations with property owners?

6.4 yes. Please explain your policy. JURY TRIAL DETERMINES COST, DAMAGES AWARDED IF PROPERTY IS ACQUIRED.

87.2 no. 6.4 No response

13. Are any planned, ongoing, or completed studies being conducted by your organization with regard to either determining the effects of raised or traversable medians or developing guidelines for selecting median type for urban facilities?

14.9 yes. Contact STUDIES BEING CONDUCTED IN GEORGIA, ILLINOIS, MICHIGAN, NORTH CAROLINA, TEXAS, VIRGINIA, AND WISCONSIN.

Phone
Area Code ( ) ______

or please include a copy of the report or project status.

85.1 no. 0 No response

14. Additional comments or observations. 15 STATES OFFERED ADDITIONAL COMMENTS. - SEE APPENDIX 6.

15. Would you like a copy of our final report on this project?

97.9 yes.

0 no.

2.1 no response

-10

APPENDIX F

RESULTS OF QUESTIONNAIRE SURVEY

Part B — Opinions of City Design Engineers

Return Completed Questionnaire To:

Martin R. Parker, Jr., P.E.
Research Engineer
Virginia Highway & Transportation Research Council
Box 3817 University Station
Charlottesville, Virginia 22903

QUESTIONNAIRE SURVEY OF PRACTICES IN DESIGN OF URBAN MEDIANS

1. Jurisdiction 66 CITIES IN 36 STATES State UNITED STATES Date AUGUST 1, 1978

2. Of the total mileage of four-lane urban divided highways (excluding urban freeways) under your jurisdiction, please estimate the percentage of the mileage for each median type listed below.

Average %

49 % Raised median

9 % Depressed median

13 % Narrow traversable median (a median less than 8-foot wide without a physical barrier)

27 % Traversable median with left turn lane(s) but no physical barrier

2 % Other (Please specify type) BARRIER, REVERSIBLE LANE

3. Does your organization have a set of guidelines (or a policy) that is used by your designers to select a median type for an urban project?

36.4 yes. If yes, please briefly outline your policy or enclose a copy of your guidelines.

SEE TABLE

53.0 no. 10.6 NO RESPONSE

4. If you do not have a set of guidelines, on what basis do you select the type of median to be used? (Check one or more)

a. 13.6 A raised or depressed median is always used

b. 63.6 Engineering judgement

c. 45.5 Experience

d. 30.3 Public input

e. 22.7 Political input

f. 24.2 Other. Please describe USE RAISED MEDIANS AT INTERSECTIONS AND ON STREETS WITH LANDSCAPING, COST, AVAILABLE RIGHT-OF-WAY, NEED FOR ACCESS, TRAFFIC VOLUME, SPEED, LAND USE, AASTHO POLICY.

NOTE: Results are expressed as a percentage of the total number of responses.

5. For each of the following conditions, please indicate if you would always, usually, sometimes, rarely, or never use a raised median. If the condition is not considered important in your decision to use a raised median, indicate that it is not a factor. Assume that each criterion is independent of other factors.

Condition	Always	Usually	Sometimes	Rarely	Never	Not a Factor	Not Applicable	No Response
Traffic Volume								
a. 10,000 ADT or less	0	3.0	21.2	37.9	6.1	10.6	3.0	18.2
b. 10,000 to 25,000 ADT	3.0	19.7	42.4	6.1	0	9.1	3.0	16.7
c. 25,000 ADT or greater	16.7	31.8	19.7	1.5	0	9.1	3.0	18.2
Traffic Speed								
a. 30 mph or less	0	3.0	18.2	28.8	1.5	28.8	3.0	16.7
b. 30 to 40 mph	0	13.6	36.4	4.5	0	25.8	3.0	16.7
c. 40 to 50 mph	10.6	21.2	19.7	1.5	0	24.2	4.5	18.2
d. 50 mph or greater	21.2	18.2	7.6	4.5	0	22.7	6.1	19.7
Roadside Development								
a. Light residential	0	4.5	18.2	24.2	13.6	14.7	3.0	16.7
b. Heavy residential	0	3.0	25.8	23.8	4.5	18.2	3.0	16.7
c. Light commercial	0	6.1	40.9	19.7	0	13.6	3.0	16.7
d. Heavy commercial	1.5	16.7	34.8	15.2	1.5	10.6	3.0	16.7
e. Industrial	1.5	16.7	36.4	13.6	0	12.1	3.0	16.7
f. Land prime for development	4.5	15.2	31.8	9.1	0	19.7	3.0	16.7
Intersecting Street Patterns								
a. Interconnecting streets adjacent to main road	4.5	10.6	21.2	6.1	1.5	31.8	3.0	21.2
b. Streets are not interconnected	0	3.0	30.3	9.1	1.5	33.3	3.0	19.7
Demand for Mid-block Left Turns								
a. Heavy	6.1	15.2	19.7	24.2	6.1	7.6	3.0	18.2
b. Moderate	1.5	12.1	33.3	19.7	0	12.1	3.0	18.2
c. Light	1.5	16.7	33.3	12.1	3.0	13.6	3.0	16.7
Pedestrian Crossings								
a. Heavy	10.6	12.1	18.2	6.1	1.5	31.8	3.0	16.7
b. Moderate	3.0	7.6	21.2	9.1	1.5	34.8	3.0	19.7
c. Light	1.5	4.5	15.2	15.2	3.0	37.9	3.0	19.7
Other Considerations								
a. Limited sight distance	6.1	12.1	21.2	10.6	1.5	28.8	3.0	16.7
b. Six or more through lanes	19.7	25.8	18.2	7.6	1.5	7.6	3.0	16.7
c. Public request	1.5	10.6	27.3	25.8	3.0	10.6	3.0	18.2
d. Political request	3.0	9.1	31.8	21.2	1.5	12.1	3.0	18.2
e. Business request	1.5	7.6	28.8	22.7	4.5	13.6	3.0	18.2
f. Limited construction funds	0	6.1	27.3	27.3	3.0	16.7	3.0	16.7
g. Limited right-of-way	1.5	6.1	36.4	25.8	1.5	6.1	3.0	19.7
h. Other. Please specify:								
FEW PRIVATE DRIVEWAYS,	1.5	4.5	1.5	1.5	0	1.5	1.5	87.9
NEW ALIGNMENT BASED	0	1.5	1.5	1.5	0	1.5	1.5	92.4

ON THROUGH FARE PLAN, ACCIDENT PATTERNS, CONGESTION.

