National Cooperative Highway Research Program

NCHRP Synthesis 273

Project Development Methodologies for Reconstruction of Urban Freeways and Expressways

A Synthesis of Highway Practice

Transportation Research Board
National Research Council

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Project Development Methodologies for Reconstruction of Urban Freeways and Expressways

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Subject Areas
Planning and Administration, and
Highway and Facility Design

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

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The members of the technical committee selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and, while they have been accepted as appropriate by the technical committee, they are not necessarily those of the Transportation Research Board, the National Research Council, the American Association of State Highway and Transportation Officials, or the Federal Highway Administration of the U.S. Department of Transportation.

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PREFACE

A vast storehouse of information exists on nearly every subject of concern to highway administrators and engineers. Much of this information has resulted from both research and the successful application of solutions to the problems faced by practitioners in their daily work. Because previously there has been no systematic means for compiling such useful information and making it available to the entire community, the American Association of State Highway and Transportation Officials has, through the mechanism of the National Cooperative Highway Research Program, authorized the Transportation Research Board to undertake a continuing project to search out and synthesize useful knowledge from all available sources and to prepare documented reports on current practices in the subject areas of concern.

This synthesis series reports on various practices, making specific recommendations where appropriate but without the detailed directions usually found in handbooks or design manuals. Nonetheless, these documents can serve similar purposes, for each is a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems. The extent to which these reports are useful will be tempered by the user's knowledge and experience in the particular problem area.

FOREWORD

By Staff
Transportation Research Board

This synthesis presents a review of the current practices associated with the techniques and policies employed by state and local transportation agencies to address the many project development issues required for the reconstruction of existing urban and suburban freeways and expressways. This topic is of special interest because there is a need to reconstruct many highway facilities that have been in existence for over 40 years. The need arises both from the deterioration of the infrastructure and from changes in capacity requirements. This synthesis will be of interest to state and local highway design engineers, traffic engineers, finance and contracting specialists, and contracting personnel in these agencies. It will also be of interest to consultants who are engaged in freeway/expressway reconstruction projects.

Administrators, engineers, and researchers are continually faced with highway problems on which much information exists, either in the form of reports or in terms of undocumented experience and practice. Unfortunately, this information often is scattered and unevaluated and, as a consequence, in seeking solutions, full information on what has been learned about a problem frequently is not assembled. Costly research findings may go unused, valuable experience may be overlooked, and full consideration may not be given to available practices for solving or alleviating the problem. In an effort to correct this situation, a continuing NCHRP project, carried out by the Transportation Research Board as the research agency, has the objective of reporting on common highway problems and synthesizing available information. The synthesis reports from this endeavor constitute an NCHRP publication series in which various forms of relevant information are assembled into single, concise documents pertaining to specific highway problems or sets of closely related problems.

While many of the project development methodologies in practice for reconstruction of urban and suburban freeways and expressways are similar to those used for new construction, there are unique differences that apply primarily to the reconstruction of major urban highway facilities. This report of the Transportation Research Board highlights the similarities and differences in the planning and management of projects as well as in contracting and financing innovations. Methods for effectively managing traffic during the reconstruction process are important to the process, as are traffic control procedures in the work zone. Public participation and public information dissemination related to traffic changes are vitally important to the effective completion of a reconstruction project. Other aspects, such as the design process, including the use of 3-D and 4-D visualization; pavement renewal procedures; environmental impact mitigation and enhancement activities that are considered in the process are also addressed.

To develop this synthesis in a comprehensive manner and to ensure inclusion of significant knowledge, the Board analyzed available information assembled from numerous sources, including a large number of state highway and transportation departments. A topic panel of experts in the subject area was established to guide the research in organizing and evaluating the collected data, and to review the final synthesis report.

This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As the processes of advancement continue, new knowledge can be expected to be added to that now at hand.

CONTENTS

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James B. Saag, P.E., CH2M HILL, Chicago, Illinois, collected the data and prepared the report.

Valuable assistance in the preparation of this synthesis was provided by the Topic Panel, consisting of Michael M. Christensen, Assistant Division Engineer, Minnesota Department of Transportation; Phillips C. Crocker, Regional Design Engineer, New York State Department of Transportation, Region 8; Cleavon Govan, Senior Environmental Planner, California Department of Transportation, District 7; Frederick D. Hejl, Engineer of Materials and Construction, Transportation Research Board; John P. Kos, Engineer of Project Implementation, Illinois Department of Transportation; George T. Lathrop, Deputy Director, Charlotte Department of Transportation; C. Ian MacGillivary, Director, Engineering Division, Iowa Department of Transportation; Jon Obenberger, Transportation Specialist, Federal Highway Administration; and James R. Robinson, ITS Director, Virginia Department of Transportation.

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PROJECT DEVELOPMENT METHODOLOGIES FOR RECONSTRUCTION OF URBAN FREEWAYS AND EXPRESSWAYS

SUMMARY

The focus of many transportation development programs in urban areas has shifted from the construction of new freeways and expressways to the reconstruction of existing facilities. The cost of reconstruction, in many instances, will exceed the original construction cost, and will likely be the most costly of all projects undertaken by transportation agencies. Moreover, most transportation agencies have limited experience in reconstruction of major highways. Since most urban and suburban freeways and expressways are less than 40 years old, this is a relatively new type of program.

Reconstruction of existing urban and suburban freeways and expressways may be undertaken for any one or a combination of the following reasons:

- Provide additional capacity to meet unforeseen traffic demand;
- Mitigate geometric deficiencies that have resulted in poor operational conditions;
- Bring the highway into conformance with current design standards and criteria in order to improve safety performance;
- Add high-occupancy vehicle (HOV) lanes or other special-use facilities that are intended to improve efficiency and assist in meeting air quality goals; and
- Preserve the existing pavement and structural conditions.

Provision of additional capacity has been the prominent reason for reconstruction, followed by improved safety and conformance with current design standards.

A questionnaire survey of state departments of transportation, as well as several county and toll highway agencies, resulted in 39 agencies providing information on 58 urban freeway and expressway reconstruction projects. Information in the survey responses indicates that a variety of management structures have been developed to administer major freeway and expressway reconstruction projects. The general intent is to shorten the chain of command between the day-to-day project manager and the chief administrative officer. Project management is recognized as one of the most critical elements in successfully reconstructing major urban and suburban freeways and expressways.

Duration of construction is an especially important factor in the reconstruction of urban freeways and expressways. Construction activities impact not only drivers who must use the corridor, but local residents and businesses and the community as a whole. A number of innovative contracting methods are being used, therefore, to speed completion of construction while still maintaining quality. The use of incentive/disincentive (I/D) clauses in construction contracts is now commonplace. A number of transportation agencies have been testing cost-plus-time (A+B) bidding along with I/D. Lane rental, wherein a fee is assessed for the time a contractor occupies or obstructs part of the roadway, is another innovative technique that has been used successfully to lessen the disruption caused by construction. Design-build

contracting is also being tested in several states as a means of both speeding construction and reducing costs.

Considering the massive investment required and the need to compress the implementation schedule of reconstruction projects, many agencies are turning to non-traditional financing sources. The Federal Highway Administration (FHWA) is cooperating with various state DOTs in testing a number of innovative financing techniques including the State Infrastructure Bank (SIB) program, which includes 43 states.

Public involvement and communication are essential to nearly every highway reconstruction project. The need to involve the public transcends all study phases from early planning through construction. There is general agreement as to the importance of early contact with the public. In cases where public and stakeholder support for the reconstruction project was absent, the lack of early public involvement was commonly cited as the reason. Experience has also shown that personal contact and small group meetings are among the most effective means of dealing with the public. The most common forms of communications—newspapers, radio, and TV—are usually the most effective ways of reaching drivers and other travelers directly affected by the project.

There is a sizable difference in the methods employed and the funding that different transportation agencies have allocated for public involvement and information programs. In view of the importance of public involvement and communications, many agencies have found it highly advisable to enlist professional support in handling these functions.

Because urban freeways and expressways usually carry the highest traffic volumes in the urban area, the ability to maintain traffic service in the corridor during reconstruction is of primary importance.

The total cost of the reconstruction project may be considered in the following categories:

- Costs borne directly by the implementing agency, such as for engineering, construction, and administration;
- The additional road-user costs borne by motorists during construction, such as increased travel time, vehicle operating costs, and accident costs;
- Social, economic, and environmental costs borne by neighboring businesses and residents.

An effective traffic management plan is essential to a successful urban highway effort. The three components of a corridor traffic management plan are: (1) a traffic-handling strategy for the highway being reconstructed; (2) impact-mitigation strategies for alternative routes and modes in the corridor; and, (3) a public involvement and information program.

The three general categories of traffic handling strategies are:

- Minor capacity reductions, which provide the same number of lanes on the highway being reconstructed, at least during peak periods,
- Lane closures,
- Total roadway closure.

Even when lane closures during construction are required, experience has shown that many predictions of dire adverse traffic conditions resulting from the closures did not materialize. The most common motorist response to lane closures is diversion to an alternative route. Some shifting in departure times, which spreads out the traffic peaks, has also been observed and some discretionary trips during off-peak hours have been foregone. Experience suggests that a reconstruction project is, by itself, unlikely to cause large numbers of motorists to change long-held travel habits and prompts little or no shift to transit as a consequence of reconstruction.

There is wide variance in experience regarding changes in corridor-wide traffic conditions during reconstruction. Where convenient alternatives exist, motorists are likely to change routes and continue to drive without significant delay or inconvenience. But where roadway alternatives are limited, many travelers may be expected to change to other modes, change the time of travel, or forego discretionary trips.

Impacts to highway users in the construction zone may be mitigated by speeding up the construction process and/or scheduling project activities to minimize impacts. The public will accept delays, but they must also believe that absolutely everything possible is being done to shorten the inconvenience. To minimize severe congestion, many agencies restrict reconstruction activities to hours of off-peak traffic, weekends, and nighttime. Because of the increased emphasis on maintenance and reconstruction of existing facilities, coupled with high traffic volumes in urban areas, there is reason to believe that more night operations will have to be scheduled.

It was reported that, for those projects where significant diversion occurred, most of the diverted traffic was traced to alternative routes in the corridor. Impact mitigation programs can help to improve alternative routes and modes in the reconstruction area. The types of improvements provided are generally minor and the amount spent for mitigation is usually relatively modest. Overall, improvements to alternative routes have been found to be worthwhile impact mitigation actions.

Passive control and active control are two types of speed control in freeway reconstruction zones. Passive speed control refers to posting a reduced speed limit in the construction zone. It is generally sufficient at locations where the hazards are obvious, and drivers have plenty of time to make reasonable and safe speed decisions without special encouragement. Active control refers to techniques that restrict movement, display real-time information or enforce compliance to a passive control. Some active controls applied in construction zones include flagging, law enforcement, changeable message signs, and effective lane width reductions.

Concern for safety in freeway reconstruction work zones is of utmost importance. The disruption of normal driving practice that accompanies construction activities and lane and ramp closures poses an inherent hazard for motorists driving through the construction zone. Typically, agencies reported little change in accident experience during construction, but there are some projects where the crash rate increased significantly. In some instances, however, the increase in the number of crashes was accompanied by a decrease in severe (personal injury/fatality) crashes.

Quick detection and response to freeway incidents takes on added importance during reconstruction. A variety of incident management programs have been developed, most including emergency assistance vehicles. At least one state incorporated the cost of the maintenance of traffic program into the contractor's construction bid, thereby including it in the total capital funding package.

Constructibility reviews, value engineering, and consideration of life-cycle costs are effective quality control techniques commonly incorporated into freeway and expressway reconstruction projects.

Adverse environmental impacts may result from reconstruction projects during the construction period, and sometimes, as with noise, continue after reconstruction is completed.

A number of urban freeway and expressway reconstruction projects include an enhancement element. The predominant enhancement features of such projects are landscaping, aesthetic treatment of noise barriers, pedestrian/bicycle facilities, and illumination.

Three- and four-dimensional computer "visualization" is being employed more often for environmental studies, conceptual design, and development of design alternatives. There is also a role for this newly developed tool when dealing with adjacent landowners and other interested parties.

CHAPTER ONE

INTRODUCTION

Construction of the nation's Interstate Highway System is nearly complete. The emphasis, particularly in urban areas, has shifted away from new construction of freeways and expressways to the reconstruction of these major traffic arteries. When viewed in a nationwide context, the scope and complexity of this reconstruction effort is astounding. The cost of reconstruction in many instances will exceed the original construction cost of the facilities they are replacing. Moreover, reconstruction affects drivers, businesses, and other community functions in ways that are different and of even greater consequence than at the time of the original construction.

Reconstruction of existing urban freeways and expressways may be undertaken for any one, or a combination, of the following reasons:

- Provide additional capacity to meet unforeseen traffic demand;
- Mitigate geometric deficiencies that have resulted in poor operational conditions;
- Bring the highway into conformance with current design standards and criteria to improve safety performance;
- Add high-occupancy vehicle (HOV) lanes or other special-use facilities that are intended to improve efficiency and assist in meeting air quality goals; and
- Preserve the existing pavement and structural conditions.

Most agencies charged with reconstruction of major urban highways have limited experience with this type of project. Yet these reconstruction projects will likely be the most challenging, costly, and time-consuming planning, design, and construction efforts undertaken by state departments of transportation, toll authorities, and local communities. There is particular importance, therefore, in assembling current practices, problems, experience, and lessons learned from completed or ongoing projects to assist planners, designers, managers, and others in developing similar projects.

This synthesis is concerned with limited-access highways—freeways and expressways. It pertains primarily to facilities located within the urban and suburban portions of a metropolitan area (termed "urban" for simplicity) as opposed to rural freeways and expressways. This does not imply that there are not problems with reconstructing other types of highways, or major rural facilities. There are particular considerations, however, with respect to reconstruction of urban freeways and expressways that would not apply to other types of projects. While the synthesis is concerned with highway *reconstruction,* rather than *rehabilitation,* it is recognized that many of the factors considered would apply to both. Reconstruction implies major modification of the highway in contrast with simple overlays or otherwise rehabilitating the roadway surface and structures.

Finally, the synthesis pertains to the "project development" phase of the transportation development process. To understand the implied limits of the synthesis, the total transportation development process, as illustrated in Figure 1, needs to be considered. The process consists of a number of interrelated activities, which include planning, project development, project mitigation, right-of-way acquisition, and design within the framework of continuous public involvement and a seamless decisionmaking process (*1*). Although the emphasis of this synthesis is on activities that generally follow location/design approval, the preceding public involvement, facility planning, operational analysis, and other related activities must also be carried forward.

WHY THIS SUBJECT IS OF COMPELLING IMPORTANCE NOW

According to the Federal Highway Administration (FHWA) *Highway Statistics*, there were 114,900 lane-kilometers (71,400 lane-miles) of urban freeways and expressways in the United States in 1995. These facilities accommodated annually approximately 547 trillion vh-km (340 trillion vh-mi.) of travel, or 27 percent of total travel in urban areas. They are the backbones of our metropolitan areas and important links for regional travel. Without these vital elements of our infrastructure, mobility would break down and the economy would be affected.

Freeways and expressways are among the newest elements of the urban transportation fabric. Nearly all have been constructed in the 40 years since the interstate system was initiated in 1956. Only since the 1980s has the need arisen to reconstruct some of the oldest and most deficient of these highways. Consequently, the techniques for reconstructing urban freeways and expressways are relatively new. Few public transportation agencies have extensive experience along these lines and many are facing this type of reconstruction project for the first time.

The situation takes on even more importance when one considers the economic and environmental impacts associated with reconstructing urban freeways and expressways. First, there is the actual cost of reconstruction, including planning, design, labor, materials, testing, etc. These costs will make up a significant share of most DOT programs over at least the next several decades. Next, there is the economic effect on motorists who may be delayed, detoured, or otherwise impacted by the reconstruction project. Finally, the economic effects extend to the entire community, which relies on the urban freeways and expressways for daily movement of people and goods.

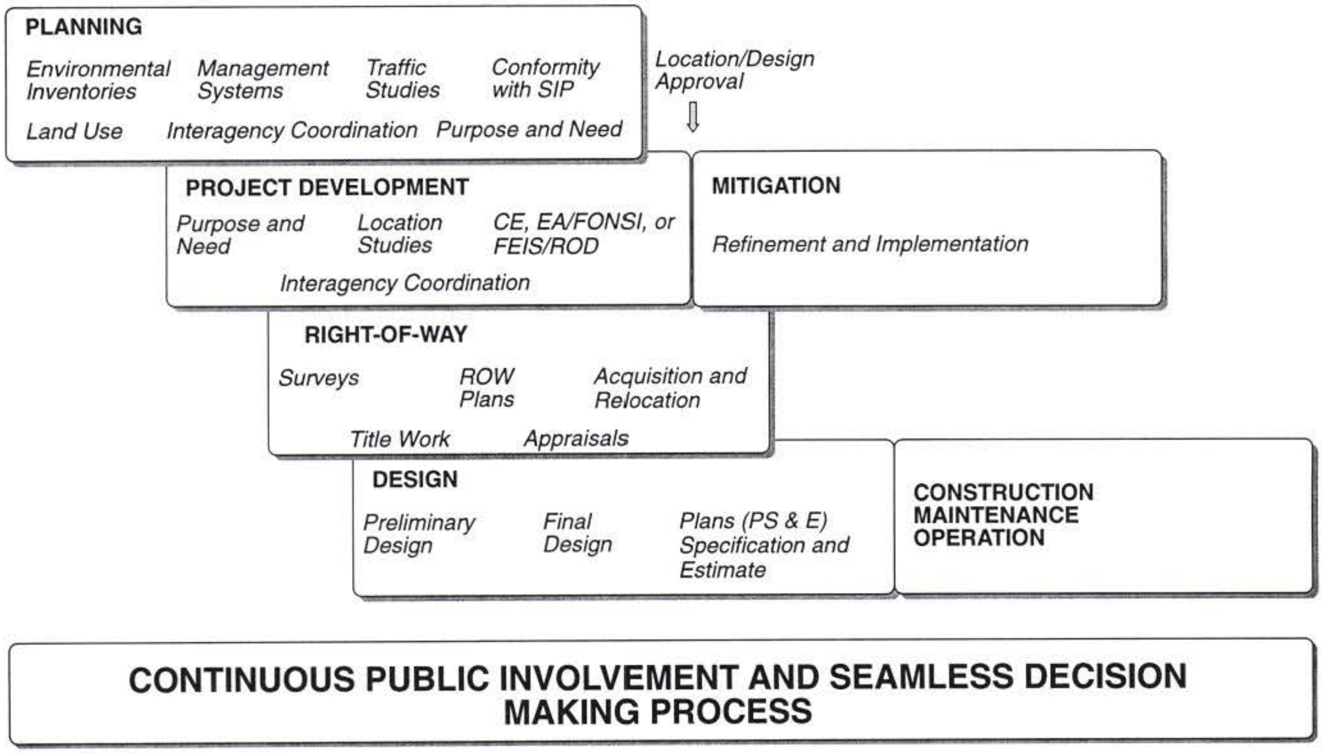

FIGURE 1 Transportation development process (after *1*).

