Iowa Department of Transportation Accelerated Bridge Construction Workshop

Workshop Report

August 11-12, 2008

Des Moines, Iowa

Sponsored By:

Iowa Department of Transportation
Iowa State University Bridge Engineering Center
Highways for LIFE — Accelerating Innovation for the American Driving Experience.
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Acknowledgements

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About the Workshop
The Iowa DOT, state DOTs in adjacent states, and other bridge partners met for the invitation-only day-and-a-half Accelerated Bridge Construction (ABC) Workshop held August 11-12, 2008, in Des Moines, Iowa. See Appendices A, B, and C of this report for workshop agenda and participants. The purpose of the workshop, sponsored by the Iowa DOT, FHWA, and ISU was to obtain recommended actions for the Iowa DOT to consider on three upcoming projects and on its prefabricated component design details as it works to implement ABC. This report documents the activities and products of the workshop.

Mary Lou Ralls, Workshop Moderator/Facilitator and author of Workshop Report

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Executive Summary

The Iowa Department of Transportation (Iowa DOT) hosted the Accelerated Bridge Construction (ABC) Workshop to bring together Iowa DOT engineers, engineers from adjacent states, and other bridge partners to explore ABC approaches that could be implemented in Iowa and other states. The reason that ABC is being considered is to reduce construction time, minimize traffic disruption, improve safety, reduce environmental impact, enhance constructability, and improve quality and life-cycle costs. The invitation-only day-and-a-half workshop was co-sponsored by the Federal Highway Administration (FHWA) Office of Bridge Technology and Highways for LIFE Program (HfL), and the Iowa State University (ISU) Bridge Engineering Center.

Update on ABC

Several presentations were given to bring participants up to date on ABC across the country to set the stage for workshop discussions. Presentation topics included the need to standardize prefabrication details and FHWA's new connection details manual that will soon be available. The keys to ABC success were also discussed from both a contractor's perspective and a state DOT owner's perspective. ABC projects in California, Texas, and Washington State were described in addition to the ABC projects to date in Iowa.

ABC Ideas and Proposed Activities

Discussed during the workshop were specific ideas for ABC approaches to major projects that require construction acceleration. The focus was on three Iowa DOT projects for ABC implementation: the replacement of an urban viaduct, the replacement of a historic structure, and the rehabilitation of a congested interstate bridge. Also discussed were design details for prefabricated bridge components that have been used in Iowa. Opportunities and obstacles were discussed and actions were proposed to implement ABC for these types of bridges and to improve ABC details currently in use.

Below are the prioritized ideas developed during the workshop. Proposed activities for each of these ideas were also developed.

<u>Team 1: Broadway Viaduct</u>
The Broadway Viaduct on US Highway 6 near the east end of the town of Council Bluffs is to be replaced. Breakout team objectives were to study various methods to accelerate construction using phased construction and considering site constraints. The prioritized proposed ideas developed in the workshop were to use detour rental for the closure period, drill the shafts prior to closing, precast the caps and columns, and prefabricate the deck systems.

<u>Team 2: Iowa Falls Steel Arch</u>
This bridge replacement is located on US 65 just south of Iowa Falls. Breakout team objectives were to identify ABC methods to completely remove and replace the bridge in one construction season. The prioritized proposed ideas developed in the workshop were to erect the ribs and struts around the existing bridge, skid the arch / struts into place, and prefabricate the floor system components.

Team 3: I-80 Reconstruction
The I-80 reconstruction project is located on the west side of Des Moines where I-35 and I-80 run together. Breakout team objectives included identifying accelerated construction methods to replace the original deck while maintaining three traffic lanes during peak hours, evaluating replacement options for deck versus superstructure, and evaluating precast versus cast-in-place deck options. The prioritized proposed ideas developed in the workshop were to re-use the steel beams and prefabricate the superstructure.

Team 4: Prefabricated Components Design Details
Details for the Iowa DOT's six ABC projects to date include joints between precast panels, post-tensioning ducts and anchorages, connections in stud pockets between panels and girders, haunch construction, box beam connections, and precast substructure connections. Breakout team objectives were to identify details used for accelerated construction projects, evaluate best practices and look for optimization opportunities for details to speed construction, reduce cost, and improve long-term durability. The prioritized proposed ideas developed in the workshop were precast deck systems, precast substructures, and precast integral abutment-to-superstructure connections.

1. Background

The nation's four-million-mile highway system is considered the most extensive and heavily traveled highway network in the world. Perhaps no other public asset is as central to the national economy and the day-to-day life of Americans. Care must be taken to keep the nation's highways and bridges in good condition at minimum cost and with minimum traffic disruption. In recent years unprecedented increases in traffic volume coupled with the aging infrastructure have increased construction activities. Although highway construction cannot be avoided, lengthy construction times must be reduced because they are costly and also expose construction workers to traffic hazards and the traveling public to substandard conditions longer than necessary. Transportation agencies are committed to providing quality long-lasting bridges, and their priorities are to save the 40,000 lives that are lost each year in accidents and the $63 billion lost each year due to congestion. However, they operate with challenges that include intensified construction activities needed to rebuild a highway system that was largely built in the 1950s and 60s, capacity that has increased little in the past two decades, and increasing traffic volumes and growing communities. For most agencies, accelerated bridge construction (ABC) is a new way of doing business that changes the way bridges are designed and constructed, and this new way of doing business will dramatically change America's driving experience.

Comments by Vasant Mistry, Office of Bridge Technology, FHWA

The Iowa Department of Transportation (Iowa DOT) mission is to provide safe and modern transportation systems and services to travelers in Iowa. Its strategic goals are accessibility, responsiveness, and accountability as it strives to better serve its customers. The Iowa DOT has a long history of research and innovation to advance its state's transportation infrastructure. A current need of Iowa and other DOTs is to upgrade their aging bridge inventories while minimizing traffic impacts. ABC is one means to address this need.

2. Workshop Objective

The objective of this invitation-only day-and-a-half workshop was to bring together Iowa DOT engineers, engineers from adjacent states, and other bridge partners to explore accelerated bridge construction (ABC) approaches that could be implemented in Iowa and other states. The reason that ABC is being considered is to reduce construction time, minimize traffic disruption, improve safety, reduce environmental impact, enhance constructability, and improve quality and life-cycle costs. See Appendices A, B, and C of this report for the workshop agenda and participants.

Discussed during the workshop were specific ideas for ABC approaches to major projects that require construction acceleration. The focus was on three Iowa DOT projects for ABC implementation: the replacement of an urban viaduct, the replacement of a historic structure, and the rehabilitation of a congested interstate bridge. Also discussed were design details for prefabricated bridge components that have been used in Iowa. Opportunities and obstacles were discussed and actions were proposed to implement ABC for these types of bridges and to improve ABC details currently in use.

3. Welcome by Sponsors

Workshop sponsors from the Iowa DOT and FHWA welcomed participants to the workshop and gave opening remarks. (See Appendix B for presenter bios.)

3.1 Norman L. McDonald, P.E.

Norm McDonald, State Bridge Engineer and Director of the Office of Bridges and Structures at the Iowa DOT, welcomed participants to the workshop. He said the Iowa DOT has completed a few accelerated bridge construction (ABC) projects to date and that his staff has picked several interesting bridge projects to brainstorm accelerated construction solutions during the workshop.

3.2 Sandra Larson, P.E.

Sandra Larson, Research and Technology Bureau Director in the Highway Division of the Iowa DOT, welcomed participants to Iowa and the workshop and thanked them for their participation. She thanked the Federal Highway Administration (FHWA) and Iowa State University (ISU) for co-sponsoring the workshop and recognized the Workshop Planning Committee. She said this workshop will hopefully be a model for how other States might understand, learn, and benefit from ABC concepts.

Ms. Larson said this workshop originated at the Transportation Research Board's Annual Meeting in January 2008 when several from Iowa attended an ABC session. In the session the Iowa DOT engineers heard how ABC can benefit smaller routine bridges as well as the larger major bridges. Not only can routine bridges use accelerated construction concepts, but these concepts can be used without much additional cost and sometimes with no additional cost. The Iowa DOT decided to host this ABC workshop in Des Moines to bring together its engineers, engineers from adjacent states, and other bridge partners to discuss how ABC could be used in this region of the country.

Ms. Larson said she looked forward to the outcomes of the workshop for benefits to Iowa and other states. She thanked the Bridge Office for coordinating the workshop and for the work to be done after the workshop to use ABC concepts. Ms. Larson said a workshop report and professional DVD will be developed after the workshop to share its outcomes.

3.3 Vasant Mistry, P.E.

Vasant Mistry, Senior Bridge Engineer in the Office of Bridge Technology at FHWA in Washington, D.C., welcomed participants and expressed FHWA's appreciation to the Iowa DOT for providing leadership in promoting ABC. He also thanked the participants for taking time from their busy schedules to participate in the workshop and promote ABC.

Mr. Mistry then talked briefly about the national highway system and work-zone impacts of the infrastructure renewal program. He said in a 2003 study the total number of highway work zones during that summer was estimated to be more than 6,400 with a corresponding 6,157 lane miles closed, causing a 20 percent capacity reduction in that part of the national highway system. In terms of loss of time and resources, congestion translates to four billion hours per year of time delay, 2.7 billion gallons of wasted gas per year, and a total congestion cost of $73 billion in 75 urban areas.

As time spent in commuting has grown, Americans have less time to spend with their families and friends. According to a survey by the Washington Family Council, 55 percent of those with children at home miss one or more family activities per week because of congestion. Some 85 percent said they would spend more time with their families if they could spend less time in congestion. Evidence suggests that each additional 10 minutes in daily commuting time cuts involvement time in community affairs by 10 percent. Mr. Mistry then cited several examples of the time and cost impacts of congestion on businesses.

Mr. Mistry closed by challenging participants to work together to recommend the best use of ABC in each of the three Iowa DOT projects and the prefabricated component details to be discussed during the workshop.

3.4 Curtis Monk, P.E.

Curtis Monk, the FHWA Division Bridge Engineer in Iowa, welcomed participants and gave opening remarks for the FHWA Highways for LIFE Program (HfL). He said HfL supports workshops like this one because of the innovation they bring and the new approaches they encourage for construction and relief of congestion. He then cited projections: a 70 percent increase in freight tonnage estimated by 2020, 90 percent of urban interstates expected to exceed their capacities by 2020, and 10 percent of congestion due to construction work zones. Replacing the 200,000 bridges that are currently structurally deficient or functionally obsolete will require more work zones, and one of HfL's objectives is to reduce the length of time of those work zones. With over six million crashes with 40,000 deaths and close to three million injuries costing $230 billion dollars each year, much incentive is provided to construct highway facilities better and faster.

Mr. Monk said that HfL has technology partnerships with state DOTs to encourage new thinking of how this needed construction can be accomplished. The goal is to do construction projects faster, with less congestion and better safety and quality, and to accomplish this at lower cost. The HfL projects are encouraged to develop performance standards, with goals for safety, quality, construction congestion mitigation, and user satisfaction. Are motorists satisfied with how long projects are taking? Have they been consulted concerning whether a specific project would best be done with staged construction that lasts two years, or by closing the roadway for two months, or by accelerating it for completion in weeks instead of months or years? While doing this, quality must be maintained as part of the innovation and total costs must be considered, including life-cycle and user costs in addition to initial construction costs.

HfL is involved in a number of demonstration projects, including the Iowa project at 24th Street over I-80/29 in Council Bluffs. Mr. Monk said the Iowa project will have a closeout workshop to promote what was done to reduce congestion, improve construction quality, and reduce construction time. He closed by encouraging participants to think differently about how construction projects are approached, looking for innovation and quality while building the projects faster to reduce congestion. He thanked participants for their activities in the workshop.

4. National Update on ABC

Several presentations were given to update workshop participants on the status of accelerated bridge construction (ABC) across the country. (Note: See Appendix B for presenter bios and Appendix D for the Iowa DOT link to view and download the presentations.)

4.1 National Vision: Making ABC Standard Practice

Vasant Mistry with the FHWA Office of Bridge Technology presented the national vision for making ABC standard practice. Topics covered in his presentation were a general discussion on ABC, standardizing prefabricated bridge elements and systems, a 6-minute video of pier construction using prefabricated columns and caps, and available tools and resources. He said FHWA bridge engineers in partnership with AASHTO have been promoting ABC by holding workshops, seminars, and conferences across the nation. The vision for ABC is to build the bridge offsite before cones are set, and then bring the bridge to the site for quick installation, for example, in hours or over a weekend.

Congestion and environmental impact can be reduced by reducing onsite construction time and by standardizing prefabricated bridge elements and systems (PBES). The national vision is to standardize PBES and ultimately to standardize the bridge construction process. Mr. Mistry then discussed prefabricated components that can be standardized, including precast abutments, precast piers, precast decks on precast concrete girders, precast decks on steel framing, fiber-reinforced polymer decks, and retaining walls. He also discussed total bridge prefabrication with steel framing and with precast concrete girders, as well as multi-span superstructure prefabrication installed simply-supported for dead load and continuous for live load. A video was shown on a Georgia I-85 interchange project with pier construction using prefabricated caps and columns; the use of prefabrication saved six weeks of onsite construction time that would otherwise have been required to construct cast-in-place piers.

Mr. Mistry then discussed available tools and resources that FHWA has prepared to help implement ABC technologies. The FHWA prefabricated bridges website (http://www.fhwa.dot.gov/bridge/prefab) includes information on prefabricated bridge projects constructed across the country, including contact information to learn more about what made those projects a success. FHWA has also prepared two documents on ABC technology that are available in hard copy and from the website: a decision-making framework for the effective use of PBES, and a manual on the use of self-propelled modular transporters to move bridges. FHWA is working on a PBES connection details manual that has about 150 details being used by bridge owners across the country; this manual will be available soon. In addition, if funding permits, a manual for designing and constructing entire bridges with PBES will be developed. Mr. Mistry said FHWA will also continue co-sponsoring ABC workshops for DOTs. He closed his presentation by encouraging bridge owners to use ABC to take advantage of its significant advantages over cast-in-place bridge construction, as appropriate, to help the traveling public.

4.2 PBES Connection Details Manual and ABC Projects that Save Money

Mike Culmo with CME Engineering, Inc. gave a presentation on two topics, first the Connection Details for Prefabricated Elements and Systems (PBES) Manual sponsored by FHWA and currently under his development, and then examples of ABC projects that save money. He said the schedule for manual completion is Fall 2008. It will then be available on the FHWA website.

As part of the FHWA contract to develop the manual, Mr. Culmo said he has traveled across the country talking with bridge owners. Their primary concerns regarding adoption of accelerated construction techniques include the need for quality details that last at least as long as conventional construction, design methodologies and training for prefabricated bridges, and construction methodologies that show how the prefabricated components can go together. Mr. Culmo said the purpose of the manual is to address those concerns by showing durable, quality details that are easy to construct. The focus is on connection details that have been used on ABC projects across the country. They are also investigating connection details used in other markets – in parking garages, stadiums, and buildings such as hotels – for transfer into the bridge market.

Currently about 150 details are in the manual. All details must pass a critical test before being included. The connection detail must result in rapid construction, transmit forces between elements effectively, be durable, have performed well under traffic and in an exposed environment, be cost effective and easy to construction, and have been incorporated into a number of projects without producing contracting issues if the connection detail is proprietary. The connection details come from State DOTs, federal agencies, international organizations, researchers, and producers.

Mr. Culmo discussed the manual's layout, describing in detail the content on the connection data sheets. He also mentioned other manuals currently available: the PCI Northeast Bridge Technical Committee's Guidelines for Accelerated Bridge Construction (available at www.pcine.org) and FHWA's Framework for Prefabricated Bridge Elements and Systems Decision-Making and their Manual on Use of Self-Propelled Modular Transporters, both available on the FHWA prefabricated bridges website.

Mr. Culmo described connection details for precast abutments and piers, precast decks on prestressed beams, precast decks on steel framing, and prefabricated decks including precast concrete, fiber-reinforced polymer (FRP), grid decks and partial-depth deck panels. All bridge components can be prefabricated, resulting in much shorter onsite construction time. He then showed a time-lapse video of the New Hampshire DOT's prefabricated Epping Bridge installed in eight days. Connection details for the Epping Bridge are included in the manual.

Mr. Culmo presented a schematic design of a prefabricated bridge to show how the manual could be used to select connection details. In this example, the businesses said in a public hearing that they did not want a long construction process with staged construction. While they did not favor a detour, they accepted a 30-day closure with detour rather than a long-term staged project. Mr. Culmo then described how to use the manual to select connection details for the prefabricated bridge. He ended the schematic design with cost figures that showed a net savings by using prefabrication, due to the elimination of a temporary bridge that would otherwise have been required.

In talking about quality of prefabricated bridges, Mr. Culmo said that Florida has had success with precast piers in very harsh environments, and that Connecticut has had full-depth precast concrete decks in place for over 17 years that have remained crack free and in excellent condition. He cited an example of using integral abutments to eliminate deck joints. He said the old adage that you can only have two of the following – rapid construction, high quality, low cost – is not true for prefabricated bridges because temporary bridges, costly staged construction, and extended onsite construction time can be eliminated. Mr. Culmo also described other ways to save money in accelerated construction, including standardization so that contractors can use the same details, by making ABC programmatic to have multiple bridges with the same details, by reduced project site time, by reduced maintenance of traffic, by reduced inflation due to shorter project time, and other non-bid savings. Value and standardization are the keys. He closed by discussing several ABC projects where money was saved.

Following his presentation, Mr. Culmo was asked several questions:

- In response to a question on how to do the integral connection between the beam and the abutment, he responded that the PCI Northeast Bridge Technical Committee has just developed a detail that uses couplers and a precast backwall to create a back form and support for the approach slab. The beams are set with forming only between the beams, followed by a simple closure pour. Essentially a bathtub is created into which concrete is poured.
- In response to a question on options other than steel railing for states such as Florida that do not use steel railings, he responded that railings are required to be crash tested. Only a handful of precast concrete railings have been crash tested to date. Any of those can be used. Another option is to slipform the railing, as done in some states. Slipforming can go quickly, for example, 200 ft of railing can be slipformed in an hour.
- In response to a question of whether the manual includes details for railing-to-deck connections, he responded that each state has its own standards that are essentially bolt-down details. Most of the details are proprietary systems. The manual discusses those railings but the details are not in the manual.
- In response to a question on whether the 250 psi concentric longitudinal post-tensioning for the precast decks is a minimum and if there is a design for it, Mr. Culmo said Virginia Tech has recently completed research recommending that the post-tensioning could go down to 200 psi but not below that level. He said most states like to use post-tensioning. The code currently recommends 250 psi but does not say whether that number is a final number after losses; that question is under debate now. Most states use 250 psi at release, with some losses occurring over time due to creep and shrinkage. Just using 250 psi at release makes the design simple. That level is relatively high for a deck. The deck wants to creep and shrink while the girders restrain it, making this a complex problem, so most designers use 250 psi at release and let it go. NCHRP 12-65 has developed a precast deck panel connection that does not have post-tensioning; a bar is dropped into a slot; that is a good detail as well. The Texas DOT has constructed a bridge deck per NCHRP 12-65, with no longitudinal post-tensioning.
- In response to a question on whether zero tension should be designed for continuous structures with deck panels to avoid long-term maintenance problems, he said his firm recommends increasing the post-tensioning in the negative moment regions to end with 250 psi net after dead loads are applied, for zero live load tension.

- In response to a question on increasing the AASHTO LRFD specification requirement of maximum 2-ft shear pocket spacing over the girders, Mr. Culmo said that no one can remember the origin of the 2-ft maximum shear connector spacing. Texas and other states have used 4-ft pocket spacing. Maher Tadros has conducted research on 4-ft pocket spacing using larger 1.25-inch diameter shear studs, but an issue is the large number of studs required in each pocket. Virginia Tech's recent research also found pockets get congested using 4-ft spacing. Another issue is the large size of the pockets at 4-ft spacing, and minor problems with hairline shrinkage cracks have been seen around the perimeter of the pockets. Mr. Culmo clarified that the shear connectors are studs on steel beams and shear reinforcement on concrete beams.

