Dramatically Reducing Highway Construction Project Times: Suggestions for Research

Research and Technology Coordinating Committee (FHWA)

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DRAMATICALLY REDUCING HIGHWAY CONSTRUCTION PROJECT TIMES: SUGGESTIONS FOR RESEARCH

INTRODUCTION

The purpose of this brief report is to summarize an analysis by the Research and Technology Coordinating Committee (RTCC) of the issues associated with dramatically reducing highway construction project times and the potential for research to help achieve such reductions. In this report the committee uses the term highway construction projects to encompass the entire range of planning, design, management, and construction activities that comprise highway rehabilitation or reconstruction projects. Project time spans all these activities. It believes that achieving *dramatic* reductions in highway construction project times requires a broader, more comprehensive approach to the problem than looking for marginal improvements in existing techniques. Reconcept- ualization of the problem during the planning phase, for example, might lead to alternative designs or approaches to construction that could yield greater benefits in terms of reduced delay and disruption than could be achieved through typical approaches to minimizing contractor lane occupancy. It also recognizes that although project time reductions can be achieved in each of the project activities, the primary benefits will be realized during construction. These benefits include reduced traffic delay and associated costs, fewer collisions and injuries associated with construction-related accidents, and lower capital costs for maintaining traffic that are associated with highway construction projects.

The committee addressed this topic at the urging of several members who noted that a growing portion of the nation's Interstate highway system is in need of major rehabilitation or reconstruction. Since many of these highway segments are located in or near major urban corridors, they are often critical links for local and through traffic, and serve high traffic volumes throughout the day. Thus, they cannot be shut down for extended periods of time without considerable inconvenience and increased delays for road users, major community disruption, and significant economic loss.

Several recent activities underscore the growing interest in this topic.[1] In October 1997, the Federal Highway Administration (FHWA) and the National Asphalt Pavement Association conducted a workshop on improving safety, reducing delays, and minimizing disruption in highway construction and maintenance work areas. With representation from a broad cross section of the highway community, the workshop focused on the need for highway agencies and contractors to work together to achieve reductions in construction time and developed a set of action items aimed at affecting current practice.

[1] The topic, however, is not new. A report published in 1975 addressed reducing roadway occupancy during routine maintenance activities in order to improve safety and traffic flow (National Cooperative Highway Research Program, 1975).

However, the workshop did not address research focused on identifying how construction processes could be improved to reduce project times (National Asphalt Pavement Association, 1998).

In February 1998, FHWA and the Transportation Research Board organized a 4-day workshop during which four teams of experts examined a specific urban freeway segment as a representative reconstruction project and developed innovative alternative approaches for pavement renewal aimed at reducing costs and delays to road users. In early June, selected workshop participants met in a follow-up session to review preliminary cost estimates and drawings for the implementation of these approaches, prepared by the California Department of Transportation. The results of the workshop and the follow-up meetings were so encouraging that several states began making plans for similar workshops. The workshop also yielded several suggestions for research that could be undertaken to support the goal of reducing construction project times. These suggestions were helpful to the committee in formulating the recommendations presented in this report.

In addition, there is a growing body of experience with fast-track highway rehabilitation and repair projects necessitated by disasters, special events, or destructive accidents. These projects have demonstrated that state highway agencies and highway construction firms can team successfully to reduce highway project construction times when required to do so by emergency conditions or unexpected circumstances. However, there has as yet been no systematic examination of the lessons learned from such projects or of how these lessons can be applied more broadly to reduce highway construction project times.

The primary benefits of reducing highway construction project times is to reduce traffic delay and associated costs, decrease the number of collisions and injuries associated with construction-related accidents, and lower the capital costs of maintaining traffic that are associated with highway construction projects. From the perspective of a road user, the impacts of construction are obvious, but solutions to reduce those impacts are not. Generally, travelers accept construction projects as a fact of life. There are rumblings and questions about "why it can't be done as it was after the earthquake/flood/fire/hurricane," but nothing that approximates a revolt against the policy of business as usual. An estimate that 1 out of 12 miles of freeway in California is under reconstruction at any given time suggests why travelers are inured to these conditions. When asked, however, road users clearly express their resentment about construction delays (Coopers & Lybrand, 1997). (On at least one occasion, residents agreed to harsher impacts over a shorter time rather than a long, drawn-out set of moderate impacts.)

