Considerations and Case Studies in Rapid Highway Construction Using Asphalt Pavement

November 2015
**Abstract**

The construction zone is the visible and perhaps only connection between the driving public and the delivery of a roadway for public use. The driving public is very aware of and sensitive to the time it spends in delays in work zones. From the driver’s point of view, any amount of time delay due to roadway activities is excessive and inconvenient. Significant public support and financial savings result when the speed of construction is increased on projects or construction on roadways is made unnoticeable to the driving public. Congestion is the primary driving force in implementing rapid construction and, according to the Federal Highway Administration, will become increasingly worse in the coming decades. Safety for both the traveling public and highway construction personnel is another motivating factor as rapid construction strategies often employ multiple-lane closures for shorter total time periods than normal construction under traffic. This results in greater separation of traffic from work zone personnel.

This project reviewed the available information which included factors to be considered in rapid pavement construction and case studies. Two particular case studies on rapid construction from Louisiana and Indiana were developed using information from project documents and contractor interviews. It was found that the keys to rapid pavement construction include: 1) isolating the work zone from traffic, 2) using as much of the in-place material as possible, 3) maintaining lane closures as long as possible to improve productivity, 4) allowing contractors as much control as possible over work zone activities, and 5) developing innovative approaches to moving traffic in and around work zones. Future research topics include: 1) development of better engineering investigation techniques, 2) use of rapid and more thorough quality control/quality assurance techniques, 3) development of better work zone traffic modeling, 4) better procedures to use the in-place materials, 5) faster demolition and disposal procedures, 6) improved construction methods to balance materials production to the rate of construction, and 7) improved equipment and methods to increase work zone productivity.

**Key Words**

Rapid Construction, Accelerated Construction, Road User Delay, User Delay Costs, Work Zone Traffic Control

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Considerations and Case Studies in Rapid Highway Construction Using Asphalt Pavement

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INTRODUCTION

The Need for Rapid Construction

The construction zone is the visible and perhaps only connection between the driving public and the delivery of a roadway for public use. The driving public is very aware of and sensitive to the time it spends in delays in work zones. From the driver’s point of view, any amount of time delay due to roadway activities is excessive and inconvenient. Significant public support and financial savings result when the speed of construction is increased on projects or construction on roadways is made unnoticeable to the driving public.

“Accelerated construction is about minimizing time impacts to the public,” say Blanchard et al. (2009) after reviewing successful practices in five states from Florida to California. The importance of speed of construction to the public can be illustrated by the maps of current and projected levels of congestion in the United States for 2011 and 2040, respectively, in Figure 1(a) and Figure 1(b). The current levels of congestion in Figure 1(a) center on major metropolitan areas. By the year 2040, a little over one generation from now, the congestion is projected to be as shown in Figure 1(b). The areas that are currently impacted by congestion will become worse, and areas that are not currently problematic will become congested. Although rapid construction techniques are currently in use, they need to be refined and further streamlined in the future just to keep up with the demands of the traveling public and the transportation of goods and services.

The time required for a project to be delivered (inception to completion) is exceedingly long and unacceptable. Planning, financing, scoping, development, bidding/letting, and construction typically require 8 to 15 years. If the time required for the various activities can be reduced, significant cost savings can result for the agency, user, and adjacent businesses. These costs saving can far exceed project construction costs.

While a need to reduce the time required for all of the individual activities exists, the asphalt paving industry can significantly reduce the time associated with new project delivery, capacity improvements (congestion mitigation), reconstruction, rehabilitation, and maintenance.
Time savings on the order of 70 percent have been realized with asphalt paving projects using accelerated construction approaches. The asphalt paving industry can complete pavement construction, reconstruction, rehabilitation, and maintenance operations at a significantly faster rate than those associated with other pavement types.

Rapid construction provides faster project delivery and substantially increased safety due to reduced traffic delays in the affected area due to work zones. Time savings and improved safety are noticed by the public and rapid construction is demanded by the public.

**Background**

Speed of construction is important at the national, state and local levels. State Departments of Transportation (DOTs) have let and built projects utilizing accelerated schedules. These projects have been very successful in California, Washington, Oregon, Maine, Delaware, and Michigan among other states. Encouraging reduced construction times based on bidding practices (A+B) and incentives, these states were able to cut project durations anywhere from 50 to 85 percent.

The National Asphalt Pavement Association (NAPA) and the Texas A&M Transportation Institute (TTI) co-funded the project “Effect of Speed of Construction on Total Costs for Maintenance, Rehabilitation and Reconstruction of Existing Pavements,” which provides a foundation for defining society’s cost savings associated with accelerated or rapid pavement construction. These cost savings are substantial from a user and non-user standpoint and are a major factor associated with justifying the use of rapid construction operations for public agencies. Information was obtained on actual field projects as well as typical types of rehabilitation and maintenance operations.

This literature review discusses the approaches that have been taken by agencies and construction contractors to minimize the amount of time required to plan, build, and open a roadway to traffic. As will be illustrated, this time minimization requires innovative approaches to be taken at various points in the process. Thus, it is important for those involved to remain open-minded regarding measures that are currently outside of the normal methods for specifying, designing, and constructing projects. Successful case studies from the literature are presented to illustrate asphalt technology’s contribution to rapid construction and recent key innovations.
Contracting Methods

Accelerated project delivery begins with setting the right environment for innovation, speed, and quality. Innovation from the contractor is needed in order to bring new techniques to materials delivery, construction methods, and work zone configurations. These innovations will lead to shorter construction durations as these companies live by the motto “time is money.” The sooner they finish a project and get paid for it, the quicker they move on to other projects. The quality of the delivered project must be ensured so that the structure lasts for its intended life and additional congestion is not caused by correcting defects in the work. A number of contracting techniques can be employed to encourage early completion of projects and are often referred to as alternative contracting methods (ACMs). Anderson and Damnjanovic (2008) investigated ACMs used in accelerating project completion for the National Cooperative Highway Research Program Synthesis No. 379. In addition to explaining how ACMs are selected for use in accelerated construction, they identified characteristics that made the selection of a given method more attractive than others. They also examined issues associated with effectiveness of project delivery, costs, quality of the delivered project, and safety.

Of the contracting methods reviewed by Anderson and Damnjanovic (2008), the five which showed the most benefit to accelerated construction, in order of highest effectiveness were: 1) Design-build (D-B), 2) Incentives and disincentives, 3) Cost-plus-time bidding (sometimes referred to as A+B), 4) Interim completion dates, and 5) No-excuses incentives. These researchers established that while all five of these methods are useful in reducing project delivery times, only the first three tend to reduce the overall project duration by 10 percent or more. They also discovered through a survey of state DOTs that the overall cost of projects constructed under these methods generally fall within five percent of the planned costs and that the quality of the constructed pavements is equivalent to those built under normal contracting practices. These three ACMs are discussed below, and while they are discussed separately, they are often used in combinations.

A D-B contract is one in which the agency advertises for design and construction services to be rendered by a single entity which is often a joint venture between an engineering design firm, a construction company, and occasionally a construction management firm. Most often the designer is required to meet state agency standards when preparing plans and specifications. Geometric features, safety measures, design methods, and specifications are normally stipulated in a request for proposals or services. Usually there are separate technical and cost evaluations, and the low cost proposal is not necessarily the one selected. The project usually comes with the requirement for a warranty over a certain period of time, which could result in higher costs due to the increased risk to the D-B team. This approach is attractive for expedited project delivery because the lines of communication between the design team, construction managers, and the construction company are direct and all have a stake in the success of the project.

