

# CIRCULAR



## Research Problem Statements in Freeway Operations

RESEARCH PROBLEM STATEMENTS  
IN FREEWAY OPERATIONS



Committee on Freeway Operations  
Ronald C. Sonntag, Chair

TRB Staff  
Richard A. Cunard

|                   |                      |                   |
|-------------------|----------------------|-------------------|
| B. Beukers        | Kim C. Henry         | Gordon F. Paesani |
| Elmer N. Burns    | Dennis C. Judycki    | Gary C. Price     |
| Donald G. Capelle | Jack L. Kay          | Colin Rayman      |
| Glen C. Carlson   | Robert J. Kelly      | David H. Roper    |
| Robert F. Dale    | Jeffrey A. Lindley   | James F. Shea     |
| Conrad L. Dudek   | Louis E. Lipp        | Thomas Werner     |
| Walter M. Dunn    | Adolf D. May         | Phillip Zove      |
| P. Kay Griffin    | William R. McCasland |                   |
| Herman E. Haenel  | Joseph M. McDermott  |                   |

The Transportation Research Board is a unit of the National Research Council, which serves as an independent advisor to the federal government on scientific and technical questions of national importance. The Research Council, jointly administered by the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine, brings the resources of the entire scientific and technical community to bear on national problems through its volunteer advisory committees.

FOREWORD

The Committee on Freeway Operations (A3A09) last published research problem statements in January 1983. In January 1987, the Committee decided to pursue publication of new statements and assigned this task to the Research Subcommittee. During 1987 and 1988 more than 40 new problem statements were gathered and developed from a number of sources, including new ideas generated by Committee members. In 1989, Committee members ranked the problem statements and at the June, 1989 Committee meeting, the top 13 statements were approved for publication in this circular.

Members of the Research Subcommittee include: Jeffrey A. Lindley (Chairman), John W. Erdman, Timothy J. Lomax, Adolf D. May, David H. Roper, and Thomas Urbanik.

**PROBLEM NO. 1**

**1.1 TITLE:** Evaluation of Integrated Urban Traffic Operations Techniques

**1.2 PROBLEM:** Many urban areas have installed or are planning to install various types of traffic management or motorist information systems. These systems are typically operated independent of one another by different operating agencies. A recent FHWA study concluded that integrating the operation of these various systems could result in reduced system installation, operating and maintenance costs and reduced levels of traffic congestion.

**1.3 OBJECTIVE:** Through a field demonstration, thoroughly evaluate the impacts of integrating two or more computerized traffic management systems in an urban area.

**1.4 KEY WORDS:** Freeway Surveillance and Control, Traffic Signal Control, Parking Advisory System, Transit Scheduling and Information System, Motorist Information System, System Integration

**1.5 RELATED WORK:** Follow-on to FHWA study, "Feasibility of Integrating Urban Traffic Operations Techniques" (Report No. FHWA/RD-87/022). FHWA is currently partially funding evaluation of integrated systems in several urban areas.

**1.6 URGENCY/PRIORITY:** As more urban areas install various types of computerized traffic management systems over the next several years, the potential for system integration will rapidly grow.

**1.7 COSTS:** \$600,000

**1.8 USER COMMUNITY:** Federal Highway Administration, State and Local Transportation Agencies, System Designers

**1.9 IMPLEMENTATION:** The results of this research could be implemented in any urban area with more than one existing or planned computerized traffic management system.

**1.10 EFFECTIVENESS:** Paper case studies have indicated substantial benefits from integration of traffic management systems. This study will measure these benefits in a real-world situation.

**PROBLEM NO. 2**

**2.1 TITLE:** Freeway Corridor Improvement Analysis

**2.2 PROBLEM:** To improve the operation of congested urban freeways, it has been recognized that the entire freeway corridor must be considered. This requires analysis of the improvement potential of the freeway, surface streets, other access points (e.g. parking lots) in the corridor.

There is a need to provide a step-by-step procedure to logically and systematically improve a freeway corridor with funds available to governmental agencies. Guidelines for determining low-cost, short-range and the high-cost, long-range improvements are needed to cover the wide range of alternatives, such as: geometric changes at intersections, traffic signal improvements and coordination, high occupancy vehicle (HOV) facilities,

reversible lanes along arterials, improved interchange design, access controls, traffic responsive freeway management systems, and additional freeway lanes. Non-construction improvements must also be considered, such as improved transit service, incentives for forming carpools, and staggered working hours.

