

Emergency Reconstruction of Critical Transportation Infrastructure

By

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16. Abstract <p>The recent damage caused by hurricanes, Katrina, Rita, and Wilma have demonstrated the potential for enormous property damage and loss of life as well as disruption of government and other institutions in Alabama. Similar damage could be the result of a terrorist attack or series of attacks. Due to the low probability of terrorist attacks and uncertainty where natural disasters or terrorist attacks will occur, it is difficult to justify contingency planning dollars for the repair or even replacement of specific facilities. Nevertheless, when a disaster incident occurs, the urgency of the situation suggests that a deliberate design-bid-build process is not practical and an alternative approach is used to resolve the crisis. It is reasonable to question whether the quality of design; value engineering; material and service procurement; contractor selection; worker compensation and safety; and government oversight are in proper balance to insure just and reasonable costs to the taxpayers. Well crafted and comprehensive plans and procedures for the management, control and oversight of the Construction Industry during the recovery and rebuilding operations in Alabama is a responsible and proactive approach to security management. The proposed research project addresses the need to review historical performance and to present ideas for preplanning and implementation process enhancement. The project consists of four work tasks. The first task was a compilation of available data describing the recovery and reconstruction experiences of transportation infrastructure facilities after accidents or natural disasters. The second phase was a study of the potential approval, procurement, contracting, funding and scheduling processes associated with recovery and reconstruction from disaster events. The third phase was the formulation of recommended contingency planning processes for recovery and reconstruction operations based on the results of the workshops and other supporting research. The final phase consisted of documentation and preparation of the final report.</p>			
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Executive Summary

The damages caused by Hurricanes Katrina, Rita, and Wilma have demonstrated the potential for enormous property damage and loss of life as well as disruption of government and other institutions in Alabama and neighboring Gulf Coast States. Similar damages could be the result of a terrorist attack or series of attacks. Due to the low probability of terrorist attacks and uncertainty where natural disasters or terrorist attacks will occur, it is difficult to justify contingency planning dollars for the repair or even replacement of specific facilities or to be staffed at organization and equipment levels needed during a major recovery operation. Nevertheless, when a disaster incident occurs, the urgency of the situation suggests that a deliberate design-bid-build process is not practical and an alternative approach is used to resolve the crisis. It is reasonable to question whether the quality of design, value engineering, material and service procurement, contractor selection, worker compensation and safety, and government oversight are in proper balance to insure just and reasonable costs to the taxpayers. Well-crafted and comprehensive plans and procedures for the management, control, and oversight of the construction industry during the recovery and rebuilding operations in Alabama is a responsible and proactive approach to security management. The research project addresses the need to review historical performance and to present ideas for preplanning and implementation process enhancement. The project consisted of four work tasks. The first task was a compilation of available data describing the recovery and reconstruction experiences of transportation infrastructure facilities after accidents or natural disasters. The second phase was a study of the potential approval, procurement, contracting, funding, and scheduling processes associated with recovery and reconstruction from disaster events. The third phase was the formulation of recommended contingency planning processes for recovery and reconstruction operations based on the results of the interviews and other supporting research. The final phase consisted of documentation and preparation of the final report.

Section 1.0 Introduction

Terrorist attacks against the infrastructure of the United States, including the transportation infrastructure of Alabama, are likely and major natural disasters are certain. The recent damage caused by Hurricanes Katrina, Rita, and Wilma have demonstrated the potential for enormous property damage and loss of life as well as disruption of government and other institutions in Alabama. As part of the comprehensive Homeland Security initiatives ongoing throughout the nation, plans for rapid restoration of the transportation network after a catastrophic event are an essential element in the restoration of the economy and confidence in government and governmental agencies. In addition, a key factor in deterring terrorist activities is the demonstrated ability to rapidly recover to normal from a terrorist act or act of nature at minimal cost. When such massive resources are focused on recovery operations over a relatively short period of time, it is reasonable to question whether the quality of design, value engineering, material and service procurement, contractor selection, worker compensation and safety, and government oversight are in proper balance to ensure just and reasonable costs to the taxpayer. This project addresses the need to review recent reconstruction activities and to make sound recommendations for preplanning and implementation processes.

Objectives

The objective of this project was to review historical and ongoing methodologies employed in Alabama and neighboring states for damage assessment, redesign, construction contracting, funding, project management, and overall fiscal management oversight in the event of major transportation facility infrastructure damage due to natural forces or malicious terrorist acts. Results were used to recommend a framework for a formalized contingency planning process involving the transportation infrastructure.

Task 1

The first task was a compilation of available information describing the recovery and reconstruction experiences from a sample of regional transportation infrastructure facilities after accidents or natural disasters with particular emphasis on the recovery activities following Hurricane Katrina in Alabama, Mississippi, and Louisiana. Government and private sector participants were interviewed and public records, such as contracts, costs, and Inspector General Reports, were reviewed. Local site visits were conducted, and some of the prime contractors and subcontractors involved in reconstruction were interviewed.

Task 2

The second task was a study of the potential approval, procurement, contracting, funding, and scheduling processes associated with recovery and reconstruction from disaster events. This phase included detailed literature review of contracting processes established by law and historically used to accelerate transportation infrastructure repair and reconstruction and interviews with government and construction industry experts.

Task 3

The third task was the formulation of recommended future courses of action aimed to improve the contingency planning process and overall emergency response preparedness based on the results of the interviews and other supporting research.

Task 4

The fourth task was the completion of this final report and submission for review.

Section 2.0

High Impact Transportation Infrastructure Disasters

The Changing Nature of Transportation Reconstruction Emergencies

As the United States has become more urbanized and the industrial, manufacturing and commercial sectors increasingly engaged in intense global competition, we have become dependent on just-in-time delivery for virtually every need. The balance is fragile, and without a robust and resilient transportation network, substantial commercial economic damage and threats to public health and safety can occur and occur quickly. In fact, if the transportation infrastructure sector is congested or severely damaged, other critical infrastructure, such as energy and telecommunications, might waiver or fail. In Alabama there is diversity of transportation modes within the state, and commercial competition is strong. However, the public safety, health, and well-being are dependent upon a reliable and resilient transportation network assuring crucial human services sectors remain operational and economic activities are bustling.

The Alabama Transportation Network Is a Critical Lifeline

The roadway system is the most critical component of the state transportation network, accounting for the vast majority of person-movements within the state as well as nearly 80% (by value) of all freight shipments (U.S. Bureau of Transportation Statistics, 2002). Alabama's highways also serve an important function within the national transportation system, providing an important connecting corridor for freight movements between Texas, Louisiana, and other points in the Southeast to locations in the Northeast and Midwest.

A secure and functioning roadway network is essential to the social and economic vitality of the state. Nearly one billion tons of freight was moved over Alabama highways in the year 2002 (U.S. Bureau of Transportation Statistics, 2002). This included freight movements within the state, freight originating in Alabama destined for other areas, freight entering Alabama from other areas, and freight being moved through Alabama between origins and destinations in other states. For freight that originates within Alabama, 70% of all tonnage is carried by truck. By value, nearly 80% of all freight is transported by truck. This reflects the fact that higher value shipments are typically carried by truck. Rail, and to a lesser extent, barges, tend to carry heavier bulk cargo with a lower value per unit weight, such as coal and bulk materials.

The importance of a resilient and efficient highway network to both State and national commerce cannot be overstated. As reported in detail by Killingsworth and Harris (2005), the transportation infrastructure of Alabama links key economic concentrations nodes within the state. Alabama's highways already are experiencing congestion during peak hours, and

economic growth projections suggest road congestion could become a severe problem. In fact, at the time of this study a detailed multidisciplinary study group sponsored by *Manufacture Alabama* involving 50 government and private sector experts was looking into the future transportation congestion issues in Alabama. This effort is an indication of the importance and urgency of the problem.

The state of Alabama has over 94,000 miles of public roads that serve the state's commuters, commerce, and security, and there are over 15,600 bridges (Hitchcock, *et al.*, 2007). Any disruptions to this network due to congestion, natural disaster, accidents or deliberate acts can have serious effects on the State economy. Particularly vulnerable are the auto industry and other manufacturers that rely on just-in-time deliveries. Some Alabama commodities that rely on trucking for over 90% of their transport include:

- Animal feed
- Meat, seafood, and other food products
- Gasoline (excluding pipelines)
- Fuel oil

The vast extent of the roadway network and its interconnectivity would seem to provide a substantial amount of redundancy and resiliency, allowing vehicles to detour around network blockages or congested areas using numerous connecting roadways. In some respects this is true, but for the most part, the bulk of transportation within the state, both in terms of freight and persons moved, utilizes only a very small portion of the total roadway network and is thus vulnerable to disruptions with relief only available from a small number of primary roadways. Furthermore, even in areas where there is great redundancy in the roadway network, alternate routes may be less efficient or more congested than the primary routes so that disruptions in the primary network, while not catastrophic, will still carry substantial social and economic penalties.

The integrity of the roadway network is vital to the welfare of the state, and therefore protection of the transportation infrastructure is of paramount concern to all governments, private sector organizations, and the public. Protection implies an understanding of the potential threats to the physical integrity of the infrastructure and the vulnerability of the infrastructure to those threats. Threats to the integrity of the transportation infrastructure include:

- Natural disasters, such as hurricanes, flooding, tornados, and earthquakes
- Damage to infrastructure caused by vehicle crashes
- Structural failures due to age or lack of maintenance
- Deliberate terrorist acts
- Congestion

When catastrophic failures in the roadway network occur because of one of the potential threats, beyond the shock of the loss of life and property occurring at the time of the incident, a lingering monster, residual congestion, may begin to expand the impact of the event. Roadway congestion occurs when traffic volumes approach or exceed roadway capacity, and results in vehicle delays,

increased fuel use, increased vehicle emissions, and lost productivity. Alabama has multiple high congestion choke points in the network near the major cities. These choke points are of concern not only because of the recurring delays associated with them, but also because they represent areas where catastrophic network failures would likely result in inordinate costs to the transportation system. Network failures in these areas would not only exacerbate existing congestion, they could also overwhelm adjacent roadway facilities as vehicles attempt to reroute around the failure or blockage.

While the enormous force of a hurricane and associated storm surge can cause perhaps the most significant damage in terms of square mile extent, tornadoes, flooding, and earthquakes are also potential hazards for service interruption. When such damage from the forces of nature does occur, ideally ALDOT will be positioned to move quickly to replace the facilities and restore service. The time necessary to accomplish the repair or replacement depends on the extent of the damage, the government approval requirements, availability of funding, availability of equipment and materials, availability of qualified contractors, and the availability of qualified labor to do the work.

So how much should be spent on repair or replacement, and who should do it? There is another question of conceptual importance. Is the urgency to replace certain critical transportation infrastructure components more urgent in today's environment than it has been historically? These questions are not easy to answer.

For the most part the answer lies in understanding what the daily cost of the outage is. Ideally, the cost of a full or partial outage could be quantified in economic terms taking into consideration all impacts of the outage to include direct economic loss as well as the impact on the public health and welfare. Conceptually, a comprehensive cost analysis would require a thorough understanding of all the interdependencies associated with the damaged or destroyed infrastructure component coupled with appropriate analysis tools to produce a timely valuation. To date such analytical tools have not been developed and tested for general application. Until such tools are available, more simplified models are employed based on historical traffic flow data and the degree of disruption caused by the incident as compared with the conditions before the incident.

Usually, when a major disruption in traffic flow occurs and the cost analysis justifies the increased expense, accelerated reconstruction methods are employed to repair or replace the damaged infrastructure. The objective of this project was to study the process of repair or replacement of critical transportation infrastructures in Alabama, compare it to relevant recovery experiences in neighboring states, and to make final observations, ask questions and make recommendations. The approach taken was to illuminate the issues of interest by referencing historical catastrophic events to include a discussion of key response/ recovery decisions, methods employed, and a summary of lessons learned.

Recent Large Scale Transportation Infrastructure Disaster Examples

Certainly, the horrific destruction of life and property imparted by Hurricane Katrina demonstrates how wide spread and overwhelming a single event can be. While the full fury of Katrina was unleashed primarily on Louisiana and Mississippi, significant damage did occur in Alabama and Texas as well. Images of destroyed infrastructure, businesses, and homes were shocking at the time of the event, and the lingering devastation nearly 18 months after the catastrophe is a testimony as to how long-term, expensive, and to some extent, controversial recovery can be. A more detailed discussion of the significant transportation infrastructure damaged incurred during Hurricane Katrina is discussed later in the report. As informational background, it can be illuminating to recall other major events in which transportation infrastructure was damaged and/or destroyed at considerable cost in terms of loss of life, loss of economic value, and substantial public inconvenience.

Recent Historical Events in Alabama

The state of Alabama has recently experienced two significant bridge damage events due to accidents involving trucks and another near major disaster in the Port of Mobile when the fury of Hurricane Katrina delivered a glancing blow to the city.

On January 5, 2002, an explosion took place on the I-65 North overpass bridge in Birmingham, Alabama, when a vehicle crashed into a tanker truck that was carrying 9,000 gallons of fuel. According to the FHWA description of the accident, the heat from the explosion exceeded 2,000 degrees Fahrenheit, causing the steel girders in the overpass to sag approximately 7 to 10 feet. (FHWA, 2007). The explosion, as well as the fire, caused not only severe damages on the bridge carrying I-65 southbound traffic in Birmingham, but also the death of the driver of the tanker truck. The Alabama Department of Transportation (ALDOT) immediately closed the I-65 northbound and the I-65 southbound bridge. At the time, the closure of the I-65 southbound affected approximately 140,000 vehicles per day. Fortunately, the I-65 northbound lanes were again opened to traffic flow three days after the event. However, the I-65 southbound lanes were close until February 25, 2002, because the bridge spans were destroyed and the deck required replacement. ALDOT clearly recognized the need to complete the reconstruction as soon as physically possible. The details of the response are explained later in the report.

Remarkably, on October 21, 2004, another accident occurred in the same interchange damaging a bridge very close to the one damaged in 2002. In this case a 9,000 gallon fuel tanker truck crashed under the I-20/59 north bridge at the interchange of I-65 and I-20/59 producing a massive explosion and severely damaging the 413-foot long bridge (Brasfield & Gorrie, 2005). ALDOT immediately closed the I-20/59 eastbound bridge and established a traffic detour through city streets. The closure of this bridge affected approximately 245,000 vehicles per day with an estimated daily user cost to the state of \$200,000.

On August 29, 2005 during Hurricane Katrina, the Cochrane-Africatown Bridge in Mobile, Alabama was struck by a 13,000-ton semi-submersible drilling platform that broke free from its dry-dock moorings due to the strong winds generated by the hurricane and collided into the

Cochrane-Africatown Bridge. While the bridge experienced damage and was closed briefly for inspection by ALDOT engineers and consultants, devastating destruction of the bridge support system on one end of the bridge with the subsequent catastrophic collapse of the cabled bridge spans was narrowly avoided. After a thorough inspection, bridge engineers determined that the traffic flow could be continued on a restricted basis prior to the commencement of restoration operations.

All of these cases are discussed in detail in Appendix A of this report.

Section 3.0

Overview of the Emergency Repair/ Replacement Process

Emergency Funding

When disasters strike and significant damage to highway infrastructure occurs, transportation officials must be in position to respond quickly for the safety and convenience of the public. A necessary component to rapid response is funding, and a well-defined emergency response funding process exists for Federal-Aid highway systems through the FHWA.

Federal aid for the emergency repair of federally funded highway facilities (ER) has been in existence for over seventy years. The original legislative act to authorize separate funds for the ER program was in the Federal-Aid Highway Act of 1956 which established the interstate highway system as we know it today. At that time, the law was codified in the now-familiar *Title 23 U.S.C., Highways*. The designation “U.S.C.” means United States Code and refers to laws passed by Congress. These laws are implemented by the federal agencies executive branch through the development of the Code of Federal Regulations (CFR). The CFR is divided into 50 titles and is published in the *Federal Register*. Volumes of the CFR are updated at least one a year and are accessible online. (GPO, 2007)

Authorization acts usually cover several years and establish the maximum program authorizations, funding distribution levels and may amend or abolish components of the Federal-Aid Highway Program. Each year there is an appropriations act that covers one federal fiscal year (October 1 – September 30). The appropriation acts provides funding for the year and may modify the law and program activities. The most recent authorization act, the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) (P.L. 109-59; Stat 1144) authorizes the ER program through 2009, and the details are codified in 23 U.S.C. (Kirk, 2005). Multiple specific citations within 23 U.S.C. or FHWA documents derived from 23 U.S.C. are included throughout this report.

In most cases, critical transportation infrastructure outages capable of imparting substantial economic harm and personal inconvenience will be Federal-Aid highway facilities. In the event a roadway in need of repair is not in this category, requests for emergency repairs and debris removal can be submitted to FEMA based on funding authorization contained in the Stafford Act, P.L. 93-288 (FHWA, 2003). This research is limited to the procedures associated with projects that qualify totally or in part for funding under the FHWA emergency relief (ER) program.

Qualifying Disasters

Funding under the emergency relief program is intended to assist State and local governments in the restoration of highway facilities that have incurred severe and high expense damage over a wide area. According to the FHWA guidelines (FHWA, 2003), the failure must be catastrophic in nature and must have been caused by a source external to the facility. To be catastrophic the disaster must be “the sudden and complete failure of a major element or segment of the highway system that causes a disastrous impact on transportation services” (FHWA, 2003). In order to qualify for ER funding the disaster must be substantial and therefore exceeding the scope of heavy or routine maintenance. Subpart 668A of Title 23 of the CFR includes a \$700,000 (federal share) threshold for a disaster to be eligible, and the cost to repair a single site within the area of damage should be a minimum of \$5,000 (FHWA, 2003). ER funding is specifically limited to emergency repair costs to return the facility to pre-disaster conditions. If a bridge is destroyed, replacement is authorized up to current design standards and current design year volume provided the bridge is not scheduled for replacement under another funding program.

Betterments, such as lane widening or raising lane height, are not generally considered fundable under ER. However, facility improvements can occur at the time of the replacement construction by incorporating other funding sources with the ER funding. In order to gain FHWA approval, states must file all appropriate reports and requests before construction begins. In some instances betterments can be approved by the FHWA for ER funding if the State can demonstrate (with full documentation presented to FHWA) that the future cost/benefit ratio savings in ER program repair costs justifies the betterment expenditure (FHWA, 2003).

