Case Study

Strategies for Planned Project Acceleration

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Abstract: Departments of transportation in the United States are under increasing pressure to accelerate projects to meet user-defined constraints and reduce the inconvenience to the traveling public. Although there is information about acceleration projects in other industries, there has been little specifically aimed at highway projects. A domestic scan sponsored by the National Cooperative Highway Research Program was tasked with providing information in this area. The objective of this paper is to synthesize the resulting information into fundamentals that support successful planned accelerated highway project delivery. Case studies of how departments of transportation successfully accelerated the construction of four very different projects in California, Florida, and Texas serve as the basis for identifying these fundamentals. The fundamentals include upfront and detailed planning, designs that facilitate accelerated construction, a collaborative environment for project stakeholders, and incentives and disincentives to motivate construction contractors. **DOI: 10.1061/(ASCE)CO.1943-7862.0000289.** *© 2011 American Society of Civil Engineers.*

CE Database subject headings: Construction management; Planning; Project management; Contracts; United States.

Author keywords: Construction; Construction planning; Project collaboration; Project design; Contracting.

Background

To meet community desires and specific externally imposed project duration constraints, transportation agencies often take steps to accelerate project construction. Over 130 bridges and a number of other projects have been completed across the nation in recent years by using accelerated methods (FHWA 2008). It is obvious that with careful planning, projects can be accelerated and roadways reopened with only minimum inconvenience to the traveling public; however, there is very little specific guidance for these types of projects. The most significant works available in the transportation field are the reports from Accelerated Highway Construction Workshops that the Federal Highway Administration (FHWA) has sponsored (Farragut 2003; FHWA 2007).

This lack of a definitive body of knowledge caused the National Academies National Cooperative Research Program (NCHRP) to undertake a U.S. Domestic Scan of Best Practices in Accelerated Construction Practices (Blanchard et al. 2009). From this study, fundamentals of successful planned project acceleration are identified. This paper is a synthesis of the NCHRP research study focusing on best practices related to planned acceleration.

Agencies can no longer take months or years to deliver new or repair vital transportation infrastructure. Finding ways to accelerate construction activities that impede commerce has become paramount and essential for project delivery success. Additional reasons for planned acceleration of projects may include high average daily traffic (ADT) counts, opening prior to scheduled significant events, or increased creditability with the traveling public. This study specifically sought data on projects programmed for acceleration action. No emergency acceleration projects are discussed. The cases are not an all-inclusive study of current activities. Rather, it documents through in-depth studies the key fundamentals that support successful delivery of projects when time is of critical importance.

The projects studied and the individuals interviewed were identified through a desk scan of reports concerning accelerated construction experience (Ralls and Tang 2003; CTC & Associates LLC 2004; Goodrum et al. 2005; Chabannes et al. 2005, 2006; Schexnayder et al. 2006; Cho 2007) and communication with practitioners across the United States. Case study information was then gathered through on-site interviews with transportation agency representatives, contractors, suppliers, and engineering consultants having accelerated project experience.

The writers and a team of transportation agency professionals used their expertise and experience to derive qualitative judgments concerning acceleration practices. Agency professionals on the NCHRP team represented the FHWA, the Texas Department of Transportation (DOT), the Florida DOT, the North Carolina Turnpike Authority, the Oklahoma DOT, and the Mississippi DOT.

Research Methodology

The research team utilized a two-part methodology to gather information on desk scan and case studies involving on-site interviews and discussions. A desk scan is much like a literature review in that it entails a review of current and past literature about the subject. Literature included books, journal articles, conference proceedings, and reports. DOT websites were also explored as they often covered details concerning specific projects. Similar to a literature review, the desk scan provided background information for the research team. In addition to the literature review, the desk scan involved contact with agency personnel to directly discuss specific projects and identify available project information. This enabled the

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Note. This manuscript was submitted on November 24, 2009; approved on September 8, 2010; published online on September 10, 2010. Discussion period open until October 1, 2011; separate discussions must be submitted for individual papers. This paper is part of the ***Journal of Construction Engineering and Management***, Vol. 137, No. 5, May 1, 2011. ©ASCE, ISSN 0733-9364/2011/5-372–381/$25.00.

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research team to select projects for further examination in the second phase of the study.

Case studies were the second part of the research methodology utilized in this research. The selected case study projects were chosen by the NCHRP team after examination and discussion of the desk scan information. The cases were selected on the basis of geographical location, the type of project, and level of acceleration. This case study selection approach was used to ensure the team's ability to generalize the findings as well as the need to document successes and capture lessons learned regarding accelerated projects. One benefit of case studies is the ability to conduct a comprehensive interview with those individuals intimately familiar with the subject matter.

The research team began the case studies by developing a set of questionnaires that included a number of open-ended questions. Two separate questionnaires were prepared. One questionnaire, containing 45 questions was prepared from state highway agency perspective, and one set of 34 questions was prepared from a contractor perspective. The questionnaire instruments covered six areas with a focus on planned project acceleration. All of the questions were open ended. The following are the areas and example questions:

1. General program level issues
   a. What issues and topics are addressed and analyzed during development of the accelerated construction approach (traffic management, traffic within construction zone, phasing and construction sequencing)?
   b. Are accelerated construction approaches successful? If so, why and if not? Please provide reasons why they are not successful.
2. Contracting strategies/contract administration.
   a. What were the critical issues addressed during the contracting strategy selection process?
   b. How did the DOT view their relative importance (schedule, deadlines, cost, traffic, cash flow)?
3. Planning and scheduling
4. Construction practices—cost, time, quality
5. Traffic control and management
6. Postconstruction—What did happen?
   a. What were the processes for corrective actions to mitigate the impacts of problems that occurred during construction?
   b. What are the types of constructability related problems typically encountered during an accelerated construction project?
   c. What methods and techniques do contractors employ to gain efficiency during accelerated construction?