4.3 SHRP2 Project R04, Innovative Bridge Designs for Rapid Renewal

Frank Russo is PI for the Strategic Highway Research Program 2 (SHRP2) R04 project entitled "Innovative Bridge Designs for Rapid Renewal." He said the focus of the R04 project is on rapid replacement as a common way of doing business. The major questions are how to construct bridges quicker, how to make them durable for 75-100 years, and what technical and deployment issues are in the way.

This is the first year of the four-year research project. The research team has surveyed approximately half the State DOTs. Some of the major themes from responses are that there is a strong impetus in their departments to implement ABC. This is either coming politically from elected officials, from Commission level, or from technical staff. They also say that the support is strong at most levels and is deep enough for this to take hold. Those agencies that have been reluctant to use accelerated construction list construction and implementation costs as the main impediment, e.g., new standards, new design manuals, technical training, plus the construction costs. Accelerated construction when used has a remarkable satisfaction rate. These contracts have typically been either design-build with A+B bidding components, incentive/disincentive, or some form of innovative contracting. They have not traditionally been hard-bid jobs with owner-supplied plans with innovative construction as part of the concept.

State DOTs said that traffic and worker/public safety were the most common reasons for using ABC. Few agencies have a formal process to identify or screen for ABC projects. Common answers for not using ABC are they do not believe there has been sufficient research to support certain connection details or structural concepts, or it is an issue of institutional change. Five agencies responded with substantial details on their ABC projects. Only one of those five agencies treats user costs as real costs. Most agencies use user costs as a measure of whether the project makes sense but not as a financial offset; it is just some measure to help them understand if there is a significant need for accelerated construction at a particular site. When asked whether the accelerated construction projects were worth the extra cost, all five of the State DOTs said yes.

Dr. Russo said there are many flavors of ABC and no one is promoting a strategy that all 50 states should adopt. The states are taking various approaches, all of which are working fairly well for them. For example, Florida was an early adopter of self-propelled modular transporter (SPMT) technology. They have several SPMT projects completed and more are planned. They also use precast pier construction. Texas makes significant use of prefabricated bridges and has sponsored research, e.g., on precast bent cap connections.

Utah is making ABC a standard practice by 2010. North Carolina has created an alternative delivery unit.

Dr. Russo then discussed innovative contracting used by several US bridge owners as well as the European model. He described various accelerated construction technologies used in the US and around the world, e.g., gantry beam erection used in the US and full-span launching segment delivery used in China. He also discussed the use of ABC in bridge foundations, e.g., FHWA's geosynthetic reinforced soil (GRS) bridge abutments.

The R04 project will continue data gathering and reviews, determine which methods have promise, implement new research, and coordinate with other related SHRP2 projects. The goal is new bridge designs that better use innovative construction techniques, and new or refined construction techniques for existing bridges and new bridge designs.

5. The Keys to ABC Success from Contractor and Owner Perspectives

Presentations were given on the keys to accelerated bridge construction (ABC) success from both the construction contractor's perspective and the State DOT bridge owner's perspective. (Note: See Appendix B for presenter bios and Appendix D for Iowa DOT link to view and download the presentations.)

5.1 Keys to ABC Success from a Contractor's Perspective

William G. (Bill) Duguay, construction contractor with J.D. Abrams, LP in Houston, Texas, gave the presentation on keys to success on ABC projects from a contractor's perspective. He talked about contractor relationships, what the contractor likes about ABC, and thoughts to keep in mind as ABC is implemented so that the contractor community can help keep it on target to meet the goals. All share the same mandate to change the way highways are built, to build them faster to last longer and be safer at a lesser cost. Thinking needs to be changed from the old school to the new school to be bold and audacious as stated by former DOT Deputy Secretary Michael P. Jackson.

Many of the players are old school, but ABC and other new ways of doing business require learning how to make what worked previously also work in this new market. ABC can be successful when the contractor is provided an opportunity to have a competitive edge. This can be done through means and methods, available equipment, time of year and current workload, and existing technology or availability of major supplies in the market place. The philosophy must be successful across the board and needs to fit the limits of the organization.

ABC is really about efficiency. Efficiency can be defined by simplicity of design and specifications, by having the costs and benefits in line with expectations, by including aesthetics that are appropriate for the location and use, and by meeting longevity and life-cycle cost goals.

An important part of the ABC program is to share or define the risk. The contractors' perceived level of risk translates to dollars on bid day and may prevent interest in the project. The owner should limit what is incidental and what cannot be defined by specification or plans. To be effective it needs to be achievable with acceptable risk, predictable in a variety of applications, and satisfy the majority or as a minimum the most important goals.

Prefabrication, including precasting, provides the opportunity to accelerate. With prefabrication a contractor has lower risk from uncertainty, labor availability or quality, access or site constraints, and weather. With prefabrication a significant number of man-hours are spent in a controlled low-risk environment or subcontracted out for a fixed price. Contractors like to self-perform as much as possible, but they also like to subcontract for fixed pricing to transfer risk.

Repeatability is a key for ABC. Multiple repetitions drive contractors' cost reporting. Cost for first-time use is typically more expensive. With multiple repetitions, cost can be improved over time. The fewer new operations on a larger ABC project, the more time is available to refine ongoing operations.

Precast specifications are rarely ambiguous, and erection or assembly of components is typically straightforward. Lower costs are obtained with clean and simple details.

Priority projects can be profitable. Fast-track projects can and should use incentive/damage clauses. The plans and specifications should not be geared toward the contractor having to spend an equivalent amount to earn the bonus.

Successful ABC means developing an idea that meets the needs, selling it for a price that meets the needs, and building it in a timeframe that meets the needs. Contractors do not like undue risk or schedule demands. Fast-track projects should be reserved for when the acceleration is needed. Specifications that unduly favor one party are ones that typically are faulty and are used to cover less than satisfactory plans and detailing. If risk is inappropriately placed on the contractor, the bids will be higher in cost and fewer in number. If risk is inappropriately placed on the owner, there will be concerns related to performance, quality, and sustainability. Plans and specifications should keep risk in the center of the table.

Project goals must be communicated effectively. There is a national movement to eliminate details, phasing requirements, and schedule demands from the plans, and allow the contractor and the contractor's engineer to develop a significant portion of it. Some say this drives innovation; others say it gives up too much control. In either case, it should be a project goal and communicated effectively.

A contractor's perception is reality on bid day. Cost will be driven by the contractor's perception of undefined items of work or method/timing of payment, restrictive specifications, and poorly crafted bid documents.

Sole sourcing may be necessary due to approved lists from an agency, but they limit competitive advantage. If sole sourcing is necessary, develop ways for the contractor to maintain an edge. Make sure the sole source will be able to meet the demands of the project prior to specification. Similarly, one-of-a-kind designs limit the re-use of technology, equipment, forms, yards, cost history, and personnel.

The owner and the contractor need to understand the perspective of each other related to speed, quality, traffic disruption, and cost, e.g., use of electronic transmission of documents saves contractors time and improves quality and costs.

In summary, specify the different roles for participants, assign responsibilities and authority to team participants, define turn-around times for information transfer, ensure all participants are equal stakeholders, make sure processes and staffing match the requirements of the project, and follow through with the objectives by critical evaluation. Partnering from concept to completion will ensure project success. Embrace the drivers of price and schedule: repeatability, durability, reliability, adaptability, survivability of the idea, and profitability.

Following his presentation, Mr. Duguay was asked several questions:

- In response to a question on how often he has problems on the job because the owner does not understand the contractor's situation and needs, Mr. Duguay said that in an ABC partnering process, both the owner and contractor are working for the job. It is not one side's problem. Sometimes the agency is more capable of resolving the problem and sometimes the contractor is more capable of resolving it. Some agencies may be hesitant to alter their way of thinking to allow a contractor's redesign to be integrated into the design. Mr. Duguay said he is fortunate that he has not often run into this issue.
- In response to a question on how often for proprietary reasons he is unable to explain his situation or needs, Mr. Duguay said that once it is on the job, it is common knowledge. Sometimes contractors only submit what is called out by the contract because they do not want it to go into the public domain. The better a problem is understood, whether it is new equipment that has been bought or new methodology being used, the more agreeable the other party is going to be to help solve the issue. Partnering is really about developing a level of trust so that both parties at any point in the project can talk back and forth to resolve whatever needs to be fixed.

5.2 Keys to ABC Success from a State DOT Owner's Perspective

Jim McMinimee, Director of Project Development at the Utah DOT, gave the presentation on keys to success on ABC projects from an owner's perspective. He discussed how the Utah DOT defines ABC, the benefits and why they are using ABC, some examples of completed and future ABC projects, and some lessons learned.

Utah defines ABC as innovative methods to decrease bridge construction time. The idea is to build elements offsite so that traffic is not impacted, and then to transport them to the site and install them rapidly. Benefits include minimized traffic disruptions from months to days, improved work zone safety and worker safety, and improved product quality due to the controlled environment, cure times, and easier access.

Utah thinks of ABC as a family of innovative elements and methods that includes precast concrete elements, modular construction where pieces of the bridge are constructed near site and then moved in with a crane or pushed over, and structure placement methods such as using self-propelled modular transporters (SPMTs). Utah also uses accelerated geotechnical work in conjunction with ABC, as well as fast track contracting. Precast concrete elements used in Utah include post-tensioned approach slabs, post-tensioned deck panels and bent caps, abutments, columns, wingwalls, and footings. Modular construction used in Utah includes prefabricated modular steel bridge systems, prefabricated concrete arches, precast concrete segmental superstructures, and precast concrete box culvert systems. Structure placement methods used in Utah include bridge launching, SPMT and other heavy lift systems, and sliding systems. Accelerated geotechnical work has included geofoam, lightweight fill, and stone columns to help with settlement. Fast track contracting has included 17 projects with Construction Manager General Contractor (CMGC), $1 billion design-build in the process of letting or under contract, lane rentals, A+B and A+B combined with design-build, and total closures. All these methods are complementary to ABC. The Utah DOT calls this accelerated project construction; the whole project needs to be accelerated, not just the bridges.

Mr. McMinimee said the reason Utah is doing ABC is because of its desire to increase project delivery and decrease the amount of time that users are impacted by construction.

The traditional business model uses lowest construction cost. This was a successful business model that built the existing interstate. Competition determines the lowest construction cost, and contractors select time and method for the lowest cost project. This model built the interstate on new alignment that did not impact traffic.

Now reconstruction is being done in locations that have societal cost, on existing roads where users are impacted. Societal cost versus time is a linear relationship where cost depends on the volume of traffic. The longer the construction takes, the higher the impact to users. Utah's new business model explains why more money is needed to speed up construction of projects. The sum of the construction cost and the user cost is the lowest project cost; the Utah DOT's business model has gone from the lowest construction cost to the lowest project cost where societal costs are minimized. This new business model has lead to political capital and public praise. Previously Utah was primarily a federal aid state. Now Utah is a state that has only 15 percent federal money each year. Its current construction budget is $1.8 billion for 178 projects under construction this summer. Utah DOT paid attention to delivering projects, and the better it got at delivering projects, the more money the legislature was willing to provide. Mr. McMinimee said the legislature understands the new business model and that transportation is the economic engine that drives the State. He said they have demonstrated commitment to ensure that money is available to decrease impacts to users to increase the quality of life in Utah.

Mr. McMinimee said the Utah DOT is looking for new methods that cost less. He said conversations likely took place 50 years ago when people said it would cost too much to cast girders offsite and haul them to the site. Now it is the standard. Girders are an example that shows that prefabrication is cost-effective. ABC has the potential to provide similar savings. If cost to users in work zones is quantified, a strong cost-benefit ratio becomes apparent for using prefabricated systems on high volume roads. The Utah DOT has been tracking its ABC projects, and its numbers are now showing 5-to-1 in terms of benefit-to-cost ratio on its ABC projects.

Utah has completed 17 projects to date that utilize ABC, including a total of 80 bridges. They have an additional 40 ABC projects under construction. These projects include bridges moved with SPMTs, half-depth and full-depth deck panels, precast voided slabs, a segmental bridge and a bridge utilizing heavy lift cranes.

The fastest deck that UDOT had previously constructed took 15 days; it was an emergency deck replacement in downtown Salt Lake City that used high-early-strength concrete. To reduce that time UDOT constructed its first project that it called ABC in 2004, a rapid deck replacement over I-80 near Wanship. This was a rural county bridge deck replacement that took 10 days. The panels were site cast. The total construction cost was $366,000 of which the ABC cost was estimated to be about $10,000. An estimated 90 days were saved by using prefabrication. With a facility user cost of $4,000 per day, this resulted in a benefit-cost ratio of 36. Now, after having done many deck replacement projects, the precasters use steel casting beds and steel blockouts, and they requested that UDOT develop precast deck panel standards.

Also in 2004 UDOT built a full superstructure replacement on the I-215 East Bridge over 3760 South. These were span-length half-width precast-deck-on-steel-girder segments that were lifted in place with cranes. A crowd of about 150 citizens showed up to watch this project. The total construction cost was $2.7 million of which the ABC cost was

$600,000 mainly for the heavy cranes. The project was projected to take 90 days, with 30 days saved by using prefabrication. With a facility user cost of $34,000 per day, this resulted in a benefit-cost ratio of 2.

In October 2007 UDOT moved its first bridge with SPMTs, the 4500 South Bridge over I-215. UDOT closed I-215 at 10 p.m. on Friday night. By the next Monday morning, the 4500 South Bridge was in place. It is 173-ft long and weighed 3.5 million pounds. The total construction cost was $7.7 million of which the ABC cost was $900,000 mainly for mobilization and use of the SPMTs. An estimated 120 days were saved by using ABC. With a facility user cost of $35,500 per day, this resulted in a benefit-cost ratio of 5. The existing 4500 South Bridge was structurally deficient, and a construction season was saved by using CMGC in combination with ABC. Approximately 4,000 citizens watched the bridge move. Mr. McMinimee said now the public is asking to see more ABC projects.

Mr. McMinimee said current UDOT ABC projects include the following:

- Three large bridge deck replacement projects (600 ft, 400 ft, and 150 ft in length) are being reconstructed on I-84 between US 80 and SR 167 in Weber Canyon. The decks are being replaced with precast deck panels on the existing steel girders. Overhead power lines limit crane size and access, and reverse curves make fitting the panels complex. A railroad under one structure limits access for work, and the Weber River crossing also increases complexity. This is a design-build project with Wadsworth.
- A wildlife crossing and MP 200 railroad bridge are being constructed on US 6 completely of prefabricated elements – abutments, decks, parapets, and approach slabs, and steel diaphragms. This project also saves an entire construction season by using prefabrication.
- Seven bridges are being replaced on I-80 between State Street and 1300 East. The bridges are being constructed on a nearby “bridge farm” and moved to the location using SPMTs, transferred to a skid-shoe-and-rail system to skid them into final position, and then lowered to final elevation using climbing jacks. This was a $130 million design-build project. The contractor proposed the bridge farm and the use of SPMTs to be able to build the project in two seasons rather than three. The heaviest superstructure weighed three million pounds. These seven bridges are all now in place.
- The I-80 East and Lambs Canyon project is on the interstate between Salt Lake City and Park City. The contractor had 24 hours to replace the two bridges, and they completed the work in about 22 hours. The two bridges were being replaced simultaneously. The existing I-80 bridge was removed in an hour with SPMTs, and within four hours of the bridge closure the new bridge was in place. The existing Lambs Canyon Bridge was conventionally demolished in four hours and then the SPMTs moved in the new bridge.
- The 3300 South Bridge over I-215 is the remaining SPMT bridge move to be completed during the summer of 2008.

Mr. McMinimee discussed ABC lessons learned and best practices:

- The number one lesson learned is to engage the industry, including the construction contractors, suppliers, and designers, all working in partnership with the owner.
- UDOT is tracking its ABC costs. For example, the first full-depth precast deck project cost about $63 per sq ft of deck area compared to conventional cast-in-place deck cost of $52-53 per sq ft. As more precast deck replacement projects were constructed, the number of bidders has increased and the costs have come down, with the latest

project bid at $38 per sq ft. While there are not enough projects to be statistically valid, this is a good indicator trend of what can happen with ABC projects.
- Get the Department leadership committed to ABC. UDOT has also done outreach to the legislature.
- Obtain funding for demonstration projects, for example, FHWA's Highways for LIFE program and Innovative Bridge Research and Deployment (IBRD) program.
- Change the process. Start at the concept level with dedicated funds and initiate within the central structures design group.
- Use decision support tools for ABC methods, starting with FHWA's decision-making framework for prefabricated bridges as well as other FHWA tools.
- Apply the synergy of innovative contracting.
- Identify a program of projects. The owner must demonstrate commitment to ABC.
- Perform scanning tours. UDOT took construction contractors, design consultants, and department personnel to other states to see ABC projects.
- Get involved nationally, for example, workshops such as this one.
- Implement standardization.
- Educate and communicate within the industry.

Public opinion is an important reason to become involved in ABC. UDOT has done surveys with the public on its projects. Typically about a third of the public does not like the project, about a third says it was good, and about a third do not care. However, for the first SPMT bridge move project in 2007, the survey showed the majority were very satisfied with the project. That told UDOT that people would like more ABC projects.

Mr. McMinimee ended his presentation by mentioning a recent trip to Greece where he visited the Acropolis in Athens. Among the rubble he found prefabricated pieces. He said even back then they must have seen the benefit of prefabrication.

6. Iowa DOT ABC Projects to Date

6.1 Projects Overview

Jim Nelson in the Office of Bridges and Structures of the Iowa DOT presented the Iowa DOT's accelerated bridge construction (ABC) experience. The Iowa DOT has done six ABC projects to date. Five are test projects and one is a production project. Of the six projects, four are complete, one is currently under construction, and one of them is at the beginning of the conceptual stage. Two of them are not really bridge projects because they deal with the approach paving but are included because they touch the bridges.

6.2 Boone County Mackey Bridge Replacement

This bridge received FHWA Innovative Bridge Research and Construction (IBRD) program funding and was totally precast. The bridge owner is Boone County, the designer was the Iowa DOT, the fabricator was Andrews Prestressed Concrete in Clear Lake, and the contractor was Peterson Contractors Inc. Iowa State University did the testing and monitoring.

The replacement structure is a two-lane, precast pretensioned concrete beam bridge with steel H piling and pipe piling foundation and gravel approach roadway surface. It has three spans (47'-5", 56'-6", 47'-5") for a total roadway width of 33'-2" and 30'-0" gutter-line to gutter-line. Awarded in March 2006, the bridge portion of the winning bid was approximately $0.5 million, equating to $90 per sq ft bridge unit cost. A comparable conventional bridge would have cost about $60 per sq ft.

To make construction faster, prefabricated components were used. By changing from a DOT standard design to a custom design, the number of beams per span was reduced from 5 to 4, resulting in a beam spacing of 8'-4", and full-depth precast deck panels were used. The panels were transversely pretensioned and longitudinally post-tensioned. The substructure consisted of precast integral abutment footings on H-pile foundations and precast pier caps on pipe pile foundations.

The abutment footing was a legal load for transportation. The abutment footing was delivered and set in place in less than 30 minutes. The H piling at the abutments were driven in about half a day. Therefore, theoretically the H piles and abutment could have been placed and grouted in one day. For this project a re-tap of the H piles was required to get full capacity. For future accelerated projects, rather than being highly economical in the piling design, Mr. Nelson said it may be preferable to add 5 to 10 ft to avoid a re-tap on the critical path.

