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Accelerated Bridge Construction and Structural Move - Workshop

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RESEARCH

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16. Abstract <p>The Michigan Department of Transportation (MDOT) is committed to provide the highest level of safety and mobility during each step of a project's development and delivery. To fulfil the above commitment, MDOT embraces technology and uses innovations. One such example is the implementation of the Accelerated Bridge Construction (ABC) project delivery process. MDOT is planning to implement the Slide-In and Self-Propelled Modular Transporter (SPMT) project delivery methods. MDOT foresees the future ABC projects to be design-bid-build; thus, they require the contracting industry and those delivering the projects to be knowledgeable of the methods. Also, this process requires the owners, in this case MDOT, to consider the means and methods that are required to complete an ABC project. ABC is a paradigm shift in bridge engineering and requires a change in bridge design engineers' thinking process to that of a contractor.</p> <p>Hence, MDOT hosted the workshop on December 9, 2013 at the Williams Auditorium in Lansing, Michigan. The objective was to leverage knowledge and experience developed in other state highway agencies, and to encourage the involvement of local consultants, contractors, prefabricators, and other highway agencies during implementation of innovative project delivery techniques in Michigan. This report provides summaries of all the presentations and a strategic plan for promoting ABC in Michigan.</p>			
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Accelerated Bridge Construction and Structural Move - Workshop

Report

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EXECUTIVE SUMMARY

The Michigan Department of Transportation (MDOT) is committed to provide the highest level of safety and mobility during each step of a project's development and delivery. To fulfill the above commitment, MDOT embraces technology and innovations. One such example is the implementation of the Accelerated Bridge Construction (ABC) project delivery process. After completing the first ABC project in 2008 using prefabricated bridge elements, MDOT built several bridges using the same technology.

MDOT is planning to implement the Slide-In and Self-Propelled Modular Transporter (SPMT) project delivery methods. MDOT foresees the future bridge slide-in projects to be design-bid-build; thus, they encourage the contracting industry and those delivering the projects to develop deep knowledge on this technology. Also, this process requires MDOT to consider the means and methods that are required to complete an ABC project. ABC is a paradigm shift in bridge engineering and requires owners to think like a contractor.

MDOT hosted an ABC workshop on December 9, 2013 at the Williams Auditorium in Lansing, Michigan. The workshop emphasis was on bridge slides and structural moves. The objective was to leverage knowledge and experience developed in North America, and to provide in-depth information to the Michigan consulting, construction and prefabrication industry as well as MDOT and local agency engineers. The long-term goal was to encourage the involvement of local consultants, contractors, prefabricators, and other highway agencies during implementation of innovative project delivery techniques in Michigan.

Based on the information presented during the workshop and the expertise of the authors, a strategic plan for promoting ABC in Michigan is proposed with the following steps:

- Organize an expert group of owners, designers, academicians and contractors with experience in accelerated bridge construction to provide feedback on specifications, guidelines, and details for implementing a specific ABC technology.
- Incentives and disincentives typically tend to motivate contractors, but when the project completion is delayed due to unforeseen events, the contractors are penalized twice: the first for their increased cost due to the delay, and the second the owners' delay penalty. Owners may incentivize continuing education of the contractor's

engineering staff as well as their length of tenure with the company. This may assure contractors developing and retaining experience in ABC.

- Develop a performance management strategy for ABC projects to assure that quality and durability are expectations as well as the speed of construction.
- Conduct ABC projects as demonstration projects, for their educational value to the local contractors, local agencies, and public.
- Document ABC project activities to develop case-study examples. These examples can be included in workshops. The following information describes the minimum documentation needs of ABC projects:
 - Scoping, decision-making, planning, and cost
 - Structural analysis and design
 - Contracting
 - Equipment selection
 - Scheduling
 - Contingency plans
 - Demolition methods
 - Construction
 - Testing bridge moves
 - Monitoring bridge moves, deformations and stresses
 - Maintenance of traffic (MOT)
 - Workforce management
 - Observations and lessons learned.
- Develop research to continually review the literature for domestic and international ABC implementations, and the information presented in the resources listed in chapter 5. Also, develop workshops co-sponsored by industry associations.

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1 INTRODUCTION

1.1 OVERVIEW

MDOT is committed to provide the highest level of safety and mobility during each step of a project development and delivery (MDOT 2010). To fulfil the above commitment, MDOT embraces technology and innovations (MDOT 2007). One example is the implementation of the Accelerated Bridge Construction (ABC) project delivery process. After completing the first ABC project in 2008 using prefabricated bridge elements and systems (PBES), MDOT constructed several additional bridges using PBES. Using Self-Propelled Modular Transporters (SPMT) or a slide-in technique to replace a bridge is another innovation in the ABC project delivery. According to the data provided in the National ABC/PBES Project Exchange database, as of May 2014, in the U.S., only 9 projects were completed using SPMTs, and an additional 14 projects were completed using the slide-in technique (FHWA 2014). However, with the current trends in implementing ABC techniques, the number of projects delivered or being delivered today using SPMTs and slide-in may exceed the numbers reported to the National ABC/PBES Project Exchange database.

The emphasis of the first phase of Every Day Counts Initiative (EDCI) was on PBES (FHWA 2013a). The second phase (EDC2) is focused on continuing with PBES while promoting implementation of slide-in as an additional ABC option (FHWA 2013a, b). As the mobility managers in the state, MDOT is committed to deploying ABC technologies. In 2014, two bridge slide-in projects will be delivered in the Grand region using the Construction-Manager – General-Contractor (CM/GC) contracting method. These projects will be the first slide-in implementations in Michigan. For the first two slide projects, the CM/GC contracting method will bring a contractor to participate on the project team with MDOT during the design phase. MDOT foresees the future bridge slide-in projects to be design-bid-build; thus, they encourage the contracting industry and those delivering the projects to develop deep knowledge on this technology. Also, this process requires MDOT to consider the means and methods that are required to complete an ABC project. In ABC design, the owner considers and stipulates a majority of the means and methods that a

contractor would undertake in a conventional project, such as demolition drawings, erection drawing, schematics of temporary works, etc. The complete ABC process is laid out by the owner prior to bidding, including the construction activities. ABC is a paradigm shift in bridge engineering and requires the designer to think like a contractor.

The industry needs to understand that slide technology is not a specialized tool; rather, it is a project delivery alternative that will be included as an option in future programs, and can be deployed as needed and dictated by the site conditions. The SPMT technology, as a project delivery alternative, is also very new to Michigan. In order to advance the knowledge of those involved in the bridge project delivery, MDOT hosted an ABC workshop on December 9, 2013 at the Williams Auditorium in Lansing, Michigan. The workshop emphasis was on bridge slides and structural moves. The objective was to leverage knowledge and experience developed in North America, and to provide in-depth information and materials to the Michigan consulting, construction and prefabrication industry as well as MDOT and local agency engineers. The long-term goal was to encourage the involvement of local consultants, contractors, prefabricators, and other highway agencies during implementation of innovative project delivery techniques in Michigan.

1.2 WORKSHOP GOALS

The specific goals of the workshop were to educate the participants on the following topics:

- Specifications for design and construction and how these are different between ABC and conventional construction
- Jacking operations and Self-Propelled Modular Transporter (SPMT) moves
- Design of temporary structures and geotechnical aspects of SPMT and structural moves
- Observations and lessons learned from completed ABC projects that involved slides and structural moves.
- Educating participants on the ABC project delivery and differences from conventional construction.