The two questionnaires were distributed to each of the case study project participants prior to the site visit. Formal written responses to the questions contained in the questionnaires were obtained during the visits. Each case study site was visited by six to eight research team members as a group. The research team utilized the questionnaires as a tool to guide the site visits. In many cases, the questionnaires were completed by the agency or contractor personnel prior to the meetings. During the site visits respondents elaborated on all of the questions through presentations, completed documents and question and answer periods with the research team members who asked clarifying questions and took notes.

The typical site visit began with detailed presentations by the agency project personnel on the case study project. These presentations lasted from 30 to 60 min. This was followed by discussions between the research team and the project stakeholders, using the completed questionnaires and presentations as a guide. After every visit the research team combined the notes taken throughout the visit. As the case study visits were taking place and the additional data became available, patterns for successful acceleration efforts and fundamentals for success began to emerge. These patterns resulted from the aggregate viewpoints of the research team. Development of the results using case studies is an iterative process that includes developing possible conclusions which are then tested and revised in later case studies.

The findings of this study were confirmed through multiple sources of information from each case study and the desk scan data. Information obtained from case studies included the presentation, project documents, question and answers throughout the site visit, as well as from the completed questionnaire instruments. There were multiple parties involved in each case study, representing the different stakeholders involved in each project. Multiple sources of information within the case study projects as well as between case study projects provided a basis upon which fundamentals for successful planned project acceleration were formulated.

Four of the seven case study projects are described in this paper. Information abstracted includes responses from a number of agency and contractors involved in each of these projects. The California Department of Transportation (Caltrans) projects are represented by 13 agency participants and 11 industry participants. The Florida DOT (FDOT) project includes information from three agency representatives and six contractor or consultant participants. Finally, the Texas DOT (TxDOT) project is the result of interviews with five agency personnel and four contractor or consultant respondents. These projects demonstrate the fundamentals for strategies for successful completion of accelerated projects in highway sector construction in the United States.

I-15 Devore Corridor, California

In 2004, Caltrans used its Long-Life Pavement Rehabilitation Strategies (LLPRS) (Caltrans 2007) program for an innovative approach to rebuild a heavily traveled section of I-15 in the city of Devore (Fig. 1). The Devore corridor carries approximately 110,000 ADT, with approximately 10% heavy trucks. In contrast to typical urban freeways in California that has low traffic on weekends and high traffic during rush-hour weekday peak periods, the Devore corridor has both high weekday commuter-peaks and high leisure traffic volume on weekends. The two highest peak traffic volumes are northbound on Friday afternoon and southbound on Sunday afternoon, when leisure travelers in the Los Angeles area are going to and from Las Vegas.

During this project, a 4.5 km stretch of badly damaged concrete was rebuilt in only two single continuous closures (also called "extended closures") totaling 210 h, using counterflow traffic (opposite direction to the main traffic flow) and 24-h-per-day construction operations. Traditional nighttime-only closures would have required 10 months of work, as estimated on the preconstruction schedule. Instead, the rebuilding took 19 days, with each extended closure for one roadbed lasting 9.5 days.

I-15 Project Description

The preconstruction analysis sought the most economical reconstruction closure scenario while integrating the competing concerns of construction schedule, traffic impact, and agency cost. Four closure scenarios were compared: (1) 72-h weekday; (2) 55-h weekend; (3) one-roadbed continuous (24 h per day, 7 days per week); and (4) 10-h nighttime. The analysis concluded that the continuous/extended closure scenario would be the most economical. Compared with traditional 10-h nighttime closures, the preconstruction analysis indicated that the extended closure scenario (two single-roadbed continuous closures) would need approximately

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Fig. 1. Location map I-15 project at Devore (Blanchard et al. 2009, reprinted with permission from Transportation Research Board)

80% less total closure time, resulting in approximately 30% less road-user cost because of traffic delay, and about 25% less agency cost for construction and traffic control. This analysis was performed using Construction Analysis for Pavement Rehabilitation Strategies (CA4PRS). CA4PRS identified the costs associated with road-user traffic delay in order to determine appropriate incentives and disincentives for the construction contract (Caltrans 2007).

Initially, Caltrans moved ahead assuming the use of 72-h weekday closures because of major concerns about traffic delay on weekends for Las Vegas–bound leisure traffic. However, at public hearings, Caltrans met strong opposition from weekday commuters to the 72-h weekday closures. Weekday commuters felt that their time delay was of greater value than that of leisure traffic. Although the contract was awarded based on the 72-h weekday closures, Caltrans adjusted the reconstruction plan to one-roadbed continuous closures just 1 month before the first extended closure was set to begin.

For this type of work in California, the Devore project was the first to implement an automated information system in the work zones. Before construction, it was decided to have a 24-h command center. The system provided motorists with real-time information on travel and detour routes. The information was posted on permanent and temporary changeable message signs that were placed in strategic locations where roadway users could make decisions about travel routes. As part of an interactive public outreach program, the information was also posted on a traffic roadmap accessible on the project website.

By structuring the work as continuous, Caltrans was able to specify rapid-strength concrete with a 12-h curing time rather than fast-setting hydraulic cement concrete (FSHCC) with a 4-h curing time. The 8-h time advantage of FSHCC is offset by higher concrete slump and material stickiness, the need for more delivery trucks and a smaller paving machine, the restriction to single-lane paving at one time, and the typically rougher finished surface that frequently requires diamond grinding after curing. In addition, FSHCC is about twice as expensive as Type III portland cement concrete (PCC) in California.

Another measure to speed the work was the substitution of a 15.2 cm new asphalt concrete base (ACB) instead of the usual 15.2 cm lean concrete base (LCB). LCB requires a 12-h curing time before PCC slab paving. LCB also requires placement of a bond-breaker, which could slow production, to minimize friction between the base and slab that increases the risk of early-age cracking. The ACB scenario additionally permitted parallel production of the base and slabs, with each operation utilizing its own resources, whereas the LCB needs to use the PCC plant and a paver.

