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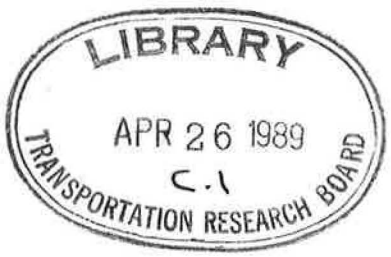
Research Problem Statements

Operational Effects of Geometrics and Geometric Design



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INTRODUCTION

This circular represents a joint effort of two committees. Both committees, A3A08, "Operational Effects of Geometrics," and A2A02, "Geometric Design," have similar interests in the advancement of highway design and resulting improvements to operational efficiency and safety.

Because of their overlapping interests, the committees have maintained a close liaison. A joint mid-year 1986 meeting was held in Evanston, Illinois, at which the decision was made to publish a circular containing research statements from both committees.

As each committee's work proceeded, two points became clear. First, there are many perceived problems concerning highway design and operation. A quick inspection of the high priority statements from both committees shows concerns in the areas of cross section, horizontal alignment and its resulting dynamics, and intersection design elements and their operation, among others. Second, there is a clear, strong consensus between both committees that the subject of stopping sight distance—either on an existing highway or as a control in design of new highways—requires the attention of those responsible for sponsoring highway research.

COMMITTEE A3A08 "OPERATIONAL EFFECTS OF GEOMETRICS"

One of the major functions of Committee A3A08, "Operational Effects of Geometrics," is identifying research needs and communicating them to the transportation research community. The committee has regularly evaluated and published research statements in the past; publication of this circular is a continuation of that activity.

The committee received ten research problem statements for evaluation during 1986. These research problem statements were circulated to the committee members, who were asked to evaluate each of them for perceived and relative importance, allocation of a hypothetical research budget, and probability of success. The members were also asked to provide a brief rationale for each evaluation. Eighteen committee members responded to this request. The results were then summarized in such a way that the respondents would remain anonymous, and the summary was distributed to the entire committee.

The results showed a great diversity among the committee members in their assessment of the individual problem statements. On a scale of 1 to 5, every problem statement received the highest possible ranking (1) and the lowest possible rankings (4 or 5) from at least one evaluator. Proposed budget allocations ranged from $60,000 to $190,000, and the average probability of success anticipated from the problem statements ranged from 55 percent to 75 percent.

These results were discussed at the committee's 1986 mid-year meeting in Evanston. After considerable debate, a decision was made to publish nine of the ten problem statements that had been evaluated, but to clearly indicate the relative priority of each. The tenth statement was no longer considered a problem in light of recent research results.

The nine research problem statements considered by the committee are presented in order of priority. The first two statements were clearly identified as important, timely research problems requiring immediate attention. The next three statements were also considered important problems, although by fewer committee members. They should be addressed by the research community as well.

The final four statements are published in an abbreviated format. Although these research problems are considered valid, it was the committee's consensus that these four statements were of lower priority. Interested researchers can contact the committee chairman for further details concerning these problems.

PROBLEM STATEMENTS RATED AS HIGHEST PRIORITY

"OPERATIONAL AND SAFETY EFFECTS OF REDUCED LANE AND SHOULDER WIDTHS ON URBAN FREEWAYS"

Problem Statement. Transportation agencies are faced with problems such as increased travel demand, construction costs, and safety and enviromental concerns. At the same time, available funds for highway improvement are not keeping up with the need. Several states have increased the number of through lanes on urban freeways by reducing lane widths and reducing or eliminating shoulders.

The desirable design standards for freeway cross sections are lane widths of 12 feet and shoulder widths of 8 to 10 feet on both sides of the roadway. Reducing lane and shoulder widths on urban freeways may result in operational problems such as adjacent lane encroachments, problems in critical ramp merging areas, reduced emergency parking areas, and reduced rideability of the pavement surface.

Research Objectives. The research objectives of this study would be to determine the operational and safety impacts of reduced lane and shoulder widths on urban freeways, and, if appropriate, to develop guidelines for the implementation of reduced lane and shoulder widths on urban freeways.

Key Words. Key words for this study include the following: freeways, lane widths, shoulder widths, freeway operations, and freeway safety.

Related Work. One related work is "Freeway Modifications to Increase Traffic Flow," Technology Sharing Report, FHWA-TS-80-203, Federal Highway Administration, January 1980.

The Federal Highway Administration has a proposed contract for fiscal year 1986 titled "Safety of Wider Trucks on Narrow Roadways." The operation of trucks 96 inches and 102 inches in width will be studied to determine the effect of truck width on overall highway operations and safety.