Incentives and disincentives, as the name suggests, provide the contractor a bonus for early completion and penalties if the project is delivered late. The desired completion date is set by the agency in the contract documents along with the amounts of the incentives and disincentives. The contractor may or may not have latitude in the timing of lane closures within the work zone.
in order to complete the project. The design and specifications for the project are fixed by the agency in the bid documents with very little latitude for change once the work begins (Anderson and Damnjanovic, 2008). It is important for the contractor to assess the constructability of the project prior to beginning the work. Normally the amount of money involved is determined on the basis of traffic safety, traffic maintenance, and road user costs (AASHTO, 2006). Incentives and disincentives provide the contractor with a motivation to complete the project early within the constraints of the bid documents and any subsequent change orders.

Cost-plus-time bidding is often referred to as A+B contracting where the A component is the cost of the pavement and B refers to the number of calendar days for completion. Usually the bid costs are the A portion which are added to the number of calendar days multiplied by the estimated daily road user costs stipulated by the agency. The contract is awarded to the contractor with the lowest A+B cost, but the contractor payment is based on the A component. Once the award is made, an incentive/disincentive process is used based on the number of days in the bid. It provides the contractor with motivation to finish the work as quickly as possible in order to maximize profit from the job. Figure 2 shows a schematic of the process.

Cost-plus-time bidding is often referred to as A+B contracting where the A component is the cost of the pavement and B refers to the number of calendar days for completion. Usually the bid costs are the A portion which are added to the number of calendar days multiplied by the estimated daily road user costs stipulated by the agency. The contract is awarded to the contractor with the lowest A+B cost, but the contractor payment is based on the A component. Once the award is made, an incentive/disincentive process is used based on the number of days in the bid. It provides the contractor with motivation to finish the work as quickly as possible in order to maximize profit from the job. Figure 2 shows a schematic of the process.

Many state and regional governments are using a number of private-public-partnership models to deliver and finance highway projects including concession, D-B, and design-build-operate. In order to assess the effectiveness of these innovative contracting practices, Crawford et al. (2013) undertook a study to review construction technologies and methods, work zone traffic controls, travel demand management with local governments, incident management, and public information practices. This report identified over 30 innovations that could be adopted to accelerate construction projects in the areas of design, operations, equipment, materials, and coordination. Among the innovative construction methods identified in this study were recycling in-place (e.g., rubblization) and the use of asphalt pavement to accelerate project delivery.
Project Evaluation

Golder Associates et al. (2011) proposed a risk-based approach to the overall evaluation of rapid construction projects for the Strategic Highway Research Program 2 (SHRP2) Project R09. This type of an approach to project evaluation and management is supported by Blanchard et al. (2009) in a review of accelerated construction practices during a Federal Highway Administration (FHWA) domestic scan tour. A project diagnosis is used to identify the potential performance issues along with an evaluation of the magnitude of the impacts and their likelihood. This information is fed into a risk register which is used to track the potential problems and reassess threats at various times. Treatments for the various problems are identified to help develop possible contingencies in a risk management plan that also contains implementation strategies, contingency evaluations, and revision at various time intervals within the project. This detailed planning is justified in high-profile pavement construction projects where the risk of project delays presents agencies with potentially enormous road user costs due to delays and contractors are faced with substantial rewards or penalties based on their ability to complete the project on time according to the project time frame.

Another approach to accelerate construction suggested under another SHRP 2 project (Scott et al., 2014) was the use of performance specifications for pavement structure and traffic control. This research project produced guide specifications and implementation plans to put the specifications into practice. In addition to potentially contributing to rapid construction it was suggested that performance specifications could be used to encourage contractor innovation, reduce the cost of inspection, and improve quality. However, the success of performance specifications is considered to be highly dependent upon the individual project parameters. In the implementation guidelines, the authors offer help in the identification of performance factors and how these factors should be measured in order to fit the project and the characteristics of the local industry and agency. To the extent possible, the researchers encouraged the use of non-destructive testing (NDT) that would enhance the speed of construction while monitoring the desired performance characteristics.

While it is important for the agency to focus its attention on the optimization of construction operations and traffic flow, FHWA (2013) also suggests seeking early industry input. For instance, the Oklahoma DOT (ODOT), Colorado DOT (CDOT), the Virginia DOT (VDOT) (in some instances), and the North Carolina DOT (NCDOT) allow contractors to review project plans ahead of advertising them. This provides a number of benefits to the DOT including better design and construction insights possibly leading to cost and time savings. It also allows for corrections of plan and specification errors before bidding as well as allowing contractors to familiarize themselves with the project.

Construction Productivity

Construction productivity is where the contractor’s creativity can play a key role in rapid project delivery. To the extent possible, construction contracts with tight time limits should be written to take advantage of the innovation that might be possible. The project plans should reflect the best advice that has resulted from the constructability review.
It is important for the design to take into account not only the constructability of the pavement but also issues surrounding moving materials into and out of the project limits. Construction personnel need to provide input to the design concerning the availability of materials and any possible limitations on the production of materials. It is often desirable to have design and materials specialists representing the owner and the contractor at the site during construction. As Blanchard et al. (2009) note, production increases whenever the design can lend itself to repetition of tasks. As will be noted in the case studies presented later, facilitating construction traffic by providing extra lanes for demolition removal and materials delivery will increase productivity by allowing concurrent activities within the work zone.

Determination of productivity requires the computation of the rates of construction activities for mobilization, demolition, materials production, materials delivery, speed of paving, material curing or cooling, striping, and demobilization. Included in the mobilization and demobilization costs would be associated traffic control set-up and tear-down. The fewer times the contractor has to mobilize and demobilize the faster the construction can proceed. There are resources for determining construction rates such as standard tables for certain activities, equipment manufacturers, and industry sources. However, these are not found in a central location and often do not present the variability that can be expected during construction. The total amount of construction time and its effect on traffic is predominantly affected by the allowable lane closures, and a variety of scenarios should be evaluated to find the one with the least impact in terms of the road users’ cost (RUC).

The Strategic Highway Research Program 2 (SHRP 2) Renewal program focused on long-lasting highway projects that could be constructed with as little disruption as possible to traffic. Within this program, Project R23 investigated high-volume highway pavement construction practices to avoid reconstruction and to use as much of the existing material in the roadway as possible (Jackson et al., 2012). They examined practices for both flexible and rigid pavements.

Lee et al. (2007) assert that the demolition of the existing pavement is usually the slowest phase of a reconstruction project and that the speed of simultaneous pavement removal and construction will be dictated by the demolition. Lee et al. (2007) also stated that the rate at which dump trucks can be filled is fairly similar between projects, and the best estimate for this part of the construction comes from evaluation of previous job’s production rates. The Minnesota Department of Transportation (MnDOT) (2005) presents a table of construction production rates for various activities to provide a planning basis for computing working days in contracts. The mid-range of their estimates for pavement removal are 3,000 square yards per day for concrete pavement and 10,000 square yards per 8-hour day for asphalt pavement. A number of agencies have posted their estimates of production rates online, and a summary of some of these web sites is given in Table 1. Generally speaking these agencies do not show great consistency in their production rates due to various assumptions embedded in the calculations. For instance, the degree of difficulty is affected by whether the job is rural or urban, and while some agencies have factors or separate rates for each condition, others do not. The construction industry would be well-served by an effort to uniformly define construction rates.
Table 1. Posted Construction Rates Used by Various Agencies.