6. For each of the following conditions, please indicate if you would always, usually, sometimes, rarely, or never use a traversable median. If the condition is not considered important in your decision to use a traversable median, indicate that it is not a factor. Assume that each criterion is independent of other factors.

Condition	Always	Usually	Sometimes	Rarely	Never	Not A Factor	Not Applicable	No Response
Traffic Volume								
a. 10,000 ADT or less	1.5	21.2	24.2	15.2	7.6	10.6	7.6	12.1
b. 10,000 to 25,000 ADT	1.5	19.7	30.3	15.2	3.0	10.6	7.6	12.1
c. 25,000 ADT or greater	3.0	16.7	19.7	22.7	9.1	9.1	7.6	12.1
Traffic Speed								
a. 30 mph or less	1.5	22.7	24.2	7.6	3.0	21.2	7.6	12.1
b. 30 to 40 mph	1.5	16.7	31.8	7.6	1.5	21.2	7.6	12.1
c. 40 to 50 mph	1.5	12.1	13.6	21.2	6.1	22.7	9.1	13.6
d. 50 mph or greater	1.5	9.1	6.1	13.6	21.2	22.7	10.6	15.2
Roadside Development								
a. Light residential	1.5	13.6	21.2	19.7	10.6	12.1	9.1	12.1
b. Heavy residential	0	18.2	28.8	16.7	4.5	10.6	9.1	12.1
c. Light commercial	1.5	18.2	31.8	15.2	1.5	9.1	9.1	13.6
d. Heavy commercial	1.5	28.8	30.3	9.1	1.5	7.6	9.1	12.1
e. Industrial	1.5	21.2	30.3	10.6	4.5	10.6	9.1	12.1
f. Land prime for development	1.5	12.1	22.7	16.7	9.1	16.7	9.1	12.1
Intersecting Street Patterns								
a. Interconnecting streets adjacent to main road	0	12.1	15.2	9.1	6.1	33.3	9.1	15.2
b. Streets are not interconnected	1.5	13.6	9.1	15.2	3.0	31.8	9.1	16.7
Demand for Mid-block Left Turns								
a. Heavy	1.5	39.4	19.7	7.6	4.5	6.1	9.1	12.1
b. Moderate	1.5	27.3	27.3	10.6	4.5	7.6	9.1	12.1
c. Light	1.5	12.1	27.3	21.2	6.1	10.6	9.1	12.1
Pedestrian Crossings								
a. Heavy	0	6.1	19.7	13.6	10.6	28.8	9.1	12.1
b. Moderate	0	7.6	19.7	15.2	6.1	28.8	9.1	13.6
c. Light	0	9.1	21.2	9.1	6.1	31.8	9.1	13.6
Other Considerations								
a. Limited sight distance	0	4.5	13.6	27.3	6.1	28.8	7.6	12.1
b. Six or more through lanes	0	7.6	21.2	18.2	16.7	16.7	7.6	12.1
c. Public request	0	9.1	39.4	21.2	0	10.6	7.6	12.1
d. Political request	1.5	7.6	39.4	18.2	1.5	12.1	7.6	12.1
e. Business request	0	9.1	40.9	18.2	1.5	9.1	7.6	13.6
f. Limited construction funds	0	15.2	22.7	13.6	4.5	22.7	7.6	13.6
g. Limited right-of-way	1.5	9.1	37.9	16.7	3.0	12.1	7.6	12.1
h. Other. Please specify								
NUMEROUS DRIVEWAYS,	3.0	4.5	1.5	0	3.0	0	7.6	80.3
UPGRADE EXISTING FACILITY, CONGESTION AND DELAY.	1.5	1.5	3.0	0	0	0	7.6	86.4

'1025

7. Please describe your experience with raised medians with regard to the following items. For each item, if you are unaware of any problems, indicate none.

a. Access problems YES (42) NONE (7) MINIMAL (4)
b. Public response ADVERSE (14) MIXED (4) FAVORABLE (13) NO PROBLEMS (12) MIN. (5)
c. Business response ADVERSE (38) MIXED (6) MINIMAL (5) FAVORABLE (1)
d. Political response NONE (21) ADVERSE (8) MIXED (7) FAVORABLE (6)
e. Traffic accidents DECREASED (32) NO PROBLEMS (9) MORE FIXED OBJECT ACC. (3)
f. Pedestrian problems NONE (24) IMPROVED WITH INSTAL. (19) YES (2) HANDICAP PROBS. (2)
g. Traffic operational problems NONE OR FEW (23) IMPROVED (11) SOME (9)
h. U-turning problems at crossovers A PROBLEM (19) NO PROBLEM (17) MINOR (8) PROHIBITED ( )
i. Wrong-way driving to reach crossovers MINOR (20) NONE (17) SOME (9)
j. Maintenance problems NONE OR MIN. (27) COST (6) YES (8) MOWING (5) SNOW (3)
k. Construction problems NONE (41) COST (4) YES (3)
l. Other. Please specify. NOT FLEXIBLE (2), R.O.W. EXPENSIVE OR LIMITED (2), NOT GOOD FOR EMERGENCY VEHICLES, COST MORE TO CONSTRUCT, SIMPLIFIES LEFT TURN PROBLEM, GLARE SCREENING,

8. Please describe your experience with traversable medians with regard to the following items. For each item, if you are unaware of any problems, indicate none.