**2.3 OBJECTIVE:** Develop a step-by-step procedure to evaluate various corridor improvement alternatives on a system basis. This will consist primarily of integrating past research and development activities in this area. The procedure developed will likely be computerized.

**2.4 KEY WORDS:** Traffic Management, Transportation Planning, Alternatives Analysis

**2.5 RELATED WORK:** NCHRP Project 3-18(3), NCHRP Project 3-22A, NCHRP Report No. 232, NCHRP Report 205, TRR 841, FHWA/RD-87/022, FHWA/RD-78/5, Existing Corridor Analysis Programs FREQ, FREFLO, TRAF, PASSER II, PASSER III.

**2.6 URGENCY/PRIORITY:** Restrictions in the construction of new urban freeways dictate that the most efficient use be made of existing facilities. The product of this project will help achieve this goal.

**2.7 COSTS:** \$350,000

**2.8 USER COMMUNITY:** State and Local Transportation Engineers and Planners, Consultants

**2.9 IMPLEMENTATION:** The product of this research will become an essential part of the project planning and evaluation

process at the State and local levels.

**2.10 EFFECTIVENESS:** More efficiently operated freeway corridors will reduce urban congestion levels.

### **PROBLEM NO. 3**

**3.1 TITLE:** Use of Shoulders and Narrow Lanes for Additional Lanes to Increase Capacity

**3.2 PROBLEM:** There are many instances in which lanes can be added to existing freeways through the narrowing of existing lanes and/or the use of shoulders. This approach frequently offers a low-cost, minimal-community-impact, quickly implemented alternative to adding lanes by widening the freeway. There is a need to fully understand the implications of such measures on both safety and capacity as a result of operation under narrowed lane conditions and no (or narrowed) shoulders. Further, there is a need to develop a set of guidelines on when and where to use narrowed lanes and/or shoulders as traffic lanes.

**3.3 OBJECTIVE:** Develop criteria and guidelines on when and where to use narrowed freeway lanes and/or existing shoulders for the purpose of adding lanes to existing freeways. Include case studies of existing applications and a discussion of potential adverse safety impacts.

**3.4 KEY WORDS:** Narrowed Traffic Lanes, Use of Shoulders as Traffic Lanes, Non-Standard Lane Widths

**3.5 RELATED WORK:** Both narrowed traffic lanes and shoulders as traffic lanes have been used extensively in California and in other urban areas for several years. The California Department of Transportation has conducted preliminary research into the development of criteria and guidelines for the use of these measures. The Texas Transportation Institute has also completed a study, "Safety and Operational Evaluation of Shoulders on Urban Freeways". The proposed research will broaden the work already done to develop criteria and guidelines that can be applied on a national basis.

**3.6 URGENCY/PRIORITY:** There is a critical need to develop acceptable, low-cost, quickly implementable solutions to urban freeway congestion problems. Use of shoulders and narrow lanes to increase freeway capacity fills this need, but criteria and guidelines for the use of these strategies must be developed before they can be applied in all urban areas.

**3.7 COSTS:** \$300,000

**3.8 USER COMMUNITY:** Federal Highway Administration, State and Local Transportation Agencies

**3.9 IMPLEMENTATION:** Study results will be implemented during the normal course of investigating alternative improvements to reduce freeway congestion.

**3.10 EFFECTIVENESS:** The results of the study will make considering this potentially highly effective improvement easier and more widely accepted.

#### **PROBLEM NO. 4**

**4.1 TITLE:** Development and Testing of Improved Incident Detection Algorithms

**4.2 PROBLEM:** One of the key elements in a freeway traffic management system is the detection of incidents. Many existing freeway traffic management systems have used available incident detection software for this task. However, the current software needs to be improved because it may not detect an incident for several minutes and because the false alarm rate (detection of incidents which do not exist) can be very high. The slow detection time contributes to the freeway congestion problem, since incident delay increases in a geometric fashion as incident duration increases. The high false alarm rate poses a problem for operators of the freeway management system, since they usually do not have the resources to respond to each detected incident. Unless a quick detection confirmation source, such as closed circuit television, is available, valuable time is lost while confirmation is achieved from another source.