<table>
<thead>
<tr>
<th>Agency</th>
<th>Production Rate URL</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minnesota DOT</td>
<td><a href="http://www.dot.state.mn.us/const/documents/Productionrates_000.pdf">http://www.dot.state.mn.us/const/documents/Productionrates_000.pdf</a></td>
<td>2005</td>
</tr>
</tbody>
</table>

Jackson et al. (2012) state that the productivity of a given construction project is frequently a function of work zone access for construction traffic and control of adjacent traffic. Thus, the provisions for temporary ramps in the work zone and the degree of separation between traffic and construction operations are crucial considerations during the planning process. In California, the rehabilitation of the I-710 freeway in the vicinity of Long Beach saw California Department of Transportation (Caltrans) elect to use a series of 55-hour weekend closures in one direction by diverting the traffic to the other side of the freeway during construction operations. Figure 3 shows that one side of I-710 contains the two-way traffic while the work zone occupies the other.

![Figure 3. Full-Side Weekend Shutdown on I-710 near Long Beach, California (Caltrans, 2004).](image)

**Traffic Evaluation**

The key to minimizing impact on road users is understanding how to minimize delays due to construction while maximizing production. This requires a careful study of traffic patterns, timing, and possible detour routes. In some instances it may be necessary to perform night work only when traffic volumes are steady on all days of the week. In others, weekend closures of more lanes may not affect traffic as much as nightly closures. Night work will increase the amount of mobilization and demobilization, as it will reoccur every day. For weekend closures
only one mobilization and demobilization will occur each week, but for the 55 hours or so that
lanes are closed the contractor will need to operate around the clock. Special events such as
holidays, sporting events, and concerts will need to be considered as well before working at
certain times. It is also important to note whether there alternative routes that road users can take
to avoid the work zone. In most urban areas, the opportunities for detours are often numerous,
but in the more rural areas where there are limited roads or geographical features such as rivers
or lakes most of the traffic will need to use the route that is under construction. Traffic studies
and traffic modeling ahead of the project can be very helpful in determining the optimum times
for closures.

Traffic Modeling

Two work zone impact models were reviewed by Jackson et al. (2012) including QuickZone 2.0
and CA4PRS. These were both described by the authors as being sketch-planning tools that
could be used in obtaining traffic impact estimates for a relatively low cost. The term “sketch-
planning tool” as used by FHWA (Hardy and Wunderlich, 2008) is meant to denote models
based on relatively simple relationships that can be used to differentiate work zone impacts on a
general basis. They do not provide the detailed analysis that may be obtained from more
sophisticated tools. CA4PRS was used in modeling the work zone impact of the rehabilitation of
I-710 near the Port of Long Beach in California (Caltrans, 2004).

Developing an estimate of users that may take alternate routes or cancel their trips due to
construction is difficult even with very complex models. Often, the amount of public outreach
that occurs ahead of lane closures and the number of alternatives available dictates how many
travelers opt for a different route to their destination (ODOT, 2000). It is usually best to obtain
this estimate from past experience with similar conditions (Jackson et al., 2012). Lee and Harvey
(2006) and Lee et al. (2001) warn that detour route capacity may need to be improved through
actions such as adding more lanes or creating temporary reversible lanes ahead of the
rehabilitation activity in order to handle the additional traffic.

Modeling of traffic in work zones can vary from localized approaches such as sketch planning
tools to macroscopic models which treat traffic flow in an aggregated manner to determine large
area impacts (Hardy and Wunderlich, 2008). As the models increase in complexity so do the
inputs, and the outputs become increasingly detailed. Hardy and Wunderlich (2008) state that the
most appropriate model for a given work zone depends upon the nature of the work zone,
transportation management strategies in play, the availability and quality of data, agency
capabilities and resources, and the desired work zone performance measures. Due to the
uncertain nature of work zone traffic, it may be best to have a model which provides a range of
possible cost outcomes for traffic flow through the construction.

Impact of Work Zones on Traffic and Construction

For major highways and freeways, construction operations can rarely be confined to one lane
which means that either a second lane or a minimum of a 10-ft shoulder needs to be available.
Also, if concurrent activities are taking place in the lane under construction then another lane
may be needed to facilitate the flow of construction traffic (Lee, 2008). A work zone in which
traffic flows on both sides of the construction operation should not be allowed as it will create a
number of worker and traffic safety issues (Jackson et al., 2012). Overly complicated traffic patterns in work zones should be avoided in order to reduce driver confusion and improve the overall safety. A good example of simplifying work zone traffic flow is the “Merge Left” policy used by the Arkansas Department of Highways and Transportation during their rubblization and overlay efforts in 2001. In this case, all vehicles merged to the left to enter the work zones after which they were directed through the work zone. Motorists knew what to expect and they tended to merge early which helped to maintain speed through the work zone (FHWA, 2001).

Normally, the Highway Capacity Manual (HCM) (TRB, 2010) is the starting point for estimating the work zone traffic flow. A flow of 1,600 passenger cars per lane per hour (pc/ln/hr) is suggested for short duration work zones, and the actual flow may be only half that value, depending upon numerous factors such as the separation of traffic from the work zone, geometric considerations, the nature of the traffic, etc. (Jackson et al., 2012). Hourly traffic counts from manual or automated counts are the best data for obtaining a realistic sense of how road users will be impacted. While the annual daily traffic is distributed according to hourly factors for a given type of roadway, this may not accurately reflect the local conditions in which the construction will take place.

According to FHWA (2004), one of the biggest factors in work zone delays is the occurrence of incidents such as wrecks and breakdowns which could normally be handled on shoulders and additional lanes. Such occurrences can be handled with the use of video surveillance and incident management vehicles and having stalled vehicle action plans in place.

Scott et al. (2014) encouraged the development of performance specifications for work zone traffic control as traditional methods are often viewed as being inefficient and more expensive. Allowing the contractor flexibility in dictating the work zone traffic flow could mean greater efficiency in getting vehicles flowing. Specific objectives for the contractor to achieve during construction, such as “no queue greater than 3000 ft,” could lead to better overall traffic conditions. Agencies have numerous concerns about the issue of performance specifications for work zone traffic control such as the uncertainty of costs, potential loss of control of traffic patterns and safety, as well as the potential loss of quality.

FHWA (2003) credits longer lane closures with greater productivity and worker safety than shorter work zone durations such as overnight closures as well as being more palatable to the public. They presented compelling arguments for the consideration of full road closures where practical, including project personnel assertions that the improved construction processes led to time-saving construction practices that reduced the overall duration and improved the safety of construction personnel and motorists. The public approved of the full road closures in these instances. Thus, FHWA noted the following benefits for full road closures:

- Faster project delivery.
- Reduced inconvenience to motorists.
- Larger working area and increased productivity.
- Reduced congestion.
- Reduced exposure for construction personnel and road users.
- Reduced traffic accidents.
- Smoother roadway.
Better public image.

With full lane closures also come a number of other factors that must be taken into consideration (FHWA, 2003). For instance, the benefits of road closures must be communicated to local governments along with potential impacts to the local road systems. The contractor must ensure that any required increase in materials production can be accommodated to meet the schedule. Publicized dates for re-opening the facility places additional pressure to make sure the schedule is met. There is a need to consider the impact on businesses and residents in the area and account for any special events.

**The Role of Publicity in Reducing Work Zone Congestion**

Publicity is often credited with minimizing work zone traffic problems. This was the case in the Arkansas interstate rehabilitation effort where public service announcements, brochures and posters, a newsletter, radio broadcasts, and variable message signs were all used to inform motorists of construction activities (FHWA, 2001). While Arkansas made statewide use of media in the course of their rehabilitation campaign, other states such as California have used media for more localized efforts such as the rehabilitation on I-710 near Long Beach. In this case, news releases and forewarning motorists of the directional closure on weekends prevented massive traffic back-ups as travelers found alternative routes (Caltrans, 2004).