Urgency/Priority. Increasing the capacity of urban freeways without major reconstruction could be very cost-effective. This proposed study should have a high priority.

Cost. The estimated cost of this study is $250,000.

User Community. The research results would be useful to highway design engineers in evaluating alternatives for urban freeway improvements.

Implementation. The research results could be included in courses dealing with highway design and traffic operations, packaged as a design guide and distributed to state and highway design engineers, and distributed through articles in professional publications.

Effectiveness. The research reports could make possible improved urban freeway operations at a nominal cost. The anticipated benefits include: reduction in travel time, air pollution, fuel consumption, and construction costs without compromising safety.

"EVALUATION OF SUBSTANDARD STOPPING SIGHT DISTANCES ON EXISTING HIGHWAYS"

Problem Statement. Stopping sight distance (SSD) is a fundamental element of highway safety. Today, most highway designs are for 3R/4R-type projects. To properly address available SSD on existing highways, three elements must be available:

1. a theoretical SSD model
2. an analytical tool to determine the available SSD, and
3. a technique to evaluate the adequacy of available SSD.

AASHTO presents its theoretical model in the 1984 "Green Book." NCHRP 270, *Parameters Affecting Stopping Sight Distance*, presents a theoretical model which has monumental differences from the AASHTO model. It will likely be several years before these differences are resolved. NCHRP 270 also presents excellent analytical tools to determine the available SSD at crest vertical curves (sight distance graphs) and horizontal curves (middle ordinate graphs). What is lacking, however, is a technique to evaluate the adequacy of the available SSD. If such a technique were developed, it could be used to decide whether or not geometric improvements are warranted.

Research Objectives. The first objective would be to determine the magnitude of the problem for various functional classes of highway. A field investigation on a random sample of highway segments might be used to estimate the extent of substandard SSDs on existing highways. The second objective would be to develop an evaluation technique which would incorporate some or all of the following elements:

Time Duration. The time for which a driver does not have desirable and/or minimum SSD is obviously related to safety. The greater the time duration, the greater the safety deficiency and the greater the potential benefits from a construction improvement.

Extent of Deficiency. Also directly related to safety is the amount by which the existing crest vertical curve or horizontal curve fails to meet the required SSD.

Variance of SSD Model Elements. The analytical tools in NCHRP 270 allow the designer to vary the SSD model elements (driver eye height, object height, speed, friction factors, and controlled or locked-wheel stop). The designer is then able to determine for what set of assumptions the existing SSD is sufficient. There is, however, currently no evaluation technique which addresses the sensitivity of each model element to safety. For example, the object height of 4 inches (NCHRP 270) or 6 inches (AASHTO) is perhaps much less important to safety than the available tangential friction.

Accident Reduction. Ideally, an accident reduction factor would be available to determine the safety benefits of improving SSD. Given the great number of factors in the SSDmodel, however, it may be impossible to set up a controlled study which would yield results with a universal application. At a minimum, however, the evaluation technique would discuss how to evaluate the accident history in order to judge when the safety problem is severe enough to warrant correcting substandard SSD.

Traffic Control Devices. The evaluation technique will often lead to the conclusion that it is not warranted to correct the substandard SSD. In these cases, a standard warning sign is needed to warn the motorists of the hazard. As of today, the FHWA is proposing to eliminate the existing "Limited Sight Distance" sign (W14-4) from the MUTCD. An effective replacement sign is needed.

Key Words. Key words for this study include the following: stopping sight distance, driver eye height, object height, tangential friction, controlled stop, locked-wheel stop, and braking distance.

Related Work. Related work includes the following: (1) *A Policy on Geometric Design of Highways and Streets*, AASHTO, 1984; (2) NCHRP 270, *Parameters Affecting Stopping Sight Distance*, TRB, June, 1984. NCHRP 270 contains 75 references directly related to SSD.

Urgency/Priority. This research could provide valuable information to the design engineer for a rational evaluation of substandard SSDs. Considering the large number of existing substandard SSDs, the significant costs of improving crest vertical curves and horizontal curves, and the potential tort liability problems, this research should have a high priority.

Cost. The estimated cost of this study is $100,000.

User Community. The research results would be useful to highway agencies at the federal, state, and local levels.

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.

Effectiveness. Implementing this project should lead to more cost-effective, supportable decisions on when to make geometric improvements to correct substandard SSDs.