A widened 4.3-m-wide lane, rather than the usual 3.7-m-wide lane, tied the new concrete shoulder to the outermost truck lane. However, high project bids in the first round of bidding resulted in altering the rehabilitation scope. The initial scope included reconstruction of two (outermost and adjacent) lanes, but the revised project included reconstruction of only the outermost lane and targeted partial (approximately 10%) slab replacement on the adjacent lane.

Project Execution

The I-15 northbound roadbed was closed for reconstruction first, and northbound traffic was switched to the southbound side via median crossovers at the ends of the work zone. The two directions of traffic shared the southbound lanes as counterflow traffic separated by a Quickchange Moveable Barrier (QMB) system. The same process was repeated for reconstruction of the southbound roadbed. The use of the moveable barriers, at a cost of $1.5 million, helped to balance traffic impacts to commuters and weekend travelers by providing dynamic lane configuration. Twice-daily operations required only 30 min to move the barrier and convert one additional lane temporarily from the rehabilitated asphalt concrete shoulder to accommodate peak directional commute traffic.

The work combined conventional construction materials and operations with state-of-the-practice technologies to expedite construction and minimize traffic impacts. The contract required that the contractor have contingency plans for items identified by previous LLPRS case studies as risk that could impact progress. One contingency issue was the possibility of encountering poor subgrade during demolition and excavation. It was agreed that FSHCC could be used, either to achieve more production at the end of the closure, to make up for any unforeseen delay, or as a temporary paving material in case of an emergency. Project features that contributed to traffic control included the following:

1. A project command center that facilitated department coordination between disciplines (construction, design, traffic, and public affairs) and with other agencies. The command center also enabled remote monitoring of traffic and construction on closed-circuit television. Caltrans shared information and received constructive feedback from the local community through the High Desert Commute Advisory Committee.
2. Caltrans allocated $65,000 to establish free commuter bus service to promote ridesharing. Fourteen buses were added to existing lines serving commuters traveling from the High Desert to the south, increasing overall usage by 40%. The Freeway Service Patrol tow truck service removed 1,243 disabled vehicles from the work zones at a cost of approximately $100,000.
3. The Construction Zone Enhanced Enforcement Program improved traffic control and enforcement in the construction work zones. The California Highway Patrol issued 1,034 traffic citations during the construction period.

Contractor production rates exhibited a significant learning curve. The majority of the reconstruction operations during the southbound reconstruction (later in the project) were 28% more rapid for slab removal and 22% more rapid for paving than those of the northbound reconstruction (earlier in the project). The continuous lane reconstruction on the outer truck lane had twice the productivity of the random slab replacement operation on the inner truck lane.

Acceleration Efforts and Fundamentals of Success

The advantages of using the continuous closure approach to planned acceleration of construction were a shorter period of disruption for the traveling public; greater life expectancy for the new pavement than could have been obtained using nighttime closures; improved safety for motorist and workers; and significantly reduced construction costs (about $6 million).

Planning

Caltrans dedicated efforts in analyzing the impacts of different road closure. The scenarios supported best alternative decisions in construction speed, construction cost, and cost to the public. Caltrans also retained the contractual authority to open the freeway prior to the end of closure because of emergencies (e.g., severe weather, fires, vehicle accidents, or construction-related problems that would compromise the quality of the finished product). Under such circumstances, the contractor was required to use FSHCC, hot mix asphalt, or cold-mix asphalt concrete (AC) as temporary paving materials to be eventually replaced with specified materials. Caltrans was also involved in planning how the project work should be scheduled.

Caltrans planned focused public involvement and outreach campaigns. Prior to construction, large employers and affected business (airports, postal, and package service companies) were informed through project fliers, public meetings, and intensive media outreach. Project planners hoped that the dynamic effort to raise public awareness could prompt a 20% reduction in peak-hour traffic demand and the effort was successful. In the five months preceding the extended closures and while the closures lasted, the project website received nearly 100,000 hits and played an important role as an interactive tool to gain input from the public. Community Web surveys indicated that the majority (72%) of the people who used the site considered the project information useful to their trip planning (Lee and Thomas 2007).

Design

Caltrans specified rapid-strength concrete with a 12-h curing time rather than fast-setting hydraulic cement concrete with a 4-h curing time and substituted a 15.24-cm new AC base for the usual 15.24-cm lean concrete base.

Collaborative Environment

Formal partnering was used by Caltrans and the contractor on this project.

Incentives and Disincentives

The contract had incentive/disincentive provisions to encourage the contractor to complete the closures on time. There were two incentives/disincentives (I/Ds) provisions. One was to minimize the duration of each roadbed closure (a closure incentive bonus of $300,000) and the second to minimize the total closure days of the entire main reconstruction. This last was set at $75,000 per day for each day less than 19.

Bay Bridge Yerba Buena Island Viaduct Roll-in, California

The Yerba Buena Island (YBI) Viaduct carries Interstate 80 traffic across YBI and links the east spans of the San Francisco Oakland Bay Bridge (SFOBB) with the YBI Tunnel. A 106-m portion of the YBI Viaduct was in need of replacement (or significant retrofit and modification) to accommodate a detour structure required to allow traffic to bypass construction on YBI during the replacement of the east spans of the SFOBB. The replacement structure was also needed to replace a section of the YBI Viaduct that was considered seismically deficient.

Numerous advance planning studies (APS) for both retrofit and replacement of this section of the YBI Viaduct were completed. All examined project approaches required significant traffic delays (lane closures and short-term bridge closures for approximately 8 h) for at least 9 to 12 months to complete the project. Construction was risky because of the close proximity of live traffic and tight schedules for closures. These approaches were all deemed too risky and disruptive to implement.