**4.3 OBJECTIVE:** This study will develop and test improved incident detection algorithms which quickly and reliably detect freeway incidents. This study will include examination of technology such as the Wide Area Detection System (WADS) and artificial intelligence software which may be useful in achieving this goal.

**4.4 KEY WORDS:** Incident Detection, Algorithms, Traffic Management System

**4.5 RELATED WORK:** Several incident algorithms exist. McMaster University is currently developing an improved algorithm. A review of existing algorithms and ongoing work should be an initial task of this study.

**4.6 URGENCY/PRIORITY:** Recent studies have indicated that incidents cause over 60 percent of all urban freeway congestion. Rapid detection of these incidents can significantly reduce resulting congestion. This is an urgently needed project.

**4.7 COSTS:** \$600,000

**4.8 USER COMMUNITY:** State and Local Traffic Engineers, Consultants

**4.9 IMPLEMENTATION:** The algorithms developed could be implemented in an existing traffic management system as a demonstration project.

**4.10 EFFECTIVENESS:** Improved incident detection algorithms would reduce incident duration and traffic congestion due to freeway incidents.

## PROBLEM NO. 5

**5.1 TITLE:** Development and Testing of On-line Computer Based Alternative Traffic Diversion Strategies

**5.2 PROBLEM:** One of the potential benefits of a comprehensive, corridorwide traffic management system is the ability to detect congestion and advise motorists of less congested alternate routes. Currently, this is generally handled in a manual fashion by

a system operator monitoring the freeway condition, deciding on the best alternate route, and advising motorists through changeable message signs. The major shortcoming of this arrangement is its dependence on the attention and skill of a system operator. Often, good opportunities to beneficially divert traffic onto alternate routes are missed because the operator does not recognize them or is distracted by another task.

**5.3 OBJECTIVE:** This study will develop alternative diversion strategies which could be incorporated into the operating system logic of a traffic management system to automatically detect traffic diversion opportunities, select a best diversion route, and implement the diversion using predetermined messages on variable message signs. The system operator would be advised that implementation of a diversion strategy is in progress, and would be allowed to override the diversion strategy if desired. This study will include testing of the most promising diversion strategies developed on an existing system. Commencement of this research should be delayed until research to determine the expected rate of diversion for various auditory or visual messages is complete (see Problem No. 8).

**5.4 KEY WORDS:** Diversion, Traffic Management System, Alternate Route

**5.5 RELATED WORK:** The Integrated Motorist Information System (IMIS) on Long Island, New York contains provisions in the operating software for the implementation of diversion

strategies on parallel freeways and arterials in a 5 mile by 30 mile corridor. This study should include a review of these provisions. Diversion strategies used for the Burlington Skyway and proposed for the Highway 401 freeway traffic management systems in Toronto should also be reviewed.

**5.6 URGENCY/PRIORITY:** This project will result in the more effective use of overall corridor capacity in areas where traffic management systems exist or are planned. This is urgently needed.

**5.7 COSTS:** \$600,000

**5.8 USER COMMUNITY:** State and Local Traffic Engineers, Consultants.

**5.9 IMPLEMENTATION:** The research results will be implemented by designers and operators of computerized traffic management systems.

**5.10 EFFECTIVENESS:** This project will develop the means of making more effective use of overall corridor capacity.

#### **PROBLEM NO. 6**

**6.1 TITLE:** Guidelines for Improved Incident Response

**6.2 PROBLEM:** Recent studies indicate that incidents are responsible for more than 60 percent of all urban freeway congestion. Delay due to an incident is directly related to the time spent detecting, responding to and clearing it. Different methods have been developed and are being used by various agencies to respond to incidents and handle disabled

or damaged vehicles on freeways. A means of sharing information among agencies on what incident management strategies have been implemented and their relative effectiveness is needed.

**6.3 OBJECTIVE:** Evaluate the methods used by different jurisdictions for incident response and clearance and develop guidelines for when and how various methods should be used.

**6.4 KEY WORDS:** Incident Management, Incident Response, Incident Clearance

**6.5 RELATED WORK:** A recently completed NCHRP synthesis on incident management techniques, as well as an incident management handbook and videotape currently being developed by the Federal Highway Administration will serve as primary sources of background information for this study.