Emergency Funding Relief Application and Approval

Under the traditional and most time-consuming process, funding relief is initiated by either a Governor’s formal proclamation of the existence of a disaster or a declaration by the President that a disaster exists. In either event, the state must file a letter of intent to file for relief with the FHWA Division Office located in the state. The FHWA Division Office will follow up with a written acknowledgement that the request was received. Then, preliminary damage inspection assessments are conducted jointly by the FHWA Division Office and the state and local officials to verify the extent of damage and to document initial cost estimates for funding eligibility under the ER support program. Subsequent detailed damage assessments may be required to gain final approval for a program of projects requested for ER funding support. After damage assessment is completed, the FHWA Division Office assists the state in preparing a “Damage Survey Summary Report” which is then submitted to the FHWA Division Office to form a basis for the final finding of relief qualification by the FHWA Division Administrator. Among other things, the summary report delineates the apportionment of funding from the federal, state and local sources. This total process could take 6 to 10 weeks.

If an accelerated process approval schedule is required, the first alternative approach is to expedite the assessment process by conducting a “windshield” inspection and sampling of the damage for purposes of the cost estimates. The paper flow remains the same. Detailed site inspections are deferred until after ER qualification is determined but are still necessary to

establish funding approval for a program of projects to be ultimately included in the recovering process. This process could take 2 to 3 weeks. If the situation dictates a faster response, a “Quick Release” process can be followed whereby the initial release of ER funding will require only the state’s letter of intent and request for ER funding coupled with current and best available reliable information describing the extent of damage. The formal state request for funding is based on the preliminary damage assessment and does not require a “Damage Survey Summary Report.” The “Quick Release” methodology is designed to begin initial funding. When time permits, follow-up site inspections and a modified abbreviated Damage Survey Summary Report must be submitted to the FHWA Division Office.

Level of Funding Support

The ER program provides for the repair or reconstruction of seriously damaged highway facilities in cooperation with the impacted state to include some cost sharing. The provisions of the ER program allow FHWA to provide a maximum of \$100 million per state for each disaster that occurs. If the cost of the disaster exceeds \$100 million for a state, Congress must lift the restriction and authorize funding through an appropriations act (FHWA, 2006). The federal share for the repairs and/or replacement depends on timing, availability of other funds, and the State’s ability to contribute the typical matching portion specified in the regulations.

Generally the funding level is in two categories, ***emergency*** and ***permanent*** repairs. Emergency repairs are those essential to the flow of traffic and public safety such as debris removal, ramp repair, temporary detours, erection of temporary bridges, etc. Federal compensation for emergency repairs completed within 180 days is 100%. It is the expectation that funding expenditures on emergency repairs will reduce the cost of the permanent repairs. Permanent repairs go beyond the immediate needs to restore essential traffic service. The federal share for permanent repairs is 90% for interstate highways and 80% for all others. If the road is on federal land, the federal share is 100% for all repairs and replacement.

Funding Administration

During the course of the repair and replacement construction process, project operations are managed by the state, to include requests for ER funding reimbursement. All construction records must be maintained in accordance with current funding program requirements and are subject to state and federal audit. Because of the nature of emergencies state and local authorities must sometimes commence repairs immediately without prior approval of the FHWA. If state or local authorities act prior to approval, they must submit a funding request following the procedures described above as soon as practical after the incident, because all repair work must be ultimately deemed qualified by the FHWA Division Administrator.

Contracting Alternatives

Contracting for the emergency repair and long-term permanent repairs of highways qualifying for the Federal ER program is well defined in the Code of Federal Regulations (particularly 23

CFR and 49 CFR), FHWA *Federal Agency Policy Guide*, the FHWA *Emergency Relief Manual*, and the FHWA *Contract Administration Core Curriculum Participant's manual and Reference Guide 2006*. The purpose of this section is to briefly summarize key established procedures and to point out the flexibility that is currently available to states in contracting emergency and permanent repairs of damaged highway facilities that qualify for the ER funding program.

The ER funding program is a federal aid program, and therefore contracting for construction services receiving ER funding must comply with the employment and implementation requirements of the Clean Air Act and the Federal Water Pollution Control Act as well as all other provisions that shall be required from time-to-time by law and regulation as conditions of Federal assistance (FHWA, 2003).

Construction Contracting

The ER program is in place to insure that public health and safety are a priority in the response to a disaster. Because of the time consuming nature of the traditional Design-Bid-Build approach to highway contracting, it is often not appropriate for emergency repair/replacement construction requiring immediate action. Flexibility in emergency repair contracting makes sense if the public health and safety is to be of paramount importance. The regulations clearly state that alternative contracting is anticipated by the regulations when warranted by an emergency. The ER program permits flexibility in construction contracting for emergency repairs as deemed most appropriate by the state transportation agency, to include the advertised contract, negotiated contract or force account methods (transportation agency, county, railroad, or public utility). However, the advertised contract method is the recommended approach by FHWA to be employed wherever feasible.

The flexibility provided for construction contracting under the ER program is necessary for states to develop innovative approaches to highway infrastructure restoration after a disaster. In addition, flexibility in contracting can be coupled with other important preplanning processes, such as prequalification of engineers, contractors and suppliers and the use of materials and equipment held specifically in reserve for use in the response to disasters.

Permanent repairs “must be done using the competitive bid contract method unless the state demonstrates some other method is cost effective as described in 23 CFR 635.204” (FHWA, 2003). The competitive bid process is expected to be formally advertised whenever it is feasible to do so. In the case where the state decides to depart from the competitive bid contract method, the state must clearly explain to the FHWA Division Administrator the particulars of the project and the reasons for the application of an alternative contracting method. Requests for alternative contracting are evaluated under the provisions of FHWA’s SEP-14, more fully explained in the next section of this report.

Non-Traditional Alternatives to Competitive Design-Bid-Build Contracting

When transportation infrastructure has experienced catastrophic damage from an accident or natural hazard, the health, safety and economic interests of the public will likely dictate a

reconstruction process that places time as a top priority in the reconstruction process. In fact, the ever-changing dynamics of national and world economic supply chaining demands that transportation networks be resilient. In some cases, transportation system outages beyond a few days may trigger substantial cascading economic damage or worse, severe public health and safety conditions. For many years contracting for highway construction projects employed the design-bid-build approach subject to all additional requirements in place for federal funded project work. This method is well understood and is founded on a process of well-established design standards and guidelines. Contracts are awarded to the lowest qualifying bidder, and project scope and quality inspection are managed by the owner. The design-bid-build method is a linear progressive process where time is sacrificed in favor of detailed pre-project planning, full advertising, competitive low-cost bidding, and a progressive construction scope and quality inspection program. In situations where time becomes a top priority, traditional contracting methodologies become a liability.

The need to investigate alternative contracting practices was recognized by the FHWA in the 1980s. By 1988 the Transportation Research Board (TRB) established a task force of 23 representatives from state highway agencies to evaluate contract practices and provisions which would allow more flexible options to owners in contracting for highway construction projects. (TRB, 1991). The TRB initiative led to the FHWA formalized evaluation of alternative contracting methods under its Special Experimental Project No. 14 (SEP -14) (FHWA Briefing, 2002). There is deep inventory of case studies and reports in the literature since 1988 concerning the evolution of highway construction contracting innovations from experimental to accepted practice. Readers interested in finding generally recognized detailed source document references are encouraged to investigate the FHWA, AASHTO, and TRB web pages for reference lists in addition to traditional library literature search tools. Another excellent comprehensive information source was produced by the American Society of Civil Engineers Construction Institute: *Alternative Project Delivery, Procurement and Contracting Methods for Highways* (Molenaar, *et al.*, 2007). This reference is a composition of eight peer-reviewed chapters prepared by industry experts from across the nation. Each chapter is replete with current literature references on the subject of alternative contracting methods for highway infrastructure construction.

Brief summaries of alternative contracting methods relevant to Alabama as described in many of the references discussed in the previous paragraph are presented in following paragraphs because they are referred to in the analysis and recommendation sections of this report. The methods deemed to be most applicable are Bid Contracts with Incentives/Disincentives, Design-Build, A+B with Incentives/Disincentives, and Lane Rental. All of the methods are designed to reduce the time necessary to complete the project and yet (1) preserve fair opportunity for participation by construction firms, subcontractors and material suppliers, (2) assure reasonable contract pricing for public projects, and (3) insure responsibilities for scope and quality inspection and testing are not diluted.

It is interesting to note that in a recent research project in which state transportation agencies were questioned about the effectiveness of alternative contracting methods, it was determined that the A+B with Incentives/Disincentives is the most attractive of the three methods (Molenaar,

et al., 2007). The state of California transportation agency (Caltrans) has extensive experience with alternative contracting and used the A + B method exclusively to restore critical bridges damaged and destroyed by the Northridge earthquake in 1994. Caltrans now requires the A + B bidding method for all projects with a construction cost of \$5 million or more and a daily road user cost of \$5,000 or more (AASHTO, 2006).

Advertised Bid Contracting with Incentives/Disincentives This contracting method is different from the traditional design-bid-build approach primarily because of the focus on compressing the time to completion of the contract. To initiate the process the state transportation agency, often with the help of retained engineers and/or architects, will complete the design and specifications for the reconstruction project and will also specify a desired project completion date. The contract is then advertised for bids on a compressed approval schedule. The list of invited bidders will most likely be restricted to a list of prequalified contractors. To provide an impetus to complete the project ahead of the specified project completion date, a daily cash incentive is included in the contract to encourage the contractor to use innovative construction techniques and overtime to complete the project ahead of schedule. Similarly, a disincentive clause is established to discourage contractors from construction delays beyond the stated completion date. When this process is used, standard approval timelines, procurement schedules and reporting protocols are typically streamlined.

Design-Build Contracting The design-build method recognizes that the experience of contractors can contribute to the shortening of project duration if the contractors are engaged in the details of the design of the project early in the process. For highway contracting, the design-build method begins with the owner defining the end result parameters, design criteria, and specifications. The contractors qualified to bid on the project are then allowed to submit proposals to accomplish the defined project in such a way as to optimize the technical skills, construction assets, and scheduling acumen of the bidder. This process allows for creative thinking by the contractors and encourages innovation. In addition, since the design and construction are considered as one procurement contract, project duration can be compressed because the contractor can begin work on initial elements of the project before all detailed design work has been completed. Clearly, the contractor has more responsibility under this delivery system, and therefore state agencies must insure that only qualified contractors with the financial resources, technical capabilities, and insurance and bonding capacity needed to complete the defined project scope are invited to submit proposals.

When the contracting methodology differs from the traditional design-bid-build, it is important to note that the responsibilities of the project stakeholders are also modified. Design-build projects are attractive because they are likely to save project duration time because contractors have more responsibility for design and quality control. One limitation is that owners must have the resources necessary to manage a project with more concurrent ongoing activities and maintain quality assurance testing programs. Researchers evaluating the design-build approach for use by the Texas Department of Transportation advised that design-build contracting makes sense when project speed is desired to benefit the public and design innovations are desired by the engineering team (Molenaar, *et al.*, 2007).

In a recent report by researchers at Iowa State University, the advantages and disadvantages of design-build contracting were presented as follows (Strong, 2006):

Advantages:

- *Does not require 100% design prior to award*
- *Allows for some construction work to be performed before final design approval*
- *Allows for innovative scheduling, construction techniques, and materials*
- *Creates single entity contractual responsibility*
- *Reduces errors, omissions, and rework claims*
- *Saves on time and third party Road Utilization Charge costs*
- *Allows for more costs to be included in capital project budgets*
- *Improves utility coordination by allowing the contractor to schedule activities directly with utilities*
- *Allows early commitment by design-builder to overall project cost*

Disadvantages:

- *Demands time sensitivity regarding permit approvals and ROW acquisition*
- *Results in higher procurement costs*
- *Increases potential for reduction of the number of bidders willing to submit proposals due to the possibility of high upfront costs for bidders*
- *Creates possible confusion about the process between the owner and design-builder due to lack of familiarity with the process*
- *Requires greater time demands for calculating risk allocation*
- *Causes owner to transfer design and some other project functions (e.g. Quality Control inspections) depending on how the contract is structured*
- *Makes the practice of “bridging” by owner problematic in an attempt to retain control*
- *Creates a system where design reviews need to be based on contract requirements rather than personal preferences*

A+B Contracting (Cost-Plus-Time Bidding) The A + B contracting method includes two components in contractors’ bids for evaluation by the owner. The “A” component is the dollar amount the contractor bids to complete the work identified by the owner in the bid package. The “B” component is the total number of calendar days the contractor requires to complete the work at the proposed price. The owner then evaluates the bids based on the combination of the cost and time to complete. For a rational comparison, the owner must establish a value day Road User Cost (RUC) such that the value of a contract proposal takes the form: $(A) + (B \times \text{RUC}/\text{day}) = \text{Bid Value}$ (FHWA, 2006). This contracting method may also contain a liquidated damages provision and/or “Incentive and Disincentive (I/D)” clauses. Liquidated damages are independent of I/D amounts and must be based on the estimated cost per day to the owner, at the time of contracting, should the contractor not complete the project by the time specified in the bid (i.e., the B component of the bid). I/D incentives are a cash bonus for completing the project in less days than B and a cash penalty (in addition to liquidated damages, if any, for every day the project is completed excess of B days. All I/D clauses and liquidated damage clauses must

contain provisions for owner-forced schedule changes, project scope changes and any other probable causes for project duration delays not included in the basic project scope definition.

The A+B contracting method with I/D clauses is an appropriate vehicle for accelerating project duration completion when time is of the essence and the cost to accelerate the project can be clearly justified. A brief discussion of daily road use valuation is presented in a later section of the report. The Iowa State University previously referenced summarized advantages and disadvantages of this method (Strong, 2006):

Advantages:

- *Shifts more risk to contractor in terms of bidding optimum combinations of time, costs, efficient planning, and managing work.*
- *Utilizes contractor's expertise*
- *Contractors will propose both aggressive schedules and competitive costs.*
- *Discourages contractors to use unbalanced bids*
- *Encourages scheduling innovation*
- *Reduces construction time and user costs/delays*
- *Greater coordination between prime bidders and their subcontractors prior to bid*

Disadvantages:

- *Requires 100% design prior to award*
- *Risks potential claims by the contractor for contract changes*
- *Risks limiting the incentive payments to the contractor due to overtime costs and increased administrative costs*
- *Needs minimum Road Utilization Charge to be effective*
- *Owner needs to resolve potential issues that could cause delays after construction start*
- *May cause staffing concerns by local district personnel*

Lane Rental Contracting This method has similarities to the A + B contracting methodology in that it is based on the user costs associated with the highway structure undergoing repair or replacement. Under this method, the contractor pays a fee for the time traffic service is obstructed or restricted in order for the contractor to perform contracted work. The fee typically is based on the number of lanes impacted and can be a daily rate or even an hourly rate in instances where rush hour traffic flow is of particular importance. When this method is used neither the state agency nor the contractor will indicate how many days or hours the lanes will be impacted. Bids are evaluated based on the price bid to complete the construction. If properly priced, the contractor has the incentive to minimize the lane rental fees and therefore should seek a construction scheduling solution that has the least amount of lane disruption to complete the contracted work. However, this incentive mechanism does not necessarily lead to a compressed overall construction schedule in terms of days from beginning to end. Advantages and disadvantages according to the Iowa State researchers are:

Advantages:

- *Utilizes contractor's expertise*
- *Allows innovation in the scheduling of activities*
- *Considers costs associated with lane closures*
- *Reduces detours and delays for traveling public*

Disadvantages:

- *Requires 100% design prior to bid*
- *Requires individual Road Utilization Charges calculated for each project, along with a determination of reasonableness*
- *Requires definition of essential project expectations from agency*
- *Lacks flexibility in maintenance of traffic plans (no alternate routes or traffic bypass methods can be considered)*

Guidelines for Determining and Implementing RUC, I/D, and Liquidated Damages

Use of alternative contracting methods typically requires the determination of the daily *road use cost* (RUC) associated with the outage. The daily cost of the outage is necessary information when distinguishing between projects that should be handled with the traditional design-bid-build approach and those where an alternative method is cost justifiable. If some form of A+B contracting is employed, the RUC is an important element in determining contractor bid values. In addition, in contracting methods where I/D clauses are included in the contract, there must be a rational method for determining what the incentive and disincentive daily amounts should be.

A comprehensive determination as to what the true overall cost impact of a transportation facility outage to all affected individuals and businesses could become extremely complex and must be determined on a case-by-case basis. The FHWA recognized the complexity and in 1989 published guidance for employing I/D provisions in contracts (FHWA, 1989). The guidance specifies that the daily I/D amount “is calculated on a project-by-project basis using established construction engineering inspection costs, state related traffic control and maintenance costs, detour costs, and road user costs.” It is particularly important to note that the guidance specifically states that cost impacts on adjacent businesses **should not** be included in the I/D calculation. In addition, it is the responsibility of each state highway transportation agency to establish a methodology for determining the RUC calculation methodology (FHWA, 1989).

Determining the Road User Cost (RUC)

As mentioned in the previous section, determination of the RUC is a necessary step in the process of determining if the repair/replacement of a damaged component of the transportation infrastructure requires an alternative contracting approach with incentives in order to restore traffic flow to normal as soon as possible. The FHWA (2006) recommends several references for states to use as guidance in estimating RUC such as:

- FHWA, FHWA-RD-97-087, Attachment C-1: Guide for Calculation of Road User Costs, *Contract Management Techniques for Improving Construction Quality*, July 1997; and
- AASHTO, “A Manual of User Benefit Analysis for Highways”, AASHTO, (Washington D.C., 2003)

Computer programs have been developed for computing the RUC, and the FHWA has initiated an effort in cooperation with Mitretek Systems to estimate the construction zone costs and other impact measures with software called *Quickzone Software* (FHWA, 2006). The Quickzone Software is part of the FHWA initiative known as the “Strategic Work Zone Analysis Tools” (SWAT) program which is an effort to provide state transportation agencies with tools to help mitigate construction zone delays and costs (FHWA, 2007). The RUC is driven by the daily traffic impact, and can be quite sensitive to peak period congestion caused by the construction work.

Determination of I/D Amounts and Time

When alternative contracting methods are employed to expedite construction time, important components of the contract from the standpoint of contractor interest and results are the I/D provisions of the contract. Initial guidance from the FHWA (1989) to state transportation agencies was published in 1989 and still applies today.

More than one form of contracting could include I/D provisions in the contract. For example, the state transportation agency could establish a base construction time for contractors to bid on with I/D provisions to encourage contractors to complete the construction faster than the target contract completion time. Contractors would bid on the project based on the established time set by the state transportation agency. In the case where A+B+I/D contracting is employed, the contractor actually bids the base cost and the base completion time. A recent research project conducted on behalf of the Oregon Department of Transportation, “Establishing Guidelines for Incentive/Disincentive Contract at ODOT”, provides an excellent detailed literature review and experiential background pertaining to I/D provisions. In addition, the research proposes a methodology for calculating upper and lower bounds on the contractor acceleration costs. The scope of this research project is to summarize available alternatives and thus interested readers are encouraged to review this work for a more detailed report on I/D contracting methods (Sillars, 2007).