The last APS study considered building a new structure next to the existing structure and then quickly demolishing the old structure and moving in the new structure. This required at least three full days of bridge closure. It was felt the public would be more accepting of a 3-day closure than months of traffic delays. The other major advantage was that construction would take place away from live traffic, thereby reducing both risks to the traveling public and risk to the construction schedule.

YBI Viaduct Roll-in Project Description

The project goal for the viaduct replacement was to limit the bridge closure to 3 days. Traffic Operations estimated that the economic impact was best minimized with the 3-day shutdown compared to the conventional staged partial detours that would take more than a year. Labor Day weekend 2007 was selected to be the target time frame for roll-in, as the bridge had the least traffic demand over Labor Day and thus the closure would inflict the least economic impact.

A cast-in-place/posttensioned (CIP/PS) box girder with transverse girders and large edge beams spanning column supports was the selected design. The edge beams sit on bearing pads (placed on top of the columns) and are tied to the support columns with structural steel pins. This enabled the placement of the superstructure onto the support columns to be achieved with minimum complexity.

The construction sequence was developed with input from the contractor and the bridge moving contractor. It was decided to move the bridge with skid shoes that ran on oiled steel tracks pushed by hydraulic rams. The bridge had to be designed to withstand the moving loads. The basic construction sequence was as follows:

- Prepare a level staging area adjacent to the existing structure for construction of the new superstructure—in this case, two large soil nail walls were needed to provide the level staging area for the roll-in operation;
- Build the new support columns on the side of the existing viaduct;
- Build the new superstructure, including temporary support columns, in the staging area;
- Place the moving equipment, including skid shoe rails and rail foundations;
- Close the SFOBB to traffic for up to three days;
- Demolish the existing structure;
- Move in the new structure;
- Set the new structure down on the support columns and place the column pins;
- Place the closure pour between the new and existing viaduct; and
- Open the SFOBB to traffic.

Project Execution

The staging area required level ground for the skid shoes to perform adequately. New temporary concrete columns were built in the staging area that mimicked the location of the new columns. This was required to minimize differential settlement at support locations during construction. This proved to be expensive since the temporary columns were almost as expensive as the permanent columns.

The CIP/PS box girder was built on falsework, and then post-tensioned. The falsework was then removed and the moving equipment was installed between the temporary columns.

The roll-in operation meant the SFOBB was closed to traffic at 8 p.m. on Friday night. Since there was no room to roll-out the existing superstructure span, the contractor chose to demolish the 6,500-t structure on site within two days. The existing floor beams (each 23 m long) were saw cut and hauled across the east span of the SFOBB to a dumpsite in Oakland. The substructure was demolished using demolition hammers. Lifting and moving the new span into place required slightly less than 3 h (Fig. 2). The clearance between the new and existing structure was 7.62 cm on each end. The superstructure was set on its new columns, and the column pins were installed. The column pins were dropped through prefabricated holes in the edge beam into prefabricated holes in the columns. The successful installation of the column pins was a testament to the tight tolerances the contractor was able to achieve during construction and moving. Traffic was placed back on the SFOBB at 6 p.m. Monday, 11 h ahead of the scheduled 5 a.m. Tuesday opening. A video of the demolition and roll-in operation can be found at www.mtc.ca.gov/news/info/bay_bridge_9-07.htm.

Acceleration Efforts and Fundamentals of Success

The YBI Viaduct roll-in approach enabled Caltrans to build the new roadway section without impacting traffic until the new structure was complete. This approach minimized bridge closure to only 3 days.

Fig. 2. Roll-in of new YBI Viaduct (Blanchard et al. 2009, reprinted with permission from Transportation Research Board)

Planning

Risk management has proven to be an invaluable asset in dealing with the inherent risks with a project as massive and complex in scope and scale as the SFOBB of which the YBI Viaduct roll-in is one component. Caltrans developed a six-step process that constantly monitors existing risks and seeks to anticipate potential risks. The six steps are management planning, identification, qualitative analysis, quantitative analysis, response planning, and monitoring and control (Bay Bridge Public Information Office 2010). The SFOBB east spans project schedules were all centered around and driven by the self-anchored suspension (SAS) bridge. To keep the entire project moving forward, the YBI Viaduct span had to be completed expeditiously to fit into the time available for the subsequent YBI transition structure, which in turn had to match to the SAS schedule. The test lift of the span that demonstrated problems allowed time to adjust the jacking arrangement and led to a successful roll-in of the span. The process helped project leaders respond to design challenges, that is, a structure capable of resisting the loads imposed by the moving process. Contract risk transfer elements maintained a focus on acceleration, such as responsibility for bridge closure duration. Risk management was the impetus for the test lift as a strategy to mitigate risk.

Additional planning included Caltrans' extensive notification campaign 6 months before the closure. Caltrans spent nearly $1 million on websites, flyers, radio ads, and premovie commercials to warn residents of the Bay Area, the Central Valley, and Southern California of the closure. The department also subsidized mass transit, paying for Bay Area Regional Transit (BART) to offer limited overnight service and for the ferry systems to operate additional boats.

Design

This was a project fraught with risk and unknowns. Originally, it was a design-build contract but as the number of issues began to mount, Caltrans took over design and it was completed through force account. The design team worked with the contractor and the heavy lift contractor.

Collaborative Environment

The 2007 roll-in clearly demonstrated the importance of partnering. A partnering atmosphere that included all members of the project

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team, Caltrans, the contractor, the designer, subcontractors, and fabricators, was instrumental to project success. The use of the innovative roll-in/roll-out equipment had never been utilized on a Caltrans project. The collaborative environment was exemplified by the willingness to pursue a risky new construction technology for which there was no Caltrans in-house experience and required substantial coordination between the design team and the contractor providing the hydraulic skidding system.

