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OPERATION AND MAINTENANCE OF TRANSPORTATION FACILITIES

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INTRODUCTION

Committee A3A08, Operational Effects of Geometrics, believes that identifying research needs and communicating them to the transportation research community is one of its major functions and activities. The publication of this circular is a continuation of this activity. The committee received twelve research problem statements for evaluation during 1988. The statements were reviewed and evaluated by the committee members. They were asked to evaluate each statement for perceived importance in terms of priority and for relative importance versus the other statements. The committee members also were asked to allocate a hypothetical limited research budget among the statements and to predict probability of success for each statement. They were also asked to summarize their rationale for each evaluation criteria. There were twelve committee members who fully participated in this process. The process used kept the responses anonymous and independent. A summary of the results was distributed to the entire committee for comments and guidance.

The results were then discussed at the committee's midyear meetings in Texas and the four lowest categorized statements were dropped because of the feeling that they were not fully developed enough to be included. The committee decided to publish the eight remaining problem statements and to include a category classification to indicate the relative importance of each statement.

The eight research problem statements are presented in order of priority average. The first four problem statements were classified into a high priority and considered important enough to need immediate attention. The next four statements were ranked slightly higher than a moderate priority and considered as being needed to be addressed. For the priority classification, the range was from urgent-high-moderate-low-to none.

For each criterion considered--priority, ranking, budget, and probability of success--the first four problem statements fell in the same general order as follows:

PROBLEM STATEMENTS IN THE HIGHEST PRIORITY

Evaluation of Intersection Sight Distance Criteria

PROBLEM: Intersection sight distance (ISD) is a critical highway safety element. It may be argued that, given the volume of traffic that passes through an intersection, the limits of the ISD criteria are tested far more frequently than, for example, the limits of stopping sight distance. Several studies have indicated that inadequate ISD is a significant contributing factor to accidents at intersections.

The Green Book presents the AASHTO ISD criteria on pages 774-800. This is a significant revision from the prior Blue Book criteria. The ISD model in the Green Book is based on the type of traffic control device at the intersection and, for the first time, presents criteria for left- and right-turning vehicles. However, the ISD criteria has been criticized by many State highway agencies as being unrealistic and/or being unrepresentative of actual highway operating characteristics. The following summarizes possible deficiencies with the Green Book ISD model:

1. The criteria for yield control (Case II, pages 780-789) are inconsistent with typical driver action at a yield control. Also, the Green Book does not discuss how to determine the leg of the sight triangle on the major road at yield intersections.
2. For stop-controlled intersections (Case III, pages 780-789), the assumed acceleration rates for passenger cars are based on studies reported in 1937. Several more recent studies have suggested that drivers today choose to accelerate from a stop at an intersection at a faster rate than assumed in the Green Book.
3. The Cases IIIB and IIIC criteria for turning vehicles does not consider trucks. It may be warranted to develop ISD criteria for trucks when their turning volume exceeds some threshold.
4. The assumptions of driver action on the major road within the model don't consider factors such as traffic volume, functional class, urban/rural or two-lane/multilane differences. These are important factors when determining what assumed driver action on the major road is reasonable.
5. The height of object for measurement of ISD is 4.25'. This assumes that a driver will see the roof of a car just when it just barely comes into view. It may be more appropriate to use a 3.5' or 3.75' height of object.
6. Page 782 establishes the location of the bumper of the stopped vehicle as 10' from the edge of travel lane (ETL). The Green Book should present criteria for the location of the driver eye, which may be 15-20' from the ETL. Also, it may be appropriate to lower this value for low-volume and/or low-speed roads. As another consideration, it may be appropriate to view ISD from an entirely different perspective -- driver gap acceptance. The ITE Handbook and 1985 Highway Capacity Manual have presented criteria for gap acceptance. It can be argued that drivers are, in effect, determining whether or not a given maneuver is safe. This data could then be used to develop the ISD criteria.

OBJECTIVE: The objectives of the research can be summarized as follows:

1. ISD Concept. Determine what basic approach should be used for the ISD model. This could be based

on driver gap acceptance; acceleration rates of stopped vehicles combined with an assumed action by the driver on the major road; or another conceptual approach.

2. Design Vehicles. Develop criteria for when to use which design vehicle.

3. ISD Elements. Identify the elements of the ISD model. These may include vehicle acceleration rates, perception/reaction time, deceleration rates of vehicle on major road, lane change criteria (for multilane highways) and tailgate distance between the turning and overtaking vehicles.

4. ISD Element Values. Select the most applicable numerical value for each ISD element and for each design vehicle. Also, identify where research may be needed to fill information gaps.

5. Application. Determine how the ISD model should be applied based on traffic volumes, functional classification, urban/rural location and two lane/multilane facilities.