**Road User Costs**

The inconvenience of delays due to construction to the traveling public is normally expressed in terms of road user costs (RUC). These costs are calculated as a result of modeling the effects of lane closures on traffic flow. User delays during construction are normally considered in terms of total user delay, total user costs due to delays, the maximum length of queues, or the maximum time a vehicle spends in a queue (Jackson, et al., 2012). Traffic impacts are most often quantified by the total user cost estimated to occur as the result of a construction work zone.

User delay can be estimated using Equation 1 from TTI (2013), which is often employed in computing the impact of congestion:

\[
\text{Delay/Mile} = \frac{(TT_a - TT_{ff}) \times V \times VO}{L_{wz} \times 60}
\]

(Equation 1)

Where:
- \(TT_a\) = Actual Travel Time through the Work Zone, minutes
- \(TT_{ff}\) = Free Flow Travel Time through the Work Zone, minutes
- \(V\) = Vehicle Volume, number of vehicles
- \(VO\) = Vehicle Occupancy, persons/vehicle
- \(L_{wz}\) = Length of Work Zone, miles

Using more complex models results in greater precision of the estimate of user delays, but in actuality it is probably best to calculate a range of expected user costs as a wide range of delays can result for a given set of conditions. Walls and Smith (1998) of the FHWA presented a more in-depth procedure for calculating user delays associated with work zones for use in life cycle cost analysis. This procedure is relatively straight forward but does require some inputs that may not be readily available. The avoidance of a work zone by certain segments of drivers and the
cost of vehicle crashes are not accounted for in the FHWA procedure although means for calculating these are suggested by Walls and Smith (1998).

Most computations of RUC are based on 1996 values for different classes of vehicles provided in a FHWA report (Walls and Smith, 1998) adjusted for the overall consumer price index (CPI) (Jackson et al., 2012). Table 2 shows these values in 1996 dollars.

**Table 2. Recommended Values (1996 Dollars) of Delay Times (Walls and Smith, 1998).**

<table>
<thead>
<tr>
<th>Vehicle Class</th>
<th>1996 Dollars</th>
<th>Value per Vehicle Hour</th>
<th>Value Range</th>
<th>2014 Adjusted Dollars</th>
<th>Value per Vehicle Hour</th>
<th>Value Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger</td>
<td>$11.58</td>
<td>$10–13</td>
<td>$17.48</td>
<td>$15–20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single-Unit Truck</td>
<td>$18.54</td>
<td>$17–20</td>
<td>$27.99</td>
<td>$26–30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Combination Truck</td>
<td>$22.31</td>
<td>$21–24</td>
<td>$33.67</td>
<td>$32–36</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The New Jersey DOT (NJDOT) and Texas DOT (TxDOT) both consider road user costs in relation to the construction costs in order to reduce the inconvenience to the traveling public as well as providing a justification for the amount of incentives and disincentives for contractor adherence to the construction schedule (NJDOT, 2001; Daniels et al., 1999).

Jackson et al. (2012) used the following procedure to estimate the road user cost:

1) Determine construction productivity.
2) Determine the existing traffic.
3) Estimate the portion of travelers that will cancel their trips or take alternate routes due to construction.
4) Develop construction alternatives.
5) Use a modeling tool to estimate delays.
6) Apply rates for vehicles caught in the delay.

FHWA (Walls and Smith, 1998) encourages the inclusion of RUC in the calculation of the project life cycle cost (LCC). This is normally estimated using the Net Present Value (NPV) method of discounting future costs which takes into account all future rehabilitation activities that are predicted to be necessary to keeping the pavement in a serviceable condition over a long period of time (usually 35 to 50 years). This is the approach taken by the FHWA. The RUC of future construction activities may also be calculated in this fashion, however due to inaccuracies in future traffic predictions and pavement performance predictions the RUC may vary over a wide range. For this reason, the LCC and RUC should be considered separately.

**Construction Scheduling**

The construction schedule will dictate the traffic control required to complete the project. The number of lane closures, their lengths of duration, and the order in which they are closed will be tied to the construction production rates and the number of allowable hours of lane closures. This
is a somewhat iterative process because the construction sequencing will also be dependent upon
the traffic flow at any given time. If the work zone capacity remains at or above the expected
traffic for a given period, then user costs are held to a minimum.

According to Jackson et al. (2012), among the options for lane closures are: 1) partial night, 2)
full night, 3) partial day, 4) full day, 5) partial or full weekend (typically 55 hours), or 6) partial
or full week-long continuous closures (168 hours). While partial night or partial day closures
may be useful for preparatory or finishing work such as milling or restriping, they often will not
be suited to construction work due to the short windows of time in which mobilization,
construction, and demobilization must occur. Full nighttime and daytime closures may involve
shutting down an entire direction and using a counterflow lane in the opposite direction, frontage
roads, or temporary bypasses to handle traffic. Weekend and week-long closures are best from
the standpoint of minimizing the total time of closure due to the ability to work continuously
without frequent mobilization and demobilization.

**Connecting Traffic Control, Construction Productivity, and Scheduling in Asphalt
Paving**

The ability to accelerate construction through the use of asphalt pavement has been documented
in many instances. This section illustrates the tie between the various components of traffic
control in the work zone, construction productivity, and scheduling. The advantage of flexibility
asphalt provides in rapid construction and minimizing user costs are illustrated.

In Strategic Highway Research Program II (SHRP-II) Project R23, a comparison of four
different scenarios using CA4PRS for the removal and replacement of a concrete pavement were
presented (Jackson et al., 2012). In one case, the existing concrete pavement was removed and
replaced with concrete using fixed-form construction. In another case, the concrete pavement
was replaced by concrete using a slipform paver. In the two asphalt options, one option was to
remove the concrete pavement and replace it with full-depth asphalt, and the other option was to
crack and seat the concrete pavement and overlay it with asphalt. Figure 4 shows the result of
this hypothetical comparison. It shows that the crack, seat, and overlay (CSOL) option is by far
the fastest of those considered. It should be noted that while the slipform concrete option is
shown to have the same rate of production as the asphalt replacement option, in the example both
materials were considered to have a 12-hour “cure” time. As asphalt does not have a cure time,
the rates of production for the asphalt replacement scenario and the CSOL scenario should have
been faster than shown. In fact, the MnDOT (2005) guidelines for contract time planning call for
approximately equal production rates for concrete slipform and asphalt paving but specify a
concrete cure time of three days for high-early strength and seven days for standard concrete
mixtures.

The Arkansas DOT demonstrated the speed associated with the rubblization and overlay of
concrete pavements in their interstate rehabilitation effort of over 300 miles (Decker and Hansen,
2006; FHWA, 2001). As noted earlier, the slowest component in construction is often the
demolition and removal of the existing structure. This is avoided in the CSOL and rubblization
approaches where the existing concrete is fractured and serves as a high-quality base material.
The rate of rubblization is typically one lane-mile per day or more (Decker and Hansen, 2006).
This rate of production is more than two times MnDOT’s estimated productivity for concrete
pavement removal alone (MnDOT, 2005). Rubblization’s speed led the Louisiana DOT to specify this method of rehabilitation for I-55, a hurricane evacuation route, so that the work could be completed in seven months instead of the two to three years estimated for reconstruction of the concrete roadway (Landers, 2011).

Figure 4. Comparison of Production Rates for the Removal and Replacement of an Existing Concrete Pavement (Jackson et al., 2012).