a. Access problems NONE (39) MINIMAL (4)
b. Public response NONE (22) FAVORABLE (17) AGAINST (3) MIXED (3) SOME (1)
c. Business response FAVORABLE (29) NONE (21) NEUTRAL (1)
d. Political response NONE (27) FAVORABLE (13) SOME (3) AGAINST (2) NEUTRAL OR MIXED (1)
e. Traffic accidents NONE (10) REDUCED (6) SOME (7) HIGHER (6) REDUCED R.E. (3) INCR. H.O. (3)
f. Pedestrian problems NONE (22) SOME (6) NO REFUGE (4) HAZARDOUS (7) GOOD (2)
g. Traffic operational problems NONE (17) MINOR (9) CONGESTION + CONFLICTS (8) MISUSE (3) BAD IN SNOW OR RAIN (2)
h. Improper use of median lane NONE (14) MINOR (10) ACCELERATING (3) PASSING (3) SOME (9) YES (7)
i. Maintenance problems NONE (30) REPAINTING (9) REDUCED (3) COLLECTS DIRT (2)
j. Construction problems NONE (42) MORE R.O.W. NEEDED (2) ADDED COST (2) FEW (2)
k. Other. Please specify. EDUCATION IN USE IMPORTANT, PROBLEMS OBTAINING R.O.W., PROBLEMS AT SIGNALS, TURNS MADE FROM THRU LANES, PREFER FLUSH MEDIAN.

9. Based on your experience, are you aware of any situations where a raised median should not be used?

60.6 yes. Please describe conditions. SEE TABLE 3

27.3 no.

12.1 no response.

-1026

10. Based on your experience, are you aware of any situations where a traversable median should not be used?

60.6 yes. Please describe conditions. SEE TABLE 5.

24.2 no. 4.5 Not applicable 10.6 No response

11. Is your organization designing more projects with traversable medians than it did a few years ago?

39.4 yes. Please list your reasons. COST EFFECTIVE, WORK WELL, DESIGN IS FLEXIBLE, THEY INCREASE CAPACITY, FAVORABLE RESPONSE, IMPROVES ACCESS, REQUIRES LITTLE RIGHT-OF-WAY.

50.0 no. 10.6 NO RESPONSE

12. When raised medians are used, direct access to both directions of travel from every existing business or residential development is not possible in a number of cases. When direct access to both lanes is restricted, is this access problem a compensable item in your jurisdiction during right-of-way negotiations with property owners?

13.6 yes. Please explain your policy. ACCESSABILITY IS BECOMMING AN IMPORTANT ITEM IN APPRAISING PROPERTY VALUE, BUT ONLY IN RARE CASES IS LACK OF ACCESS A COMPENSABLE ITEM.

68.2 no. 16.7 No response 1.5 NOT APPLICABLE (NO RAISED MEDIANS ARE USED).

13. Are any planned, ongoing, or completed studies being conducted by your organization with regard to either determining the effects of raised or traversable medians or developing guidelines for selecting median type for urban facilities?

9.1 yes. Contact STUDIES ARE BEING CONDUCTED IN THE CITIES OF OMAHA, NEBRASKA AND LAS VEGAS, NEVADA.

Phone
Area Code ( ) __________

or please include a copy of the report or project status.

78.8 no. 12.1 No response

14. Additional comments or observations. 21 CITIES OFFERED ADDITIONAL COMMENTS. SEE APPENDIX G.

15. Would you like a copy of our final report on this project?

77.3 yes.

7.6 no.

15.2 no response

"1027"

APPENDIX D

SUMMARY OF COMMENTS ON THE QUESTIONNAIRE

PART A: Comments From State Design Engineers

ALASKA (Central)

Operational effectiveness of two-way, left-turn lane is reduced but not eliminated under heavy snow conditions.

ARIZONA

We believe the traversable median has many advantages both in lower cost and operation. One plus factor has been the use for emergency vehicles during traffic tie-ups.

GEORGIA

Many times this one factor (selection of median treatments) becomes the major factor at our design public hearings — for and against.

HAWAII

The state has very limited experience with traversable medians.

KANSAS

We still support the use of raised medians at major intersections, but are leaning toward center two-way, left-turn lanes because of their flexibility, economic feasibility, public acceptance, and apparent safety benefits.

KENTUCKY

We are considering changing our design criteria to direct that "On urban and suburban curb and gutter facilities where the control of access is by permit and the operating speed is less than 45 mph, flush medians will be utilized."

MICHIGAN

Our general practice is that our designs are usually 12-foot flush medians or 60-foot raised boulevard.

MINNESOTA

We have had a limited amount of experience with traversable medians. While we recognize their value in some cases, we do not have reservations. Due to our snow problems in winter, we question their effectiveness then. Also, we are concerned over their use when operating speeds exceed 40 mph.

NEVADA

Nevada prefers a raised median when possible because of the improved traffic controls, the reduction in turning movement conflicts, and the added dimension of better roadway delineation.

NEW MEXICO

Urban areas have just lately started to use traversable painted medians or continual left turns. Operationally, the medians appear to work well with no apparent increase in accident rates. As more are built, we will continue to monitor general acceptance by the public and safety.

NORTH CAROLINA

You should contact Mr. Babcock because the research project he is working on is almost identical to your study.

NORTH DAKOTA

Raised medians, in one instance when access was required in numerous cases, a third right-turn-only lane was added which is operating satisfactorily and was acceptable to owners and developers.

OREGON

Raised medians are a hazard at best and we avoid their use whenever possible, except to prevent left turns or when politically forced into their construction.

PENNSYLVANIA

In urban areas, the raised median with periodic left-turn standby lanes is preferred to the traversable median, providing the standby lanes are located "reasonably" to provide adequate access to satisfy public demand.

TEXAS

Flush medians with two-way, left-turn markings are generally preferred over raised medians for urban streets. We have experienced success under the following conditions: (1) posted speed up to 55 mph, (2) four or six travel lanes, (3) closely spaced (approximately 300 feet) or infrequent signalized intersections; and (4) light, moderate, or heavy demand for mid-block access.