**6.6 URGENCY/PRIORITY:** High. Urban freeway congestion due to freeway incidents is a severe and growing problem.

**6.7 COSTS:** \$200,000

**6.8 USER COMMUNITY:** State and Local Traffic Engineers, Consultants

**6.9 IMPLEMENTATION:** Copies of the guidelines developed would be provided to State and local officials in urban areas.

**6.10 EFFECTIVENESS:** Developing guidelines for incident management techniques based on the experiences of other agencies will provide a useful product while avoiding costly duplication of effort.



**PROBLEM NO. 7**

**7.1 TITLE:** Feasibility of Freeway Mainline Metering

**7.2 PROBLEM:** Freeway entrance ramp metering has been used to maintain acceptable mainline travel speeds, reduce accident rates, and improve high occupancy vehicle treatment usage. Commuters who begin their trip outside the metered area, however, are allowed unrestricted access to the freeway. Fair allocation of the freeway space would require metering all entrance ramps within the urban area commutershed and the freeway mainline at the edge of the commutershed. This would be significantly more expensive than metering just in congested areas, might lead to enforcement problems in uncongested areas, and could lead to other operational and jurisdictional problems.

**7.3 OBJECTIVE:** Perform research on a demonstration basis to determine the potential problems associated with mainline metering and develop solutions to these problems. The basic equity issues involved in mainline metering should be investigated, as well as enforcement, safety, driver expectancy, and operational issues and general warranting conditions.

**7.4 KEY WORDS:** Ramp Metering, Mainline Metering, Freeway Operations

**7.5 RELATED WORK:** NCHRP 232, NCHRP 235, experience with freeway connector metering in San Diego, Minneapolis and other urban areas.

**7.6 URGENCY/PRIORITY:** Increased interest in freeway operational improvements as alternatives to mainline capacity additions has led to the extensive use of ramp metering strategies. The issues associated with mainline metering have been discussed, but no resolution of these issues or demonstration case study has ever been completed.

**7.7 COSTS:** \$400,000

**7.8 USER COMMUNITY:** Federal Highway Administration, State and Local Freeway Operating Agencies

**7.9 IMPLEMENTATION:** The research findings will improve the information base available to traffic engineers studying methods of solving peak-period traffic congestion problems.

**7.10 EFFECTIVENESS:** Entrance ramp metering is a very cost effective freeway traffic congestion reduction strategy. Equity and political issues have prevented extension of these concepts to the freeway mainline.

**PROBLEM NO. 8**

**8.1 TITLE:** The Use of Auditory Versus Visual Messages for Motorist Information and Traffic Diversion

**8.2 PROBLEM:** Various auditory and visual mediums are available to communicate traffic congestion and diversion route information to the motorist. Examples include highway advisory radio, variable message signs, cellular radio, and in-vehicle route guidance devices. The use of all of these

techniques in freeway traffic management systems has grown in recent years. While research on the effectiveness of some of these techniques in providing motorist information exists, a thorough analysis of the relative effectiveness of each system in diverting traffic has not been performed.

**8.3 OBJECTIVE:** Through a field study, determine the relative effectiveness of various auditory and visual techniques in providing motorist information and diverting traffic. This will include determining what degree of diversion can be expected for various types of messages.

**8.4 KEY WORDS:** Highway Advisory Radio, Variable Message Signs, Cellular Radio, In-Vehicle Route Guidance, Motorist Acceptance

**8.5 RELATED WORK:** Several past research reports on motorist response to variable message signs and highway advisory radio.

**8.6 URGENCY/PRIORITY:** Several freeway surveillance and control projects have been completed, while many more are in planning stages. The results of this research could result in a greater degree of effectiveness or lower costs for some of the components of these systems.

**8.7 COSTS:** \$500,000

**8.8 USER COMMUNITY:** Federal Highway Administration, State and Local Transportation Agencies

**8.9 IMPLEMENTATION:** The results of this research would be

implemented routinely during the planning and implementation of a freeway surveillance and control system.

**8.10 EFFECTIVENESS:** Effectiveness of various auditory and visual techniques would be measured by relative motorist acceptance, system reliability and cost.

## **PROBLEM NO. 9**

**9.1 TITLE:** Communications Techniques in Freeway Surveillance and Control Systems

**9.2 PROBLEM:** The communications subsystem of a freeway surveillance and control system is typically the most expensive component. Many media options exist for this subsystem, including twisted-pair cable, coaxial cable, fiber optics cable, and microwave and laser technologies. Many options for configuring the communications subsystem exist as well. The designer of a freeway surveillance and control system must choose from among these many options to produce an economical, yet functional and effective system. Communications technology has advanced so rapidly in recent years that no reference document exists that performs detailed trade-off analyses of various communications media and configurations in freeway surveillance and control systems.

