TRANSPORTATION RESEARCH CIRCULAR

Number 296, December 1985
ISSN 0097-8515

Transportation Research Board, National Research Council, 2101 Constitution Avenue, N.W., Washington, D.C. 20418

RESEARCH PROBLEM STATEMENTS: Operational Effects of Geometrics

modes
1 highway transportation

subject areas
21 facilities design
54 operations and traffic control

OPERATION AND MAINTENANCE OF TRANSPORTATION FACILITIES

Donald E. Orne, Chairman
Group 3 Council
Michigan Department of Transportation, Lansing, Michigan

COMMITTEE ON OPERATIONAL EFFECTS OF GEOMETRICS
(As of June 30, 1984)

Sheldon Schumacher, Chairman
Schumacher and Bowman, Inc
Chicago, Illinois

Myung-Soon Chang
Julie Anna Cirillo
George A. Dale
Ronald W. Eck
Daniel B. Fambro
Jerome W. Hall
Douglas W. Harwood
Robert P. Morris
Timothy R. Neuman
Ronald C. Pfefer
Abishai Polus
Ramey O. Rogness
James J. Schuster
Rudolph K. Shearin, Jr.
Bob L. Smith
Daniel S. Turner
Stephen Van Winkle
Clinton A. Venable
Walter E. Witt

David K. Witheford, Transportation Research Board Staff

INTRODUCTION

The Committee on Operational Effects of Geometrics (A3A08) considers the development and review of research statements to be among its most important tasks. Ever increasing demands on limited highway construction resources dictate a concern for operational and safety research. Such research can lead to operational guidelines or changes in design policy that can significantly improve utilization of the highway system at little additional cost.

The importance of continuing research is reflected in the procedures adopted by Committee A3A08. Each year, committee members submit research statements for consideration by the entire committee. A winnowing process is applied, in which some statements are referred to other TRB committees, and others of a similar nature are consolidated into one statement. Committee members then carefully review all statements, and select those most appropriate or timely. A committee decision is then made to publish certain or all research statements.

The purpose of reviewing and publishing research statements contains an inherent conflict that the committee must deal with each year. There are always many research problems believed worthy of publication and consideration by the research community. However, the committee also sees its role as providing advice and direction to researchers in terms of priorities. As the 1985 review process indicated, certain research statements were clearly identified by a consensus of the committee as being of the greatest priority. Other statements, no less valid technically, were considered of less immediate importance to the research community.

After much debate, the committee chose to publish all worthy statements, but to clearly indicate the relative priority of each. The following nine statements are listed in order of priority. The first three were clearly identified as important, timely research problems requiring attention. The second three statements were also considered important problems, although by fewer committee members. The research community is urged to address these six statements, and in particular, the first three.

The final three statements are published in an abbreviated format. While considered valid research problems, it was the consensus of the committee that these three statements were of lower priority. Researchers interested in these statements can contact the Committee chairman or author of this circular for further details.

RESEARCH PROBLEM STATEMENTS

Problem No 1

TITLE: INFLUENCE OF APPROACH GEOMETRL ON EFFECTIVENESS OF COUNTERMEASURES AT HIGH-SPEED SIGNALIZED INTERSECTIONS.

STATEMENT OF PROBLEM: Introduction of signalization on high-speed highways (posted speeds greater than or equal to 45 mph) creates the potential for a significant increase in traffic accidents. Two common problems at such locations are the creation of a dilemma zone and the existence of geometrics such that the signal is not expected or that the display cannot be seen in time. Different solutions to these problems, ranging from improved detectorization to various types of signs and flashers (such as the "Prepare to Stop When Flashing" device) have been employed. While the availability of solutions has reduced some of the problems, accidents at high-speed signalized approaches continue to be a persistent problem nationwide. A recent survey of over 100 practicing engineers indicated that there is no discernible consistency in the countermeasures used nor have there been any published comprehensive evaluations of such countermeasures. For example, one agency might rate a particular countermeasure as effective in a given situation while another agency might experience unsatisfactory results under slightly different circumstances. Some states reported left turn movements as being a problem while others did not. It is apparent that intersection geometry has at least some effect on counter-measure effectiveness but the nature of the relationship is not fully understood. To provide guidance to traffic engineers who face decisions about countermeasures at high-speed signalized intersections, there is a need for an evaluation of the influence of approach geometry on intersection operation and countermeasure effectiveness.

OBJECTIVES: Objectives of this research would be to: (1) correlate accident data from high-speed signalized intersections with approach geometry, (2) supplement this field effort with a laboratory investigation using a driving simulator and (3) develop warrants or guidelines for the use of various active warning devices under different geometric configurations.