A corrugated metal pipe (CMP) was used to create a blockout in the precast abutment footing. The Iowa DOT specification requires a start-of-driving tolerance, but not an end-of-driving tolerance. For this project an end-of-driving tolerance was added in the plans. The 21-inch diameter CMP and the piling tip-to-tip on the diagonal of just over 15 inches resulted in about 3 inches of tolerance in any direction to allow the cap to fit over the piling. The contractor had no problem with these tolerances.

The precast pier cap was erected in about the same time frame. The contractor built falsework to support the precast cap, and this falsework was also used as the driving template to drive the nine pipe piles. The 16-inch diameter pipe pile and the 21-inch CMP resulted in about 2.5 inches of tolerance in any direction. Once again the contractor had no problem meeting those tolerances.

The voids in the blockouts were filled with a high-early-strength concrete mix having a high cement content, low water-cement ratio, and small 3/8-inch top-size aggregate. Due to the low slump a high-range water reducer was used to get good workability and consolidation. The concrete mix was key because the concrete curing was on the critical path, with 3,500 psi required to set the beams. Curing conditions were good for the first pour, with high-60s during the day and mid-40s during the night in late September to early October. These conditions resulted in 2,200 psi in 24 hours. Mr. Nelson said for cooler weather the contractor may need to heat the components to speed curing and keep the project moving.

The superstructure was constructed with traditional pretensioned concrete beams. Beam and diaphragm erection took 6.5 hours. The precast deck panels were similar to the NU-deck developed in Nebraska. The panels were pretensioned transversely and post-tensioned longitudinally. The 32 interior deck panels were identical, and the four end panels had post-tensioned anchorage zones that required two unique panels at each end because the bridge was skewed.

A cast-in-place longitudinal joint was placed at midspan to accommodate the roadway crown. Mechanical splicers were used for barrier rail post connections. The panels had V-shaped transverse edges and cast-in-place transverse closure joints. An open channel ran over the beams for the longitudinal post-tensioning. The open channel was bridged by mild reinforcing that was in compression after the pretensioned strands were released. A total of 12 post-tensioned strands were in two layers in each channel, for a total of 48 post-tensioned strands in the bridge.

Mr. Nelson said the deck panel erection sequence included setting panels, leveling panels, casting transverse joints, longitudinally post-tensioning, and casting longitudinal joints and abutment diaphragms. A legal load was three panels per truck. Half the panels were erected in one day, and the other half were erected in half the time the next day. The contractor designed the leveling device to set the cross slope and longitudinal grade. Casting the transverse joints took half a day. A minimum age prior to use was specified to control losses in the post-tensioning, and the end panels ended up on the critical path because of the required cure time. The post-tensioning operation took about four hours. The design was 250 psi deck compression, with slightly less obtained in the field. The concrete in the longitudinal joints was cast the same day.

A cast-in-place closure at the end was used to create the integral abutment. The deck panel portion of the bridge was nine inches longer than design. This was likely due to fabrication of the panels at the high end of their tolerance, and transverse closure joints at the high end of the specified half-inch tolerance. The cast-in-place closure accommodated the extra length.

The contract had a bid item for surface profile grooving and grinding. This was done although it was smooth enough for a gravel road without it.

Iowa State University (ISU) had a significant testing and monitoring role in this project to validate some of the design assumptions. One concern was the interface between the abutment joint concrete and H pile and the pier cap joint concrete and pipe pile. ISU tested a mock-up with no significant cracking or problems. The connection exceeded the geotechnical capacity of the piling; Mr. Nelson said this is one area where the connection may be made more economical. ISU also load tested the deck panels and monitored strains during panel erection.

Mr. Nelson said opportunities for improvement included the following:

- Pretensioning the substructure. The substructure for this bridge was precast but not pretensioned.
- Matching the skew of the stirrups to the skew of the panels. The panels were skewed to the bridge but the beam stirrups were not skewed, causing conflicts at places where the reinforcing bars crossed.
- Wider beam flanges. The pretensioned concrete beams in the interior span had a 16-inch-wide top flange, whereas the exterior spans had a 13-inch-wide top flange. The longitudinal channel over the beams was 10 inches wide. The panels for the interior span were set without problems because they had 3 inches of tolerance on each side of the channel. The exterior spans had only 1.5 inches of tolerance on each side of the channel, and that was tight for the contractor.
- Leveling device system. It worked but there is room for improvement.
- Haunch-forming system. This was a time-consuming process for the contractor. They chose to form it by stick building. They tacked wood up and it was not efficient. They used about 50 man-hours to build the haunch forming for the bridge.
- High-early-strength concrete mix. The contractor must be ready for weather conditions to get strength in an accelerated fashion.

6.3 Council Bluffs 24th Street over I-80/I-29 Bridge Replacement

Mr. Nelson said this deck panel project is currently under construction and about 50 percent complete. The bridge owner is the Iowa DOT, the designer was HDR Engineering Inc, the deck panel fabricator was Coreslab Structures in La Platte, Nebraska, and the contractor is Cramer and Associates. Iowa State University is doing the testing and monitoring.

This bridge is the first component of the Council Bluffs Interstate System Improvement project that includes I-80 and I-29 in Council Bluffs. It is an FHWA Highways for LIFE project ($1 million) and has some FHWA Innovative Bridge Research and Construction (IBRC) program funds. It has accelerated construction and is at a critical location. The existing structure is being replaced with a two-span, 354-ft long and 106-ft wide steel girder bridge. Staged construction will be used to maintain one-lane traffic in each direction plus a turning lane.

A variety of innovative techniques are being used to improve safety and reduce impact on the traveling public. Those techniques include full-depth precast deck panels, Iowa DOT's high performance concrete developmental specification, high performance steel, structural health monitoring system, a new detail called fully-contained flooded backfill, A+B bidding, and intelligent transportation system.

The project was let in October 2007 and the bridge will be completed by Fall 2008. The Iowa DOT put a maximum of 210 days in the contract, and the winning bid was 175 days. Road user costs were $1,500 per day. Up to 14 closure detours of I-80/I-29 were allowed, with liquidated damages of $4,000 per hour if the specified time to open was not met. The bridge portion of the winning bid was $5.9 million, equating to $140 per sq ft bridge unit cost. A comparable conventional bridge would have cost about $120 per sq ft.

One lane in each direction and left-turn lanes will be maintained on the 24th Street Bridge throughout construction, and the current lanes of I-80/I-29 will be maintained during peak traffic hours. Some overnight closures will be required to both 24th Street and I-80/I-29. Initially the existing bridge will be partially removed to construct the first stage of the new bridge. Then traffic will be switched to the new portion of the bridge to construct the remaining half. A longitudinal closure joint will then be constructed to complete the bridge.

The full-depth precast concrete deck panels will be transversely pretensioned and longitudinally post-tensioned. The deck will have cast-in-place transverse joints between the panels and a cast-in-place longitudinal joint to tie the two construction phases together. A 2-inch Portland cement concrete overlay will be constructed over the panels. The bridge will have a total of 70 deck panels. Twenty-eight longitudinal ducts are spaced across the deck width, with each duct having four post-tensioned strands. The panels are 52-ft long and 10-ft wide. An optional leveling bolt detail was included in the plans. The lifting loop detail was not specified in the plans.

The contractor chose to use self-consolidating concrete for the panels. Each panel pocket had six studs, varied in height. The plans did not specify whether the studs were to be installed in the plant or in the field; the contractor chose to install them in the field.

The contractor was given choices for the minimum concrete compressive strength of the panels relative to age at time of post-tensioning, ranging from 11,000 psi at 28 days to 8,000 psi at 100 days. The contractor used 10,000 psi panels post-tensioned at 40 days. It took 1.5 days to post-tension the 112 strands. Following post-tensioning, the shear stud pockets were filled with self-consolidated concrete per the contractor’s request. A 12-inch wide longitudinal closure joint completed the deck construction.

Iowa State University (ISU) did pre-construction testing that included investigating the shear stud installation and bend testing, evaluating the concrete consolidation in the shear stud pocket and beam haunch, and evaluating joint shear transfer. Where cast-in-place concrete is placed against deck panels in the field, the Iowa DOT specified roughening by sand blasting. ISU did comparative testing with a sand blasting mock-up, a checker plate mock-up, a chemical etching mock-up which consisted of coating the forms with a retarder followed by power washing, and a mock-up with no treatment. The sand blasting performed almost five times better than any of the other treatments.

Other innovations include the structural health monitoring system to monitor construction stresses and long-term performance. The bridge is wired with corrosion sensors on dummy post-tensioning strands, a load cell in the deck panels to monitor the post-tensioning, strain gauges on panels during erection to measure stresses, and strain gauges on panels and girders for a diagnostic load test. High performance concrete is being used on this bridge primarily for improved permeability characteristics to ensure durability. High performance steel is being used in the girders, with HPS 70W in the bottom flange and the top flange in the negative moment region, also providing improved toughness and corrosion resistance. Fully-contained flooded backfill is being used to minimize approach settlement and avoid the bump at the end of the bridge. This includes a new compaction detail and a large paving notch. The process includes lining the area with a filter fabric, having a subdrain, using lifts of sand, flooding, and using vibratory compaction to consolidate. Based on the successful use of an intelligent transportation system (ITS) on a similar urban project in Iowa, ITS will be used on this project to manage traffic delays during construction and ease congestion after construction.

In summary, Mr. Nelson said the Iowa DOT is pleased with the HfL and IBRC programs that provided opportunities for accelerated construction innovations. This allowed many innovations to be introduced. Also, collaboration with the industry was important for the success of this project, and laboratory testing to validate design assumptions prior to construction will reduce risks.

6.4 Madison County Bridge Replacement

Mr. Nelson said this was a small single-span bridge using all precast components. It received $200,000 IBRC funds. The bridge owner is Madison County, the designer was the Iowa DOT, the box beam fabricator was Andrews Prestressed Concrete in Clear Lake, and the contractor was Peterson Contractors Inc. Iowa State University is doing testing and monitoring.

The replacement structure is a 46'-8" long, 24'-0" wide, single-span bridge composed of six precast pretensioned concrete box girders. The bridge has precast abutment footings, steel H pile foundation, and gravel approach roadway surface. The bridge portion of the winning bid was approximately $121,000, equating to $102 per sq ft bridge unit cost.

Instrumentation includes corrosion sensors on girder pretensioned strands. Surface texture was applied to the girders in the plant, with no grinding or surface texture applied in the field since this was a gravel road.

The box beams were designed with a precast integral backwall. This was changed to a cast-in-place backwall by contract modification at the county request. The opportunity for improvement on this project is the elimination of the cast-in-place backwall for future projects.

6.5 Buena Vista County Project

Mr. Nelson said this project is conceptual now and will be let in early 2009. The bridge owner is Buena Vista County, and the designer is the Iowa DOT. The Iowa DOT is considering using all precast concrete components for this small bridge, including precast wingwalls and making improvements on what was done in Madison County.

6.6 O'Brien County Precast Approach Panel Demonstration Project

These approach panels were precast and post-tensioned in the field. They had match-cast transverse joints and cast-in-place longitudinal joints. The precast panels were added by contract modification and were adjacent to conventional cast-in-place construction. The precast panels were $739 per sq yd compared to $120 per sq yd for conventional construction. ISU had significant instrumentation on these panels.

6.7 Marion County Precast Paving Notch Demonstration Project

Mr. Nelson said the bump at the end of the bridge can be caused by several construction issues. Dirt on the paving notch when it was cast, subgrade not level with the paving notch, deterioration of the paving notch, and voids can all lead to the bump at the end of the bridge. Three mock-ups were done at ISU: cast-in place, precast, and precast with ultra-high performance concrete. ISU eliminated ultra-high performance concrete as not being necessary because of good performance of the precast concrete.

A demonstration project was done on Iowa 5 near Knoxville. The existing paving notch was initially saw cut and then jack hammered off; in the future Mr. Nelson said they will likely do a full-depth saw cut. The same form was used for the precast paving notch as was used for the precast piling, eliminating the need for the fabricator to buy new forms. A bonding agent was applied, and epoxy anchors attached the precast units. The holes were then injected with grout to fill the voids where the bars came through. Flowable mortar was used to backfill under the paving notch. Cost of the precast paving notch was $145 per linear foot, compared to cast-in-place at $44 per linear foot.

7. ABC Projects in Other States

State DOT presentations were given on accelerated bridge construction (ABC) projects in three states: California, Texas, and Washington State. (Note: See Appendix B for presenter bios and Appendix D for Iowa DOT link to view and download the presentations.)

7.1 ABC Projects: California

Ray Wolfe with the California Department of Transportation (Caltrans) gave a presentation on California's ABC practice. He said Caltrans is interested in accelerating its project delivery. Caltrans' mission/vision states that it "enhances mobility across California," and he said that Caltrans understands this cannot be done using conventional construction and project delivery techniques. Caltrans is motivated to move forward with the use of innovative techniques and to create standardized techniques for day-to-day use. Fear of the initial cost of innovations exists, but Caltrans understands that more standardization of the innovations can be expected to reduce costs to levels that are competitive with conventional construction. Since its construction boom of the 1950s through 1970s, California has traditionally built cast-in-place box girder bridges, one of the only states that still do that type of construction, and industry has a reluctance to move away from it because that is the type of construction they are geared up to do. Another issue is seismic concerns, although Caltrans has done research that mitigates some of those concerns. Another concern is risk, since innovation does not necessarily lead to success.

With each of its projects, Caltrans looks at its project goals and how the project can be accelerated if needed. Acceleration is included when there are safety concerns with an existing facility or when it is an emergency project, has seasonal construction windows, political pressure, or impact to the traveling public such as detour length and trip time delay.

California has earthquakes, and Caltrans' premise for design is no collapse. Caltrans understands that the structure may require replacement after the earthquake, but collapse is to be avoided. It tries to force all the damage into the substructure, either in the base or top of the column in the plastic hinge zone, to limit the amount of damage and protect the bent cap and superstructure. The connection detailing is critical to transfer loads such that the location of damage is limited to areas that can be repaired. Caltrans is continuing research into these connections to ensure they provide the capacity needed to meet the demands expected in a major event. Caltrans is also considering a move toward the Japanese philosophy of superstructure isolation for seismic mitigation rather than its current philosophy of depending on the connection details between the superstructure and substructure and its elements. This could also help deploy ABC in California.

Dr. Wolfe said Caltrans has put together a strategic action plan to move forward with ABC and has also written a lessons-learned document. Both are available in electronic format. The plan pursues further widespread ABC practice for future standard bridge projects. Caltrans is reaching out to industry and in the next six months is planning a forum with the general contracting community to bring them on board to assist with developing techniques. More research is planned, particularly looking at connections in collaboration with FHWA, TRB, and NCHRP. Caltrans is also developing ABC selection criteria similar to FHWA's "Framework for Prefabricated Bridge Elements and Systems (PBES) Decision-Making" (see Appendix D for reference).

The lessons learned document was developed about a year ago by Caltrans to look at projects in which ABC techniques were deployed in California in the last five years. The projects were divided into emergency projects and planned (non-emergency) projects. Included were the project goals; why a particular ABC innovation was used to try to achieve those goals; what some of the obstacles were that had to be overcome in the design, construction, and contracting process to make this work; how it worked; and lessons learned that could be applied if that method was used again.

Dr. Wolfe said as Caltrans moves forward in developing its strategic action plan, part is research driven and part is technical specification development. In its development of ABC design specifications and standard details that address seismic demands, Caltrans is making use of existing resources such as the FHWA Connection Details Manual. It is assessing long-term connection durability and maintainability and is considering installation of monitoring devices. Caltrans is developing inspection practices, looking at non-destructive evaluation methods and tools, and investigating potential corrosion issues. Caltrans will perhaps be changing maintenance practices to address some of the new innovations deployed in the field.

Dr. Wolfe then discussed several of Caltrans' ABC projects, first four emergency projects (all A+B bidding with incentives/disincentives), then a planned (non-emergency) project, and last a project damaged in the recent Chino Hills earthquake. A lesson learned in California is that innovative engineering must be combined with innovative contracting methods (e.g., A+B bidding, incentives/disincentives).

7.1.1 <u>Emergency Projects</u>

The Russian River Bridge in the Napa Valley area of northern California had scour damage and pier settlement during heavy rains in December 2005 and was closed. Environmental constraints prevented construction from starting before May, and there was political pressure to get the bridge opened before school started in the fall. The bridge was designed using standard AASHTO precast box girders. The contractor proposed an innovation to change the girders to precast pretensioned non-standard double tees; this cut the number of girders by half (from 120). Construction occurred from May to August 2006, with the bridge opened in time for the start of school.

The second emergency project was along Interstate 40 in the Mojave Desert in southern California. Twelve bridges on the divided highway were in substantial distress due to ASR, traffic impact loads, and girder spacing. The location was remote with moderate seismic concerns. Precast girders were used. One bridge, Marble Wash Bridge, was on the critical path and built with part of its abutment precast; the precast abutment weighed 82 tons and was transported 170 miles from the precast plant to the site. The entire abutment was not precast due to weight concerns. Caltrans has subsequently constructed entire precast abutments.

The third emergency project was on the I-580/I-880 (MacArthur Maze) connector. On April 29, 2007 a gasoline tanker traveling on the I-880 connector crashed and burst into flames immediately below the I-580 connector. The I-580 connector was a steel girder structure with steel bent caps. The fire weakened the steel girders and two I-580 spans collapsed. The decision was made to replace the I-580 connector and repair the I-880 (lower) connector. The construction contract was awarded on May 7 and construction was completed on May 24, just 26 days after the accident. The I-880 connector was repaired in eight days, and the two I-580 spans were replaced under an accelerated construction schedule. The I-580 replacement design consisted of steel girders with dual bent cap designs (steel as original and precast concrete); the contractor used the precast concrete bent cap.

The fourth emergency project was on southbound I-5 about 50 miles north of downtown Los Angeles. On October 13, 2007 a truck hit wet pavement, skidded, and resulted in a fire with 30-vehicle pileup and three deaths. The fire melted portions of the concrete structure. Cleanup and structural assessment took two weeks. A large portion of the superstructure was replaced with precast I-girders using stay-in-place metal deck forms. It was reopened on November 15, just over a month after the accident.

7.1.2 Planned (Non-Emergency) ABC Project

Dr. Wolfe said in the past Caltrans has looked at how to maintain X number of traffic lanes in staged construction. Now it is looking at costs and benefits of closing the structure to get the work done quickly. That is what Caltrans did when it replaced the east span of the Oakland Bay Bridge on the Yerba Buena side over the 2007 Labor Day weekend. Caltrans built the superstructure section to be replaced on the side adjacent to the bridge, built new columns under the existing bridge, put the new bridge superstructure on skids, and pushed it into place after demolishing the existing bridge. It took two hours to push a bridge the size of a football field into place with no more than three inches of tolerance on either side.

7.1.3 Recent Earthquake Project

The moderate Chino Hills earthquake (5.4 magnitude) occurred on July 29, 2008 within a couple miles of Dr. Wolfe's office on State Route 71 in the Pomona area of southern California. The damaged Grier Street Bridge was a precast prestressed voided slab superstructure on pier walls that was constructed in 1958. It was an ABC project from the 1950s, but had pinned dowel connections at the ends of the slab since the design predated current seismic design codes. Of the five spans on the bridge, only one span was damaged by the earthquake; it moved transversely about 3-4 inches off the pier cap. Caltrans discovered the bridge had a number of overheight hits through the years, and that the earthquake-damaged span had staining in the fractured area that indicated the fractures were not new. Dr. Wolfe said the key to ensuring safe structures as innovations are implemented is to consider all loads that may occur, and to carefully consider connection details to prevent the potential for collapse.