PROBLEM STATEMENTS RATED AS HIGH PRIORITY

"PASSING BEHAVIOR ON TWO-LANE RURAL HIGHWAYS"

Problem Statement. Passing sight distance is a major input in two-lane rural highway design. Although there have been some limited scope studies which investigated passings under certain assumptions or conditions, a comprehensive and extensive passing study has not been conducted in the U. S. for four decades. A two-lane highway without adequate passing sight distance may experience deterioration in its safety level and reduction of capacity. Therefore, an investigation to determine if the current passing sight distances are still adequate is both necessary and timely.

Research Objectives. The purpose of the proposed study is to investigate the distance and time elements involved in the passing process. These include the travel time and distance while the overtaking vehicle is in the left (opposing) lane, safety margin at the end of the process, gap acceptance behavior of passing vehicles, and the exact location of the point of "no return."

Key Words. The key words for this study include the following: passing, two-lane highway, speed, distance, gap-acceptance, and safety.

Related Work. A few previous prominent studies have been done on this subject. These include U.S. studies by Holmes (1939), Norman (1940), Prisk (1941), and Lieberman (1982); Austrailian studies by Miller and Pretty (1968) and Troutback (1981); and an English study by Crawford (1963).

Urgency/Priority. In order to get better use—in terms of safety and capacity—of existing two-lane highway facilities, the information sought in this study is needed as first priority.

Cost. The estimated cost of this study is $250,000.

User Community. The research results could be useful to state highway departments, AASHTO, D.O.T., safety research institutes, and design agencies.

Implementation. The research results could be used in the design of new two-lane highways, in evaluation of capacity problems of existing facilities, in examination of sign and marking procedures, and in in-depth investigation of existing problem sections.

"GEOMETRIC DESIGN FOR THE IMPAIRED DRIVER"

Problem Statement. A great deal of attention has been focused on driver education and enforcement approaches to dealing with the safety problems caused by drivers who have been drinking or are otherwise impaired. These approaches, however, have been basically unsuccessful in restraining drinkers from driving. Impairments may involve not only alcohol, but also drugs, poor vision, or fatigue. Because the problem is so widespread, it is apparent that engineers must consider the impaired driver when designing or upgrading roadway facilities. There is, however, a dearth of objective information on the relationship between impairment and driver ability to deal with the highway environment. Knowledge of the relationship between impaired driver performance and geometric design is especially limited. The information that is available shows a direct relationship between impaired driver accidents and road alignment. As a first step to providing highway engineers with guidance in this regard, there is a need to synthesize what is known about the impaired driver (from the human factors standpoint) with current geometric design considerations.

Research Objectives. The proposed study would involve identifying existing and needed research which examine the effects of geometric design on impaired drivers and identifying geometric characteristics that are compatible with the impaired driver. Specific objectives are as follows: (1) to conduct a thorough review of the geometric design and human factors literature to gather information on performance of impaired drivers and the relationship to geometric design, (2) to prepare a synthesis of current knowledge relative to impaired drivers and geometric design (including preliminary guidelines for designing for the impaired driver), (3) to identify specific areas where additional research is needed to address unanswered questions, and (4) to develop specific research plans for the identified areas.

Key Words. The key words for this study include the following: accident countermeasures, accident, design standards, driver behavior, geometric design, human factors, impairments, and incompatibilities.

Related Work. Related work includes the following: (1) Johnston, I.R., "The Role of Alcohol in Road Crashes," *Ergonomics*, Vol. 25, No. 10, 1982, pp. 941-946; (2) McKeen, F.P., "The Human Factor in Driving Accidents: An Overview of Approaches and Problems," *Ergonomics*, Vol. 25, No. 10, 1982, pp. 867-877; (3) Sabey, B.E., "A Review of Drinking and DrugTaking in Road Accidents in Great Britain," *TRRL Supplementary Report 441*, Transport and Road Research Laboratory, 1978, pp. 1-9.

Urgency/Priority. This synthesis should be compiled in the very near future to provide objective guidelines for considering the impaired driver in highway design and redesign. Upon implementation of the countermeasures, a significant reduction in accidents could be expected.

Cost. The estimated cost of this study is $150,000.

User Community. The research results would be useful to primarily state (and secondarily county and local) engineers responsible for the design, re-design, and reconstruction of highways and streets.

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 enhancing safety for impaired drivers traveling on highways and streets. This would have the added benefit of increasing safety for the driving public in general.