PART B: Comments From City Design Engineers

CALIFORNIA

Los Angeles

Raised or depressed medians should generally be used only on high-speed rural expressways or freeways. They are not generally recommended in urban areas.

Sacramento

Before receipt of this questionnaire there had been no thought given to types of medians. Future developments in the city will tend to have exclusively raised medians on those streets requiring medians. One major nonengineering reason for this is aesthetics.

San Diego

In California it is illegal to cross a painted (simulated) island formed by 4 painted yellow lines.

GEORGIA

Columbus

Public education on proper use of two-way, left-turn lanes is essential before, during, and after implementation of these facilities.

FLORIDA

Tampa

Generally the city prefers to use raised medians wherever they are feasible.

HAWAII

Honolulu

Usable land in Honolulu is very scarce. Therefore, on new projects, landowners object to giving up land to have medians constructed. To provide increased traffic capacity, the city was required to pave the median because landowners refused to give up land.

ILLINOIS

Chicago

Use of either mountable or barrier type medians (or painted medians) should be determined by a competent traffic engineering staff.

INDIANA

Gary

We do not use medians to any degree due to right-of-way constrictions on 90% of our streets. The raised medians do offer higher traffic safety at the cost of limited maneuverability. Our experience with traversable medians is that they create unstable traffic conditions.

LOUISIANA

Baton Rouge

There are several other boulevard type streets in our city but they were built by the highway department under their policies.

Shreveport

This report is for city streets only. State highway system has several miles of divided roadway containing all types of medians.

MARYLAND

Baltimore

This questionnaire was filled out based on our policy and input from the Department of Transit and Traffic.

MASSACHUSETTS

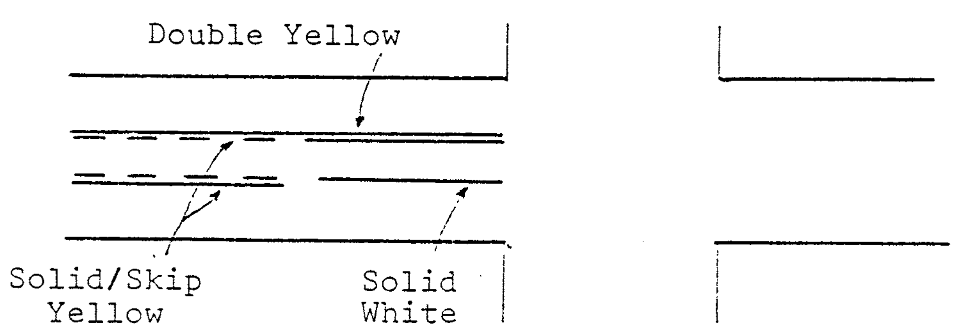
Boston

Some community groups have argued that medians increase speeds thereby resulting in increased number of accidents. We need more data on median experience to offset these arguments.

MICHIGAN

Grand Rapids

The yellow color of the solid skip lines, as set by the MUTCD, causes some drivers to be reluctant to cross over lines and occupy lane. At some intersections we have employed the scheme shown below.



OHIO

Cincinnati

I have answered the questions from my own personal observations.

I have not analyzed accident reports on the two types of medians.

TENNESSEE

Knoxville

Suggest a non-traversable median if at all possible. Traversable median is a cop-out to continuous turn lane which should be avoided if at all possible.

TEXAS

Austin

Questions 5 and 6 are worded so that it is easy to interpret them in very different ways. Your results for those two questions may provide information of questionable usefulness.

El Paso

We never deliberately design a street with a traversable median. This device is used to increase the capacity of an existing street when it is not feasible to acquire additional right-of-way for widening the street.

San Antonio

We have removed raised medians on a number of streets and replaced them with traversable medians.

OREGON

Portland

Proper design of raised medians with appropriate lighting and signing, plus advance devices, to reduce vehicular collisions at ends of medians (is necessary for their safe operation).

WASHINGTON

Seattle

(1) In the past decade Seattle decision makers have been moving toward a pragmatic "composite community interest" position, taking the street user, the abutting property viability, the general public and municipal tax/business base economics into the process. This has resulted in

occasional subjugations of street user interest, but none of these to date have been serious. The street user in Seattle will stand up and be recognized (with those of other interests) when he is stepped on. We are not far from the right track in Seattle.

(2) I note that your form did not include conflict/accidents or congestion/delay under your "conditions" heading, while we find these among the most useful of parameter/indicator issues in defining public travel system interest/impacts.

(3) I note that your form is oriented to some user issues but does not relate to the abutting owner, general public, and municipal economic interests cited in 14-D above.

I suggest that you expand your perspective more than a little if your objective includes the satisfaction/approval of the general public. A state level target (highway and transportation) agency may be at a legal/budgetary and public input disadvantage in regard to perspective (compared with municipal/urban county and even federal levels) — but without perspective there is no polarization and program conflict.

Tacoma

The city of Tacoma has no major arterials of six through lanes or of over forty mph speed limit. We feel it is desirable to provide two-way, left-turn-lanes in all possible locations. Usually it would be a right-of-way or economic constraint that would limit its use. Occasionally, for business or political reasons we are unable to remove parking on the street, which is usually a requirement.

MEDIAN SELECTION GUIDELINES

PART A: Utah Criteria

M E D I A N S

In order to promote the safe and efficient movement of traffic, it shall be the policy of the Utah State Road Commission to divide all multi-lane arterial highways through the use of a dividing section or distinctive roadway markings as prescribed in the provisions of Section 41-6-63 and 41-6-63.10, Utah Code Annotated, as amended by the State Road Commission resolution of February 13, 1970.

The design shall be based on a consideration of travel speeds, turning movements, pedestrians, accident rates and the traffic volume-capacity relationships. The basic intent will be to establish the least restrictive condition consistent with these factors.

A median barrier (New Jersey type, double-backed guardrail, etc.) may be considered if the following conditions exist:

1. The current ADT exceeds 25,000.
2. The accident history reveals a high incidence of cross-median accidents.
3. The speed limit exceeds 40 mph.