On the other hand, even though shortening highway construction project times could result in fewer delays, crashes, and injuries to road users, as well as fewer construction-related accidents and injuries, there is no widely accepted methodology for estimating such benefits. In addition, the few benefits that would accrue to highway agencies cannot easily be used to offset associated higher project costs. Yet despite these hurdles, some highway agencies are using estimated benefits to justify innovative approaches, such as long-lived pavements that yield lower life-cycle costs (New York State Department of Transportation, 1993; Pennsylvania DOT, 1998).

The committee recognizes that reducing highway construction project times is an issue of varying importance among the states. Projects that would yield large benefits due to reduced construction project times are likely to be on heavily trafficked sections of Interstate highways and/or on highways located in major urban areas. These are areas in which there are also likely to be few options for alternative traffic routing. Moreover, even highway agencies facing such construction needs often are limited in their ability to focus a large portion of their resources and/or staff effort on a single project. Others are unable to mobilize enough qualified construction management or inspection staff to monitor and ensure quality construction day and night at many locations on a single project.

Nevertheless, the committee believes that dramatically reducing highway construction project times is a significant concern for highway agencies throughout the nation and the committee has concluded that research focused on systematically examining highway construction processes to determine means of reducing construction project times is not being pursued sufficiently at any level (Wright, 1995). Reconstruction and rehabilitation are currently being addressed with many of the same tools and techniques used to build the Interstate highway system (Carr, 1997). The RTCC believes that research aimed at reducing highway construction project times represents an opportunity for improvement that would yield important benefits to highway agencies and users.

The committee's findings and recommendations for further research are presented below. The appendix provides further detail on the benefits, challenges, and opportunities associated with reducing highway construction project times and served as a useful resource for several committee discussions. The committee recognizes that research aimed at dramatically reducing highway construction project times will require the support and contributions of a broad constituency, including FHWA, state and local highway agencies, the American Association of State Highway and Transportation Officials (AASHTO), the American Road and Transportation Builders Association, the Association of General Contractors, the National Asphalt Pavement Association, the Portland Cement Association, the American Consulting Engineers Council, and others. The committee is prepared to assist FHWA by reviewing plans for a broad-based program of research aimed at reducing highway construction project times.

FINDINGS AND RECOMMENDATIONS

Finding: In the short term, opportunities exist to reduce highway construction project times through judicious use of methods and techniques that have been applied successfully in recent projects.

Opportunities exist to reduce highway construction project times without undertaking additional research or developing and implementing innovative technologies. Innovative contracting techniques, such as incentives and disincentives for expediting construction and the design–build approach, are being used by a number of agencies. Innovative construction techniques have been used primarily because of special circumstances or emergency conditions. The California Department of Transportation and its highway contractors successfully used both innovative contracting and innovative construction techniques in quickly making repairs following the Northridge earthquake (Federal Highway Administration, 1995). Both types of innovations should be examined to determine their applicability for wider use.

Several private- and public-sector highway projects in California and the reconstruction of I-15 in Salt Lake City provide additional evidence that construction project times can be substantially reduced.[2] In addition, considerable interest in and support for improvements and innovation in this area have been reported throughout the highway industry.[3] It would be helpful to document the lessons learned from such projects to determine the effects on project costs and to guide interested state highway agencies in implementing successful approaches.

> **Recommendation: FHWA, in cooperation with AASHTO and highway industry participants, should examine examples of innovative approaches in recent construction and rehabilitation projects to determine the lessons learned from these approaches and their applicability to a wider range of projects.**

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[2] The opportunity currently exists to document through completion the innovative approaches considered and implemented in the I-15 reconstruction project.

[3] For example, the Transportation Research Board (1996) suggests a mechanism for accelerating the pace of innovation that would involve leaders from throughout the highway industry. The National Asphalt Pavement Association (1998) provides suggestions formulated by a group of industry and highway agency practitioners. The Construction Industry Institute (1997) summarizes a series of workshops aimed at identifying research needs in the construction industry and developing a research agenda.

Finding: There is a lack of basic knowledge and information about highway construction processes that needs to be overcome before the processes can be changed to greatly reduce highway construction project times.