HOW THESE PROJECTS DIFFER FROM OTHER RECONSTRUCTION

Most DOTs and other transportation agencies have been reconstructing existing highways for many years. Why then devote an entire research effort to investigating specifically the reconstruction of urban freeways and expressways? The answer is found in the fact that reconstruction of these particular types of highway poses unique problems or conditions that are not found on other types of facilities. There are special considerations related to the techniques and procedures incorporated in the plans for reconstructing urban freeways and expressways that differ significantly from those employed on other types of highways:

- Because of the huge costs involved in urban freeway and expressway reconstruction, different and innovative financing techniques often have to be found.
- The magnitude of the work to be undertaken often requires organizational modifications at the agency level to ensure that appropriate attention is given to the project without adversely affecting other work.
- Because partial closure or disruption of travel on these important traffic arteries has a daily effect on drivers and the community as a whole, methods of accelerating completion of construction without loss of quality take on even more importance.
- The need for communication with and involvement of the public spans all phases of project development. The audiences involved include: elected officials; other public and agency officials; local residents and businesses; affected drivers and passengers; and others throughout the urban area that are directly or peripherally affected by the project.
- Accommodations must be made for continuance of travel through or around the construction zone. The volumes of persons and vehicles that need to be handled are among the highest that are usually encountered in any urban setting.
- The combination of construction under traffic and heavy traffic volumes results in situations with the potential for unsafe conditions unless anticipated beforehand.

METHODOLOGY

The material assembled for this synthesis was developed from two sources:

1) A review of literature pertaining to reconstruction of urban freeways and expressways, and
2) A questionnaire survey sent to all state DOTs as well as to selected counties and toll highway operating agencies.

The literature review was particularly valuable in uncovering prior experience on various aspects of reconstruction projects. The success or failure of earlier efforts is a useful guide for agencies that are now confronted with the necessity to reconstruct major urban highways.

Because the subject of this synthesis covers a broad range of issues, it was necessary to carefully screen literature references to extract only that information that pertained to reconstruction of urban freeways and expressways. In many cases, entire volumes or previous syntheses apply to just one of the

TABLE 1

SURVEY QUESTIONNAIRE RESPONSES

State DOT or Transportation Agency	Number of Case Study Reports	State DOT or Transportation Agency	Number of Case Study Reports
Alaska	0	Mississippi	3
Arkansas	0	Missouri	1
California	3	Montana	0
Colorado	1	Nebraska	2
Connecticut	2	Nevada	1
Contra Costa County	5	New Jersey	1
Delaware	1	New York	2
Florida (and Turnpike)	2	North Carolina	3
Georgia	2	North Dakota	0
Hawaii	0	Ohio	1
Idaho	1	Oklahoma	2
Illinois	4	Oregon	2
Illinois Tollway	1	South Carolina	1
Iowa	1	Texas	1
Kansas	1	Texas Turnpike	0
Kentucky	2	Vermont	0
Louisiana	1	Virginia	1
Maine	2	Wisconsin	4
Michigan	2	Wyoming	0
Minnesota	1		

elements included in the development process for the type of project being considered. Several of the references were particularly applicable to this subject and are cited frequently in the discussion. Still, there is a great deal more information that could not be included, yet may be valuable to the reader. The following references are recommended for further elaboration:

- Transportation Management for Major Highway Reconstruction, *Proceedings of the National Conference on Corridor Traffic Management for Major Highway Reconstruction,* Transportation Research Board (1986) (Ref. 2).
- *Transportation Research Board Circular 386: Innovative Contracting Practices,* (December 1991) (Ref. 3)
- *Innovative Finance,* Federal Highway Administration, A current bimonthly publication dating back to August 1996 (Ref. 4).
- Krammes, R.A., G.L. Ulman and C.I. Dudek, *Corridor Traffic Management Planning Guidelines for Major Urban Freeway Reconstruction,* Report No. FHWA/TX-91/1188-4F, Texas Transportation Institute, College Station, (Ref. 5).

A copy of the two-part survey questionnaire is presented in Appendix A. The questionnaire first explained the purpose of the project, and then asked each state DOT or operating agency to provide information regarding urban freeway and expressway reconstruction projects they had implemented. If the DOT or agency had no prior experience with this type of project, it was asked to so indicate and return the questionnaire.

Questionnaire responses were received from 39 state, county, and toll highway agencies (see Table 1). Of these, 32 DOTs or other agencies indicated prior experience in reconstruction of urban freeways or expressways. Usable information was provided for 58 separate reconstruction projects. For the most part, the data were not of the type that could be summed or tabulated, but were more descriptive of the particular features of the projects.

The remainder of this synthesis covers:

- Program and Project Development,
- Public Participation and Communication with the Public,
- Traffic Management,
- Construction Management, and
- Other Considerations.

CHAPTER TWO

PROGRAM AND PROJECT DEVELOPMENT

Prior experience in the reconstruction of urban freeways and expressways bears out the axiom that a good job is one that is well started. The decisions made early in the project development process will be largely responsible for success or failure in later stages. Moreover, mistakes made at this early stage are sometimes harder to rectify than those made later.

CRITERIA INFLUENCING PLANNING DECISIONS

A key factor in many of the planning and design decisions required throughout a reconstruction project is the underlying purpose or objective of the project. Some of the prominent reasons for reconstructing an urban freeway or expressway are as follows:

- *Additional Capacity*—Growth of urban areas beyond expectations, or development patterns that have evolved differently than anticipated when the major highways were originally constructed, have produced the need to increase travel capacity.
- *Safety*—Portions of the highways or ramps with a poor safety record warrant study and reconstruction to correct conditions that might be responsible for crashes.
- *Improved Design Standards*—Many urban freeways and expressways were designed and constructed before criteria had been fully developed for this type of facility. The first American Association of State Highway and Transportation Officials (AASHTO) *Policy on Geometric Design of Highways and Streets* was published in 1954 and has been updated several times since *(6)*. Consequently, many existing facilities have geometric or other operational features that are not in compliance with current standards.
- *Add Transit Accommodations, HOV Lanes or Other Special Use*—In response to mobility needs, multi-modal considerations and environmental (particularly, air quality) and capacity concerns, there is a move to increase the people-carrying capacity of existing urban freeways and expressways through provision of features that give priority to high-occupancy vehicles. This may take the form of special and/or reserved lanes along with the ramps or roadway needed to access the special lanes.
- *Infrastructure Preservation*—The pavement, structures, appurtenances, and other features of many existing freeways and expressways have simply worn out through age and heavy usage.
- *Other*—A variety of other reasons, such as changes in development patterns or modification of the arterial street system, also influence the decision to reconstruct an existing freeway or expressway.

State DOT and other transportation agency respondents provided information on 58 prior or on-going urban reconstruction projects. The criteria that influenced the planning decision for each of these projects are illustrated in Figure 2. Most agencies indicated a combination of reasons for freeway reconstruction. Of the reasons given, the most prominent was provision of additional capacity. This was one of the criteria that influenced the decision to reconstruct 45 projects, or approximately three-quarters of the total. The highways where additional capacity was not a criterion were generally established freeways that had already been developed for the maximum practical number of lanes. Examples of these are Chicago's Dan Ryan (I-90/ I-94), Kennedy (I-94), and Stevenson (I-55) Expressways; the Lodge Freeway (M-10) in Detroit and I-75/I-85 in central Atlanta.

Safety and improved design standards, which are highly interrelated, were among the prominent reasons for reconstruction of 30, or about one-half, of the projects. For all but six of these projects, *both* safety and improved design standards were named as criteria that influenced the decision to make geometric improvements.

California has been a leader in provision of HOV lanes on major freeways and expressways. It is not surprising, therefore, that more than one-half of the reported projects for which provision of HOV lanes or transit accommodations was a major influencing factor in the decision to reconstruct were under the jurisdiction of either the California DOT (Caltrans) or Contra Costa County. As some of the environmental concerns that have been particularly influential in California's transportation program spread throughout the remainder of the nation, the provision of HOV facilities is likely to become a more prominent factor in freeway reconstruction. In fact, the addition of HOV lanes to existing freeways and expressways is already being planned and implemented in many other states.

For approximately one-third of the projects reported in the questionnaire survey, preservation of the highway infrastructure was given as a reason for reconstruction. Many urban freeways and expressways are at an age where the useful life of pavement structure and bridge decks have nearly expired. The intent of many reconstruction projects is not only to replace the deficient features, but also to replace them with a new facility that has a longer expected life than was provided for in the original construction.

Other reasons for freeway reconstruction include the provision of access to new developments, completion of partial interchanges, and accommodation of special toll collection systems. A clear understanding of the compelling factors for each project is basic to many of the decisions that will be made later in project development and implementation.

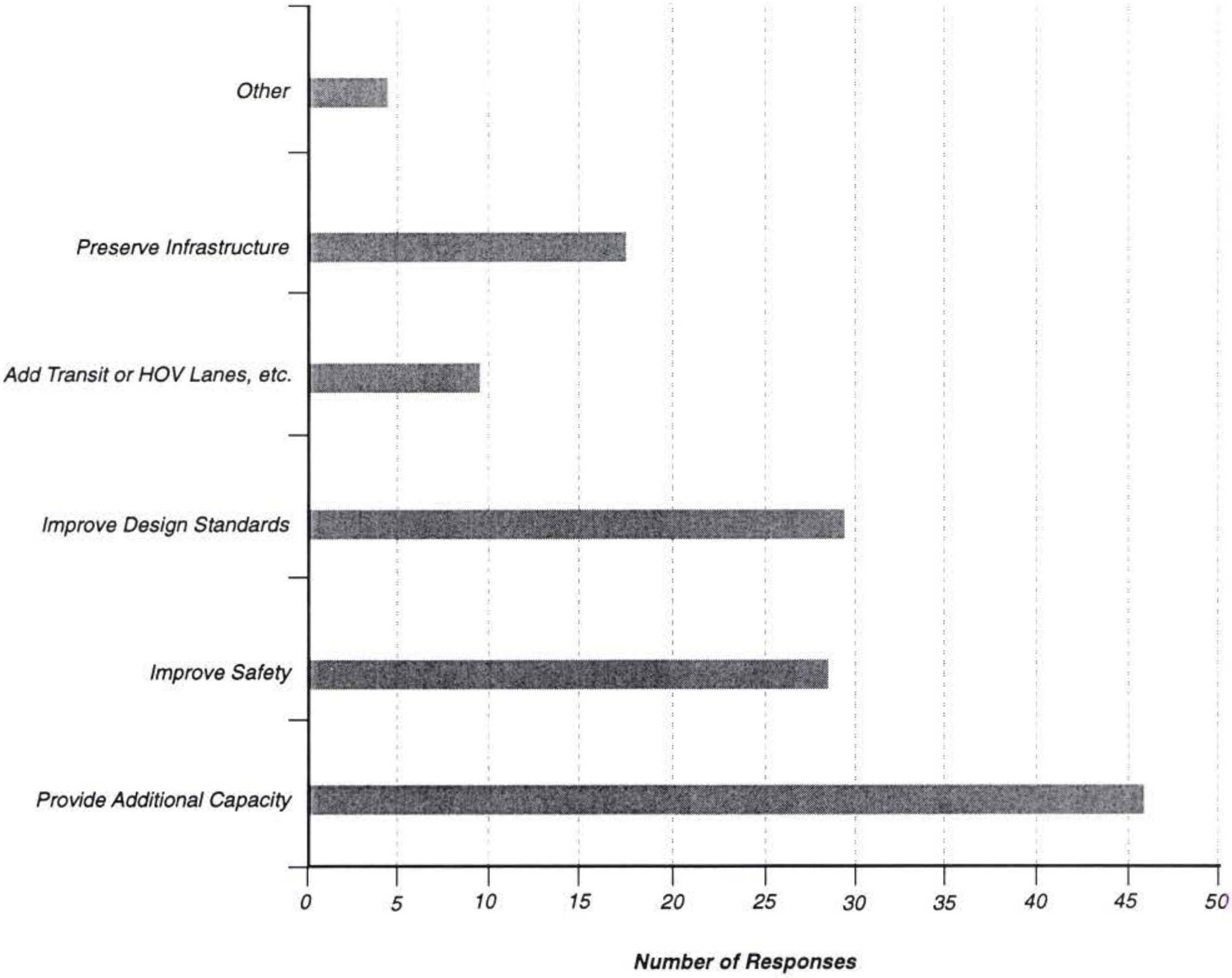

FIGURE 2 Factors that influenced planning decisions for projects reported in the questionnaire survey (after *1*).

MANAGEMENT STRUCTURE

Project management is recognized as one of the most critical elements in successfully reconstructing major urban freeways and expressways. A variety of management structures have been developed for completed projects, each tailored to the particular needs of the undertaking. For many of the largest and most complex projects, a separate department or division has been established within the transportation agency to oversee the activities from preliminary planning through construction. Others have employed a task force or other multi-agency management team. Of the 58 reconstruction projects reported on in the questionnaire survey, 22 used a management structure different from that normally employed by the transportation agency. Examples of some of the management configurations that have been used are as follows:

- I-5 Caltrans—A Steering Committee was formed with subcommittees responsible for landscaping, traffic management, utilities, right-of-way acquisition, and relocations.
- I-80 Caltrans—An in-house project manager was designated along with coordinators of traffic management and public involvement who were dedicated to the project.
- I-70 Colorado DOT—Management designated co-project managers from CDOT and the Denver International Airport (DIA). This project furnished access to the new airport.
- I-75/I-85 Georgia DOT—A special in-house design group was established to develop the project.
- I-94 Illinois DOT—A Steering Committee was formed consisting of upper management of both the IDOT Central Office and the District Office.
- I-235 Iowa DOT—An internal design team has been formed to focus only on this project.
- I-75 Texas DOT—The District created the North Central Project Office to manage design and construction.
- I-94 Wisconsin DOT—A traffic planning group and multi-agency traffic planning committee were formed along with an in-house design team.

One presenter at the TRB Conference on Transportation Management for Major Highway Reconstruction (*2*) stressed the importance of a short chain of command between the day-to-day project manager and the chief administrative officer. Certain issues that arise in the planning and implementation of a major reconstruction project need to be handled quickly and at the highest level.

Approximately one-half of the management structures established for projects reported in the questionnaire survey incorporated a special decisionmaking process to deal with problems during design and construction. Most such processes were anchored by a multi-agency team or task force.

A separate field office was established by TxDOT in the North Central Expressway corridor in Dallas to monitor design of that facility only. At the peak, approximately 20 TxDOT staff were assigned to the North Central office. They monitored consultants responsible for design of five roadway sections and one tunnel drainage project. The field office was closed and its functions transferred to the area engineering offices when the last set of plans was completed. This project-specific field office is generally considered to have been a successful concept for this large reconstruction project.

In Contra Costa County, California, a "trend" team was established consisting of transportation agency and contractor personnel along with representatives of the design consultant and the funding agency. The trend team meetings are held periodically during design and weekly during construction. A number of projects had special teams to deal with specific problems.

DOT staff in Illinois assigned the highest priority to all issues dealing with major freeway reconstruction in order to avoid affecting the project schedule. The Idaho DOT did not establish a special management unit for the I-84 reconstruction project, but acknowledged that, in hindsight, they should have.

PARTNERING

Partnering has gained substantial popularity in project development. Partnering is a voluntary process in which the transportation agency, contractor(s), engineers, other agencies and jurisdictions, and the public come together at the start of a project. They commit to doing everything possible to work in a cooperative manner.

Partnering usually begins with a one- or two-day workshop at which the participants attempt to identify potential problems and plan ahead by establishing procedures to address problems as they arise. The workshop concludes with a "Partnering Charter" signed by all participants.

Responses to the questionnaire survey indicated that partnering was employed on 22 of the case study projects, or approximately 38 percent of the total. On a majority of these reconstruction projects, however, the transportation agency indicated that the partnering only included the agency and the contractor. Consultants were also included in some cases, but the public or affected agencies were involved in partnering for fewer than 10 of the case study projects.

The Idaho Transportation Department (ITD) embraced partnering in the construction of $47 million Cole/Overland interchange in Boise. The partnering participants included the contractors, ITD, and affected citizens. Partnering on this project was so successful that formal partnering is now an element of all ITD major projects. The requirement to partner is specified in the contract documents. The process usually provides for a period each week when citizens have an opportunity to appear before the partnering participants to comment on various aspects of the project.

Partnering was also a feature of the I-180 reconstruction project by the Nebraska Department of Roads. The charter adopted for this project also provided for weekly meetings at which problems could be brought to the attention of the participants for resolution.

CONTRACTING INNOVATIONS

Duration of construction is an especially important factor in the reconstruction of urban freeways and expressways because these facilities accommodate the region's major traffic movements. The length of time during which there are closures or delays during construction affects the motorists through increased user costs; local businesses and residents through disruption of their usual means of access; and the community as a whole through social and economic effects. Because these facilities are the "backbone" of the urban transportation system, extensive delays are less tolerable than for other types of highway. Consequently, many implementing agencies have developed or tested innovative contracting methods that are intended to speed completion of the reconstruction and still maintain quality of the work.

Special Experimental Projects No. 14

In an effort to encourage the use of some nontraditional innovative contracting practices that have the potential to enhance the quality of construction and minimize negative impacts on road users, FHWA embarked on a Special Experimental Project, SEP 14. The objective of SEP-14 is to evaluate "project specific" innovative contracting practices undertaken by state highway agencies that have the potential to reduce the life-cycle costs of projects, while at the same time maintaining product quality (7). Four major topic areas were evaluated by state agencies:

- cost + time bidding,
- lane rental,
- design-build contracting, and
- warranty clauses.

Following an evaluation period, FHWA approved cost + time bidding, lane rental, and warranty clauses as nonexperimental contracting procedures. The design-build concept is still allowed by the FHWA on experimental basis (7).

Cost + Time Bidding

Cost + time bidding, more commonly referred to as A+B bidding, involves contract time with an associated cost in determining the low bid. Under A+B bidding, each bid submitted consists of two parts. The "A" component is the traditional bid for the contract items and is the dollar amount for all work to be performed under the contract. The "B" component is a bid for the total number of calendar days required to complete the project, as estimated by the bidder. The lowest and best bid is based on a combination of the bid for the contract items and the associated cost of the contract time, according to the formula *(7,8)*: A + (B × road user cost/day).

In nearly all cases, A + B bidding is used in conjunction with some other contract provision to assure that the bidder will complete the project within the specified time or sooner. The most common provisions used for this purpose are the incentive/disincentive (I/D) clauses described above. This type of contract is then referred to as A + B, I/D. The FHWA reports that 38 states had entered into contracts with a cost + time element for all types of construction/reconstruction contracts *(7,8)*.