6. ISD Measurement. Develop criteria for location of (stopped) driver eye and height of object.

KEY WORDS: Intersection sight distances, acceleration rates, deceleration rates, object height.

RELATED WORK:

1. A Policy on Geometric Design of Highways and Streets, AASHTO, 1984.

2. NCHRP 270, Parameters Affecting Stopping Sight Distance, (Appendix F), TRB, June 1984.

3. Special Report 209, Highway Capacity Manual, TRB, 1985.

4. Transportation and Traffic Engineering Handbook, ITE, 1982.

URGENCY/PRIORITY: This research could provide valuable information to a design engineer for a rational evaluation of intersection sight distance. Considering the large number of times that the limits of the ISD criteria are tested, this research should have a high priority.

PRIORITY RATING: High

COST: $300,000

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

IMPLEMENTATION: The results of this research could be disseminated through a NCHRP Report, publications, or by federal and state circulation procedures.

EFFECTIVENESS: Implementing this project should lead to more cost effective, supportable decisions on how to provide ISD at intersections.

Compatability of Design and Posted Speeds

PROBLEM: For several reasons, a designer may select a design speed that will later turn out not to be the speed a traffic engineer will find appropriate to post on the basis of a study of the prevailing speeds. This is particularly prevalent where the designer may feel the need to avoid the clear zone requirements that go along with design speeds of 50 mph or greater. Another reason the designer may select a lower speed limit is that, based on the functional classification and/or design volumes on a section of highway, design policies may call for a lower design speed than motorists will actually driver the facility.

Such discrepancies create several potential problems. One is the liability that could exist where a highway is posted at a higher speed than the one for which it was designed. If an accident occurred a highway agency could be in an extremely vulnerable position. Even if the liability threat did not exist, there is still a disservice being done to the motorists by posting a speed limit (which implies that it is an acceptable speed) where subtle design features are not compatible with that speed. A less than posted speed horizontal curve can be rather easily handled by the posting of an advisory speed. However, other design elements such as stopping sight distance, recovery areas, etc., can be easily resolved.

OBJECTIVE: The objectives of this research would be to review the procedures used to determine design and posted speeds; to determine situations where a discrepancy could result; and search for ways of resolving such discrepancies. The resolution could be to either avoid the discrepancy or to handle it by means such as advisory (in addition to the regulatory) speed signs.

KEY WORDS: Speed limit, design speed, posted speed, accident liability, driver expectancy.

RELATED WORK: Historical studies and findings

URGENCY/PRIORITY: High

COST: $100,000

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

IMPLEMENTATION: The results of this research could be distributed as a NCHRP Report and could be incorporated into appropriate design and traffic policies, and manuals.

EFFECTIVENESS: The research results would be useful in relieving highway agencies of potentially liable

conditions and avoiding motorist expectancy violations where the posted speed is greater than the design speed.

Proper Stopping Sight Distance for Trucks Compared to Automobiles for Design Criteria

PROBLEM: The Green Book provides use with adequate information for designing vertical curves for the proper lengths of stopping sight distances for cars. There is a high percentage increase of trucks in the traffic mix. We need to become more aware that the stopping sight distance for trucks is much greater than for cars. What should be the design criteria? This affects the proper design approach since the difference in automobile and truck characteristics may not be totally compensated for by just considering automobiles as the governing case. With the 3R work being done, it may be that with this current work, we are still building new deficiencies into our newest roads.

OBJECTIVE: To determine if there is a problem with the design criteria presently being used and, if so, what is the proper criteria to use.

KEY WORDS: Vertical sight distance, stopping sight distance, driver eye height, trucks, cars and traffic mix.

RELATED WORK:

A Policy on the Geometric Design of Highways and Streets, AASHTO, 1984.

URGENCY/PRIORITY: Increasing truck traffic plus 3R work being accomplished calls for consideration of this problem immediately.

PRIORITY RATING: High

COST: $90,000

USER COMMUNITY: All planners and designers of roads, streets and highways.

IMPLEMENTATION: Published papers and notices should alert all users until an addendum can be made to existing manuals and guidelines.

EFFECTIVENESS: There should be a noticeable decrease in total accidents related in any way to vertical stopping sight distance.

AASHTO Stopping Sight Distance Versus Accident Rate

PROBLEM: The AASHTO stopping sight distances (SSD) are based on calculations using worse case values (e.g., bald tires on wet pavement). While this gives SSD values that are safe, they may be unrealistic as a limit for corrective action of existing highway conditions.

OBJECTIVE: To determine minimum existing SSD values that should be allowed to remain based on accident rates. This would be similar to the ball-banking criteria versus design standards for horizontal curves.

KEY WORDS: Stopping sight distance

RELATED WORK: Historical studies

URGENCY/PRIORITY: This research would provide information for highway designers to use for corrective action. Results would have high benefits for specific problem locations.