Changes in highway construction processes are currently slow, expensive, and often ad hoc.[4] Recent efforts focused on improved contracting and procurement procedures and associated institutional issues are helpful, but do not address the basic construction processes. Research that systematically examines highway construction processes is needed to identify potential changes that offer the potential to reduce highway construction project times (Carr, 1997; Grant, 1995). Research conducted for the Construction Industry Institute, which focuses on construction issues for the industrial and manufacturing sectors, suggests that a detailed examination of the specific stages of highway construction processes can yield valuable information needed to realize significant time savings (Construction Industry Institute, 1986). This research has shown, for example, that innovative construction technologies, such as those using large amounts of off-site precasting and prefabrication and those employing advanced high-strength or composite materials, could help shorten highway construction project times. Similar research focused on highway construction could yield improvements to existing methods and procedures and provide the basis for research into innovative technologies, materials, and methods to achieve revolutionary changes in the highway construction industry.

> **Recommendation: FHWA should support research aimed at defining and describing highway construction processes in order to identify potential changes that could lead to reduced construction project times.**

Finding: Reducing highway construction project times would yield a range of benefits that would accrue primarily to road users, construction firms, local businesses, and the local community. Although such benefits could be substantial, they would be widely dispersed, and highway agencies would be able to use only a portion of them to offset any increased costs associated with the time reductions.

The primary benefits of reducing highway construction project times would be reduced user delays and associated costs, fewer collisions and injuries to both road users and construction workers within and around construction areas, and lower traffic maintenance costs during the construction period. In addition, reducing project times would likely reduce business losses and community disruption along the project route. The public understands the importance of these benefits, having witnessed them during major disasters such as the Northridge earthquake in California, preparations for a special event such as the Olympics, or the repair of damages to key components of the road network resulting from major traffic crashes such as the recent I-95 tanker truck crash.

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[4] This observation applies to the processes employed in highway and bridge construction for earthworks, pavements, bridge foundations, and bridge structures, etc.

Since highway construction projects invariably result in user delays and community disruption, highway agencies and the highway industry need credible methods for estimating the value of the benefits of reduced project times (Poister et al., 1998). Such methods might be applicable to all projects, including those not related to a special event or in response to a disaster or emergency, that disrupt highway use for a long period. The resulting estimates could aid highway agencies in decision making related to their construction programs. They would also be helpful for project planning since reducing construction project times involves a wide range of options, and since each project is inherently different and must be analyzed independently. In addition, concurrent and systemwide effects of multiple projects should be considered in the analysis.

> **Recommendation: FHWA, state highway agencies, and the highway industry should support research aimed at developing credible methods for estimating the value of reduced highway construction project times. Research should also address whether these benefits can be captured to help defray increased construction costs associated with the reduced project times.**

Finding: Financing a large highway construction project is a major challenge for a state highway agency. Many agencies cannot concentrate limited state funds on one or a few fast-track projects while other projects languish because of a lack of funds. More information is needed about how state highway agencies finance and program their highway projects, and what can be done to enable these states to accommodate a small number of large, fast-track projects without adversely affecting overall state program priorities.

Federal-aid funding for Interstate highways is an incremental stream of funds that is dependent upon procedures and formulas determined by federal legislation. Federal-aid funding is also dependent on state matching funds. Most state highway programming plans call for statewide needs analysis; political reality requires a balance between needs estimates and the distribution of projects throughout the state (Niemeier et al., 1996). In some states, a single major highway construction project could overwhelm the state agency's budget and create political difficulties. Previous efforts aimed at compressing project schedules in response to disasters, destructive accidents, or special-event conditions have benefited from specially earmarked federal aid and a strong political and financial commitment by the states involved.

> **Recommendation: Highway agencies and the highway industry need a careful examination of the highway financing process, including federal-aid rules and regulations, as well as accurate information about the actual costs of adopting measures that would reduce construction project times. This examination should be aimed at providing information on how states can accommodate a small number of fast-track projects without adversely affecting overall state program priorities.**

Finding: Risks associated with highway construction projects can add to project costs and cause schedule delays if not explicitly addressed by both the contractor and the highway agency. Full recognition and better understanding of project risks, who controls the risks, and the costs of risks could lead to early and improved risk mitigation. Assigning risk to the party controlling the risk could lower project costs and support any steps taken to reduce highway construction project times, especially if these steps add to overall project costs.

Highway construction projects can involve considerable risk for highway agencies, designers, and contractors (Levitt et al., 1980). Factors that affect project risks include local traffic conditions; land use development patterns; subsurface conditions (geotechnical); and development (utilities such as water supply pipes, sewers, and underground electrical connections) and mitigating conditions (limits on land taking). One of the most complex risk areas for construction projects is the protection of adjacent properties from damage due to nearby construction activity.