**9.3 OBJECTIVE:** Prepare a handbook on communications technology in freeway surveillance and control systems. Include trade-off analyses for various communications methods and various system configurations.

**9.4 KEY WORDS:** Communications Technology, Freeway Surveillance and Control System, Twisted-Pair Cable, Coaxial Cable, Fiber Optics

**9.5 RELATED WORK:** A recent FHWA report, "Communications in Traffic Control Systems" contains an assessment of various existing and emerging communications technologies. The report lacks trade-off analyses for various communications methods and configurations.

**9.6 URGENCY/PRIORITY:** High. The product of this study will help insure that prudent decisions on the type and configuration of the communications network are made.

**9.7 COSTS:** \$200,000

**9.8 USER COMMUNITY:** State and Local Traffic Engineers, System Designers

**9.9 IMPLEMENTATION:** The product of this study will be used directly as input for decisions on the optimum configuration of the communications subsystem in a freeway surveillance and control system.

**9.10 EFFECTIVENESS:** Example trade-off analyses will be a very effective means of demonstrating the advantages and disadvantages of various communications media and configurations to system designers.

#### PROBLEM NO. 10

**10.1 TITLE:** Improved Incident Analysis Techniques

**10.2 PROBLEM:** Analysis of the costs, benefits and efficiency of traffic incident related

congestion reduction measures have not resulted in procedures that can be readily transferred to other locations. The use of general, standard benefit/cost ratio information will assist those responsible for developing incident management programs.

**10.3 OBJECTIVE:** Develop a family of curves that compare the cost of typical incident management procedures for various types of incidents with the estimated cost of the delay that would result from the incident, if an incident management program were not in place. The curves would use standard fixed values where appropriate (e.g. value of time) and ranges for variable parameters (volumes per lane, length of time for incident removal, etc.).

**10.4 KEY WORDS:** Incident Management, Delay Cost

**10.5 RELATED WORK:** TRB Circular 295, TRR 841, various computerized analysis programs which can simulate the impacts of incidents.

**10.6 URGENCY/PRIORITY:** Incidents are estimated to cause over 60 percent of all urban freeway delay. Incident management programs can greatly reduce this impact.

**10.7 COSTS:** \$75,000

**10.8 USER COMMUNITY:** State and Local Transportation Agencies, Consultants

**10.9 IMPLEMENTATION:** Standardization of the values and procedures necessary for consistent, accurate analyses of various incident management techniques will benefit the

entire transportation engineering community.

**10.10 EFFECTIVENESS:** The development of these analysis procedures will increase the confidence of the transportation engineering community in the projected impacts of various incident management strategies.

#### **PROBLEM NO. 11**

**11.1 TITLE:** Provision of Motorist Access to Freeway Surveillance and Control System Information

**11.2 PROBLEM:** Significant effort has been expended in many urban areas to gather real-time information on traffic volumes and roadway system operation. These data are typically available at a central control point. Local operating agencies benefit from this real-time information and can use changeable message signs, highway advisory radio broadcasts, and commercial radio or television stations to alert motorists of problem areas. Individual motorists, however, generally have no direct access to the available information.

**11.3 OBJECTIVE:** Develop a means by which motorists could query (by telephone and/or personal computer) the real-time database for the freeway surveillance system to obtain congestion information for their desired route prior to making their trip. The increased dissemination of congestion information public could benefit the motoring public by allowing specific routes to be examined without the extraneous information contained in congestion reports

disseminated by existing means. The news media could also use the real-time information as a means of broadcasting more accurate and timely reports.

**11.4 KEY WORDS:** Freeway Surveillance Information, Traffic Monitoring

**11.5 RELATED WORK:** Initiatives in this area are underway or planned in many urban areas. This study should include a review of these ongoing efforts.

**11.6 URGENCY/PRIORITY:** Significant funding is being devoted to implementing freeway surveillance and control systems to address existing and projected urban freeway congestion problems. Access to the data collected by these systems is currently limited to transportation agencies and the media. Providing access to this data to the general public will not only increase its usefulness, but would also increase public support for freeway traffic management systems.