1.3 WORKSHOP PRESENTERS

The workshop was one day long and included seven morning and three afternoon presenters followed by a question and answer session. The list of presenters is given below with their affiliation and the presentation topic:

- Gregory C. Johnson, Chief Operations Officer, MDOT
Welcome/Michigan Department of Transportation (MDOT) Plans for ABC
- Matthew J. Chynoweth, P.E., Bridge Field Services Engineer, MDOT
Upcoming ABC Projects
- Rebecca Nix, S.E., Bridge Program Manager, Utah Department of Transportation
Implementing New Technology and Construction Practices
- Bala Sivakumar, P.E., Vice President and Director of Special Bridge Projects, HNTB
Rapid Renewal Project (SHRP-02 R04) Findings
- John Almeida, P.E., General Manager, Aecon Group Inc.
Overcoming Obstacles and Comparison to Traditional Construction Practices
- Frido De Greef, P.E., Procurement Manager, Mammoet USA Inc.
Jacking and SPMT Operations: Quality Control and Quality Assurance
- Brent Archibald, P.E., Senior Principal and Technical Director, Delcan
Proven Bridge and Structure Sliding Techniques
- Kenneth Price, P.E., Vice President, HNTB
Advances and New Options
- Benjamin Beerman, P.E., Senior Structural Engineer, Federal Highway Administration
Nationwide Perspective on ABC Implementation
- Haluk Aktan, Ph.D., P.E., Professor, Western Michigan University
Processes and Tools for Alternative Analysis of ABC for Project Delivery

1.4 REPORT ORGANIZATION

The report contains five chapters and five appendices:

Chapter 1 provides an overview of MDOT needs and goals of the workshop.

Chapter 2 presents the workshop participants' background.

Chapter 3 describes the key ideas learned from the workshop.

Chapter 4 presents a summary and a strategic plan for promoting ABC in Michigan.

Chapter 5 presents the resources on ABC.

Appendix A provides the workshop exit survey.

Appendix B provides detailed summaries of each presentation.

Appendix C provides a list of questions asked during the panel discussion held at the conclusion of the workshop and the answers provided by the panel members.

Appendix D provides presentation slides.

Appendix E lists workshop participants' names, affiliations, and contact information.

2 BACKGROUND OF THE WORKSHOP PARTICIPANTS

At the conclusion of the workshop, participants completed a survey. The survey template is provided in Appendix A. Out of 145 participants, 65 responded to the survey (i.e., 45%). As shown in Figure 2-1, 65% represented local agencies and contractors while 35% represented state agencies including MDOT.

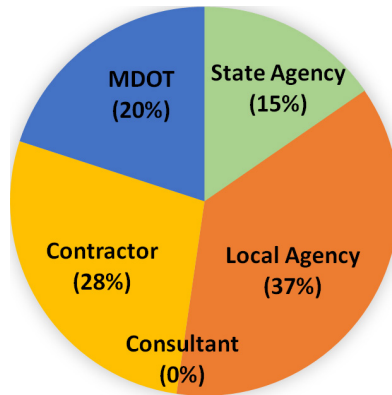


Figure 2-1. Affiliation of the participants

The second question of the survey asked participants' involvement in previous ABC projects. The response is analyzed and presented in Figure 2-2. As shown below, less than 30% of the local agencies and contractors had the opportunity to participate in previous ABC projects. State agencies were most involved in previous ABC projects.

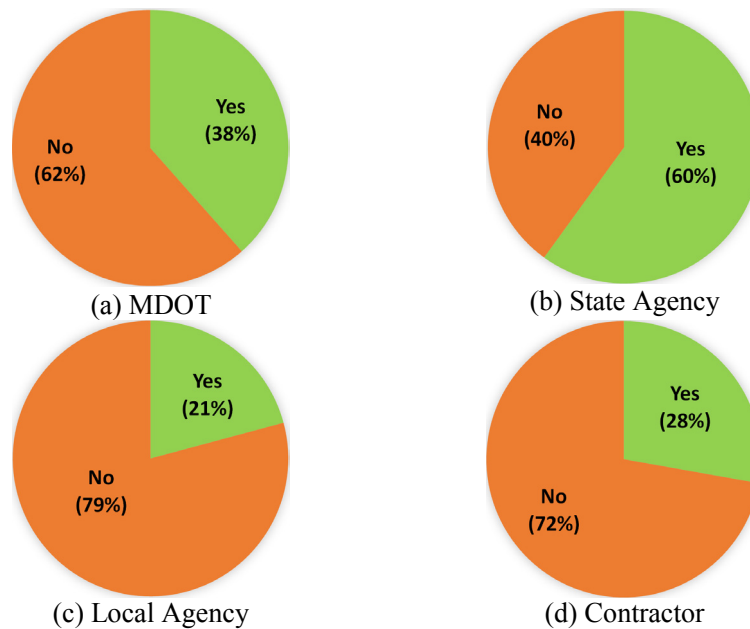


Figure 2-2. Participation in previous ABC projects

The third question of the survey asked participants' involvement in previous ABC demonstration projects. The response is analyzed and presented in Figure 2-3. Even though more than 75% of MDOT engineers participated in previous demonstration projects, local agencies and contractors did not.

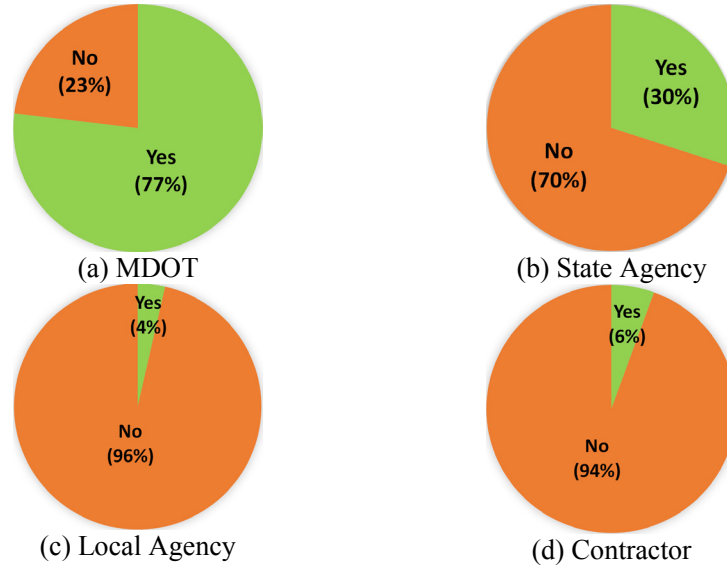


Figure 2-3. Participation in previous ABC demonstration projects

The third question of the survey asked participants' involvement in workshops, meetings or presentations on ABC. The response was analyzed and presented in Figure 2-4. While MDOT engineers had the highest participation in previous workshops/meetings/presentations on ABC, about 40% of local agencies and contractors also participated in such events to learn about ABC.

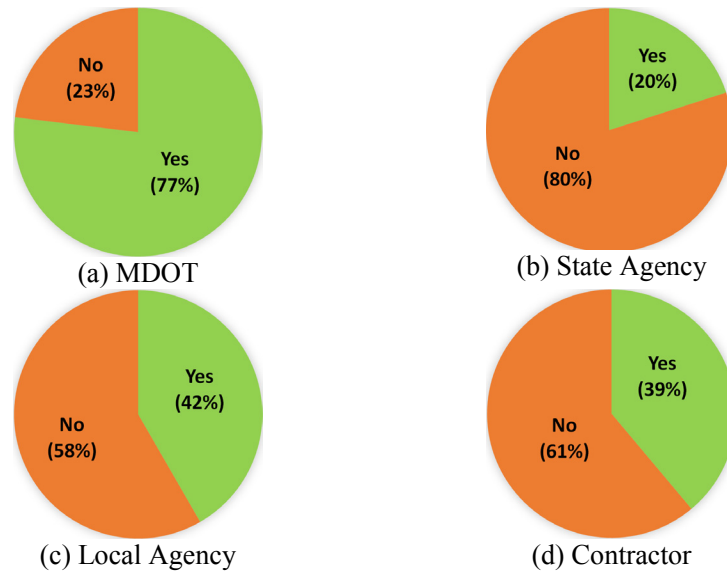


Figure 2-4. Participation in workshops/meetings/presentations on ABC

3 SUMMARY OF PRESENTATIONS

Detailed summaries of each presentation are provided in Appendix B. This chapter presents the key information extracted from the presentations under the following topics:

- Scoping, decision-making, planning, and cost
- Contracting
- Rapid demolition methods for ABC projects
- Structural analysis and design
- Structural move plans
- Contingency plans
- Construction
- Monitoring during moves
- Maintenance of traffic (MOT)
- Workforce management
- Observations and lessons learned.