Project risks and the way they are perceived by highway agencies, designers, and contractors increase project costs (Ashley, 1984). For example, faced with uncertainties in site inspection and construction quality, a designer will often overdesign to protect against future claims (Touran et al., 1994). If highway agencies took more responsibility for design and project uncertainties, contractors would be faced with fewer unknowns and might submit lower bids for related items. Thus, cost savings achieved through risk mitigation could be used to offset any increased costs of steps aimed at reducing highway construction project times.

To achieve cost reductions in support of time reductions, however, will require more knowledge about the risks involved and how to manage them. Decisions made early in a project can have large effects on the risks encountered and the cost and duration of the projects. Such decisions should therefore be made carefully so as not to foreclose any opportunities to include innovations and advanced technologies that could ultimately lead to lower project costs and reduced project times (Hamilton and Gibson, 1996).

> **Recommendation: Research is needed on how contractors and highway agencies estimate project risks, which risk factors have the greatest influence on project costs, and how risks can be mitigated to reduce overall project costs. Attention should be given to risk factors associated with methods and techniques aimed at reducing highway construction project times.**

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APPENDIX

REDUCING HIGHWAY CONSTRUCTION PROJECT TIMES: BENEFITS, CHALLENGES, AND OPPORTUNITIES

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INTRODUCTION

Highway construction projects, particularly those in urban areas, take longer to complete than is either required or desirable. Impacts on the traveling public from construction projects with nonoptimal schedules and durations are considerable. While methods for determining user costs incurred from delays to the traveling public remain controversial, such costs are substantial, if not overwhelming on many projects. User costs in urban settings will continue to increase as a result of growing populations, increasing levels of traffic, and greater emphasis on the expansion and reconstruction of existing transportation facilities.

Highway agencies are facing the reality that the public will not tolerate construction projects that are insensitive to road users and adjacent communities. The "business as usual" paradigm needs to be replaced by greater project schedule accountability. Project schedules must be given as much attention as project budgets have received in the past, and the emergence of innovative management, design, and construction approaches and technologies makes it possible to realize reduced project times and the associated benefits. Highway agencies and design consultants should seek out and implement these innovative approaches.

The purpose of this paper is to provide background information for the Research and Technology Coordinating Committee's discussions on reducing highway construction project times. The paper suggests research, demonstration, and training activities aimed at such reductions.

BENEFITS FROM REDUCING HIGHWAY CONSTRUCTION PROJECT TIMES

The primary motive for and benefits from reducing project times are obvious to road users stuck in a construction bottleneck. In addition to reduced user delays are savings in project administrative and overhead costs to both public agencies and contractors, fewer construction zone accidents, lower costs for temporary facilities for maintaining traffic, and enhanced agency public relations.

More focus should be placed on schedule management by both contractors and administrative agencies. Greater emphasis on project schedule accountability will stimulate highway contractors, reduce contractor claims, raise the overall level of industry performance, increase national productivity, and even increase national competitiveness.

BARRIERS TO REDUCING PROJECT CONSTRUCTION TIMES

The barriers and challenges to reducing project times are many and varied, and they must be addressed if success with innovative approaches and improved project schedule performance are to be achieved. The barriers described below are classified as legal/political, organizational, and technical.

Legal/Political Barriers

Many public-sector procurement regulations are in place to protect public expenditures and achieve fairness in contractor competition and selection. However, they usually apply only to cost and do not address quality or ability, resulting in contract award mechanisms that focus on cost. The project management mentality in many public agencies is to trade time for money when necessary.

Procurement regulations often constrain agencies from using innovative contracting approaches such as privatization, fast-track design–build, use of multiple prime contractors, and contractor prequalification (which should incorporate review of contractors' past schedule performance). Contractor associations often oppose such practices and can generate considerable political support to oppose them.

There is a lack of confidence in the methods available for estimating road user costs associated with construction delays. The concept is rarely applied in project decision making and related economic analyses.

Organizational Barriers

Many public projects suffer from a lack of continuity in key project management positions during a project because most public agencies separate the management of planning and design from the management of construction. Thus the project is passed from one manager to another. Both responsibility and accountability for overall project success, including schedule performance, are distributed and diluted to the point of being less effective.