Unless traffic engineering studies indicate the need for a median barrier, a painted median or permissive two-way left-turn lane shall be the standard installation. Curbed medians may be installed for other reasons such as to contain plantings, traffic signals, etc.

The following policy shall govern the location of openings in either painted or curbed medians:

1. Openings at Intersections

   Median openings shall be established to provide access to improved public streets at a spacing which provides for adequate left-turn (U-turn) storage lanes. The spacing shall not be less than 330 feet.

Revised March 7, 1973

NUMBER 08-25
PAGE 1 of 2
EFFECTIVE DATE Feb 23, 1973

2. Openings Between Intersections

Median openings between intersections may be established fo. public safety and convenience if indicated by an appropriate engineering study, provided that:

a. In an urban area the opening is not closer than 660 feet to an intersection with an improved public street or another median opening.

b. In a rural area the median opening is not less than 1320 feet from an intersection with an improved public road or another median opening.

3. Other Openings

Median openings may be established for business generating relatively high traffic volumes, provided that:

a. The minimum left-turn traffic volume is 500 vehicles per day or 100 vehicles during the peak hour in urban areas where the major street speed limit is less than 40 mph.

b. The minimum left-turn traffic volume is 350 vehicles per day or 70 vehicles during the peak hour in (1) urban areas where the major street speed limit is 40 mph or greater, (2) isolated communities having a population less than 10,000, and (3) rural areas.

c. The distance to the nearest adjacent median opening is not less than 330 feet.

For the purpose of this policy, an urban area exists where property abutting the highway is 50 percent developed and improved for a minimum length of one-half mile on either side of the roadway and a regular pattern of side streets has been dedicated and improved for public usage. A rural area is a location not classified as urban.

All median openings shall be designed to include median storage lanes for both directions of travel. The length of storage lanes shall be determined from appropriate traffic data but shall not be less than 100 feet. The length of taper shall be determined from the design speed of the roadway.

Where practicable, subdividers of abutting lands should provide parallel frontage roads to minimize the necessity for median openings.

Revised March 7, 1973

(2) Two-Way Left-Turn Lanes.

(a) General. A two-way left-turn is a lane reserved in the center of a street or highway for exclusive use of left-turn vehicles and shall not be used for passing or overtaking or travel by a driver except to make a left turn. The lane may be used by drivers making the left turn in either direction.

When a roadway section has an accident pattern caused by vehicle operators turning left across a centerline stripe, and there is no reasonable alternate means for the circulation of traffic, or when such turning movements impede the free flow of traffic on the through lanes so that it decreases the capacity of the highway, a field operational traffic analysis shall be made to determine the most feasible corrective measures. Consideration may then be given to the installation of two-way left-turn lanes.

Pavement markings, signs and other traffic control devices for two-way left-turn lanes shall be funded in accordance with RCW 47.24.020.

(b) Design Guides. The following factors shall be considered as support criteria for two-way left-turn lanes:

- The lack of a reasonable alternate circulation of traffic.
- Multiple points of access justifying continuous left-turn capability.
- Approximate existing volumes on thru-way:

Multi-lane:	Maximum ADT 25,000;
	Minimum ADT 10,000
Two-lane:	Maximum ADT 12,500;
	Minimum ADT 5,000.

- Speed Limit: Not to exceed 50 mph.
- An accident study showing that accidents are of types subject to a significant reduction by the proposed installation.

(c) Design Criteria.

- Width of left-turn lane:

Minimum:	10 Feet.
Desirable:	15 Feet.

- Pavement marking, signs, and other traffic control devices, shall be in accordance with Figure 3-24.08(2).

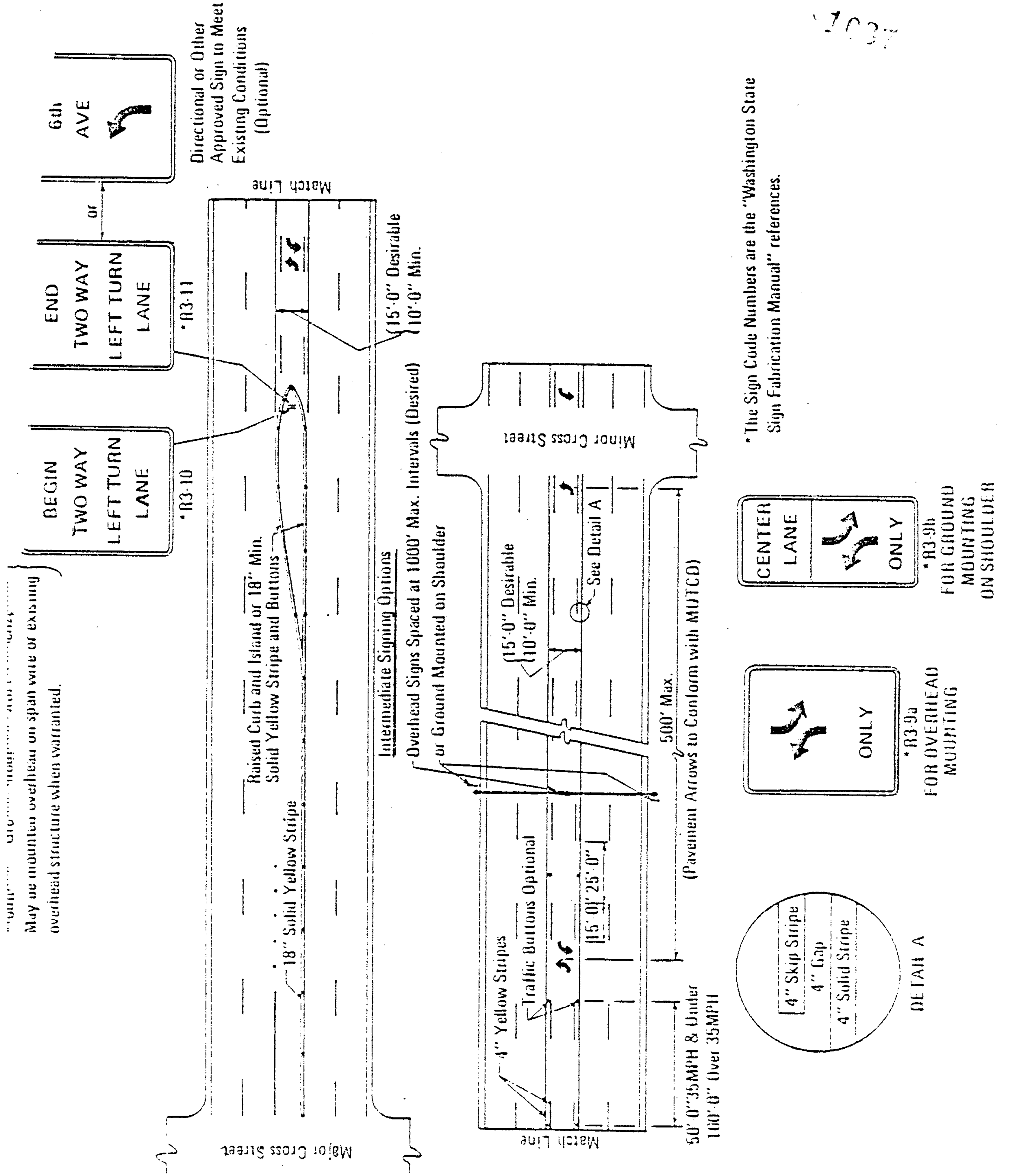
The signing for a two-way left-turn lane must be developed recognizing the advantages and desirability of uniformity. The installation of overhead signs (generally span wire mounted) shall be considered recognizing that pavement markings are obliterated by wear, especially in late winter and early spring, that they are difficult to see during wet weather, especially at night, and that they can be covered by snow. Such consideration is especially important on higher volume, high speed facilities and those likely to be traveled by large numbers of drivers unfamiliar with the area. In areas where overall roadway aesthetics is a special issue, particular attention must be given to the design of traffic control features. Proposed ground-mounted signing in lieu of overhead signing should be accompanied by a documentary explaining the desirability and justification for ground-mounted signs.