KEY WORDS: Accidents, Advance Warning Signs, Driver Behavior, Geometric Design, Signalized Intersections, Traffic Operations.

RELATED WORK:

1. Baker, R.L., Clouse, D. and Karr, D., "Evaluation of the Prepare to Stop When Flashing Sign," Ohio Department of Transportation, Columbus, February 21, 1980, 7 pages.

2. Ozanne, J.T., "Effectiveness Warning for the Hidden Traffic Signal and Eliminating the Dilemma Zone," Compendium of Technical Papers, Institute of Transportation Engineers, 49th Annual Meeting, Toronto, Canada, 1979, pp. 44-51.

3. Radwan, A.E., Sinha, K.C., and Michael, H.L., "Guidelines for Traffic Control of Isolated Intersections on High-Speed Rural Highways," Transportation Research Record 737, 1979, pp. 10-17.

4. Radwan, A.E., Sinha, K.C., "Countermeasures to Improve Safety of Multi-lane Rural Intersections," Transportation Research Record 773 1980, pp. 14-18.

5. Styles, W.J., Evaluation of the Flashing Red Signal Ahead Sign, Bureau of Traffic Projects, Maryland Department of Transportation, Baltimore, MD, June 1982.

6. Styles, W.J., Evaluation of the Flashing Red Strobe Signal, Bureau of Traffic Projects, Maryland Department of Transportation, Baltimore, MD, June 1982.

7. Zegeer, C.V., Effectiveness of Green-Extension System at High-Speed Intersections, Kentucky DOT, Lexington, KY, May 1977, 31 pp.

URGENCY/PRIORITY: This information should be acquired in the very near future to determine objectively the specific conditions under which particular countermeasures should be used. Significant cost savings would be expected due to the high cost (tens of thousands of dollars) of retrofitting an intersection where an inappropriate device has been installed.

COST: $200,000

USER COMMUNITY: Primarily state (and secondarily county and local) engineers responsible for installation and maintenance of traffic signals at high-speed signalized intersections.

IMPLEMENTATION: The warrants or guidelines developed as a result of this research would be immediately useful to highway agencies in decision-making relative to installation and maintenance of traffic control devices.

EFFECTIVENESS: Research results will be useful in enhancing safety at high-speed signalized intersections while maximizing benefits from available funds. There should be decreased potential for liability or lawsuits arising from highway accidents

Problem No. 2

TITLE: GUIDELINES FOR DESIGN OF RURAL INTERSECTIONS.

STATEMENT OF PROBLEM: Ongoing research confirms a wide range of nationwide practices in design of intersections of high-speed, rural highways. This diversity is partially due to differences of opinion as to what constitutes "safe" operations. For example, some states do not provide acceleration lanes at two-way stop-controlled intersections, so as not to encourage acceptance of too-short gaps. In other states, acceleration lanes or tapers are extensively used.

A rational set of operational and safety guidelines are clearly needed. The following specific issues require study:

- Warrants for left-turn lanes
- Warrants for right-turn lanes
- Guidelines for design of right-turn channelization (traffic islands, corner radii)
- Warrants and design guidelines for design of acceleration lanes and tapers
- Design guidelines for left-turn lanes in wide medians
- Guidelines for design of approaches to stop controlled intersections.

The problem entails establishment of desirable operating characteristics and acceptable safety characteristics; and translation of these characteristics to cost-effective design guidelines. Factors affecting development of the guidelines 7ould include traffic volume, vehicle mix, cross section, functional classifications, traffic control, and approach geometry.

OBJECTIVES: (1) To establish operational and safety criteria for evaluation of rural intersections, and (2) to translate those criteria into cost-effective guidelines for design of rural intersections.

KEY WORDS: Intersections, Geometric Design, Accidents, Traffic Operations.

RELATED WORK:

1. "Volume Warrants for Left-turn Lanes at Unsignaled Grade Intersections," Harmelink, M.D., Ontario Department of Highways, 1968.

2. "Intersection Channelization," NCHRP Research Project 3-30 (In Progress).

3. AASHTO Design Policies

URGENCY/PRIORITY: Very High

COST: $200,000

USER COMMUNITY: AASHTO

IMPLEMENTATION: The research would be directly applicable to new design and reconstruction of rural highways. The guidelines would augment AASHTO policy and individual state policies and standards.

EFFECTIVENESS: As intersection operations and safety are particularly important on rural highways, successful completion and implementation of this research would result in measurable benefits.

Problem No. 3

TITLE: GEOMETRIC DESIGN CONSISTENCY FOR RANGE OF VEHICLE TYPES.