There are no widely accepted methods, or metrics, for measuring schedule performance. Such measures are needed for accountability purposes and would be useful for benchmarking best performance levels and targeting future performance levels. Projects seldom include any schedule performance reporting or accountability to senior agency executives or legislators. In addition, projects are rarely differentiated on the basis of importance of schedule, so that all projects are frequently treated the same in terms of schedule management practices.

Because compensation is not linked to project schedule performance, there is little incentive for project administrators to be knowledgeable about historical performance norms and seek to surpass them. Project managers in the public sector are underpaid in comparison with their private-sector counterparts, and public agencies have difficulty in attracting and keeping the best and brightest. Efforts aimed at raising project performance levels would certainly have to be accompanied by higher project management salaries.

Other issues related to schedule performance include the following:

- Even though implementation of innovative approaches requires some risk taking by project managers, there is often little or no support or incentive to do so.

- Schedule-sensitive issues such as right-of-way acquisition, utility relocation, and other frequent causes of project delays are often assigned a low management priority.

- There is little use of contractor incentives for schedule performance, a practice often employed successfully in the private sector.

- While partnering is common between contractors and contract administrators, it is rare (and possibly illegal) between design consultants and construction contractors, where it could have a significant impact on constructability and project times.

- There is an industry-wide failure to take advantage of project lessons learned, including those pertaining to effective schedule management practices.

Technical Barriers

There has been little analysis of advanced time-saving construction technologies, except on an ad hoc basis. Public agency project administrators lack access to guidance or training in the application of schedule-reduction tactics on schedule-driven projects. They are often unfamiliar with best practices for schedule management, such as appropriate levels of schedule detail, the critical path scheduling technique, schedule updating practices, effective reporting practices, and progress-monitoring practices, making it difficult to judge improvement potential. In addition, public administrators have little historical data on project times, so few are aware of truly outstanding levels of project schedule performance. This lack of information and training can lead to loose enforcement of contractual requirements, such as liquidated damages, pertaining to schedule performance.

Project planning processes often do not include a deliberate and rigorous analysis of alternative traffic control plans and construction work sequences or a systematic examination of the risks associated with project schedule performance.

OPPORTUNITIES AND MECHANISMS FOR REDUCING PROJECT TIMES

Opportunities for reducing project construction times currently exist, are emerging, or need to be developed. Like the barriers and challenges discussed above, these opportunities can be classified as legal/political, organizational, and technical. These opportunities can be explored or achieved through research and development of a new technology or procedure, implementation of a demonstration project, or training.

A demonstration project is often effective in implementing change within a large, bureaucratic organization such as a public agency. Initially, such projects involve selected personnel on a few projects. Treated as experiments, demonstration projects are less threatening to staff and have proven to be successful. Demonstration projects require systematic tracking and documentation of performance outcomes, successes, difficulties, and lessons learned.

Legal/Political Opportunities

Research is needed on how to estimate user costs associated with construction project delays. Mechanisms are needed for measuring the marginal user costs at different points in the life of a project. Further demonstration of design–build contracting is needed. Information such as process sequences, time savings, benefits, difficulties, and lessons learned needs to be documented. Guidance is needed on contract and remuneration issues (including use of guaranteed maximum price).

Organizational Opportunities

Research is needed on how time is actually spent on highway construction projects, the causes of delay, suggested methods for reducing times of lengthy activities (such as right-of-way acquisition, utility relocation, demolition, drainage construction, and intersection reconstruction), and methods for avoiding delays. Procedures need to be developed for determining when it is beneficial to divide large projects into multiple contracts with higher levels of concurrent work activity; such procedures should include guidelines for managing the interfaces between contracts.

The highway industry needs a project lessons-learned database that would allow quick retrieval of best practices associated with project schedule management. Such a database would include successful practices from a wide variety of projects across state and department boundaries.

Highway agencies need a method for classifying projects based on level of schedule urgency. For example, projects could be classified as conventional, schedule-driven, and urgent/emergency. Research could aid in identifying appropriate schedule-management strategies, tactics, and implementation tools for each type. The Construction Industry Institute has cataloged 90 project schedule compression techniques that should be reviewed for applicability and effectiveness in public transportation projects (Construction Industry Institute, 1988).