There is an appeal for the impact of incentives and disincentives to be equally balanced, but in practice there may be reasons to restrict one or both. FHWA provides general guidelines for employing I/D provisions in contracts, and the guidance is clear that I/D provisions are only suitable for a small number of highway construction projects (FHWA, 2006). Highlights of the general FHWA guidance for state transportation administrators are provided in the following paragraphs.

- I/D provisions are intended to motivate contractors to complete construction work faster than the time required to complete the same project under normal construction conditions, equipment, and labor availability. There must also be a balancing penalty or

disincentive should the contractor take longer than the estimated normal construction time. The use of I/D provisions then requires three components: the normal time, the incentive amount, and finally, the disincentive amount.

- Projects suitable for the use of I/D provisions must have a sufficiently high RUC value to justify the potential increase in construction costs and added administration resources required for the project. This situation will only occur if the project is a critical component of the highway infrastructure seriously affecting the flow of goods and services, the workforce, and the larger public traffic volume. The inconvenience ultimately translates to lost time in the form of congestion, slow moving traffic, lengthy detours, etc. In addition, the driving benefit of I/D contracting, reduction in time to construct, is only going to be optimally realized if the decision to use I/D is made early in the project planning and construction process.
- I/D contracting demands extra effort to insure design drawings and specifications are updated and accurate. Design changes and omissions can be very costly in any contract delivery system, but particularly in an A+B +I/D project. Poor preparatory planning and/or engineering can result in disagreements and even litigation, all potentially diminishing the original objective, complete the construction as early as possible at a reasonable cost.
- I/D amounts should be calculated on a project-by-project basis in accordance with the established state transportation agency methodology. Incentives and disincentives must be based on traffic control, maintenance, and detour costs as well as road user costs. According to FHWA, some states use a cap on the incentive payment of 5% of the total contract based on the FHWA 1989 Technical Advisory guidance (FHWA, 2006).
- The base project completion time established for the contract is situation specific and will require engineering judgment. The purpose and benefit of A+B+I/D contracting is largely compromised if a rational and reasonable methodology for establishing the base project time is not in place. A good practice is to use calendar time for the milestones taking into account the time of year and important geographic factors influencing the project. Close coordination between the state transportation agency, design engineers, and the contractor is crucial to the success of the project. Detailed critical path method networks and schedules should be included in the documentation of the construction agreement. Generic guidance for establishing a rational approach for determining project time is provided in the *FHWA Guide for Construction Contract Time Determination Procedures* (FHWA, 2002). The typical elements used to determine project completion time are: (1) establishing production rates, (2) adopting production rates for the specific project, (3) understanding externalities such as business closures, environmental constraints, etc. and (4) computation of the contract time based on critical path method scheduling techniques.

Liquidated Damages

Liquidated damages must be clearly distinguished from cost I/D provisions in a contract. The requirement for liquidated damage provisions in federally funded highway construction contracts is found in 23 CFR 635.127. Some of the provisions contained in this section of the code are:

- Liquidated damages are specifically in place to reimburse the state transportation agency for actual incurred construction engineering and/or other costs associated with the failure of the contractor to complete the project by the time specified in the contract.
- Each state is required to develop and maintain liquidated damages rates and update them every two years.
- If the project does not have an I/D provision in the contract, the state transportation agency may include additional amounts “to cover other anticipated costs of the project related delays or inconveniences to the State Highway Agency or the public. Costs resulting from winter shutdowns, retaining detours for an extended time, additional damage, or similar costs as well as road user delays costs may be included.”
- If I/D clauses are included, the liquidated damages provision is specifically included to cover the estimated average daily construction engineering costs directly related to the delay.

Additional Ways to Reduce the Construction Process Time

When a disaster occurs, the responsible parties must move quickly to restore operations of critical transportation infrastructure. Careful planning and training ahead of time is crucial when disasters occur, because time is precious during emergencies. It is therefore logical to prepare as much as possible within the protocols and guidelines of the emergency response process. As described above, substantial flexibility does exist for accelerated contracting methods to reduce the construction time in instances where a premium for reconstruction makes sense. There are other important practices that will enhance the process when emergencies occur.

Prequalification of Contractors and Architects/Engineers

When recovering from a disaster, certainly the desired result of the construction contract will be a project completed as rapidly as possible, at a fair price to the contracting agency, and in full compliance with the design drawings and specifications. Major repair or replacement construction will require engineering and contractor services except for those rare cases when the work is accomplished using force account. In cases where the standard competitive bidding process is waived because of the urgent nature of the emergency, the state transportation agency will likely seek bids for the work from contractors known to be qualified to do the work. The process might be confidently expedited if the agency has a prequalified list of engineers and contractors to contact. While prequalification of engineering firms and contractors cannot guarantee future performance and has pros and cons, a well-conceived and managed process might improve the likelihood of an optimal outcome. As a minimum the process can be a useful supplement to bonding requirements and a worthwhile tool in the preparedness planning process.

The scope of this research work did not include a detailed investigation into prequalification policies and procedures. However, a literature search was performed to gain background information as to current practices and previous research on the topic. Of particular interest in the research was to determine current practices for prequalification of contractors with emphasis on contractor capabilities and the contractors' historical records as to timeliness of project completion and quality of work. An excellent background review on the topic was completed in 2001 by researchers at Pennsylvania State University (Minchin, Jr. and Smith, 2001). The report summarizes the approaches taken by various states and concludes that prequalification of contractors is not defined consistently and that the views as to how the process should be utilized and the process for prequalification differ from state to state. It cautioned against using "quality of previous work" as a prequalification element because the criteria of quality is hard to define and is consequently objective in nature. A similar conclusion about using "quality of work" in prequalification of contractors was reported by the Wisconsin Department of Transportation (CTC & Associates, 2002). The report concluded that "before embarking on a mission to improve quality by pre-qualifying contractors for quality, a DOT must be sure its processes provide specifications and drawings commensurate with the quality of output desired." This advice addresses the importance of clearly defining what quality means.

While the use of quality of work as a category in prequalification of contractors can be vague and subjective, AASHTO suggests that certain elements are generally accepted information categories for use in a prequalification application form (FHWA, 2006). The list includes:

- Detailed financial statements
- Resident agent
- Capacity and control classification
- Experience and performance
- Ownership or control
- Equipment
- Updated information if there is a corporate or affiliate ownership change or reduction of 10% or more of the firm's assets

Guidance for the selection of architects and engineers for highway construction projects is found in Title 40 U.S.C., *Public Buildings, Property and Works*, Chapter 11, Sections 1101 – 1104 and is based on the "Brooks Act" passed in October of 1972. State transportation agencies are to insure that properly licensed architects and engineers are employed in the design and specifications preparation process. The state transportation agency should annually request submissions of qualifications and performance data from interested architects and engineers. For each project, the transportation agency will ideally select at least three qualified firms to bid on the project. After reviewing the bids, the agency will order the firm bids based on the specifications established for the work and selected the highest rated bid. The agency will then attempt to negotiate a just and reasonable contract with the selected firm. If this process is coupled with annual communications between the state agency and interested architects and engineers, including the submission of qualifications by the architects and engineers, the mechanism should be adequate to handle the emergency situation, provided the list of available professionals are available when emergencies occur.

Acceleration of Approvals

During the normal construction process, time is required to process all necessary approvals throughout the planning and implementation phases of the construction process. During times of emergency, an accelerated administrative approval process makes sense in those situations where the safety, health and well-being of the citizens and the economic health of the impacted area are measurably dependent on rapid recovery action. Within the guidelines for approval under emergency conditions, local, state and federal officials should work closely to minimize administrative approval delays. This can be accomplished if the protocols are established and practiced in advance.

Maintenance of Design Drawings and Specifications

When transportation infrastructure is damaged or destroyed during a disaster, the impacted facilities will likely be repaired or replaced. As discussed early in the report, emergency repairs and/or replacement return the facility to the pre-disaster condition unless the damaged facility does not meet current standards. In this case, the replacement will be to current design standards, and emergency funds may be applied provided the facility was not scheduled for replacement under another funding program. It is important for transportation agencies to maintain clear and current standard specifications as a general practice, but particularly when they are needed for emergency repair/replacement design and construction of a critical transportation infrastructure components.

States should insure that the transportation infrastructure is periodically reviewed and the critical infrastructure components identified and prioritized. The current as-built drawings, information pertaining to the rights of way, and any special considerations that might impact construction activities should be maintained and readily accessible. In addition, important design specifications and supplemental drawings should be developed in advance where deemed appropriate. The positioning of these key documents should also be carefully considered. It may be prudent to establish backup document storage at alternate locations in case the primary location is destroyed during the emergency.

Project Management

The construction, maintenance and repair of federally funded highways are a shared responsibility of the FHWA, the state departments of transportation and in some cases local governments. The process can be challenging in instances of large-scale disasters, such as Hurricane Katrina, when local officials may be injured or severely impacted in some way by the nature of the damage.

Responsibilities

In order for state transportation agencies to utilize federal funding, Title 23 U.S.C. 302 states that “Any state desiring to avail itself of the provisions of this title shall have a State transportation

agency which shall have adequate powers, and be suitably equipped and organized to discharge to the satisfaction of the Secretary the duties required by this title.” The requirement places a large burden on state transportation agencies to insure that they have adequate management and engineering staff, equipment, and ancillary systems necessary to overview the construction and maintenance work associated with the roads and highway facilities under their jurisdiction. This suggests that the necessary planning and training must be accomplished so that adequate resources can be expected to be available even in times of large scale natural disasters, accidents or terrorist attacks.

The responsibilities of the state transportation agencies are more fully explained in the CFR. According to 23 CFR 635.105(a), the state transportation agency has responsibility for the construction project to insure adequate supervision and inspections are conducted so that the construction project is completed in accordance with the design drawings and specifications. Section 635 (b) permits the use of a consultant to perform field work, but the state transportation agency must still have a full-time engineer responsible for the project albeit this engineer may be responsible for multiple projects concurrently.

During times of emergency, the availability of consultants may be severely constrained, particularly if the nature of the disaster adversely impacts the buildings and homes in the region. In fact, the same circumstances adversely impacting the availability of consultants, engineers and even contractors (equipment, labor, supervision, etc.) may also be impacting the ability of the state transportation agency employees to perform their roles.

In the end, the state transportation agency retains responsibility for managing the process. If the resources of the state are overwhelmed, technical assistance can be requested from the FHWA Division Office. Clearly, a comprehensive preparedness plan for disaster management must include the possibility of a substantial loss of state and local work employees in the immediate aftermath of a major disaster.

Quality Assurance

In construction projects the burden of insuring quality specifications are met falls to both the contractor and the transportation agency owner. When emergency contracting methodology is employed and time is of the essence, more pressure falls on the contractor to insure quality standards and design specifications are met. However, the state transportation agency is responsible for construction inspections and general project oversight.

Documentation of Administrative Expenses

As part of the responsibility for managing the reconstruction project, the state transportation agency is responsible to insure that all documentation and supporting information required by FHWA for federal funding reimbursement is properly and timely collected.

Checks and Balances

Checks and balances are built into the process in a variety of ways. From the beginning of the emergency action, the FHWA Division Office is involved in the process to assist the state transportation agency, but also insure that proper protocols are followed so that the project is managed correctly in order to be eligible for emergency relief funding under the ER program. At the construction level, the state transportation agency is responsible for providing project management oversight to assure contractor compliance with the project drawings, specifications and contract conditions. In addition to the daily project management oversight provided by the responsible state transportation agency, multiple reports are required for internal review and submission to FHWA as administrative backup support for requests for payment.

Project Management Excellence: Impact on Project Duration

Timely completion of a project requires the efforts of all of the stakeholders in the project to be well-coordinated. The process must establish a cooperative teamwork environment where communications and central focus are crucial. For this to occur, a well-conceived process management plan should be developed, implemented, and tested through individual training and group exercises.

Methodology for Studying the Emergency Reconstruction Process in Alabama

The approach to analyzing the emergency reconstruction process in Alabama involved the following steps:

- Establish a description as to how the ALDOT organization is organized to respond transportation infrastructure emergency reconstruction projects.
- Study actual emergency reconstruction case studies of recent emergency reconstruction projects in Alabama and neighboring states.
- Summarize the lessons learned and potential best practices from the case studies.
- Formulate recommendations for consideration by ALDOT.

Section 4.0

The ALDOT Emergency Reconstruction Process

Overview

There are many possible natural and terrorist hazards that could adversely impact the physical transportation infrastructure and the personnel resources of ALDOT. The focus of this research was the investigation and analysis of the emergency reconstruction process in place today to respond to any of the possible hazards capable of destroying or disabling critical transportation infrastructure in Alabama.

Large natural or terrorist-sourced disasters are likely to trigger the provisions of the Alabama Emergency Response Plan (AERP). In that event, ALDOT responsibilities include the designated responsibilities in the AERP in addition to the responsibilities established by the Alabama Constitution, State Statutes and ALDOT established policies and procedures. On the other hand, localized accidents or incidents resulting in the destruction or serious disabling of key transportation infrastructure may be such that local government and ALDOT are teamed to manage the incident because the scope and geographic extent of the damage does not necessitate the implementation of the AERP. In either case, ALDOT will play a central role in the reconstruction or repair of damaged critical transportation infrastructure.

This section provides a brief description of the key organizational components of ALDOT involved with expedited emergency reconstruction. The purpose is to identify the participants and processes involved in expedited transportation infrastructure reconstruction based on the current operating procedures and guidelines of ALDOT. While the nature of the disaster will likely dictate some modifications to the generalized description, it is believed that the basic responsibilities and processes below will generally exist regardless of the source of the damage.

The Alabama Department of Transportation consists of a central office in Montgomery and Division Offices geographically positioned throughout the state. The Division Offices have District Offices under their supervision. The following sections briefly describe organization responsibilities considered critical to the emergency repair and reconstruction process.

Central Office and Division Offices

The headquarters of ALDOT is located in Montgomery, Alabama. The Transportation Director is appointed by the Governor and has overall executive responsibility for all activities of ALDOT. The Director is located at the central office headquarters, together with an Assistant Transportation Director, Executive Assistant Transportation Director, Chief Engineer and 22

supporting Bureaus. The Chief Engineer is supported by four Assistant Chief Engineers (Administrative Pre-Construction, Policy and Planning (Arkle), and Operations. With the exception of the public relations bureau responsibilities, the majority of activities associated with the emergency response and recovery, and reconstruction of critical transportation infrastructure falls under the purview of the Chief Engineer. The Chief Engineer manages resources in the Central Office, and through the Assistant Chief Engineer of Operations, provides oversight to the nine Division Offices. An ALDOT organization chart is shown in Figure 4.1.

District Offices and Project Offices

Each Division has multiple District Offices. The District Offices have District Managers who supervise the maintenance and construction activities. Project Engineers will either report to the District or Division, depending on the situation. The Project Engineer and assistants make up the Project Office and are the representatives of ALDOT to the contractors, material suppliers, and the public.

Standard Guidelines for Non-Emergency Projects

ALDOT has well established standard procedures and specifications for highway construction projects completed in the non-emergency environment. Standard specifications and construction guidelines have been published by the Design and Construction Bureaus, and the general processes for the bidding, administration and management of highway roadway and bridges construction are described in detail. It is important to understand the standard procedures in order to contrast the differences in procedures demanded by high impact emergencies.

Response Procedures for High-Impact Design/Construction Emergencies

During the course of the research it was determined that ALDOT does not have a formal written emergency plan which details the responsibilities and coordination protocols to be followed in the event an emergency event requiring substantial restoration or reconstruction of highway infrastructure. However, after multiple interviews with personnel from different Bureaus in ALDOT, there is a process that is well understood within the management team, and some offices do have written outline guidelines for action.

As would be expected, ultimately the response required after an incident depends on the circumstances. Typically when an incident occurs, the Maintenance Bureau and representatives from the appropriate division office will investigate the scene and make an assessment. Once the site of the emergency is stabilized and traffic safety considerations initiated, clean up and detours must commence immediately if traffic flow is to be restored to the maximum achievable level. The Public Affairs Bureau will provide information to the public as soon as it is available. When emergency disaster relief funding from the FHWA is requested, the Office Engineer Bureau provides the coordination and administration services for ALDOT. If a bridge is involved, the

Bridge Bureau and Design Bureau will be work with engineering and design consultants and the FHWA in formulating the plan for repair/replacement activities. Early in the process the decision will be made as to whether expedited construction contracting is required. Management of the emergency repairs and construction will be handled by the appropriate Division and District Offices.

Examples of Expedited Construction

The approach to understanding the process in Alabama and neighboring states was to investigate the details of the most recent major infrastructure incidents that have occurred over the last five years. Three accidents involving bridges in Alabama, one bridge reconstruction in Florida and one bridge reconstruction in Louisiana were selected for study. The detailed case studies are included in Appendix A. In each case study the incident is explained and the recovery process outlined. The information gained from the case studies was the foundation for the discussion and recommendations included later in the report.