7.1.4 Conclusion

Dr. Wolfe concluded his presentation with a discussion on ABC as a subset of accelerated project delivery. He said ABC focuses on what bridge engineers can control, but in reality the goal is to accelerate the delivery of the project to the end user, the motoring public. That begins when a capacity issue is discovered, whether due to lost lanes because of an emergency or whether due to changes in land use that has driven the demand to a higher level than the original facility design. From that point forward the goal should be to accelerate the entire delivery process. Whether looking at the construction phase, the environmental document phase, the right-of-way acquisition phase, or any other phase, all the pieces must come together to deliver a project. An umbrella view is needed to deliver the projects faster, with ABC as a piece of that process. Ongoing NCHRP Project 20-73, “Accelerating Transportation Program and Project Delivery: Conception to Completion,” is looking into this. Dr. Wolfe said he met with the panel and some of the researchers a couple weeks ago, and they are interested in ABC as a piece of their work.

Dr. Wolfe said for ABC to succeed at the state level, the knowledge base that exists from other states, from FHWA, and from international successes in accelerating project delivery needs to be leveraged. National and regional coordination exists and is essential. He summed up his presentation by saying that successful implementation requires innovation, and research is an integral component in the effort to advance ABC techniques.

7.2 ABC Projects: Texas

Dacio Marin with the Texas Department of Transportation (TxDOT) gave a presentation on Texas ABC practice. He started with a quick overview of bridges in the state, and then described the ABC techniques used on smaller off-system bridges and larger on-system bridges. Texas has about 50,000 bridges or about eight percent of the nation’s bridges. TxDOT builds 600-800 bridges each year, and another 250 bridges are built by cities, counties, and others each year. Mr. Marin said that with this volume of construction, TxDOT is clearly interested in ABC to get bridges into service quickly.

7.2.1 Off-System Bridges

Mr. Marin said most off-system bridges in Texas are rural stream crossings that are 40-80 ft in length and can readily be replaced with 1-3 spans. Roadway widths range from 24-30 ft and traffic counts are usually low. Overtopping is often an issue. Sites are frequently remote, and the road is usually closed for the bridge replacement because of right-of-way limits or the existing structures makes phasing and temporary detours difficult. An important consideration when TxDOT uses rapid construction is to coordinate with the local officials, including cities, counties, schools, and emergency services as appropriate. TxDOT also ensures the utilities are cleared prior to letting, and considers working day charges, whether 6-day, 7-day, or calendar contract. TxDOT also considers liquidated damages and road user cost damages if milestones are not met, and allows adequate time for staging of materials. Another important issue is to simplify bridge geometry to the extent possible. For example, have a constant or zero skew, no horizontal curves, no flares (width transitions), and no superelevation transitions on the bridge. Complicated geometry can better be handled on the roadway than on the bridge.

TxDOT has a family of standards that are used for off-system bridges.

- The standard pretensioned concrete box beam bridge is built with or without a composite slab. If built without composite slab, a two-course surface treatment and asphalt concrete pavement (ACP) overlay plus transverse post-tensioning are used. A 20-inch deep box beam can span up to 60 ft.
- The standard pretensioned concrete double-tee beam bridge is similar to the double tees used in parking garages. The more efficient cross section of the double tee yields a beam that is lighter weight than a box beam, but its span-to-depth is not quite as

good. Double-tee beam bridges can also be built with or without a composite slab, but skews are not allowed. The shallowest double tee is a 22-inch deep beam that can span up to 55 ft.

- The pretensioned slab beam bridge is similar to the box beams except that the slab beams have a simple non-voided rectangular shape. The current standards require a 5-inch composite cast-in-place concrete deck. The beams come in two depths, a 12-inch beam that can span up to 40 ft, and a 15-inch beam that can span up to 50 ft.
- The decked slab beam bridge is a new standard that was initiated as part of TxDOT's efforts to do ABC. Modified from the slab beam, the decked slab beam is hollow to keep the weight down. Because this bridge has become so popular, fewer double-tee beam bridges are being built. These beams are not used when both a vertical curve and a skew are required. The beams are designed to be topped with an ACP overlay to provide a smooth ride over the cambered beams. Beam widths are 6.5 ft, 7.5 ft, and 8 ft, and beam depths are 20 inches and 23 inches. Skews up to 30 degrees are accommodated. The 20-inch-deep beam can span up to 50 ft, and the 23-inch-deep beam can span up to 60 ft.

An example of a simple off-system bridge replacement is the Cottonwood Creek Bridge in Williamson County. The existing structurally deficient bridge was built in 1953 and had two 11-inch deep slab spans that were 25 ft in length. The roadway width was 20 ft and it carried 1,800 vehicles per day. The question was how best to replace the bridge. A shallow structure was needed because overtopping was a concern. Closing the bridge meant long detours, and phasing was problematic because the existing curbs were integral to the structural capacity. Because of these issues rapid replacement was selected. Site challenges included limited right-of-way that required retaining walls. Precast abutments were designed with piling that had variable spacing to avoid sub-surface utilities. The beams, bent caps, and abutments were fabricated and the H-piles on either side of the existing bridge were driven before the road was closed. After the road was closed, the retaining wall was constructed, the existing bridge was demolished, and the new bridge and approaches were constructed. The new bridge had two 50-ft spans and an overall width of 42 ft. It consisted of decked slab beams, precast abutments and bent caps, flowable backfill, and steel H-piles. The contractor built the precast caps and abutments at a site several miles from the bridge. The bridge contract cost was $380,700 or $90.60 per sq ft of deck area.

Steel anchor plates were cast into the bottom of the caps and abutments. Piles were driven at a rate of one pile per hour and then cut to the required length. The plates cast in the cap were matched with the H-piling and welded into place. The bottoms of the caps were level and the tops of the caps matched the roadway's two percent cross slope. Six 7-ft-wide decked slab beams were erected in each span and laterally connected with a welded plate detail developed as part of a TxDOT-sponsored double-tee beam research project. The embedded weld plates are 12 inches long, 4 inches wide, and ½ inch thick and spaced at 5-ft intervals. After welding the connector plates, the longitudinal strips were filled with non-shrink grout and the deck was overlayed.

The bridge was closed a total of 33 days. Only six days were required for the bridge demolition and construction; the remaining days were required for roadwork and construction of the cast-in-place retaining wall. The bridge contract cost was $380,700 or an overall cost of $90 per sq ft of deck area, with breakdown of $43 for the superstructure and $47 for the substructure. This was about 30 percent higher than a conventionally constructed bridge.

Mr. Marin said ABC advantages of the decked slab beam include:

- Field welding instead of transverse post-tensioning for an easier connection detail
- No cast-in-place concrete slab
- Fewer beams and fewer joints because of the wider beam width
- Low depth-to-span ratio (up to 1/30)
- Minimum disruption to traffic
- Reduced sq ft costs with increased usage.

7.2.2 On-System Bridges

Mr. Marin described several on-system ABC projects that TxDOT has built. The US 290 Ramp E-3 precast bent cap project, built in 1996 in Austin, reduced the ramp closure from several weeks to just six hours. The 2-mile I-45 Pierce Elevated precast bent cap project, built in 1997 in Houston, rehabilitated 226 spans in 190 days versus 1.5 years. These two projects identified questions about the cap-to-column connections that led to TxDOT sponsoring a research project with The University of Texas at Austin to test precast cap to cast-in-place column connection details (see Appendix D for reference). This research project tested three connection types – grout pockets, grouted vertical ducts, and bolted connections – and developed sample details, design methodology, and construction specifications for each. The research showed what TxDOT had been doing was working.

The research connection details were used on the precast caps for the State Highway 66 over Lake Ray Hubbard Bridge completed in 2003 at a cost of $43 per sq ft of deck area. TxDOT also used the research details on the precast caps for the State Highway 36 over Lake Belton Bridge completed in 2004. The Lake Belton Bridge contract was awarded in 2002 for $20 million, of which $8 million was for the bridge. This was $47 per sq ft, comparable to conventional construction at that time. The repetition of 62 identical caps made it economical to precast the caps, even with a 140-mile transport from the precast plant to the jobsite. Precasting also led to better quality control and much improved safety since the caps were constructed on the ground rather than in the air over water.

Mr. Marin said the most recent ABC project has a full-depth precast concrete deck designed in accordance with NCHRP 12-65 (see Appendix D for reference). Completed in 2008, the Live Oak Creek Bridge had limited access to batch plants, with the closest being 75 miles away. The bridge is 700 ft long and 32 ft wide. AASHTO Type IV beams were used, with shear studs placed during fabrication of the beams. The contractor was required to construct a precast deck. There were 86 panels with a total area of 22,400 sq ft. The project was awarded in December 2006 at a cost of $2.7 million or $121 per sq ft of deck area. Each panel weighed about 12 tons. The contractor became efficient in setting the panels in 5-6 minutes each. The panels were connected to each other transversely by placing a reinforcing bar in the slots along the transverse edges and filling the slots with non-shrink grout. It worked most of the time; occasionally the slots were offset from each other and required grinding. The caps and deck panels were level. A two percent housetop cross slope was obtained in the deck by using a variable thickness ACP overlay.

The final on-system accelerated bridge construction project that Mr. Marin discussed was the four Loop 340 Bridges over I-35 south of Waco. I-35 has about 70,000 vehicles per day, and Loop 340 has about 40,000 vehicles per day. The contract had an early completion bonus of $272,000. In order to discourage the contractor from requesting closure of the interstate, a lane rental charge was built into the contract. Each of the four bridges has four 115-ft spans. The project was awarded to Archer Western Contractors for $40.5 million under A+B bidding. Construction began in January 2005. The bridges used for the first time the precast pretensioned pre-topped U-beams and precast column shells. The interior column shell top dimensions were 4.5 ft by 3.0 ft and the exterior shell top dimensions were 10 ft x 3 ft, weighing 13 tons and 19 tons, respectively. The shells were cast offsite while conventional footings on drilled shafts were built onsite. The shells were transported to the site, erected over the column rebar cage, and then filled with concrete. The substructure consisted of these individual columns without cap; the beams sat directly on the columns. The beams complete with decks were erected on the columns, and the transverse and longitudinal closure joints constructed. The steel T-77 rail was used for the first time on this bridge. The contractor initially completed the erection of one superstructure span per night but with time increased to two spans per night with only lane closures. No I-35 road closures were required, compared to closures of 2-3 weeks scattered throughout the project for conventional construction. The bridge was completed in 2007 at a cost of $84 per sq ft of deck area.

7.2.3 <u>Conclusion</u>

Mr. Marin discussed what is next for ABC in Texas.

- Partial-depth precast deck end panels. Partial-depth (half-depth) precast concrete deck panels have been an option in Texas bridges since the 1960s. These panels are four inches thick and are topped with four inches of cast-in-place concrete for an eight-inch composite deck. Contractors choose partial-depth deck panels for 85 percent of the bridges in Texas. For conventional construction, these panels end two feet short of the span end, with 10-inch-deep full-depth cast-in-place concrete used at the ends as a thickened slab. TxDOT is now evaluating extending the panels to the end of the spans. To date a couple bridges have been built with this detail to give a safer work environment and more speed. Performance of this detail is being evaluated.
- Full-depth precast deck overhang panels. The outside panel extends to the second beam, with a full-depth precast deck to the inside of the first beam and half that thickness to the second beam. The railing connection reinforcement extends from the surface of these precast overhangs. The first bridge using this option will be let soon.

Mr. Marin said the bottom line is that ABC projects require personnel, equipment which sometimes is specialized, and incentive which means money. That buys speed, safety, and minimized disruption to the traveling public. In the case of the larger bridges, economy of scale makes the costs competitive, resulting in speed and a quality product. Mr. Marin said that ABC techniques have been fruitful for TxDOT.

7.3 ABC Projects: Washington State

Jugesh Kapur, State Bridge & Structures Engineer for the Washington State DOT, developed the presentation for ABC in Washington State but was not able to attend the workshop due to travel restrictions. Mike Culmo gave his presentation.

Mr. Culmo said Washington State achieves ABC by precasting superstructure and substructure members and using innovative bridge construction methods. Its concerns include seismic design and detailing, construction equipment and cost, and construction tolerances. WSDOT's current bridge inventory by material type includes 35 percent reinforced concrete, 41 percent pretensioned or post-tensioned concrete, 23 percent steel, and 1 percent timber. Seven out of 10 WSDOT bridges built in the past 10 years have been precast pretensioned or post-tensioned concrete.

WSDOT has a long history of developing girders. They have several girder types in their inventory. Their standard girders can be viewed on their website. The more common ones are the W girders, which are like bulb tees except they have smaller flanges and are different from the standard AASHTO bulb tees. With normal strength concrete the maximum span lengths range from 70 ft for the W42G (42-inch deep) to 130 ft for the W74G. For high strength concrete, the range increases to 80-145 ft. In 1993 WSDOT developed what they call super girders. These are true bulb tee girders, and they are quite large. Maximum span capabilities of these new standard wide-flange girders range from 110 ft for the WF42G to 190 ft for the W95G (95-inch deep). Their website includes a new girder that is over 100 inches deep with span capability up to 225 ft. These are precast prestressed girders. WSDOT is doing quite a bit with post-tensioning as well.

Mr. Culmo said a railroad tanker caught fire under Span 8 of the SR 509 Puyallup River Bridge in Tacoma. The original bridge was a pretensioned concrete girder span with tight spacing, 48 ft above the railroad tracks. The girders in the span were damaged and had to be replaced. The original 1992 design had 15 W74G girders with concrete compressive strength of 6,000 psi and 0.5-inch diameter prestressed strands. The new design required only eight WF74G girders with concrete compressive strength of 10,000 psi and 0.6-inch diameter strands. The new wide-flange girders cost more but their improved efficiency overcomes the cost difference.

WSDOT also uses trapezoidal tubs as does Texas. They use them primarily for aesthetics rather than for economy. Aesthetics is a big concern for many of Washington State's intercity bridges, and tub girders are used for those bridges. Maximum span capabilities of the WSDOT trapezoidal tub girders range from 130 ft for the U54G4 to 185 ft for the UF84G4 (84-inch deep). WSDOT post-tensions these longer-span girders, breaking the girders into multiple pieces for lighter weight to accommodate shipping.

Standard spliced I-girders are also used in Washington State. WSDOT has an in-state policy that from 0 to about 120 ft the girders are pretensioned, and from about 120 ft to about 160 ft the contractor has the option to pretension and ship in one piece or break into pieces for shipment and then post-tension at the site. Over about 160 ft WSDOT requires post-tensioning. WSDOT works with the contractor to get the best value, taking it out of the designers' hands. Maximum span capabilities of the WF74PTG standard spliced I-girders range from 165 ft when all post-tensioning is done before the deck is cast (PT before) to 180 ft when partial post-tensioning is done before the deck is cast and then final post-tensioning is done (PT after). Maximum span capabilities for the W83PTG are 185 ft "PT before" to 205 ft "PT after," and for the W95PTG are 200 ft "PT before" to 235 ft "PT after." The two-stage post-tensioning is another way to push the span length out.

Standard post-tensioned high-strength concrete spliced U-girders are also used in Washington State. Maximum span capability of the U54PTG6 is 145 ft, the U66PTG6 is 165 ft, and the U78PTG6 is 190 ft.

WSDOT has done some bridges with partial-depth deck panels, but has not standardized the panels to date. WSDOT is primarily only using them in positive moment regions. The I-5 South 38th Street Overcrossing included partial-depth deck panels.

Mr. Culmo said precast substructures have been used some in Washington State but WSDOT is looking at more innovation. Research on precast substructures has been done by the University of Washington. Precast substructures in Washington State must meet AASHTO specifications for seismic design and durability. Monolithic super-to-substructure connections are used. WSDOT is also concerned with construction tolerances.

Fixed intermediate diaphragm connections between superstructures and substructures are being used in Washington State because of its high seismic regions; a project using the fixed intermediate diaphragm is the Methow River Bridge. The intent is to have a continuity connection between the precast columns and precast girders, and also make a connection between the foundation and the superstructure. An integral pier bent is effective for seismic loads. WSDOT is developing details for this connection with a small closure pour and has built a few of these. WSDOT likes to use closure pours to handle high seismic connections and is concerned about some of the proprietary systems.

Another WSDOT detail is a precast column with a steel angle coming out of the bottom. The steel angle temporarily supports the column while a cast-in-place footing is constructed, as done on I-405. Taking this technique to the next level is a precast slanted column on cast-in-place spread footing, used on SR 16. WSDOT is using a similar technique with drilled shafts. They do a small closure pour at the top of the drilled shaft, precast the column and temporary column support, and have the bars spliced within the closure pour.

WSDOT has used innovative construction on a couple bridges. They built temporary falsework alongside the original SR 101 Dosewalips River Bridge and then jacked it horizontally to use as a temporary bridge. They then built the new bridge on the original alignment.

Another innovative ABC technique used in Washington State is transverse skidding to move entire superstructures into place. This was done for the NE 8th Street Bridge Replacement over SR 405 in Bellevue. While maintaining traffic on the existing NE 8th Street Bridge they built a portion of the new bridge on temporary supports to the side of the existing bridge and then moved one direction of traffic onto it. They then took out half the existing bridge on the side opposite the new portion of the bridge and built a new substructure and superstructure in its place. They moved the other direction of traffic onto the second new portion of bridge. They then took out the remaining old bridge between the two new portions and extended the new substructure. Then on a weekend they closed the bridge and horizontally jacked into place the new portion of the bridge that had been constructed to the side of the original alignment.

Another innovative project is the Hood Canal Bridge. They built extensions on the existing piers, and built a new superstructure on one of the extensions. Then on a weekend they jacked the old bridge out of position and jacked the new bridge into the final alignment. After the weekend they demolished the old bridge and the pier extensions. Mr. Culmo said this was another way of using horizontal jacking to get a bridge built quickly with only a weekend closure.

The last example presented by Mr. Culmo was the redecking of the Lewis and Clark Bridge. WSDOT had to replace the deck with very limited clearance for equipment and had to do so while allowing the bridge to remain open during peak hour traffic because of lengthy detours. Working with the contractor and the self-propelled modular transporter (SPMT) supplier, they developed a framing system to replace the existing deck and stringers. They drove the SPMTs onto the bridge with a new full-width deck segment hung from below the frame, lifted the old deck segment out, drove forward to lower the new segment into place, and then drove the old deck segment off the bridge. Using this method they replaced one segment per night.

Mr. Culmo said in conclusion, WSDOT believes precast bridges are an effective system for ABC. The following should be considered:

- Design and detailing guidelines include seismic loading
- Monolithic connections meet design construction tolerances
- Construction specifications
- Availability of construction equipment
- Long-term performance.

8.0 Breakout Session Overview

8.1 Topics for Breakout Sessions

Ahmad Abu-Hawash, Chief Structural Engineer for the Iowa DOT, introduced the topics for the breakout sessions and the four project experts that would be giving the project presentations.

The primary goals for the breakout sessions were to look at three critical projects in Iowa where the Iowa DOT has promised the public to accelerate construction and to also look at some of the design details used on past ABC projects for opportunities to improve. The Broadway Viaduct and Iowa Falls Steel Arch projects are currently under design and may be limited in how much improvement can be incorporated. The I-80 reconstruction project is just getting started and may have more opportunities for improvement.

Mr. Abu-Hawash then introduced the leads for each of the four breakout teams:

- Broadway Viaduct (Team 1)
  - Project Expert: Steve Kathol, Schemmer
  - Facilitator: Kelly Strong, Iowa State University
  - Recorder: Sri Sritharan, Iowa State University
- Iowa Falls Steel Arch (Team 2)
  - Project Expert: Hussein Khalil, HDR
  - Facilitator: Dennis Mertz, University of Delaware
  - Recorder: Chuck Jahren, Iowa State University
- I-80 Reconstruction (Team 3)
  - Project Expert: Norm McDonald, Iowa DOT
  - Facilitator: Wayne Klaiber, Iowa State University
  - Recorder: Brent Phares, Iowa State University
- Prefabricated Components Details (Team 4)
  - Project Expert: Jim Nelson, Iowa DOT
  - Facilitator: Mike Culmo, CME Associate
  - Recorder: Matt Rouse, Iowa State University

8.2 Charge to Breakout Teams

Workshop participants were given their charge prior to assembling into the four teams. Participants were to recommend ideas for ABC approaches for three types of bridge projects and for component details. Teams 1-3 were each to look at a specific Iowa project, and Team 4 was to look at Iowa DOT component details.