Demonstration projects could be formulated to test a variety of contractor bidding and incentive systems, such as lump-sum bidding, lump-sum cost plus duration bidding, and lump-sum cost plus likely bonus minus likely penalty. Contractual requirements pertaining to schedule performance, such as liquidated damages, are often loosely enforced for a wide variety of reasons.

Demonstrations should be undertaken to examine how risk management models, decision analysis, and simulation tools can be used to predict the way project processes, uncertain schedule determinants, and various approaches to execution affect project schedule outcomes given different scenarios.

Support for projects that encourage partnering between design consultants and construction contractors to promote constructability and achieve project schedule objectives should be continued and expanded if possible.

Technical Opportunities

Research should be undertaken to.

- Identify innovative, time-reducing design concepts and construction technologies, including design configurations, materials, construction equipment, design and construction sequences, repair methods, automated systems, modularization and preassembly.
- Benchmark schedule performance for highway construction projects, taking account of type and size of project and associated causal and enabling factors. Information on effects on user delays should be included.

- Examine the effect on project performance of various approaches to traffic control measures (e.g., complete closure with short-term detour vs. partial closure with longer duration).

- Determine which schedule-reduction tactics are most appropriate for each project implementation phase, and document their impact on project duration and their ease of implementation.

- Develop duration-estimating systems that can provide target durations given key project characteristics (e.g., project type, location, length, width, bridges).

- Establish effective procedures for screening or prequalifying potential bidders based on past schedule performance and other parameters.

- Evaluate the concepts and applications of project liquidated damages.

- Develop mechanisms for evaluating project site operations plans, addressing such factors as field organization structure; optimal work calendar and day; number of concurrent work locations; number, size, and makeup of crews; and equipment selection.

Demonstration of an integrated traffic control planning/constructability program, of advanced time-saving technologies and methods, of fast-track multiple-primes contracting, and of risk-containment plans and strategies would be helpful.

Training activities that would be beneficial include the following:

- A training program targeted to project administrators and focused on best practices associated with schedule management.

- Training for engineering departments/offices to enable systematic and routine investigations into time-saving technologies.

- Training on project schedule performance measures and on how to collect and analyze schedule performance data.

CASE STUDIES OF INNOVATION IN CONSTRUCTION

The following case studies, the first on the use of design–build and the second on developing alternative construction plans, illustrate how construction times can be reduced by a variety of techniques.

Design–Build: An Opportunity for the Public Sector

Design–build (also known as "turnkey" or EPC for engineering, procurement, and construction) is a project-delivery system in which a single organization prepares the design and undertakes construction of a project. Design–build is an alternative to the traditional design–bid–build approach, which has been the dominant project-delivery system in the domestic public sector.

Design–build can substantially shorten project times, primarily by overlapping the design and construction phases so that concurrent activity is possible, and construction starts and ends sooner. The overall project schedule is construction-driven, with construction sequencing driving the production of engineering information packages that support construction activities. An additional benefit of the design–build approach is single-source responsibility for design and construction, which can result in consolidated risk management, fewer change orders, and reduced litigation.

While design–build has been widely used in the private sector for many years, regulatory barriers have prevented public agencies from taking advantage of the approach (National Society of Professional Engineers, 1994). Specifically, regulations pertaining to competitive bidding, lump-sum contracts, and professional licensing often limit the application of design–build in the public sector. However, a growing number of public agencies have adopted the design–build approach, including the General Services Administration, the U.S. Postal Service, the Department of Defense, the Federal Transit Administration and several state departments of transportation (most notably those of Florida, Michigan, and Utah) (Huffman 1995).

The Design–Build Institute of America (DBIA), organized in 1993, promotes the use of the design–build approach. Its mission is to improve the professional standards of the design and construction industry. Major DBIA program elements include development of best practices, monitoring and analysis of successful applications (projects), standardized selection procedures, educational publications, national forums, and development of a model procurement code.

The design–build approach was used successfully in the reconstruction of the Santa Monica Freeway following the January 1994 earthquake in Northridge, California. The reconstruction was predicted to take 5 months to complete, but was accomplished in just 2 months, earning the contractor a $15 million bonus.

The largest current domestic transportation design–build project is the $1.32 billion I-15 Reconstruction Project in Salt Lake City, Utah. This project involves the complete replacement of 17 miles of Interstate highway in an urban area, including widening from six to 10 main lanes and the addition of one high-occupancy vehicle lane in each direction. A total of 140 bridge structures will be replaced, and an advanced traffic management system will encompass 550 traffic signals and 350 miles of fiber-optic cable.