ALABAMA DEPARTMENT OF TRANSPORTATION ORGANIZATIONAL CHART

March 1, 2008

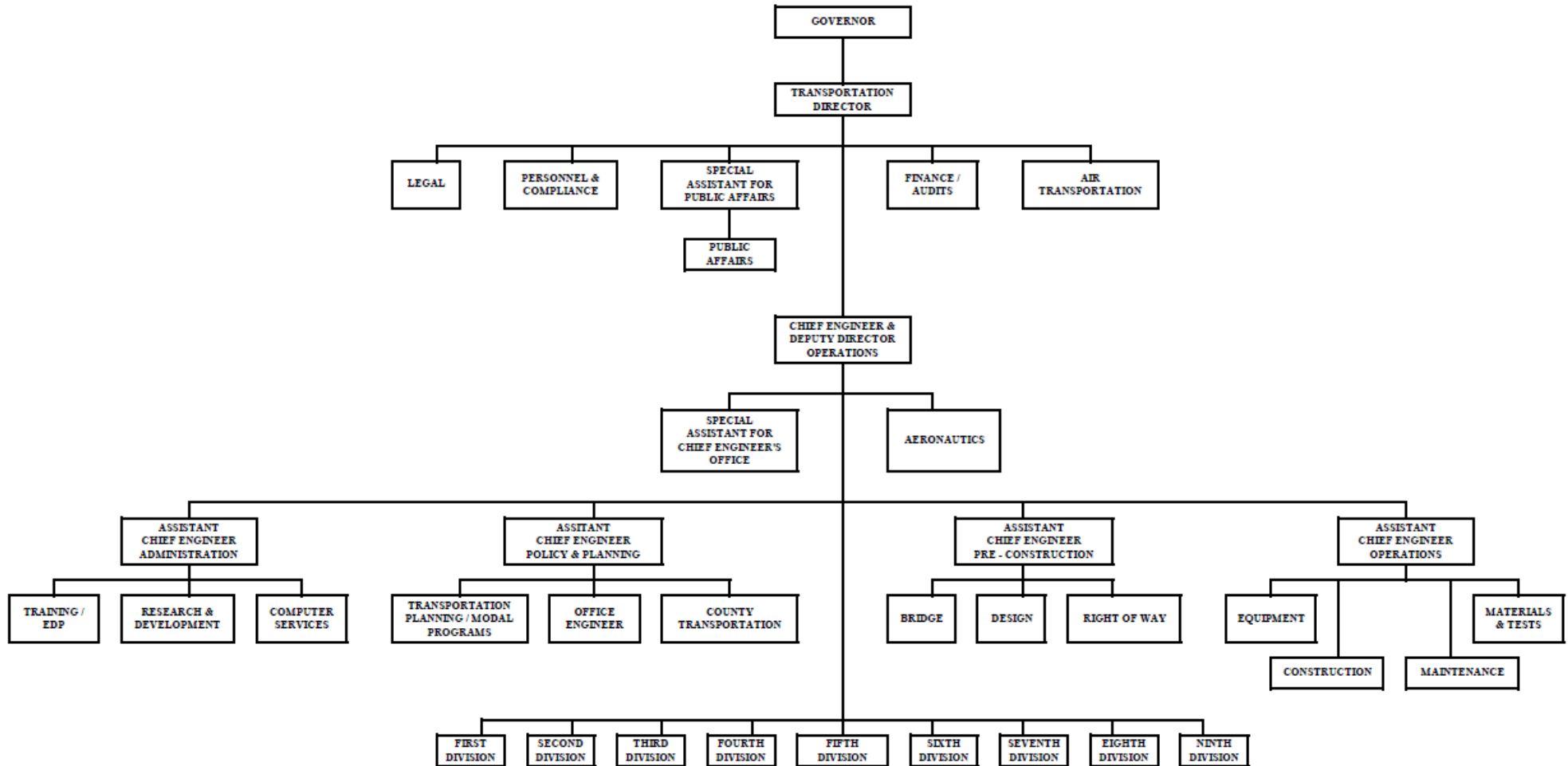


Figure 4-1. ALDOT organization chart
(Source: ALDOT)

Section 5.0 Observations and Discussion

Approach to Case Study Analysis

When the research plan was formulated for this project, the events of Hurricane Katrina were ongoing, and the two bridge replacement projects in Birmingham were recent history. The approach taken was to contact individuals from ALDOT, the Alabama Emergency Management Agency, neighboring state departments of transportation along with construction companies who participated in the construction efforts. In addition, news articles and other information found in the literature were reviewed. Early in the process, researchers determined that it would be important to understand the differences within the state of Alabama between recovery operations involving federal highway infrastructure utilizing FHWA emergency funding and virtually all other major catastrophe recovery operations which qualify for funding from FEMA under the Stafford Act. It was necessary to coordinate with the Alabama Emergency Management Agency (AEMA) and ALDOT.

Applicability of the Alabama Emergency Operations Plan and the Alabama State Hazard Mitigation Plan to Major Federal Highway Reconstruction

The federal *National Incident Management System (NIMS)* (March 2004) established the national template for *what is to be done* in order to manage major disasters at all jurisdictional levels. The *National Response Framework* (published January 2008) replaced the *National Response Plan (NRP)* and explains *how* the nation conducts all-hazard incident responses. Each state is required to publish an emergency operating plan with more detailed protocols and mechanics explaining how the *NIMS* would be implemented within the state. In addition, each state is required to file a hazard mitigation plan for FEMA approval. The *Alabama Emergency Operations Plan (AEOP)* was published in April 2006, (Alabama Emergency Management Agency, 2006). The *AEOP* uses the framework of both the *NIMS* and *Framework* to formulate mechanisms for accomplishing the following goals:

- Maximize the integration of incident-related prevention, preparedness, response, and recovery activities.
- Improve coordination and integration of state, county, local, tribal, private-sector, and nongovernmental organization partners.
- Maximize efficient utilization of resources needed for effective incident management.
- Improve communications and increase situational awareness.
- Facilitate mutual aid and state support to county, local, and tribal governments.
- Facilitate state-to-state support.

- Provide proactive and integrated state response to catastrophic events.
- Determine priorities and coordinate protection, response, and recovery of critical infrastructure.

The *AEOP* has a small section dedicated to transportation emergency reconstruction. There is not sufficient detail to clearly define the process of transportation reconstruction when emergency federal funding would be requested. It is important to note that by far the majority of the miles of roadway and the number of bridges within the state of Alabama fall under the management and funding responsibilities of the counties and municipalities. These facilities do fall under the relief funding provisions of the Stafford Act.

The *Alabama State Hazard Mitigation Plan (ASHMP)* was first published in 2004 and updated in 2007. It was approved by FEMA in October 2007. The plan is in place to clearly establish the process for identifying all hazards within the state through comprehensive vulnerability analyses and to establish appropriate mitigation action plans. The *ASHMP* is applicable for mitigation planning where FEMA emergency funding will be utilized. It is applicable to hazard mitigation planning for roads and bridges not qualifying for federal emergency funding.

This research effort focused on the large-scale state highway infrastructure which qualifies for federal funding, and for the most part the *AEOP* and *ASHMP* do not address the protocols and mechanics for emergency response and hazard mitigation in these instances. The important point is that the *AEOP* and *ASHMP* are published and updated by the Alabama Emergency Management Agency, leaving the responsibility for the planning of emergency response and hazard mitigation for federally funded infrastructure with ALDOT in cooperation with the FHWA.

Observations from Case Studies

A standardized approach was adopted to present the incident description information for the five case studies in order to establish a format for reporting observations, comparisons and recommendations. The basic information categories for each case study include:

- Damage Assessment
- Site Clean Up and Detours
- Design and Scope of Work
- Contracting Method
- Contractor Selection Process
- Funding
- The Construction Process
- Project Oversight
- Keys to Project Completion Success
- Lessons Learned

The details of the five case studies are provided in Appendix A. In summary, researchers compiled the following general observations from the composite group of case studies:

- **Damage Assessment:**
 - Early assessment decisions set the tone for the efficiency of the recovery.
 - The quality and diversity of the assessment team has a major impact on early decisions as to the contractors for debris removal, the urgency of repair/replacement, the necessary design, and the contracting method. These early decisions have an enormous impact on the time and cost of the construction project.
 - Early information communication among responders, engineers, all other impacted stakeholders, including the media, is essential.

- **Site Clean Up and Detours:**
 - Traffic safety, user convenience, and the restoration of economic supply chains depend on timely debris removal and efficient detours.
 - Quick action to inform the public of the congestion status and detours is crucial.

- **Design and Scope of Work:**
 - Early decisions as to using the “as built” design or redesigning the structure determine the minimum recovery time achievable.
 - In the cases of the I-65 replacement bridge construction in Birmingham, the use of prestressed concrete girders in lieu of the original steel girders coupled with the accelerated production of the girders by the manufacturer allowed both projects to be completed in less than 40 days, remarkable accomplishments if compared to traditional construction time schedules for the same type of work.

- **Contracting Methods and Pricing:**
 - Incentive contracting attracts the best equipped and skilled contractors available.
 - In order to determine incentive amounts for the contracts, it was necessary to establish target completion times of completion and a daily incentives/disincentives for each day under or over the target completion time. The current approach to estimating possible compressed construction schedule and a reasonable price for the contractor and tax payer needs to be reviewed.
 - Phased construction arrangements or an acceptable form of design-build allows the earliest start to construction and the best chance for optimal completion time.

- **Contractor Selection Process:**
 - Construction projects with compressed schedules and contract premiums attract the region’s most capable builders.

- Prequalification of contractors was used and is a necessity for quick response and also a quality bidders list.
- It is important to have a fresh list of potential contractors available so that competitive bidding (cost and ideas) are solicited whenever practical to do so.
- Funding:
 - In the three Alabama case studies, the coordination with FHWA representatives was excellent and the projects qualified for funding from the Federal Emergency Relief Fund.
 - The I-10 bridges in Florida and Louisiana were caused by hurricanes and both qualified for relief under the FHWA Federal Emergency Relief Fund. However, because of the costs of the construction and association of the bridge damage within the larger disaster situation, funding for both projects came as a result of special appropriations by Congress.
- The Construction Process:
 - Reduction in administrative approval time can substantially reduce project schedule and improve relationships between project participants.
 - Accelerated construction at a reasonable cost and with a safe project site environment requires coordination and cooperation between all project participants which is contrary to the sometimes acrimonious relationships that exist during typical highway infrastructure projects.
 - Innovative use of construction equipment and materials can reduce construction time significantly.
 - Large disaster projects require FHWA District assistance.
- Project Oversight:
 - FHWA project oversight is needed in large emergency projects which over task the resources of the state.
 - Smooth project completion requires exceptional coordination between the stakeholders in the project. This need requires workers and managers to communicate across communication barriers so that information is passed horizontally and quickly.
- Keys to Project Completion Success:
 - Rapid response
 - Prequalified engineers and contractors
 - Selective bidding
 - Clear and streamlined communications
 - Experienced FHWA and state DOT participants
 - Incentive contracting
 - Innovative use of equipment and materials
 - Cooperative attitude among project stakeholders
 - Streamlined administration
 - Project phasing with design-build delivery system

- Lessons Learned:
 - Understand the keys for success

Discussion

Extraordinarily large disaster scenarios generally result in situations where the local and state resources are overwhelmed by the magnitude of the event as demonstrated during the onset and aftermath of Hurricane Katrina where the scope of the damage went far beyond the infrastructure damage itself to include partial or total decimation of the local work force, equipment and material supplies. In contrast, when the I-35W bridge collapsed in Minneapolis, local resources were not disrupted and were available in total to respond to the incident. The two case studies involving the I-65 bridge replacements in Birmingham were similar to the Minneapolis bridge collapse in that respect.

The observations, keys to project completion success, and lessons learned all point to the importance of established emergency response procedures and speeding response when a disaster occurs. The resources of the state DOTs must be supplemented by FHWA District personnel, contract engineers, and contractors. It is financially impractical to staff state transportation agencies to handle major disasters without supplemental help. It is also true that local engineering consultants and contractors may not be available or capable to respond when a disaster occurs. Therefore, responsible preparation requires preparedness planning if optimal time and cost effective outcomes are to be expected in emergency reconstruction situations. Detailed plans cannot be developed for every possible scenario, but if the key players are involved in preparedness planning and practical exercises involving real possible scenarios, the process conducted ahead of time will be the model for emergency action. Resource sharing plans can be worked out in advance. One important benefit is that the key players have experience working together and do not require a background check and exchange of personal CVs at the time of the emergency.

One way to expand current capabilities would be to establish a regional public/private cooperative organization without political bias. A good form for the organization is a non-profit 501(c). For example, The Emergency Management Assistance Compact (EMAC) is an agreement between all fifty states to share resources during a disaster. The compact is managed by The National Emergency Management Association, a non-partisan, non-profit 501(c)(3) association dedicated to enhancing public safety by improving the nation's ability to prepare for, respond to and recover from all emergencies, disasters, and threats to our nations security. Under the EMAC, the Alabama Emergency Management Agency knows in advance how to request resources and how compensation is requested and reimbursed (the work may be pro bono in some cases).

A non-profit organization could be an excellent framework for advanced planning for regional sharing of resources specifically focused on federally funded highway infrastructure. Each state in the compact would conduct state planning closely coordinated with the FHWA and the state DOT. It would make a great deal of sense for the state Emergency Management Agency to

participate as well. A multi-state cooperative effort particularly makes sense for states with smaller resources and annual budgets.

A comprehensive preparedness planning agenda would include as a minimum the following issues and questions.

Issues

- Traffic Flow and Public Information
- Facility Assessment (of what is most important facility need)
- Temporary Repair Construction Decisions
- Design Flexibility
- Preparation Planning
- Communications Procedures
- FHWA/State DOT Staffing and Cooperation
- Prequalification of Contractors
- Prequalification of Government Emergency Managers
- Resource Sharing (between states, FHWA, and private sector)
- Training Exercises (for uncertain future infrastructure recovery events)

Questions for Planning Scenarios

- What is the potential consequence of this event?
- What must be done?
- What is the status of the workforce?
- Are supplemental resources available?
- What are impediments?
- What are possible alternatives?
- What is the most efficient and cost-effective way to determine contract incentives?
- Specifically how would emergency preparation planning have helped?
- How should practice exercises be conducted and who should participate?

Section 6.0

Conclusions and Recommendations

Conclusions

The case studies revealed some important keys to cost and time efficient emergency highway infrastructure repair and reconstruction and certainly demonstrated the importance of cooperative efforts by all involved participants at all levels in the organization. Smooth operations require leadership, prepared participants, and creative thinking. Proper preparation planning and hands-on training exercises are necessary for quality performance. Without proper planning, poor performance is a likely outcome as indicated by the following summary conclusions:

- Emergency situations will generally bring together diverse experts who may not work together on non emergency highway infrastructure construction projects.
- Consistent optimal response and recovery operations require preparation, planning, and practice involving the parties who will play the major roles in an actual crisis incident.
- Major incidents may adversely impact the availability of local management, engineering, and contracting resources that would normally be expected to be available. Regional joint planning and exercises would help efficiently prepare supplementary support resources.
- Regional formal resource sharing compacts make sense.
- Prequalification of contractors is helpful, but not sufficient, to insure the necessary expertise, equipment and materials will be available when needed most.
- Proper cost estimating and contracting pricing schemes attempting to insure timely recovery at a fair price to the contractor and the public requires training and experience prior to the incident.

Recommendations

In the case studies included in this report ALDOT responded efficiently and the replacement bridges were completed ahead of schedule. Successful operations can serve as a good foundation for improvements in emergency response and recovery operations. With that in mind, the researchers in this project offer the following recommendation practices for consideration:

1. ALDOT Emergency Recovery Plan

- Although ALDOT has demonstrated the ability to handle emergency response and reconstruction situations in recent years, ALDOT could benefit from a written emergency plan that every division and district can follow.
- While all potential future disasters cannot be included in any single plan, the planning process itself is valuable, provided the key management of ALDOT participates and supports the planning process. Ask questions and discover potential weaknesses in practice so that the approach to problem solving is in place when real emergencies occur.

2. Emergency Contracting Incentive Pricing and Contracting:

- State DOTs might be able to estimate more accurately the duration and cost of future emergency projects if they collect data from various states, study the duration and cost of the projects, and evaluate the factors that help the projects to finish early.
- State DOTs should continue to study new contracting methods that help to accelerate the process and at the same time insure that the cost is commensurate with the cost of the outage.
- In addition, state DOTs should find new methods to improve the already established contracting methods such lane rental, A+B, design-build, etc.

3. Future Design Considerations:

- In the coastal areas, bridges should be designed to resist hurricane wave forces, and bridge elevations should be determined based on a hurricane storm surge analyses.

4. Develop Supplemental Resource Capabilities:

ALDOT should consider working with other states in the Southeast (such as Mississippi, Louisiana, Florida, and Georgia) to establish a non-profit 501 (c) organization with the specific purpose of establishing supplemental regional highway disaster recovery resources in advance. The organization would be run by a regional multi-disciplinary board of advisors. One proven approach taken would be with a multi-disciplinary board of advisors. The organization would be a source for expertise and support for those responsible for preparing, responding and recovery from highway infrastructure disasters. As a minimum resource preparedness planning should include:

- Human Resources
- Equipment
- Materials
- Contractors

- Engineers
- Administrators
- Inspectors

5. Emergency preplanning workshops:

- State resource sharing concepts should be discussed in workshops.
- Workshops should involve representatives of all the entities who would play a significant role in recovery operations.

6. Emergency Planning Exercises:

Reasons for training exercises simulating possible disaster scenarios have proven to improve the performance of organizations and individuals during times of crisis. The specifics of the training scenarios are important, but the real benefit is in the interaction experience, identification of shortcomings, and revelation of the potential scope of a disaster. ALDOT is encouraged to organize and participate in exercises to improve preparedness. In summary, emergency exercises can do the following:

- Establish working relationships between key participants.
- Reveal communications deficiencies and limitations.
- Provide an opportunity to question response tactics in a variety of conditions.
- Helps to learn how to access a situation and ask the right questions.

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Section 8.0 References

- AASHTO, *Primer on Contracting for the Twenty-first Century, Fifth Edition 2006, A Report of the Contract Administration Section of the AASHTO Subcommittee on Construction*, Washington, D.C.2006.
- ALDOT, 2004. *Construction Contract for Bridge Replacement Awarded*. Available on-line <http://www.dot.state.al.us/Docs/Bureaus/Public+Affairs/ALDOTPress2.htm>. Accessed April, 2006.
- ALDOT, 2005. *Alabama Department of Transportation for Immediate Release. Mobile*. Available on-line from <http://www.disastercenter.com/Katrina%20Alabama.html>. Accessed November, 2006.
- Allen C., 2005. *DOTD sets Sept. 9 bid submission date for I-10 'twin-span' repairs. September 6, 2005*. Available on-line from <http://www.dotd.state.la.us/press/pressrelease.asp?nRelease=515>. Accessed November 3, 2006.
- Andres, T., Assistant State Structures Design Engineer. Florida Department of Transportation. Telephone interview in May 16, 2007.
- Bid Tabulations, *Letting of 9/09/2005 Headquarters*. Available on-line <http://www.dotd.louisiana.gov/lettings/bidstabs/tabulations/bt05090901.shtml>. Accessed November 3, 2006.
- Brasfield & Gorrie, 2004. *I-65 Emergency Bridge Replacement*. Available on-line <http://www.brasfieldgorrie.com/portfolio/portfolio.aspx?type=20>. Accessed December, 2006.
- Bradfield & Gorrie, 2006. *Cochrane Bridge*. Available on-line from <http://www.brasfieldgorrie.com/portfolio/project-detail.aspx?type=20&subtype=2&id=12>. Accessed December, 2006.
- Brasfield & Gorrie, 2005. *I-59/20 Emergency Bridge Replacement*. 2005PMI Project of the Year Award Submittal.
- Chambliss, J. 2007. Chief Engineer from Brasfield & Gorrie. Email Interview. May 22, 2007.