The desirable length of a two-way lane shall be not less than 250 ft. Pavement arrow spacing shall be 500 ft. maximum in interval, with a minimum of two sets in any one section. Two-way left turn lanes are illuminated.

- Major cross street, as shown in Figure 3-23.05(2), is defined as (1) a cross street at which there is an existing traffic signal, (2) a cross street occurring at an intersection having traffic volumes which, for any four hours of an average day, satisfy the minimum vehicular volume warrants for a traffic signal or, (3) a state highway route crossing another state route.

(d) Procedure. The District Engineer is responsible for the selection of locations, development of plans, and a discussion of the problem and the reasoning for the proposed solution. This material is to be submitted to the Headquarter's Location-Design Branch for coordinated approval with the Traffic Division.

TWO WAY LEFT TURN LANE



APPENDIX F

CHARACTERISTICS OF STUDY SITES

Project Number	Route	Jurisdiction	Termini	Length (Miles)	Median Type	Area Type	1977 ADT	Pedestrian Volume	Speed Limit	Street Illumination	On-Street Parking	Curb & Gutter
1	11	Abingdon	From: Palmer St. To: Holston St.	0.41	(Two-way) Traversable	Comm.	9840	Light	35	Yes	No	Yes
2	11/421	Bristol	From: Tenn.State Line To: Vance St.	0.54	(Grass) Raised	Comm.	15820	Light	35	Yes	Yes	Yes
3	Bob Morrison Blvd.	Bristol	From: State St. To: Euclid Ave.	0.46	(Grass) Raised	Comm.	5460	Light	35	Yes	No	Yes
4	Commonwealth Avenue	Bristol	From: Euclid Ave. To: Spurgeon Ln.	0.42	(Grass) Raised	Comm.	18660	Light	35	Yes	Yes	Yes
5	419	Salem	From: Salem City Lts. To: Route 221	3.22	(Grass) Raised	Comm. Res.	22880	Moderate	45	No	No	No
6	460	Salem	From: W. 4th St. To: Route 112	1.31	Undivided	Comm.	18656	Light	25-35	Yes	No	No
7	220	Roanoke	From: McClanahan St. To: Avenham Rd.	1.24	(Two-way) Traversable	Comm.	31810	Light	35	Yes	No	Yes
8	11	Roanoke	From: Orange Ave. To: Hershberger Rd.	2.75	Undivided	Comm.	19048	Light	30	Yes	No	Yes
9	58	Galax	From: Caldwells Rd. To: Country Club Ln.	0.67	(Two-way) Traversable	Comm.	9860	Light	35	No	No	Yes
10	460 Bus.	Blacksburg	From: N. Giles Rd. To: Faculty St.	1.57	Undivided	Comm. Res.	10254	Light	35-45	Yes	No	Yes
11	220	Henry Co.	From: Rt. 1141 To: Rt. 796	2.27	(Two-way) Traversable	Comm.	17685	Moderate	35	No	No	Yes
12	29	Amherst Co.	From: Rt. 29 Bus. To: Rt. 130	2.58	(Grass) Raised	Comm. Res.	24770	Moderate	45	No	No	Yes
13	29 Bus.	Lynchburg	From: Fort Ave. To: Edgewood Ave.	0.32	(Alternating) Traversable	Comm.	19020	Light	35	Yes	No	Yes
14	15-460	Farmville	From: Buffalo St. To: N.W. R.R. Overpass	1.15	(Two-way) Traversable	Comm.	11640	Moderate	40	Partial	No	Yes
15	15-460	Farmville	From: Appomattox St. To: A St.	0.95	Undivided	Comm.	9126	Heavy	25-35	Yes	No	Yes