In Breakout Session A, Teams 1-3 were to brainstorm ideas for how these types of bridge projects could be built using ABC approaches, and Team 4 was to brainstorm ideas for how the prefabricated details could be improved. First a brief presentation was to be given on the specific project or details, followed by open brainstorming. For each idea, opportunities and obstacles were to be discussed, and the ideas prioritized. The ideas were then to be discussed further, including key features and estimates of time and cost savings.

In Feedback Session A, the teams were to come back together and give team presentations on their ideas. The overall group would then discuss each team's ideas and provide a group prioritization.

In Breakout Session B, the teams were to take the group-prioritized ideas and further develop them and their opportunities and obstacles. The teams were then to develop proposed activities or steps needed to implement those ideas, for example, needed research, policy change, or specifications.

In the Closeout Session B the teams were to give presentations of their ideas with proposed activities or steps, followed by group discussion of any recommended changes.

9. Breakout Team 1: Broadway Viaduct

9.1 Project Overview

Steve Kathol with Schemmer described the Broadway Viaduct project. Schemmer is beginning the final design of the Broadway Viaduct project. This project is on US Highway 6 near the east end of the town of Council Bluffs, near the Kanesville Boulevard and Broadway Avenue split.

Several project constraints and issues affect the design and construction of the viaduct. There are historic structures on the east and west end. Indian Creek runs in an open channel just to the south edge of the viaduct where it then passes into a culvert and travels for several miles through Council Bluffs. The culvert is also a historic structure that was built in the 1930s. There are three Union Pacific railroad tracks near the center of the viaduct and one additional track near the west end of the viaduct operated by the CNIC railroad. Several other buildings are also adjacent to the structure, so vibration is an issue. Three city streets pass underneath the viaduct.

The existing viaduct was built in 1955. It is 1,394 ft long and 64 ft wide with 19 steel I-beam spans and cellular abutments on the east and west ends. Those abutments are hollow abutments behind the retaining walls, and they are 300-400 ft on each side. There are about 33,000 vehicles that travel across the viaduct each day, and it has been determined that phasing will be necessary to accommodate the traffic volume since there is no acceptable detour that allows the viaduct to be closed. Two eastbound lanes will remain open through the two phases of construction. The westbound traffic will be detoured throughout construction for both phases.

The proposed plan and section for the replacement structure will be 1,537 ft long and consist of 12 spans, the largest being 152 ft. The abutments at each end will be removed and filled. A lightweight material is being investigated to fill the abutments to eliminate the need to do soil improvements since compressible materials are in those areas. Four-column piers with base grouted drilled shafts are proposed to help limit vibrations in the area. Standard Iowa BTE beams are proposed. The largest part of the project in which the scope is being determined is aesthetics, and several stakeholders are involved.

The existing structure carries two lanes in each direction, and has a 6-ft wide sidewalk on the north side, and traffic lanes are separated by a center barrier. The existing piers have three columns with concrete cap.

Phase 1 construction will begin on the south side while maintaining two eastbound lanes and the sidewalk on the north side. The lightweight fill being investigated on each side for the embankments will require a retaining wall and a temporary retaining wall to separate the phases of construction. Phase 2 will complete the construction by maintaining two eastbound lanes on the newly constructed south portion, and pedestrians will be maintained on the 8-ft shoulder. The embankment fill and retaining walls will be completed during Phase 2.

The final bridge cross section consists of 9 BTE beams spaced at just over 9 ft centers. There will be two lanes in each direction. The addition of two 8-ft shoulders will widen the bridge to 80'-2" out-to-out, maintaining the 6-ft shoulder on the north side.

The session objectives are to study various methods to accelerate construction using phased construction and to consider the site constraints, e.g., vibration and the use of lightweight fill for embankment material.

9.2 Feedback Session

9.2.1 Presentation of Breakout Ideas

Kelly Strong presented Team 1's Breakout Session discussions. The documentation of discussions as provided by the team recorder is given in Appendix E.

During its brainstorming, Dr. Strong said the team generated 21 ideas. A quick evaluation resulted in eight to nine ideas, and those ideas were further reduced to five ideas the team felt were realistic. The prioritized ideas in order were:

1. Drilled shafts prior to closing. Because of the historic structures and the poor soils in the area, the team felt that drilled shafts should be used for the foundation system to control vibrations. The top priority idea was to drill as many shafts as possible before closing the bridge for demolition. A+B bidding and incentive/disincentive contracting were discussed and scored high but not included in the final list because the team believed they would be used in any case.
2. Precast columns. The number two idea was a tie for precast columns and precast pier caps. Concerns included having enough time for shop drawings and scheduling the prefabrication early enough to avoid running out of the precast elements during onsite assembly. Another concern was that these connection details would be new for the Iowa DOT.
3. Precast caps. See item #2 above.
4. Precast deck panels. The number four most-time-saving idea was precast deck panels. For this project it was felt that half-depth panels would be best. There was less consensus on this idea because of the follow-up steps (placing reinforcement, casting the composite topping, etc.) needed after the panels are erected.
5. Geofoam. The number five idea included geofoam, geopiers, and lightweight concrete fill for the cellular abutments. Tradeoffs in what could generate the fastest construction time included cost, headroom clearance, and poor soils. Apparently even if geofoam was used, a facing wall would be required and the soils would not even support that. The result for the number five idea was a list of possibilities that need to be thought out because of the tradeoffs.

Dr. Strong said that these ideas would reduce traffic disruption more than speed up construction time; for example, drilling the shafts before the road was closed. A concern was expressed that specifying these solutions crosses the line to dictate means and methods to the contractor. Also, if the Iowa DOT says they will try it but are not sure if these ideas will work, high first costs are likely and fabricators would be less willing to invest in new forms, etc., if they think this is a one-time project.

9.2.2 Overall Group Discussion and Prioritization

The overall group asked clarifying questions and then prioritized the ideas. As shown in Table 9.1 below, four ideas received high votes. Team 1 reconvened to further discuss the four ideas and develop proposed activities needed to implement those ideas.

Table 9.1 Team 1 Group-Prioritized Ideas from Feedback Session

Team Priority	Idea Descriptors	Group Vote	Group Rank
T1-1	Drilled shafts prior to closing	61	G1-1
T1-2	Precast columns (combine with precast caps)	53	G1-2
T1-2	Precast caps (combine with precast columns)	53	G1-2
T1-4	Partial-depth precast deck panels	27	G1-3
T1-5	Geofoam	3	

9.3 Closeout Session

In the closeout session Kelly Strong presented the proposed activities for Team 1's ideas, as shown in Table 9.2 below.

1. Detour rental for closure period. As the team started talking about activities for each of the three group-prioritized ideas, discussions evolved to letting the contractor decide how best to do it as being appropriate for each of these ideas. The new idea was to specify a detour rental. Several at-grade railroad crossings in the immediate area limit the detour options. A detour rental would encourage the contractor to minimize the detour time. This became the team's new #1 idea, with the other three group-prioritized ideas following in the order previously discussed. Proposed activities were for the Iowa DOT to provide alternate designs for precast caps, precast columns, and segmental drilled shafts; and to determine a realistic period to have the road closed and a detour rental in place. The contractor can then decide how best to replace the bridge considering the detour rental in the contract.
2. Drilled shafts prior to closing. To drill the 70-ft long shafts prior to closure will require that they be designed for segmental placement because of the limited headroom (15 ft) under the existing viaduct. The shafts are cased; designs would need to consider partial casing, rebar cages that are spliced, couplers, etc., to allow the contractor to put them in early.
3. Precast caps and columns. Activities proposed were to develop cap-to-column and column-to-shaft connection details; to determine appropriate construction tolerance while ensuring anchorage at the connection; to determine how the caps would be tied together laterally since this is staged construction; and to develop specifications for material, workmanship standards, installation, and design.
4. Prefabricated deck systems. The team discussed prefabricated full-depth deck panels, partial-depth deck panels, and stay-in-place metal deck forms; these options all had issues for this project because of the upcoming letting date. For future projects, the team felt research needs to be reviewed and conducted as needed to address reflective cracking in the composite topping on partial-depth deck panels, composite action, transverse unbonded post-tensioning, moisture entrapment and inspectability of stay-in-place forms, and labor flexibility. Labor flexibility is related to the contracting community's concerned that acceleration of the many small steps conducted by small labor units may not be possible. For some of these small construction processes, e.g.,

constructing grout pockets, productivity cannot be increased by adding workforce. An activity could be to work with the contracting community to differentiate between what can be accelerated with familiarity of the technical aspects and what cannot be accelerated because of the process.

In the discussions that followed Dr. Strong's presentation, an observation was that full-depth precast deck spans can be installed in a couple of days compared to many days for conventional cast-in-place concrete deck construction. Even with longitudinal post-tensioning, precast decks have small tasks versus large tasks such as forming a cast-in-place deck. It was agreed that activities should include collaborating with the contracting community to increase contractors' familiarity with precast decks. The overall group had no additional comments and concurred with the additional idea with updated ranking as developed by Team 1.

Table 9.2 Team 1 Final Prioritized Ideas & Activities from Closeout Session

Group Rank	Idea Descriptors with Proposed Activities or Steps	Final Group Rank
	Detour Rental for Closure Period: 1. Provide alternate designs for precast caps, precast columns, and segmental drilled shafts 2. Determine a realistic period to have road closed and detour rental in place	FG1-1
G1-1	**Drilled Shafts Prior to Closing:** 1. Design shafts for segmental placement, considering partial casing, rebar cages that are spliced, couplers, etc.	FG1-2
G1-2	**Precast Caps and Columns:** 1. Develop connection details for cap to column and column to shaft 2. Determine appropriate construction tolerance while ensuring connection anchorage 3. Determine cap lateral tie-in for staged construction 4. Develop specifications for material, workmanship standards, installation, and design	FG1-3
G1-3	**Prefabricated Deck Systems for Future Projects:** 1. Review and conduct research as needed to investigate full-depth panel, partial-depth panel, and stay-in-place metal form issues such as reflective cracking, composite action, transverse unbonded post-tensioning, moisture entrapment and inspectability of stay-in-place forms, and labor flexibility 2. Collaborate with industry to increase contractors' familiarity with precast decks	FG1-4

10. Breakout Team 2: Iowa Falls Steel Arch

10.1 Project Overview

Hussein Khalil with HDR described the Iowa Falls bridge replacement project. The project is located on US 65 just south of Iowa Falls. Iowa Falls is a small town about 55 miles north of Ames. The town is proud of its other arch bridges.

The project will replace a 255-ft long, 24-ft wide open spandrel concrete arch with a 288.5-ft long, 64-ft wide partial through steel arch. The site conditions are difficult, with vertical limestone banks in an environmentally sensitive area. At the northwest corner a historic church causes construction vibration concerns. Two sanitary sewer lines directly under the bridge need to be either protected during construction or relocated prior to bridge construction. Also, a dam is 1,500 ft downstream.

The new bridge will have a 15-ft traffic lane in each direction, a 12-ft turn lane in the center, a 5-ft sidewalk on one side, and a 12-ft multi-use trail on the other side. Some approach work will be required. The traffic count is expected to increase from 11,000 vehicles per day to about 15,000 vehicles per day by 2031, with eight percent trucks.

The Iowa DOT did a study that determined the replacement bridge would be a steel arch. Five options were considered: single-span steel arch, single-span concrete deck arch, two-span prestressed girder bridge, steel box girder bridge, and steel plate girder bridge. Through a public involvement process it was decided to replace the bridge with an open spandrel bridge having decorative railing, walkways, and lighting. This will be the only steel arch in Iowa Falls; the others are all concrete.

Session objectives are to identify ABC methods to completely remove and replace the bridge in one construction season. The current proposal for demolition is to not drop any concrete pieces into the river because of concerns related to vibrations or waves that could affect the dam downstream. Also, the sewer line needs to be protected. The access to the bridge is difficult due to the rock walls. The session discussions will include the use of falsework and/or barges to construct the bridge.

10.2 Feedback Session

10.2.1 <u>Presentation of Breakout Ideas</u>

Dennis Mertz presented Team 2's Breakout Session discussions. The documentation of discussions as provided by the team recorder is given in Appendix F.

During its brainstorming, Dr. Mertz said that Team 2 also expressed concern about dictating means and methods to the contractor. However, to meet the need to replace the bridge in one construction season it was necessary to determine how the bridge could be erected in that number of days. After brainstorming, the team's prioritized ideas in order were:

1. Erect arch ribs and struts before demolishing bridge. These would be erected outside the existing 24-ft wide bridge, perhaps using the old bridge to help erect the new 64-ft wide bridge and then use the new bridge to help demolish the old bridge. The goal is

to get the bridge constructed in one construction season rather than the two construction seasons otherwise required.

2. Prefab whole arch and slide in place. The whole arch, not just the ribs, would be fabricated to one side of the existing bridge. While it would have the struts, it could also perhaps have precast half-depth deck panels or full-depth deck panels. Half of the new abutment would be used to build the new bridge on, and then the new bridge would be slid transversely into place after demolishing the old bridge. Because of concerns about vibration and a dam downsteam, it would not be possible to drop the old bridge into the river.
3. Prefab arch and float in. The arch ribs would be fabricated near site and floated into place. Advantages would be no falsework and no splices in the air.
4. Demo and erect from barge or work platform. The existing bridge would be demolished and the new bridge erected from a barge or work platform on the river.

Other ideas not fully developed included discussion that where the arch was to be supported had about 10 ft of soil or bad rock that needed to be excavated to get to good rock. The question was whether it was an ABC idea to auger in micropiles rather than excavate to that level. Other ideas included using a tower crane in the middle of the river and also erecting the bridge on the bank and rotating it into place. The ideas to move the church and move the sewer line were lumped together because they were so controversial; if the church were going to be moved, the sewer line might as well be moved also. The team thought moving the church was a better idea than tearing it down. However, the team doubted that such moves were likely and, therefore, did not rank that combined idea. Discussion also included whether the team was discussing ABC or just how to put the arch ribs in place. However, if A+B bidding was to be used, an estimate would be needed for the number of days required to erect it quickly.

10.2.2 Overall Group Discussion and Prioritization

The overall group asked clarifying questions. A question was raised concerning the option of replacing the deck and floor beams. In the discussion it was decided to add a prefabricated composite deck/floor beam/stringer system similar to the WSDOT Lewis & Clark Bridge deck replacement. The group then prioritized the ideas. As shown in Table 10.1 below, three ideas received high votes. Team 2 reconvened to further discuss the three ideas and develop proposed activities needed to implement those ideas.

Table 10.1 Team 2 Group-Prioritized Ideas from Feedback Session

Team Priority	Idea Descriptors	Group Vote	Group Rank
T2-1	Erect arch ribs and struts before demolishing bridge	67	G2-1
T2-2	Prefab whole arch and slide in place, possibly adding precast deck	44	G2-2
T2-3	Prefab arch and float in	21	
T2-4	Demo and erect from barge or work platform		
	Prefab system for floor beams / stringers / deck (added per group discussion)	42	G2-3

10.3 Closeout Session

In the closeout session Dennis Mertz presented the proposed activities for Team 2's ideas, as shown in Table 10.2 below.

1. Erect ribs and struts around the existing bridge. Proposed activities included evaluating the load-carrying capacity of the existing arch to determine if it could be used to help build the new arch; evaluating use of the old rib to build a work platform for the new bridge, although the disadvantage is the old bridge could not be used to maintain traffic as long; evaluating whether the new arch might be used to help demolish the existing arch; evaluating the effect of the new foundation on the old foundation to determine whether the new foundation could be constructed on the outboard of the old foundation without disrupting the capacity of the old foundation; evaluating the vibration tolerance of both the church and the sensitive sewer line; and comparing costs between this idea and idea #2 to determine the most cost-effective solution.
2. Skid arch / struts into place. This idea is to build the arch transverse to the existing bridge, downstream to avoid the church. Proposed activities included determining how much of the bridge could be built before it is skid into place, determined by evaluating available skid equipment and the feasibility of temporary supports including consideration of sewer line locations; investigating right-of-way availability because an additional bridge width downstream would be required; evaluating vibration tolerances of sewer line and historic church and wall; and comparing costs between this idea and idea #1.
3. Prefabricated floor system components. Proposed activities include determining whether or not to require post-tensioning; evaluating the barge capacity of the river for floating the prefabricated system to the site on a barge and lifting into place; evaluating the possible use of existing standard details; and evaluating the extent that prefabrication might limit worker accident exposure.

Dr. Mertz said that the team favored the use of idea #3 with either idea #1 or idea #2, and favored idea #1 over idea #2. For both idea #1 and idea #2, there is a need to interact with contractors to verify that the concepts are constructible. The team extensively discussed project delivery systems for this project, and proposed activities also included buying the steel as early as possible to get the contractor locked into a reasonable price and moving the letting as needed to accommodate that; defining advance milestone for certain construction activities completed before the existing bridge could be closed; and providing the contractor as much flexibility as possible to get the best price. While construction will be limited to one season, much upfront work is needed and the contractor should have a contract for more than one construction season.

In the discussions that followed Dr. Mertz's presentation, a question was raised concerning whether modular barges might help with barge access. Modules can be added to reduce the draft. The group was informed that modular barges would be required for site access. However, calculations showed that a 4-ft draft was needed and this would require dredging or other access. The overall group had no additional comments and the final group ranking of the three ideas remained the same.

Table 10.2 Team 2 Final Prioritized Ideas & Activities from Closeout Session

Group Rank	Idea Descriptors with Proposed Activities or Steps	Final Group Rank
G2-1	**Erect Ribs and Struts around Existing Bridge:** 1. Evaluate load carrying capacity of existing 2. Evaluate using existing ribs for work platform 3. Evaluate implications of using new arch to demo old 4. Evaluate vibration tolerance of church and sewer 5. Evaluate effects of new foundation on the old foundation 6. Compare costs between 1 and 2	FG2-1
G2-2	**Skid Arch / Struts into Place:** 1. Evaluation of feasibility of temporary supports (including sewer location) 2. Consider R/W acquisition costs 3. Evaluate vibration tolerance of church and sewer 4. Compare costs between 1 and 2	FG2-2
G2-3	**Prefab Floor System Components:** 1. Evaluate post-tensioning and non post-tensioning solutions 2. Evaluate barge capacity for work on river 3. Evaluate possible use of existing standard details 4. Evaluate extent that prefab might limit worker accident exposure	FG2-3
	General Development Comments: 1. For 1 and 2 above, the evaluation includes discussions with contractors for constructability verification. 2. Buying steel early may shorten the construction cycle, but might restrict the contractor's erection method. 3. Define advance milestones in contract documents (such as when bridge demo begins). 4. Project deliver issues need to be investigated (allow contractors to choose whether or not to use the old bridge as part of their construction methods). 5. The bridge can be built in one construction season, but the letting will have to be sooner to allow for submittals.	

11. Breakout Team 3: I-80 Reconstruction

11.1 Project Overview

Norm McDonald, State Bridge Engineer for the Iowa DOT, described the I-80 reconstruction project. The project is located on the west side of Des Moines where I-35 and I-80 run together. The project is complicated because the bridge over Walnut Creek is very near the Hickman Interchange. The bridge has ample room underneath it although the area is not a good location for work because of the stream and uneven surface.

The existing bridge is a 406.5-ft variable continuous steel I-beam bridge with four 73.5-ft interior spans and 57.25-ft end spans. The original bridge was built in 1958 and has been widened twice. It has three eastbound/northbound lanes plus an exit ramp. The original deck on the northbound bridge is in need of replacement; the southbound bridge is not as deteriorated.