"TRUCK DYNAMICS CONTRIBUTING TO ROLLOVER ON TIGHT CURVES"

Problem Statement. The design of interchange ramps in highly developed urban areas often calls for the use of tight (high degree) curves to reduce right-of-way requirements. The standard design method does not account for the changing dynamics of large trucks as they negotiate these curves, thus creating a potential hazard for overturning. Of particular importance are the high centers of gravity and shifting loads of trucks such as liquid tankers and livestock haulers. Ramps expected to accomodate large trucks should be designed so as to account for the trucks' changing dynamics.

Research Objectives. This study has two research objectives. The first objective is to gather accident data on numerous ramp sections of this type as a means to statistically measure the relationship between truck rollover accidents and ramp curve design. The second objective is to prepare, using data gathered and analyzed, a design chart or table for use by design engineers.

Key Words. The key words for this study include the following: ramp superelevation and truck rollover accidents.

Related Work. Related work includes the following: (1) Ervin, R.D., et. al. "Influence of the Geometric Design of Highway Ramps on the Stability and Control of Heavy-Duty Trucks," Transportation Research Record 1052, 1986, pp. 77-89.

Urgency/Priority. The priority of this study is moderate.

Cost. The estimated cost of this study is $150,000.

User Community. The research results would be useful to AASHTO and FHWA.

Implementation. The research would lead to the refinement of the basic guidelines used by design engineers.

Effectiveness. The primary benefit of this research would be the improvement of design practices that would lead to an increase in motorist safety through accident reduction.

ADDITIONAL PROBLEM STATEMENTS

"GUIDELINES FOR MEDIAN CONTROL OF TWO-WAY LEFT-TURN LANES AT SIGNALIZED INTERSECTIONS"

Problem Statement. Median two-way left-turn lane sections are being designed for use on roadway sections in urban areas. This situation leads to the question of whether major intersections, those that are signalized, should be further controlled by the use of a center median curb. When left uncontrolled, operational problems could develop. If a parcel at an intersection generates any traffic at all, left-turn ingress and egress from driveways within 200 feet will have a negative effect on the intersection operation.

Research Objectives. There would be two research objectives for this study. The first objective would be to determine if and when the center curb should be introduced in the median two-way left-turn lane section. Second, the study's findings should provide guidelines relating to vehicle volumes, number of driveways, and proximity of driveway to intersection, as to when the center curb should be introduced.

"GUIDELINES FOR SELECTING BARRIER CURB OR TWO-WAY LEFT-TURN LANE CROSS SECTIONS ON URBAN ARTERIALS"

Problem Statement. An urban section of roadway, through a commercial or industrial business area with numerous driveways, usually sustains substantial through traffic volumes. The problem the engineer must face is which type of roadway cross-section should be used.

A choice must be made between using a barrier curb to control left-turn access or a median lane with two-way left-turn capabilities to allow left-turn access. Selection of the wrong roadway section could lead to operational problems that may adversely affect the capacity of the roadway. A decrease in capacity would increase the accident potential of the roadway section. Therefore, the need exists for guidelines for design engineers when selecting the most desirable roadway cross section to use.

Research Objectives. There would be two research objectives for this study. The first objective would be to determine at what point the type of traffic generators, volumes, and density of driveways would determine the use of barrier curb median control over the median two-way left-turn lane. The second objective would be to prepare a chart or table to be used as a set of guidelines.

"OPERATIONAL AND SAFETY EFFECTS OF OFFSET LEFT-TURN LANES"

Problem Statement. Many channelized intersections have been constructed providing left-turn lanes. It is becoming apparent that left-turn accidents are still occuring. Observations reveal that left-turning vehicles waiting to turn are blocking the view of the opposing left-turning vehicles. Accidents are occuring when one of the vehicles begins a turn and collides with a through vehicle that was hidden from view by the opposing left-turner.

Research Objectives. The objectives of this research would be to determine if there is a practical way to provide better visibility for all vehicles in the intersection by offsetting the left-turn lanes from each other.

"GEOMETRIC ACCOMMODATIONS FOR TRAFFIC CONTROL DEVICES"

Problem Statement. It is common practice to place traffic control devices in the best locations available on an already designed or constructed street or highway. This has always presented a certain number of problems. These problems are becoming more acute, however, with the increased use of flush cross-sections (e.g., center 2WLT lanes) and larger intersection corner flares required by larger trucks.

Research Objectives. The study objectives would be to identify problems relating to the effective placement of critical traffic control devices and to determine geometric features, improved traffic control devices, or supports that would aid in proper placement of such devices. Guidelines, standards, etc. need to be made available to assist the designer and traffic engineer in determining ways of effectively displaying critical traffic control devices. The greater use of devices such as raised pavement markers that can be placed on the pavement surface should be considered.