PRIORITY RATING: High

COST: $60,000

USER COMMUNITY: AASHTO, federal, state, and local agencies.

IMPLEMENTATION: Through a TRB Special Report

EFFECTIVENESS: Cost-effective for standards for stopping sight distance on existing highway facilities.

PROBLEM STATEMENTS RANKED AS MODERATE PRIORITY

Accident Versus Rate of Change of Lateral Acceleration on Curves

PROBLEM: Too rapid change of lateral acceleration entering a curve from a tangent, or while moving from the flatter part to the sharper part of a compound curve, can result in load shifting on trucks, vehicle encroachment on shoulders and opposing lanes of traffic, and loss of control accidents. This is nothing new, having been recognized at least as early as the 1954 AASHO Blue Book in its discussions on spiral transition curves and compound circular curves. Both the 1954 Blue Book

and the 1984 Green Book recommend transition curves for sharper curves in their tables. Both contain the same philosophy that "on compound curves for open highways it is generally accepted that the ratio of the flatter radius to the sharper radius should not exceed 1.5". Accident experience on sharp curves and compound curves suggests that these "standards" may not be strict enough, and that additional criteria are needed to assist the designer in determining where transition curves are needed.

OBJECTIVE: Identify the extent to which a relationship exists between accidents and the rate of change of lateral acceleration, and, if appropriate, establish a maximum rate for design purposes. The desirability of transition curves between tangents and sharp curves is generally recognized. However, the similar need between elements of a compound curve is not generally known. By establishing a maximum desirable rate of change of lateral acceleration based on "accident experience" rather than "comfort", related design standards could be more positive. Benefits would accrue to the population at large from lowered accident costs and reduced delays from traffic accidents involving overturned trucks at critical locations.

KEY WORDS: Transition curves, compound curves

RELATED WORK: Work has been done on vehicle paths entering curves and on accidents versus sharp curves.

PRIORITY/URGENCY: This problem needs to be addressed to improve curve geometrics for trucks and reduce accident experience.

PRIORITY RATING: Moderate

COST: $100,000

USER COMMUNITY: AASHTO, FHWA, NHTSA, and state and local agencies

IMPLEMENTATION: The research findings, if found significant, would be manifested in forthcoming design policies of the various road agencies, and would be applied to safety improvement projects at high accident locations.

EFFECTIVENESS: High in terms of addressing accident problems at critical locations.

Superelevation Requirements for Trucks

PROBLEM: It is believed that trucks, due to different centers of gravity, are having some difficulties negotiating superelevations that are presently being constructed based on superelevation criteria for cars.

OBJECTIVE: To find a superelevation rate that is suitable for both cars and trucks. To develop superelevation criteria to satisfy both needs.

KEY WORDS: Horizontal curves, superelevation criteria, center of gravity, trucks, cars

RELATED WORK: A Policy on Geometric Design of Highways and Streets, AASHTO, 1984.

URGENCY/PRIORITY: Increased percentage of trucks in the traffic mix continues to make this a bigger problem. This is a continuing problem. With the increased size and weight of trucks, the changes in the truck mix present a wider variation in need that may not be currently addressed.

PRIORITY RATING: Moderate

COST: $75,000

USER COMMUNITY: All planners and designers of roads, streets and highways.

IMPLEMENTATION: Revised guidelines developed should be published as notices for immediate usage. Then they could be incorporated into guidelines and procedures.

EFFECTIVENESS: There should be a decrease in total accidents caused by lack of or improper superelevation on curves.

Enhancing Snow Removal and Ice Control Through Geometric Design

PROBLEM: Snow has a detrimental effect on highway operations. Blowing snow obscures visibility and, when it accumulates on the pavement surface, can make vehicle control difficult. In extreme cases, wind-blown deposits may accumulate to such depths that closure of the roadway is necessitated. The literature on controlling snow drifting through highway design is rather extensive. However, much of the information comes from alpine regions or from the northern plains of the United States. Little theoretical work has been done to examine how highway design features affect blowing snow in intermediate terrain, i.e., between relatively flat and sharply mountainous terrain.

The Strategic Highway Research Program recognized this situation and noted that improper design of roadways creates many severe drifting situations that could be avoided if information on better designs were

available. The objectives of a proposed SHRP project include applying appropriate aerodynamic principles to improve existing methods of designing drift-free roads and to prepare design drawings and specifications and a procedure for selection and implementation of measures to reduce or prevent snow drifting on new or existing roads. While completion of the SHRP research will provide useful information, there are a number of other issues that must be addressed, e.g. interchange design modifications to reduce drifting, designing bridge deck widths for snow storage, and the economics of providing crossovers for snow removal equipment. The tradeoff between permanent terrain modifications to reduce drifting versus annual installation of snow control structures should be examined. In other words, a systems approach is needed to address the issue of designing highways for enhanced snow removal and ice control, which in turn will lead to improved highway operations.