Caltrans, with help from the University of California, developed a coordinated construction and traffic management plan to rehabilitate a 2.7-mile portion of the I-710 freeway serving the Port of Long Beach in 2003. The pavement design (shown in Figure 5) included breaking and seating the existing concrete pavement and overlaying it with 8 total inches of dense-graded asphalt mix and one inch of an open-graded friction course (OGFC). For areas where bridge clearance would not allow an overlay of the concrete pavement, a full depth asphalt pavement with 12 inches of dense-graded mix and one inch of OGFC was used.

Figure 5. Pavement Cross-Sections Used on I-710.
In this project, a series of eight full lane shutdowns in one direction for 55-hour work windows on the weekends provided the contractor with adequate time to rehabilitate. During each of these periods the contractor was able to produce and place on the order of 15,000 tons of asphalt mix while being subject to very strict quality control standards (Santucci, 2011). A review of the pavement performance on this portion of I-710 in 2009 by Monismith et al. shows that it is performing better than expected.

Lee et al. (2011) performed a life cycle cost analysis on this project comparing: 1) a long-life asphalt pavement (Perpetual Pavement), 2) a conventional asphalt pavement, and 3) a long-life concrete pavement. The results of the analysis are presented in Figure 6, and on the basis of total agency life-cycle and road user costs, the long-life asphalt option was over 33 percent cheaper than the long-life concrete option and about 20 percent cheaper than the conventional asphalt pavement.

![Figure 6. Comparison of Alternatives for I-710 Freeway near Long Beach, CA. (Lee et al., 2011).](image)


This project used full-road closures over two weekends to complete 33 lane miles of asphalt paving. The average daily traffic for the roadway was 180,000 vehicles with seven percent commercial vehicles. The project dates spanned August 2–12, 2002. A 5.5-mile stretch of the six-lane roadway was rehabilitated within a total window of 100 hours using 40,000 tons of asphalt mix. The total duration of the project was reduced by 85 percent using weekend closures instead of night time closures. Without the weekend road closures, the paving would have taken a total of 32 nights. The project savings amounted to $100,000 out of a total construction cost of $5,000,000. ODOT reported that public opinion of the construction was very positive and there was an improved level of safety for workers and travelers.


This project called for the demolition and replacement of concrete pavement along with its shoulders and traffic barriers. Originally, the concrete was to be repaired in place by milling and patching along with other improvements. There were also five bridges that needed various types of structural upgrades within the project. A+B contracting was used to make sure the project was
completed prior to winter in 2002. This portion of M-10 is a six-lane highway, and the project length was 1.27 miles (7.6 lane miles). The total project cost was $12.5 million, and the ADT of the facility was about 98,000 vehicles with one percent commercial vehicles. The project dates spanned from July 9 to August 30, 2002.

It was determined in the planning of the project that an asphalt pavement would provide a lower life cycle cost than a concrete pavement. Due to the full road closure for 53 days, the contractor gained substantial efficiency and was able to reduce the duration of the project by 71 percent over a previous staging plan that would have taken 6 months to complete. Thus, a project which would have required six months with staging different phases of the work only was completed in 53 days. Also, due to the better staging of construction operations and reduced traffic control, the maintenance of traffic costs were reduced from 10 percent of the project costs to 1.3 percent.

Wilmington, Delaware – I-95, 2000 (FHWA, 2003)

This portion of I-95 was scheduled for pavement rehabilitation, reconstruction of 10 interchanges, and repairs to bridges, drainage structures, lighting, and safety features over a length of 6.1 miles (24.4 lane miles). This project had an ADT of 100,000 vehicles with 11 percent commercial truck traffic. A full-road closure was considered feasible as an alternative interstate class roadway (I-495) ran parallel to this portion of the road and was capable of handling the additional traffic. For areas not subject to bridge clearance restrictions, rubblization with an asphalt overlay was used to avoid the cost and time associated with demolition and road reconstruction. In the areas of bridges, full-depth removal of the concrete with full-depth asphalt replacement was used.

The southbound lanes of the project area were closed for approximately 3 months from April through June, and the northbound lanes were closed from the middle of July to the middle of October. The deadlines for four phases were enforced by an incentive/disincentive contract where the contractor could receive an incentive of $25,000 per day for every day of early completion for up to 10 days and a $25,000 per day penalty for every day of late completion up to 10 days. Thus, it was possible for the contractor to receive up to $1,000,000 in incentive money or penalties based upon the compliance with the schedule.

The total cost of this project (exclusive of schedule compliance) was $23.5 million. Due to the need to improve detour routes, the overall cost of the project was increased. It was estimated that this project would have required two years to construct in a conventional scenario, but the actual construction was only 185 days—a 75 percent reduction in project duration. Because of the reduced time, there was improved road user and construction personnel safety as well as a reduced cost for the maintenance of traffic going from a traditional 10 percent of the project costs to two percent.

Maine – I-295, 2008 (Lane, 2009)

This route in southern Maine was comprised of a jointed concrete pavement constructed in the 1970s that was deteriorating due to alkali-silica reaction (ASR). I-295 is considered an important access route for a number of Maine’s tourist destinations, and during the summer it has a traffic volume of about 13,500 vehicles per day.
ASR is a chemical interaction between the cement and aggregate that results in an expansion of the concrete creating widespread cracking and weakening of the pavement. There are no effective treatments to stop ASR once it begins in a mass of concrete. Concrete pavements with ASR generally start with a relatively slow rate of deterioration which accelerates with time. Once the cracking has reached an unacceptable level, the options for rehabilitation are essentially to remove and replace the existing pavement or overlay the existing structure. The Maine DOT opted to remove the top three inches of the existing concrete, rubblize the remaining material, and overlay it with eight inches of asphalt pavement.

In order to complete the project as quickly as possible, the Maine DOT elected to use a full road closure of the southbound lanes from the middle of June to the end of August 2008. The DOT estimated that a conventional approach using lane closures would have lasted over the span of three construction seasons. Traffic was detoured onto local roads to circumvent the construction zone which was considered to be safer, cheaper and faster than trying to contra-flow traffic on the northbound lanes of I-295. Improvements were needed at intersections on the local routes as well as increased traffic enforcement and the provision of a patrol truck to aid motorists.

An incentive/disincentive contract was used to motivate the contractor with an incentive of up to $2 million for finishing early. The contractor was able to complete the work 20 days ahead of schedule by concurrently rubblizing the concrete and constructing the overlay. Because the work zone was not restricted the contractor was able to perform multiple operations and use as many as five paving crews at one time. The full road closure not only allowed the contractor to receive a time incentives but also bonuses for smoothness and quality.
CASE STUDY – US 31 IN BERRIEN COUNTY, MICHIGAN, RIETH-RILEY CONSTRUCTION COMPANY, INC.

The 2009 project by Rieth-Riley Construction Company for the Michigan Department of Transportation (MDOT) on US 31 in Berrien County, Michigan, is an example of how traffic flow and mobility hinge on innovation in traffic control and accessibility. Rieth-Riley used an approach which maximized flow through the work zone and avoided detours so that traffic could smoothly and quickly access ramps to routes.

This portion of US 31 is a 3.27-mile long, 4-lane, divided highway with a grass median and restricted access as shown in Figure 7. The project is shown in the blue shaded area in the picture, and extended from the state boundary with Indiana (at the bottom of the picture) to the intersection with US 12. There was only one interchange at the northern end of the project. The terrain was relatively flat, and the primary land use was agricultural. The 2009 average daily traffic was 16,500 vehicles with 19 percent trucks, and the ADT was expected to increase to 19,500 by 2029 with same truck percentage. The 20-year flexible pavement projected equivalent single axle loads (ESAL) was approximately 7.4 million, and the rigid pavement ESAL was 10.5 million. Thus, the current moderate traffic levels were expected to continue into the future.