A consultant has looked at options for crossing over traffic and the number of lanes that could be maintained during construction. The Highway Division Director wants three lanes maintained during peak traffic hours. Some sketches for this project were developed for the workshop. Stage 1 of the northbound bridge may require a barrier in the middle of the bridge to create an area for the contractor to replace the deck; this gets into the issue of having traffic running on both sides of the construction area. A Stage 2 option during the day time would give traffic as much room as possible and constrict the construction area. Another option would be to give the contractor more access during the nighttime and keep the traffic on one side of the barrier rail.

The session objectives will include identifying accelerated construction methods to replace the original deck while maintaining three traffic lanes during peak hours. Also, replacement options for deck versus superstructure need to be evaluated. An issue is the shear studs on the continuous rolled beams; the Iowa DOT is having a fatigue study done now. The results will likely be that fatigue is not a problem with the existing rolled beams, but a question still exists whether the entire superstructure should be replaced. Also, precast versus cast-in-place deck options need to be evaluated.

11.2 Feedback Session

11.2.1 <u>Presentation of Breakout Ideas</u>

Norm McDonald presented Team 3's Breakout Session discussions. The documentation of discussions as provided by the team recorder is given in Appendix G.

Mr. McDonald said the team discussed re-routing traffic to I-235 and maybe to Iowa 5, but re-routing traffic was not an idea by itself. It was to be used with the two ideas that were tied as the top ranked ideas. The prioritized ideas in order were:

1. Prefab. Prefabrication of the superstructure in two 14-ft wide sections was a general idea with several variations. The center 28 ft of the northbound six-span bridge was to be replaced. It could be replaced one span at a time; this would require additional supports for the other sections since it is a continuous design now. It could be replaced to the existing splices; this would require temporary supports since only the center

portion of the span would be replaced. Another idea was to build large replacement sections on the shoulder or to the side of the bridge and replace several spans of the width at a time by rolling it over.
2. Reuse steel. Removing the deck and reusing the steel beams was tied with idea #1. This would require getting underneath the bridge, maybe water blast, cutting off the shear studs with a wire saw. The size of a section at a time was not discussed.
3. Replace cross-sections in small segments. The team felt that replacing in three sections rather than two sections would be easier because after one-third of the deck was replaced, there would probably be room to maintain three lanes of traffic both ways during the remainder of the work.

The team considered time and expense for each option.
- Time. The team felt idea #2 was the quickest construction, even though the deck would be cast-in-place conventionally, because it reused the steel. They felt idea #3 would require the longest construction time because smaller sections would be taken out and the deck would be poured conventionally.
- Relative cost. The team considered idea #2 the least expensive because the steel was to be reused. They considered idea #1 the most expensive because of the precast deck panels.

11.2.2 Overall Group Discussion and Prioritization

The overall group asked clarifying questions. Mr. McDonald confirmed that a fatigue study of the steel beams was being conducted but the assumption currently was that the beams would be able to be reused. He also said that corrosion of the beams was not a problem. One of the other complications is the nearby Hickman interchange, which is already operating at capacity. When it is replaced in the future, possibly in the next 25-30 years, this project would also be torn out. With no additional questions, the group then prioritized the ideas. As shown in Table 11.1 below, two of the three ideas received high votes. Team 3 reconvened to further discuss the two ideas and develop proposed activities needed to implement those ideas.

Table 11.1 Team 3 Group-Prioritized Ideas from Feedback Session

Team Priority	Idea Descriptors	Group Vote	Group Rank
T3-1	Prefab	43	G3-2
T3-1	Reuse steel	77	G3-1
T3-2	Replace cross-sections in small segments	4	

11.3 Closeout Session

In the closeout session, Norm McDonald presented the proposed activities for Team 3's ideas, as shown in Table 11.2 below.
1. Re-use steel beams. The team prioritized its proposed activities. The first priority was the ongoing fatigue study to determine if the rolled beams have sufficient life for re-use. The second priority was the ongoing traffic analysis, followed by a staging review. These two activities are required before further activities to ensure this idea is viable. The third proposed activity is to determine how to detail the transverse bar splice to connect the 14-ft-wide replacement sections in the center of the bridge to the existing

bridge and between the two sections. The fourth priority is to strengthen or support the existing superstructure, looking at least at the adjacent existing beams to be sure the capacity is adequate. The fifth priority is to determine how best to remove the welded angle studs that are on the existing bridge rather than the more typical headed studs.

2. Prefabricated superstructure. The team also prioritized its proposed activities for this idea. The first priority was the ongoing fatigue study. The second priority was to do the traffic analysis and staging since they are critical to the project. The third priority is to review the existing bridge capacity for construction loads and the substructure for loading since they are more critical for this idea. The fourth priority is the transverse bar splice similar to idea #1.

In the discussions that followed Mr. McDonald's presentation, a question was asked for idea #2 about whether the team had considered overnight replacement of the segments rather than closing the bridge for an extended time. Mr. McDonald said anything not discussed was not ruled out. However, overnight closure on the interstate could not begin until 9:00 p.m. and the lanes would need to be opened again by 5:00 a.m. That is a short window considering the large area being worked on in the center of the bridge. A follow-up comment was made that many states have looked at overnight or weekend closures to replace deck segments. One issue for composite structures is that as the work approaches midspan, there will be a non-composite joint between the old and new segments, and the beams could be overstressed. However, much work can be done over a weekend closure, e.g., 150 ft on a previous job. The longer (weekend vs. overnight) closure could avoid the potential of overstressing the beams. Mr. McDonald said the team had significant discussions on different options to avoid overstressing the beams. The overall group had no additional comments and the final group ranking of the two ideas remained the same.

Table 11.2 Team 3 Final Prioritized Ideas & Activities from Closeout Session

Group Rank	Idea Descriptors with Proposed Activities or Steps	Final Group Rank
G3-1	**Re-use the Steel Beams:** 1. Finalize beam fatigue study 2. Finalize traffic analysis, followed by staging review 3. Determine how to detail the transverse bar splice 4. Determine how to strengthen or support the existing superstructure 5. Determine how to remove the welded angle shear studs	FG3-1
G3-2	**Prefabricated Superstructure:** 1. Finalize beam fatigue study 2. Finalize traffic analysis, followed by staging review 3. Review the existing bridge capacity for construction loads and the substructure for loading 4. Determine how to detail the transverse bar splice	FG3-2

12. Breakout Team 4: Prefabricated Components Design Details

12.1 Details Overview

Jim Nelson in the Office of Bridges & Structures of the Iowa DOT presented an overview of the Iowa DOT's ABC experience, referencing his earlier presentation (see Chapter 6). Details for the six ABC projects to date include joints between precast panels, post-tensioning ducts and anchorages, connections in stud pockets between panels and girders, haunch construction, box beam connections, and precast substructure connections. He said it is the connection details that can really make or break a project. Investigation to improve those details is the task of this breakout team.

Mr. Nelson said one of the interesting implications of what has been done to date in terms of accelerating construction using prefabricated components is the impact on the critical path. Bridge projects are fairly linear projects: drive piles, build substructure, set girders, and form deck. Accelerated projects add more steps that all line up on the critical path: drive piles, make connections to precast substructures, set deck panels, level panels, shoot studs, grout transverse joints, thread post-tensioning strands, pull tension, etc. Rather than having a few larger critical path steps, accelerated construction projects have a dozen small critical path steps. If any of those steps get hung up, the project is slowed down. This is one of the issues to investigate in this group. The question is whether the prefabricated component details are constructible, cost effective, and durable.

The session objectives for this team were to identify details used for accelerated construction projects, evaluate best practices and look for optimization opportunities for details to speed construction, reduce cost, and improve long-term durability.

12.2 Feedback Session

12.2.1 Presentation of Breakout Ideas

Mike Culmo presented Team 4's Breakout Session discussions. The documentation of discussions as provided by the team recorder is given in Appendix H.

Mr. Culmo said the team built on ABC work already done in Iowa. They brainstormed many ideas, then pared them down. The team felt the ideas could use further study and refinement to be more adaptable to Iowa bridges. The prioritized ideas in order were:

1. Precast full-depth deck panel systems. Details discussed included the joints, keys, post-tensioning, haunch forming and pouring, different types of reinforcing, stud pocket spacing, overlays, etc. The team felt it is a high priority to go through the work done in Iowa and nationally, then select a system and develop standards for that system.
2. Precast integral abutments. Iowa and a number of other states are using integral abutments to eliminate deck joints. The team felt there would be benefit to developing connections between the precast integral abutment stem and the superstructure that are more buildable and faster construction.
3. Precast substructure and foundation connection details, including piers, abutments, piles, footings.
4. Butted beam systems, including decked bulb tees, double tees, adjacent box beams. Box beams and voided slabs are currently used in Iowa for county and rural roads.

Improved longitudinal connections to join butted beam systems cold improve performance and speed construction. Current research and details being used in other states should be investigated.

5. Parapets. Connection of the parapet to the deck is critical. Crash testing is required. Better details that are faster to construct are needed.

Other details that are important but ranked lower by the team were for walls, simple dead load and continuous live load, and partial-depth deck panels.

12.2.2 Overall Group Discussion and Prioritization

The overall group asked clarifying questions. The group felt that full-depth and partial-depth decks should be considered together rather than separately; they were combined. The group then prioritized the ideas. As shown in Table 12.1 below, three ideas received high votes. Team 4 reconvened to further discuss the three ideas and develop proposed activities needed to implement those ideas.

Table 12.1 Team 4 Group-Prioritized Ideas from Feedback Session

Team Priority	Idea Descriptors	Group Vote	Group Rank
T4-1	Precast full-depth deck panels (partial-depth deck panels added from T4-8)	72	G4-1
T4-2	Precast integral abutments	49	G4-3
T4-3	Precast substructures	54	G4-2
T4-4	Butted beam joints	14	
T4-5	Parapets		
T4-6	Walls		
T4-7	Simple DL, cont. LL		
T4-8	Partial-depth deck panels (moved to T4-1)		

12.3 Closeout Session

In the closeout session Mike Culmo presented the proposed activities for Team 4's three ideas, as shown in Table 12.2 below.

1. Precast deck systems. Discussions were mainly on precast full-depth deck panels, with some discussion of partial-depth deck panels and other prefabricated deck systems. Proposed activities were to review other states' experience, looking at both state DOT and other industry standards; review existing research on deck panel connections and conduct research if needed; participate in domestic scanning tours to other states such as Utah and Texas that have significant use of precast deck panels; and develop standards.

2. Precast substructures. Discussions mainly focused on precast piers, looking at precast footings, columns, and cap beams. Proposed activities are to review other states' experience and standards; review the FHWA connection details manual that will soon be released; review building, railroad, and other industry experience; review research such as NCHRP 12-74 for applications in Iowa; do pilot projects such as precast piers; and develop standards.
3. Precast integral abutment-to-superstructure connections. The Iowa DOT is already doing precast integral abutments, but a fairly complex closure pour is being used. Proposed activities were to review other states' experience and standards, do pilot projects, and develop standards.

In the discussions that followed Mr. Culmo's presentation, the group commented on the importance of collaboration with industry in the development of the details, and also the importance of pilot projects as shown for the second and third ideas. Collaboration with industry and pilot projects find any changes needed to make the details work better for both the owner and industry. Also discussed was the need to stay with those standards once they are developed, improving them as needed through collaboration with industry, because the fabricators must buy steel formwork for new shapes, and formwork is expensive. The final group ranking of the three ideas remained the same.

Table 12.2 Team 4 Final Prioritized Ideas & Activities from Closeout Session

Group Rank	Idea Descriptors with Proposed Activities or Steps	Final Group Rank
G4-1	**Precast Deck Systems (full- and partial-depth):** 1. Review other states' experience (DOT & other industry standards) 2. Research review (possibly do research) 3. Scanning tour (e.g., Utah, Texas) 4. Develop standards	FG4-1
G4-2	**Precast Substructures (esp. Piers):** 1. Review other states' experience (DOT & other industry standards) 2. Review FHWA connection details manual 3 Review building/railroad/petroleum industry experience 4. Research review (NCHRP 12-74) 5. Pilot project (e.g., precast pier) 6. Develop standards	FG4-2
G4-3	**Precast Integral Abutment Connections to Superstructure:** 1. Review other states' experience (DOT & other industry standards) 2. Trial design and build 3. Develop standards	FG4-3

13. Summary and Next Steps

13.1 Summary

Mary Lou Ralls summarized the workshop activities and thanked the Iowa DOT for hosting the workshop, FHWA and ISU for co-sponsoring it, and the presenters and other participants for achieving the workshop goals of providing ideas with proposed activities for the Iowa DOT and other states to implement ABC on their projects. Final products of the workshop are the ideas with proposed activities for the three upcoming Iowa DOT projects and projects similar to those projects (Tables 9.2, 10.2, and 11.2), and ideas with proposed activities for prefabricated component details (Tables 12.2).

13.2 Next Steps

13.2.1 Vasant Mistry, P.E.

Vasant Mistry provided closing comments. FHWA has been co-sponsoring a number of ABC workshops, and he said this was one of the best workshops to date. He thanked the Iowa DOT and all involved for their participation in the workshop. Mr. Mistry then discussed possible follow-up steps. Those steps include implementing standardization for prefabricated bridge elements and systems; identifying a program of ABC work and implementing it; getting early industry involvement to allow the industry time to gear up for ABC work, as done in Utah; and attending the AASHTO Subcommittee on Bridges and Structures Annual Meetings and other bridge engineering venues to share ABC experience. He said he anticipates the Iowa DOT's next steps could include designating a champion and conducting follow-up workshops on details of how to implement the ideas in each of the projects discussed in this workshop, establishing realistic milestones and empowering the champions to achieve those goals. Mr. Mistry concluded his comments by inviting any state or county DOT that would like to host an ABC workshop or has any other ABC needs to contact him at FHWA's Office of Bridge Technology (Vasant.Mistry@dot.gov) or Kathleen Bergeron with FHWA's HfL Program (Kathleen.Bergeron@dot.gov).

13.2.2 Norman L. McDonald, P.E.

Norm McDonald thanked everyone for attending the workshop and sharing their expertise. He said the Iowa DOT will be considering implementation of the ideas developed in the workshop.

13.2.3 Sandra Larson, P.E.

Sandra Larson closed out the workshop with her comments on next steps. Costs are up and funding is down, bridges are continuing to deteriorate, and traffic is building. Innovation helps meet these challenges, and ABC is an innovation that provides the opportunity to further improve the way bridges are constructed. She said the Iowa DOT will be looking at the ideas and proposed activities that came from the workshop, including those related to needed research. Tours of ABC projects in other states will be considered. She said the participants have a wide variety of expertise and experience, and her hope is that the workshop was beneficial to all. She said participants will receive an electronic copy of the workshop report and a DVD with portions of the workshop, including short interviews with several of the participants. She thanked the participants and adjourned the workshop.

APPENDIX A

Iowa DOT Accelerated Bridge Construction Workshop Agenda

Airport Holiday Inn, 6111 Fleur Drive
Des Moines, Iowa
August 11-12, 2008
(Dress Code: Business Casual)

Workshop Objective:

Discuss accelerated bridge construction (ABC) practices in Iowa and other states. Explore specific ideas for ABC approaches to major projects that require construction acceleration. Examine design details for prefabricated bridge components that have been used in Iowa, and focus on three critical Iowa DOT projects for ABC implementation (the replacement of an urban viaduct, the replacement of a historic structure, and the rehabilitation of a congested interstate bridge). Discuss opportunities and obstacles and propose action to implement ABC for these types of bridges. The ABC approaches are intended to result in reduced construction time, minimized traffic disruption, improved safety, reduced environmental impact, enhanced constructability, and improved quality and life-cycle costs.

Moderator and Facilitator: Mary Lou Ralls of Ralls Newman, LLC

Monday, August 11, 2008

8:00-8:30 a.m.	Welcome and Opening Remarks: Iowa DOT (Sandra Larson & Norm McDonald) FHWA Office of Bridge Technology (Vasant Mistry) FHWA Highways for LIFE (Curtis Monk, FHWA Iowa Division Bridge Engineer) Workshop Objective (Mary Lou Ralls)
8:30-8:45 a.m.	National Vision: Making ABC Standard Practice (Vasant Mistry)
8:45-9:30 a.m.	ABC Projects That Save Money / Connection Details Manual Overview (Mike Culmo, CME Engineering, Inc.)
9:30-10:15 a.m.	Iowa DOT ABC Projects to Date (Jim Nelson, Iowa DOT)
10:15-10:30 a.m.	*Break*
10:30-11:15 a.m.	Details and Projects to be Discussed in Breakout Sessions (Ahmad Abu-Hawash, Iowa DOT)
11:15-11:30 a.m.	TRB SHRP2 R04, Innovative Bridge Designs for Rapid Renewal Overview (Frank Russo, R04 Principal Investigator)

11:30a.-12:00 p.m.	State Presentations on ABC Projects: California (Ray Wolfe, Caltrans)
12:00-12:30 p.m.	State presentations on ABC Projects: Texas (Dacio Marin, TxDOT)
12:30-1:30 p.m.	*Working Lunch (provided)* Lunch Presentation: Accelerated Bridge Construction: The Keys to Success from a Contractor's Perspective (Bill Duguay, J.D. Abrams)
1:30-2:00 p.m.	State Presentations on ABC Projects: Washington State (Jugesh Kapur, WSDOT)
2:00-2:30 p.m.	Accelerated Bridge Construction: The Keys to Success from an Owner's Perspective (Jim McMinimee, UDOT)
2:30- 2:45 p.m.	Charge to Breakout Session Teams (Mary Lou Ralls)
2:45-3:00 p.m.	*Break*
3:00-4:30 p.m.	Session A: Teams 1-3 brainstorm ideas for how these types of bridge projects could be built using ABC approaches, and Team 4 brainstorms ideas for how prefab details could be improved; discuss opportunities and obstacles to ideas; consolidate and prioritize ideas. ▪ Breakout Team 1: Broadway Viaduct (Kelly Strong) ▪ Breakout Team 2: Iowa Falls Steel Arch (Dennis Mertz) ▪ Breakout Team 3: I-80 Reconstruction (Wayne Klaiber) ▪ Breakout Team 4: Prefabricated Components Design Details (Mike Culmo) (Breakout Teams 1-3 each start with 10-minute overview presentation of their example project; Breakout Team 4 starts with 10-minute overview presentation of details used to date in Iowa [overview presentations will be given by project engineers]).
4:30-5:30 p.m.	Feedback Session A: Teams 1-3 report prioritized ideas for how their bridge projects could be built using ABC approaches; Team 4 reports prioritized ideas for how prefab details could be improved.
5:30 p.m.	Adjourn for the day

Tuesday, August 12, 2008

8:00-8:45 a.m.	Overall group discussion and prioritization of each team's ideas.
8:45-10:45 a.m.	Breakout Session B: Taking the overall group's priorities for its team's ideas, each team further develops the ideas and their opportunities and obstacles; develops proposed activities or steps needed to implement ideas including any needed research, policy change, specifications, etc.; prioritizes activities or steps for each idea as needed.

Break during Breakout Session

10:45 a.-12:45 p.m.	Closeout Session B: Each team reports proposed activities or steps for group-prioritized ideas in round table interactive presentation; overall group discussion, consolidation, and prioritization as needed.
12:45-1:00 p.m.	Summary (Mary Lou Ralls) Next Steps (Vasant Mistry, FHWA; Sandra Larson & Norm McDonald, Iowa DOT)
1:00 p.m.	Adjourn *(box lunch provided)*

APPENDIX B

Presenter and Sponsor Bios

Ahmad Abu-Hawash is the Chief Structural Engineer with the Iowa Department of Transportation. Mr. Abu-Hawash received his BS degree in Civil Engineering from the University of Iowa and his MS degree in Structural Engineering from Iowa State University. He has about twenty five years with the Iowa Department of Transportation in construction and bridge design.