STATEMENT OF PROBLEM: The occurrence of varying vehicle mix and change in vehicle characteristics have caused concern with respect to specific design elements (sight distance and curve design). Considering the different types of vehicles presently or projected to be on the road, there is a need for the roadway to accommodate these vehicles safety. While historically, design speed has been the principal criterion (along with terrain, superelevation, traffic volumes and roadway classification) in selecting design element values, the presence of different vehicle types on the roadway may mean that the design criteria will not adequately consider particular vehicles. Although specific vehicle types are considered in determination of design standards of a roadway, it is on a piecewise basis.

For the long term, there is a need to consider the design criteria, elements and standards as a total system and determine if there are any problems for particular vehicle types with the set of current design standards. While considering the roadway-driver-vehicle-environment as a design system, the range of vehicles should specifically be addressed to ascertain that a design vehicle adequately represents the range of vehicle characteristics that could be present on the roadway.

OBJECTIVE: To determine if any geometric design consistency problems occur considering various vehicle types in terms of operations or safety.

KEY WORDS: Design Consistency, Design Criteria, Design Standards, Vehicle Characteristics, Geometric Design.

RELATED WORK: Large Truck Studies

URGENCY/PRIORITY: Highest priority because of the wider range of vehicle types and characteristics occurring.

COST: $150,000 DURATION: 18 months

USER COMMUNITY: FHWA, AASHTO

IMPLEMENTATION: Workshop, guidelines, and input to Green Book revisions.

EFFECTIVENESS: High in terms of determination whether existing design standards as a system satisfy particular vehicle types. Moderate in terms of major implementation in geometric design.

Problem No. 4

TITLE: SELECTION OF DESIGN VEHICLE FOR GEOMETRIC DESIGN OF AT-GRADE INTERSECTIONS.

PROBLEM STATEMENT: Many geometric design elements for at-grade intersections require the selection of a design vehicle. These include corner sight distance, curb radii, turning roadways and median openings. AASHTO provides the detailed criteria for the design of each element for several design vehicles. However, little guidance is provided for selecting the design vehicle. The selection is especially important at intersections where truck volumes are significant.

RESEARCH OBJECTIVES: The objective of this research would be to develop a methodology or a set of guidelines to assist the designer in selecting a design vehicle. The methodology for at-grade intersections should reflect:

- Traffic volumes for various design vehicles
- Through and turning volumes
- Design speed
- Accident history
- Allowable encroachment on adjacent lanes
- One-way or two-way operation
- Urban/rural location, and
- Construction cost

KEY WORDS: Design Vehicle, Intersections, Corner Sight Distance, Curb Radii, Turning Roadways, Median Openings.

RELATED WORK:

1. A Policy on Geometric Design of Highways and Streets, AASHTO, 1984.
2. NCHRP 93, Guidelines for Medial and Marginal Access Control on Major Highways.

URGENCY/PRIORITY: This research could provide valuable information to the design engineer for a rational, cost-effective design for at-grade intersections. With a ten to twenty year design life, the cumulative benefits of designing an intersection which is commensurate with the traffic conditions would be significant.

COST: Estimated Cost: $100,000

USER COMMUNITY: Highway agencies at the federal, state and local level.

IMPLEMENTATION: The results of this research could be distributed through articles in professional publications, through an NCHRP Report, or by federal and state internal circulation procedures.

FFECTIVENESS: Implementing this project should lead to better designs of at-grade intersections. The designer will be able to select a design vehicle for geometric design which will yield a cost-effective balance among safety, operational and cost considerations.

Problem No. 5

TITLE: THE USE OF SHOULDERS AS CONTINUOUS TURNOUTS ON RURAL TWO-LANE HIGHWAYS.

PROBLEM STATEMENT: The operational and safety problems on rural two-lane highways are likely to become worse as the disparity of vehicle performance among passenger cars, overloaded automobiles, recreational vehicles, and heavy trucks grows. Further, the prevalent terrain and opposing volumes are not favorable to frequent passing. Some western states legally require a slow moving vehicle to use turnouts if one or more following vehicles are impeded. The shoulders with adequate width can be considered as continuous turnouts. However, it is not known what benefits, costs, and requirements are expected for legalization of shoulders as continuous turnouts on rural two-lane highways.

OBJECTIVE: The study objective is (1) to evaluate the feasibility of shoulders as continuous turnouts, (2) to analyze the benefits, costs, and requirements for legalization of shoulders as continuous turnouts, and (3) to provide guidelines on when, where, and how shoulders can be used as continuous turnouts.

KEY WORDS: Turnouts, Shoulders.

RELATED WORK: NCHRP Synthesis 63(1) reported that 15 states allow the use of shoulders for slow moving vehicles at all times or under certain conditions. The use of turnouts and their operational characteristics along with the geometric elements and traffic control devices are reported (2,3).