Project Number	Route	Jurisdiction	Termini	Length (Miles)	Median Type	Area Type	1977 ADT	Pedestrian Volume	Speed Limit	Street Illumination	On-Street Parking	Curb & Gutter
16	1	Henrico Co.	From: Cole Blvd. To: Mountain Rd.	0.92	Undivided	Comm. Res.	15965	Light	45-55	No	No	No
17	6	Henrico Co.	From: W. City Lts. of Richmond To: Mayberry Rd.	2.81	(Concrete) Raised	Comm. Res.	19790	Light	35-55	No	No	No
18	33	Henrico Co.	From: Beauregard Ave. To: Kenway Ave.	1.86	Undivided	Comm.	20195	Light	45	No	No	No
19	147	Chesterfield Co.	From: Rt. 1989-Dolfield Rd. To: Rt. 1728- Jimmy Winters Rd.	1.49	(Grass) Raised	Res.	25040	Light	45	No	No	No
20	147	Chesterfield Co.	From: Rt. 1728-Jimmy Winters Rd. To: Chippenham Pkwy.	1.23	(Alternating) Traversable	Comm. Res.	25040	Light	45	No	No	No
21	161	Richmond	From: Entrance-Circle Shopping Center To: Old Midlothian Pk.	0.70	Traversable	Comm.	22870	Light	35	No	No	No
22	Forrest Hill Ave.	Richmond	From: Leicester Rd. To: Fairlee Rd.	0.69	Undivided	Res.	17952	Light	40	No	No	No
23	1	Colonial Heights	From: Washington St. To: Temple St.	1.37	Undivided	Comm.	21072	Light	30-40	Yes	Yes	Yes
24	301	Petersburg	From: Washington St. To: N.W. R.R. Cross.	2.43	(Concrete) Raised	Comm. Res.	20965	Light	35	Yes	No	Yes
25	337	Portsmouth	From: Airline Blvd. To: Melvin Dr.	2.29	(Grass) Raised	Comm. Res.	16449	Light	35	Yes	No	Yes
26	190	Va. Beach	From: Providence Rd. To: Bonney Rd.	1.16	(Grass) Raised	Comm. Res.	15746	Heavy	35	Partial	No	Yes
27	Providence Rd.	Va. Beach	From: Rt. 13-Military Highway To: Rt. 190-Kempsville Rd.	3.03	(Grass) Raised	Comm. Res.	15540	Light	40-45	Partial	No	Yes
28	165	Va. Beach	From: Edwin Dr. To: S. Parliment Rd.	1.68	(Grass) Raised	Comm. Res.	18145	Light	35-45	Yes	No	Yes
29	460	Norfolk	From: Market St. To: 21st St.	1.29	(Two-way) Traversable	Comm.	15263	Moderate	30	Yes	No	Yes
30	165	Norfolk	From: Robin Hd. Rd. To: Norview Rd.	0.93	(Two-way) Traversable	Comm.	25002	Light	45	Yes	No	No
31	168	Norfolk	From: Willowood Dr. To: Shoop Ave.	1.10	(Two-way) Traversable	Comm. Res.	29720	Light	25-35	Yes	No	Yes

Project Number	Route	Jurisdiction	Termini	Length (Miles)	Median Type	Area Type	1977 ADT	Pedestrian Volume	Speed Limit	Street Illumination	On-Street Parking	Curb & Gutter
32	60	Williamsburg	From: Rt. 132 To: Northern City Limits	0.63	(Two-way) Traversable	Comm.	27040	Moderate	35	Yes	No	Yes
33	31	Williamsburg	From: Rolff Rd. To: John Tyler Hwy.	0.73	Undivided	Res.	10940	Light	35	Yes	One side only	Yes
34	1	Spotsylvania Co.	From: Frontage Rd. Entrance beside Holiday Inn To: Beginning of Divided Hwy.	0.50	Undivided	Comm.	12680	Moderate	45	No	No	No
35	360	Tappahannock	From: Queen St. To: East End of Hoskins Creek Bridge	0.78	Undivided	Comm.	11865	Heavy	25-35	Yes	No	Yes
36	29 Bus.	Char'ville	From: Massie Rd. To: Earhart St.	0.95	(Grass) Raised	Comm.	25184	Light	40	Yes	No	Yes
37	236	Fairfax	From: Rt. 123-West St. To: Rt. 29/211	0.96	(Grass) Raised	Comm. Res.	25680	Moderate	30&35	Yes	No	Yes
38	650	Fairfax Co.	From: Rt. 29/211 To: Rt. 50	0.61	(Two-way) Traversable	Comm.	18552	Moderate	35	No	No	Yes
39	613	Fairfax Co.	From: Rt. 395 Exit Ramp To: Franconia Rd.	0.67	Undivided	Res.	17344	Light	35	Yes	Yes	Yes
40	29/211	Falls Church	From: W. City Limits of Falls Church To: W. Greenway Blvd.	0.41	(Grass) Raised	Comm. Res.	21850	Heavy	30	Yes	No	Yes
41	29/211	Falls Church	From: Greenway Blvd. To: Cavalier Trail	0.17	(Two-way) Traversable	Comm.	21850	Heavy	30	Yes	No	Yes
42	7	Falls Church	From: Rt. 29/211 To: Gordon St.	1.28	Undivided	Comm.	27755	Heavy	25	Yes	No	Yes
43	123	Vienna	From: Rt. 7 To: Westbriar Dr.	0.96	(Grass) Raised	Comm. Res.	30465	Light	40&45	Yes	No	Yes
44	123	Vienna	From: East St. To: Pleasant St.	1.07	(Two-way) Traversable	Comm.	31941	Moderate	30	Yes	No	Yes
45	Braddock Rd.	Alexandria	From: N. Howard St. To: Quaker Lane	0.86	(Grass) Raised	Comm. Res.	14668	Heavy	35	Yes	No	Yes
46	1	Alexandria	From: 15th St. To: Glebe Rd.	1.21	Undivided	Comm.	31050	Moderate	35	Yes	No	Yes