COMMITTEE A2A02 "GEOMETRIC DESIGN"

Committee A2A02, "Geometric Design," has completed an extensive compilation and review of research statements generated by its members. This circular is the culmination of a two-year problem statement effort. It represents a clear statement of research interest and priority by the entire committee.

A total of 15 statements were submitted, discussed at the 1986 annual and mid-year meetings, and reviewed by the committee. Nineteen committee members responded to a survey in which they were asked to prioritize the statements and comment on their importance, scope, or proposed budget.

The results of the survey clearly identified two of the statements as important, timely research problems requiring immediate attention, particularly the statement concerning stopping sight distance. Six of the remaining statements were also identified as high priority research problems, although by fewer committee members. The research community is strongly encouraged to address these statements as well.

The remaining statements received a small measure of support. These are considered worthy statements, but of a lower priority. They are published in abstract form. Those interested in further details regarding these statements can contact the chairman of Committee A2A02.

PROBLEM STATEMENTS RATED AS HIGHEST PRIORITY

"RISK ASSESSMENT OF HIGHWAY GEOMETRIC DESIGN FEATURES"

Problem Statement. The combined effects of states losing their sovereign immunity, the increasing cost of higher defect case losses, and changes in design criteria which have taken place since a highway was designed and built are forcing the states and local transportation agencies toward risk management of their highways, roads, and streets. This study will review the last five years of design defect cases to provide the states with a better understanding of the history, trends, and distribution of claims made against them. These will be reviewed according to the most prevalent defect cases, the frequency of plaintiffs' successes, and the distribution of awards.

Research Objectives. There are three objectives to be achieved by this research. The first objective is to improve the geometric design criteria of the features receiving the most prevalent defect claims. The second objective is to better prioritize safety improvement projects. The third objective is to prepare a more informed defense for design defect cases.

Key Words. The key words for this study include the following: design defects, geometric design, highway operations, highway safety, legal liability, risk assessment, risk management, and tort liability.

Related Work. There has been no work in this specific area. All previous studies of geometric design, highway operations, highway safety, legal liability, and risk management are related to this research and will provide appropriate background information.

Urgency/Priority. This research should receive the highest priority because of continuously escalating design costs.

Cost. The estimated cost of this study is $250,000.

User Community. The research results would be useful to AASHTO, FHWA, state and local transportation agencies and their legal staffs, and foreign Department/Ministries of Transportation.

Implementation. The improved design criteria can be implemented at all levels of highway activity from maintenance through construction, and the results of the risk assessment can be used immediately to reprogram safety improvement projects. Also, the better understanding of the underlying issues of the design defect cases will provide the basis for better defense in design defect cases, as well as better selection of cases to contest. These improvements will, in turn, provide a higher ratio of cases where actions of the transportation agency are found appropriate to the situation.

Effectiveness. Society will benefit from this research in two ways. First, a safe and more operationally efficient highway will be maintained, thus reducing fatalities and injuries. Second, taxes will be reduced due to reduced numbers of design defect claims and reduced numbers of "lost" cases.

"HIGHWAY SIGHT DISTANCE REQUIREMENTS"

Problem Statement. There has been increasing concern that the needs for a safe sight distance vary by highway location according to traffic volume and speed, vehicle clasification, level of development, and a combination of existing geometric and route elements. Yet, with this kind of complexity, the AASHTO sight distance requirements are based on questionable operational abstractions, employ inconsistent assumptions about driver and vehicle characteristics, and do not directly relate to the critical need for sight distance.

The need, therefore, is to critically synthesize existing information, perform functional analyses, and conduct additional research to fill existing gaps in our knowledge in order to validate existing design standards and/or make recommendations to change them so they are consistent with the functional requirements of highway operations.

Research Objectives. The research objectives for this study involve examining the validity of current AASHTO criteria for the following: stopping, passing, decision, and intersection and railroad grade crossing sight distances.

Key Words. Key words for this study include the following: sight distance, clear view, sight triangle, and stopping distances.

Related Work. There is an ongoing FHWA contract on intersection sight distance. There are also several recent NCHRP, TRB, and FHWA studies.

Urgency/Priority. This study should be a high priority.

Cost. The estimated cost of this study is $400,000.

User Community. The research results would be useful to federal, state, local, and consulting highway design engineers.

Implementation. The research results would lead to the development of more comprehensive and flexible design policy.

Effectiveness. More optimal application of sight distance principles will improve safety on highways at existing sight restricted locations.