US 31 was comprised of a 9-inch continuously reinforced concrete pavement (CRCP) over 4 inches of aggregate base over 18 inches of sandy subbase over clayey subgrade. The concrete pavement was well over 25 years old and in very poor condition at the time of construction. The MDOT plans called for the removal and replacement of the CRCP with either a new concrete or new asphalt pavement surface. The existing concrete cross section and the new asphalt and concrete cross sections are shown in Figure 8.
Figure 8. Cross-Sections of US 31 of (a) Existing Concrete, (b) New Asphalt Design, and (c) New Concrete Design.

The alternate bid process allowed prospective contractors to choose either the asphalt or concrete design with a prescribed traffic control plan. This was a cost plus time (A+B) contract with an engineer’s estimate of approximately $11,626,000 for the construction, excluding time considerations. Table 3 shows the user delay assessment for the project. Rieth-Riley’s winning asphalt bid had a construction cost of $10,769,04 with a time component of $1,330,466 for a total of $12,099,470. The second place concrete bid was $9,612,573 for construction and $3,010,646 for time for a total of $12,623,219. So, while the concrete construction bid was cheaper by about $1 million, Rieth-Riley won the bid by reducing the time component by about $1.7 million using the speed and flexibility of asphalt construction to their advantage.

Table 3. User Delay Assessment for US 31.

<table>
<thead>
<tr>
<th>Lane Closure Segment</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>US 31 Single Lane</td>
<td>$6,441.49</td>
</tr>
<tr>
<td>Ramp B (NB Off-Ramp)</td>
<td>$6,843.41</td>
</tr>
<tr>
<td>Ramp C (SB On-Ramp)</td>
<td>$4,486.52</td>
</tr>
<tr>
<td>Ramp F (SB On-Ramp)</td>
<td>$2,885.95</td>
</tr>
<tr>
<td>Ramp E (NB On-Ramp)</td>
<td>$527.96</td>
</tr>
</tbody>
</table>

The MDOT phasing of the project and traffic control through seven stages included in the bidding documents consisted of a closure of one side of the roadway with traffic diverted to the other side. The original staging plans called for a single lane in each direction separated by a barrier wall. Rieth-Riley proposed another traffic control plan that resulted in greater mobility through the work zone and greater accessibility to interchange ramps. Rieth-Riley’s plan of adding 1.5 ft of width on the inside shoulder, at their cost, which allowed for 2 lanes of traffic in one direction and a single lane in the opposing direction as shown in Figure 9. The ability to
keep two lanes open in one direction greatly lowered lane rental cost for Rieth-Riley as MDOT charged a user delay cost (Table 3) for each lane that was closed during construction. Thus, having only one lane closed during the entire construction essentially halved Rieth-Riley’s user delay costs. Rieth-Riley provided special cross-over ramps at their own cost to allow traffic to access interchange ramps for the majority of the construction (Figure 10). This resulted in a reduction of long turn-around detours that would have been necessary under the original plan, so that motorists had access to the ramps for 35 of the 40 work days.

![Figure 9. Reith-Riley Work Zone Traffic Control for US 31 for Both Northbound and Southbound Reconstruction.](image)

![Figure 10. Temporary Asphalt Cross-Over to Interchange Ramps from US 31 to US 12.](image)

The construction of the project consisting of the excavation of the existing CRCP and 8 lane-miles of paving with shoulder replacement, and base strengthening began in May 2009 and was completed by November 3, 2009.

After constructing the shoulder widening and cross-overs for the direction that was to be trafficked, the other direction (the work zone) was closed to traffic. Next underdrains were
installed for the lanes in the work zone. This was followed by the demolition and excavation of the concrete in the work zone. The demolition was followed by excavating the concrete and removing the steel reinforcing. The debris was then hauled to a crusher unit to recycle the material into a base aggregate. A Demolition Impact Roller Breaker (Figure 11a) was used initially on the project in the northbound direction. A large excavator was used to remove the concrete with the steel reinforcement in one operation, but this resulted in a tangled mass of concrete and steel (Figure 11b) which had to be cut by a pincher mounted on an excavator. Another approach was used to demolish the concrete pavement in the southbound direction. Here a guillotine-type concrete breaker (Figure 11c) was used in the concrete pavement in six-inch segments, and an excavator with a frost tooth (Figure 11d) was used to separate and remove steel prior to removing the material from the paving site. In both instances, the salvaged steel was sold to a recycler and the concrete was crushed and recycled into new base material. The rate of production for the demolition and material hauling was approximately 2,000 yd$^2$/day.

The asphalt mix was produced in a portable plant on site with a typical production rate of 400 tons per hour. Rieth-Riley chose to use a portable mixing plant as their nearest permanent plant was 25 miles from the project site with potential traffic congestion. The paving crews on this project worked 12- to 14-hour days to complete the placement of the asphalt pavement. Although a higher rate of production from the plant was available, Rieth-Riley focused on achieving density in the mat to meet the agency’s specifications. In-place density comprised 40 percent of the pay factors. This focus on quality resulted in production and placement rates that were a little less than 200 tons per hour. The longer working days and the uninterrupted flow of operations provided by dedicated closures more than compensated for the rate of paving. The total paving time for the project was 40 14-hour days.

The performance of this project over the past six years has been very good. Figure 12 shows that the roadway is free of transverse and wheelpath cracking. The climate in Michigan could be expected to produce some thermal cracking, but that has not happened to date. The only treatment the pavement has received was the sealing of the longitudinal joint between lanes as shown in Figure 12.

In the end, the ability to construct US 31 in Michigan while minimizing user delay costs was mostly about the ability of Rieth-Riley to control their work zone. They were able to maintain a safe working environment for their employees and the traveling public and to provide a smoother flow of traffic than if they had used the agency-planned traffic control. They were able to accomplish these because of the ability to widen the inside shoulder and convert it into a traffic lane on the non-construction side of the road. Because Rieth-Riley was able to reduce the road user costs, they were able to submit a bid that was about $524,000 lower than the lowest concrete bid by providing increased mobility and accessibility to exit ramps.
Figure 11. Northbound Concrete Breaking Operation with (a) Demolition Impact Roller Breaker and (b) Resulting Concrete and Rebar, and Southbound Operation with (c) Guillotine Breaker and (d) Frost Tooth for Removing Rebar from Concrete.

Figure 12. A 2015 Picture of the Rieth-Riley Project on US 31.
CASE STUDY – LOUISIANA INTERCHANGE EAST OF NEW ORLEANS

The interchange of I-10, I-12, and I-59 east of New Orleans, currently under reconstruction, presents a very compelling case to in asphalt’s speed of construction when rehabilitating a roadway. This project has been designated by the Louisiana Department of Transportation and Development (LADOTD) as SPN H.003107 (I-10: French Branch Bridge – W. Pearl River Bridge). Each of these interstate roadways is a storm evacuation route which must be opened within 48 hours of a tropical storm entering the Gulf of Mexico during hurricane season from June through November. The project’s location in Slidell, relative to New Orleans, the Gulf Coast, the Pearl River, and Lake Pontchartrain, can be seen in Figure 13. The Pearl River crosses I-59 to the north of the project and I-10 to the east, virtually eliminating any bypass routes for those sections. Further, the interchange of three interstate highways presents very limited opportunities to detour traffic during construction due to a lack of frontage roads and very high traffic volumes. Thus, construction activities are severely impacted due to its location relative to bodies of water, the geometric restrictions of an interchange, and the hurricane season requirements. Figure 14 shows the layout of the interchange and the planned work with the red sections noting “fast” sections where speed of construction is of the utmost importance due to the lateral confinement prohibiting the placement of barricades in the work zone.