Project Number	Route	Jurisdiction	Termini	Length (Miles)	Median Type	Area Type	1977 ADT	Pedestrian Volume	Speed Limit	Street Illumination	On-Street Parking	Curb & Gutter
47	29/211	Warrenton	From: Rt. 17 To: Rt. 211/29	0.87	(Continuous One-way) Traversable	Comm.	30810	Moderate	40	Partial	No	Yes
48	42	Rockingham Co.	From: S. City Limits of Harrisonburg To: Route 910	0.87	(Grass) Raised	Comm. Res.	10690	Light	45-55	No	No	Yes
49	250	Staunton	From: Entrance - Olivet Presby-terian Church To: Harner Wheels Inc.	1.10	(Grass) Raised	Comm. Res.	16962	Light	40	Yes	No	Yes
50	250	Waynesboro	From: North Wayne To: Rt. 254-Poplar St.	0.51	(Alternating) Traversable	Comm.	16860	Moderate	35	Yes	No	Yes

APPENDIX G

AVERAGE ANNUAL ACCIDENTS — FOR 1975-1977

Project Number	Median Type	No. of Accidents	No. Fatal Accidents	Number Killed	No. Injury Accidents	No. Injured	No. Property Damage Accidents	Amt. of Damage
1	Two-way Traversable	2.5	0.00	0.00	1.00	1.50	1.50	$ 3,100
2	Raised Grass	21.0						
3	Raised Grass	7.5	0.00	0.00	0.00	0.00	7.50	5,340
4	Raised Grass	9.7	0.00	0.00	2.67	3.33	5.33	7,840
5	Raised Grass	48.0	0.33	0.33	11.00	17.67	36.70	43,300
6	Undivided	103.7	0.00	0.00	17.00	26.00	86.70	64,400
7	Two-way Traversable	53.0	0.00	0.00	5.00	8.50	48.00	29,800
8	Undivided	196.5	0.00	0.00	22.00	28.00	174.50	120,000
9	Two-way Traversable	7.7	0.00	0.00	.70	1.00	7.00	3,661
10	Undivided	41.3			10.70	16.30	30.70	25,800
11	Two-way Traversable	89.7	0.67	0.67	20.00	29.00	69.00	102,000
12	Raised Grass	114.0	0.67	0.67	26.30	37.70	87.00	85,600
13	Alternating Traversable	7.0	0.00	0.00	0.00	0.00	7.00	3,290
14	Two-way Traversable	5.0	0.00	0.00	1.67	1.67	3.33	4,970
15	Undivided	29.7	0.00	0.00	8.00	10.70	21.70	19,350
16	Undivided	12.0	0.33	0.33	5.33	8.00	6.33	12,200
17	Raised Raised Concrete	81.3	0.00	0.00	24.30	38.00	57.00	62,400

Project Number	Median Type	No. of Accidents	No. Fatal Accidents	Number Killed	No. Injury Accidents	No. Injured	No. Property Damage Accidents	Amt. of Damage
18	Undivided	60.0	1.00	1.00	20.30	38.30	38.70	$ 54,500
19	Raised Grass	12.0	0.30	0.30	4.00	5.00	7.70	15,650
20	Alternating Traversable	10.7	0.00	0.00	2.70	3.70	8.00	13,800
21	Two-way Traversable	19.3	0.00	0.00	6.00		13.30	
22	Undivided	10.0	0.30	0.30	4.00	6.30	5.70	10,100
23	Undivided	82.7	0.00	0.00	28.00	43.00	53.00	47,650
24	Raised Concrete	68.7	0.30	0.30	20.30	26.30	48.00	56,700
25	Raised Grass	79.5	0.00	0.00	23.50	32.50	56.00	71,100
26	Raised Grass	39.4	0.00	0.00	4.00	6.00	19.00	9,520
27	Raised Grass	60.0	0.00*	0.00*	6.00*	9.00*	29.00*	20,474*
28	Raised Grass	47.5	0.00	0.00	5.50	6.50	42.00	24,800
29	Two-way Traversable	117.5	0.00	0.00	13.50	28.00	104.00	66,000
30	Two-way Traversable	85.5	0.00	0.00	11.50	14.50	74.00	55,600
31	Two-way Traversable	104.5	0.00	0.00	17.00	19.00	87.50	70,400
32	Two-way Traversable	23.0						
33	Undivided	2.0						
34	Undivided	22.7	0.30	0.30	6.00	11.30	16.30	20,100

*Based on seven months of accident data — January through July.

Project Number	Median Type	No. of Accidents	No. Fatal Accidents	Number Killed	No. Injury Accidents	No. Injured	No. Property Damage Accidents	Amt. of Damage
35	Undivided	34.0	0.00	0.00	7.70	10.30	26.30	$29,500
36	Raised Grass	60.5	0.00	0.00	11.50	16.50	49.00	
37	Raised Grass	71.0	0.00	0.00	10.10	14.00	60.01	44,200
38	Two-way Traversable	55.7	0.00	0.00	9.30	10.30	46.30	36,500
39	Undivided	18.3	0.30	0.30	4.00	4.70	14.00	13,800
40	Raised Grass	11.3	0.00	0.00	3.00	3.70	8.30	9,320
41	Two-way Traversable	11.5	0.00	0.00	1.00	1.00	10.50	11,300
42	Undivided	86.0	2.00	2.00	20.00	35.00	64.00	61,000
43	Raised Grass	27.3	0.00	0.00	8.00	12.00	19.30	25,600
44	Two-way Traversable	91.0	0.50	0.50	20.00	23.00	70.50	68,900
45	Raised Grass	17.0	0.00	0.00	3.50	4.00	13.50	10,350
46	Undivided	81.0	0.00	0.00	23.30	29.30	57.70	67,500
47	One-way Traversable	53.0	0.00	0.00	11.30	14.70	41.70	40,550
48	Raised Grass	5.7	0.70	1.00	0.70	3.30	3.30	6,080
49	Raised Grass	14.0	0.30	0.30	3.30	4.00	10.30	7,800
50	Alternating Traversable	22.0	0.00	0.00	5.00	8.70	17.00	14,500