Kathleen Bergeron is marketing coordinator for the Federal Highway Administration's Highways for LIFE program. She has more than three decades of experience with marketing and communication efforts for highway-related activities, including work at state, local, and federal government agencies, as well as international consulting engineering firms. At FHWA, she has led the use of modern marketing techniques in the agency's efforts to deploy innovations, and those efforts have resulted in significant shortening in the deployment time. Prior to joining FHWA, Ms. Bergeron served as Public Affairs Director at the Texas Department of Transportation and Deputy Division Director of the Texas Railroad Commission's Alternative Fuel Research and Education Division. She also was Marketing Director for Bernard Johnson Incorporated, an international architecture & engineering consulting firm. She has taught communication courses at the University of Texas at Austin and Austin Community College. She holds a Bachelor of Journalism from the University of Texas at Austin and a Master of Science in Transportation Management from San Jose State University. She received her accreditation in public relations by the Public Relations Society of America in 1992.

Michael (Mike) Culmo is Vice President of Transportation and Structures for CME Associates, Inc., of East Hartford, Connecticut, his employer for the past 11 years. He earned a B.S. in civil engineering in 1983 and a master’s degree in structural engineering in 1986, both from the University of Connecticut. Previously he was a supervisor in a bridge design unit for the Connecticut Department of Transportation, where he worked for 13 years. He is a member of the TRB Concrete Bridges Committee and Steel Bridges Committee, and has been a member of the PCI North East Technical Committee for Bridges for the past 15 years.

William G. (Bill) Duguay graduated in 1983 from UMASS Amherst with a BS in Civil Engineering, and has his PE license in Connecticut and New York. Having worked in 5 states before settling down in Texas, he has had the opportunity to work on several major projects around the county, comprising bridges, marine structures, deep foundations, dams, bascule bridges, balanced cast-in-place cantilever, precast segmental, and immersed tube tunnel. Some of these projects included setting up job-specific precast plants for segmental, flat slab, pile and panel production as well as incorporating contractor initiated design changes to allow ABC techniques. He is active in the American Segmental Bridge Institute where he was a member of their Construction Practices Committee; Deep Foundations Institute, former member of their Marine Foundations Committee; American Society of Civil Engineers and Construction Institute; and the Texas Chapter of the Associated General Contractors of America/ARBTA where he is a member of the Specifications Committee, and the Joint Committee in Houston. Over the past 8 years, Mr. Duguay has also been active with the Transportation Research Board presenting on ABC for several years at their annual convention, and is a member of several Expert Task Groups emphasizing Accelerated Bridge Construction. He has also met with various State agencies and this year’s International Bridge Conference promoting implementation of Accelerated Bridge Construction.

Jugesh Kapur is the State Bridge Engineer for Washington State and has held this position for the last 2.5 years. He has been with the Washington State DOT for 17 years and was in the private sector for 6 years prior to that. Mr. Kapur is a licensed civil and structural engineer in Washington and Oregon.

Steve D. Kathol is manager of Schemmer Associate Inc.'s bridge design department and responsible for managing, coordinating and scheduling all structural design efforts. His experience includes the design of a variety of structures including multi-lane urban and highway bridges, box culverts, retaining walls, approach slabs, and the structural design of drainage structures. Mr. Kathol received his Masters of Science degree in Structural Engineering from the University of Nebraska. He is a licensed engineer in eight states. Memberships and accomplishments include: Charter Member of the Structural Engineering Institute; Nebraska Society of Professional Engineers, 2002-2003 NSPE Young Engineer of the Year; Charter Member of Structural Engineering Association of Nebraska; Past President Local Chapter of ASCE; National Society of Professional Engineers; and Omaha Engineering Partnership Committee Chair for ACEC of Nebraska.

Hussein Khalil is a vice president and a Professional Associate with HDR Engineering in Omaha, Nebraska and currently serves as the Construction Services Section Manager for the transportation group. Mr. Khalil's practical design and construction experience of 23 years is backed with research experience dealing with acceleration. Mr. Khalil was the principle author for the Design Example Chapter and co-author on several other chapters of the PCI Bridge Design Manual. Mr. Khalil graduated from University of Nebraska-Lincoln with BSCE and MSSE degrees.

F. Wayne Klaiber received all his degrees in civil/structural engineering from Purdue University [BSCE '62, MSCE '64, PhD '68]. After being a faculty member in the Iowa State University Civil, Construction, and Environmental Engineering Department for 39 years, he retired in May, 2007. He currently is employed part time by ISU and holds the title Anson Marston Distinguished Professor Emeritus. He still is involved in research and is professionally active in TRB [Member of the Design and Construction Group and a member of the "Structural Fiber Reinforced Plastics Committee] and AREMA [Member of the "Concrete and Foundations" Committee]. The majority of his research continues to be in the areas of bridge testing, bridge strengthening and development of bridge alternatives for use on low volume roads.

Sandra Larson is currently the Research and Technology Bureau Director in the Highway Division of the Iowa Department of Transportation. She has held this position the last six years. She has held various positions during her twenty years with the Iowa Department of Transportation including: Engineering Bureau Director, State Bridge Engineer, Ames Resident Construction Engineer and Bridge Design Engineer. Sandra has two Bachelor of Science degrees from Iowa State University in Civil Engineering (1988) and General Science/Biology (1975) and is a registered professional engineer in the state of Iowa in Civil and Structural Engineering.

Dacio Marin III is a 1984 graduate of Texas A&M University with a B.S. in Civil Engineering with an emphasis in Structural Engineering. He received his Professional Engineer's license in 1989. Mr. Marin came to work for the Bridge Division in June of 1984 and has been designing bridges since that time. He has worked in several bridge design production groups and in the Special Projects Group of the Bridge Division's Technical Services Section. He has served the department as an instructor in a class for the development of bridge layouts and simple bridge details. Mr. Marin is currently a Bridge Design Manager, supervising a group of engineers and technicians in the design and detailing of bridge plans and other structural projects. His responsibilities include performing bridge design engineering and coordination of activities on highly complex bridge designs.

Norman L. (Norm) McDonald is the Bridge Engineer for the Iowa Department of Transportation. He graduated from Iowa State University with a BS in Construction Engineering. Mr. McDonald is a member of the AASHTO Subcommittees on Bridges and Structures and serves as Vice-Chair on the Technical Committee for Bridge Preservation (T-9) and is a Region III member on the Technical Committee for Structural Supports for Signs, Luminaires and Traffic Signals (T-12) and the Technical Committee for Structural Steel Design (T-14).

James (Jim) McMinimee is the Director of Project Development at the Utah Department of Transportation. He has been with UDOT for 22 years. Since 2002 UDOT has implemented Design-Build and Construction Manager/General Contractor (CM/GC) contracting, Accelerated Bridge Construction, the Transportation Technician program and the GPS Network. The Project Development Division is also responsible for engineering policy and business strategy for the Department. Before coming to Project Development in 2001, Mr. McMinimee served as the Region Two Director in Salt Lake City for six years. Additionally, he has over 10 years combined experience in Materials and Central Maintenance Operations at UDOT. During his career he and his teams have received numerous awards. Mr. McMinimee received his BS in Civil Engineering from the University of Utah and is a licensed PE with the State of Utah.

Dennis R. Mertz is the Director of the University of Delaware's (UD) Center for Innovative Bridge Engineering (CIBrE) as well as a Professor of Civil Engineering. Prior to his appointment at the University of Delaware, he was an Associate of the bridge-design firm of Modjeski and Masters, Inc. As co-principal investigator of the National Cooperative Highway Research Program (NCHRP) Project 12-33, Professor Mertz was one of the original authors of the 1st edition of the American Association of State Highway and Transportation Officials' (AASHTO) *LRFD Bridge Design Specifications*. As a consultant to Modjeski and Masters, he continues to assist AASHTO in writing annual interim changes to the *LRFD Specifications*. In addition, Professor Mertz has assisted in writing bridge-design manuals for Montana and South Carolina, and is completing bridge manuals for Nevada, Oklahoma and Alaska as well, as a consultant to Roy Jorgensen Associates.

Vasant Mistry is the Senior Bridge Engineer, U.S. Department of Transportation, Federal Highway Administration (FHWA), Office of Bridge Technology, Washington D.C. He serves as the national technical expert and review authority for all steel bridge and structural matters for the FHWA bridge program. He is responsible for drafting Federal policies and regulations as well as championing the use of innovative bridge technologies and materials, including accelerated bridge construction. Mr. Mistry is a member of the AASHTO Technical Committee for Steel Designs (T-14). He also serves as a technical committee member for six national committees. He is a Professional Engineer and has a degree of Master of Science in Structural Engineering and has over 35 years of experience in bridge design and review.

Curtis Monk is currently the FHWA Division Bridge Engineer in Iowa, a position he has held for 15 years. Mr. Monk graduated with a BSCE in 1974 from North Dakota State University and attained an MSCE in Geotechnical from Iowa State University in 1993. He has worked with FHWA in various offices and capacities for 34 years. Mr. Monk has been involved in bridge design and construction for his entire career. He serves on various national interagency committees and work groups including HPC and drilled shafts.

James (Jim) Nelson is a Transportation Engineer Specialist with the Iowa Department of Transportation. He has been with the Iowa DOT Office of Bridges and Structures for nine years. Recent projects include working on bridges on Interstate 235 corridor in Des Moines and the Council Bluffs Interstate System reconstruction. Research projects include the state of Iowa's first accelerated bridge construction project utilizing all precast components in Boone County and an FRP deck bridge for temporary bypass applications. Mr. Nelson is a graduate of Iowa State University with a Bachelor of Science degree in Civil Engineering and a Master of Science degree in Civil Engineering with emphasis in Construction Engineering and Management.

Mary Lou Ralls is an engineering consultant and principal of Ralls Newman, LLC in Austin, Texas. She earned BSCE and MSE degrees from the University of Texas at Austin in 1981 and 1984, respectively, before joining the Texas Department of Transportation (TxDOT). At TxDOT she worked in various engineering positions before being appointed the state bridge engineer and director of the Bridge Division in 1999. Ralls retired from TxDOT in September 2004 after 20 years of service. She is a registered professional engineer in Texas and continues work to advance innovative bridge technologies.

Francesco (Frank) Russo is a project engineer and project manager with more than 14 years of continuous experience in bridge engineering and a professional career lasting 18 years in academia, public service and consulting engineering. This includes five years with the Iowa DOT in the Office of Bridges and Structures. As the chief bridge engineer of HNTB's two Pennsylvania offices, Dr. Russo is responsible for technical oversight of the firm's local bridge practice and serves as a project manager on complex assignments. His experience includes design and project management support for multiple projects with constructed values in excess of $100M each. As a member of the firm's complex bridge and tunnel group, Dr. Russo has provided marketing support, project concept development, design support, QA/QC and construction services support for numerous projects throughout the country. For the past three years he has been an instructor in the FHWA NHI program teaching courses on LRFD bridge design for superstructures and substructures. Dr. Russo is currently the Principal Investigator for TRB Project R04 - Innovative Bridge Designs for Rapid Replacement. He is advising several DOT's and assisting them in developing design policies and practices related to accelerated bridge replacement. His personal experience in accelerated delivery includes bridges constructed using incremental launching, SPMT movement, lateral rolling and use of large prefabricated elements.

Kelly Strong earned his Baccalaureate degree in Civil Engineering from Iowa State University in 1980, a MBA from the University of St. Thomas in 1988, and a Ph.D. in Strategy and Organization Management from the University of Colorado in 1992. Dr. Strong is currently an Associate Professor of Civil and Construction Engineering at Iowa State University and Associate Director for Construction Management and Technology Research at the Center for Transportation Research and Education. Before entering academia, Dr. Strong was a project manager for seven years involved with several design-build projects. Dr. Strong has sponsored research contracts through Iowa State University with the Iowa Department of Transportation, the Minnesota Department of Transportation, the Midwest Transportation Consortium, the Associated General Contractors of America, and the DataBuilder Corporation.

Terry Wipf is the Pitt-Des Moines Professor in Civil Engineering within the Civil, Construction and Environmental Engineering Department at Iowa State University (ISU). He also serves as the Director of the Bridge Engineering Center at ISU. Prior to joining ISU, he had worked four years as a bridge engineer with HNTB in Kansas City, Mo., and he is a registered professional engineer. During his career he has directed more than 100 bridge related research projects funded by state, federal and industrial sponsors. His research specialty areas include bridge engineering, structural health monitoring, and bridge testing and evaluation, and he has conducted several recent research projects focusing on accelerated bridge construction topics. The projects have included laboratory and field demonstration testing and evaluation of precast concrete substructure and superstructure elements. Dr. Wipf is currently a member of the Transportation Research Board Committee, Dynamics and Field Testing of Bridges.

Raymond W. (Ray) Wolfe graduated from the University of Southern California with a B.S. in Aerospace Engineering in 1988, then from the California State Polytechnic University Pomona with a M.S. in Structural Engineering in 1995. He received his Ph.D. in Civil Engineering from the University of Southern Californian in 2002 with an emphasis in system identification and health monitoring. He is registered as a Civil Engineer and as a Mechanical Engineer in California. After a brief stint in the defense industry, Dr. Wolfe joined the California Department of Transportation (Caltrans) in 1991 as an entry-level engineer working in Structure Construction. His subsequent career has included experience in Structure Design, Structural Materials, and Structure Maintenance and Investigations. He currently manages a bridge design office located in Southern California, and is active with FHWA in developing standards for ABC implementation in regions of moderate-to-high seismic activity.

APPENDIX C

Participants List

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1	Abdou, Hossam	Alfred Benesch & Co.	habdou@benesch.com	Engineering Consultant – Iowa DOT projects
2	Abu-Hawash, Ahmad	Iowa DOT	Ahmad.abu-hawash@dot.iowa.gov	Bridges and Structures, Chief Structural Engineer
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7	Bergeron, Kathleen	FHWA Highways for LIFE Program	Kathleen.Bergeron@dot.gov	FHWA Workshop Co-Sponsor
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9	Bilow, Dave	NCBC	dbilow@cement.org	National Precast Bridge Industry
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12	Brubaker, Brent	PDM Bridge	bbrubaker@pdmbridge.com	Local Steel Fabrication
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16	Cramer, Robert	Cramer & Associates	rcramer@cramerandassociatesinc.com	Bridge Contractor – Iowa DOT projects
17	Culmo, Mike	CME Associates, Inc.	Culmo@cmeengineering.com	FHWA Connections Manual; PCINE
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		Concrete Institute		
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22	Dunker, Ken	Iowa DOT	Kenneth.dunker@dot.iowa.gov	Bridges and Structures, Bridge Design Manual
23	Dunn, Mark	Iowa DOT	Mark.dunn@dot.iowa.gov	Research Engineer, Iowa Highway Research Board
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25	Feazell, George	Iowa DOT	George.feazell@dot.iowa.gov	District Construction Engineer, District 4
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31	Hurst, Ken	Kansas DOT	KenH@ksdot.org	State DOT Bridge Engineer; AASHTO T-4 Construction Chair
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93	Wipf, Terry	Iowa State Bridge Engineering Center	tjwipf@iastate.edu	Co-PI, SHRP2 R04, “Innovative Bridge Designs for Rapid Renewal”
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95	Wolfe, Ray	Caltrans	ray_w_wolfe@dot.ca.gov	State DOT; National Seismic ABC Initiative

APPENDIX D

ABC-Related Websites and References

Websites

http://www.iowadot.gov/bridge/abc_ppt.htm
(for August 2008 Iowa DOT ABC Workshop presentations)

http://www.udot.utah.gov/main/f?p=100:pg:1126907402770386460:::1:T,V:1991,
(for information and updates on Utah DOT Accelerated Bridge Construction)

http://www.fhwa.dot.gov/bridge/

http://www.fhwa.dot.gov/bridge/prefab/

Projects constructed to date: http://www.fhwa.dot.gov/bridge/prefab/projects.htm

Publications: http://www.fhwa.dot.gov/bridge/prefab/pubs.htm

Research: http://www.fhwa.dot.gov/bridge/prefab/research.htm

http://www.fhwa.dot.gov/bridge/conferen.cfm (calendar of upcoming bridge events)

http://www.fhwa.dot.gov/hfl/ (Highways for LIFE)

http://www.aashtotig.org/ (AASHTO Technology Implementation Group)

http://www.trb.org/shrp2/ (TRB Strategic Highway Research Program 2)

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"Guidelines for Accelerated Bridge Construction," PCI Northeast Bridge Technical Committee, http://www.pcine.org

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“Prefabricated Bridge Elements and Systems in Japan and Europe Summary Report,” FHWA International Technology Exchange Programs, May 2004, http://www.fhwa.dot.gov/bridge/prefab/pbesscan.htm

“Prefabricated Bridge Elements and Systems in Japan and Europe Scan Team Implementation Plan,” FHWA International Technology Exchange Programs, Rev 10/25/04, http://www.fhwa.dot.gov/bridge/prefab/stip.htm

“Prefabricated Bridge Elements and Systems in Japan and Europe Final Report,” FHWA International Technology Exchange Programs, FHWA-PL-05-003, 2005, http://international.fhwa.dot.gov/links/pubs.cfm

“Accelerated Construction Technology Transfer (ACTT): A ‘How To’ Guide for State Highway Agencies,” Federal Highway Administration, Publication Number FHWA-IF-05-038, Fall 2005, http://www.fhwa.dot.gov/construction/accelerated/howtoguide01.cfm

APPENDIX E

Breakout and Closeout Session Notes from Breakout Team 1: Broadway Viaduct

Breakout A Team # 1: Worksheet A-2. Brainstorming

Open brainstorming on ideas; no critiquing.

Idea #:1	Hollow cell columns

Idea #:2	Drilled shaft prior to demolishing the existing structures

Idea #:	Reduce number of columns at each bent

Idea #:	Use train for site logistics

Idea #:	Extend work hours per week including night construction

Idea #:	Innovative Contracting (A&B; I/D)

Idea #:	Precast cap

Idea #:	Precast abutments

Idea #:	Light wight fill

Idea #:	Geopiers

Idea #:	Geo-form for fill

Idea #:1	Geosynthetic wall for temp. retaining wall

Idea #:2	Vibration control

Idea #:	Single staging/pedestrian access

Idea #:	Prebuild structures to North

Idea #:	Prefab reinforcement cage for the drill shafts

Idea #:	Lift-in sections built on site just adjacent to the existing bridge

Idea #:	Stay in place decking with LRFD deck?

Idea #:	Precast approaches

Idea #:	Overhead drop-in precast elements

Idea #:	Alternative foundation (e.g.; spread footing)

Breakout A Team # 1: Worksheet A-3. Evaluation

For each idea, discuss opportunities and obstacles.

Idea #:	Precast Columns
Descriptor:	
Opportunities	**Obstacles**
	Time needed for shop drawings; casting schedule
	Connection details new to DOT

Idea #:	Precast deck panels
Descriptor:	
Opportunities	**Obstacles**
Use half depth panel to overcome challenges	Contractors familiarity; smoothness; close-up (too many steps)
	Less flexibility

Idea #:	Precast Caps
Descriptor:	
Opportunities	**Obstacles**
Improve connection details	connections

Idea #:	Innovative fills
Descriptor:	Lightweight fill; geopiers or geoform etc

Opportunities	Obstacles
	Geoform – will be an expensive option; durability is a concern
	Retaining wall/vibration/ soil/head room/settlement trade off

Idea #:	Drilled shaft prior to closing
Descriptor:	

Opportunities	Obstacles
	Low head room
	Means and methods

Breakout A Team # 1: Worksheet A-4. Development, Part 1

Members individually rate the ideas. Team votes on each idea with a pass/fail (simple majority thumbs up). Team then prioritizes the ideas that pass (e.g., Team #2's top priority is designated "T2-1"; the "Team Priority" becomes the idea identifier number).

Idea #	Idea Descriptors	Individual Vote	Team Vote (pass/fail)	Team Priority

Breakout A Team # 1: Worksheet A-4. Development, Part 2

Team further develops prioritized ideas, including key features and estimates of time and cost savings. Team then considers its prioritization of ideas and re-prioritizes as needed. Team leader/facilitator presents prioritized ideas in Feedback Session A (4:30-5:30 p.m.).