OBJECTIVE: The objective of the proposed research is to use a systems approach to develop technical and economic guidelines for enhancing snow removal and ice control through geometric design. Design elements to be considered include alignment, grade, cut sections, fill sections, superelevation, shoulders, medians, interchange areas, structures, crossovers and drainage. The economic evaluation will weight the cost of a one-time expenditure for a permanent design modification against the recurring maintenance expenses of snow control structures and removal operations and attempt to include continuing benefits to highway users during storm periods.

KEY WORDS: Design elements, economics, geometric design, guidelines, snow control structures, snow drifting, snow removal, winter maintenance.

RELATED WORK:

1. Byrd, Tallamy, MacDonald and Lewis, "Snow Removal and Ice Control Techniques at Interchanges," National Cooperative Highway Research Report 127, Highway Research Board, Washington, D.C. 1971.

2. Jumikis, A. R., "About Snow Drifts," Transportation Research Board Special Report 185, 1979, pp. 254-258.

3. Tabler, R. D. "New Engineering Criteria for Snow Fence Systems," Transportation Research Record 506, 1974, pp. 65-78.

4. Tabler, R. D., "Determination of Snow Fence Design Criteria and Development of a Handbook for Snow Control, in progress.

5. Strategic Highway Research Program: Research Plans, Transportation Research Board, Washington, D.C., May 1986, pp. TRA b-i to TRA b-c-2.

URGENCY/PRIORITY: This research should be completed in the near future to provide objective guidelines to highway agencies interested in reducing systems costs for snow removal and ice control and in improving highway operations.

PRIORITY RATING: Moderate

COST: $250,000

USER COMMUNITY: Primarily state (and secondarily county and local) engineers responsible for design, re-design and maintenance of highways.

IMPLEMENTATION: The guidelines developed as a result of this research would be immediately useful to highway agencies in decision-making relative to roadway design.

EFFECTIVENESS: Research results will be useful in reducing winter maintenance expenditures. There should also be increased safety for the driving public during and shortly after snowfall events.

Lifecycle Cost Analysis - Fully Access Controlled Versus Partially Access Controlled Rural and Suburban Multi-Laned Highways

PROBLEM: When designing multi-laned rural and suburban highway facilities, several important variables must be considered. Often, these variables are in conflict with one another, necessitating compromise. Examples of such variables are: 1) initial cost; 2) access availability; 3) needed right-of-way; 4) public safety; 5) public convenience; 6) impacts to adjacent property owners; and 7) lifecycle costs.

Of these seven factors, there could be more, lifecycle cost consideration is seldom, if ever, applied. The public commitment to a multi-laned rural and/or suburban highway facility is substantial. The anticipated use of this facility borders on perpetuity. Only a major change in the form of transportation or land use could challenge the extended need and use of such a facility.

Full access control can guarantee a consistent level of service over extended periods of time, as long as it is not given up. Anything less than initial and continued full access control simply can not guarantee a consistent level of service. The examples and case studies are numerous of the loss of service when full access control is not retained.

An in-depth economic analysis is needed to provide lifecycle costs for typical existing rural and suburban multi-laned highways. A comparative study should be made between fully- and partially-access controlled facilities, while attempting to control other variables interaction.

The price the public pays through reduced highway safety and increased congestion is significant. The price the public must pay to replace lost safety and capacity is enormous.

OBJECTIVES: Compare the cost to acquire property; access control; and to construct, maintain, and rehabilitate multi-laned rural and/or suburban highway facilities (including a convenience factor to adjacent property owners) between a fully-access controlled design and a design that allows some degree of at-grade access.

Case studies of existing facilities should be utilized to illustrate the results. Costs should be applied, reflecting highway safety and delay for at-grade intersections and interchanges. Finally, a cost should be applied to replace or supplement the facility due to capacity and safety degeneration.

KEY WORDS: Lifecycle cost analysis, fully-access control, partially-access control, multi-laned highways, level of service

RELATED WORK: None found in a literature search.

URGENCY/PRIORITY: Construction of new fully- or partially- access controlled, multi-laned rural or suburban highway facilities is not extensive. However, one facility's lifecycle cost is enormous. A study that would influence this major design factor (access control) can not come too soon. The cost payback may not be instantaneous, but if not, will accumulate over time.

PRIORITY RATING: Moderate

COST: The cost depends on the number of facilities analyzed. The research can use existing sites and data and should provide meaningful results and not exceed $50,000.

USER COMMUNITY: FHWA, state DOTs, and larger municipal and county governments

IMPLEMENTATION: Through modification of policy guidelines (local, state and federal) on access control needs for multi-laned rural and suburban roads.

EFFECTIVENESS: This research would provide both technical and political understanding to this highly visible issue. The payback would accumulate more quickly over an extended period of time.

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