**11.7 COSTS:** \$400,000

**11.8 USER COMMUNITY:** State and Local Transportation Agencies with Existing or Planned Freeway Traffic Management Systems

**11.9 IMPLEMENTATION:** The results of this research would eventually be routinely implemented with a freeway traffic management system.

**11.10 EFFECTIVENESS:** Increased availability of freeway surveillance data will lead to more informed route choice decisions and will reduce urban freeway congestion.

**PROBLEM NO. 12**

**12.1 TITLE:** Quantification of the Impacts of Ramp Metering

**12.2 PROBLEM:** Freeway surveillance and control systems, which typically include metering of traffic at entrance ramps, are becoming increasingly popular as a means of combating congestion on urban freeways. Several dozen of these systems are currently operational. Benefits of systems with ramp metering typically include increased vehicle throughput, reduced average travel time, and increased average speed. Unfortunately, the benefits provided by ramp metering in many of these systems have never been quantified. Also, in systems where an evaluation has been performed, the benefits of the ramp metering component are often difficult to separate from the benefits of other system components. The lack of a definitive quantification of the typical impacts of ramp metering makes it difficult for local officials in areas where ramp metering has not been implemented to justify it as a means of reducing congestion on urban freeways.

**12.3 OBJECTIVE:** Conduct a review of documentation from existing ramp metering projects to identify existing sources of information on the impacts of ramp metering. Identify the characteristics of several idealized urban freeway test segments for the purpose of determining the effects of ramp metering under a wide range of system geometric and traffic conditions. Use these test segments to perform "before" and "after" evaluations of ramp

metering using various macroscopic and microscopic computerized traffic simulation models.

**12.4 KEY WORDS:** Ramp Metering, Freeway Surveillance and Control System

**12.5 RELATED WORK:** Several individual jurisdictions have completed studies of the effectiveness of ramp metering for specific situations.

**12.6 URGENCY/PRIORITY:** Use of ramp metering can substantially reduce urban freeway congestion and can be implemented more quickly and at a lower cost than solutions requiring major construction.

**12.7 COSTS:** \$200,000

**12.8 USER COMMUNITY:** State and Local Traffic Engineers, Consultants

**12.9 IMPLEMENTATION:** The results of this study will be used directly on a day-to-day basis by individuals seeking to justify ramp metering as a means of reducing the impacts of urban congestion.

**12.10 EFFECTIVENESS:** Ramp Metering has been shown to be effective in increasing throughput and reducing delay and accidents on congested urban freeways. The results of this study will help to justify increased application of ramp metering.

**PROBLEM NO. 13**

**13.1 TITLE:** Guidelines for Developing Alternative Congestion Mitigation Measures During Reconstruction of Major Highway Facilities

**13.2 PROBLEM:** A number of techniques have been and are being used to minimize the traffic flow impact of major highway reconstruction, such as narrowing existing lanes and using shoulders as travel lanes, using contraflow lanes, improvement of alternate routes, and increased emphasis on ridesharing and high occupancy vehicle (HOV) strategies. The potential effectiveness of various strategies is dependent on the capacity of the highway being reconstructed, the capacity of alternate routes, and the availability of viable alternate modes, as well as the demand characteristics of the freeway.

**13.3 OBJECTIVE:** Develop guidelines for deciding which congestion mitigation measures to use to minimize the traffic impacts of a major freeway reconstruction project.

**13.4 KEY WORDS:** Temporary Roadway Relocation, Alternative Routing, Transportation System Management, Park and Ride, Ridesharing, Public Information Programs

**13.5 RELATED WORK:** TRB Special Report 212, documentation from past major freeway reconstruction projects.

**13.6 URGENCY/PRIORITY:** Over the coming years, one of every 10-15 freeway miles will be reconstructed each year. Strategies to alleviate the adverse

traffic impacts of these projects are needed.

**13.7 COSTS:** \$250,000

**13.8 USER COMMUNITY:** State and Local Highway Agencies, Transit Agencies, Transportation Management Associations, Enforcement Agencies

**13.9 IMPLEMENTATION:** The guidelines developed will be routinely used for future major reconstruction projects.

**13.10 EFFECTIVENESS:** The guidelines developed will help reduce both transportation agency and motorist costs during major reconstruction projects.