3.1 SCOPING, DECISION-MAKING, PLANNING, AND COST

3.1.1 Scoping

MDOT approved the first ABC policy document in October 2012. The policy made ABC/PBES part of MDOT's business process. In the call for projects, MDOT requires the project selection to be based on the feasibility of ABC for project delivery. If ABC is not justified for a project, a rationale is required. MDOT's current mobility policy deals with defining a major project. Currently, the criteria included in the mobility policy are (i) Volume to capacity ratio of more than 0.80, (ii) Work zone travel delay of more than 10 minutes, (iii) Any corridors of significance, and (iv) LOS is D/E or during construction drops from A to C. MDOT's ABC focus is primarily on user delay and work zone safety which will be further emphasized as additional performance criteria standards are set. The most recent update includes (i) User delay costs, (ii) Project schedule (lengths/events), and (iii) Part-width construction, detours, or temporary bridge construction (MDOT 2014).

3.1.2 Decision-Making

The decision to implement ABC should be strategic and not solely for the purpose of trying it out. If the decision is not based on a deliberate analysis, then the contractor may propose to use conventional construction after winning the bid. Hence, the site evaluation for ABC is made by a decision-making tool that utilizes project specific data. Currently, a software platform developed for the Michigan Accelerated Bridge Construction Decision-Making (Mi-ABCD) based on site specific data is being evaluated by MDOT.

Mi-ABCD incorporates project-specific data. Moreover, it includes life-cycle cost (LCC) and user cost (UC) models and allows collaborative input from multiple users. Analysis methodology of the Mi-ABCD improves usability and efficiency of the decision-making process along with addressing the sensitivity of results through an automated process, and it is based on mathematically sound and validated concepts (Aktan et al. 2013).

3.1.3 Planning

Planning activities need to be performed, and detailed schedules need to be prepared prior to performing the work. The activities are grouped under: (1) pre-ABC procedures, (2) ABC procedures, and (3) post-ABC procedures. From the contractors' perspectives, this work requires approximately 6 months for most projects.

Considerations during the planning process are as follows:

- Perform ground surveys and geotechnical surveys. Surveys require experienced personnel to use technologies to document underground utilities such as Ground Penetrating Radar (GPR).
- Evaluate slide or structural move alternatives by considering site constraints, allowable closure duration, maintenance of traffic, etc.
- Consider the logistics of deploying the selected slide or structural move technology.
- Develop detailed plans from start to completion. The equipment and number of workers required for each job activity and associated specific time durations are critical. Planning

needs to include small details, such as installing transition rails at the approach that may require a temporary concrete barrier. It should also include identifying proper equipment, tools, and procedures for each activity.

- Select appropriate methodology, type of equipment, and personnel with specific skills for the work to be performed. The potential for using the same equipment for removal and installation needs to be considered. This may lead to major cost savings for the project.
- In the early planning phase of an ABC project, communicate with a heavy lift or heavy haul contractor about potential means and methods. Providing the heavy lift contractor with clear expectations of the project may save funds in the long run by selecting methods that can be executed with cost effective equipment.
- Provide bracings for structural stability while implementing vertical move technologies such as climbing jacks. Specialty contractors may try to avoid bracings to save costs, yet this increases the risk of failure. The climbing jacks in conjunction with SPMTs can provide additional raising or lowering in the final position or staging area. The need of climbing jacks should be evaluated and communicated with the heavy lift/haul subcontractor early in the project to preplan for providing sufficient bracings. For example, a heavy lift/haul subcontractor may decide to use climbing jacks instead of specialized frames for falsework to reduce cost.
- Deploying specialty equipment such as SPMT or slide rails, temporary structures for staging new and/or removed superstructure, etc., can limit the space available in the work zone and significantly impact the use of the general contractor's/owner's resources such as cranes and forklifts. Hence, a detailed analysis of the work zone is essential in positioning the crane considering the lifting and placing radius.
- Speed of implementing a particular slide or structural move method needs to be defined as limited time is available with bridge replacement projects. Thus, the time frame must be coordinated with the specialty contractor beforehand.

- Structural move or slide can be completed in a very short time frame. However, approach work could take a considerably long time if not planned in detail. After the bridge superstructure is in place, there is still a significant amount of work to tie the approach to some degree prior to opening to traffic. A few examples of such activities are backfilling at the abutment, pavement restoration, pavement markings, and installing guardrails. Some of these activities take place simultaneously and require detailed plans. As an example, the backfilling in proximity to the slide-in, or moved structure, is a time consuming operation and a critical activity in the ABC time window. The quantity of asphalt and fill removed directly impact the amount of post-ABC work for backfilling and pavement restoration. An approach is to use marker tapes to define the excavation area.
- The saw-cutting of abutment walls is a critical activity. A highly skilled worker is required for this operation because a slight deviation in the cutting angle may lead to unintended damage to the structure as well as unsafe conditions.

3.1.3.1 Planning for pre-ABC work

- Prior to sliding or structural move operations, at least six-months of detailed planning and other work need to be performed. The planning includes minute-by-minute details with *5-minute* milestones, including detailed contingency plans.
- Detailed planning needs to include the number of employees needed and their associated responsibilities. As an example, several field engineers, who are solely responsible for keeping track of progress, need to be on-site. Unexpected events can happen such as SPMTs failing due to bearing pressure or any other operational issues. These events are highly complex and require skilled workers to tackle them. It is very critical to select appropriate specialty contractors and highly skilled crews.
- The detailed planning is also essential for strategic equipment management. For example, it may be more practical to specify rubber tired excavators which are light and fast with small footprints. These machines can move on freshly placed asphalt; whereas, the track-mounted equipment, while excavating, will damage the asphalt and may

require padding, etc. Conversely, the use of rubber-tired equipment will require asphalt to be cooled prior to access.

- It is necessary to maintain accurate tolerances at the abutment location when the new structure is brought in, especially if the new superstructure is being placed on an existing substructure. This is to ensure accurate grouting operation to connect the existing abutment with the new superstructure. Employing highly skilled workers to saw cut the abutments is important.
- Adequate lighting needs to be provided at the site for safety during quick moving work. Illumination needs to be designed specifically for the equipment at the site and site layout. As an example, use of rubber-tired equipment may require additional lights due to low reflectivity.

3.1.4 Cost

- Approximately 25% of the project cost is for specialty subcontractors' activities when ABC projects involve heavy lifting or moving. One-third of the specialty subcontractor's cost is for mobilization and demobilization. Hence, planning and designing to move a structure with the least possible weight will require less equipment, and it reduces the cost of mobilization and demobilization operations.
- Deployment of a SPMT unit, which includes 6 axles, requires one truck. Transportation cost for each truck today is about \$4-\$5 per mile.
- Heavy lifting crane deployment cost is proportional to the number of boom sections because each boom section requires one truck for transportation. Also, load permits are required because of the heavier and wider sections. In this case, transportation cost of each truck today is about \$7-\$8 per mile.
- Lifting and transportation costs can be up to 2%-3% of the total project cost.
- Savings of up to 20% to 30% of a specialty subcontractor's contract can be achieved by implementing the following practices:
 - Involving a lifting/ transportation contractor during the design phase
 - Including specialized engineers to review the lift and/or transport method

- Designing elements that are relatively light or using voided sections
- Designing support and lifting points during the early design stages
- Constructing the structure as low to the ground as possible with sufficient space for transportation or lifting access
- Combining removal and installation of structures using the same equipment
- Providing bracings between structural components, barges, SPMTs, jacks, etc. Bracings are an extremely crucial aspect for a structure move.
- In addition to minimizing risks and unforeseen costs, the following need to be avoided:
 - Adding extra weight at the last moment. This requires bringing extra equipment, engineering staff, and resubmittal of the structural move plan, monitoring plan, contingency plan, etc.
 - Using falsework such as containers with unknown load-bearing capacities for the staging area. The containers need to be tested, certified, and approved by the lifting contractor.
 - Using custom made rigging, towers, etc. This is because the construction works, as well as moving operation activities, are performed around these structures, and requires significant engineering.
 - Establishing extreme deadlines. This may lead to extra labor cost, especially if the deadlines are communicated late.