PROBLEM STATEMENTS RATED AS HIGH PRIORITY

"DRIVEWAY INTERSECTION SIGHT DISTANCE REQUIREMENTS"

Problem Statement. The recently adopted *A Policy on the Geometric Design of Highways and Streets*, AASHTO, 1984, indicates that access drives constitute intersections with the public highways and streets. It further indicates that such intersections should be designed in the same manner as the intersection of two public facilities of the same functional classification. This implies that the sight distance at all intersections along a major highway or street should be appropriate for the speed of the major route. On-street parking is presently permitted on many state highways in small urban areas. This results in restricted sight distance of private access drives. Vegetation, advertising signs, and off-street parking immediately adjacent to the intersection are other common restrictions to sight distance. Also, the new AASHTO policy includes specific criteria for two-lane, two-way roads only.

Research Objectives. The main objective of this research would be to identify sight distances at driveways on a sample of the on-system highways within urbanized areas. The distribution of sight distances would be summarized by various cross-classification as city population, number of traffic lanes, parking angle, and adjacent land use. Minimum and desirable sight distance requirements would be developed for highway designs other than two-lane roadways based on the 1984 AASHTO criteria.

Key Words. The key words for this study include the following: intersection sight distance and driveway sight distance.

Related Work. There is an ongoing FHWA contract on intersection sight distance, as well as several recent NCHRP, TRB, and FHWA studies.

Urgency/Priority. Data should be made available for inclusion in the next AASHTO revision.

Cost. The estimated cost of this study is $220,000.

User Community. The research results could be useful at city, county, and state levels.

Implementation. The sight distance requirements for various roadway designs (number of traffic lanes and median design, etc.) would complement those contained in the 1984 AASHTO policy.

Effectiveness. This research will provide a basis for developing minimum sight distance criteria which can be uniformly and consistently applied.

"CRITIQUE OF AASHTO'S SUPERELEVATION CRITERIA"

Problem Statement. The new AASHTO "Green Book" provides limited guidance on the advantages/disadvantages or benefits/shortcomings of distributing "e" (superelevation) and "f" (side friction factor) in areas of transition from highway tangents to the circular curve. Similarly, the positive and negative features of spiral transition curves, while strongly advocated in the new publication, are not well documented. Furthermore, current policy recommends reduced pavement cross-slopes in urban areas with greater dependence on side friction. Although tolerable by the passenger car, recent evidence indicates that the high center of gravity of trucks can cause them to "rollover" under low speed situations where side friction demand is high and superelevation is low.

Research Objectives. The main objective of this research would be to prepare a critique of AASHTO's current policy on the development of superelevation. This examination should be done in close coordination and cooperation with AASHTO. A comprehensive report would establish the state-of-the-art.

Key Words. Key words for this study include the following: superelevation, transition, runoff, runout, and side friction factor.

Related Work. There is no related work in this area.

Urgency/Priority. With the significant increase in reconstruction/rehabilitation efforts, a critical review is very timely.

Cost. The estimated cost of this study is between $100,000 and $300,000, depending on field/test track testing.

User Community. The research results would be useful to FHWA and state and local agencies.

Implementation. It is envisioned that this effort would be performed in a series of coordinated tasks, monitored and guided by an AASHTO Technical Advisory Committee.

Effectiveness. The project tasks should be conducted with practical implementation of the findings as a principal objective to ensure adoption by AASHTO.

"HANDBOOK ON GEOMETRIC DESIGN CONSISTENCY"

Problem Statement. The FCP Project 1S Review Panel, at its final meeting on October 31, 1985, identified "Development of Guidelines and Procedures to Promote Design Consistency in Highway Geometric Design" as one of the eight most important areas for RD&T development. The consequences of design inconsistencies are becoming more critical as the trend toward larger trucks and smaller cars continues. If this handbook and training materials are not developed, there will be less attention given to the correction of design inconsistencies with a likely increase in both the frequency and severity of related accidents.

Research Objectives. A survey will be made of the various U.S. and European procedures for obtaining design consistency. A handbook will be prepared to describe these procedures with some explanation of how they are used. The handbook will also describe common design inconsistencies which sometimes cause safety and operational problems. Innovative highway design elements will be described along with criteria for their application. Various methods for analyzing costs and benefits of various alternative design improvements will be examined and recommendations made for use of the most feasible method. Also, a workshop format will be developed for one day instruction into the various consistency procedures and will be pilot-tested. The workshop materials will then be developed for use by RTAP centers.

Key Words. Key words for this study include the following: geometric design, design consistency, and safety.