- CTC & Associates, LLC, *Contractor Prequalification Quality-Based Rating*, Transportation Synthesis Report, WisDOT RD&T Program, October 30, 2002, Available on-line: <http://www.dot.wisconsin.gov/library/research/docs/tsrs/tsrcontractorprequalification.pdf>. Accessed May, 2007.
- D'Andrea, A. 2006. I-10 Twin Span Design Project Manager. Louisiana Department of Transportation and Development. Email interview. September 9, 2006.
- DesRoches, R. 2006. *Hurricane Katrina Performance of Transportation Systems*. ASCE. Technical Council on Lifeline Earthquake Engineering Monograph No. 29. August 2006.
- Dipietre, J., and D. Kane. (October 2004) *Governor Bush Thanks Florida DOT and Contractor for Reopening Hurricane-Damaged I-10 Bridge in 17 days*. Available on-line from <http://www.dot.state.fl.us/publicinformationoffice/moreDOT/spenews/2004/i10l.htm>. Accessed November, 2006.
- Federal Register, 2006. *FTA Fiscal Year 2006 Apportionments and Allocations Changes and Corrections; Announcement of States selected for Participation in Section 5310 Pilot Program; Notice*. Department of Transportation. Volume 71, No. 23. February 2006.
- FHWA, 2006. *Contract Administration Core Curriculum Participant's Manual and Reference Guide 2006, Update*, Office of Infrastructure, Office of Program Administration, Contract Administration Group, Washington, D.C., Available on-line from <http://199.79.179.101/programadmin/contracts/core01.cfm>. Accessed April, 2007.
- FHWA Resource Center 2002, RC Success Stories. *ALDOT'S Interchange Emergency High Traffic Bridge Rebuild in Record Time*. Available on-line from <http://www.fhwa.dot.gov/resorcececenter/success/successstories/volliss10.cfm>. Accessed October, 2006.
- Florida Department of Transportation, DVD. *I-10 Bridge Escambia Bay*. <ftp://ftp.dot.state.fl.us/fdot/co/structures/EscambiaDVD.wmv>. Accessed May, 2007.
- Fossier, P. B. 2007. Assistant State Bridge Design Engineer. Louisiana Department of Transportation. Email interview in July 7, 2007
- Fossier, P. B. 2006. I-10 Twin Bridges in Louisiana. *Bridge Views*, Summer 2006 Issue 44.
- FHWA Briefing – *Special Experimental Projects No. 14 – Innovative Contracting (SEP-14)*, Washington, D.C. February 28, 2002.
- FHWA, *Contract Administration Core Curriculum Participant's manual and Reference Guide 2006, Update*, Office of Infrastructure, Office of Program Administration, Contract Administration Group, (Washington, D.C., 2006) Available on-line: <http://www.fhwa.dot.gov/programadmin/contracts/cacc.pdf> . Accessed April, 2007.

- FHWA, *Emergency Relief Manual (Federal-Aid Highways) Interim Update*, Office of Infrastructure, Office of Program Administration, (Washington, D.C., August 2003). Available on-line: <http://www.fhwa.dot.gov/reports/erm/erm.pdf>. Accessed March, 2007.
- FHWA, *FHWA Guide for Construction Contract Time Determination Procedures*, Technical Advisory T5080.15, October 15, 2002. Available on-line: <http://www.fhwa.dot.gov/legsregs/directives/techadv/t508015.htm> . Accessed April 2007.
- FHWA, *Strategic Workzone Analysis Tools, Turner-Fairbank Highway Research Center*, Available on-line: <http://www.tfhrc.gov/its/swat.htm> . Accessed April, 2007.
- FHWA, *Success Story: Alabama Employs Incentives to Replace Bridge*. Available on-line from: <http://www.fhwa.dot.gov/hfl/successstory.cfm?id=1>. Accessed March, 2007.
- FHWA, *Technical Advisory, Incentive/Disincentive (I/D) for Early Completion, T 5080.10*, U.S. Department of Transportation Federal Highway Administration, Washington, D.C., February 8, 1989. Available on-line: <http://www.fhwa.dot.gov/legsregs/directives/techadv/t508010.htm> . Accessed April, 2007.
- GPO Access, *Code of Federal Regulations*. Available on-line from: <http://www.gpoaccess.gov/cfr/about.htm> . Accessed May, 2007.
- Hitchcock, W., A. Sullivan, and S. Watson. *Transportation CIP Education*. , UTCA Report Number 05231, Prepared for University Transportation Center for Alabama, University of Alabama at Birmingham, April 30, 2007.
- Killingsworth W., and G. Harris. *Transportation Infrastructure in Alabama: Meeting the Needs for Economic Growth*, Office of Economic Development. The University of Alabama at Huntsville, 2005.
- Kirk, R. S., *Repairing and Reconstruction Disaster-Damaged Roads and Bridges: The Role of Federal-Aid Highway Assistance*”, CRS Report for Congress, Order Code RS22268, (Washington, D.C. September 16, 2005).
- Lambert, M. 2005. *DOTD puts I-10 “Twin Span” Bridge on 45-days fast-track schedule. September 9, 2005*. <http://www.dotd.state.la.us/press/pressrelease.asp?nRelease=526>. Accessed November 3, 2006.
- Lambert M. 2006. *DOTD to reopen westbound lanes of I-10 ‘twin-span’ bridge Friday. January 3, 2006*. <http://www.dotd.louisiana.gov/press/pressrelease.asp?nRelease=584>. Accessed November 3, 2006.

- Minchin, Jr., R.E., and G. R. Smith. *Quality-Based Performance Rating of Contractors for Prequalification and Bidding Purposes*, NCHRP Web Document 38 (Project D10-54), Prepared for: National Cooperative Highway Research Program, Transportation Research Board and National Research Council, March 2001, Available on-line: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_w38.pdf . Accessed May, 2007.
- Molenaar, K.R., and G. Yakowenko. *Alternative Project Delivery, Procurement and Contracting Methods for Highways*, ASCE Alexandria, VA, 2007.
- Parsons, 2005. *Project of the Month*. http://www.parsons.com/about/press_rm/potm/04-2005/index.html. Accessed, January 2007.
- Richter, C. 2007. Director of Engineering & Operations, FHWA Florida Division. Email interview in May 31, 2007.
- Sillars, D. N., PhD, PE, “*Establishing Guidelines for Incentive/Disincentive Contracting at ODOT*”, *Final Report SPR 630*. Prepared for Oregon Department of Transportation and Federal Highway Administration (February, 2007).
- Stinson, M. 2007. Mega Projects Engineer. FHWA Louisiana Division. Email interview in July 17, 2007.
- Stinson, M. 2007. Mega Projects Engineer. FHWA Louisiana Division. Email interview in July 26, 2007.
- Strong, K., *Performance Effectiveness of Design-build, Lane Rental, and A + B Contracting Techniques, Final Report 2006-09*, Minnesota Department of Transportation, Center for Transportation Research and Education, Iowa State University, St. Paul Minnesota, March 2006.
- Talbot, J. (2005). *Steel Speed Repair of Hurricane-Damaged Bridge*. Steel Bridge New. Vol.6, No. 2 April 2005.
- Thomas. *The Library of the Congress*. Available on-line from: <http://thomas.loc.gov/cgi-bin/query/D?c109:1:./temp/~c109fhT8Tr:e303222>. Accessed April 3, 2007
- TRB (Transportation Research Board), *Transportation Research Circular* Number 386, Washington, D.C., 1991.
- U.S Department of Transportation (DOT). *Office of Public Affairs*. March 29, 2006. Available on-line from: <http://www.dot.gov/affairs/dot4506.htm>. Accessed February 22, 2007.

Section 9.0

Abbreviations

AEOP	Alabama Emergency Operations Plan
AERP	Alabama Emergency Response Plan
ALDOT	Alabama Department of Transportation
AASHTO	American Association of State Highway Transportation Officials
AEMA	Alabama Emergency Management Agency
ASCE	American Society of Civil Engineers
ASMP	Alabama State hazard Mitigation Plan
Caltrans	California Transportation Agency
CFR	Code of Federal Regulations
DOT	Department of Transportation
ER	Emergency Relief
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FDOT	Florida Department of Transportation
I/D	Incentive/Disincentive
LADOT	Louisiana Department of Transportation
LADOTD	Louisiana Department of Transportation and Development
NRP	National Response Plan
RUC	Road User Cost
SPMT	Self-Propelled Motorized Transports
TRB	Transportation Research Board
UAB	The University of Alabama at Birmingham
USC	United States Code

Appendix A: Case Studies Observations and Lessons Learned

I-65 Bridge Birmingham, Alabama

On January 5, 2002, an explosion took place on the I-65 North in Birmingham, Alabama, when a vehicle crashed into a tanker truck carrying 9,000 gallons of fuel. The heat from the explosion exceeded 2,000 degrees Fahrenheit, causing the steel girders in the overpass to sag approximately 7 to 10 feet. The explosion as well as the fire caused not only severe damages on the bridge carrying I-65 southbound traffic in Birmingham, but also the death of the driver of the tanker truck.

The Alabama Department of Transportation (ALDOT) immediately closed the I-65 northbound and the I-65 southbound bridge. The closure of the I-65 southbound affected approximately 140,000 vehicles per day, and represented an estimated user cost of at least \$ 100,000 a day to the State (FHWA Resource Center, 2002). After three days, the I-65 Northbound bridge was reopened. However, the I-65 Southbound bridge remained close until February 25, 2002 because the bridge was not in any condition to be used by the traveling public. During this outage period, the traffic was detoured temporary to U.S. Highway 78/Arkadelphia Road.

Damage Assessment

As soon as ALDOT bridge engineers and District 1 maintenance personnel heard the news about the accident, they went to the scene to assess the situation, offer immediate help where needed and begin working on the recovery operations. ALDOT bridge engineers evaluated the damages to the bridge and concluded that given the severity of the damages, the bridge was beyond repair. Based on this information from the site, several officials from ALDOT, including the Director of ALDOT, Mr. Paul Bowlin, met to establish the necessary recovery operations actions steps. The meeting participants agreed in the following:

- The bridge should be removed and rebuilt in 90 days.
- In order to expedite the job, ALDOT's Bridge Bureau should be responsible for the new design and should have it ready within six days.
- Once the new design is completed, ALDOT should take bids from prequalified contractors.
- The contract should have an incentive/disincentive clause for early or late completion (FHWA RC, 2002).

Clean Up and Detours

Clean up operations were completed by the ALDOT Maintenance Division crew and the Morris Group. Committed to restoring traffic as soon as possible, many of these people worked 48 hours continuously. ALDOT oversight was provided by Mr. George Conner, State Bridge

Maintenance Engineer and Michael Mahaffey ALDOT's District Engineer, Third Division District 1. Thanks to the diligent work of this group of people, three I-65 Northbound lanes were opened three days after the crash. It should also be mentioned that the Division 3 of ALDOT worked hard to produce an effective detour plan and to keep the public informed about the alternate routes and the construction progress on the bridge.

Design and Scope of Repair

Mr. Tim Colquett and Mr. Fred Conway led ALDOT's Bridge Design team. They worked closely with Mr. Robert King, Bridge Engineer of FHWA Alabama Division, throughout the review and approval of the new design.

The team proposed several alternatives for the new design. The options were as follows:

- Replace Spans 2 and 3 and Bent 3 only using plans from original bridge (Replace in kind).
- Replace entire bridge with a one span bridge with girders perpendicular to roadway (eliminating skew).
- Replace entire three span bridge using AASHTO type IV pre-stressed concrete (PSC) girders (FHWA RC, 2002).

This project demanded that the bridge be back in service as soon as possible. With time being such an important consideration for design and construction, the use of steel girders was not a viable option because of the time required for fabrication and shipping. Therefore, the decision was made to replace the entire three span bridge using prestressed concrete girders.

The new bridge design also incorporated an additional lane. The clear span length was increased from 120 to 140 feet. Consequently, 0.6-inch strands were used instead of the typical 0.5-inch strands.

Contracting Method

The contracting method used by ALDOT was a standard unit price contract with early completion incentives and late completion disincentives (Chambliss, 2007).

Contractor Selection

ALDOT completed the new bridge design and solicited bids from a selected group of contractors including the Morris Group, Alabama Bridge, Dawson Bridge, Mcinnis, and Scott Bridge (Chambliss, 2007). These contractors were selected based on experience in Alabama, prequalification, and expertise. ALDOT engineers analyzed the bids and awarded the contract to the Brasfield & Gorrie/Morris Group joint venture; it was the lowest bid. Their bid was \$ 2,096,421.20 and next closest bid was \$3,780,654.15 (FHWA RC, 2002). The Brasfield & Gorrie/Morris Group joint venture faced the challenge to complete the construction of the new bridge within 90 days. In addition, the contract had an incentive of \$25,000 for every day the

project was completed early than the 90-day deadline established by ALDOT, and a \$25,000 penalty for every day past the deadline. The contract also specified that the interstate could be closed only for one period of 24 hours. The Brasfield & Gorrie/Morris Group joint venture agreed on these clauses and signed the contract, and work began on January 21, 2002.

Funding

The funds used to repair I-65 came from the FHWA Emergency Relief program. This program reimburses to the states the funds for costs related to road damages associated with natural disasters and emergency conditions.

Mr. Joe Wilkerson, Alabama's Division Administrator of FHWA acted as a liaison between ALDOT and FHWA; he was there to provide support, expertise and Federal Aid through the ER Program (FHWA RC, 2002).

Construction Process

The Brasfield & Gorrie/Morris Group joint venture began the I-65 project with a team of 50 members charged with the task of finishing this project in 90 days. To meet the deadline, the work was accomplished using two 12-hour shifts, with each shift working between 75 to 80 hours per week. To accelerate the project further, the team worked in different sections of the project at the same time. While the urgency to complete the project was clear to all concerned, the project team and ALDOT's personnel always kept in mind that safety and quality was the priority of the project. Consequently, ALDOT's engineers and FHWA personnel conducted inspections and quality control during the daytime and nighttime.

As mentioned, the contractor as well as ALDOT used some accelerated techniques and administrative processes to speed up the construction of the bridge. The construction sequence is summarized as follows:

- Clean up and mobilization of materials and equipment (Figures A-1 and A-2)
- Installation of 7,800 linear feet of steel H-piling foundation (FHWA RC, 2002)
- Use of prefabricated concrete culvert sections as forms to construct each of the pier footings (FHWA RC, 2002)
- Construction of the reinforced concrete caps/columns as shown in Figure A-3
- Place the girders on the 140-foot main span and the 75-foot approaches. The contractor utilized modified AASHTO-PCI BT-54 girders (14-day strength of 8,000 psi.). To set the 15 girders on the 140-foot span overhead, the traffic was stopped for only 12 hours (FHWA RC, 2002). Figure A-4 shows concrete girders in place and construction of the reinforced concrete deck in process.
- Construction of the 6-foot high crash wall
- Construction of the reinforced concrete bridge deck as can be seen in Figure A-5
- Paint lines on the bridge deck and entry ramps
- Open to traffic as seen in Figure A-6



**Figure A-1. Beginning the I-65 bridge replacement
(Courtesy of Brasfield & Gorrie)**



**Figure A-2. First week of construction: materials and equipment
(Courtesy of Brasfield & Gorrie)**



Figure A-3. Second week of construction: concrete caps and columns
(Courtesy of Brasfield & Gorrie)



Figure A-4. Third week of construction: concrete girders and reinforced concrete deck
(Courtesy of Brasfield & Gorrie)



**Figure A-5. Fourth week of construction: concrete deck reinforcement
(Courtesy of Brasfield & Gorrie)**



**Figure A-6. Fifth week of construction: I-65 bridge complete
(Courtesy of Brasfield & Gorrie)**

Project Oversight

A project of this magnitude and importance involves many key people pooling their support, expertise, and supervision. Key contributors to this project included:

- Daniel Graves, Project Engineer, Third Division – District 1. He was ALDOT’s onsite project coordinator, on the construction site every day.
- David Hand, ALDOT’s Assistant Division Construction Engineer, served as the on-call supervisor.
- Chris Brown was the Contractor’s Project Superintendent.
- Juan Carlos Ospina, Project Manager for Brasfield & Gorrie
- Duncan Morris, Project Manager for the Morris Group

Keys to the Project Completion Success

The I-65 Bridge was complete in 37 days, a remarkable effort considering that a project of this scope could take nine months under standard conditions (Chambliss, 2007). Keys to early project completion without injuries include:

- Commitment of enough labor and equipment resources working around the clock to complete the project as soon as possible
- The decision to use precast and prestressed concrete girders rather than steel girders to accelerate the replacement process
- The early delivery of the girders by Sherman International Cooperation
- The rapid review and approval of documents and decisions by ALDOT’s engineers

The bridge was finished 52 days ahead of schedule and the Brasfield & Gorrie/Morris Group joint venture earned a \$1,300,000 incentives. Even with the incentive pay added in, the total amount of the contract was less than the cost proposed by the lowest bidder (Brasfield & Gorrie, 2004). Table A -1 shows a summary of the project

Table A-1. I-65 Bridge Project Summary

Project Summary	
Location	Interchange I-20/I-59/I-65
Type of repair	Replace Bridge
Design by	ALDOT
Type of Design	Concrete girders AASHTO type IV pre-stressed concrete (PSC) girders
Bidders	Brasfield & Gorrie and Morris group joint venture, Alabama Bridge, Dawson Bridge, Mcinnis, and Scott Bridge
Competitive Bid	Low bid
Type of Contract	Unit Price with incentive/disincentive
Contractor	Brasfield & Gorrie- Morris Group Join Venture
Contract Amount	\$2,096,421.20
Incentive/disincentive per day	\$25,000
Bonus (early completion)	\$1,300,000.00
Contract time	90 days
Completion	37 days
Days ahead of schedule	52 days

Lessons Learned

Although this project was the result of unfortunate accident valuable lessons can be learned from this experience, particularly given the rapid and accident-free reconstruction of the I-65 Bridge. Researchers selected this case study because it is not only relevant to Alabama, but it is also an excellent example for any emergency reconstruction of a major highway intersection bridge. A compact summary of this successful reconstruction effort in a lessons learned format follows:

- ALDOT crews began the clean up right after the incident, and quickly established a detour route. Doing this reduced the traffic congestion and provided clear route instructions for the traveling public.
- ALDOT’s Division 3 established an effective detour plan and kept the public informed about the alternative routes and the construction progress on the bridge. Doing this reduced the uncertainty and helped to mitigate hardships on the public.
- Under State Emergency Declaration, ALDOT solicited bids from a selected group of contractors without public advertisement. This procedure saved time in the award and contracting process.
- The ALDOT team designed the new bridge quickly (six days). This allowed timely solicitation of bid packages and award of contracts in a short period of time.
- Commitment from both the contractor and ALDOT to do what it takes in a cooperative environment. ALDOT engineers were ready to answer questions, and review and approve the contractor’s documents in the same day. This helped to speed up the administrative process and significantly contributed to the project’s early completion.
- Quality and safety remained priorities for the contractor and ALDOT’s team.
- ALDOT engineers decided to use prestressed concrete girders instead of steel girders, thus saving valuable fabrication time.
- The prestressed concrete girders were the most critical item in the construction process. Sherman Prestressed/Precast division was committed to work around the clock to

produce these girders in a minimum time. As a result, Sherman Company delivered these prestressed concrete girders earlier than the original schedule called for. The early delivery directly impacted the time to complete the bridge and contributed obviously to the early completion incentive paid to the contractor.