3.2 CONTRACTING

The traditional contracting methods do not provide opportunity for leveraging contractor experience during project planning and development. With the introduction of ABC techniques, highway agencies are evaluating various contracting methods such as Best Value, CM/GC, Design Build, A+B, A+B+C, and Warranties for delivering successful bridge projects. The following sections present Utah and Michigan contracting experience.

3.2.1.1 *Utah Experience*

The following are the three different levels of contracting documents used in Utah:

- ABC means and methods are not provided. In this case, the structural plans are provided by the DOT similar to Cast-In-Place (CIP) structure and the contractor can decide on the mobilization method and develop any associated details. This was mostly useful for design-build projects.
- Show a schematic of one viable option. In this case, the DOT will choose and provide one viable method for mobilization of the structure, but will not provide the process of mobilization and associated details to the contractor. This was also useful for design-bid-build projects.
- Show permissible move details. In this case, the DOT will provide the viable method of mobilization along with associated details. The documents in this case are detailed. This was mostly useful for CM/GC projects.

In the contract documents, the goals, limitations, and requirements of the project should be defined. The specifications should include the following:

- Submittal requirements: Specify design and other associated details such as temporary support details, etc. Provide guidance on the level of design and details under the contractor's responsibility.
- Contractor flexibility: This can be done by limiting to one prescribed method and associated details or allowing the contractor to select a method.
- Tolerance limitations: Tolerance requirements are relaxed a bit compared to conventional construction. However, the contractor needs to identify and understand the precision required when the bridge is brought to its final location.
- MOT requirements: For example, on several projects Utah DOT allowed lane closures a day before the SPMT move in order to demolish one lane of the bridge. The contractors were also permitted to move the bridge a short distance a day before the move in order to perform a system check during daylight hours.

- Incentives and disincentives: Several projects in Utah were awarded with incentives when the roadway was opened to traffic ahead of schedule. However, contractors incurred disincentives in some projects in Utah because of delays in roadway opening. Utah DOT has a tier system for penalties, wherein a reduced disincentive is imposed within the first 2 hours to assure structure quality is not impacted. After 2-4 hours beyond the schedule, higher disincentives are imposed.
- The contract documents should indicate that the schedule must allow for review time. Also, the design team and the contractor are to be notified about the level of effort required in submitting and reviewing the following items:
 - Changes to contract plans
 - Temporary supports including geotechnical evaluation
 - Staging areas
 - Hour-by-hour schedule
 - Communication plan
 - Contingency plan.

3.2.1.2 MDOT Special Provisions for Sliding

MDOT developed special provisions for sliding a prefabricated structure, an ABC method. It is MDOT's intent to make these “previously approved” special provisions available on its website. The following are some of the requirements of the slide-in special provisions:

- Working drawings, calculations, and submittals
- Move operations manual: This is to ensure that MDOT inspectors, MDOT engineers, contractor, superintendent, and contractor’s engineer are coordinated. Thus, if any issue arises during the slide, all the associates on-site will be clear on their responsibilities in mitigating that issue.
- Geometry control and monitoring plan
- Contingency plan
- Trial horizontal slide
- Movement of superstructure requirements
- Allowable tolerances.

3.2.1.3 Contingency Plan

The contingency plan ensures that the hour-by-hour schedule is observed. This provides an interpretation of the move or slide progress and allows for prompt issue mitigation. In addition, public involvement needs to be coordinated well. Additionally, a couple of hours of contingency are reserved beyond the contractor's proposed time. The closure time advertised to the public is a couple of hours longer than the contractor's proposed time.

There should be a contingency plan for means to pull the bridge back. Pull back may be required if the bridge is moved in at an inappropriate angle and/or is rubbing on the substructure. In addition, there should be a plan as well as an ability to adjust the bridge horizontal alignment, such as, if the structure is very close to one abutment compared to the other.

Also, for critical equipment such as jacks, control units for SPMTs, and parts with short life, it is essential to have spare equipment and/or parts in stock, on-site.

3.3 RAPID DEMOLITION METHODS FOR ABC PROJECTS

The following three potential methods were discussed:

- Use of SPMT
 - Sliding out
 - Saw cutting and removing with cranes
 - Use of explosives.
- When SPMTs are used to replace a bridge, temporary shoring can be used to support the existing bridge for demolition. The cost effective approach is to cut the old bridge on the temporary shoring, lift, place on the ground, and demolish.
 - It is critical to document the extent of deterioration of structural members, weight and center of gravity of the structure before implementing any move technology for removal.

- Extreme consideration must be given for prediction capabilities while using explosives for demolition. Alternatives to using explosives, such as cutting the structure and moving for safe demolition, must be investigated. .

3.4 STRUCTURAL ANALYSIS AND DESIGN

ABC is a paradigm shift in bridge engineering. ABC requires that the bridge design engineers think like a contractor. Also, the design engineers must evaluate constructability of the structure during the design phase.

3.4.1 Prefabricated Bridge Elements and Systems (PBES)

When PBES are specified, three separate designs are prepared for a project. One is final bridge design in its final alignment/construction (similar to conventional bridge). The second design is when the bridge is being fabricated, and the third design is when the bridge is being lifted and erected in place or moved or slid into the final place. Each of the designs include additional loading and stress requirements. Most of the time, the governing design may not be the final bridge design but the design including lifting and erection or moving or sliding conditions.

Limit states shall be considered in the design for the following stages: (1) prefabrication process, (2) shipping process, (3) erection process, and (4) final as-built state of the bridge.

In prestressed concrete design, strand release stresses may control the design of the beam, and they are mitigated accordingly to ensure sufficient capacity for the operational life of the structure. In ABC, additional checks are required for stresses/deflections during shipping and handling. This is because heavier and longer girders are often used. In addition, camber and deflections need to be checked at release, erection, and final as-built state. Design documents need to specify the time duration the girders are allowed to remain in the staging area or prefabrication yard before being erected. The schedule for fabrication, curing, and transporting the elements also needs to be specified.

A challenge for most designers is the erection concepts for PBES. For constructability, the designer should understand the site and contractors' capabilities. This requires sufficient planning time to evaluate the site and communicate with the contractors.

The following are challenges to designing PBES:

- Insufficient knowledge and experience in detailing connections, specifying tolerances, tracking durability, designing curvilinear geometry, and accounting for negative moment continuity
- Availability of precast contractors
- Designing a component size suitable for transport and erection.

In order to address the component size and weight adequacy for transport and erection, the SHRP-02 R04 project team identified the weight of 200 kips as the optimal for shipping and handling/erecting with conventional equipment. When the 200 kips weight limit is exceeded, the contractors need to deploy heavy lifting equipment. Also, shipping the component becomes complex and requires permits increasing the project cost.

An ABC toolkit was developed to provide assistance to the bridge engineering community with PBES implementation. The components of the tool-kit are as follows:

- ABC standard design concepts
- ABC erection concepts
- ABC design examples
- Recommended modifications to AASHTO LRFD
- ABC construction specifications.

3.4.2 Bridge Slide

The critical aspects of slide projects are as follows:

- The coefficients of friction (static and dynamic) are critical estimates as they define the required jacking hydraulics for mobilizing the structure. MDOT is involved in developing jacking force calculations based on static and kinetic friction coefficients. This will allow selecting appropriate sliding surface and jacks for the jacking operation.

- Project slide-in systems consisted of structural steel track beams supported on a temporary substructure. A series of Teflon laminated neoprene steel reinforced pads are set on the steel track beams with the Teflon facing upwards. Then, welded steel carriages with a stainless steel surface are placed on top of the Teflon pads. The kinetic friction is typically around 1-2%.
- When the sliding surface is bronze on steel, static friction of 15% and kinetic friction of 8% is expected.
- Lateral restraint needs to be provided to the structure during the slide-in operation.
- Sliding a multi-span structure introduces additional complications. These complications include keeping the structure aligned and guided. Multi-spans require more precise operation than sliding a single span structure.
- Utah DOT and the Michael Baker Corporation prepared a slide-in bridge construction (SIBC) guide for Federal Highway Administration's (FHWA) Every Day Counts Initiative. The guide can be downloaded from FHWA website (FHWA 2013b). Topics included in the guide are listed below:
 - Introduction of Slide-In Bridge Construction
 - Owner Considerations
 - Design Considerations
 - Construction Considerations
 - Case Studies
 - Sample Plans
 - Sample Special Provisions.