An example application of A + B bidding is the repair of the Santa Monica Freeway (I-10) that was damaged severely by the January 1994 earthquake that rocked the Los Angeles area. The construction cost estimate for the project was $21 million and the cap on the time to open to traffic was set at 150 days. A road user delay cost of $330,000 was calculated on the basis of the number of users and the estimated delay. A daily incentive/disincentive of $200,000, about 60 percent of the calculated road user cost, was included in the contract. The A and B components of the lowest responsive, reasonable bid were $14.9 million and 140 calendar days, respectively. By completing the project 69 days early, the contractor earned an incentive of $13.8 million and saved the traveling public an estimated $22.8 million in road user costs *(8)*.

Lane Rental

Lane rental is intended to encourage contractors to minimize road user impacts during construction. Under this concept, a provision for a rental fee assessment is included in the contract. The lane rental fee is based on estimated cost of delay or inconvenience to the road user during the rental period. The fee is assessed for the time the contractor occupies or obstructs part of the roadway, and is deducted from the contractor's payments.

The rental fee rates are stated in the bidding proposal in dollars per lane per time period. The rental fee rates are dependent on the number and type of lanes closed and can vary for different hours of the day *(7,8)*. Examples of daily and hourly rental charges are shown in Tables 2 and 3 *(9,10)*.

As of 1996, six states had used lane rental and reported favorable results *(7)*. For example:

TABLE 2

EXAMPLE OF DAILY LANE RENTAL CHARGES *(10)*

Closure or Obstruction	Rental Charge ($)
One lane	20,000
One shoulder	5,000
One lane and shoulder	25,500
Two lanes and shoulder	50,000

NOTE: Example is for illustrative purposes only; appropriate rental charge must be determined for each project on a case-by-case basis.

TABLE 3

EXAMPLE OF HOURLY LANE RENTAL CHARGES *(9)*

	Hourly Rental Charge	
Closure or Obstruction	6:30–9:00 a.m. and 3:00–6:00 p.m.	All Other Hours
One lane	2,000	500
One shoulder	500	125
One lane and shoulder	2,500	625
Two lanes	4,500	1,250
Two lanes and shoulder	5,000	1,375

NOTE: Example is for illustrative purposes only; appropriate rental charge must be determined for each project on a case-by-case basis.

- Colorado has used lane rental on a project in the Denver area involving an interchange ramp closure with a rental fee of $2,850/lane/day.
- Oklahoma has used the concept on a project to reconstruct the I-35/I-40E interchange in Oklahoma City at a rental fee of $5,000/lane/day.
- Oregon has awarded contracts for two major reconstruction projects on U.S. 26 in Portland. Rental fees have been established in 15-minute increments and range from $0 to $21,000 for a lane closure.
- Washington is using lane rental on the SR-99 contract. Rental fees are established for half-day ($7,500) and full-day ($15,000) periods of lane closure.

Design-Build

Design-build is a project delivery system in which a single entity provides design services and constructs the project—all under one contract. It is a contracting technique that combines the procurement procedures employed in the traditional engineering and design services contracts with those used in the traditional construction contracts, and thus embodies characteristics of both. These procedures may include prequalification, competitive sealed bidding, and award criteria based on price and other factors *(11)*.

From the contracting agency's perspective, the potential timesavings produced by design/build is a significant benefit. Since final design and construction are performed through one procurement, construction can begin before all design details are finalized. Because both design and construction are performed under the same contract, claims for design errors or construction delays due to redesign are not allowed, and the potential for other types of claims is greatly reduced *(12)*.

Of 58 projects reported in the questionnaire survey, only Colorado reported a design/build type of contract (I-70). However, as of late 1996, three states had completed design/build projects under SEP 14 and 10 others had projects approved or underway *(7)*.

California used the design/build contracting method on several toll road projects in the state. These toll roads include the San Joaquin Hills Transportation Corridor, Eastern Transportation Corridors and Foothill Transportation Corridors. These three corridors will provide over 96 km (60 mi) of new freeways at a cost of approximately $2.5 billion. Although these are new construction projects, the contracting methodology would apply equally to reconstruction.

Utah recently selected a design/build team for a $1.3 billion project to rebuild I-15. The Utah DOT's decision to use the design/build method of contracting was motivated by two factors. The first was the strong public support for completing the project as soon as possible to minimize the period of severe traffic congestion associated with the diversion of more than half of the traffic off of I-15 during the construction period. The second factor was the desire to have the project completed prior to the 2002 Winter Olympics, which will be hosted in Salt Lake City. It was generally accepted that use of the design/build contracting methodology was the only way to satisfy these goals (*13*).

Three contractor groups submitted qualifications and proposals for the I-15 project. The contract was subsequently awarded to the proposer who provided the best value offer to the Utah DOT considering price and other factors. For example, if one of the proposers submitted a proposal that significantly reduced traffic disruption during the construction period or offered a shorter construction period, the value to the traveling public would be taken into consideration in the award process. Each of the unsuccessful contractor groups was paid $950,000 to cover a portion of the proposal development costs, provided that an acceptable bid was submitted. Also, UDOT was then able to use parts of these proposals, if deemed appropriate, in the actual contract with the successful bidder.

In 1987, Florida undertook a state funded design build pilot program. Conclusions from the Florida program were:

- Total time for design/build projects was up to 40 percent less than that required for conventional design-bid projects;
- There was no significant change in project costs;
- Claims were essentially eliminated; and
- Both state and industry participants indicated a majority supported the concept.

Warranty Clauses

Warranties for material and workmanship are common in the construction industry; most performance bonds cover such items for one year following completion of a project. However, the new emphasis on warranties for highway construction involves the guarantee of the long-term performance of highways. In Europe, where warranties have been more prevalent, a long-term warranty typically covers a period of from 2 to 5 years (*12*). The major benefit anticipated by owners from using warranties is the increased quality of the products they purchase with a resulting lower life-cycle cost. Although the results are still inconclusive, all of the DOTs involved are somewhat encouraged with these efforts and are willing to try more such projects (*14*).

Long-term maintenance and warranties were key issues in the development of the Request for Proposals (RFP) for the I-15 reconstruction project in Salt Lake City. The specified maintenance period is 10 years; an initial 5-year maintenance option and five 1-year renewable options covering years 6 through 10.

Performance specifications, as opposed to traditional prescriptive specifications, were used to encourage innovation in construction and design. Performance specifications, when coupled with long warranties, force the successful bidder to make life-cycle cost analyses of all design and construction options. Many design and construction quality related problems do not surface until 15 or 20 years after construction. For that reason, the specifications for the I-15 project were generally a blend of performance specifications and prescriptive specifications (*15*).

Contract Segmentation

For any of a number of reasons, it is often necessary to break the total construction contract into several smaller contracts. Funding constraints are always an integral part of project planning and design. Sometimes, contracts are segmented to facilitate scheduling; there are often situations wherein some phases of the work can be advanced. For example, several transportation agencies have found it expedient to contract for critical materials in advance of the general construction. In some localities it has been found necessary to reduce the size and scope of individual contracts in order to increase competition and to encourage participation by smaller local contractors.

Incentives/Disincentives

Penalty clauses have been commonplace for some time in highway construction contracts. The contractor is given a specified period of time to perform his work, and is penalized an amount equal to "liquidated damages" for each day beyond the deadline. In reconstruction projects, the duration of construction is of particular importance because of the effect on drivers, businesses, nearby residents, and the community as a whole. The concept of providing the contractor an incentive to complete his work ahead of schedule, therefore, has gained popularity among the implementing agencies.

Incentives are used in construction contracting to reduce overall contract cost, to control time, and to increase support of specific performance goals such as productivity, safety, technological progress, innovation, and management (*3*). They are more effective in maintaining project schedule than simple specified completion dates. Expediting completion of construction results in reduced duration of the construction related delays and the least total cost to motorists during construction.

Of 58 projects reported on in the questionnaire survey, 25, or more than 40 percent, incorporated incentives for early completion of construction. The amount of the incentive is usually representative of a portion of the road user savings that result from early completion. Jaraiedei et al. (*16*) suggest that for a contract to be worthy of an incentive/disincentive (I/D) provision, the road user saving must exceed the cost to the contractor of expediting the work. Road user costs consist of items such as increased fuel consumption, increased safety risks, and time lost to long delays or detours. The value of the road user cost due to lost time may be determined using QUEWZ, a computer software package developed by the Texas Transportation

Institute and distributed by McTrans, the Center for Microcomputers in Transportation at the University of Florida *(17)*, or by manual methods or a combination of both. QUEWZ determines additional road user costs in the construction zone, but not those of road users forced to detour.

The daily incentive amount represents a portion of the road user savings to be passed on to the contractor. The basis of the incentive is the amount that the contracting agency is willing to provide the contractor for assuming the extra costs and risks associated with expediting the construction. The same value is commonly used for both the daily incentive and disincentive. The maximum incentive payment is based on how much time can be saved and how much the contracting agency can afford to pay the contractor (*2*).

The Michigan Department of Transportation placed a value on the inconvenience to all motorists caused by reconstruction of the Lodge Freeway at $50,000 per day. This amount was budgeted into the cost of construction. The contractor then was offered a bonus of $30,000 per day, up to $1 million, for completing the project earlier than the projected finish date. The money helped defray the contractor's cost of paying overtime and provided incentive to complete the project early. Also included in the contract was a provision for the contractor to pay the state a like amount for every day the project exceeded the agreed upon completion date. The contractor completed the project 30 days early, earning $900,000 in addition to the base fee. The estimated savings realized by all motorists amounted to $1.5 million, for a net savings of $600,000. Because of the success of the Lodge Freeway Reconstruction Project, the department has adopted the process for future projects (*18*).

No Excuse Bonuses

The Florida DOT has implemented a system of bonuses intended to reward a contractor for early completion of a contract. The bonus can be tied to either milestones, a final completion date, or both. These bonuses differ from incentive/disincentive clauses in that bonuses do not allow for any time extensions. They are tied to a "drop dead" date (time frame) that is either met or not met. There are "no excuses" allowed for weather delays, and other such issues, which normally extend contract time (*12*).

Reconstruction of I-4 in Orlando had "no excuse" bonuses of $500,000 at each of three milestone dates.

Cost Reduction Incentive Program

Contra Costa County (California) includes a Caltrans provision in bidding documents that gives the contractor an incentive to reduce total project costs. The Cost Reduction Incentive Program (CRIP) provides that the contractor and the state share equally in any cost savings realized from project modifications brought forth by the contractor. The contractor makes recommendations to the Caltrans engineer who determines the acceptability of the proposal based on its ability to reduce costs without impairing service life, economy of operation, ease of maintenance, desired appearance, or design and safety standards *(19)*. Such a provision was included in the contract documents for a Contra Costa County project to reconstruct SR 242 and SR 4.

INNOVATIVE FINANCING

Considering the massive amount of investment required and the need to compress the implementation schedule of reconstruction projects, many agencies are turning to nontraditional financing sources. It is likely that many of the major freeway reconstruction projects undertaken by state DOTs and other implementing agencies over the next several decades will find it necessary to combine some of the nontraditional financing sources now provided for in federal programs with the traditional sources used up to this time.

In response to the increased interest in new methods of financing highway improvements, the FHWA launched, in August 1996, a bi-monthly publication entitled *Innovative Finance* (*4*). This publication is contained in several technical journals and is available electronically through the FHWA's Internet home page. This is the best source of up-to-date information on innovative financing techniques and their application throughout the United States.

Innovative financing techniques that have been used by state and other transportation agencies, as allowed by the FHWA, include leveraging tools designed to increase the funds available for transportation infrastructure investment, and cash flow tools, which are designed to more quickly advance project construction. Examples of both types of technique as described in *Innovative Finance* are provided below.

Flexible Match

Flexible match is a program allowing states to apply the value of third party donated funds, materials, or services toward their share of the project costs. The Maryland DOT is currently crediting $8 million in private funds toward its matching share of project costs for the reconstruction of a portion of MD 355 in Montgomery County (*4*).

Public-Private Partnerships

Similar to the flexible match, the public-private partnership makes use of private donations to cover part of the cost of reconstruction. This type of arrangement generally comes into play for improvements supporting a particular private development. In Kansas City, private donations covered approximately one-half of the cost of I-435 interchange improvements that were required to accommodate traffic generated by new developments. The amount assigned to private sources was determined by the proportion of the total new traffic that would be generated by the new development. The remainder was paid by the Jackson County Urban Road System *(20)*.

Another example of public-private partnering in financing highway reconstruction is found in Northern Virginia where certain interchange and mainline improvements were needed to support new residential and commercial development *(21)*. The public and private funding sources were leveraged to provide more improvements than either sector could have individually provided. A case study of this project prepared by Papazian provides further details *(21)*.

Soft Match

Current legislation allows states to earn credits on toll revenue expenditures, which can then be applied toward the non-federal matching share of current federal-aid projects. The New Jersey DOT, for example, is using a soft match to help finance the construction of a southbound viaduct over the Waverly Yards in Newark, which was demolished to accommodate reconstruction of the northbound viaduct.

Tapered Match

Tapered match allows states to vary the required matching ratio over the life of a project. The Washington State DOT (WSDOT) is using a tapered match to help finance the construction of HOV lanes on SR 520, northeast of Seattle. Tapering the federal share allows WSDOT to begin construction of the project a year earlier, while achieving better cash flow management.

Shared Resources

Shared resources are private donations of communications technology (principally fiber optic communications) granted in exchange for access to public rights-of-way. The Missouri DOT has entered into an agreement with a fiber optic communications firm that will provide the DOT with access to an extensive communications network in exchange for granting the firm access to the public rights-of-way. In addition, the FHWA has recognized the value of the donation and is allowing Missouri DOT to receive credit toward its matching share on ITS deployment projects in the St. Louis area.

State Infrastructure Banks

The U.S. DOT has established a system of state infrastructure banks (SIBs), which are intended to stretch limited federal dollars. The program was authorized by Congress in 1995 as a 10-state test. In June 1997, U.S. DOT added another 29 states and Puerto Rico to those already in the program *(4,22)*. Four more states were added in the Transportation Equity Act for the 21st Century (TEA-21). SIBs can offer:

- Lower-cost financing than otherwise may be available to a project sponsor;
- Flexible repayment terms that can be tailored to a project's needs; and
- Credit enhancements that improve a project sponsor's access to bond issuance's and other forms of financing.

Initially, Congress authorized $150 million for the SIB program. This was increased by another $150 million in 1996.

A SIB can provide many types of financial assistance, ranging from loans to credit enhancements. Forms of assistance may include interest subsidies, letters of credit, capital reserves for bond financing, construction loans, and purchase and lease agreements. Missouri, for example, plans to hold funds in its SIB to cover debt service reserve requirements as part of a future bond issuance for Missouri Highway 179. These funds will only be used on an as-needed basis.

Unlike traditional transportation funding, a SIB can provide financial assistance throughout all stages of transportation project development and to a multitude of project sponsors. Furthermore, SIB assistance can be set at any amount or percentage of the total project costs, rather than the traditional fixed percent contributions.

By the end of 1998, U.S. DOT expects the first 10 banks to use $324 million in regular federal aid to help finance as much as $1.6 billion in projects *(22)*.

Value Capture

Value capture refers to a type of public/private partnership in which the private sector compensates a public agency for the cost of a facility that generates economic value. Reconstruction projects may create or improve the adjacent market for new development, and thus generate a windfall for private landowners. In turn, value can be captured by public agencies through any of a variety of mechanisms, such as: special assessment districts; joint public-private development of adjacent sites; pre-purchase and subsequent sale or lease of adjacent sites; tax increment financing districts; and others.

For Denver's E-470 tollway, the E-470 Public Highway Authority levied a value capture tax equal to 25 percent of the increase in property tax revenues collected within the highway corridor. Revenue from the value capture tax and a motor vehicle registration fee enabled the E-470 Authority to issue bonds *(10)*.

CHAPTER THREE

INVOLVING AND INFORMING THE PUBLIC

Public involvement is an integral element of nearly every highway reconstruction project. Moreover, public involvement transcends all of the development phases of these projects. In the earliest project stage, when the planning and design phases are just evolving, contact with the affected constituency has proven to be an effective tool in building project support. During development of design plans, it is important to involve the local business and residential communities with regard to construction schedules, detour routes, and access provisions. As construction begins, changes in roadway availability, access restrictions, and detours must be communicated to local businesses and residents and to the motoring public.

Highway reconstruction projects have wide-ranging impacts throughout the community. They affect users of the highway who are required to accept certain inconveniences or alter their travel habits. Local businesses and residents are affected by construction operations, access restrictions, and changed traffic patterns. The economic effects of a major reconstruction project extend well beyond the project limits.

There are two distinct elements, therefore, that comprise the public involvement process: (1) the public participation program, which begins at the outset of project development and continues until completion, and (2) communications with the public regarding construction schedules, access restrictions, detour routes, etc. that begin in the design phase and continue until completion of construction. While the audiences within each of these elements are sometimes similar, different methods of communication are employed depending on the particular project development stage.

THE IMPORTANCE OF EARLY AND CONTINUOUS PUBLIC PARTICIPATION

In 1986, the Transportation Research Board convened a conference on Corridor Management for Major Highway Reconstruction *(2)*. One roundtable considered the importance of public participation in the policy and plan development phase.

> Most roundtable participants agreed that the potentially damaging political effects of reconstructing major highways can be avoided by *early coordination* with concerned neighborhood groups, civic associations, local elected officials, and representatives of all affected local, state, and federal agencies, as well as the news media. When planners involve these groups at the outset, they have the opportunity to establish the need for the project and discuss the process being used to identify timing and construction details and possible impacts. Early coordination with all groups could also help the project sponsor determine the most appropriate mitigation measures.

Responses to questionnaire surveys that were part of this synthesis indicated general agreement with the importance of early contact with the public. There was public/stakeholder support for the vast majority of the improvement projects, but in cases where this support was absent, the lack of early public involvement was commonly cited as the reason.

The New York State DOT indicated that there was highway user support for the I-490 and I-590 Eastern Expressway Outer Loop Interchange improvement, but residents in the vicinity of the highway never accepted the solution. It is the DOT's belief that if interaction with the local task force to provide public input had been started earlier, the result may have been buy-in of the recommended solution by the public.

The North Carolina DOT also cited insufficient citizen involvement in early planning phases as a reason for lack of public/stakeholder support for the I-85 reconstruction project in Durham. Other transportation agencies (Florida, Mississippi, and Oklahoma DOTs) suggested that if given the opportunity, public involvement activities would have begun earlier.