- The emergency contract with the I/D clause was clearly effective in reducing the time of construction process.
- FHWA Alabama Division engineers played a very important role in the emergency repair process. FHWA Alabama Division personnel were ready to review and approve ALDOT documents in a short period. In addition, they performed construction inspection and conducted overall coordination with ALDOT. This helped to speed up the administrative process without sacrificing quality and safety.

Recommendations

ALDOT responded quickly in this emergency situation, and the replacement of the I-65 Bridge was accomplished 52 days ahead of schedule. Successful operations can serve as a good foundation to further improvements in emergency response and recovery operations. With that in mind, the researchers in this project offer the following recommendation practices for consideration:

- Although ALDOT has demonstrated the ability to handle emergency response and reconstruction situations in recent years, ALDOT could benefit from a written emergency plan that every Division and District can follow.
- ALDOT might be able to estimate more accurately the duration and cost of future emergency projects if they collect data from various states, study the duration and cost of the projects, and evaluate the factors that help the projects to finish early.
- ALDOT should continue to study new contracting methods that help to accelerate the process and at the same time insure that the cost is commensurate with the cost of the outage.

I-20/59 Bridge Birmingham, Alabama

On October 21, 2004, a 9,000 gallon fuel tanker truck crashed under the I-20/59 north bridge at the interchange of I-65 and I-20/59 producing a massive explosion and severely damaging the 413-foot long bridge (Brasfield & Gorrie, 2005). ALDOT immediately closed the I-20/59 eastbound and established a traffic detour through city streets. The closure of this bridge affected approximately 245,000 vehicles per day with an estimated daily user cost to the State of \$200,000.

Damage Assessment

ALDOT's Bridge Engineers and District 1 maintenance personnel responded quickly to the news about the accident. They went to the scene to offer their help and to begin clean up and recovery operations. ALDOT Bridge Engineers evaluated the damage to the bridge and concluded that

the bridge must be replaced. Based on the assessment of the situation, ALDOT commissioned Brasfield & Gorrie to demolish the damaged bridge. Based on the similar experience in replacing a bridge near this bridge in the winter of 2002, the ALDOT Bridge Engineers decided to use concrete girders instead of steel girders in the new bridge design. ALDOT started the new design with the intent of having the design ready in a few days, in order to proceed with the bidding process. In addition, ALDOT decided to invite a selected group of contractors to bid on the project. These contractors were selected based on their expertise and experience in Alabama. Additionally, the contract included a stringent I/D clause (Brasfield & Gorrie, 2005).

Clean Up and Detours

Brasfield & Gorrie completed the clean up (Figure A -7) and demolition of the bridge under the direction of superintendent Arizona Jackson. This was a massive effort to remove the pieces of the damaged bridge in a short period of time. Mr. George Conner, State Bridge Maintenance Engineer and Michael Mahaffey, at the time ALDOT's District Construction Engineer Third Division District 1, provided ALDOT oversight during clean up operations. Thanks to the diligent work of the contractor and ALDOT's personnel, two lanes on I-20/59 southbound and one lane on the I-65 northbound ramp that merges into I-20/59 south were opened eight days after the incident. ALDOT kept these three lanes open until the completion of the new bridge (ALDOT, 2004). In addition, ALDOT's Division 3 worked around the clock to produce an effective detour plan and to keep the public informed about the alternate routes and the construction progress on the bridge.



**Figure A-7. Clean up of I-20/I-59 bridge
(Courtesy of Brasfield & Gorrie)**

A.2.3 Design and Scope of Repair

The new bridge design was prepared by the ALDOT team lead by Mr. Tim Colquett and Mr. Fred Conway, both from ALDOT's Bridge Design Bureau. They worked closely with Mr. Robert King, Bridge Engineer of FHWA Alabama Division, to get the review and approval of the design completed in a short period.

From the beginning, it was clear that steel girders were not a feasible option because of the amount of time required for fabrication and shipping. Therefore, the decision was made early on to replace the entire three span bridge using prestressed concrete girders.

The new bridge design included:

- Steel pile foundations
- Reinforced concrete columns
- Three span bridge using Bulb-T 63 Modified pre-stressed concrete girders and reinforced concrete bridge deck (Brasfield & Gorrie, 2005)

Contracting Method

The contracting method used by ALDOT was a standard unit price with I/D clause.

Contractor Selection

After the design of the bridge was completed, ALDOT solicited bids from a select group of contractors including Morris Group, Brasfield & Gorrie, Dawson, Alabama Bridge, McInnis, and Scott Bridge. These contractors were selected base on prequalification, expertise, and experience in Alabama (Chambliss, 2007). ALDOT's engineers analyzed the bids and awarded the contract to the lowest bidder, the Brasfield & Gorrie/ Morris Group joint venture at a bid price of \$5,443,000. The Brasfield & Gorrie/ Morris Group venture faced the challenge of completing the construction of the new bridge on or before December 31, 2004. In addition, the contract had an incentive of \$50,000 per day for each day the project was completed earlier than the 60 days established by ALDOT, and a \$50,000 per day penalty for every day beyond the deadline. The contract also stipulated that the interstate could be closed only for one period of 24 hours. The contractor and ALDOT agreed on these clauses and the parties signed the contract. The contractor began to work on October 29, 2004 (Brasfield & Gorrie, 2005).

Funding

The funds used to replace the I-59/20 Eastbound Bridge came from the FHWA ER program. This program reimburses to the states funds for costs related to road damages associated with natural disasters and disastrous events.

Mr. Joe Wilkerson, Alabama's Division Administrator of FHWA acted during the emergency as a liaison between the ALDOT and FHWA. He was there to provide support, expertise and Federal Aid through the ER Program.

Construction Process

The Brasfield & Gorrie/ Morris Group joint venture began the I-59/20 Eastbound Bridge project with a team of 50 members. In order to make schedule, the team was committed to work on shifts of 11-hours with a day off every seventh day. To further accelerate the project, the team worked in different phases of the project simultaneously while maintaining safety and quality as priorities of the project.

ALDOT and the contractor used accelerated construction and administrative techniques to speed up the construction time of the bridge. The construction sequence is summarized as follows:

- The contractor team began with the clean up of the area
- Installation of the H- steel piles as seen in Figure A-8
- Construction of the reinforced concrete caps/columns as shown in Figure A-9
- Placement of the new Bulb-T 63 Modified pre-stressed concrete girders as shown in Figure A-10. Sherman Prestressed/Precast division produced these girders. The contractor gave Sherman Prestressed/Precast division an incentive compensation for working overtime to produce these girders (Brasfield & Gorrie, 2005).
- Construction of the reinforced concrete bridge deck as can be seen in Figure A-11
- Painting the new bridge deck and entry ramps
- Open to traffic Figure A-12 (Brasfield & Gorrie, 2005)



**Figure A-8. First week: clean up and placement of steel piling
(Courtesy Brasfield & Gorrie)**



Figure A-9. Second week: concrete caps and columns
(Courtesy Brasfield & Gorrie)



Figure A-10. Third week: girders were placed on the bridge
(Courtesy Brasfield & Gorrie)



**Figure A-11. Fourth week: reinforced concrete bridge deck
(Courtesy of Brasfield & Gorrie)**



**Figure A-12. Fifth week: completed I-59/20 bridge
(Courtesy of Brasfield & Gorrie)**

Project Oversight

The following individuals were in charge of the administration and oversight of the overall project.

- Mike Mahaffey, ALDOT Construction Engineer
- Fred Conway, ALDOT Bridge Bureau Chief
- Chris Brown, Morris Group Superintendent
- Jerry Underwood, Brasfield & Gorrie Superintendent
- John Chambliss, Brasfield & Gorrie Chief Estimator Engineer
- Juan Carlos Ospina, Project Manager for Brasfield & Gorrie
- Duncan Morris, Project Manager for the Morris Group

Keys to the Project Completion Success

The I-59/20 Eastbound Bridge was finished in 36 days, an excellent outcome given a project of similar scope and ordinary construction circumstances might take nine months (Chambliss, 2007). Factors contributing to the early and safe completion of the project include:

- The effort placed into the planning and organization of the contractor's team
- The decision to use precast/prestressed concrete girders instead of steel girders to accelerate the fabrication of these key components of the bridge
- The early delivery of the girders by Sherman International Cooperation
- The accelerated review and approval of documents and decisions by ALDOT engineers

The I-59/20 Bridge was finished 26 days ahead of schedule and the Brasfield & Gorrie/Morris Group joint venture earned a \$ 1,300,000 incentive. The total amount of the contract including the incentive payment was \$6,743,000. Table A-2 shows a summary of the project.

Table A-2. I-20/I-59 Bridge Project Summary

Project Summary	
Location	I-59/20 Eastbound Bridge over I-59/20 Westbound
Type of repair	Bridge Replacement
Design by	ALDOT
Type of Design	Three bridge spans of Bult-T 63 Modified pre-stressed concrete girders
Bidders	Brasfield & Gorrie-Morris Group Join Venture; Dawson, Alabama Bridge, McInnis, and Scott Bridge
Type of Contract	Unit Price
Contractor	Brasfield & Gorrie- Morris Group Join Venture
Contract Amount including bonus	\$6,743,000
Incentive/disincentive per day	\$50,000
Bonus (early completion)	\$1,300,000.00
Length of the Contract	62 days
Length of the project	36 days
Days ahead of schedule	26 days

Lessons Learned

Although this project was the result of an unfortunate incident, its successful completion is an excellent case study for planning response to future incidents that require the emergency replacement of an important highway bridge in a congested area. A summary of this case study in a lessons learned format is as follows:

- ALDOT crews began the clean up effort immediately after the incident and quickly established alternative routes.
- ALDOT's ITS group established an effective detour plan and kept the public informed about the alternative routes and the construction progress on the bridge. Doing this reduced the pressure on the public.
- Safety is an important element in construction projects because if an accident occurs at the construction site, it would not only delay the project but also affect the performance of the teamwork. The contractor's attention to safety and quality significantly contributed to the early completion of the project.
- Under State Emergency Declaration, ALDOT was allowed to solicit bids from a selected group of contractors without public advertisement. This saved time in the award and contract process.
- Commitment from both the contractor and ALDOT to work diligently and cooperatively was one of the key components of success. ALDOT engineers were ready to solve questions, and review and approve the contractor's documents in the same day. This helped to speed up the administrative process and contributed to the project early completion.
- ALDOT engineers decided to use prestressed concrete girders instead of steel girders. This decision saved time in the construction process.
- The prestressed concrete girders were the most critical item in the construction process. The contractor gave to Sherman Prestressed/Precast division an incentive compensation for working overtime to produce these girders. As a result, the Sherman Company delivered these prestressed concrete girders early than the original schedule. This saved time on the construction process.
- The emergency contract with the I/D clause had a very positive influence on the early completion time of this project.

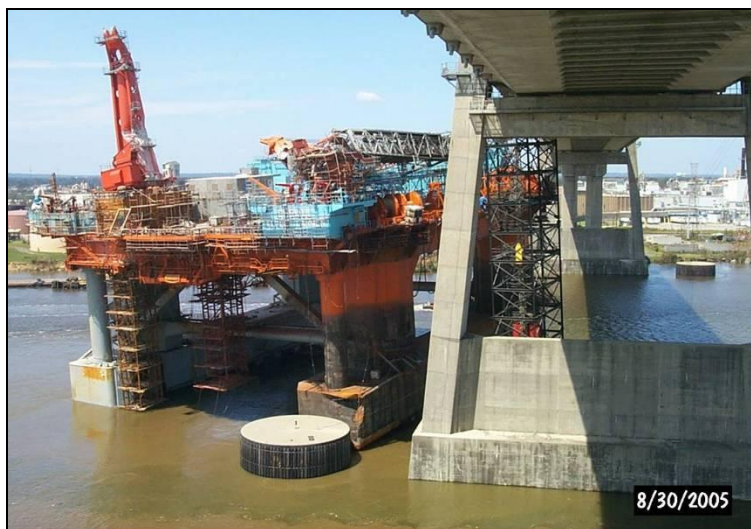
Recommendations

ALDOT responded quickly in this emergency, and the replacement of the I-59/20 Eastbound Bridge was accomplished 26 days ahead of schedule. The responders at ALDOT and the contractor joint venture benefited from the similar experience in the winter of 2002. While the outcome was considered good, it is good to use the case study for improvements. With that in mind, the researchers in this project offer the following recommendation practices for consideration:

- Although ALDOT has shown an organized process for emergency response and reconstruction process, it could be improved if ALDOT had a written emergency plan that every division and district could follow.
- ALDOT could estimate more accurately the duration of the emergency projects if they collect data from various states and study not only the duration of the projects but also the factors that help the projects to finish early.
- ALDOT should continue to study new contracting methods that help to accelerate and improve the contract process.

Cochrane Bridge Mobile, Alabama

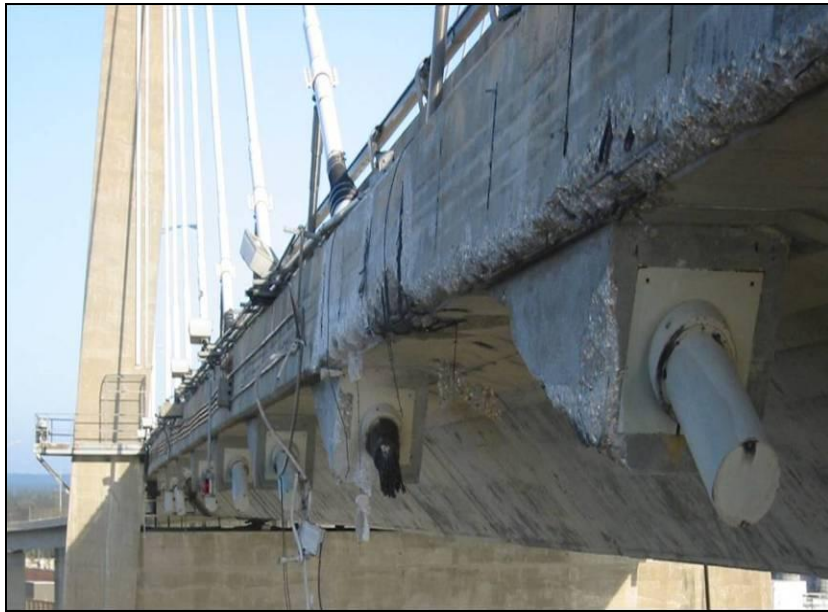
On August 29, 2005 during Hurricane Katrina, the Cochrane-Africatown Bridge in Mobile, Alabama was struck by a 13,000-ton semi-submersible drilling platform, the PSS Chemul. The platform broke free from its dry-dock moorings due to the strong winds generated by the hurricane and collided into the Cochrane-Africatown Bridge, as shown in Figure A -13. The impact caused severe damage to the bridge. Engineers from ALDOT closed the bridge until they could complete the assessment of the structural damage. After a thorough initial review, the bridge engineers determined that the traffic flow across the bridge on a restricted basis prior to the commencement of restoration operations. The flow was restricted to one lane in each direction and established a weight restriction for vehicles (ALDOT, 2005). Two lanes of the bridge were open to traffic on August 31, 2005. Built in 1991 by Volkert and Associates, the Cochrane-Africatown USA Bridge is a crucial component of the transportation infrastructure in and around Mobile, Alabama. The bridge carries US Highway 90 and Truck Route US 98 across Mobile and is particularly important because it is the bypass route for hazardous materials entering and exiting Mobile. These materials are not allowed to travel through the Wallace Tunnel on Interstate 10 (ALDOT, 2005).



**Figure A-13. Oil drilling platform struck Cochrane-Africatown bridge
(Courtesy of Brasfield & Gorrie)**

Damage Assessment

The bridge is a cable-stayed bridge with the following characteristics: a reinforced concrete box girder, two reinforced concrete pylons of 140 feet in height, a main span of 780 feet long, and a total length of 7,291 feet. When fully operational, the bridge has two lanes of traffic in each direction (DesRoches, 2006). Figg Engineering, the bridge designer, and ALDOT's Mobile Division conducted the post-Katrina structural damage assessment. The damage caused to the bridge from the impact with the platform included damage to the cable stays, as shown in Figure A -14, some external cracked concrete on the superstructure, as in Figure A -15, damage to the concrete barrier systems and most significantly, displaced the main span a few inches on one end bearing support (Chambliss, 2007).



**Figure A-14. Damages to the bridge cables
(Courtesy of Brasfield & Gorrie)**



**Figure A-15. Damage to the superstructure concrete
(Courtesy of Brasfield & Gorrie)**

Clean Up and Detours

After the storm, the ALDOT Maintenance Division sent to the site a team to begin the clean up and to evaluate the damage. Based on the damage assessment, ALDOT engineers determined that two of the four lanes of the bridge could be opened with the established a weight restriction. In addition, ALDOT established a detour route for trucks. Trucks used Interstate 65 and State Highway 59 as a detour route (ALDOT, 2005).

Design and Scope of Repair

The scope of the work included:

- Repair of the damage to superstructure concrete, to the concrete barrier systems, and to the cable stays.
- The primary task consisted of realigning the main span and setting it back on the original support system after the bearing system was repaired (Chambliss, 2007).

Contracting Method

The contracting method used by ALDOT was hard bid lump sum (Chambliss, 2007).

Contractor Selection

ALDOT invited a selected group of contractors that had been previously pre-qualified to bid on the repair project. These contractors were the Morris Group, Brasfield & Gorrie, Alabama Bridges, McInnis, Scott Bridge, and Dawson. These contractors met with ALDOT engineers to review the bridge damage assessment and to present their proposals. Personnel from the

ALDOT Engineering Bureau evaluated the proposals and awarded the bid to the lowest bidder, Brasfield & Gorrie for a lump sum \$1,700,000 to repair the Cochrane-Africatown Bridge. This contract was expected to be completed in 50 working days and did not include any I/D clause (Chambliss, 2007).

Funding

The funds used to repair the Cochrane Bridge came from the FHWA ER Program. This program reimburses the states for costs related to road damages associated with natural disasters and emergencies. In 2005, the congress approved the Emergency Highway Aid Package requested by President Bush. These funds were released by U.S. DOT through the FHWA to reimburse the State of Alabama for expenses related to repairing the roads damage associated with Hurricane Katrina. A portion of these funds were used to repair the Cochrane Bridge (Department of Transportation, 2006).