Related Work. Related work includes the following: "Driver Perception of Risk," "Highway Geometric Design Consistency and Driver Expectancy," "AASHTO Manual Driver Expectancy Checklist-Design Review Tool," and "Driver Needs on Two-Lane Rural Highways."

Urgency/Priority. This study is identified as a high priority by the FCP Project 1S Review Panel.

Cost. The estimated cost for this study can be divided as follows: Data Collection, $30,000; Handbook Preparation, $30,000; Editing, $10,000; Training Materials Preparation, $20,000; Pilot Presentations $10,000. The total estimated cost is $100,000.

User Community. The research results could be useful to highway designers.

Implementation. Handbooks, manuals, and training courses could be used to implement the results of this study.

Effectiveness. This study will bring together the output from several R&D projects related to geometric design practices and geometric design consistency.

"TRADE-OFF BETWEEN ROADWAY WIDTH AND FORESLOPES ON TWO-LANE RURAL HIGHWAYS"

Problem Statement. The Federal-Aid Highway Act of 1976 amended Section 101 of Title 23 U.S.C. to allow the states to apply federal funds to resurfacing, restoration, and rehabilitation (RRR) projects. In response to that legislation, the FHWA has tried on several occasions (e.g., June 28, 1976; August 25, 1977; and August 23, 1978) to develop minimum design standards for RRR projects, but their proposals have drawn objections from the states for being too restrictive, and from safety advocacy groups for being too permissive.

The most appropriate combinations of lane width, shoulder width, shoulder surface type, and rate of foreslope are four design elements which are part of the RRR controversy. These four elements have been studied in part, but usually as individual elements. The conclusions of these studies were not only inconsistent, but also contradictory in many cases. A study of the effect of these four elements on highway safety is needed to determine the benefits and costs of various combinations of these elements.

Research Objectives. The main objective of this study would be to determine the benefits and costs of various combinations of lane widths, shoulder widths, shoulder surface types, and rate of foreslopes.

Key Words. The key words for this study include the following: lane width, shoulder width, side slope, foreslope, and roadside safety.

Related Work. There is an ongoing FHWA research contract looking at the comparative safety of various cross-section dimensions.

Urgency/Priority. This is a critical question in current RRR projects.

Cost. The estimated cost of this study is $350,000.

User Community. The research results could be useful to operating highway agencies.

Implementation. Results should lead directly to implementation.

Effectiveness. The results should lead to more optimal designs.

"PROCESS FOR IDENTIFYING, DEVELOPING, AND IMPLEMENTING AASHTO GEOMETRIC DESIGN GUIDANCE ON A CONTINUING BASIS"

Problem Statement. Design of transportation elements is a dynamic science which changes with technology, conditions, legislation, vehicles, drivers, public concerns, research, etc. Because of this fact, the need to provide current, relevant, and factual design guidance based on the latest proven information is important. There is a need to design a process which will assimilate scientific data and field practice into the geometric design policy guidance on a dynamic basis. Although technology transfer is a key element in keeping design current, there is a need to formalize the accepted policy guidance in the authoritative resource document on a regular basis.

Research Objectives. The main research objective for this study would be to determine a process for identifying, developing, and implementing Geometric Design Policy Guidance on a continuing basis.

Key Words. The key word for this study is geometric design policy.

Related Work. There is an ongoing AASHTO Task Force on geometric design.

Urgency/Priority. Effective design policy commands ongoing high priority.

Cost. The estimated cost for this study is $40,000/yr. ongoing.

User Community. The research results could be useful to federal, state, local, and consulting highway design engineers.

Implementation. Research results would lead to updated design policies.

Effectiveness. This study could have incalculable impact on traffic efficiency, highway safety, and cost effective highway construction programming.

"CLEAR RECOVERY ZONES"

Problem Statement. At present, no warrants or guidelines exist to aid engineers or adminstrators in determining what width clear recovery zones should be provided for each functional classification of highway facility and system for both new construction and RRR construction. With traffic accidents, deaths, injuries, and property damage being substantial due to an insufficient clear zone in which to recover, it is critical that we find some way to reduce this hazard. With the perpetual shortage of construction and reconstruction funds, these warrants and guidelines should incorporate the most cost and safety-effective method to be obtained. Clear zones are generally defined as those widths measured from the edge of the outside travel lane which are relatively free of potentially hazardous obstacles.

Research Objectives. The main objective of this study would be to develop warrants and guidelines that will allow the engineer and the administrator to choose, design, and apply the most cost and safety-effective clear recovery zones in the construction and reconstruction of any type of highway facility.