Public Involvement Participants

Along with timing of public involvement activities, an early determination is needed of the persons and agencies to be reached. The range of constituencies that are brought into the planning process varies by type of project and type of area. The following is a list of some of the constituencies that may be considered as suggested at a national conference convened by the TRB *(15)*:

- Neighborhood and civic groups,
- Homeowners associations,
- Utility companies,
- Business associations,
- Chambers of commerce,
- Elected officials,
- Police and fire departments,
- Municipal engineering and public works departments (and traffic engineering departments, if separate),
- Regional and local public transit agencies,
- Privately owned transit companies,
- Automobile clubs,
- Trucking companies and associations,
- Regional and municipal planning agencies,
- Public school officials,
- Officials responsible for the safe shipment of hazardous materials,
- Media traffic reporters,
- Construction management professionals and contractors, and
- Others.

Early coordination and scoping with environmental natural resource agencies are also important aspects of agency involvement.

Involving every constituency early in project development can serve to build acceptance even when the parties do not get exactly what they want *(22)*. In planning for the I-74 freeway reconstruction in Peoria, the Illinois DOT found it important to remain flexible toward stakeholder identification as the project unfolded. Several months after project development began, some neighborhood groups surfaced that believed they were not being included. By adding these groups to the project committee and holding meetings with them, potential opposition was avoided. These groups could have proved more contentious had the DOT not veered from the original membership or meeting schedule.

The Importance of Personal Contact

As long ago as 1983, an FHWA survey of the use of public involvement techniques by state highway agencies found a trend toward smaller meetings *(23)*. Small group meetings were found to be used widely in the systems planning or programming phase. It is believed that many citizens find it difficult to understand and participate in the rather abstract future-oriented and technical subject matter of systems planning.

More emphasis on personal contacts is suggested, especially in the infant stages of project planning. Asking people to attend evening meetings can often be unproductive, especially when construction is still years away or there is little early controversy. But, informal meetings with landowners, interest groups and individuals in their homes or at a neutral location such as the local coffee shop often is useful for the exchange of information.

COMMUNICATING WITH THE PUBLIC

A variety of public information techniques may be used to disseminate information to the public. The appropriate tools depend on both the intended audience and the type and amount of information provided. Krammes et al. *(5)* group the available techniques as described below.

Traditional Public Information Tools

Traditional public information tools encompass press conferences, media events, press tours, press kits, news releases, public service announcements, interviews, and public meetings and presentations. Except for the latter, these are methods of providing general information to a large audience through newspaper, radio, and television. They are relatively inexpensive, unless paid advertising is used. However, in many cases one does not have control over what information is provided to the public, because media personnel interpret and edit coverage to fit their own time and space limitations.

Special Publications

Special publications may include posters, pamphlets, newsletters, maps, and special mailings. Experience indicates that these techniques can be effective at: 1) informing the public of the presence of construction and of changes in condition that may occur as the work progresses, and 2) promoting commuter use of alternative routes and modes during construction. These publications may be distributed at the project or public information office, public meetings, public displays at shopping malls or major employers, and presentations to special groups. They may also be mailed separately, included as inserts in utility or telephone bills, or used as handouts at toll booths or information centers.

Toll-free Hotlines

Toll-free hotlines provide a way for the public to obtain up-to-date information concerning traffic conditions and construction schedules as well as to voice their concerns and complaints about a project. A hotline may be operated with staff personnel or by using recorded messages.

Telephone hotlines provide the public with immediate access to information on reconstruction projects and a forum for praising or condemning those projects. While they can be effective during the early weeks of a project, they have several drawbacks. They are labor-intensive and, consequently, costly to operate. They can be overrun with nonproject questions, and require staff and agency dedication to be effective. Frequently, hotline use dwindles markedly after a few weeks, no matter how successful or controversial the project may be.

Marketing and planning personnel on the Minnesota DOT I-394 project believed that their telephone hotline was valuable only during the early weeks of the project. A telephone hotline set up in conjunction with the establishment of HOV lanes on the Santa Monica freeway in Los Angeles received more than 800 calls on the project's opening day. This dropped off to less than 50 calls per day in just two weeks.

Changeable Message Signs

Changeable message signs can be effective at keeping motorists informed about lane closures and changes in traffic control during the project. When using changeable message signs, it is important that available guidelines on their design and application be followed *(5)*.

Special Informational Signing

Special informational signing is a commonly used technique. This category includes: 1) special signing designating alternative routes or warning of changes to a traffic control plan such as ramp closures, and 2) large billboard advertisements to encourage ridesharing during construction.

Highway Advisory Radio

Highway advisory radio (HAR) is another aspect of a successful public involvement program. It provides drivers with real-time information concerning travel conditions on the freeway under construction as well as on alternative routes in the corridor. The ability of highway advisory radio to influence driver travel patterns has been well documented, and guidelines regarding the operation of highway advisory radio are available *(5)*.

A survey was conducted for the Minnesota DOT of persons who either used or lived adjacent to the I-35W reconstruction zone in the Twin Cities. One objective of the survey was to determine the impact and effectiveness of the HAR system. The survey found that *(24)*:

- Nearly two-thirds of the drivers sampled reported that they saw a sign on I-35W asking them to tune to AM 1610 for more information about road construction,
- One of four persons who saw the HAR sign actually tuned in to AM 1610,
- Of those who tuned to AM 1610, more than half (54 percent) actually took the suggested alternative route, and
- Of the total drivers sampled, nine percent said they chose to use an alternate route after tuning to AM 1610.

The HAR seems to have attracted attention, therefore, and persuaded some drivers to choose an alternate route. The project clearly left a favorable impression of Minnesota DOT in the minds of many respondents *(24)*.

An Ombudsman

An ombudsman is a government official who investigates citizens' complaints against a governmental agency. On several projects, an ombudsman has been designated to work with community organizations as well as individuals to resolve home or business problems related to dust, noise, cracked walls, or other impacts caused (or perceived to be caused) by the construction.

Emerging Technologies

Emerging technologies of various kinds are being developed that could be used effectively during reconstruction projects either now or in the foreseeable future. For example, two experimental systems being tested in the Houston area are: 1) the use of cellular telephones to transmit real-time information to and from a central control center, and 2) the installation of video monitors in the Greenway Plaza complex to provide information on traffic conditions during the US-59 Southwest Freeway reconstruction project. Internet websites are also gaining prominence as a means of communicating information. As these and other technologies become available, their application to reconstruction project public information programs should be evaluated.

EFFECTIVENESS OF PUBLIC INVOLVEMENT TECHNIQUES

The types of media used to inform the public with regard to reconstruction plans may be viewed in three ways: first, the forms of media used by the transportation agencies in communicating with the public; second, the sources of information as viewed by the public; and third, the usefulness of the various forms of information in the opinion of the users.

The questionnaire survey asked each transportation agency to specify what forms of media were used in communicating with the public for each reconstruction project. The results for 58 projects reported on are shown in Figure 3. Nearly all projects provided press releases as a public information tool. Public meetings were also a popular venue recognizing, however, that many such meetings were held to fulfill legal or procedural regulations. Radio and TV slots were used as a public information tool on more than one-half of all projects. Some other media forms that were used by the implementing agencies are shown in Table 4.

Experience indicates that public information strategies used most frequently by the transportation agencies were selected based on their effectiveness in reaching the public. The Massachusetts Highway Department (formerly Department of Public Works) conducted a survey of 6,000 households obtained from the license plates of motorists using Boston's Southeast Expressway during reconstruction *(25)*. One question asked the respondents to list up to three sources of information that they were exposed to on alternative means of travel. The responses to this request are summarized in Table 5.

It is noteworthy that the two predominant forms of communication—newspaper, radio, and TV—are also among the most frequently used by the transportation agencies to reach the public. However, public meetings, which were the second most popular media form used by the transportation agencies, were barely mentioned by the respondents in Boston.

In a survey conducted for the Minnesota DOT of drivers traveling through the Highway 169 construction zone in suburban Minneapolis, nearly half (47 percent) of the total number surveyed recalled seeing safety related media messages about construction zones. Of those who were aware of such messages, 44 percent indicated seeing something on television, 24 percent heard messages on the radio, 16 percent read about it in the newspaper, and 14 percent recalled seeing the messages on billboards *(26)*.

The Pennsylvania DOT (PennDOT) surveyed motorists who were users of the Schuylkill Expressway (I-76) during the period of reconstruction to determine how they received information about the project and the usefulness of the information *(27)*. Figure 4 depicts the responses to the question regarding how useful the drivers found certain types of information. Nearly 85 percent of the survey respondents to the PennDOT survey indicated that radio and TV programs provided useful information about the project. The other big winner in the usefulness contest was the category, "Advisory signs along roadways." Of the motorists who recalled these signs, 70 percent said they were useful. The least useful sources were those that provided information on forming car/vanpools and using

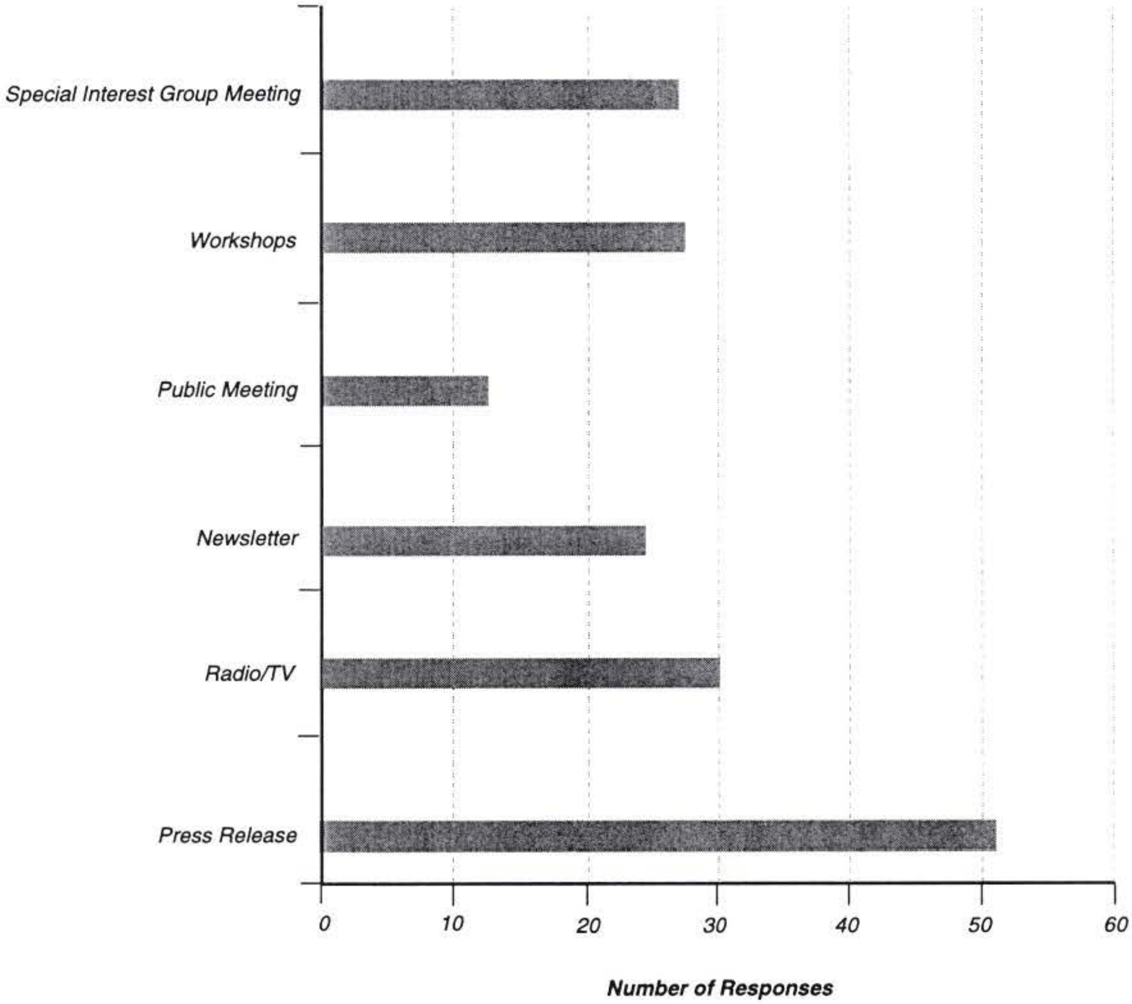

FIGURE 3 Media forms used by transportation agencies to communicate with the public.

TABLE 4

OTHER MEDIA FORMS REPORTED IN THE SURVEY

Other Media Forms	Number of Projects
Meetings with Homeowners/Neighborhood Associations	11
Meetings with Business and Civic Groups	5
Meetings with Special Interests (Schools, Hospitals, etc.)	4
Speakers Bureau	3
Satellite Office near the project	2
Miscellaneous Other	15

TABLE 5

SOURCES OF INFORMATION ON TRANSPORTATION ALTERNATIVES DURING RECONSTRUCTION OF SOUTHEAST FREEWAY IN BOSTON *(26)*

Sources	Respondents
Newspaper	345
Radio/television	300
Word of mouth	158
Pamphlet	82
Poster	33
Community meetings	13
Telephone information line	7

NOTE: Respondents were asked to list no more than three sources.

transit, despite fairly widespread knowledge of the existence of these sources. PennDOT was particularly disappointed with how few of the survey respondents even indicated knowledge of some other tools, such as a Commuters' and Visitors' Guide, published four times during the reconstruction, or the PennDOT hotline, which fewer than 30 percent recalled knowing about and less than 10 percent found useful. PennDOT spent more than $750,000 to print over three million brochures and expended more than 40,000 staff-hours at a cost of nearly one-half million dollars for the hotline. There was apparently a very low rate of return on these two expenditures.

ADMINISTRATION OF THE PUBLIC INVOLVEMENT PROGRAM

In response to the survey questionnaire, more than one-half of the transportation agencies indicated that programs to

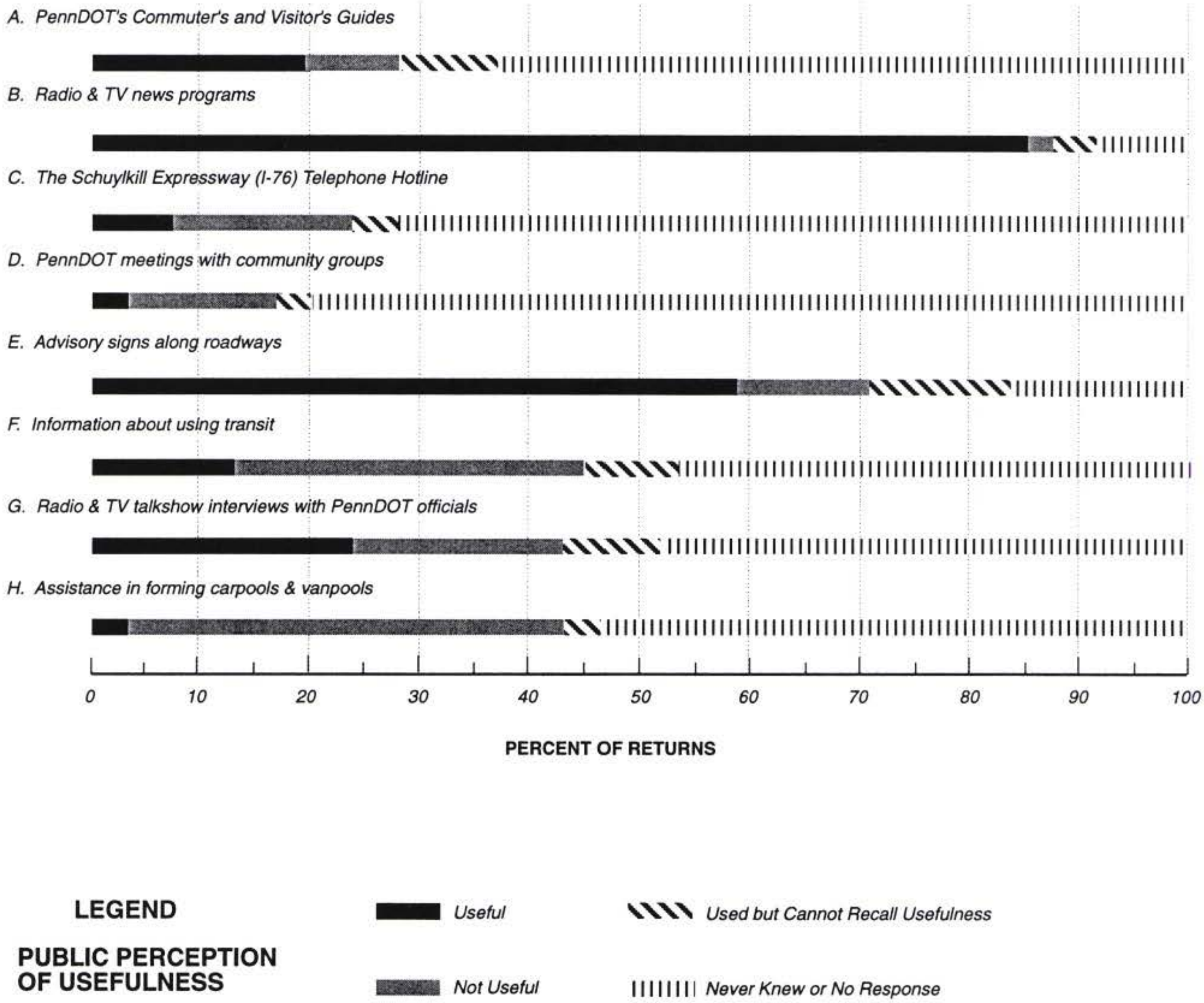

FIGURE 4 Public perception of the usefulness of information provided in connection with reconstruction of the Schuykill Expressway in Philadelphia *(10)*.

involve the public with reconstruction projects were conducted entirely with agency staff. Of the remainder, about one-quarter used an outside consultant and one-quarter relied on a combination of agency staff and outside consultant.

Because of the size and complexity of the work, urban freeways and expressway reconstruction projects are more likely than others to require outside assistance in the important task of reaching the public. There are some areas, however, that are generally always the obligation of the public agency. These include communicating with elected officials and dealing with the general public on matters of right-of-way.

A wide range of expenditures for public relations was reported in the questionnaire survey. On projects handled entirely by an outside agency, the estimated cost of public involvement was as much as $5 million. Even at the higher cost level, however, the amount spent on a public involvement program still amounted to less than one percent of total construction cost. One highway agency indicated that it believed public involvement to be the most cost-effective of any of the processes included in project development. The broad range of costs incurred for public involvement underlines the diversity of public involvement or public outreach for urban freeway reconstruction projects.

The matter of responsibility for public involvement on reconstruction projects was defined as follows at a National Conference on Highway Reconstruction sponsored by the TRB *(2)*.

> Public information is by far the most critical ingredient in a successful major reconstruction project. The public information aspects of major reconstruction projects are too critical to assign to an engineer, no matter how skilled. A trained public relations and communications expert should be assigned to the project. The expert will advise on how to educate the public about possible problems, inform them when things are going to happen, advise them on alternatives, and explain things that don't go quite right. In the final analysis, of all of the experts, the public relations and communications expert will have been the most valuable.