1. Design and Use of Highway Shoulders, NCHRP-Synthesis of Highway Practice 63, 1979.

2. Rooney, F., Turnouts: Traffic Operational Report No. 1 and 2, Office of Traffic, California DOT, 1976.

3. Theoretical Analysis: Slow Moving Vehicle Turnouts, Traffic Engineering, Oregon DOT, 1978.

URGENCY/PRIORITY: Maximization of shoulder use in rural two-lane highways is needed to improve traffic operations and safety.

COST: $150,000 over an 18-month period.

USER COMMUNITY: Agencies and personnels responsible for operational and safety improvements on rural two-lane highways.

IMPLEMENTATION: The results of this research will be helpful to legal and transportation agencies in states to manage rural two-lane highways.

EFFECTIVENESS: The study will be most effective in providing the information to maximize potential shoulder use on rural-two lane highways.

Problem No. 6

TITLE: DETERMINATION OF THE OPERATIONAL AND SAFETY BENEFITS OF SPIRAL TRANSITIONS.

PROBLEM STATEMENT: The procedure for geometric design of the spiral transition between tangent and horizontal curve sections of highways has been available since the 1940's; however, there has been reluctance to use the spiral transition by highway design engineers. To date, the major reason given for not deploying the spiral is, "the benefits of spirals have not been demonstrated to justify the extra expense of building a spiral."

The benefits of a spiral transition, as opposed to the multi-centered curve transition and "no transition" designs, are that it exhibits the best operation characteristics:

1. Analytically, the spiral transition causes the least driver perturbation (the driver maintains the best steering control).

2. Comparison of vehicle paths observed in transitions from tangents into horizontal curves show that the smoothest path can be maintained in spirals.

These findings are from the research report, Evaluation of Horizontal Curves, FHWA-RD-79-48. These findings are supported by findings of a recent research study, "Safety and Operational Considerations for Design of Rural Highway Curves," to be published by FHWA.

OBJECTIVE: The objective of this study is to determine the effect of spirals upon: (1) operations, i.e., traffic volume and vehicle trajectory to include erratic maneuvers, lateral placement, and speed, and (2) safety, i.e., the frequence and severity of accidents.

The spirals at both the beginning and end of horizontal curves should be included in this evaluation.

The operational and safety effects of spirals should be compared to similar parameters of other types, i.e., no transition and the compound curve transition. The costs of construction, maintenance, and accidents due of the various transitions must also be compared.

This research should be a combination of case and field observation studies of the three transition types to determine and compare:

1. The accident history (frequency, severity, and cost).
2. The cost history (design, construction and maintenance).
3. The vehicle path and speed maintenance on each transition.
4. The design procedure used and any problems encountered.

KEY WORDS: Geometric Design, Traffic, Operations, Highway Curves, Accidents.

COST: $200,000 over 24 months.

USER COMMUNITY: State Highway Agencies.

IMPLEMENTATION: Revisions to AASHTO Policies.

EFFECTIVENESS: The potential annual payoff for providing improved operations on curves has the potential for reducing the severity of only one percent of the curve accidents is $750 million. This assumes that one-third of the highway sections are curved.

ADDITIONAL RESEARCH STATEMENTS

TITLE: GEOMETRICS FOR LARGE TRUCKS AND SMALL CARS

PROBLEM STATEMENT: Highway designers must address the dilemma of providing for larger trucks, while the population of smaller cars continues to increase. There are undoubtedly conditions for which, because of the relative rarity of very large trucks, certain design elements can be developed for passenger cars. There is a need to analyze the range of vehicle mix on various types of roads and streets. Guidelines describing the range of geometrics and their application for various mixes would prove useful in making design decisions.

TITLE: HIGH VOLUME MERGES FOR LOW-PERFORMANCE CARS

PROBLEM STATEMENT: The increase in fuel-efficient, lower performance passenger cars creates a potential problem on high volume urban freeways. Acceleration to high-speed merges may be difficult for such vehicles on many current freeways. The extent of this problem should be indentified. If it is found to occur, geometric and other solutions should be identified.

TITLE: OPTIMUM SIDEWALK WIDTH

PROBLEM STATEMENT: In urban areas and in some rural areas where sidewalks are to be provided, there is increased joint use by pedestrian and bicyclists. Studies have been made to show optimum widths for bicycle paths. Studies have also been made relative to sidewalk widths. No research to date has identified adequate or optimum width for joint use.

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

ADDRESS CORRECTION REQUESTED

NON-PROFIT ORG.
U.S. POSTAGE
PAID
WASHINGTON, D.C.
PERMIT NO. 8970