Figure 13. Location of French Branch Bridge Project.
The mainline roadways of all three interstate highways and six ramps will be impacted by this project and the LADOTD’s primary concern regarding traffic control was to avoid lane closures during peak travel hours. A complicated list of lane closure restrictions shown in the appendix challenged contractors to complete work in a timely fashion. There are certain times on weekdays and weekends when no lane closures are allowed for certain segments and other times in which single lane closures are allowed. Concurrent lane closures on adjacent sections are allowed only in instances where traffic control dictates the prevention of hazardous yield conditions. For specific critical lane closures in “fast” sections, the Department of Transportation and Development (DOTD) is imposing a $15,000 per hour penalty for exceeding the allotted time. Delays in opening the roadway completely beyond the allowed total time will result in a $15,000 per day penalty. Time lost due to storms or designated holidays will not be charged against the contractor.

Both a concrete pavement and an asphalt pavement section were designed by the LADOTD. Figure 15 shows the alternative structural designs for the pavement. The concrete pavement design is comprised of 12 inches of Portland cement concrete over 10 inches of LADOTD Class II base comprised of either an asphalt mix or stone, recycled concrete, or blended calcium
The asphalt pavement was designed with the same thickness and type of base course overlaid with 10 inches of a Superpave binder course with 2 inches of Superpave wearing course and 0.75 inches of an open-graded friction course (Lambert & Savoie, 2012). Both of the LADOTD alternatives were remove and replace options.

Figure 15. Design Alternatives for Louisiana Interchange (Lambert, J.R. and R. Savoie, 2012).

The LADOTD published the “Apparent Bid Results” for this project in January 2015. The agency had estimated a construction cost of approximately $40,757,000 with 700 days as the maximum construction time and a calculated user delay cost of $15,000 per day. The five bids are presented in Table 4 where the top-ranked bidder was Barriere Construction Co. LLC at about $39,889,000 for construction with a proposed time of 360 days (at $15,000 per day) for a time cost of $5,400,000. It is interesting to note that the second lowest overall bidder had a lower construction cost but about 1.9 times the construction time, and this made the difference between the two bidders. All of the concrete bids had construction times between 640 and 700 days, resulting in about $10,000,000 in user delay costs, almost double that of the asphalt alternative.

Table 4. Comparison of Bids for Louisiana Interchange.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Construction Bid, $</th>
<th>Proposed Time, days</th>
<th>Time Cost, $</th>
<th>Total Bid, $</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (asphalt)</td>
<td>39,888,687</td>
<td>360</td>
<td>5,400,000</td>
<td>45,288,687</td>
</tr>
<tr>
<td>2 (concrete)</td>
<td>37,473,810</td>
<td>675</td>
<td>10,125,000</td>
<td>47,598,810</td>
</tr>
<tr>
<td>3 (concrete)</td>
<td>47,524,942</td>
<td>699</td>
<td>10,485,000</td>
<td>58,009,942</td>
</tr>
<tr>
<td>4 (concrete)</td>
<td>53,532,280</td>
<td>640</td>
<td>9,600,000</td>
<td>63,132,280</td>
</tr>
<tr>
<td>5 (concrete)</td>
<td>59,918,761</td>
<td>700</td>
<td>10,500,000</td>
<td>70,418,761</td>
</tr>
</tbody>
</table>

Barriere Construction Co. representatives attribute their ability to bid a low number of construction days to having two asphalt plants within 60 miles of the project—one on either side. This allowed the contractor to change the DOTD suggested phasing to take advantage of the added material production. They also intend to concentrate their efforts in the “fast” sections of
the project by working for 54 to 60 hours on weekend time windows committing multiple paving crews to work in up to three locations concurrently with crews working 10-hour shifts. This change in construction sequencing will allow Barriere to complete these traffic exposed areas in eight weekends instead of the DOTD-allowed 27 weekends. This way the most dangerous parts of the project are completed in the fastest time allowing the remainder of the construction to be done behind barriers. Once crews are working in closed work zones away from traffic, they will be able to work uninterrupted for as many hours per day as needed to meet their schedule. An important aspect of this project is the LADOTD publicity of where and when lane closures will take place. Additionally, the LADOTD will be providing information concerning possible alternative routes.

The first step in constructing the “fast” sections is to place widened shoulders while the lanes are under traffic. These shoulders accommodate traffic during the construction of the mainline pavement. Figure 16 shows the inside and outside widened shoulders that were placed before work on the traffic lanes of IH-10 westbound on the weekend of May 30 and 31, 2015. During this weekend 2,800 ft of the two-lane pavement were removed and replaced. Removal of the reinforced concrete is being done using a pavement breaker to reduce the pavement to 18-inch chunks which could then be loaded into trucks and hauled away. The existing subbase was lime stabilized in wet and soft areas and shaped prior to the placement of 5 inches of black base which was compacted before the remaining structural layers were constructed. Barriere chose to use an asphalt-treated base course material because it could be placed and compacted to specified density much quicker than the alternate granular base or cement treated base.

![Figure 16. Widened Shoulder Placed Ahead of Weekend Lane Closure for Fast Section.](image)

Although standard LADOTD specifications will apply, particular attention will be focused on the quality control (QC) for the project. Barriere has hired a QC manager specifically for this project to ensure that they get the quality right the first time. Any test results not meeting the required level and tolerance in the specifications could result in money lost through disincentives and, in
the very worst case, removal and replacement of the pavement. Given the tight timeframe for this project, the latter scenario would create a severe hardship on the project team.

The Barriere project team pointed out some efficiencies that could be gained in constructing these pavements. First would be an improved site investigation to reduce the number of unknowns that might be encountered. It was not clear at the time of bidding what type of concrete pavement (plain or reinforced) was in place or even how thick it was. They reported finding one portion of the shoulder that consisted of 17 inches of concrete. Also, a ground-penetrating radar (GPR) survey could have detected wet spots in the subbase and provided the contractor with a much better indication of how thick the existing concrete was and if there was steel reinforcement present.

Barriere Construction does both asphalt and concrete pavement construction in Louisiana. Their choice of bidding the asphalt alternative was based on the flexibility and speed of construction that asphalt offered. Furthermore, asphalt allowed the construction in the critical “fast” zones to take place quickly allowing the remaining construction to take place behind hard barriers, thereby making the work zone safer for motorists and workers.
SUMMARY AND RECOMMENDATIONS

As the road infrastructure in the United States ages and as congestion on the roadways inevitably increases with time and population, new methods for the timely and rapid rehabilitation of the system must be found. There are a number of tools that may be employed to accelerate the delivery of highway construction projects including innovative contracting, improved project selection, optimized traffic control, and new methods to increase construction productivity. Innovative contracting procedures such as design-build, incentives and disincentives, and A+B bidding allow contractors greater flexibility in meeting agency objectives to reduce user delays and reward contractors for early completions. Tying contractor productivity to profitability and designing highway projects to minimize construction-related user delays should be a top priority for agencies in this country. In quantifying the effects of traffic delays and rehabilitation cycles, it is important that road user costs and life cycle costs become standard project evaluation tools. Several rapid construction case studies and DOT construction productivity tables show that asphalt pavements have numerous advantages in reducing highway construction times.