GENERAL CONCLUSIONS

The following general conclusions may be drawn from prior experience in public involvement and communication for urban freeway reconstruction projects:

- Public involvement and an effective public information program is especially important in freeway and expressway projects because of the sheer size of such projects as well as their substantial impact on drivers, local residents and businesses, and the community as a whole.
- Early interaction with the public is a key ingredient in building project support.
- Small meetings and person-to-person contact are the most effective means of communicating with the public local interest groups, agencies, public officials and neighbors.
- The most common forms of communication—newspaper, radio, and TV—are usually the most effective means of reaching drivers and other travelers directly concerned with the project.
- Because of the importance of public involvement and communications, it is highly advisable to enlist professional support in handling these functions.

CHAPTER FOUR

TRAFFIC MANAGEMENT

Planning the reconstruction of a major urban highway is different from the typical transportation planning effort in several ways. First, there are two major groups that will be affected by the reconstruction—the users of the facility and those who live in areas that will experience increased congestion as a result of diverted traffic. Second, the types of actions that need to be considered in reconstruction planning range from those that require physical construction (e.g., park-and-ride lots) to changes in functional behavior (e.g., variable work hours). Third, there is more urgency to complete the reconstruction than for most other types of projects.

A corridor-wide perspective for assessing traffic-handling strategies and construction staging is required for reconstruction projects. The components of a corridor traffic management plan are as follows *(29)*:

- A traffic-handling strategy for the highway being reconstructed,
- Impact-mitigation strategies for alternative routes and modes in the selected corridor,
- Scheduling construction activities to minimize impacts, and
- A public information program.

The traffic-handling strategy addresses the accommodation of traffic in the reconstruction zone. Scheduling of construction activities is a tool often employed to lessen impacts to highway users. Impact-mitigation strategies are transportation system management actions to increase capacity and improve the level of service on alternative routes and modes. The public information program educates the public about the reconstruction project, prevailing traffic conditions, and travel alternatives. The first two of these three interrelated components are discussed in the following sections. Public information programs are discussed separately in chapter 3.

Planning for major reconstruction of the I-94 Menomonee Valley Bridge in Milwaukee began with the recognition that the project had the potential to severely impact the mobility of the community and access to the downtown business and lakefront recreational areas. The Wisconsin DOT created a Project Traffic Planning Committee that proved to be an effective means to develop an overall traffic management plan that resulted in coordinated efforts by the DOT and local agencies to handle the freeway operation and diverted traffic. The Committee worked effectively in developing a traffic mitigation plan. A new position of Public Information Officer was also established for this project to develop a program to keep the public informed of all aspects of the project *(30)*.

TRAFFIC-HANDLING STRATEGIES

Because urban freeways and expressways usually carry the highest traffic volume in the urban area, the ability to maintain traffic service in the corridor during reconstruction is of primary importance. Roadway space must be divided between the required construction activity and the motoring public. The basic problem in planning reconstruction projects is to determine the best allocation and use of the limited available roadway spaces *(5)*. Krammes et al. explain:

> The way in which roadway space is used has significant cost implications. The best allocation and use is the one that minimizes the total cost of the project. It must be remembered that the (implementing agency) itself is not the only entity that bears cost. Motorists and neighboring communities also bear costs associated with freeway reconstruction projects. The total cost of a project may be divided into three categories:
>
> - The costs borne directly by the (implementing agency), including the cost of developing the plans for the project, the cost of actually performing the work, and the cost of administering contracts and inspecting the work.
> - The additional road user costs borne by motorists throughout the affected corridor, including increased travel-time, vehicle-operating, and accident costs that result from reductions in traffic-handling capacity and changes in roadway geometry.
> - The social, economic and environmental costs borne by neighboring businesses and residents.

All of these costs need to be considered in arriving at the recommended strategy.

New Technologies Applications

The Advanced Traffic Management System (ATMS) program of the FHWA is dedicated to addressing the application of new technology to increase the efficiency and safety of roadway operations while minimizing their impact on the environment. State-of-the-art transportation systems may be used effectively in development of traffic control strategies and the analysis of traffic control plans for work zones.

Several traffic simulation tools are available for use in evaluation of freeway maintenance/reconstruction activities. In 1989, Zhang, Leiman, and May developed a simulation model, FREQ10PC, designed to quantitatively predict freeway performance under different reconstruction plans *(31)*. Applications of this methodology to two major reconstruction projects showed it to be effective in evaluating the operational effects of freeway maintenance/reconstruction activities.

FHWA's new micro-simulation model, CORSIM, is the heart of the Traffic Software Integrated System (TSIS). CORSIM is a sophisticated micro-simulation model based on the older FRESIM and NETSIM models. CORSIM simulates a real-world traffic network by moving individual vehicles across a combined surface street and freeway network using accepted vehicle and driver behavior models and simulating various traffic control devices. It predicts how traffic engineering and transportation systems management strategies affect a prescribed network's operational performance as expressed in terms of various measures of effectiveness (MOEs). This is a state-of-the-art tool that is available to simulate alternative strategies and evaluate performance and impacts.

Alternative Strategy

Traffic handling strategies are grouped by Krammes and Ullman *(29)* in three general categories:

- Minor capacity reductions—the narrowing of lane and or shoulder widths to maintain the same number of lanes on the highway being reconstructed, at least during peak periods.
- Lane closures—the closure of some, but not all, lanes in one or both directions of the highway being reconstructed.
- Total roadway closure—the closure of all lanes in one or both directions of the highway being reconstructed.

Minor Capacity Reductions

In reconstruction of the Katy Freeway (I-10) in Houston, the project contract required that the number of lanes open to traffic on the freeway during peak periods be the same during reconstruction as before reconstruction. Lane closures were permitted only during off-peak periods.

For reconstruction of Boston's Southeast Expressway, the state transportation agency devised a strategy to keep four lanes open in the peak direction at all times *(26)*. The roadway was divided into four sections as shown in Figure 5. The reconstruction would begin on the outside two lanes on the northbound side with the remaining two lanes serving northbound traffic at all times. The southbound roadway was divided into two parts with 8.5 miles of barriers. The two lanes between the barriers and the expressway median were reversible lanes. By designing the traffic management scheme this way, Massachusetts DPW engineers were able to provide the same number of lanes in the peak hour direction during the project as there were before. When the two lanes under construction were finished, the next two northbound lanes would be closed to traffic and the finished lanes would be opened to traffic.

Lane Closures

The questionnaire survey conducted for this synthesis indicated that the number of lanes remaining in service was a criterion used in planning for the reconstruction of every project. Off-peak lane closures were permitted for 12 projects, with all lanes remaining open during peak periods. Several of the projects also stipulated that lane closures were not permitted during holiday periods or when there were special events (e.g., fairs, festivals, athletic events, etc.).

The Illinois DOT in reconstruction of the Edens, Dan Ryan, and Kennedy expressways in Chicago maintained at least two lanes of traffic in each direction. Work on the Dan Ryan Expressway was performed over two construction seasons. During the first phase of reconstruction, traffic was restricted to two lanes in each direction using the northbound structure while the southbound structure was being rebuilt. During the second phase, traffic was placed on the new southbound structure providing three lanes southbound and two lanes northbound while the northbound structure was being rebuilt *(32)*.

During the 2-year reconstruction period for the Parkway East (I-376) in Pittsburgh, parkway traffic was limited to one-lane in each direction and on-ramps at four interchanges were closed *(33)*. Because there were few other routes available for motorists in this corridor, a large package of improvements to alternative routes and modes in the corridor and an extensive public information program were implemented. Despite a large reduction in the effective capacity of the Parkway East

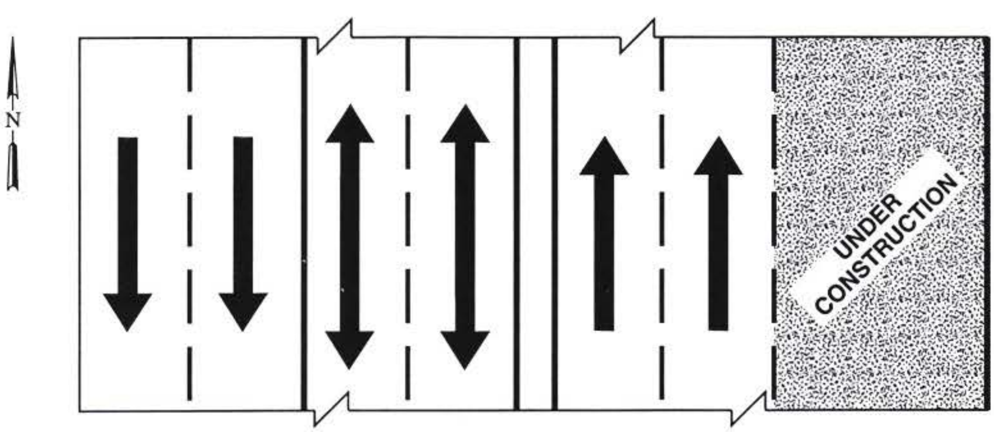

FIGURE 5 Lane configuration during construction of Boston Southeast Expressway *(26)*.

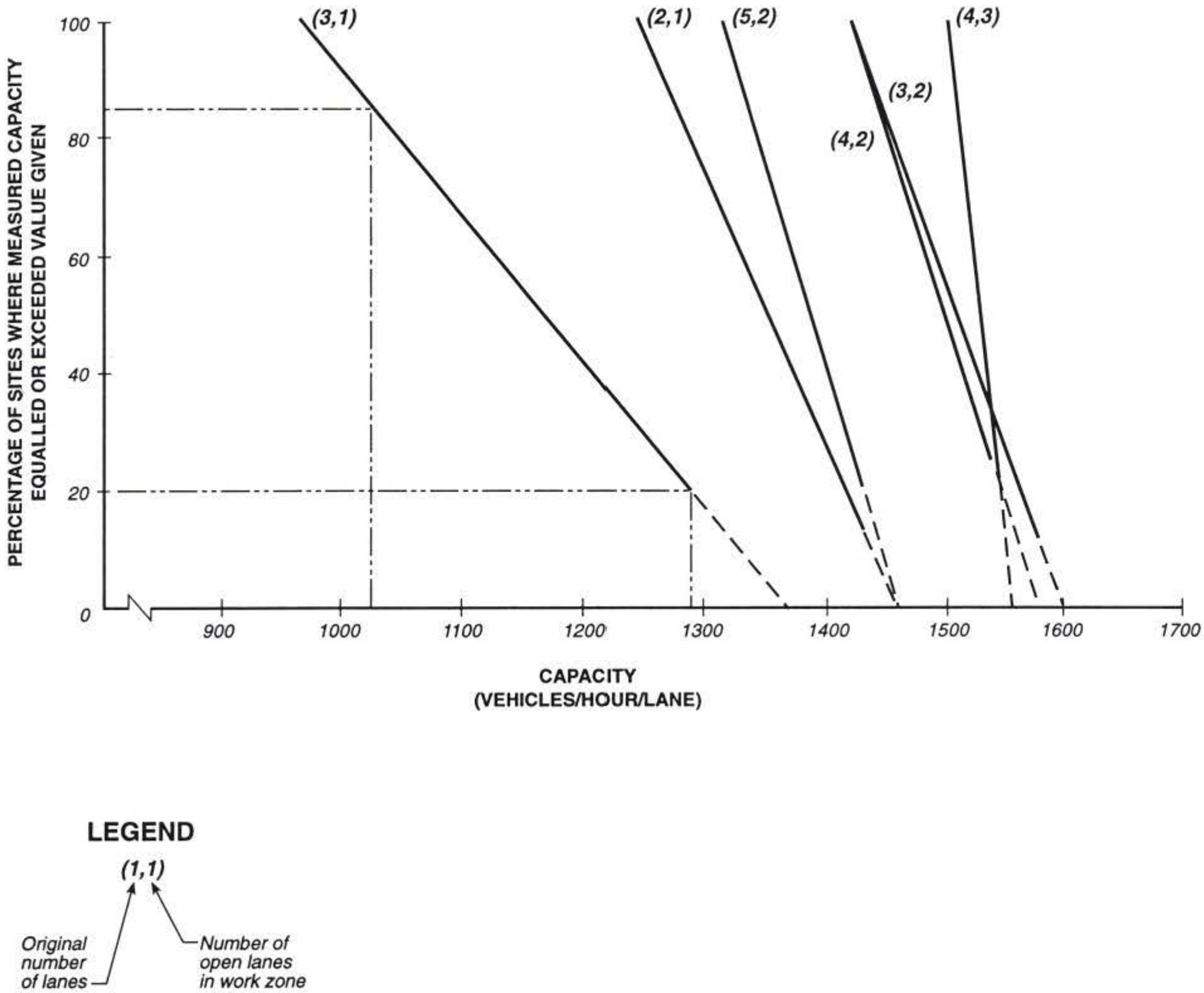

FIGURE 6 Cumulative distribution of work zone capacities *(38)*.

and a large diversion of traffic in the corridor, the overall traveler impacts and responses to the reconstruction were small. Changes in route choice and somewhat earlier departure times for work were the primary responses.

Experience has shown that many predictions of dire conditions resulting from lane closure during reconstruction do not materialize. As with the Edens Expressway in Chicago, predictions of chaos resulting from the traffic restrictions on the Parkway East in Pittsburgh were quite exaggerated *(34)*.

The heavily traveled Schuylkill Expressway (I-76) in Philadelphia is predominantly a four-lane facility. Two lanes of traffic were reconstructed at a time. Two-lane, two-way traffic was maintained on one directional roadway while work was performed on the other roadway. The outside shoulders were upgraded to allow traffic to operate on the shoulder and the median lane with a buffer lane in between. The traffic management plan was designed to enable trucks, visitors, and long-distance travelers to remain on the expressway and to encourage short-distance, local drivers to divert from the expressway. A key to diverting traffic was the closure of most of the entrance ramps and some of the exit ramps within or leading to the reconstruction zone.

Krammes and Ullman *(29)* summarize experience with lane closures as follows:

> Significant traffic volume reductions were observed at the Chicago, Pittsburgh and Philadelphia reconstruction zones. In Chicago, the AADT was approximately 30 percent less during reconstruction, and peak period volumes decreased by nearly 35 percent. In Pittsburgh, a 60 percent reduction in daily traffic volumes was observed. The most common motorist response was diversion to an alternative route. Some shifting in departure times, which spread out the peak periods, was also observed. The use of mass transit and ridesharing modes was heavily promoted, but accounted for only a small portion of traffic diverted. An overall assessment of these reconstruction projects indicates that the reconstruction was accomplished within a reasonable period of time, that the impacts on motorists were minimized to the extent possible, and that the inconveniences and delays that did occur were well tolerated by the public.

Memmott and Dudek *(35)* assembled data from which a cumulative distribution of work-zone capacities could be made for lane-closure combinations. See Figure 6. The numbers in the parenthesis indicate the original number of lanes and the number of open lanes through the work zone. For example, the 85th

percentile for the (3,1) situation is 1,030 vehicles per hour per lane (vphpl). This means that 85 percent of the studies conducted on three-lane freeway sections with one lane open through the work zone resulted in capacity flows equal to or greater than 1,030 vphpl. The capacity flow was equal to or greater than 1,290 vphpl in only 20 percent of the cases studied.

Dudek et al. *(36)* investigated single-lane closures in one direction versus a crossover with two-lane, two-way traffic operations on nine highway reconstruction projects in Texas and Oklahoma. Their cost analysis failed to indicate if either of the traffic control approaches offered cost savings under certain conditions. The best approach from a cost standpoint would appear to depend on site characteristics and details of the construction work.

Total Roadway Closure

The John C. Lodge Freeway (US 10) was closed in each direction for reconstruction over a 14 km (8.7 mi.) section in downtown Detroit. Total closure was made possible in the case of the Lodge Freeway by the availability of appropriate alternative routes with adequate capacity to ease the traffic backup to a great extent *(37)*.

In Syracuse, New York, bridge deck rehabilitation and substructure repairs required the total closure of the 4.5 km (2.8 mi.) three-lane viaduct and adjacent structures carrying southbound traffic on I-81 through the I-690 interchange *(22)*.

For both of the projects cited above, the most common motorist response to total roadway closure was to use alternative routes in the corridor. The HOV measures that were initiated or expanded during reconstruction attracted little or no increase in ridership, due largely to the availability of unused capacity on the alternative highway routes and to the lack of a travel time advantage for HOV modes. Travel times in the corridor increased, but motorists were well aware of the project, why it was important, and what travel alternatives were available. As a result, the inconveniences were well tolerated and the overall public response was positive.

The Lafayette Bridge in downtown St. Paul, Minnesota, was closed to traffic for reconstruction. Traffic was detoured around the construction zone, and Mn/DOT participated with the metropolitan transit operator in providing additional service as well as park-and-ride facilities. The transit alternative was successful in this case.

Portions of the interchange of the I-84 and I-91 in Hartford (the "busiest crossroads in Connecticut") and the freeway approaches were closed to traffic *on weekends* to facilitate reconstruction. A detour route plan was also developed, and improvements were made to some detour routes.

A study conducted for Mn/DOT asked drivers traveling through the Highway 169 construction zone in suburban Minneapolis, "Which of the following scenarios would you most prefer—always keeping at least one lane open during the construction project with assumed congestion, delays and a longer construction schedule, or closing the road completely, assuming no access for a short period of time and reducing the construction time by one-half?" Of the drivers surveyed, 57 percent opted for closing the road completely, and 43 percent to keep one lane open. Of drivers who used the road less often 74 percent showed a clear preference for closing the road during construction *(26)*.

SCHEDULING CONSTRUCTION ACTIVITIES TO MINIMIZE IMPACTS

Actions can be taken during construction to mitigate the impacts on highway users, local residents and businesses, and the community as a whole. Two basic methods of achieving this are through speeding up the construction process and/or scheduling project construction activities to minimize impacts. These two objectives have sometimes been viewed as competing, but at the TRB Conference on Transportation Management for Major Highway Reconstruction, Harvey Haack of the Pennsylvania DOT explained the trade-offs as follows *(2)*:

> This (trade-offs between speeding up the construction process or scheduling to minimize impacts) is, in a way, a false issue. Every project is different—its setting in the transportation picture, the type of traffic it carries, the work to be done. A better issue is the maintenance of the movement of people, goods and services to the greatest extent possible and fitting this movement into a construction plan that is as rapid as possible. The interests are not competing ones that can or should be the object of a trade-off analysis. If serious disruptions are unavoidable, then incentive/disincentive contracts (Chapter 2) are indicated. The construction industry can respond to a challenge to speed work. They also can respond with surprising ingenuity to work around traffic. However, the plan must be well thought out from the point of view of design. The biggest challenge is changing the institutional aspects of normal highway construction to meet the special needs of a potentially disruptive project. Once a project is no longer business as usual, the industry will respond successfully. Once traffic restrictions are in place and construction is underway, the public expects to see daily progress. If all they see is one crew doing one operation, the public's confidence will erode. Every portion of the work zone should have work going on. To the extent possible, the construction schedule should demand this. Only then is the price the public is paying in travel delay tolerable.