Replacement I-10 Bridges over Escambia Bay, Pensacola, Florida

The FDOT replaced the I-10 twin bridges over Escambia Bay. These two bridges had been repaired to immediately restore the flow of traffic under restricted conditions after Hurricane Ivan. Both bridges needed to be replaced. The new three-lane bridges were built south of the existing bridges at the very limit of the state's right-of-way. This alignment was chosen because the engineers were trying to minimize the impact of pile-driving operations on the damaged bridges. They did have to obtain a temporary easement on the south side of the right-of-way from the Florida Department of Environmental Protection.

Escambia Bay Bridges Project Description

The award amount for this project was $242 million and the final contract was $255 million. Each bridge has three 3.66 m travel lanes and 3.05 m inside and outside shoulders. They have a minimum clearance over water of 7.62 m, whereas the clearance of the original bridges damaged in Hurricane Ivan had a clearance of less than 3.66 m. Over the navigation channel, the spans reach 19.81 m above the water. This is 3.05 m higher than the original bridges and was dictated by the U.S. Coast Guard. The project began in April 2005 and was substantially complete by autumn 2007. The eastbound bridge opened in December 2006 and the westbound bridge in December 2007. Although both bridges were opened, construction work continued until April 2008 on items such as lighting and demolition of the old bridges.

FDOT used its existing design-build process, but the contract for building a replacement bridge across Escambia Bay also had an $A + B$ component. A $10-million lump sum bonus was offered as the incentive to open the Phase 1 eastbound bridge by December 29, 2006. The eastbound bridge actually opened on December 19, 2006.

The FDOT proposal guidance stated:

1. Maintain or improve to the maximum extent possible, the quality of existing traffic operations, both in flow rate and safety, throughout the duration of the project.
2. Minimize the number of different traffic control plan (TCP) phases, that is, number of different diversions and detours for a given traffic movement.
3. Accomplish Contract Work Item #1 (completion of bridge structure(s) and placement of four lanes of traffic on the completed bridge structure(s) by December 15, 2007.
4. Accomplish completion of bridge structure(s).
5. Demolish existing bridge structures (including fender system and dolphins).
6. Maintain reasonable direct access to adjacent properties at all times.

Proposals were evaluate by the formula

$$\text{Proposal rating} = (\text{Price} + \text{Time})/\text{Technical Score}$$

The engineer for the winning design-build team stated, "We only had about 3 weeks to put the proposal together. In that time, we took the whole bridge to 30% design, with certain elements at 60 to 90%. The design had to be at a level the joint venture was comfortable with" (Buckley 2006).

Table 1. Time Line for Awarding the Replacement I-10 Bridges Contract

Event	Date
Hurricane Ivan made landfall	September 16 2004
NEPA Process begins	October 5, 2004
Project advertised for letters of interest	December 21, 2004
Shortlist of design-build firms	January 10, 2005
Public information workshop	February 3, 2005
VE study completed	February 10, 2005
NEPA completed	February 11, 2005
RFP approved by FHWA and issued	February 16, 2005
Design-build contract executed	April 20, 2005

The success of the FDOT's time line (Table 1) for constructing a replacement bridge depended on the expeditious settlement of the National Environmental Policy Act (NEPA) process. Information gathered through the NEPA process was included in the request for proposals (RFP). Concurrent activities allowed for the timely delivery of both the NEPA documents and the contract documents. The project was advertised while in the midst of the NEPA process. Prospective design-build firms were not only allowed, but greatly encouraged to attend all NEPA coordination and public meetings.

Project Execution

From the geotechnical data gathered when the original bridges were constructed, from the railroad bridge further north, and from six borings completed during the proposal phase, it was clear that the site soil conditions were variable. Then from the first test piles and an additional 60 borings made during construction, engineers came to appreciate the high variability of the soil deposition in the bay. The unpredictability even from pile to pile forced the contractor to use longer piles. Most piles are 44.20 m long, but the longest measured 51.82 m and weighed 72,574 kg.

Additionally, the contractor had to deal with three major storms and take protective measures for every named storm. For a major storm, it took 5 days to demobilize the sizeable fleet of barges and 21 large-capacity cranes that were on site. Most were moved to protected locations upriver. During the project, the contractor had to demobilize because of storms four times in 2005 and twice in 2006.

Hurricane Katrina in August 2005 did little damage at the site, but it disrupted the flow of materials. Precast concrete elements were coming from two yards, one in Tampa, Florida, and another in Pass Christian, Mississippi. The Tampa plant was not severely impacted, but the one at Pass Christian was destroyed.

Acceleration Efforts and Fundamentals of Success

FDOT used a design-build contract to shorten the overall project duration. This approach was coupled with a cost-plus-time execution strategy. The result was an overall reduction in project duration.

Planning

The contractor had multiple backup strategies besides the use of two precasters. They elected to use a local off-site batch plant but also looked at alternative suppliers having state approval.

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Design

Precast was a significant element in the design decision. The bridge was not built linearly. The contractor started with three fronts and later opened two additional fronts. Multiple precasters were needed to maintain the supply of components and to reduce project risk. The design-build team selected to use 0.91-m-square precast piles (a first for an FDOT project). The larger piles created several advantages. Only five piles were needed for each substructure unit. Standard 0.76-m piles would have required seven or more per unit and a pier structure having more cast-in-place concrete. There was efficiency in the total number of pieces for a given span with piles, precast beams, and caps each weighing roughly the same. Therefore, the same equipment could lift all of the bridge components. Other construction issues were

- Pile size was also based on pile hammer availability (ensuring that it would not take extraordinary equipment); and
- Precast element size was limited by the lifting capacity of equipment at both the precast yards and placement point on the project.