The Utah Department of Transportation has contracted a joint venture involving three contractors (which has a subcontract with a two-party joint venture of engineering consultants). Preparation of detailed technical proposals began in August 1996, and included the development of conceptual traffic control plans and the standardization of many design details. The joint venture team was selected on the basis of both technical and cost proposals, which were evaluated by independent teams. The Notice to Proceed was issued on April 15, 1997, and demolition activities began within 2 weeks. As of October 1997, 3,000 plan drawings had been released for construction. The contract calls for completion by October 2001, approximately 5 months prior to the 2002 Winter Olympics in Salt Lake City.

It is estimated that the design–build approach will reduce the project time from 10 to 4.5 years. Schedule-compression techniques include liquidated damages, schedule milestone incentives, selective use of both double work shifts and 6-day work weeks, and extensive use of the critical path scheduling technique. Substantial project cost savings are expected as a result of schedule-driven savings in both project administrative expenses and contractor overhead costs.

Technical innovations include using lightweight embankment fill and using the winter season for soil consolidation surcharging. The industry is eagerly watching the developments on this innovative, challenging, and aggressively managed project.

Innovative Project Planning: Mockingbird Lane Bridge Project

Mockingbird Lane Bridge is an east-west crossing over the North Central Expressway, one of the most important highways in Dallas. The bridge intersects frontage roads at each end and has a daily traffic volume in excess of 35, 000 vehicles. The North Central Expressway connects the downtown business district with the northern suburbs of Dallas and carries more than 150,000 vehicles per day.

In 1990, the Texas Department of Transportation (TxDOT) and the City of Dallas began reconstructing the 16.1 km expressway, lowering the corridor, expanding it to four lanes in each direction, and widening and rebuilding both frontage roads and all overpassing bridges. The reconstruction is expected to be completed in 2003 at an estimated cost of $550 million. The project includes widening and rebuilding Mockingbird Lane Bridge.

The construction site is characterized by high traffic volumes, nearby buildings, and an extremely limited right-of-way that constrains available work space. The construction contract requires that two lanes of main-lane traffic in each direction be maintained during construction. With temporary detours, the expressway and bridge can be closed only briefly during the removal of the existing bridge.

The original reconstruction plan for Mockingbird Lane Bridge was developed in 1992 and included 16 diversions of main-lane traffic and 6 diversions of Mockingbird Lane Bridge traffic. The plan also included a temporary bridge to carry traffic during construction. The contractor estimated a construction duration of 662 days. TxDOT and the contractor believed that the traffic control plan and construction sequence could be improved upon. With such high traffic volumes, any improvement could have a significant impact. The two parties agreed to reinvestigate the traffic control plan and construction sequence.

Innovative Approaches. In 1994, TxDOT contracted with researchers from the University of Texas to investigate alternatives to the reconstruction plan for Mockingbird Lane Bridge. TxDOT specified that the study should provide an alternative that would reduce construction duration and traffic interruption. A study team comprising university researchers, TxDOT project engineers, and contractor project managers spent 5 months preparing a project plan based on alternatives that were evaluated on the basis of six measures—including traveler safety, worker safety, accessibility, carrying capacity, project duration, and project direct cost. By December 1994 the plan had been approved, and bridge reconstruction began in January 1995.

Successes and Benefits. The new bridge construction plan called for 33 percent fewer phases or steps (each typically requiring a traffic change) than the original plan and eliminated the need for the temporary bridge. It reduced the total number of detours and ramp closures and increased traffic accessibility to adjacent businesses. Both traffic safety and construction crew safety were enhanced.

The new plan resulted in direct cost savings of more than $450,000 (approximately 15 percent of the project direct costs) and reduced the project duration by 200 days (30 percent of the original duration). The associated savings in road user costs from such a substantial schedule reduction were estimated in the tens of millions of dollars.

Difficulties, Lessons Learned, and Opportunities for Industry. Although the late changes to the Mockingbird Lane Bridge Project traffic control plans resulted in substantial benefits, they did present challenges. Achieving optimal traffic control plans requires considerable effort on generating and evaluating alternative traffic control schemes. Such schemes are closely linked to issues of construction sequencing and project constructability and are critical drivers of overall project duration. As such, they represent a clear opportunity for improving overall project schedule planning and performance (El-Diraby, 1997).

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