Key Words. The key words for this study include the following: roadside safety, side slopes, foreslopes, guardrail, traffic barriers, and clear zone.

Related Work. NCHRP Report 247 deals with this issue.

Urgency/Priority. This study has a high priority.

Cost. The estimated cost of this study is $300,000.

User Community. The research results could be useful to highway design engineers.

Implementation. Research results could lead to more comprehensive design procedures.

Effectiveness. Results should lead directly to implementation.

ADDITIONAL PROBLEM STATEMENTS

"GEOMETRIC DESIGN TO MINIMIZE SNOW REMOVAL PROBLEMS"

Problem Statement. The design of many roadways creates special problems for snow removal personnel. These problems include inadequate storage room for snow plowed from the roadways, on ramps and other narrow roadways. Problems also arise from highway hardware, which is difficult to remove snow from, and which blocks the removal of snow from roadways.

Research Objectives. This research should determine roadway design parameters that are applicable to areas subject to snow.

"MEETING THE CLEAR ZONE REQUIREMENT ON NON-LIMITED ACCESS CONTROLLED HIGHWAYS"

Problem Statement. Transportation agencies are faced with increased construction and maintenance costs, increased safety and enviromental concerns, and the reduction of available funds to accomplish the increasing demand for more and better highways. While the design of recovery areas beyond the normal shoulder width provides the traveling motorists with a large degree of safety, it also increases the overall cost of the project.

Research Objectives. This study has two research objectives. The first objective is to develop guidelines for the assessment of providing a recovery area beyond the normal shoulder. The second objective is to include all types of barrier systems and slope combinations in the analysis process.

"DESIGN GUIDELINES FOR IDENTIFYING AND CORRECTING OPERATING SPEED INCONSISTENCIES IN HORIZONTAL ALIGNMENT ON TWO-LANE RURAL HIGHWAYS"

Problem Statement. Accidents on rural highways can be related to vehicular speeds which are inconsistent with the roadway conditions presented to the motorist. A method for identification of horizontal alignments which create speed transition problems for the motorist and guidelines for correcting them for example, through the RRR program, would help improve highway safety on this important portion of the roadway network as well as for new designs and redesigns. Such methods are already a routine part of design practices in several Western European countries.

Research Objectives. This study has several research objectives. The first objective is to establish the correlation between design parameters and traffic volume data on operating speeds and accident rates. The second objective is to develop design graphs for these relationships. The third objective is to determine appropriate ranges for operating speed changes and accident rates to identify and prevent abrupt and unsafe transitions between successive design elements. The final objective is to develop a design procedure including recommendations for good and fair designs.

"DETERMINATION OF TRUCK DRIVER EYE HEIGHT"

Problem Statement. Current information on truck driver eye height is limited; that which does exist appears to be conflicting. The differences illustrate the need to determine a representative value (and observed variations) in truck driver eye heights.

Research Objectives. An explicit procedure for determining truck driver eye height is envisioned. This procedure would specify the vehicle model years to be sampled, the driving population, and the procedure by which measurements must be taken. In addition to manufacturer's data/ specifications, actual field observations would be performed to photograph unaware drivers seated in their natural positions.

"OPTIMUM SPACING OF CROSSOVERS ON DIVIDED DUAL LANE HIGHWAYS"

Problem Statement. On expressway type facilities, there is always a question concerning number and location of crossovers. It is also questioned whether they should be limited to public road connections or not, and whether there should be some maximum spacing between crossovers. One school of thought says that it is better to provide more crossovers and scatter the turning traffic rather than limit the number of crossovers and concentrate the turning traffic.

Research Objectives. The main objective of this study is to provide a factual study that would give guidance in the selection and location of crossovers on the expressway type facilities.

"OPERATIONAL AND SAFETY EFFECTS OF MEDIAN ACCELERATION LANES AT HIGHWAY AT-GRADE 'TEE INTERSECTIONS'"

Problem Statement. Designers are uncertain of the operational and safety effects of an acceleration lane in the median of the through road for merging of the left-turn traffic movement from a tee approach. The solution frequently is to use a traffic signal that is believed to provide greater safety when, in fact, it may not. Also, the signal may be operated to result in considerable time delay to the through traffic without a compensating reduction in delay to the tee approach traffic.

Research Objectives. The main objective of this study is to determine the operational and safety effects of providing a median acceleration lane at the tee intersection. The research should cover a combination of traffic speed and volume ranges that would represent both rural and urban conditions.