3.4.3 Self-Propelled Modular Transporter (SPMT)

Resources for SPMT implementations are available through the Federal Highway Administration (FHWA) website (<https://www.fhwa.dot.gov/bridge/abc/spmts.cfm>). The workshop presenters primarily discussed the geotechnical aspects of the project that they worked on. The following are some of the considerations presented:

- The temporary supports located in the staging area need to provide an adequate bearing area to control settlement. In general, the factored bearing capacity of the soil shall be twice the applied bearing pressure in the staging area (i.e. Factor of Safety of 2). Organic clay or weak soil at the staging area needs to be removed, and a granular base is placed to achieve the required bearing capacity.
- Loads from shoring and the SPMT moves and the bearing capacity of existing soil need to be considered for calculating the granular base thickness.
- Concrete sill pads (precast blocks) and reinforced concrete footings are potential solutions for temporary support footings. The reinforced concrete footings can be recovered. The concrete sill pads are reusable.
- In addition to preparing a temporary staging area, a travel path needs to be thoroughly investigated and prepared to assure the stability of the SPMT. Weak soils such as organic clays need to be removed and a granular base prepared. The granular base thickness is calculated based on the loads from the SPMT and the bearing capacity of the existing soil underneath the granular base.

3.5 CONSTRUCTION

3.5.1 The Technologies for Moving Structures

The available technologies can be categorized into two groups as vertical and horizontal (Table 3-1).

Table 3-1. Technologies for Moving Structures

Vertical Technologies	Horizontal Technologies
Cranes	Trailers - SPMT - Conventional Trailers
Tower Systems - Strand Jacks - Gantry Systems	Skidding (sliding)
Jacking - Climbing Jacks - Titan Systems - JS 500	Barging

3.5.1.1 *Cranes*

The following are the key considerations when cranes are used in a project:

- Ground bearing pressure
- Lifting points
- Swing radius
- Weight chart for respective cranes. Preplanning is with respect to structure weight and any excess weight because of lifting/placing radius.

3.5.1.2 *Strand Jacks*

The following are the key considerations when Strand Jacks are used in a project:

- Useful for limited access areas (hard to reach areas)
- Leads to cost savings when planned early in the design phase
- Mobilization and demobilization costs are low. Each piece of equipment weighs about 4 ton (8 kips), and 5 to 6 jacks can be transported with one truck without requiring load permits.
- Jacks are integrated with a computer controlled system. Lifting velocity is slower than cranes.
- Jacks can be used for bridge removal without requiring additional equipment for lifting or lowering the bridge. However, engineering design is required.
- Jacks can lift a bridge about 3 ft in one stroke in about 10-12 minutes.

3.5.1.3 *Multiple Strand Jacks per Tower*

The following are the key considerations when implementing Multiple Strand Jacks per Tower in a project:

- Strand jacks with 100 ton (200 kips), 300 ton (600 kips), and 900 ton (1800 kips) capacities can be combined per tower.
- Hammer head tower design required for this technology is applicable for bridge projects.
- Electrical power can be used.
- Light load support cranes are needed for transporting the materials to the tower.

3.5.1.4 *Gantry Systems*

The following are the key considerations when Gantry Systems are used in a project:

- Capacities up to 1250 ton (2500 kips) are available.
- Ideal for lighter deck removal with gantry-skidding beams mounted on girders
- Limited lift height
- Only 3 or 4 hydraulic jack mounts are available for lifting operation.
- Requires extremely stable ground
- Needs providing temporary strengthening or post-tensioning to mitigate the stresses developed in the structural elements.

3.5.1.5 *Climbing Jacks*

The climbing jacks are large hydraulic cylinders supported by hard wood cribbing or blocking. The climbing process involves the hydraulic cylinder integrated with the jack to push the outer housing up and allow for placing blocking supporting the housing. Then, the housing pulls the cylinder up, and hard wood blocking is placed under the hydraulic cylinder. This process is repeated in a sequence to further advance the jack upwards.

The following are the key considerations when Climbing Jacks are used in a project:

- Pressure points for both structure and support shall be calculated.
- Height restricted: Can go up to 2-3 ft per stroke
- Labor intensive and slow: Every stroke takes about 2-3 minutes based on the access of the jacks to place jacking wood.
- Low mobilization and demobilization costs
- Low engineering cost
- Structural demolition is possible.
- Good quality of jacking wood blocking (hard wood) for bracing is required for safe operation.

3.5.1.6 *Titan Systems Jacks*

This is Mammoet's proprietary system. A photo of the Titan system is shown in slide 20 of Mammoet presentation given in the Appendix D. The following are the key considerations when Titan Systems Jacks are used in a project:

- Ideal in combination with SPMTs
- Lift capacity up to 2,400 tons (4,800 kips)
- Extremely stable and support friendly.

3.5.1.7 *JS 500 Jacks*

Refer to slide 22 of Mammoet presentation given in the Appendix D for a photo of a JS 500 jacks. The following are the key considerations when JS 500 Jacks are used in a project:

- Ideal in combination with SPMTs
- Stable
- Computer controlled jacking: Differential tolerance of 4 mm (0.16 in.) between the jacks can be achieved.
- 500 ton per tower
- Lifting above 33 ft requires additional bracing.
- Fork lifts and labor are required for faster lifting. The process requires the bracing blocks to be moved on the JS 500s rapidly for increased speed of the operation.
- Tie down to structure is required at temporary or fixed points.
- The application needs to be specified during the design phase.

3.5.1.8 *Conventional Trailers*

The following are the key considerations when Conventional Trailers are used in a project:

- 10 ft wide (i.e., 2 ft wider than SPMT); therefore, more stable than SPMTs, if used as a single trailer
- May require load permits because of extra width. However, in general, mobilization and demobilization for this technology is low cost as they are pulled behind the trucks. This technology will be lower cost if equipment is available locally.
- Limited maneuvering possibilities compared to SPMTs
- Different loading charts are available for different types and brands. They are more flexible than SPMTs.

3.5.1.9 Skidding or Sliding

The following are the key considerations when a Skidding or Sliding technique is used in a project:

- Very low cost way of moving
- Is slower than other horizontal move methods
- Push or pull points needs to have sufficient capacity.
- Combination/Installation with jacking is possible. Short stroke pushing jacks can be used in combination with pulling jacks to overcome the initial braking friction.
- Capacity ranges from 100 ton (200 kips) to 750 ton (1500 kips).
- If the new bridge cannot be constructed close enough and/or on the same elevation with the existing bridge, then Skidding or Sliding technology may not be applicable.

3.5.1.10 Barging

The following are the key considerations when barging is used in a project:

- Project schedule may be impacted by weather conditions that affect the water level/current of the waterway.
- Additional equipment is needed such as ballasting, winching, mooring, tugs, etc.
- Engineering is required with the use of additional equipment.
- Building a barge is very expensive, but they can be rented.
- Dead load calculations govern the type of barge being selected.
- In addition to the typical loads, buoyancy forces must be considered.

3.5.1.11 Self-Propelled Modular Transporters (SPMTs)

The following are the key considerations when SPMTs are used in a project:

- Ground bearing pressure. Steel bearing plates are often required along the move path.
- Can also be used for structural demolition
- The structure needs to be braced while on the SPMTs.
- Tires are air filled.
- Capacity is about 30 ton (60 kips) per axle line.
- 360° steering capability

- Can be incorporated into the Titan system presented in section 3.5.1.6
- Hydraulic systems can be customized for 3 or 4 point set up.
- Spacers (connection elements) are used for mechanical side-by-side coupling of transport units. Spacers are available in different configurations. An example is shown in Figure 3-1. Other spacer configurations are available for connecting multiple transport units as needed. Spacers can be used to combine multiple transport units to distribute loads among the transport units; hence, to reduce mobilization/demobilization costs and equipment rental costs.