The design also allowed for repetition, which was a key to the accelerated schedule. The execution plan was thoughtfully worked out so that pile driving, forming, and beam placement reached a production rate of 11.89 m of bridge per day. The contractor had constructed other accelerated construction projects and those previous experiences jump-started this project's learning curve. Designs for accelerated projects also cannot require special or one-of-a-kind equipment.

Collaborative Environment

Partnership is critical to successfully completing an accelerated construction project. Issues will always arise and the team must be committed to finding satisfactory solutions in a timely manner. The contractor developed the TCP. Beause of storms, 90 work days were lost on this project. A change was suggested to "Get it open." This was an alternate means of opening the bridges to traffic by widening the approach pavement. FDOT agreed to this alternate process and agreed to pay some of the additional cost. This was aided by ensuring that the parties on the project can make decisions in a timely manner and have an appreciation for realities of building a major project. The project team members had to be willing to make changes that were necessary to adhere to the schedule and deliver a quality project. It may even be necessary to change people to produce this collaborative environment.

Incentives and Disincentives

FDOT uses its construction, engineering, and inspection (CEI) cost times two to come up with the disincentive, instead of calculating road-user cost (RUC) for a project. There was much discussion about lump sum in lieu of daily I/Ds. FDOT can adjust a disincentive date but not a no-excuse incentive unless it is a force majeure issue. Contractors prefer a daily incentive/disincentive rate and have an aversion for lump-sum incentives, as there is too much risk that they cannot control. Additionally, the prime contractor wrote incentives and disincentives into some supplier and subcontractor contracts.

Contract language must address force majeure exceptions to no excuse. Contracts need to have clear language addressing catastrophic events and how they are handled in contract time, incentive/disincentive time, and the lump-sum bonus date, whether the event be a hurricane, war, permits, or other occurrence outside the control of the DOT and contractor. The force majeure language must spell out consideration for direct and indirect effects both on and off the project. The contract language needs to specifically address the following:

1. Additional time.
2. Price escalation.
3. Overhead for additional time.
4. Acceleration cost to return to the baseline schedule.
5. Subcontractor actions, abandoning the contract or inability to perform because of uncontrollable events.
6. Supplier actions, abandoning their purchase orders or inability to perform because of uncontrollable events.
7. Define force majeure events and address hurricanes, war, earthquakes.
   a. Duration of the impact.
   b. Impact to time for milestones and completion.
   c. Acceleration to meet deadlines.
8. Whether direct on the project or off the project impacts are eligible for consideration.

Interstate 10, Houston

Originally constructed in the 1960s, the 37-km stretch of Interstate Highway (IH) 10 (Katy Freeway) from its intersection with Interstate 610 west to the City of Katy was badly congested 11 h per day with ADTs in the range of 280,000 vehicles per day. The pavement on sections of the Katy freeway were from 30 to 40 years old. Flooding of the mainline interstate roadway and frontage roads was a continuous problem during heavy rainfall. Maintenance costs had reached nearly $8 million a year. The TxDOT, therefore, embarked upon a $2.8 billion Katy Freeway Reconstruction Program.

The planning process for the reconstruction program began with a Major Investment Study in 1995. This study focused on the entire IH 10 Katy Corridor. It involved the assessment of mobility needs and environmental and community effects of many alternative solutions. Inputs were received from the public and local agencies. A locally preferred alternative was selected and the ultimate design was based on recommendations from all affected stakeholders. Design work commenced in 2000 with an environmental impact statement (EIS) that reflected the social, economic, and environmental impacts of reconstruction. A record of decision (ROD) was issued by the Federal Highway Adminsitration (FHWA) in January 2002. TxDOT began the reconstruction of the IH 10 in late 2003 with completion coming early in 2009.

Interstate 10 Project Description

The limits of the Katy Freeway program started at the Harris/Fort Bend County line (City of Katy) approximately 32 km from Houston and the IH 610/IH 10 interchange (Fig. 3). The existing configuration included dual three-lane mainlines, dual two-lane frontage roads, and one reversible high occupancy vehicle (HOV) lane. The proposed configuration included dual four-lane

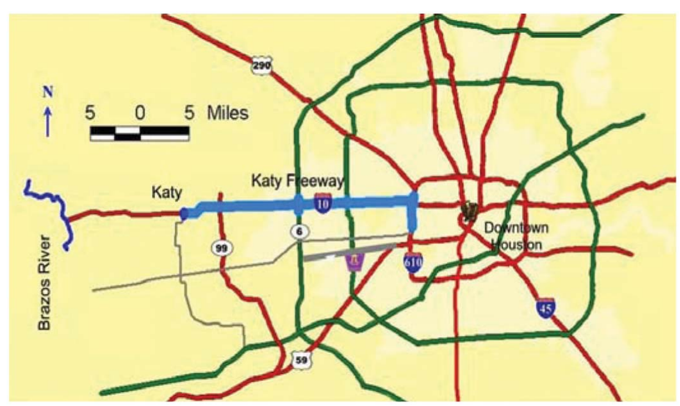

Fig. 3. Katy Freeway location (Blanchard et al. 2009, reprinted with permission from Transportation Research Board)

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mainlines, dual three-lane frontage roads, and two managed toll lanes. In addition, two freeway to freeway interchanges were reconstructed and 27 grade-separated intersections were built. The estimated cost of the project is $2.64 billion (based on final bid prices) with about two-thirds of this total program cost for construction and one-fourth for right-of-way (ROW) acquisition and utility relocation. The remaining budget cost covered design, program management, and construction management.

The Katy freeway project was one of the largest highway construction projects in the state's history. This was the first project in the nation to construct toll lanes on an existing interstate highway. There were nine major construction contracts in the reconstruction program. TxDOT hired a general engineering consultant (GEC) to provide oversight guidance to 10 section design consultants that were contracted by the Houston District of TxDOT to perform final design. The section design consultants also provided support services during construction, including shop drawing reviews and responses to requests for information. The GEC also hired subconsultants to provide various services for the execution and management of the project as directed by the district.