Construction Process

The repair process was organized into the following general tasks:

- Repair of the superstructure concrete
- Repair the cable stays
- Repair to the bearing and concrete barrier systems
- Lift and align the main span.

Brasfield & Gorrie team used a lift truck with a basket as shown in Figure A -16 to repair the superstructure concrete and the cable stays. One of the challenges during the repair of the cable stays was the high winds. These winds induced oscillation on the lift truck basket which complicated access to the cable stays for repair work.



**Figure A-16. Lift truck with basket used to repair cable stays
(Courtesy of Brasfield & Gorrie)**

The largest work task of this project consisted of lifting and aligning the main span and placing Teflon pads underneath the beams. The repair team faced the possibility that the bridge would slide on the Teflon pads. This task therefore required coordination of time and effort from the contractor's team. The contractor used twenty-four 200-ton jacks and forty-eight 20-ton jacks to raise the spans as shown in Figures A -17 and A-18 (Brasfield & Gorrie, 2006).



**Figure A-17. 200-ton jack used to lift and align the main span
(Courtesy of Brasfield & Gorrie)**



**Figure A-18. Jacks used to lift and align the main span
(Courtesy of Brasfield & Gorrie)**

Project Oversight

The following entities were in charge of the administration and oversight of the overall project:

- ALDOT Engineers (Mobile Division)
- Figg Engineering (Bridge designer)
- Brasfield & Gorrie (Contractor)

Keys to the Project Completion Success

The Cochrane-Africatown Bridge was repaired within 50 days without early or late completion incentive. Typically, this job is 50 days, even without the emergency (Chambliss, 2007). Table A-3 shows a summary of the project.

Table A-3. Cochrane-Africatown Bridge Project Summary

Project Summary	
Location	Cochrane-Africatown Bridge in Mobile, Alabama
Type of repair	Bridge Repair
Design	No need design
Type of Design	Same as original
Bidders	Brasfield & Gorrie, Morris Group, Alabama Bridges, McInnis, Scott Bridge, and Dawson.
Competitive Bid	Low bid
Type of Contract	Hard bid lump sum
Contractor	Brasfield & Gorrie
Contract	\$1,700,000
Incentive/disincentive per day	N/A
Bonus (early completion)	N/A
Length of the Contract	50 days
Length of the project	50 days
Days ahead of schedule	N/A

Lessons Learned

Although this project was the result of an unfortunate incident, its successful completion can be attributed to the following factors.

- ALDOT crews began the clean up effort right after the incident, and they established an alternative route for traffic. Doing this reduced the traffic congestion and eased travel for the public that needed to use this route. Closing off the bridge entirely during the complete repair process would have added extensive delays and potentially overburdened the alternate routes (such as the alternate truck route for hazardous materials cargo).
- ALDOT's Ninth Division established an effective detour plan and kept the public informed about the alternative routes and the construction progress on the bridge. Doing this reduced the pressure on the public.
- Under the State Emergency declaration, ALDOT was allowed to take bids from a selected group of contractors without public advertisement. This saved time in the award and contract process.
- Commitment from both the contractor and ALDOT was one of the key components of success. ALDOT engineers were ready to solve questions, and review and approve the contractor's documents in a short period of time. This helped to speed up the paper work process and contributed to the project completion.
- Emergency contracts with I/D clause have been known to be effective in reducing the time of construction process. However, since this contract did not contain such a clause, the contractor completed this project using the total time allotted.

- Safety is an important element in construction projects because if an accident occurs at the construction site, it would not only delay the project but also affect the performance of the teamwork. For that reason, the contractor made safety and quality priorities in the success of the project.

Recommendations

Despite the fact that the State DOT response was efficient, there are some practices that can be implemented to improve the emergency reconstruction process. These practices are as follows:

- Although ALDOT has shown an organized process for emergency response and reconstruction process, it could be improved if ALDOT had a written emergency plan that every division and district could follow.
- ALDOT could estimate more accurately the duration of the emergency projects if they collect data from various states and study not only the duration of the projects but also the factors that help the projects to finish early.
- ALDOT should continue to study new contracting methods that help to accelerate and improve the contract process.
- In addition, ALDOT should find new methods to improve the already established contracting methods such lane rental, A+B, design-build, etc.

I-10 Bridge Escambia Bay, Pensacola, Florida

On September 16, 2004, Hurricane Ivan struck the coast of Alabama and Florida, with winds speed of approximately 130 mph. The strong winds and the storm surge caused severe damages to the transportation infrastructure on the states of Alabama and Florida. In Florida, the I-10 Bridge over Escambia Bay in Pensacola suffered severe damages (Figure A-19). The storm surge displaced several spans into the water and misaligned several spans in both the east and westbound. Due to the severity of the damage, Florida Department of Transportation (FDOT) had to close the bridge and immediately proceed with a structural assessment. The result of the damage evaluation concluded that misaligned spans were in a good condition to be reused while the displaced spans that fell into the water needed to be replaced. In addition, FDOT decided to repair the westbound bridge because it had sustained less damage than the eastbound bridge.

I-10 is one of the main routes for interstate commerce with approximately 8,000 trucks traveling every day (Dipietre, 2004); also approximately 25,000 vehicles per day use this route to go from Escambia County to Santa Rosa County in what could be characterized as local traffic. Because of the high volume in both interstate and local traffic, it was critical for FDOT to reopen this bridge in the shortest time possible. Consequently, FDOT proceeded to award an emergency contract to repair the existing bridge by requiring working first on the westbound bridge that sustained less damage, and continue to repair the eastbound bridge.

On November 20, 2004, the two lanes of the westbound bridge and one lane of the eastbound bridge were open for traffic (Andres, 2007).



Figure A-19. Bridge damages
(Courtesy of FDOT, William Nickas and Thomas Andres)

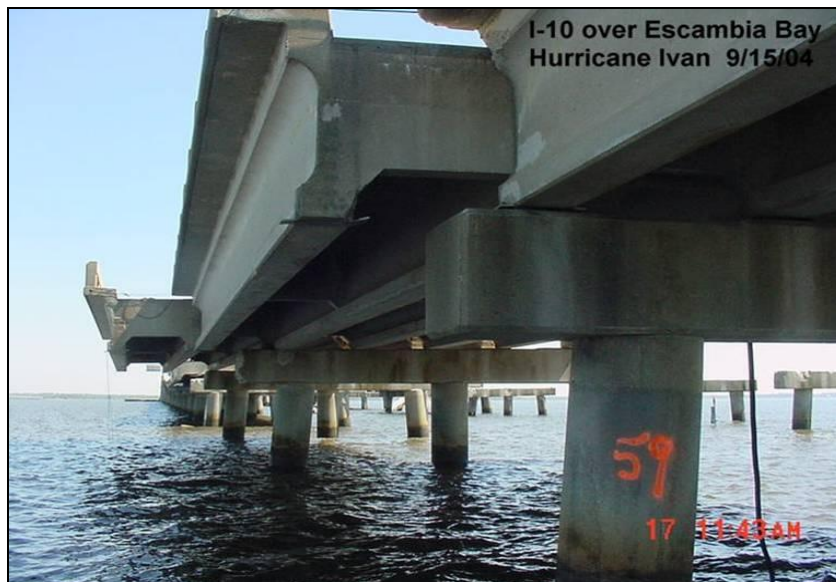
Damage Assessment

I-10 over Escambia Bay, Florida, is a four lane highway connecting Escambia county and Santa Rosa county. The I -10 Bridge consist of two structures, one for the eastbound and one for the westbound traffic. Each structure is 13,596 feet long, and its superstructure consists of low-level, precast, prestressed spans supported by six girders. The spans are 60 feet long and 35 feet wide. The bridge elevation of the water in the lower level is 12 feet while in the high level is 55 feet to allow ships traffic into the bay (Talbot, 2005).

A day after Hurricane Ivan hit the bridge, FDOT engineers evaluated the damages caused by the storm and its strong winds. In the eastbound section, forty-six spans were dislodged into the water and fifty spans were displaced. In the westbound section, twelve spans collapsed into the water and 16 spans were displaced. In addition to these damages, thirty-five pile bents were missing or destroyed (Andres, 2007). Figures A-20, A-21 and A-22 show the east and westbound damages. Based on the damage assessment, FDOT concluded that the westbound section should be repaired first in order to restore the traffic in the shortest period of time possible.



**Figure A-20. The missing eastbound and westbound spans
(Courtesy of FDOT, William Nickas, and Thomas A. Andres)**



**Figure A-21. Misaligned spans
(Courtesy of FDOT, William Nickas, and Thomas A. Andres)**



Figure A-22. Missing or destroyed pile bents
(Courtesy of FDOT, William Nickas, and Thomas A. Andres)

Clean Up and Detours

Clean up consisted of debris removal and submerged spans removal. FDOT and Gilbert Southern/Massman Construction conducted the debris removal. However, in order to not interfere with the repairs of the superstructure, FDOT allowed the clean up contractor to postpone the removal of the submerged spans and debris removal until the project was partially completed.

FDOT and Parsons Transportation, a consulting firm, worked around the clock to produce an effective detour plan and to keep the public informed about the alternate routes and the construction progress on the bridge.

Design and Scope of Repair

After a preliminary evaluation of the damages, FDOT engineers met in FDOT headquarters to develop an accelerated plan to repair the bridge and restore the traffic of this important route. In order to restore the traffic quickly, the scope of the bridge repair was divided in two phases described below:

Phase I: This phase was focused on the westbound span and consisted of realigning the 16 displaced spans, and replacing the 12 spans damaged by using the eastbound spans that were in good condition. This maneuver allowed the westbound bridge to open to two-way, single lane traffic in a short period of time.

Phase II: This phase was focused on the eastbound span. To reopen the eastbound bridge, it was necessary to realign 50 dislodged spans and to replace the damaged and missing spans with

temporary steel bridge panels. This solution allowed opening the eastbound bridge to one lane traffic.

In both phases several pile bents were also replaced (FDOT DVD, 2004).

Contracting Method

The contracting method used by FDOT was design-build with I/D clause (Andres, 2007).

Contractor Selection

One day after the storm, FDOT had already prepared bid documents and permits and had an estimated cost of the project. Because FDOT was operating under emergency conditions, it did not advertise the project. However, four contractors were invited to bid. The contractors met with FDOT engineers to survey the damages to bridge and used this information to prepare and present their proposals.

On September 18, 2004, FDOT awarded a \$ 26.4 million contract to a joint venture of Gilbert Southern of Nebraska and Massman Construction of Missouri (Gilbert Southern/Massman Construction) to repair and reopen the I-10 Bridge. Parsons Transportations Group, a consultant, assisted the joint venture. As mentioned previously, the contract consisted of two phases; phase I was expected to be completed in 24 days with a \$250,000 I/D clause, and Phase II was expected to be completed in 90 days with a \$50,000 day bonus/penalty (Dipietre, 2004).

In addition to the repair contract, FDOT awarded a \$1,695,235 contract to Consultant CEI to perform construction progress inspections (Richter, 2007).

Funding

The ER program that is led by FHWA, reimburses the States for costs related to road damages associated with natural disasters and emergencies events.

This project was administered using the FHWA ER program. However, the funds used were authorized under a special bill from Congress and did not actually come from the \$100 million national annual set aside appropriations (Richter, 2007).

Construction Process

Gilbert Southern/Massman Construction team began repairs of the I-10 Bridge on September 18, 2004. The contractor's team had the task of finishing Phase I of the project in 24 days and Phase II in 90 days. In order to maintain the schedule, the team was committed to work in twelve-hour shifts on a 24/7 schedule. FDOT as well as the contractor used accelerated construction techniques to speed up the repair of the bridge. The construction process is described in the following section.

Phase I – Westbound Bridge Repair

- First, the contractor team began to order materials and mobilize workers and equipment. One important part of the equipment was Massman’s 600-ton floating crane. This 600-ton capacity crane was needed to remove the submerge spans and replace the missing spans (Talbot, 2005).
- Second, where realignment was needed spans were lifted and realigned by using different methods and equipment such as tugs and barges, self-propelled modular trailers (SPMTs), and horizontal hydraulic jacks as shown in Figure A-23.
- Third, the contractor’s team built a new substructure. This substructure consisted of 28 steel pipe piles, 160 feet long (Talbot, 2005).
- Fourth, the contractor used a 600-ton crane to remove the submerge spans.
- Finally, the missing westbound spans were replaced with eastbound spans. These eastbound spans were lifted and transferred to the westbound span by using a 600-ton crane and SPMTs, as shown in Figure A-24.
- Figure A-25 shows the westbound bridge open to the traffic.



**Figure A-23. Span realignment by jacks and slide method
(Courtesy of FDOT and William Nickas)**



**Figure A-24. Replacement spans using crane and SPMT
(Courtesy of FDOT and William Nickas)**



**Figure A-25. Westbound bridge opens to traffic
(Courtesy of FDOT and William Nickas)**

Phase II – Eastbound Bridge Repair

- To accelerate the project, the contractor’s team began to work in Phase II when Phase I was partially complete.
- Contractor’s team removed the submerged spans. They used a 600-ton crane to remove the spans, as can be seen in Figure A-26.
- The contractor’s team built new substructure. This substructure consisted of 104 steel pipe piles, 160 feet long (Talbot, 2005).
- The team realigned 50 spans in the eastbound span by using the same techniques and equipment used in the westbound span.
- Gilbert Southern/Massman Construction used Acrow modular steel bridge panels to replace not only 46 spans that were destroyed in the eastbound span but also the eastbound spans that were used to repair the westbound spans. Figure A-27 shows Acrow panel installation.
- Figure A-28 shows the eastbound section open to traffic.

The accelerated construction techniques used during Phase I and II allowed for finishing the project ahead of schedule.



**Figure A-26. Spans removed from water
(Courtesy of FDOT and William Nickas)**



**Figure A-27. Acrow steel panels
(Courtesy of FDOT and William Nickas)**



**Figure A-28. Eastbound bridge opens to traffic
(Courtesy of FDOT and William Nickas)**

Project Oversight

As Richter, 2007, in addition to the work performed on project funding requests, the FHWA Florida Division also provided project oversight; on-site advice to state officials to develop, bid, and negotiate emergency repair contracts; review of proposals, review and approval of NEPA documents; Design-Build RFP preparation and review; contract changes review and administration; and construction inspections.

The following entities and individuals were in were primarily responsible for the administration and oversight of the overall project.

- Parsons Transportations Group
- William Nickas, State Structure Design Engineer (FDOT)
- Dale Helming, Project Manager Marina Works
- Mark Schnoebelen, VP Massman Construction
- FHWA Florida Division

Keys to the Project Completion Success

The I-10 Bridge, Phase I, was completed on October 17, 2004 and two lanes, one in each direction, were opened to traffic. Phase I was completed 7 days ahead of schedule with a bonus of \$250,000/day. Thus, Gilbert Southern/Massman Construction earned a \$1.75 million bonus. Phase II of this project was completed on November 20, 2004 and one lane was open to traffic. This phase was completed twenty-two days ahead of schedule with a bonus of \$50,000/day. Thus, the contractor earned \$ 1.1 million bonus. Therefore, the total cost of the project, including the repair contract with bonus and the consultant engineering contract, was \$37,609,500 (Richter, 2007). This project was completed early due to the combination of several factors such as:

- The efforts and hard work of the contractor’s team
- Beginning Phase II when Phase I was partially complete
- Using temporary steel bridge panels instead of precast concrete spans
- Using steel pipe piles

Table A-4 shows a summary of the project.

Table A-4. I-10 Bridge Escambia Bay Project Summary

Project Summary	
Location	I-10 Bridge Escambia Bay, Florida
Type of repair	Repair I-10 Bridge
Design by	FDOT
Type of Design	Temporary steel bridge panels
Bidders	Gilbert South/Massman
Competitive Bid	Low Bid
Type of Contract	Emergency Contract Incentive/Disincentive
Contractor	Gilbert South/Massman
Preliminary Contract Amount	\$26,400,000
Phase I Incentive/disincentive per day	\$250,000
Phase II Incentive/disincentive per day	\$75,000
Bonus (early completion phase I)	\$1,750,000.00
Bonus (early completion phase II)	\$1,100,000.00
Contract time Phase I	24 days
Completion Phase I	17 days
Days ahead of schedule	7 days
Contract time Phase II	90 days
Completion Phase II	68 days
Days ahead of schedule	22 days

Lessons Learned

The successful completion of this major repair/reconstruction project can be attributed to the following factors:

- Under State Emergency Declaration, FDOT was allowed to take bids from a selected group of contractors without public advertisement. This saved time in the award and contract process.
- The immediate response by FDOT to Hurricane Ivan was the key element to reduce the traffic congestion and increase the success of the project. The rapid response by FDOT included doing the preliminary damage assessment in record time (half of one day), beginning the debris removal and the clean up, establishing detour routes and keeping the public inform about the progress of the bridge repair project.
- FDOT used design-build contracting method to expedite the project. This saved time in the award and contract process as well as sped up the reconstruction process.
- The I/D clauses played an important role in the early completion of the project. The huge incentive in Phase I motivated the contractor to finish early.
- Commitment from both the contractor and FDOT was one of the key components of success. FDOT engineers were ready to solve questions, and review and approve the contractor's documents in the same day. This helped to speed up the paper work process and contributed to the project early completion.
- FDOT and the contractor were willing to use new techniques and equipment, such as horizontal hydraulic jacks, slide method and the SPMTs, to accelerate the repair process.
- FDOT decided to use steel pipe piles for the foundation of this project. This pipe piles were faster to fabricate than concrete piles. This decision saved time and helped to expedite the reconstruction process.
- To accelerate the project, the contractor began to work in Phase II when Phase I was partially complete.
- FDOT owns Acrow steel bridge panels. These Acrow bridge components were on hand for this project. This saved time in the reconstruction process.
- FDOT decided to use, in the eastbound span, temporary steel bridge panels instead of precast concrete spans. These temporary steel panels are a rapid solution for emergency repair projects. This solution contributed to restore the traffic over the eastbound bridge in a short period.
- FHWA Florida Division engineers played a very important role in the emergency repair process. FHWA Florida Division personnel were ready to review and approve FDOT documents in a short period. In addition, they performed construction inspection and conducted overall coordination with FDOT. This helped to speed up the paper work process and contributed to the project early completion.