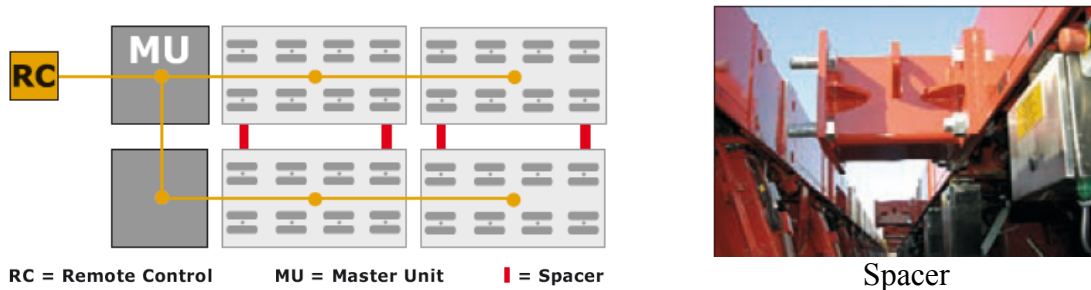


Figure 3-1. Mechanically coupled vehicle combination (Source: SCHEUERLE 2014)

In SPMT implementations, the following is a list of typical activities required in a pre-ABC lift operation:

- Remove approach slabs and pavement.
- Demarcate the excavation area using marker tapes to avoid extensive excavation.
- Excavate backfill.
- Saw-cut and stabilize the abutment walls and/or backwalls.
- Backfill the existing abutment walls and/or backwalls including sub-drain installation and connection.
- Divert the sub-drain below.
- Place temporary pavement.
- Mark the SPMT move path to direct its movement along the intended path, and supported over rolled steel plates and/or sufficiently protected utilities when needed.
- Install bearings before move (using tie downs, friction clamps, etc.).

The following is a list of typical steps involved during the ABC lift operation:

- Excavate backfill.
- Remove existing superstructure and transport to staging area.
- Transport new superstructure from staging area and erect to final position.
- Backfill with granular material.
- If an asphalt approach pavement as well as an overlay is used, place hot mix asphalt on bridge deck and approaches.
- If a concrete approach pavement is used, place precast concrete slabs to expedite the approach roadway work.
- Install temporary concrete barriers.

The following is a list of typical steps involved in a post-ABC lift operation:

- Excavation
- Grading and placement of granular base for approach slabs
- Construction of approach slabs using rapid set concrete or with precast panels
- Placement of hot mix asphalt on approach slabs and on exterior portions of the structure
- Placement of median barrier walls on approach slabs using rapid set concrete and embedded electrical work.

3.5.2 Incremental Launching

A simple cast-in-place post-tensioned structure with launching technology is ideal for reconstructing a bridge over a very busy railway that limits access of cranes. The procedure eliminates the need for interruption of railway traffic. Concrete bridges with spans up to 80 ft can be launched conveniently without a nose but with temporary piers or with a very small launching nose but without temporary piers. However, a typical steel launching nose is required for bridges with spans over 80 ft long with temporary piers. In addition, king post and stays are included for spans up to 210 ft. Bridges have been successfully launched up to 4500 ft (0.85 mile) in length. When the spans get longer, new challenges are introduced.

Generally, post-tensioning of the structure in a longitudinal direction is required for implementing launching technology. In addition, it is essential for the launching nose design

to accommodate/limit the stresses on the structure due to the cantilever action. The length of launching the nose can be up to half-a-span. However, the launching noses can be designed for a limited length provided that the span is designed to accommodate large deflections and accommodate the angle of curvature and deflection at the landing point within limits. In these cases, a “rocker” (i.e., a temporary bearing at pier location) can be utilized, on which the curved launching nose is landed, rolled up and rotated onto the piers.

The hydraulic jacks required for incremental launching technology are readily available. Launching track, launching bearing, and hydraulics are obtainable. Bridges with complex geometry, such as horizontal and vertical curvature, can also be replaced using launching technology. Implementing launching technology on spiral geometry bridges and varying-width deck bridges is also possible by using wider launch bearings.

Additional information on incremental launching can be found in LaViolette et al. (2007), a report developed as part of NCHRP Project 20-07.

3.5.3 Prefabricated Bridge Elements and Systems (PBES)

The ABC Toolkit developed under the SHRP-02 R04 project provides erection drawings (detailed erection plans) for the contractor to erect the PBES using conventional cranes. The toolkit also provides different crane placement and erection scenarios for typical bridge projects (SHRP-2 2013). It is important to be familiar with different types of cranes available for ABC. This helps identifying an appropriate crane for erection based on the site conditions.

The toolkit provides a constructability analysis considering conventional crane-based erection. The factors that are considered during the analysis are: (1) weight of a prefabricated element, (2) pick radius, (3) crane set up locations, (4) ground access/ barge/ causeway/ work trestle, and (5) truck access for delivery. The constructability analysis is recommended to be performed by preparing the site plan including all the crane locations and access options.

In most cases, construction from below (ground) is costly and time consuming. This difficulty arises in projects dealing with interstate expressways or railroads as the feature intersected. Thus, to address this issue, the toolkit considered the following ABC technologies that allow construction from above:

- Above deck driven carriers: Mostly suitable for sites with limited ROW. However, it is cost effective for bridges with 10 to 15 spans but not for bridges with 1 or 2 spans.
- Launched temporary bridge (LTB): Useful in environmentally sensitive areas or any restricted areas with limitations to on-ground placement of cranes. The LTBs increase the possibility of erecting longer spans. They are launched across or lifted over a span to act as a temporary bridge and can be used to deliver heavy prefabricated elements without inducing large erection stresses. The temporary bridge can also support transverse gantry frames.
- Transverse gantry frames: This includes gantry girders on either sides of the bridge and on which the gantry moves. The gantry then moves back and forth to pick the old span out and install the new span.
- Longitudinal gantry frames: This includes two SPMTs with long longitudinal gantry truss that lifts the old span and moves it out, and the new span is moved in and installed in a sequence. The gantry carries two spans at the same time.
- Regular cranes with sufficient reach.

3.5.4 Substructure and Foundations

- For piers, there are two concepts: (i) conventional pier with cantilever bent cap, and (ii) straddle bent. The straddle bents are preferred because new bridges are commonly wider than the old bridges, and straddle bents allow using drilled-shafts/piles and constructing foundations outside the footprint of the existing bridge.

3.6 MONITORING DURING MOVES

Accurate elevations and proper placement of the structure with frequent precision surveys are the purpose of monitoring. Also, double-checking is critical for the skew angles, bearing elevations, and span lengths.

The following are the typical technologies and methods used in structural monitoring during bridge moves:

- Load cells ranging from 5 ton (10 kips) to 750 ton (1500 kips) are placed to monitor the loads imposed on the structure.
- Lasers are used for measuring and/or comparing distance based on critical points marked on the structure for monitoring yaw (rigid body rotation about vertical axis) in order to control direction of bridge movement. Lasers are also used for measuring structural deformations when controlling lateral stresses.
- Strain gauges are used for monitoring strain and the associated stresses.
- Pressure indicators are used for monitoring hydraulic cylinder pressure.
- Surveys are performed to check the levels, string lines, and measuring gaps.
- Vertical deflections are monitored to control bridge superstructure twisting during the move.

During bridge slide, the following actions can be performed:

- CCTV cameras can be used to monitor the slide path.
- The scale markings can be marked on the slide path to inform the operator about the progress of slide-in movement.
- Monitoring can be as simple as drawing a chalk line on the abutment and diaphragm to track the slide.
- In cases when the superstructure is slid with the approach slab, frequent measurements need to be taken throughout the move to maintain the required gap between the sleeper slab and the end of approach slab.

3.7 MAINTENANCE OF TRAFFIC (MOT)

MOT requirements are critical, and the contractor needs to be focused on these activities.

Utah DOT discussed strategies used during several projects to manage traffic during one of the projects. Utah DOT allowed lane closures on features intersected a day before the SPMT move for partial removal of the bridge. The contractors were also permitted to move the bridges half-way a day before the move.

3.8 WORKFORCE MANAGEMENT

Even though it would have been valuable to learn practices related to worker training, safety management, managing workforce to reduce work related fatigue, and task assignments, presentations were limited on the given topics.