Project Execution

Detailed design for the Katy Freeway Program started in 2001 with ROW acquisition and utility relocation starting in mid-2002. Detailed design, ROW acquisition, and utility relocation were performed concurrently after mid-2002. Construction started in 2003. The project delivery approach for the Katy Freeway Program was considered design-bid-build, as all construction work was bid competitively after completion of design for a project. The construction effort was split into nine major packages. Two contractors were awarded the construction of the nine contracts; one contractor was awarded six contracts and another contractor was awarded three contracts.

The decision to use an accelerated construction approach began in the detailed design phase. TxDOT and the GEC worked closely during the detailed design phase to coordinate their efforts and to consult with construction personnel. These two teams combined efforts to reduce construction time by using past experiences and known variables to estimate anticipated time schedules. The design team carefully scrutinized every design element asking the question, "How can we reduce the expected construction time?" Every bid item was evaluated from a constructability perspective. Strategic milestones were defined and project I/Ds were tied to these milestones. In addition, lane rental fees were used to maximize efficiency of lane closures.

TxDOT modified its use of constructability reviews to incorporate these reviews at various design milestones (e.g., 60%, 90%). This approach was a departure from the normal practice of performing constructability reviews at the end of design just before construction letting. As part of these reviews, contractor input was provided on estimated construction durations and other contract time lines.

TxDOT also worked closely with major suppliers and manufacturers to help expedite the availability of materials. This interface resulted in an overview of key construction elements. Specifically, the focus of this effort was on plans, specifications, and anticipated requirements for quantities of materials, especially with longer lead material delivery items.

TxDOT typically does not start construction until ROW is acquired and utilities are relocated. This approach would not work for the Katy Freeway Program because of the decision to accelerate construction. A modified ROW plan was prepared to integrate simultaneous acquisition of ROW and the timing of utility relocations with selected construction activities. ROW acquisition required the

Fig. 4. Mainline I-10 construction (Blanchard et al. 2009, reprinted with permission from Transportation Research Board)

purchase of 442 parcels and over 910 relocations. In addition, more than 35 different utility companies were establishing relocations involving more than 130 utility agreements. The ROW team acquired over 223 parcels in 18 months, which was a significant contribution to accelerating the project. At the same time, the GEC coordinated utility relocations. The size of this effort was substantial at an estimated cost of $311 million. For example, 39 km of various sizes of pipe were relocated.

The nine construction contracts were bid and awarded over a 2-year period. The first contracts were awarded for work at each end of the total project limits, including the IH 10 and IH 610 interchange at the east end of the project. Major roadway construction started at the west end of the project near Katy. The construction packages were generally awarded moving from the west to the east. The traffic requirements during construction focused on maintaining the existing number of main lanes and frontage lanes (Fig. 4). Local access across the corridor had to be maintained as well. In addition, the existing HOV lanes had to continue to operate. Generally, construction was performed from the inside out. In other words, mainline construction was completed first while ROW acquisitions and utility relocations were completed near frontage roads. Once mainline construction was completed, construction on the frontage roads commenced.

Acceleration Efforts and Fundamentals of Success

The total project duration was substantially reduced by separating the project into discrete contract packages and overlapping the design and construction of these packages. This approach enhanced the need for innovative approaches to planning, design, collaboration, and I/Ds.

Planning

TxDOT made the decision to accelerate construction early in project development. This decision helped to maintain a constant focus on finding ways to support the accelerated construction effort during detailed design, the acquisition of ROW, and utility relocations. In this way, the construction schedule provided the framework for the program to take only 6 years. Typically, a program of this scope would take 10 to 12 years.

Project management, in consultation with and approved by district management, developed an initial traffic control plan on the basis of the amount of ROW available and the scope of work to be performed. A detailed critical path method (CPM) schedule was prepared, with input from construction and local contractor personnel that included the proposed TCP for the project. The

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schedule also included early purchasing of ROW and relocation of critical utilities, both planned as concurrent activities. The work included addressing traffic control coordination between each of the nine projects.

The district, with the assistance of the GEC, managed the interface between contractors. During construction, the GEC contract and other design contracts were extended to support construction. Their charter was to review shop drawings, utility relocations, and construction schedules. The GEC also reviewed change orders. The approach improved the time to make decisions when problems arose.

The aggressive work schedule was 24 h a day, 7 days a week, and the duration of the project was 4 to 5 years. Work was ongoing days, nights, weekends, and holidays. The contracts had three float days per month that were noncharge days that the contractor was required to take. As the contractor did not want to disrupt momentum, it was difficult to agree to the use of or need for these float days.

Communication

A key to success was consistent communication with the public. An aggressive and proactive interface with the media helped make the media a true communication partner. A public information office was established at the start of construction. Multiple forms of communication were used to keep the public informed of construction progress (see www.katyfreeway.org/). Public information officers (PIOs) attended early traffic control workshops and schedule development meetings as well as partnering meetings after construction started. As a result, the PIOs were well-versed project spokespersons. As such, they were able to really understand and explain key milestones (i.e., closures, traffic changes, phases) and emphasize successes. Media pictures gave TxDOT the ability to tell its own story. The media expanded the audience reach for advanced notifications, explanations on scheduling, and scope of work. Information was disseminated on weekend and long-term closures. When new roadways were opened and major contractor milestones were achieved, celebrations were held with the help of the media. Finally, special events and outreach campaigns were held to celebrate key program accomplishments.

Design

Several contractors provided feedback and suggestions involving constructability issues (equipment placement, material staging) as well as quantity reviews. Some suggestions were incorporated into the plans. Many of the contractor suggestions involved expanding the work zone and the TCP restrictions, unaware that the TCP was developed from the schedule of ROW acquisition. The construction staging and TCP were established on the least conflicts. The construction approach started at the west end of the corridor at Katy and work proceeded inbound toward IH-610. Construction was "inside/out" with the main lines constructed first while ROW was acquired around the frontage roads and utilities were relocated. Further, the plan to synchronize improvements at major interchanges helped facilitate construction and add capacity early. The TCP was so effective that the public often cited that traffic flows better during construction than it did prior to construction.