The public will accept delays—they expect delays—but they must also feel that absolutely everything possible is being done to shorten the inconvenience.

The average duration for projects submitted in response to the questionnaire survey was 3.5 years. However, construction of approximately 40 percent of the projects was completed in less than 30 months, indicating a recognition of the urgency of minimizing the duration of disruptions. Still, some of the most difficult landmark reconstruction projects such as U.S. 75, the North Central Expressway in Dallas, have had a construction duration extending for a much longer period. North Central Expressway construction, which began in 1990 and is still underway, is one of the five reported projects with construction duration of more than 6 years.

For the projects submitted in response to the questionnaire survey, the length of time during which traffic was disrupted by construction activities averaged approximately six months less than the total construction period. In the reconstruction of

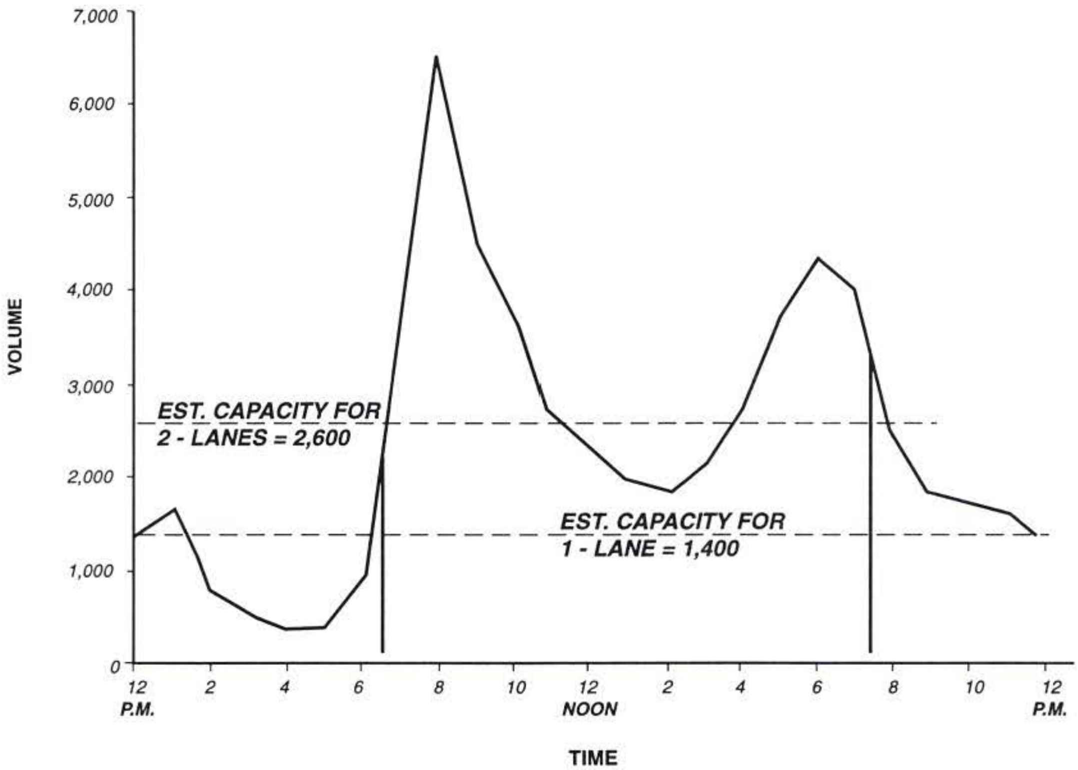

FIGURE 7 Volume distribution for three-lane freeways and estimated work area capacities *(38)*.

Chicago freeways, the Illinois DOT was able to hold the time during which traffic was affected to less than one-half of the total duration of construction by accomplishing all of the off-highway elements either before or after lanes were closed or altered to allow mainline construction.

To minimize heavy congestion, many agencies have restricted reconstruction activities to hours of off-peak traffic, weekends, and nighttime. There are two main reasons for conducting night operations: (a) to allow work over a longer period of light traffic than is possible during the off-peak period between the morning and afternoon rushes, and (b) to decrease or eliminate the excessive traffic delays and congestion associated with lane closures during the daytime *(37)*.

The ability of a lane closure strategy to accommodate traffic is the main determinant of whether operations will be conducted during the day or at night. Any strategy that does not adequately accommodate the traffic demand during the anticipated lane closure necessitates the consideration of alternatives to daytime work, especially if the strategy imposes excessive congestion. A procedure frequently used to investigate congestion is simply to plot the hourly volumes for the time period during which the work is to take place. For example, Figure 7 shows the volume distribution of a three-lane freeway during the probable construction period along with estimated capacities for the work area. It is apparent that two lanes will handle the demand during the mid-day period; however, this time period is too limited for the work to be accomplished. Also, the analysis indicates that there is a lengthy period of time each night when two lanes can be closed and only one lane will be needed to handle the traffic. The times at which the lanes can be closed and reopened to traffic can also be obtained by noting when the traffic demand and capacity are in the same range.

According to Shepard and Cottrell, the following factors should be considered when analyzing the feasibility of night operations *(37)*:

a) Determine if delays associated with potential daytime closures will be excessive.
b) Determine if cost is a factor including possible extra costs and possible cost savings.
c) Determine if adequate time is available during night for work.
d) Decide if possible secondary considerations are significant:
    - Safety, including hazard potential, poor visibility, high speeds, impaired drivers,
    - Noise, including noise ordinances and proximity to residential areas, hospitals, and
    - Quality of work, which may be lower.

Although some agencies accept long delays as being part of daytime roadwork, others do not and opt for night work, even though working at night is usually considered the least attractive alternative. Because of the increased emphasis on maintenance and reconstruction of existing facilities, coupled with high traffic volumes in urban areas, there is reason to believe that more night operations will have to be scheduled. Community awareness and buy-in to nighttime construction activities is always an important prerequisite. Nighttime work can have critical neighborhood effects such as noise, vibrations, light, etc. An especially sensitive requirement to consider is the effect on low income and minority populations in the freeway corridor.

TRAFFIC IMPACTS OF RECONSTRUCTION

Reconstruction of major urban freeways and expressways, regardless of the traffic handling strategy, is certain to impact travel habits and patterns. Krammes et al. *(38)* studied travel impacts resulting from five reconstruction projects in Texas and six projects in other states. Their major findings with regard to experiences at projects throughout the United States were as follows:

- The percentage reduction in average daily traffic volumes was approximately equal to the percentage reduction in capacity at reconstruction zones on heavily traveled urban freeways.
- Traffic volumes on the freeway varied considerably during the first several weeks of reconstruction while motorists experimented with alternative routes and adjusted their travel patterns.
- Among those motorists who changed their travel patterns, diversion to another route in the corridor was much more common than diversion to another mode (mass transit, ridesharing).
- Some discretionary trips during off-peak periods were canceled during reconstruction.
- Little change in total corridor-wide traffic volumes was observed at projects where complete screen lines were monitored.
- Changes in corridor-wide traffic conditions were relatively minor at some projects, but were fairly substantial at others.

Of all of the five projects in Texas that were analyzed, the same number of freeway lanes as existed before reconstruction were maintained. Minor freeway capacity reductions were associated with off-peak lane closures, reductions in lane and shoulder widths, and detours within the right-of-way. In general, none of the five projects had serious adverse impacts on traffic patterns or conditions either on the freeway or elsewhere in the corridor.

A total of 23 questionnaire responses were received regarding changes in traffic volume and travel impacts resulting from reconstruction projects. The range of percent traffic reduction during reconstruction was from 0 percent to 40 percent. The highest percentage reductions were reported by the Illinois DOT for reconstruction of the Dan Ryan and Kennedy Expressways in Chicago (20 to 40 percent) where there were lane reductions on facilities already operating at or near capacity.

Mn/DOT began reconstruction at the I-94 bridge in the Twin Cities by cooperating with the metropolitan transit operator in the provision of additional bus service during reconstruction of this span at the University of Minnesota. About one-third of the way into the reconstruction, the transit program was dropped. It appeared that drivers found other routes; there was no detectable change in travel patterns as a result of construction activities.

For reconstruction of a 10-mile stretch of I-66 in Virginia, the Virginia DOT determined that a reduction of 400 peak-hour vehicles would maintain traffic operational conditions at pre-construction levels. This reduction in peak-hour travel was the target of a congestion management program developed by VDOT. The program consisted of four primary elements: public information; traffic operations; transit/travel demand management (TDM); and incident management. Estimated cost of the congestion management program was $5.6 million, or slightly less than four percent of total project cost. Because the congestion management program was effective in achieving the goal of moving people through the construction zone as efficiently as before construction, VDOT plans to implement this type of program as an integral part of all future major construction projects *(39)*.

The 1994 freeway closures in California caused by the Northridge earthquake provided local planning agencies with an unusual opportunity to track and analyze traveler response and behavioral thresholds to transportation system changes *(40)*. The behavioral changes that occurred after the earthquake varied greatly by corridor and were largely a function of travelers being attracted to the most reliable and convenient alternatives to the damaged freeways. Where numerous convenient roadway alternatives existed that allowed travelers to change routes and continue to drive without significant delay, there was very limited shift to ridesharing and transit. By contrast, where roadway alternatives were limited, many travelers changed to transit and ridesharing, changed their time of travel, or eliminated discretionary trips.

Keeping the maximum amount of traffic on the highway under reconstruction, rather than diverting it elsewhere, has certain obvious advantages. One is that commuters who can continue to use familiar routes to work are less likely to be unhappy about some delay. Another is that it helps to avoid any suggestion that the project will create traffic congestion on both the subject highway and its parallel routes. Yet another advantage is that keeping trucks on the highway under construction may prevent drivers from seeking shortcuts to alternative routes through sensitive residential areas *(2)*.

IMPACT MITIGATION FOR ALTERNATIVE ROUTES

Impact mitigation techniques are improvements to alternative routes and modes in the reconstruction corridor that help accommodate the traffic that diverts from the construction zone. A wide range of transportation systems management (TSM), transportation demand management (TDM) and traffic engineering techniques may be employed to: increase the capacity and improve operating conditions on the alternative routes in the corridor; or improve service and increase ridership on public transit and ridesharing alternatives *(5)*.

Federal funding has been used for a variety of mitigation features. Funds have been used for public relations programs, traffic control, traffic incident detection and management during construction, purchasing buses, and creating one-way pairs or "offset lanes" (four in one direction and two in the other, instead of three each way) and other traffic engineering techniques *(2)*.

One of the problems that planners face in preparing a corridor management plan is that they cannot always accurately predict the relative effects of alternative mitigation measures. Trip distribution, modal split, and traffic assignment models often provide numbers that are too gross to forecast precisely the effects of any particular mitigation measure. In some instances, especially where metropolitan planning organization (MPO) area-wide travel data are somewhat outdated or insufficiently detailed, sponsors may take a special origin-destination survey of project corridor traffic as the first step toward planning needed mitigation measures. Without current data on travel and the highway/transit network inventory, judging the effectiveness of alternative mitigation strategies can become subjective *(2)*.

In anticipation of large volumes of traffic diverting to alternative routes, impact mitigation measures on arterial streets in the affected corridor have been implemented as part of several reconstruction projects. These improvements have included the following *(28)*:

- Traffic Signal Improvements
  - —Adjustments in signal phasing and timing
  - —Improvements in signal equipment (temporary traffic signals, traffic actuated signals, computerized signal control systems, etc.)
  - —Deactivating signals

- Other Intersection Improvements
  - —Temporary left-turn prohibitions
  - —Parking restrictions
  - —Improved signing, lighting, and pavement markings
  - —Police officer control during peak periods
  - —Intersection channelization
  - —Intersection widening

- Other Roadway Improvements
  - —Reversible lane on an arterial street
  - —Converting streets to one-way pairs
  - —Pavement marking changes to add additional travel lanes
  - —Mid-block parking prohibitions
  - —Pavement surface improvements
  - —Signing and lighting improvements.

Overall, improvements to alternative routes have been worthwhile impact mitigation actions. For those projects where significant diversion occurred, most of the diverted traffic was traced to alternative routes in the corridor.

Of the projects named by respondents to the questionnaire survey, 28, or one-half of the total, had designated detour routes. Of these, 13 indicated that improvements had been made to the alternative routes to accommodate the diverted traffic. Another six projects incorporated improvements to alternative routes even though specific detour routes had not been designated.

The amount spent for mitigation of traffic impacts is usually relatively modest. For reconstruction of the I-94 Menomonee Valley Bridge in Milwaukee, the Wisconsin DOT established funding of $600,000 for the first year's traffic mitigation program *(29)*. Of this amount, $174,000 was set aside for traffic operations improvements, such as revisions to traffic signal timing and phasing; signing and marking; parking restrictions; and temporary traffic signal installations by the City of Milwaukee. Also to protect the capacity of the local street system, the city established priorities strictly limiting the times and conditions when city crews, private contractors and utilities were permitted to perform work on the major alternative routes. The city contacted property owners on critical routes to solicit their cooperation in scheduling truck deliveries and railroad and port authorities to schedule their crossings and bridge openings to avoid peak periods.

Arterial improvements planned as part of the I-95 reconstruction project in Pennsylvania addressed the corridor requirements not only during reconstruction, but also for the mid- and long-term. While initially considered an add-on, the Arterial Improvement Program (AIP) came to be viewed as an integral part of the project. By improving traffic signal coordination, the AIP laid the groundwork for the corridor ITS program. Perhaps even more importantly, the AIP was a sign to neighborhood groups that PennDOT was making an effort to manage the disruptions to be caused by the reconstruction process *(41)*.

The costs of improvements on alternative routes vary widely. Some improvements, such as signal timing changes, are relatively inexpensive. Other improvements, such as intersection channelization and widening or changes in signal equipment, are more capital-intensive. From a practical standpoint the less expensive techniques are easiest to justify and should be given first consideration. Some of the higher cost improvements may not be cost-effective based solely on benefits during the reconstruction project. However, if these are improvements that remain in place after the project is completed, the cost-effectiveness evaluation should include the post-construction benefits. It may be possible to accelerate the implementation of improvements already planned for alternative routes so that they are in place before construction begins *(5)*.

Use of TDM and TSM to encourage motorists to shift trips to public transit, HOV, or other support facilities or services is another strategy for reducing demand through the construction zone and mitigating the impacts of diverted traffic elsewhere in the corridor. Furthermore, a reconstruction project may provide the additional incentive some motorists may need to change their mode of commuting and may be seen as an opportunity to produce desired increases in transit ridership and ridesharing. Many TDM and TSM techniques are available to promote public transit and ridesharing as travel alternatives, including *(5)*:

- New or expanded bus service,
- Preferential treatment for buses and HOV facilities,

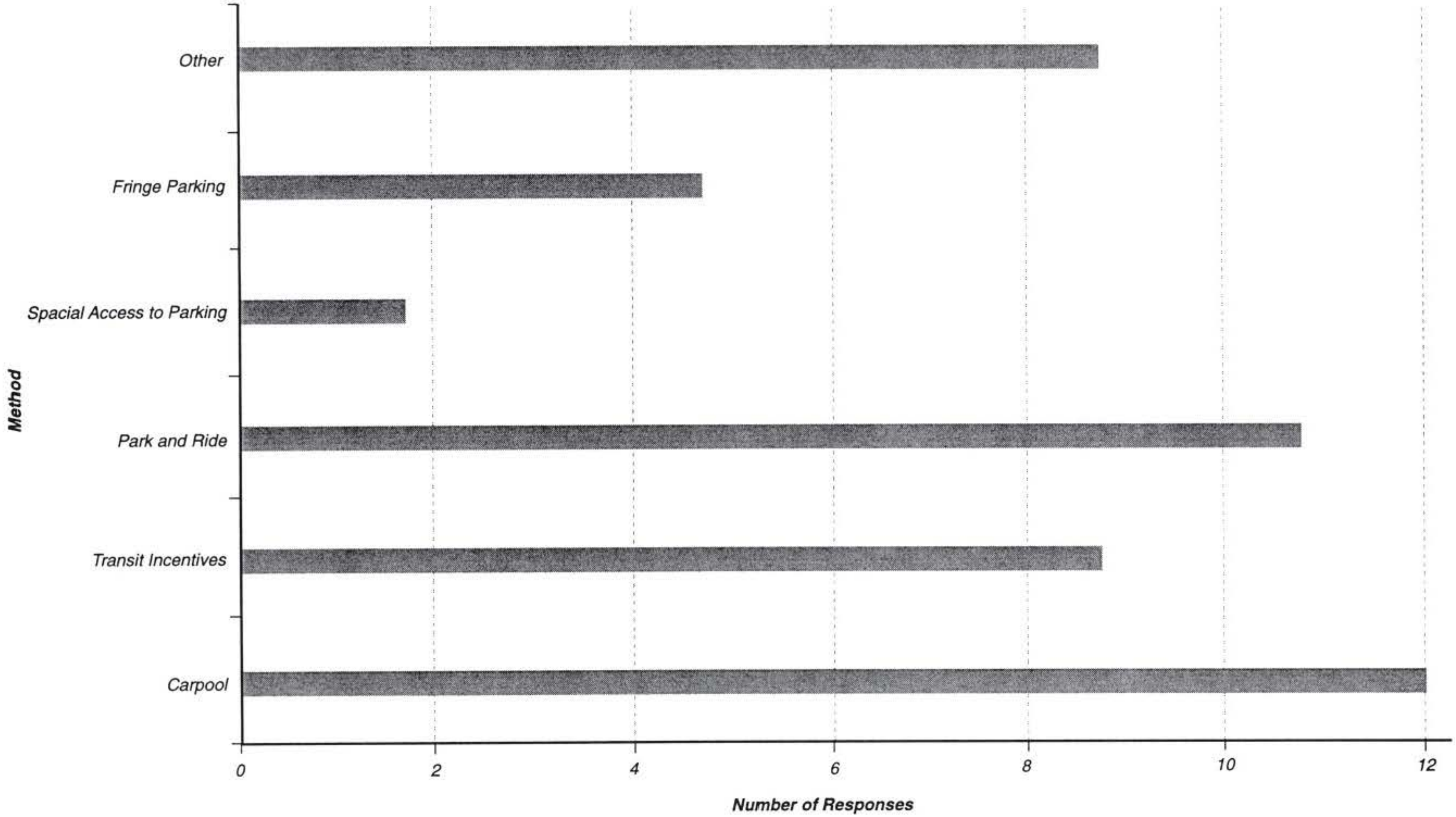

FIGURE 8 Transportation demand management strategies used by survey respondents to mitigate corridor impact during construction.