ABC projects sometimes require managing a large number of employees on site. As an example, Aecon needed to manage 110 employees, at peak, working on the Highway 417 rapid bridge replacement project in Ottawa, Canada.

Numbers and qualifications of workers required to successfully complete ABC projects are critical. The contracting community needs to make sure that sufficient numbers of workers are available. Moreover, the workforce needs to know that a majority of the work activities will be during evening and weekend hours.

It was also mentioned that, to perform a limited amount of work, at least 50 workers are required. It is indeed necessary to ensure that the workers are available for all the weekends during construction duration.

3.9 OBSERVATIONS AND LESSONS LEARNED

As with any new technology, lessons are learned during the project activities. As an example, Aecon Infrastructure Group, Inc. (as the contractor of the Highway 417 rapid bridge replacement project in Ottawa, Canada) took the lessons learned from first weekend into the second weekend and improved their performance. This highlights the need for developing

detailed lessons-learned reports following post-construction meetings with all the parties involved in the project.

3.9.1 Contracting Methods and Contractor Involvement

Table 3-2. ABC Contracting Methods: Advantages and Drawbacks

Design-bid-build	Design-build	Construction Manager/ General Contractor
<ul style="list-style-type: none"> • Traditional contracting method. • No contractor involvement during design. • In-house or consultant design. • Higher level of risk to the owner. • Increased level of change orders. • Strong team partnering and coordination needed. 	<ul style="list-style-type: none"> • Concurrent design and construction. • Early knowledge of cost: This is because the project is bid on type of work rather than individual items. • Reduction in delivery time. • Improvements to constructability. • Encourages innovation. • Risk is transferred to the contractor. 	<ul style="list-style-type: none"> • Contractor on board to consult during design. • Owner able to decide on innovations. • Reduced design errors, constructability issues, and change orders. • Ability to identify and mitigate risk. • Allows for early procurement. • Limits negotiation on project costs because the owner (DOT) understands the rationale behind the contractor's pricing.

Utah DOT's preference is the CM/GC method. Through this contracting method, an independent cost estimate is performed in-house and compared with the contractor's estimate. Utah DOT defined a limit that if the contractor's estimate exceeds the in-house estimate by a defined percentage, then the DOT has an option to convert to traditional bidding. The DOT, in this case, is not limited to the contractor on the design team.

Utah DOT did not have concerns from the contractors for the submittals. In the first few projects, DOT allowed a 14-day review period for the contractors, and later with electronic submittals a 7-day review period was allowed. The owners should consider the time required for preparing the submittal documents while developing the owners' construction schedule. Also, the owner's schedule needs to be flexible to accommodate any revisions to the submittals, especially when a temporary work plan, a communication plan, and an hour-by-hour schedule are requested. The owner needs to communicate with the contractor regarding

progress to submittals. Also, the owner shall realize that, for new contractors, there will be a learning curve in preparing the submittals. Similarly, the owner's schedule should allow for additional review time from their side as well.

During the SHRP-2 R04 projects in Iowa and New York, the project team engaged all the local contractors (by working through AGC) from the start of the ABC project and had one-on-one meetings to get their input at 30% and 60% design phases. An information session with all the contractors was conducted later prior to the bidding date. This worked very well, and competitive bids were received because of the input from the local contracting industry, rather than engaging one single contractor as in case of CM/GC.

3.9.2 Construction Methods

3.9.2.1 Self-Propelled Modular Transporter (SPMT)

- Moving the bridges with SPMT in most of the projects is not a time consuming activity, and it proceeds relatively quickly. The time consuming activities are (i) details such as backfill and (ii) time required for paving and other operations, such as lane markings, placing barriers, guard rails, etc. Adequate considerations need to be given to all the details including each and every minute activity.
- If initial cost is justified, multiple SPMTs can be used to expedite a bridge replacement activity. As an example, during the Highway 417 rapid bridge replacement project in Ottawa, Canada, the plan was to remove the existing superstructure using a set of SPMTs to transport it and place it on the temporary supports of the new superstructure while the new superstructure was supported on another set of SPMTs adjacent to the bridge site.
- In using the same temporary supports for shoring the new and the existing bridge superstructure, re-design is required considering the loads and support locations of the new and the existing superstructure. The details that need to be considered are the bearings, bearing distances, and differential elevations between the bearings.
- Following replacement with SPMT's, temporary shoring can be used to support the existing bridge for demolition. However, this option is not cost effective in terms of the

loads that temporary shoring needs to withstand during demolition. The cost effective approach is to cut the old bridge on the temporary shoring, lift, place on the ground, and then demolish.

- When two sets of SPMTs are used to support and move the new and the existing bridge superstructures simultaneously, it is necessary to consider the dimensions of the existing and new bridges to prevent conflicts on the move path and in/out of staging area.
- To assure having sufficient stroke for the lift (at the final location), consider incorporating self-climbing towers that lift/drop in 6 in. increments to the SPMT system that has jacking capability in the carrier.
- When SPMTs are not locally available, to reduce the mobilization cost, identify projects with seven to eight bridges that need replacement at the same time using SPMTs.
- Equipment availability to accomplish the project activities is critical. As an example, Utah DOT was trying to limit the tie-in lengths as much as possible to reduce the amount of filling and paving at night. However, with only large equipment available, limited excavations could not be accomplished which ended up extending the tie-in lengths.
- The following suggestions are presented based on the lessons learned from the SPMT projects in Utah:
 - The contractor should not reuse components from a demolished bridge for any load bearing activity.
 - Survey is critical.
 - Account for all utilities in travel path.
 - Specifications need to clearly outline the expectations.
 - Account for varying load paths.

3.9.2.2 *Slide-in*

- Test slides should be performed to test the entire setup before the final sliding operation.
- For lateral slides, the basic equipment such as tracks, rollers, and hydraulic jacks (or post-tensioning jacks to serve the purpose of hydraulic jacks) can be used to reduce the project cost.
- Implementation of a continuous sliding operation using tandem jacks can achieve a rate of 65 ft (20 m) per hour, compared to a conventional single jack that provides a rate of 33-40 ft (10-12 m) per hour.
- Even though a millimeter level tolerance is indicated by the strand jack manufacturer, it was not achievable. This was because of practical issues such as a strand/tendon release effect that exceeds the braking friction and cannot be controlled by the jack.
- The following suggestions are presented based on the lessons learned from the lateral slide projects in Utah:
 - Slide-in technology needs to be specified following analysis of the site constraints.
 - Interaction between temporary and permanent supports needs to be considered: Utah had one slide project where the temporary structure settled at the connection point with the permanent substructure. Additional supports were installed to the temporary structure to obtain appropriate transition to the permanent substructure.
 - Structures can be slid with approach slabs. An inverted-T shaped sleeper slab is used to support one end of the approach slab while the other end is connected to the bridge superstructure. Hence, the sleeper slab is placed prior to bridge slide. The approach slabs slide on the sleeper slabs while the end diaphragms slide on the abutments. A flowable fill is placed underneath the approach slab. This process eliminated the time required for compacting approach soil and constructing approach slabs. The approach slabs are designed for their full span to ensure proper support in case the fill underneath undergoes settlement.
 - Adequate roadway tie-in lengths must be provided.

3.9.2.3 *Prefabricated Bridge Elements and Systems (PBES)*

Most issues are related to connections and connectivity between prefabricated elements and systems. Utah DOT experienced durability problems with the closure pours and transverse joints between the panels. Utah DOT was using UHPC or HPC for the closure pours and grout for transverse connections because of difficulty in identifying a true non-shrink grout. The connections cracked and leaked after 6 months of project completion. For some of the projects, Utah DOT did request warranty for the grout connections. When the connections started leaking, it could not be verified whether the failure was the contractor's fault (due to improper installation) or a flaw in grout properties and installation instructions in datasheets (the grout manufacturer's/supplier's fault). Rather than identifying the perfect grout and requesting warranty, Utah DOT specified longitudinal post-tensioning in all the precast decks. Overlay was also placed on the deck to enhance durability.