Recommendations

Even though Phase I of the I-10 Bridge over the Escambia Bay was finished seven days ahead of schedule and Phase II was 22 days ahead of schedule, there are some practices that can be implemented to improve the emergency reconstruction process such as:

- FDOT could estimate more accurately the duration of the emergency projects if they collect data from various states and study not only the duration of the projects but also factors, such as contracting methods and accelerated construction techniques, that help the projects to finish early.
- FDOT should continue to study new contracting methods that help to accelerate and improve the emergency contracting process.

I-10 Twin Span Bridge Lake Pontchartrain, Louisiana

On August 29, 2005, Hurricane Katrina made landfall near Buras Louisiana. The eye of the hurricane was east of New Orleans, Louisiana, with winds speeds approximately of 130 miles per hour. High storm surges reached into Lake Pontchartrain. The storm and the strong winds caused severe damages to transportation infrastructure not only in the state of Louisiana but also in the states of Mississippi and Alabama. In the state of Louisiana, highways and bridges experienced most of the transportation-related damage; this was the case of the I-10 Twin Bridge Span (Figure A-29). The storm dislodged some concrete segments into the lake and misaligned other portions of the eastbound and westbound spans.

Due to the severity of the damage, Louisiana Department of Transportation and Development (LADOTD) had to close the bridge and immediately proceed to hire Volker and Associates for a damage assessment. The result of the damage evaluation concluded that misaligned spans were in good condition and could be reused, while the displaced spans that fell in the lake needed to be replaced. Based on this evaluation, LADOTD decided to repair the eastbound spans first since it exhibited less damage than the westbound bridge. It was critical for LADOTD to repair and reopen at least the eastbound bridge since this I-10 twin span bridge is one of the main routes to and from New Orleans, with approximately 55,000 vehicles traveling every day through the bridge (Lambert, 2006).

LADOTD decided to repair the bridge and immediately implement an accelerated repair plan that allowed the acceptance of competitive bids one week after the storm. The bid opening and contract awarding occurred four days later.

The eastbound bridge was reopened to two-way, single lane traffic on October 14, 2005, and the westbound bridge was reopened to two lanes on January 5, 2006 (Lambert, 2006).



Figure A-29. Bridge damages
(Courtesy of LADOTD and Paul Fossier)

Damage Assessment

The I-10 Twin Span Bridge over the Lake Pontchartrain, Louisiana, was built in 1963. This bridge is one of the main routes to and from New Orleans. The I-10 Twin Bridge span consists of two bridges that run parallel to each other, with each one having two lanes of traffic. Each bridge is 5.4 miles long and each structure consists of 433 low level spans and 3 high-level spans. The low-level, 65-foot long monolithic prestressed spans, is supported by prestressed concrete cylinder piles 54 inches in diameter and 150 feet long. The high-level composite steel plate girder spans are 100 feet long and 200 feet long respectively (Fossier, 2006).

This bridge was substantially affected by Hurricane Katrina. One day after the storm, LADOTD Bridge Inspection crews proceeded to evaluate and review the damage caused by the storm and its strong winds. The major damage found in the bridge led to the decision to close the bridge, and hire a Volkert and Associates for a detailed structural damage assessment. The main damage was in the low-level approach spans, leaving the high-level sections in good condition. The damaged sections were on both the eastbound and westbound bridges. On the eastbound bridge, thirty-eight spans were dislodged into the water (Figure A-30), and 170 spans were shifted. In addition, 130 feet of railing failed. In the westbound direction, twenty-six spans went into the water and 303 spans were shifted (Figure A-31). Additionally, 13,910 feet of barrier rail were missing (Figure A-32), with one section bent. In addition, nine piles suffered some damage. Based on this structural damage assessment, LADOTD engineers decided to repair the eastbound bridge first because it had sustained less damage than the westbound bridge.



Figure A-30. Dislodged spans
(Courtesy of LADOTD and Paul Fossier)



Figure A-31. Span displacement
(Courtesy of LADOTD and Paul Fossier)



Figure A-32. Barrier damage
(Courtesy of LADOTD and Paul Fossier)

Clean Up and Detours

Clean up consisted of debris and submerged span removal. LADOT and Boh Bros. Construction Co., LLC conducted the debris removal. However, to avoid interference with the repair of the superstructure, LADOT allowed the clean up contractor to postpone the removal of the submerged spans and debris until the project was partially completed. LADOT closed the I-10 twin span bridge and immediately established an effective detour plan. The traffic between Slidell and New Orleans was detoured onto the U.S. 11 Bridge and Interstate 55 (Lambert, 2005).

Design and Scope of Repair

After a preliminary evaluation of the damage, LADOTD engineers met in LADOTD headquarters to develop an accelerated plan to repair the bridge and restore the traffic to this important route. As part of this plan, the LADOTD consulted the FDOT engineers about the fast-track method that they used to get a contractor to repair the I-10 Bridge over the Escambia Bay in Pensacola Florida, which has similar characteristics to the I-10 Twin Span in Louisiana (Allen, 2005). Using the FDOT bridge bidding and repairing process experience as a reference, LADOTD organized the scope of work into three phases and prepared all documents and bids within seven days after the storm. In addition, LADOTD hired Volkert and Associates to conduct not only a detailed damage assessment and development of a scope of work, but also to do the construction engineering management.

In order to restore the traffic quickly, the scope of the bridge repair was divided in three phases as follows:

Phase I: This phase was focused on eastbound span and consisted of realigning the 170 displaced spans and replacing the damaged/missing 38 spans by using the westbound spans that were in good condition. This maneuver allowed the eastbound bridge to open to two-way, single-lane traffic in a short period of time.

Phase II: This phase was to repair the westbound span. To repair the westbound bridge, it was necessary to realign 303 dislodged spans and to replace the damaged spans and missing spans with temporary steel bridge panels. This solution allowed opening the westbound bridge to two-lane traffic.

Phase III: This phase was to maintain, repair or replace the temporary bridge spans portable panels. This bridge maintenance and traffic control will be in place for up to three years. (Lambert, 2005)

Contracting Method

The contracting method used by LADOTD was Design-Bid-Build with active construction design-details, I/D clauses (D’Andrea, 2006).

Contractor Selection

By nine days after the storm, LADOTD had prepared bid documents and permits and had an estimated cost of the project of \$53 million.

Because LADOTD was operating under emergency conditions, they did not advertise the project. However, they invited a selected group of contractors to submit their proposals. LADOTD selected these contractors based on their abilities to fast-track an emergency repair project, and on those who could mobilize equipment immediately after the hurricane (Fossier, 2007). Contractors were invited for a pre-bid meeting and instructed as to the requirements of the project. Three bids were submitted as described in Table A-5.

Table A-5. I-10 Bridge Repair: Bids Summary

Bidder	Phase I&II Amount	Phase III Amount	Total Bid Phases I,II, and III
Boh Bros. Construction Co., LLC	\$29,457,255.00	\$1,507,000.00	\$30,964,255.00
GilbertSouth/Massman/Traylor, JT VT	\$36,698,899.28	\$3,092,500.00	\$39,791,399.28
FLATIRON CONST/JAMES CONST,A JT VT	\$87,887,770.00	\$2,636,000.00	\$90.523,770.00

(* Information in this table was obtained from LADOTD web page: Bid Tabulations, 2005 <http://www.dotd.louisiana.gov/lettings/bidstabs/tabulations/bt05090901.shtml>)

Bids were opened on September 9, 2005, and the same day the contract was awarded to the low-bid company, Boh Bros Construction Co, a Louisiana company. They bid \$30,964,255 million and had the equipment and personnel to do the job. The next closest bid was \$40.0 million and the third bid was \$90.0 million.

Boh Bros Construction Co began the contract on September 12, 2005, 14 days after the storm.

Boh Bros faced the challenge of completing Phase I of the project in 49 days, including a four-day delay due to Hurricane Rita. Therefore, Phase I was expected to be completed on October 31, 2005. Also, Phase I included an incentive of \$75,000 per day for early completion with a maximum of 15 days; and \$75,000 penalty for every day past the deadline (no maximum days). Phase II was scheduled to be completed by January 14, 2006. Phase III is an ongoing contract to maintain the temporary bridges panels; this contract is renewable annually for up to three years.

Funding

The costs to repair the I-10 Twin Span Bridge in Louisiana were eligible for reimbursement for ER funds allocated to the FHWA in a special bill from the Congress.

On December 30, 2005, the President signed into law the “Department of Defense, Emergency Supplemental Appropriations to Address Hurricanes in the Gulf of Mexico, and Pandemic Influenza Act, 2006” H.R 2863 and hereafter called DOD Emergency Supplemental Appropriations Act (Federal Register, 2006).

This act under Chapter 9 of Title I of Division B, made additional funds available through the ER Program to cover the cost related to road and bridge damage as a consequence of Hurricanes Katrina, Rita and Wilma.

This act established the following additional funds for the Emergency Relief program:

For an additional amount for ‘Emergency relief program’ as authorized under 23 U.S.C. 125, \$2,750,000,000, to remain available until expended, for necessary expenses related to the consequences of Hurricanes Katrina, Rita, and Wilma: Provided, That of the funds provided herein, up to \$629,000,000 shall be available to repair and reconstruct the I-10 bridge spanning New Orleans and Slidell, Louisiana in accordance with current design standards as contained in 23 U.S.C. 125: Provided further, That notwithstanding 23 U.S.C. 120(e) and from funds provided herein, the Federal share for all projects for repairs or reconstruction of highways, roads, bridges, and trails to respond to damage caused by Hurricanes Katrina, Rita, and Wilma shall be 100%: (Thomas, 2007)

FHWA Louisiana Division engineers played a very important role in the emergency repair process. FHWA Louisiana Division authorized the funds for the project and approved all change orders for additional costs or design changes. The Division’s Mega Projects Engineer was assigned to the project full time for the duration of the repairs (Stinson, 2007).

Construction Process

Boh Bros Construction Company began to order materials and mobilize equipment and workers on September 12, 2005. The contractor's team was tasked to finish Phase I of the project in 49 days. In order to make the schedule, the team committed to work on twelve-hour shifts on a 24/7 schedule.

LADOTD, as well as the contractor, used accelerated construction techniques to speed up the repair of the bridge. The construction process was as follows:

Phase I – Eastbound Bridge Repair

- The work consisted of realigning the 170 displaced spans and replacing the 38 spans.
- The displaced spans were realigned by using a barge and SPMT (Figure A-33 and A-34).
- This system was also used to remove, transport and place the westbound spans that were used to replace the damaged eastbound spans (Figure A-35 and A-36).
- Bearing pads were replaced with elastomeric pads.
- Additionally, several cylinder piles were repaired and 130 feet barrier rails were replaced (Fossier, 2006).
- To accelerate the project, the contractor worked on Phase I and Phase II simultaneously.



**Figure A-33. Self-Propelled Modular Transports
(Courtesy of LADOTD and Paul Fossier)**



**Figure A-34. Realignment of spans using SPMT
(Courtesy of LADOTD and Paul Fossier)**



**Figure A-35. Lifting spans
(Courtesy of LADOTD and Paul Fossier)**



**Figure A-36. Spans switch from westbound to eastbound bridge
(Courtesy of LADOTD and Paul Fossier)**

Phase II – Westbound Bridge repair:

- The work began with realigning of the westbound spans using the same technique used to realign the eastbound spans (Figures A-33 and A-34).
- To replace the missing concrete spans, a temporary solution using Acrow 700 series steel bridge panels was implemented, allowing the bridge to reopen on two-lane traffic instead of one-lane as previously designed (Figures A-37 and A-38).
- The 13,910 feet of damaged barrier rails were replaced by using temporary concrete Jersey barriers.
- This phase also required repair of several cylinder piles and replacement of several bearing pads.



**Figure A-37. Acrow 700 series steel panels
(Courtesy of LADOTD and Paul Fossier)**



**Figure A-38. Acrow 700 series steel panels
(Courtesy of LADOTD and Paul Fossier)**

Phase III – Maintenance:

The contractor should maintain, and replace, as needed, the Acrow temporary bridge panels of the westbound bridge for up to three years (Figure A-39).



**Figure A-39. Project finished and beginning phase III
(Courtesy of LADOTD and Paul Fossier)**

Challenges

LADOTD and the contractor faced several challenges during the repair process, such as:

- Removal of spans in the lake
- Delivery of Acrow temporary bridge spans from Pennsylvania in a timely manner (concerns about potential fabrication/ production speed) (Fossier, 2007),
- Getting enough qualified labor, materials, and equipment immediately after the hurricane. Workers were displaced from their homes during the storm.
- Disruption of the communication system
The landline phone service was not available at the bridge site for 2- 3 months, and the cell phone service was very poor (Stinson, 2007).

Project Oversight

The following entities and individuals were in charge of the administration and oversight of the overall project. These entities and individuals were:

- LADOTD personnel prepared bid package and specifications.
- Paul Fossier, LADOTD design
- Gill Gautreau, LADOT Maintenance/Inspection
- Volker and Associates performed bridge inspections and construction QA for both the repair project and the ongoing maintenance project for the temporary steel spans on the existing westbound bridge (Stinson, 2007).
- Mammoet provided the SPMT.
- HNTB assisted Boh Brothers with repair design during construction.
- Boh Brothers team repaired the bridge.
- Mark Stinson, Mega Projects Engineer. FHWA Louisiana Division

Keys to the Project Completion Success

The I-10 Twin Span Bridge Phase I was completed on October 14, 2005 and two lanes (one in each direction) were opened to traffic. Phase I was completed 15 days ahead of schedule (Stinson, 2007).

Phase II of this project was completed on January 5, 2006 and two lanes were open to traffic. This phase was completed twelve days ahead of schedule (Stinson, 2007).

Typically, projects such as this one could take one year to be complete (Fossier, 2007). However, this project was completed early due to the combination of several factors such as:

- The efforts and hard work of the contractor's team,
- Using SPMT on barges

- Using temporary steel bridge panels instead of fabrication of new prestressed girder spans,
- Using precast concrete barriers rails stored in the LADOTD.
- The accelerated construction techniques used in Phases I and II allowed for completion of the project ahead of schedule.
- Good weather conditions and the high level of partnering, cooperation, and commitment for all the parties involved in this repair process (Stinson, 2007).

Because Phase I of this bridge was finished 15 days ahead of schedule, Boh Bros Construction Company, earned a \$1,125,000 incentive. In addition to the bonus for early completion, this contract was increased in \$4.1 million due to the change order to have two westbound lanes open to traffic instead of one lane (Lambert, 2006).

The total amount of the contract, including the incentive payment and the change order, was less than the cost proposed by the second bidder.

Table A-6 shows a summary of the project.

Table A-6. I-10 Twin Span Bridge Project Summary

Project Summary	
Location	I-10 Twin Span Bridge Lake Pontchartrain, Louisiana
Type of repair	Repair Twin Span Bridge
Design by	LADOTD
Type of Design	Temporary steel bridge panels instead
Bidders	Boh Bros. Construction Co. LLC GilbertSouth/Massman/Traylor, JT VT FLATIRON CONST/JAMES CONST, A JT VT
Competitive Bid	Low Bid
Type of Contract	Design-bid-build with active construction design-details, and incentive and disincentive clause.
Contractor	Boh Bros. Construction Co., LLC
Preliminary Contract Amount	\$30,964,255.00
Change Order (increased)	\$4,000,000.00
Incentive/disincentive per day 15 days cap for incentive	\$75,000
Bonus (early completion)	\$1,125,000.00
Contract time Phase I	45 days
Completion Phase I	29 days
Days ahead of schedule	16 days
Completion Phase II	108 days
Days ahead of schedule	12 days

Lessons Learned

Although this project was the result of an unfortunate natural disaster, its successful completion can be attributed to the following factors:

- Under the State Emergency Declaration, LADOTD was allowed to take bids from a selected group of contractors without public advertisement. This saved time in the award and contract process.
- LADOTD's immediate response to Hurricane Katrina was the key element to reducing the traffic congestion and ensuring the success of the project. LADOTD's rapid response included doing the preliminary damage assessment in short time, beginning the debris removal and the clean up, establishing detour routes and keeping the public informed about the progress of the bridge repair.
- LADOTD consulted FDOT about the fast-track method they used to repair the I-10 Bridge over Escambia Bay, which is similar to I-10 Twin Span. This saved time in the award and contract process.
- Based on the successful FDOT Bridge bidding and repairing process experience, LADOTD used the fast-track method to complete inspections, prepared bids and get a contractor to repair the bridge.
- FDOT used Acrow 300 series temporary steel spans for repairing the I-10 Escambia Bay. Based on FDOT experience with the Acrow panels, LADOTD was able to use a newer, stronger model of Acrow temporary steel spans that perform better than the one used on the Escambia Bay.
- In the coastal areas, bridges should be designed to resist hurricane wave forces, and bridge elevations should be determined based on a hurricane storm analysis.
- LADOTD used Design-Bid-Build with active construction design details to expedite the project. This helped to speed up the reconstruction process.
- The I/D clauses played an important role in the early completion of the project. The incentive clause in Phase I motivated the contractor to finish early.
- Commitment from both the contractor and LADOTD was one of the key components of success. LADOTD engineers were ready to solve questions, and review and approve the contractor's documents in the same day. This helped to speed up the paper work process and contributed to the project early completion.
- LADOTD and the contractor were willing to use new techniques and equipment, such as horizontal hydraulic jacks, slide method and the self-propelled modular trailers (SPMTs), to accelerate the repair process.
- To accelerate the project, the contractor began to work in Phase II when Phase I was partially complete.
- LADOTD decided to use Acrow steel bridge panels. This decision saved time in the reconstruction process.
- LADOTD decided to use, in the westbound direction, temporary steel bridge panels instead of precast concrete spans. These temporary steel panels are a rapid solution for emergency repair projects. This solution contributed to restore the traffic over the eastbound bridge in a short period.

- LADOTD approved a \$4.1 million change order to have two westbound lanes opened instead of one. This allowed restoring the traffic to the original four lanes, two eastbound lanes and two westbound lanes.
- FHWA Louisiana Division –Mega Project Engineer Division- played a very important role in the emergency repair process. The Mega Projects Engineer worked on site daily, he was ready to review and approve LADOTD documents in a short period. This helped to speed up the paper work process and contributed to the project’s early completion.

Recommendations

Despite the fact that the State DOT response was quick and efficient and the replacement of the I-10 Twin Span was finished 16 days ahead of schedule for Phase I, and nine days ahead of schedule for Phase II, there are some practices that could be implemented to improve the emergency reconstruction process. These practices are as follows:

- Bridges should be designed to resist hurricane forces.
- Bridge elevation should be determined based on hurricane analysis.
- LADOT should continue to study new contracting methods that help to accelerate and improve the emergency contract process.
- LADOT could estimate more accurately the duration of the emergency projects if they collect data from various states and study not only the duration of the projects but also factors such as contracting methods and accelerated construction techniques that help projects to finish early.