Collaborative Environment

With construction acceleration the focus, collaboration was the word of the day before and during the construction phase. The design team worked closely with the construction team to carefully evaluate every design element with a focus on acceleration. Because the project schedule required concurrent work for all major activities, new strategies to coordinate ROW acquisition and utility relocations with construction work were needed. A ROW team focused on rapid acquisition of a large number of properties through a single service provider. TxDOT and the GEC worked closely with utility companies to ensure timely relocation of priority utilities. Partnering meetings during construction included all participants including the GEC, local government agencies, and utility companies.

Partnering was a major contributor to the success of the Katy Freeway construction contracts. Formal partnering meetings occurred on a weekly basis with all the players—contractors, contractor superintendent/engineer, utility companies, section designers, inspectors, project managers, area engineer, assistant area engineer, right-of-way staff, PIOs, schedulers, and many others. One independent meeting was conducted for each construction project. A point was made to understand each participant's role, responsibilities, and issues. Timely solutions to problems were the result of this close interaction. Partnering meetings were held informally as needed when critical issues arose. Each party was challenged to keep the project on schedule.

Incentives and Disincentives

The use of incentive structures placed the emphasis on meeting key milestone dates during construction. This required dedicated staff with on-site decision makers to ensure that issues could be resolved in the field or quickly elevated to the appropriate decision maker within TxDOT. The contractor provided communication devices and satellite offices to enhance field operations and coordination.

I/Ds were used throughout the corridor in various amounts and times depending on the work and its complexity (major interchange, metro section with and without structures, or rural section). I/Ds were tied to hard milestones as follows:

- Project milestones usually involved the finishing and operational acceptance of a major part of the project such as the opening of the west bound main lanes or frontage roads;
- Interim milestones involved the finishing of a section and/or a particular task to facilitate and improve commuter's time, such as opening a direct connector or a ramp heavily used for commercial developments; and
- Project completion milestones used in some of the projects with a final completion date (hard date) with no-excuse clauses.

In addition to I/Ds, lane rental fees were used to encourage constrained timeframes for major closures. In total, approximately \$50.9 million was paid for meeting milestone incentives. Paid early completion incentives amounted to \$7.5 million. Lane rental fee assessment resulted in another \$3.7 million in credits for the contractors.

Case Study Findings

Each of the accelerated projects discussed in this paper demonstrated four key factors that contributed to the success: upfront and detailed planning, designs that facilitate accelerated construction, a collaborative environment for project stakeholders, and incentives and disincentives for stakeholder motivation. Three other case studies covered in the Scan Team Report also confirmed that these four key factors contributed to successful project outcomes. (Blanchard et al. 2009).

Planning

A detailed execution plan is a critical component of the acceleration effort and that plan must be updated regularly. Planning must include suppliers, fabricators, and equipment suppliers. Additionally, there must be contingency plans for all possible impediments. Speed is achieved by working concurrent activities. Thus, a plan

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to open multiple fronts to push construction activities with more crews and equipment is necessary. Finally, look-ahead plans should be prepared at regular intervals.

Design

A contractor must be able to procure the necessary project material in an expeditious manner. Designers must consider the availability of materials and the difficulties in moving and handling items such as bridge girders and precast elements. Logistics issues must be considered when selecting a design approach. Construction speed is achieved when the design allows repetition of activities. Designers should always review the standard specifications for opportunities to remove barriers to acceleration.

Collaborative Environment

For every project examined, another primary element leading to success was a spirited effort at partnership and collaboration. There was a partnership between the department, the designer, and contractor, together with a supportive design and detailed planning of construction execution. People are the critical element in successfully accelerating a project. Formal partnering is a beginning, but partnering is more than meetings. To accelerate a project, all team members must agree to solve issues at the lowest level of the project organization. There is a need for flexibility to allow changes in the project after the contract is awarded and more information becomes available. Every team member must exercise tremendous attention to detail and commit to an unselfish effort to ensure that there are no interruptions in moving the project forward. On many projects, the colocation of the DOT and contractor facilitated the partnering atmosphere, which adds relevance to the industry catch-phrase of "You can't go fast if you're not colocated." Partnering keys include

- Align goals—acceleration has a construction cost, establish incentives sufficient to cover increased cost plus risk;
- Delegate to the lowest level—empower people to make immediate decisions; and
- Timely decisions—have technical expertise on the ground or available at all times.

Incentives and Disincentives

Providing the proper motivation for acceleration and cooperation through incentives and disincentives is essential. This encourages the contractors to commit the necessary resources needed for construction. Owners need to develop procedures and criteria for the use of incentives and disincentives on planned acceleration projects. There are a number of different applications for these programs on different levels and for different portions of the project. Clear language in the contract will help establish these programs.

Conclusion

Planned project and/or construction acceleration approaches need to focus, at a minimum, on the four key fundamentals to ensure success. However, as the case study details demonstrate, how these fundamentals are applied in practice may vary some depending on the project type and level of acceleration required to meet the project's schedule objectives.

Acknowledgments

The writers express their appreciation to the National Highway Cooperative Research Program (NCHRP), the Transportation Research Board, under the National Academy of Sciences for sponsoring this research. Publication of this paper does not necessarily indicate acceptance by the academy of its contents, either inferred or specifically expressed herein. The writers also thank the NCHRP Scan Team and sponsor for their comments during the data collection and interpretation process. Additionally, the writers thank the state highway agency, consultant, and contractor personnel who supported this research through their time and reporting effort; without their valuable contributions, this research would not have been possible.

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