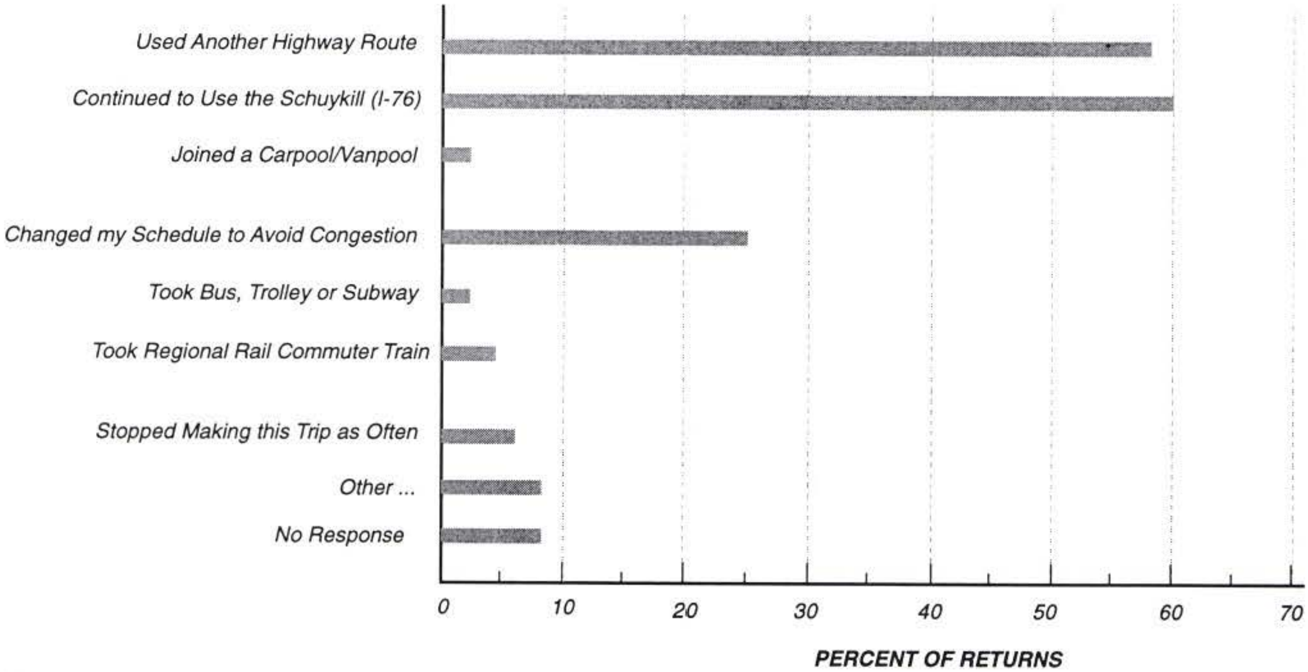

FIGURE 9 How motorists coped with reconstruction of the Schuylkill Expressway in Philadelphia *(28)*.

- New and expanded commuter park-and-ride lots,
- New or expanded ridesharing programs, and
- New or expanded rail service.

Figure 8 illustrates the questionnaire responses to questions concerning the use of TDM techniques to reduce traffic volumes or increase vehicle occupancy during construction. The DOTs and other implementing agencies who responded to the survey relied mainly on car pooling, transit incentives, and provision of park-and-ride lots to encourage use of modes other than the auto. However, TSM techniques were only utilized as a corridor management technique on 20 of the 59 projects submitted. Where these techniques were utilized, most agencies believed them to be effective.

Most reports indicate that TDM-type improvements had relatively little impact on transit ridership or ridesharing. Surveys of travelers in the Parkway East (I-376) reconstruction corridor in Pittsburgh suggested that there was little modal change despite provision of some transit and ridesharing incentives *(32)*. Changes in route choice and somewhat earlier departure times for work were the primary responses to parkway restrictions.

The results of a survey of motorists who used the Schuylkill Expressway (I-76) corridor in Philadelphia during reconstruction are shown in Figure 9. The primary motorists' reactions to the reconstruction were to continue to use the Schuylkill (I-76), divert to another highway route, or change travel schedule to avoid congestion *(27)*. The percentage of travelers who switched to public transit or ridesharing options was significantly less, but still an important component in accommodating total travel demand. Note that the percentages add up to more than 100 because respondents were allowed to specify more than one answer.

Experiences to date suggest that a reconstruction project by itself is unlikely to cause large numbers of motorists to change long-held travel habits regarding their choice of travel mode. However, a major reconstruction project could be an ideal time to implement transit and HOV improvements that are part of the long-term traffic management plan for the corridor. The delays during construction may provide the necessary additional incentive to prompt motorists to change mode *(5)*.

CHAPTER FIVE

WORK ZONE TRAFFIC CONTROL

Because of the heavy travel demands accommodated by existing urban freeways and expressways and the potential for severe disruption during the construction period, it is important that the implementing agency develop a comprehensive construction zone traffic control plan. Elements to be addressed by such a plan include methods of traffic handling and congestion relief in the construction zone; motorists' information systems (discussed earlier); safety considerations during construction; and incident management.

TRAFFIC HANDLING IN CONSTRUCTION ZONES

The primary function of traffic control procedures is to move vehicles and pedestrians safely and expeditiously through or around work areas while protecting on-site workers and equipment *(43)*. Active and passive devices are available to select from as elements of the construction zone traffic control plan.

A number of techniques are available to facilitate traffic flow through the construction zone. Narrowing lane widths and narrowing or eliminating shoulders may be a necessary compromise in order to maintain as many travel lanes as possible. Reversible or HOV-only lanes may not have widespread applications, but, where appropriate, they can improve traffic flow and increase the people-handling capacity. Ramp closures or HOV restrictions can improve traffic flow through the construction zone by reducing traffic demand and eliminating merging/diverging conflicts; in evaluating these techniques the corridor-wide impacts must be considered. Serious consideration should be given to expanding incident management capabilities during reconstruction projects, especially when shoulders are removed *(5)*.

The issue of speed control through highway work zones is another significant concern. Excessive work-zone speeds can adversely affect the safety of the work crew and motorists. Two basic types of speed control are available for use in freeway reconstruction zones *(44)*:

> *Passive Control.* Passive speed control refers to posting a reduced speed limit on a static sign (e.g., conventional regulatory and advisory signing). It is appropriate where reduced speeds are desired in the interest of safety. Passive control alone is generally sufficient at sites where the hazards are obvious, and drivers have plenty of time and information available to make reasonable and safe speed decisions without special encouragement. The selected speed should be safe and reasonable. It should not be unreasonably low, but should be the fastest speed that can still be considered safe.
>
> *Active Control.* Active control refers to techniques that restrict movement, display real time dynamic information or enforce compliance to a passive control. Such techniques include flagging, law enforcement, changeable message signs (CMSs), effective lane width reduction, rumble strips, Iowa weave sections, and so on. Active control would be needed in situations where drivers are unable or unwilling to select the appropriate safe speed without active encouragement.

Richards and Dudek *(44)* report on four speed-control approaches: flagging, law enforcement, changeable message signs, and effective lane width reduction. Some of the speed control methods reported most frequently by questionnaire respondents were:

- Use of variable message sign boards,
- Police patrols (and sometimes decoys) in the construction zone, and
- Double fines for speeding in the construction zone.

Several conclusions drawn from measures employed in the reconstruction of I-45 in Houston to minimize delay and improve safety are as follows *(45)*:

1. Advance public information of impending lane closures can minimize public complaints and erratic behavior by motorists.
2. The active presence of law enforcement officers in urban highway work zones can minimize erratic behavior by motorists.
3. Carefully planned active traffic management techniques can allow maintenance (reconstruction) work to be done on high-volume highways during daylight without severely inconveniencing the traveling public.
4. Cooperation with law enforcement agencies and other affected governmental agencies is a necessary part of the active traffic management strategies employed.

SAFETY CONSIDERATIONS DURING CONSTRUCTION

The concern for safety in freeway reconstruction work zones is of utmost importance. The disruption of normal driving practice that accompanies construction activities and lane and ramp closures poses an inherent hazard for motorists driving through the construction zone. Yet, few respondents to the questionnaire survey indicated a serious increase in the number of highway crashes. When asked about the accident experience during construction, the usual response was "typical," "normal," or "no increase." Slight reductions in the number of crashes were reported for some projects and were attributed to reduced traffic during construction. Several agencies reported an increase in the number of crashes, but fewer severe (personal injury/fatality) crashes. The reduction in the number of severe crashes was attributed to reduced speed in the construction zone.

Work zone lane closures and crossovers represent a significant contrast to normal freeway driving demands. Drivers in the closed lane must change lanes to merge into the open lane. Traffic carrying capacity is reduced by the lost capacity of the closed lane and by the traffic friction introduced by merging vehicles. Further friction is often introduced when the effective width of the open lane is reduced, delineated with traffic cones, barrels, or other safety devices used to separate it from the closed lane. Work lane traffic crossovers are characterized by very restrictive geometrics and bi-directional traffic flow *(46)*.

Rouphail et al. *(47)* reported on accident experience during reconstruction of the I-290 Extension in the Chicago area. They found that the accident rate increased sharply during construction, then decreased after construction. At least part of the increase during construction was attributed to diversion of approximately 30 percent of the traffic.

A majority of the construction accidents on I-290 occurred at or near ramps. Although somewhat counter-intuitive, it was found that when construction occurred over the left side of the roadway, the accident rate tended to increase. Rouphail concludes that this may be due to the fact that during right-side construction, both ramp and mainline traffic are constrained to operate at low speeds. During left-side construction, ramp traffic is free to approach at the desired speed. The study also showed that a three-lane section had a lower accident rate than a two-lane section, and that the average accident rate was highest in the early stages of construction and decreased thereafter as drivers became more acclimated to the project.

Analysis of data pertaining to the reconstruction of I-45 in Houston suggests that entrance ramps having higher accident rates before reconstruction were more adversely affected during construction than were ramps with lower accident rates before construction *(49)*. It may be advisable, therefore, to give extra attention to work zone traffic control at entrance ramps with higher accident rates. In some cases, it may be prudent to actually close these ramps during construction rather than further compromise ramp geometrics (or sight distance) during construction.

Most of the crashes on I-45 that resulted in the injury or death of highway workers involved drunken drivers, and nearly all of the crashes involved excessive speed within the work zone. It was obvious that many motorists ignored both regulatory and advisory signs associated with work zones.

INCIDENT MANAGEMENT

Whereas quickly detecting and responding to freeway incidents is important under normal conditions, it often becomes even more vital during construction when shoulders are narrowed or converted to travel lanes, ramps are closed within the construction zone, and portable concrete barriers (used to separate traffic from the work area) limit access by emergency and service vehicles *(5)*.

Incident management is a coordinated and planned approach for responding to incidents when they occur on the freeway systems. It involves the systematic use of human and mechanical processes for detecting, responding to, and clearing incidents. The FHWA's *Freeway Management Handbook (48)* presents a comprehensive compilation of the techniques and technologies for incident detection and verification, and incident response and clearance.

Techniques that are considered during construction projects include:

- Increasing police patrols,
- Initiating or expanding motorist assistance program (i.e., service patrols),
- Installing emergency telephones for motorists,
- Utilizing existing or providing interim freeway surveillance systems,
- Providing free tow-truck service,
- Providing accident investigation sites, and
- Surveillance and control (e.g., closed circuit TV).

Approximately one-half of projects reported on in the questionnaire survey conducted for this synthesis had a formal incident management or crisis management plan. The New York DOT has an incident management response procedure, which specifies the steps to be taken and the persons to be contacted whenever there is an emergency. The incident management coordinator (IMC) directs the response, coordinating with the contractor and the local emergency services.

The Colorado DOT predetermined diversion routes and a public information plan for the I-70/I-225 interchange reconstruction project as a result of a prior major incident that had closed the interchange for several hours. A plan of possible detours developed by the Mississippi DOT to be used in the event of an emergency incident during reconstruction of I-55/I-20 was brought into play.

For the reconstruction of the Dan Ryan and Kennedy Expressways in Chicago, a task force consisting of the Illinois state police, IDOT emergency traffic patrol and the Chicago fire and police departments developed an incident management plan for the area within the construction limits *(32)*. The goal of the plan was to remove stranded motorists as quickly as possible, and to rush emergency vehicles to assist injured motorists. Methods for responding to stranded vehicles were agreed on before construction started.

The project task force helped to coordinate incident management during the reconstruction. Illinois DOT purchased additional emergency vehicles for use by the Illinois State Police in the construction zone. "Minutemen" patrols were doubled at each end of the work zone. The Minutemen patrols were composed of large trucks equipped to assist disabled vehicles. Some of the services performed by the Minutemen crews were providing gasoline, repairing mechanical breakdowns and flats, and assisting with accidents. Throughout the 2-year construction period for the Dan Ryan Expressway, IDOT provided a monthly average of between 1,500 and 2,300 assists. There were also 830 accidents at which assistance was rendered over the two-year period.

As part of its maintenance of traffic (MOT) plan, the Florida DOT provided a service patrol to furnish services similar to those described above during reconstruction of I-95 in Broward County *(50)*. Four service patrol vehicles and their drivers were furnished by the contractors. The service patrol assisted motorists with disabled vehicles, identified abandoned vehicles, and cleared debris from the roadway. Because the service patrol was an integral part of the MOT program, and was incorporated into the contractors construction bid package, 90 percent of its cost during construction was paid using funds provided by the FHWA.

It is expected that future incident management programs will rely more heavily on computer applications using GPS software. The Texas Transportation Institute has been developing an automated incident management system (AIMS) for Texas DOT *(51)*. The AIMS will help the operator of an incident management system develop predetermined reactions and responses, calculate the impact of the incident, manage a response team, and develop alternative routes.

CHAPTER SIX

OTHER CONSIDERATIONS

DESIGN PROCESS

Some steps taken in the design process to ensure quality and cost-effectiveness are: constructibility review, value engineering, and consideration of life-cycle costs. Constructibility review is defined as a method of providing the optimum use of construction knowledge and experience in planning and design of a reconstruction project. It describes a process that gets knowledgeable construction people involved early in the design stages of projects to ensure that the project is buildable with reasonable effort *(52)*.

A constructibility review was performed for more than one-half of the reconstruction projects reported on in the questionnaire survey. This process is now commonplace in major freeway and expressway reconstruction.

For constructibility reviews to be successful, several basic premises must be followed, according to the North Carolina DOT *(52)*. These include:

- Reviews must be held early in the design process.
- Team members must be open-minded.
- There must be a commitment from those involved.
- Major design elements must be clear.
- Critical issues should be identified.
- Contractors must be familiar with critical issues.

Value engineering is a systematic process intended to ensure that the proposed improvement would be the most efficient and cost-effective means of achieving the project objectives.

All but nine of the projects reporting a constructibility review also indicated the inclusion of value engineering. Two reconstruction projects by the Kentucky DOT incorporated value engineering, but not a constructibility review. The value engineering plan usually progresses through five phases: information, speculation, evaluation, development, and implementation. A number of concepts are set forth to satisfy established goals at a particular location. A series of screening processes are then used to rank and analyze the concepts until only the most outstanding ideas remain. Those remaining are further refined in the development phase to determine the preferred solution.

A value engineering study was prepared for the Illinois DOT in connection with the reconstruction of an interchange on I-74. An adjacent landowner objected to the original concept for reasons of aesthetics and access. More than 50 general ideas were postulated and screened to a manageable number for each functional element of the interchange. The resulting plan satisfied the abutting landowner's desires and still provided adequate and safe traffic operation on the freeway and the ramps.

Life-cycle cost analyses were employed on a large majority of the projects submitted in response to the questionnaire survey. For most of these projects, the life-cycle cost analysis pertained to pavement design. Other highway elements included in the life-cycle cost analyses were retaining walls, lighting, and pipe culverts. The Minnesota DOT also indicated that life-cycle costs were used in making a determination as to whether to rehab or replace a bridge.

PAVEMENT RENEWAL

State departments of transportation and the U.S. DOT are actively supporting research in the area of pavement renewal. In February 1998, the Transportation Research Board, in cooperation with the FHWA and Caltrans, conducted a workshop on pavement renewal for urban freeways. At this workshop, multidisciplinary teams of public and private sector experts from across the country shared their experience by developing innovative pavement renewal solutions using, as a test case, a 15-mile segment of I-710 in Los Angeles County.

The reconstruction strategies developed by four teams for the renewal of the I-710 corridor shared a number of common objectives despite their unique approaches to the solution. Among these, the most prevalent was providing a safe and efficient facility while at the same time minimizing community impacts, maintenance costs, and construction time.

Due to the extremely high volumes of traffic present on I-710 and a large volume of heavy truck traffic, the majority of the teams' innovative spirit was shown in their method of traffic control. All teams agreed that careful analysis of traffic patterns through the corridor and surrounding arteries would be essential in developing a good traffic management plan. In addition, an intensive public information campaign begun in the early stages of project design and continuing through project completion would be mandatory. Everyone also agreed that the full width of the freeway should be reconstructed now, because addressing only the two outside lanes at this time would require rehabilitation of the remainder within the next 10 years.

All four teams developed solutions that provide for recycling nearly all potential waste materials from construction back into the project. Also, a complete incident management program was considered important for mitigating potential traffic snarls in the event of an accident or stalled vehicle during construction. During construction all groups believed this particular project would lend itself well to use of incentive/disincentive provisions within the contract. Offering bonuses for expeditious project completion would inspire creativity and ingenuity on the contractor's part and benefit the traveling public in the form of reduced delays.

The following is a short summary of the pavement renewal recommendations of each team. Full proceedings of the workshop will be published by the Transportation Research Board.

Yellow Team—The yellow team presented a portland cement concrete (PCC) solution combining two construction techniques: a new PCC slab atop a full-depth recycling of existing pavement and an unbonded PCC overlay. The two options could be used in combination or independently, based on results of a thorough subsurface investigation. The team believed this solution would provide 40 years of service life with little required maintenance and low life-cycle costs.

One option of the proposal was to recycle the existing 8 in. of PCC pavement and the existing 8 in. of cement treated base. The existing pavement and base would be milled out, crushed, and stabilized with cement and replaced on the subgrade at varying thickness to allow for a heavier truck design in the two outside lanes while maintaining standard pavement cross-slopes.

In areas where subgrade was considered sound and vertical clearances are adequate, an unbonded PCC overlay would be used. A 2-inch lift of hot-mix asphalt (HMA) pavement would initially be placed on the existing PCC pavement as a bond breaker. Over this, a 12-inch PCC overlay would be constructed covering the full width of the facility.

Blue Team—The blue team presented a solution involving repair and stabilization of the existing PCC pavement and overlaying with stone matrix asphalt (SMA). The team felt it was not realistic to expect a 40-year life from any HMA pavement without some kind of routine surface maintenance. Although the latest innovations in HMA pavements have not yet proven in this field, it was assumed that a sufficiently thick SMA resurfacing could give at least 25 years of service before requiring any significant surface maintenance.