Team Priority	Idea Descriptors	Key Features	Estimated Savings (time, cost)
2	Precast columns		
4	Precast deck panel		
2	Precast cap		
5	Geo form		
1	Drilled shafts prior to closing		

Team # 1: Feedback Session A Worksheet

Monday, 4:30-5:30 p.m.: Teams 1-3 report prioritized ideas for how their bridge projects could be built using ABC approaches; Team 4 reports prioritized ideas for how prefab details could be improved.

Tuesday, 8:00-8:45 a.m.: Overall group discussion and prioritization of each team's ideas.

Team Priority	Idea Descriptors	Group Rank
T1-__		G1-__

Breakout B Team # 1: Worksheet B-1. Recommendations

Team further discusses its team's group-prioritized ideas, considering opportunities and obstacles.

<table>
<tr><th>Group Rank:</th><td colspan="2"></td></tr>
<tr><th>Descriptor:</th><td colspan="2"></td></tr>
<tr><th colspan="2">Opportunities</th><th>Obstacles</th></tr>
<tr><td colspan="2"></td><td></td></tr>
</table>

Breakout B Team # 1: Worksheet B-2. Development

Team develops proposed activities or steps needed to implement ideas including any needed research, policy change, specifications, etc. Team then prioritizes activities or steps for each idea as needed. Team leader/facilitator presents proposed activities or steps for group-prioritized ideas in Closeout Session B (10:45 a.m.-12:45 p.m.).

Group Rank	Idea Descriptors	Proposed Implementation Activities or Steps

Team # 1: Closeout Session B Worksheet

Each team reports proposed activities or steps for group-prioritized ideas in round table interactive presentation; overall group discussion, consolidation & prioritization as needed.

Group Rank	Idea Descriptors with Proposed Activities or Steps	Final Group Rank
G1-__		

APPENDIX F

Breakout and Closeout Session Notes from Breakout Team 2: Iowa Falls Steel Arch

Breakout A Team # 2: Worksheet A-2. Brainstorming

Open brainstorming on ideas; no critiquing.

Idea #:1	

Breakout A Team # 2: Worksheet A-3. Evaluation

For each idea, discuss opportunities and obstacles.

Idea #:	
Descriptor:	
Opportunities	**Obstacles**

Breakout A Team # 2: Worksheet A-4. Development, Part 1

Members individually rate the ideas. Team votes on each idea with a pass/fail (simple majority thumbs up). Team then prioritizes the ideas that pass (e.g., Team #2's top priority is designated "T2-1"; the "Team Priority" becomes the idea identifier number).

Idea #	Idea Descriptors	Individual Vote	Team Vote (pass/fail)	Team Priority

Breakout A Team # 2: Worksheet A-4. Development, Part 2

Team further develops prioritized ideas, including key features and estimates of time and cost savings. Team then considers its prioritization of ideas and re-prioritizes as needed. Team leader/facilitator presents prioritized ideas in Feedback Session A (4:30-5:30 p.m.).

Team Priority	Idea Descriptors	Key Features	Estimated Savings (time, cost)
3	1. Prefab arch and float in	No falsework (quicker), less height (less need for fall protection)	7 votes
2	2. Prefab whole Arch and slide whole arch in place, possibly adding precast deck	Maintain traffic as long as possible	Use ½ of new abutment 8 votes

1	3 Erect arches and struts before demolishing bridge	Better maintenance of traffic Possibility of hanging partially demolished old arch from new arch	14 Votes
	4 Tie back to temp tower for demo and erection	Not in the river (avoid ice in winter)	2 votes
4	5 Demo and erect from barge or work platform		6 votes
	6 Build on bank and rotate into place		Zero votes
	7 Move Church and sewer		8 Votes total
	9 Micropiles to rock		5 Votes
	10 Tower Crane in river		Zero votes

Team # 2: Feedback Session A Worksheet

Monday, 4:30-5:30 p.m.: Teams 1-3 report prioritized ideas for how their bridge projects could be built using ABC approaches; Team 4 reports prioritized ideas for how prefab details could be improved.
Tuesday, 8:00-8:45 a.m.: Overall group discussion and prioritization of each team's ideas.

Team Priority	Idea Descriptors	Group Rank
T2-__		G2-__

Breakout B Team # 2: Worksheet B-1. Recommendations

Team further discusses its team's group-prioritized ideas, considering opportunities and obstacles.

Group Rank:	1
Descriptor:	Erect arch ribs and struts before demo

Opportunities	Obstacles
Many concurrent activities	New foundation walls conflict w existing
Maintain traffic as much as possible	Possible structural inadequacy of existing bridge
Works well with number 3	Ribs must remain outboard
Use new ribs and struts to demo existing bridge	If necessary to use barges, some modification of recreational boat dock, possibly including dreading would be necessary

Would eliminate the need for driven piling for falsework	
By staying out of the water, there may be less environmental impact	

Group Rank:	2
Descriptor:	Erect entire structure and skid into place
Opportunities	**Obstacles**
Concurrent activities	Whole bridge with deck would be problematic for handling
Maintains traffic	River banks are more constricted upstream and downstream
	Runways could conflict with abutment excavation
	It would be challenging to drive falsework piling

Group Rank:	3
Descriptor:	Prefab system for floorbeams/stringers/deck
Opportunities	**Obstacles**
Could be lifted up from below or launched from end	Limitation on size and proportion
Longer life deck system with good quality (industrial construction)	Requires adjustability

Breakout B Team # 2: Worksheet B-2. Development

Team develops proposed activities or steps needed to implement ideas including any needed research, policy change, specifications, etc. Team then prioritizes activities or steps for each idea as needed. Team leader/facilitator presents proposed activities or steps for group-prioritized ideas in Closeout Session B (10:45 a.m.-12:45 p.m.).

Group Rank	Idea Descriptors	Proposed Implementation Activities or Steps
1	Erect ribs and struts around existing bridge	Evaluation of load carrying capacity of existing Cost comparison between 1 and 2 Evaluate implications of using new arch to demo old Evaluate vibration tolerance of church and sewer Evaluate effects of new foundation on the old foundation. Evaluate using existing ribs for work platform
2	Skid arch /struts into place	Evaluation of feasibility of temporary supports (including sewer location) Cost comparison between 1 and 2 Consider R/W acquisition costs Evaluate vibration tolerance of church and sewer
3	Prefab floor system components	Evaluation PT/ non PT Solutions Barge capacity for work on river Evaluate possible use of existing standard details. Evaluate extent that prefab might limit worker accident exposure

	General Development Comments	For 1 and 2 above, the evaluation includes discussions with contractors for constructability verification. Buy steel early? If we do we may shorten the construction cycle, but might restrict the contractor with regard to erection method. Define advance milestones in contract documents (such as when bridge demo begins) Project deliver issues need to be investigated (allow contractors to choose whether or not to use the old bridge as part of their construction methods) The bridge can be built in one construction season, but the letting will have to be sooner to allow for submittals.

Team # 2: Closeout Session B Worksheet

Each team reports proposed activities or steps for group-prioritized ideas in round table interactive presentation; overall group discussion, consolidation & prioritization as needed.

Group Rank	Idea Descriptors with Proposed Activities or Steps	Final Group Rank
G2-__		

APPENDIX G

Breakout and Closeout Session Notes from Breakout Team 3: I-80 Reconstruction

Breakout A Team # 3: Worksheet A-2. Brainstorming

Open brainstorming on ideas; no critiquing.

Idea #:1	**Re-route traffic to I-235 and/or Highway 5**

Idea #2:	**Median cross-over**

Idea #:3	**Beam-slab combination prefabricated and "dropped-in"**
Splice to splice length section.	

Idea #:4	**Segmental deck replacement**
Leave and strength steel, remove individual deck sections, and then immediately drop in a precast deck section	

Idea #:5	**Narrow workzone with conventional deck replacement**

Breakout A Team # 3: Worksheet A-3. Evaluation

For each idea, discuss opportunities and obstacles.

Idea #:	3
Descriptor:	

Opportunities	**Obstacles**
	Replacing beams that may still have value
	Heavy equipment needed
	More expensive

Breakout A Team # 3: Worksheet A-4. Development, Part 1

Members individually rate the ideas. Team votes on each idea with a pass/fail (simple majority thumbs up). Team then prioritizes the ideas that pass (e.g., Team #2's top priority is designated "T2-1"; the "Team Priority" becomes the idea identifier number).

Idea #	Idea Descriptors	Individual Vote	Team Vote (pass/fail)	Team Priority
1			pass	
2			Fail	T3-1
3			Pass	T3-1
4			Pass	T3-3
5			Pass	

Breakout A Team # 3: Worksheet A-4. Development, Part 2

Team further develops prioritized ideas, including key features and estimates of time and cost savings. Team then considers its prioritization of ideas and re-prioritizes as needed. Team leader/facilitator presents prioritized ideas in Feedback Session A (4:30-5:30 p.m.).

Team Priority	Idea Descriptors	Key Features	Estimated Savings (time, cost)
T3-1	Prefab		
T3-1	Reuse steel		
T3-3	Replace cross-sections in small segments		

Team # 3: Feedback Session A Worksheet

Monday, 4:30-5:30 p.m.: Teams 1-3 report prioritized ideas for how their bridge projects could be built using ABC approaches; Team 4 reports prioritized ideas for how prefab details could be improved.
Tuesday, 8:00-8:45 a.m.: Overall group discussion and prioritization of each team's ideas.

Team Priority	Idea Descriptors	Group Rank
T3-__		G3-__

Breakout B Team # 3: Worksheet B-1. Recommendations

Team further discusses its team's group-prioritized ideas, considering opportunities and obstacles.

Group Rank:	1
Descriptor:	Remove deck deck and re-use beam

Opportunities	Obstacles
	How to cut the angle plus bar shear stud
	Transverse connection of deck

Group Rank:	2
Descriptor:	Prefab section drop in

Opportunities	Obstacles
Skid in a section built in the median.	Transverse connection of deck
	Amount of space available for fabrication or delivery

Breakout B Team # 3: Worksheet B-2. Development

Team develops proposed activities or steps needed to implement ideas including any needed research, policy change, specifications, etc. Team then prioritizes activities or steps for each idea as needed. Team leader/facilitator presents proposed activities or steps for group-prioritized ideas in Closeout Session B (10:45 a.m.-12:45 p.m.).

Group Rank	Idea Descriptors	Proposed Implementation Activities or Steps
2	Prefabricated super plus deck drop in	Substructure analysis. Capacity of existing/remaining bridge for holding prefab section prior to insertion. Research on transverse concrete splicing. Materials for high-early strength grouts, etc. Traffic analysis
1	Remove concrete deck and re-use steel beams	Finalize beam fatigue study. Need as built drawings. Coupon strength test. Research on transverse concrete splicing. Techniques for strengthening or support existing super. Techniques for removing angle/bar shear connector. Traffic analysis

Team # 3: Closeout Session B Worksheet

Each team reports proposed activities or steps for group-prioritized ideas in round table interactive presentation; overall group discussion, consolidation & prioritization as needed.

Group Rank	Idea Descriptors with Proposed Activities or Steps	Final Group Rank
G3-__		

APPENDIX H

Breakout and Closeout Session Notes from Breakout Team 4: Prefabricated Components Design Details

Breakout A Team # 4: Worksheet A-2. Brainstorming

Open brainstorming on ideas; no critiquing.

Idea #:	**1**
Transverse key: diamond key, female-female, horizontal fractured fin form liner, match casting (not generally preferred), v-slot, mechanical snap-together connector,	

Idea #:	**2**
Haunch forming: contractor choice, foam strips, h-channel with cross straps, steel angles,	

Idea #:	**3**
Box beam connectors: bolts, transverse PT, closure pour, welded plate [this is a major nationwide problem for primary type bridges]	

Idea #:	**4**
Integral abutment connections: closure pour, mechanical connectors,	

Idea #:	**5**
Non pretensioned, non PT deck panels, mild steel only	

Idea #:	**6**
Partial depth deck panels	

Idea #:	**7**
Foundations: standardize column connectors, integral abutments, connection between piles/precast footings (PT and mildly reinforced),	

Idea #:	**8**
Parapets: bolt-down, precast with deck, slip forming, jointless, steel railings	

Idea #:	**9**
Post-tensioning systems: VSL Oval, Nebraska, PT bars, monostrand	

Idea #:	**10**
Walls: wingwalls, retaining walls	

Idea #:	**11**
Simple DL, control LL	

Idea #:	**12**
Standardization	

Idea #:	**13**
Shear Studs: pocket spacing, studs vs. reinf. (conc.), channel @beam	

Breakout A Team # 4: Worksheet A-3. Evaluation

For each idea, discuss opportunities and obstacles.

Idea #:	1
Descriptor:	Transverse Keys

Opportunities	Obstacles
Review state standards, review academic literature,	Lack of research, or new ideas

Idea #:	2
Descriptor:	Haunch Forming

Opportunities	Obstacles
Review state standards, review academic literature, SCC, partnering with contractor, Test mock-ups,	Perceptions of contractors (means and methods vs. proscriptive),

Idea #:	3
Descriptor:	Box beam connectors

Opportunities	Obstacles
Review state standards, review academic literature, review PCI report	Lack of research, unknown forces

Idea #:	4
Descriptor:	Integral abutment connection

Opportunities	Obstacles
Review state standards,	Lack of experience
Simplify current methods	

Idea #:	5
Descriptor:	Non PS and PT decks

Opportunities	Obstacles
More competition	cracking
Reduce costs	

Idea #:	6
Descriptor:	Partial Depth deck panels

Opportunities	Obstacles
Accelerate construction	Past problems
Save money	policy

Look at state standards	

Idea #:	7
Descriptor:	foundations

Opportunities	Obstacles
Standardization to cut costs	Temporary shoring
Save money	Tolerances

Idea #:	8
Descriptor:	Parapets

Opportunities	Obstacles
Save money	Durability
	Epoxy anchors
	Crash testing

9	9
Descriptor:	PT Systems

Opportunities	Obstacles
Look at other states	Durability
Look at research	
Look at non-PT systems	

Idea #:	10
Descriptor:	walls

Opportunities	Obstacles
Speed construction	No experience
Flying wings	policy
May not require shoring	

Idea #:	11
Descriptor:	Simple DL, cont. LL

Opportunities	Obstacles
Full super prefab	Non standard details

Idea #:	12
Descriptor:	standardization

Opportunities	Obstacles
Cut costs	Internal politics
Simplify design	Up front investment

Idea #:	13
Descriptor:	Shear studs

Opportunities	Obstacles
Look at past research, state standards	Fatigue
Save money	Redundancy
	Other design issues

Breakout Team # 4: Worksheet A-4. Development, Part 1

Members individually rate the ideas. Team votes on each idea with a pass/fail (simple majority thumbs up). Team then prioritizes the ideas that pass (e.g., Team #2's top priority is designated "T2-1"; the "Team Priority" becomes the idea identifier number).

Idea #	Idea Descriptors	Individual Vote	Team Vote (pass/fail)	Team Priority
1	(lump keys, haunch, PT vs. mild, studs) Precast full-depth decks		12	1
2	Butted Beam Joints		2	4
3	Integral Abutments		9	2
4	Foundations		7	3
5	Parapets		2	5
6	Walls		0	6
7	Simple DL, cont. LL		0	7
8	Partial depth deck panels		0	0

Breakout A Team # 4: Worksheet A-4. Development, Part 2

Team further develops prioritized ideas, including key features and estimates of time and cost savings. Team then considers its prioritization of ideas and re-prioritizes as needed. Team leader/facilitator presents prioritized ideas in Feedback Session A (4:30-5:30 p.m.).

Team Priority	Idea Descriptors	Key Features	Estimated Savings (time, cost)

Team # 4: Feedback Session A Worksheet

Monday, 4:30-5:30 p.m.: Teams 1-3 report prioritized ideas for how their bridge projects could be built using ABC approaches; Team 4 reports prioritized ideas for how prefab details could be improved.
Tuesday, 8:00-8:45 a.m.: Overall group discussion and prioritization of each team's ideas.

Team Priority	Idea Descriptors	Group Rank
T4-__		G4-__

Breakout B Team #4: Worksheet B-1. Recommendations

Team further discusses its team's group-prioritized ideas, considering opportunities and obstacles.

Group Rank:	
Descriptor:	Deck Systems (1): Transverse key types (shapes, match casting, fractured fin, mechanical connectors, etc.)
Opportunities	**Obstacles**
Review other states' practices	Lack of research
Review research/literature	Cost?
Sponsor research	

Group Rank:	
Descriptor:	Deck Systems(2): Haunch forming (foam strips, steel angles with straps, etc.)
Opportunities	**Obstacles**
Review other states' practices	
SCC	
Partnering, mock-ups,	Contractors' means and methods

Group Rank:	
Descriptor:	Deck Systems(3): Shear Studs (pocket spacing, studs vs. reinf., channel/ beam)
Opportunities	**Obstacles**
Reduce pocket spacing	Lack of research – fatigue, redundancy, brittleness

Group Rank:	
Descriptor:	Deck Systems (4): PT Systems (Nebraska detail, VSL /DSI oval duct details, PT bars, monostrand systems)

Opportunities	Obstacles
Review other states' practices	Durability,
Review research/literature (recent PCI study)	redundant corrosion protection of strand, especially anchorages
Look at non-PS systems	Lack of prestress over beams with Nebraska System

Group Rank:	
Descriptor:	Deck Systems (5): Non-PS Systems

Opportunities	Obstacles
Reduce costs, expand producers	cracking

Group Rank:	
Descriptor:	Deck Systems (6): Partial depth deck panels

Opportunities	Obstacles
Review other states' practices	Past problems, cracking
Review research/literature (recent PCI study)	IDOT policy
Deliver as an option in contract documents	General Contractor resistance (not a problem in Texas)
standardization	

Group Rank:	
Descriptor:	Substructures/Piers:

Opportunities	Obstacles
Standardize column connections (reduce costs)	tolerances
Precast footings (PS & non-PS)	Temporary supports
Dry joints	
Architectural treatments	
Review other states' experience	

Group Rank:	
Descriptor:	Integral Abutments and associated connections (closure pours or mechanical connectors)

Opportunities	Obstacles
Simplify closure pour (precast tub form (PCI Northeast) detail)	Lack of experience
Review other states' experience	

Breakout B Team # 4: Worksheet B-2. Development

Team develops proposed activities or steps needed to implement ideas including any needed research, policy change, specifications, etc. Team then prioritizes activities or steps for each idea as needed. Team leader/facilitator presents proposed activities or steps for group-prioritized ideas in Closeout Session B.

Group Rank	Idea Descriptors	Proposed Implementation Activities or Steps
1	Precast Deck systems	1. Review other states' experience 2. Research review 3. Scanning tour 4. Develop Standards
2	Precast Substructures/Piers	1. Review other states' experience 2. Review FHWA report 3. Review building/railroad/petroleum industry experience 4. Research review (NCHRP 12-74) 5. Pilot Project 6. Develop Standards
3	Integral Abutment Connections	1. Review other states' experience 2. Trial Design and Build 3. Develop Standards

Team # 4: Closeout Session B Worksheet

Each team reports proposed activities or steps for group-prioritized ideas in round table interactive presentation; overall group discussion, consolidation & prioritization as needed.

Group Rank	Idea Descriptors with Proposed Activities or Steps	Final Group Rank
G4-1	**Precast Deck Systems** 3. Review other states' experience 4. Research review 5. Scanning tour 6. Develop Standards	1
G4-2	**Precast Substructures (esp. Piers)** 2. Review other states' experience 3. Review FHWA report 4. Review building/railroad/petroleum industry experience 5. Research review (NCHRP 12-74) 6. Pilot Project 7. Develop Standards	2
G4-3	**Integral Abutment Connections** 5. Review other states' experience 6. Trial Design and Build 7. Develop Standards	3