The keys to achieving rapid construction in highway projects include:

1. Isolating the construction work from the traffic to provide unimpeded access and maintain a steady flow of construction work. This will also provide a safer work zone.
2. Keeping and using as much of the existing pavement material on site to minimize excavation and hauling time.
3. Maintaining lane closures for the longest possible time to reduce the time required for mobilization and demobilization, including changing the traffic control.
4. Allowing contractors the greatest possible control over the work zone construction activities during lane closures.
5. Developing innovative approaches to facilitating traffic movement through work zones by:
   a. Providing extra temporary lanes by widening shoulders.
   b. Keeping traffic movements as simple as possible.

Although rapid construction is already practiced in the asphalt paving industry, there is a need to further refine construction operations so that even faster operations become possible in the future. As shown in Figure 1, there will be an increasing demand to complete projects rapidly. From a review of the information presented in this report, the following are recommendations for future research and development:

1. Better site investigation techniques and guidelines to develop detailed engineering reviews of roadway conditions ahead of construction. This will allow for better project definition and greatly reduce the risks to both contractors and agencies. Defining pavement thickness and detecting the presence of water in lower pavement layers through the use of GPR is a good example of technology that may be employed.
2. Rapid, more thorough QC/QA techniques through the use of faster non-destructive testing methods. Some of these are already in use in certain states. Intelligent compaction for soils and bases, the use of infrared sensors during paving, ensuring proper roller operations through global positioning systems, the use of nuclear and non-nuclear density gauges, and the use of GPR for density and thickness measurements are some of the
existing technologies that should be improved and exploited. Taking and testing materials from the roadway for laboratory evaluation is time consuming, and by the time results are available the construction operations may be so far along that corrective action is not feasible.

3. Development of better traffic modeling for work zones that can be tailored to specific conditions and used by contractors to develop alternative construction scenarios. This will help in scheduling construction operations and optimizing traffic flow. These models will help contractors especially if they are operating under a performance specification for traffic flow.

4. Improved, faster methods for treating materials in place need to be developed to minimize the need for material removal from the site. Material removal and disposal is one of the most time consuming operations in a work zone. By reducing the number of construction operations and the amount of construction traffic, the construction cost, road user cost, and the time for project delivery can be greatly reduced.

5. Improved, faster methods for excavation and disposal of materials in the existing pavement need to be developed for instances where plans require it. Normally, the techniques used for demolition in roadways rely upon general construction equipment employed in typical earth work. Specific equipment capable of removing an entire lane width of material full-depth and rapidly feeding it to dump trucks could be very useful in reducing time. Also, for example, improved methods of removing reinforcing steel from concrete during excavation could save steps in clearing the material from the site.

6. Improved, faster methods for materials delivery are strategies employed on a case-by-case basis, but guidelines for balancing production and transportation could be tools that help contractors to model construction operations. These guidelines could be integrated with the traffic model discussed above to evaluate the effect of traffic levels on material delivery to the job site and to alert the plant to potential adjustments needed during production.

7. Improved, faster methods for paving to match accelerated materials delivery need to be developed. Current methods for paving rely on traditional approaches to placing and compacting one lift at a time. Innovative approaches to paving need to be investigated for the future. One example of this is the two-lift paver in use Germany, where two different mixes can be delivered and placed simultaneously. It has been demonstrated in the United States but is not being used here currently.

The NAPA/TTI co-funded project has identified incentives and supplies sufficient information to stimulate the interest of public agencies and the industry in accelerated/rapid construction. A significant, long term effort will be needed to move the public and private sector associated with pavement operations from the present construction rates to accelerated rates. The public benefits and economic incentives will be substantial due to this change and will ultimately be demanded by the driving public and the politicians.

The first step in this effort is to accurately capture the benefits associated with accelerated/rapid reconstruction, rehabilitation and maintenance. The next step is to enlist the support of one or more state DOT’s with an interest in this area as well as representatives from industry (contractors, asphalt mixture suppliers, asphalt binder suppliers, aggregate suppliers, equipment manufacturers, etc.) to meet in workshops to discuss the economic incentives and the public perception of accelerated construction.
This workshop will identify one or more states with an interest in the development of this concept by letting a number of projects over several years requiring or providing meaningful incentives for rapid construction operations. It will also enlist the industry to develop meaningful changes/developments in materials engineering and supplies, construction equipment, construction sequencing concepts, workforce scheduling, and financial tools to reduce project construction times by 50 to 70 percent. Changes in pavement thickness design, materials selection, wider use of recycled materials and rapid quality control/quality assurance tools, and public information approaches are additional important items that will need to be considered by the workshops and implemented.
REFERENCES


Ohio Department of Transportation (ODOT) (2000). Policy on Traffic Management in Work Zones Interstate and Other Freeways, Policy No.: 516-003(P). Columbus, OH.


Texas A&M Transportation Institute (TTI) (2013). Analysis Procedures and Mobility Performance Measures 100 Most Congested Texas Road Sections. Technical Memorandum. College Station, TX.


H.003107 French Branch West Pearl River
Lane Closure Plan – Revised June 2012
This construction job affects the mainline of I-10, I-12, and I-59. Six ramps are also affected by this work. The lane closure plan for the I-10/I-12/I-59 interchange is divided into two parts: mainline interstate and ramps. Concurrent lane closures are not allowed on adjacent sections of the mainline interstate or ramps. This will only be allowed at locations where it is better to provide each approach with one lane to prevent an undesirable yield situation. The contractor must grind off any interstate shield legend pavement markings that are contrary to the temporary traffic control plan.

Mainline Interstate lane closure restrictions are as follows:
1. I-59 southbound (northern job limits to I-12): No lanes can be closed from 5am to 9am Monday through Thursday. No lanes can be closed from 6am to 7pm on Fridays. Single lane closures are allowed all day on Saturdays and Sundays.

2. I-59 northbound (northern job limits to I-12): No lanes can be closed from 2pm to 7pm Monday through Thursday. No lanes can be closed from 2pm to 10pm on Fridays. Single lane closures are allowed all day on Saturdays and Sundays.

3. I-59 northbound (I-10 to I-12 overpass): No lanes can be closed from 12pm to 7pm weekdays. Single lane closures are allowed on weekends.

4. I-59 southbound (I-10 to I-12 overpass): Single lane closures are allowed daily.

5. I-12 eastbound (western job limits to I-10): Single lane closures are allowed daily.

6. I-12 westbound (western job limits to I-10): Single lane closures are allowed daily.

7. I-10 eastbound (I-59 to eastern job limits): No lanes can be closed from 10am to 6pm daily.

8. I-10 westbound (I-59 to eastern job limits): No lanes can be closed from 2pm to 6pm weekdays. No lanes can be closed from 11am to 6pm weekends.


10. I-10 westbound (southern job limits to I-59): Single lane closures are allowed daily.

Impacts to the interchange ramps will be as follows:
Ramp C (I-12 eastbound to I-10 westbound): One open lane will be maintained at all times. Any yield control for this ramp should only be allowed during weekends.
Ramp D (I-59 northbound to I-12 westbound): Two weekend ramp closures will be used with detours to the I-10/US11/LA 1090 Interchange in Pearl River.
Ramp E (I-59 southbound to I-12 westbound): One open lane will be maintained at all times.
Ramp F (I-12 eastbound to I-59 northbound): Weekend ramp closures will be used with detours to the I-10/US 190 Business (Fremaux) Interchange.
Ramp G (I-10/I-12 westbound to I-59 northbound): One open lane will be maintained at all times.
Ramp H (I-59 southbound to I-12 eastbound): Weekend ramp closures will be used with detours to the I-10/US 190 (Gause) interchange will be used.