The existing concrete pavement would be utilized in place, where practical, as a base for 8 in. of SMA resurfacing. Broken slabs and displaced joints would be replaced or repaired prior to resurfacing. The pavement structure would consist of a base course of 6 in. of coarse-graded aggregate topped with 2 in. of SMA. An optional three-quarter inch open-graded friction course could be added if deemed necessary.

Green Team—The green team proposed a PCC pavement solution that would involve a complete reconstruction of the facility. This would include replacing all overpasses with clear span structures, thereby eliminating the median piers along the route, producing an obstruction free "Teflon" corridor. Complete reconstruction would also virtually eliminate life-cycle cost considerations.

A 12-in. doweled pavement constructed of high-performance PCC would be placed over a 14-in. lean concrete base. The existing PCC and HMA pavements would be recycled on site and provide the aggregate for construction of the lean concrete base.

Brown Team—The brown team presented an HMA pavement strategy that uses the "rubblization and asphalt concrete overlay" process. This is a strategy successfully used on the East Coast and in the Midwest.

The existing 16-in. of PCC pavement and cement treated base would be rubblized by use of low-amplitude/high-frequency vibratory hammer. After rubblizing the old pavement, the remnants would be compacted to serve as the base for the polymer-modified HMA overlay. Eight in. of high-quality polymer-modified asphaltic concrete was recommended, based on the use of recently developed materials and mix design technology.

Regardless of the pavement type, either PCC or HMA, it is this team's experience that neither will give 40 years of maintenance free service. After 20 to 25 years, a PCC pavement will require grinding, whereas an AC pavement will need milling and an AC overlay. Allowing for one surface rehabilitation after approximately 25 years, the team considered the rubblizing and AC overlay option the best combination of both price and performance.

MITIGATION OF ENVIRONMENTAL IMPACTS

Two types of environmental impacts may be associated with the reconstruction of an urban freeway or expressway: (a) impacts occurring only during the construction phase and (b) impacts in the corridor area that occur as a result of the reconstruction.

Noise is a problem both during the construction phase and thereafter. In urban areas where the community is located in the immediate vicinity of the highway, noise generated by construction of the highway is likely to be as much an issue as the noise generated by operation of the highway after reconstruction, especially with nighttime construction.

For I-440 in Nashville, the Tennessee DOT used a highway construction noise computer program (HICNOM) to calculate typical noise levels in the impacted areas assuming: rock drilling, scraper earthwork, and truck hauling (*53*). Based on the results of this analysis, several noise abatement strategies were developed. Topsoil stored for future use was used as a noise barrier. Quiet air compressors were employed for rock drilling. Some other noise abatement measures considered for this project include:

- Constructing temporary noise barriers,
- Prohibiting the contractor from working on Sunday,
- Positioning stationary equipment to take advantage of a material stockpile, or some other obstacle to act as a noise barrier,
- Locating haul roads as far away from noise sensitive areas as possible,
- Locating equipment parking and maintenance in remote areas, and
- Using some type of warning device to alert residents of an impending blast.

ENHANCEMENTS

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and the reauthorization legislation, the Transportation Equity Act for the 21st Century (TEA-21), include programs supporting enhancement elements in transportation corridors (e.g., pedestrian and bicycle facilities, landscaping and other scenic beautification, preservation of rail corridors for bicycle trails, archaeological planning and research). A number of urban freeway and expressway reconstruction projects include an enhancement element.

The North Central Expressway (U.S. 75) project in Dallas, Texas, is a total urban freeway reconstruction that provides an excellent view of the new range of opportunities available in the area of enhancements *(46)*. For 6 miles of its 10-mile length, the North Central Expressway will be depressed in a "concrete canyon," which will cross under 15 cross streets. The remaining 4 miles will have a more typical at-grade or above-grade profile. The design goals established for the facility were that it would be sensitive to its urban environment, be aesthetically pleasing to the motorists and adjacent residents and businesses, and be a technical "leading edge", providing for 21st century smart highways (ITS) technology. Design elements in which enhancement was incorporated include structures and built elements, signs, lighting, and streetscape and landscape development. Kelly and Robles offer the following advice, based on experience *(54)*:

> Any time new concepts are incorporated into complex construction activities, resistance can be expected. And any deviation from long-accepted standard practice opens up opportunities for construction glitches. In general, the more dramatic the new concepts, the greater the resistance and the opportunity for problems. Some measures can be taken to mitigate these difficulties.
>
> First, conceptual design and architectural input must have sufficient lead-time to develop the range of optional ideas that may be placed "on the table." Then, additional time is needed for soliciting public input regarding the magnitude of enhancements and the specific designs favored. Effectively soliciting the input of the community can often be difficult. A professional-level public affairs program is needed for most large urban areas to develop the type of sophisticated audience targeting wanted. It is of particular importance that all interest groups are included (e.g., bicyclists, environmentalists). In general, some competing goals will arise between commercial and residential interests. Good political skills are needed within the project management and public affairs staffs. Only after the project concept and architectural and landscaping ideas have jelled should the engineering designs begin. Simultaneous architectural and engineering starts will inevitably result in numerous revisions for both disciplines, which is inefficient and costly, and also can create an adversarial relationship between the architects, planners, and the design engineers.
>
> It is also very important to bring in construction and maintenance personnel for their input regarding new concepts and modifications of existing design/construction practice.
>
> Most major highways pass through several local jurisdictions. It is critical to consult with local staffs to apprise them of various concepts under consideration and solicit their concurrence and support. In many areas, local jurisdictions will have a role in maintenance and upkeep of the facility, and it is important that the plan has their blessing.
>
> In addition to the official local jurisdiction, adjacent commercial and residential property owners are often interested in, and willing to participate in installation and maintenance of special features such as landscaped areas. Ideally, the level of such participation will have been ferreted out in the public involvement process. It is also important that the ultimate plan include a fall-back maintenance level in case early private-sector enthusiasm dwindles or financial circumstances change.

Approximately one-half of the projects reported in the questionnaire survey incorporated enhancements. The predominant enhancement features were landscaping, esthetic treatment of noise barriers, pedestrian/bicycle facilities, and illumination.

3-D AND 4-D VISUALIZATION

Three-dimensional and four-dimensional computer technology is a branch of computer science becoming known as "visualization" *(55)*. This exciting new tool opens up a whole vista of applications in the project development process. The planner and designer now have the ability to rapidly visualize critical elements of the facility both for internal use and for presentation to outside persons or agencies. Photo simulation is used for environmental studies, conceptual design, and identifying the scope of work, as well as the development of design alternatives.

Before the advancement in computer visualization, artists' renderings were often used to study or portray project elements. In many instances, however, the artists took liberties in depicting the project and its surroundings to soften the impact or enhance the appearance. With computer visualization, there is a more realistic illustration of the end result and, of equal importance, one that the general public will find believable.

Only eight transportation agencies responding to the questionnaire survey indicated the use of 3-D or 4-D visualization, but the number of applications may be expected to grow dramatically in the future as the technology becomes more prevalent and the value is fully recognized.

In planning for the reconstruction of I-74 in downtown Peoria, the Illinois DOT encountered a situation where an abutting land owner objected to the plan because a portion of the street in front of his property would be raised above its present elevation. Computer visualization was utilized in refining the original concept, and then in presenting the revised plan to the property owner. The result was a satisfactory solution to a sticky problem.

CHAPTER SEVEN

CONCLUSIONS

The literature review and surveys of state and other transportation agencies provide a basis for identifying trends and practices in the development of urban freeway and expressway reconstruction projects. Transportation agencies embarking on projects of this type can learn from prior experience in all project phases from program development through construction management.

PROGRAM AND PROJECT DEVELOPMENT

• Because project management is recognized as the most critical element in successfully reconstructing major urban freeways and expressways, some transportation agencies have established a separate department or division to oversee such projects.

• Many implementing agencies have developed or tested innovative contracting methods that are intended to speed completion of reconstruction and still maintain quality of the work.

• Considering the massive investment required and the need to compress the implementation schedule of reconstruction projects, many state DOTs and other implementing agencies will find it necessary to combine some of the non-traditional financing sources now provided for in federal programs with traditional sources used up to this time.

INVOLVING AND COMMUNICATING WITH THE PUBLIC

• Public involvement and an effective public information program are especially important in freeway and expressway reconstruction projects because of the sheer size of such projects as well as their substantial impact on drivers, local residents and businesses, and the community as a whole.

• Early interaction with the public is a key ingredient in building project support.

• Small meetings and person-to-person contact are the most effective means of communicating with the public.

• The most common forms of communication—newspaper, radio, and TV—are the most effective means of reaching drivers.

• Because of the importance of public involvement and communications, experience indicates it is advisable to enlist professional support in handling these functions.

TRAFFIC MANAGEMENT

• A corridor-wide perspective for traffic management during construction is required. The traffic management plan includes: a traffic-handling strategy for the highway being reconstructed; impact mitigation strategies for alternative routes and modes in the affected corridor; and a public information program.

• The number of lanes remaining in service during reconstruction is a major guideline used in planning every reconstruction project.

• To minimize heavy congestion, many agencies have restricted reconstruction activities to hours of off-peak traffic, weekends, and nights. Because of the high traffic volumes encountered in reconstructing urban freeways, there is reason to believe that more night construction operations will have to be scheduled.

• Experience has shown that many predictions of dire conditions resulting from lane closure during reconstruction do not materialize.

• The most common motorist reaction to lane closures during reconstruction has been diversion to another route. Some drivers have changed their time of travel or eliminated discretionary trips, but there has usually been very limited shift to other modes, such as transit or ridesharing.

• Experiences to date suggest that a reconstruction project by itself is unlikely to cause large numbers of motorists to change long-held travel habits regarding their choice of travel mode. However, a major reconstruction project could be an ideal time to implement transit and HOV improvements that are part of the long-term traffic management plan for the corridor.

• Overall, improvements made to alternative routes as part of a reconstruction project have been worthwhile impact mitigation measures.

WORK ZONE TRAFFIC CONTROL

• It is important that implementing agencies develop a comprehensive construction management plan for each reconstruction project. Elements to be addressed by a construction management plan include: methods of mitigating construction impacts; traffic handling and congestion relief in the construction zone; motorists' information systems; and safety considerations during construction.

• The disruption of normal driving practice that accompanies reconstruction activities and lane and ramp closures poses an inherent hazard for motorists driving through the construction zone. Yet, few implementing agencies report significantly worse accident experience than before construction began.

• Whereas quickly detecting and responding to freeway incidents is important under normal conditions, it becomes even more vital during reconstruction.

OTHER CONSIDERATIONS

• Constructibility reviews get knowledgeable people involved early in the design stages of the project to ensure that the project is buildable with reasonable effort. This process is now commonplace in major freeway and expressway reconstruction.

• Of all environmental factors, noise pollution is mentioned most frequently as a problem during construction. In urban areas where the community is located in the immediate vicinity of the highway, noise generated by construction of the highway is likely to be as much of an issue as the noise generated by operation of the highway after reconstruction.

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APPENDIX A

Survey Questionnaire

QUESTIONNAIRE DOCUMENT

This questionnaire solicits information on your experience in reconstruction of major urban highways. Many agencies have limited experience with this type of project, yet will have to reconstruct much of their urban system in the near future. Your cooperation in sharing past experience can be of help to other agencies as they embark on these challenging, costly and time-consuming projects.

Name of Agency: ....

Name of Respondent: ....

Title of Respondent: ....

Phone and Fax Numbers: ....

Date ....

This synthesis is concerned with the reconstruction of existing urban freeways/ expressways which has been completed or is in process. The experience that your agency has gained in such projects will be valuable to others who are planning for reconstruction. Please indicate below the several most noteworthy projects of this type that your agency has accomplished:

Route	Facility Name (if any)	Length (mi)	Year Reconstructed	Freeway or Expressway? Y/N	Urban? Y/N
____	____	____	____	____	____
____	____	____	____	____	____
____	____	____	____	____	____
____	____	____	____	____	____

☐ We have not reconstructed an urban freeway or expressway

Please complete a separate Attachment A for **each** facility listed above, several forms are included. If more are needed, please make copies.

Returns:

Please return the completed questionnaire to:

James B. Saag, P.E.
CH2M HILL
8501 West Higgins Road
Chicago, IL 60631-2801

Survey Questions:

In the event that there are questions about the survey, please contact the Consultant, James Saag, at 773.693.3800, ext. 208 or communicate by FAX at 773.693.3823 or e-mail to jsaag@ch2m.com.

Interview:

If it would be helpful to this project, would you be receptive to either a personal or telephone interview?
☐ yes or ☐ no ________________________

ATTACHMENT A—CASE STUDY REPORT

Name of Agency ______________________________

Route ______________________________

Facility Name (if any) ______________________________

A. Criteria Influencing Planning Decision

1. What were the basic reasons leading to reconstruction? (please check as many as applicable)

   ☐ Provision of additional capacity to meet travel demand

   ☐ Safety (Accident problem)

   ☐ Improvement to new current design standards

   ☐ Add transit or HOV lanes, or other special uses

   ☐ Infrastructure preservation

   ☐ Other (please explain)______________________________

   ____

2. Was there public/stakeholder support for the need for improvement? ☐yes ☐ no

   Please explain: ______________________________

   ____

   Was there support for the types of solutions proposed? ☐yes ☐ no

   Please explain: ______________________________

   ____

3. What were the sources of funding for this project? (Check all applicable boxes)

   ☐ Federal ☐ Local ☐ Toll Authority

   ☐ State ☐ Other (Please Specify)______________________________

4. Was the implementation schedule accelerated? ☐ yes ☐ no

   If yes, how?______________________________

   Total duration of construction. ______ months

   Length of time during which users were affected. ____months

B. Public Participation and Public Information

1. When were the first steps taken in the area of public involvement?__________________

   ____

   How was this done?______________________________

   ____

   Who was involved?______________________________

   ____

2. Do you feel you were successful in building public support for the project? ☐ yes ☐ no. If yes, What were the key success factors? ______

   If no, what went wrong? ______

3. What forms of media were utilized in communicating with the public? (check applicable boxes)

   ☐ Press releases ☐ Newsletter ☐ Workshops

   ☐ Radio/television ☐ Public Meeting

   ☐ Meetings with Special Interest Groups (please explain) ______

   ☐ Other (explain) ______

4. Would you characterize any of the public participation/information techniques as being "innovative"? ☐ yes ☐ no. If yes, please explain: ______

5. Was a public relations firm hired, or was the effort performed by in-house staff?

   ☐ outside p.r. firm ☐ in-house staff

6. What was the approximate cost of the public relations effort? $______

7. Given the opportunity, what if anything, would you have done differently in dealing with the public? ______

C. <u>Program and Project Development</u>

1. Was a special management structure developed to handle the planning, design and/or implementation of this project? ☐ yes ☐ no. If yes, please explain: ______

2. Was "partnering" or public/private partnerships utilized? ☐ yes ☐ no. If yes, please describe: ______

3. Was there a special decisonmaking process to deal with problems during design or construction? ☐ yes ☐ no. If yes, please explain: ______

4. Would you consider any of the financing or project development mechanisms used on this project to be "innovative"? ☐ yes ☐ no. If yes, please explain:________________

____

____

D. Traffic Management

1. What criteria were used in planning for maintenance of traffic? (check all applicable boxes)

☐ Number of lanes remaining in service
☐ Geometrics
☐ Recurring congestion (delay)
☐ Non-recurring congestion (delay due to incidents)
☐ Other, please explain____

____

2. Were there special features or situations that had to be accommodated in maintaining traffic during construction? ☐ yes ☐ no. If yes, please explain:__________________

____

____

3. Were any of the following Transportation Demand Management (TDM) techniques utilized to reduce traffic volumes during construction? (check all applicable boxes)

☐ car pools ☐ park and ride lots
☐ transit incentives ☐ fringe parking
☐ special access to parking facilities ☐ other (please explain)____________

____

Were they effective? ☐ yes ☐ no____

____

4. Were alternative or detour routes designated? ☐ yes ☐ no. If yes, please describe the motorist information system used.________________________________

____

Were improvements performed on the alternate routes prior to their use?
☐ yes ☐ no

5. Was a crisis management plan developed to handle a major traffic and/or construction incident? ☐ yes ☐ no

If yes, what did the plan consist of?________________________________

____

Was the plan ever implemented? ☐ yes ☐ no

6. What percentage reduction in traffic was experienced during the course of construction? _______%

E. Construction Management

1. What was (or will be) the construction period? from____________ until ____________.
   (month, year) (month, year)
2. What was the accident experience during construction?________________________
3. Please describe any special measures or procedures used to improve workzone safety.____
4. Were contractor incentives incorporated into the contract documents? ☐ yes ☐ no.
   If yes, please specify: ________________________

   Were these measures effective? ☐ yes ☐ no
5. In your opinion, would any of the contracting methods be considered to be "innovative"?
   ☐ yes ☐ no. If yes, please explain:________________________
6. Did the contract documents include provision for lane rental or A and B bidding?
   ☐ yes ☐ no If yes, please explain ________________________

F. Design Process and Issues

1. Was there a formal constructability review? ☐ yes ☐ no
   value engineering? ☐ yes ☐ no
2. Were life-cycle costs considered in design and in selection of materials? ☐ yes ☐ no
   If yes, please describe:________________________
3. Were measures taken to mitigate adverse environmental effects in the following categories?
   ☐ water quality ☐ cultural resources
   ☐ noise ☐ wetlands/endangered species
   ☐ air quality ☐ other (please specify ____________)
4. What was done to minimize disruption during construction?________________________
5. Did the project include "enhancements"? ☐ yes ☐ no. If yes, please explain:____________
6. Was traffic modeling or simulation utilized in developing the reconstruction plan?
   ☐ yes ☐ no. If yes, please explain:________________________

G. Role of Advanced Technology

1. Were 3D/4D visualizations of the proposals developed? ☐yes ☐ no. If yes, were they helpful? ______

2. Were any of the following traffic management systems utilized in this project?
☐ Traffic signal systems ☐ Incident and EMS management
☐ Communications infrastructure ☐ Travel information for facility users
☐ Other (please specify) ______

3. Did this project make use of any new or different construction methods or materials?
☐ yes ☐ no. If yes, please describe: ______

H. Fiscal Management and Economic Analysis

1. Were life-cycle costs considered in design? ☐ yes ☐ no. If yes, what tools or methodologies were used? ______

2. Were user costs and benefits considered in the decision-making process? ☐yes ☐ no community benefits? ☐yes ☐ no. Others? ☐yes ☐ no. If yes, please explain: ______

3. Were future road user costs considered in the determination of pavement type?
☐yes ☐ no If yes, please explain ______

4. Please describe briefly the budgeting and programming steps leading to implementation of this project. ______

Supporting Data

Please furnish with the completed questionnaire copies of any existing printed material which we may use to help readers of the synthesis in understanding the project. Examples of such information would be brochures, reports, press releases, etc.

Attachments furnished:

______

______

______

THANK YOU FOR YOUR COOPERATION AND ASSISTANCE!

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