3.9.3 Quality Control

To ensure quality of the project, the following practices were recommended:

- Education and experience requirements, such as training, testing, and certifications of employees, need to be defined for all employees involved in preparation and execution of the project.
- Safety shall be pro-active and include (1) training, (2) pre-employment and random drug screening, and (2) kickoff, regular, and lessons-learned meetings that address safety issues.
- A detailed contingency plan needs to be developed that takes into consideration equipment maintenance and repairs according to guidelines of manufacturers, along with spare part management, documentation, and certification.
- A 7-day wet cure of the concrete superstructure in the staging area should be scheduled for SPMT or slide projects. This results in improved concrete quality in comparison to traditional construction that limits wet curing duration because of lane rental penalties.
- The prefabricator should not assume that the designer has full responsibility in specifying the tolerances and camber. This is the key issue while dealing with PBES, especially on prestressed elements. In ABC projects, the DOT needs to enforce the requirement for the prefabricator to work together with the designer in achieving proper tolerances and camber.

4 SUMMARY AND STRATEGIC PLAN FOR PROMOTING ABC IN MICHIGAN

4.1 SUMMARY

Highlighting their commitment to integrating ABC project delivery methods into the regular business process, MDOT approved an ABC policy document in October 2012. The MDOT ABC policy requires documented justification for each bridge project not delivered by ABC.

In 2008, MDOT constructed the first fully prefabricated bridge, the Parkview Avenue US-131 crossing in Kalamazoo, MI. Since then, MDOT has constructed several additional bridges with prefabricated elements. Moving ahead by demonstrating their commitment to integrate other project delivery options, MDOT is planning to implement slide technology for three projects during 2014. In addition, MDOT is analyzing sites to identify bridges for replacement using SPMTs.

MDOT foresees the bridge move or slide projects to be implemented using the traditional contracting method of design-bid-build. This requires the contracting industry to be knowledgeable about the ABC technologies. A workshop survey, summarized in chapter 2, showed that less than 6% of local agencies and contractors had the opportunity to participate in ABC demonstration projects. Further, less than 30% of the local agencies and contractors had the opportunity to participate in completed ABC projects with prefabricated elements. Hence, the local bridge engineering community has limited exposure to slide and move technology implementation.

Understanding the need, MDOT is using the CM/GC contracting method for their first two slide-in projects. These projects will provide an opportunity for the contracting industry and those delivering the projects to gain experience and knowledge. Also, as part of knowledge sharing and technology transfer, MDOT sponsored this workshop featuring experts with significant experience on ABC to share their experience, observations, and lessons learned. This workshop also provided opportunities for participants to learn about available ABC resources.

4.2 STRATEGIC PLAN FOR PROMOTING ABC IN MICHIGAN

The envisioned strategic plan for promoting ABC in Michigan is expected to include the following steps:

- Organize an expert group of owners, designers, academicians and contractors with experience in accelerated bridge construction to provide feedback on specifications, guidelines, and details for implementing a specific ABC technology.
- Incentives and disincentives typically tend to motivate contractors, but when the project completion is delayed due to unforeseen events, the contractors are penalized twice: the first for their increased cost due to the delay and, the second, by the owners' delay penalty. Owners may incentivize continuing education of the contractor's engineering staff as well as their length of tenure with the company. This may assure contractors developing and retaining experience in ABC.
- Develop a performance management strategy for ABC projects to assure that quality and durability are expectations as well as the speed of construction.
- Conduct selected ABC projects as demonstration projects, for their educational value to the local contractors, local agencies, and public.
- Document ABC project activities to develop case-study examples. These examples can be included in workshops. The following information describes the minimum documentation needs of ABC projects:
 - Scoping, decision-making, planning, and cost
 - Structural analysis and design
 - Contracting
 - Scheduling
 - Structural move plans
 - Contingency plans
 - Demolition methods
 - Construction

- Monitoring bridge moves, deformations and stresses
 - Maintenance of traffic (MOT)
 - Workforce management
 - Observations and lessons learned.
- Develop research to continually review the literature, domestic and international ABC implementations, and the information presented in the resources listed in chapter 5. Also, develop workshops co-sponsored by industry associations.

5 RESOURCES

Aktan, H., Attanayake, U., and Mohammed, A.W. (2013). *The Michigan Accelerated Bridge Construction Decision-Making (Mi-ABCD) model – Users’ Manual*, Report: MDOT RC 1602 (Appendix E), Michigan Department of Transportation (MDOT), Kalamazoo, MI. <http://michigan.gov/documents/mdot/RC-1602_Appendices_DE_444149_7.pdf>

FHWA (2013a). *Public Roads*, Publication: FHWA-HRT-13-003, Federal Highway Administration (FHWA), March/April, 76(5). <<http://www.fhwa.dot.gov/publications/publicroads/13marapr/01.cfm>> (Last accessed: March 30, 2014)

FHWA (2013b). *Slide-In Bridge Construction Implementation Guide*, Project: F-ST99 (232), Federal Highway Administration (FHWA) and Utah department of Transportation, <http://www.fhwa.dot.gov/construction/sibc/pubs/sibc_guide.pdf> (Last accessed: March 30, 2014)

FHWA (2014). “The National ABC/PBES Project Exchange database.” *Federal Highway Administration (FHWA)*, <<https://www.transportationresearch.gov/dot/fhwa/default.aspx>> (Last accessed: March 30, 2014)

Note: For accessing the ABC/PBES Project Exchange database, prior registration and site access requesting is required following the instructions presented in ABC Project Exchange User’s Guide: <<http://www.abc.fiu.edu/wp-content/uploads/2013/07/ABC-User-Guide-for-posting1.pdf>> (Last accessed: March 30, 2014)

LaViolette, M., Wipf, T., Lee, Y., Bigelow, J., and Phares B. (2007). *Bridge Construction Practices Using Incremental Launching*, Project: NCHRP 20-07 (229), National Cooperative Highway Research Program (NCHRP), Transportation Research Board. <[http://onlinepubs.trb.org/onlinepubs/archive/NotesDocs/20-07\(229\)_FR.pdf](http://onlinepubs.trb.org/onlinepubs/archive/NotesDocs/20-07(229)_FR.pdf)> (Last accessed: March 30, 2014)

MDOT (2007). *State Long-Range Transportation Plan 2005 – 2030*, Michigan Department of Transportation, Lansing, MI.

MDOT (2010). *Work Zone Safety and Mobility Manual*, Michigan Department of Transportation (MDOT), Lansing, MI.

MDOT (2014). *Project Scoping Manual*, Michigan Department of Transportation (MDOT), <http://www.michigan.gov/mdot/0,4616,7-151-9622_11044_11367-243045--,00.html> (Last accessed: March 30, 2014)

SCHEUERLE (2014). “SCHEUERLE SPMT’s Roll-lift.” *SCHEUERLE*, <<http://www.roll-lift.nl/files/download/148>> (Last accessed: March 30, 2014)

SHRP-2 (2013). *Innovative Bridge Designs for Rapid Renewal – ABC Toolkit*, Report: S2-R04-RR-2, The Second Strategic Highway Research Program (SHRP-2), Transportation Research Board, <<http://www.trb.org/Main/Blurbs/168046.aspx>> (or) <<http://www.fhwa.dot.gov/goshrp2/>> (Last accessed: March 30, 2014)

5.1 OTHER RESOURCES FOR ABC/PBES IMPLEMENTATION

Publications that include FHWA ABC manual, Connections details for PBES, Manual for use of SPMT, etc., which can be accessed from:

<<http://www.fhwa.dot.gov/bridge/prefab/pubs.cfm>> (Last accessed: March 30, 2014)

Regional/DOT websites:

<<http://www.pcline.org/>> (Last accessed: March 30, 2014)

<<http://www.udot.utah.gov/main/f?p=100:pg:0:::1:T,V:1991>> (Last accessed: March 30, 2014)

Regional Peer Exchange Meetings documents that include around 150 presentations related to ABC. The forum can be accessed from: <<http://p2p.ara-tracker.com/>> (Last accessed: March 30, 2014)

TRB Subcommittee on ABC – AFF10 (3) website:

<<https://sites.google.com/site/trbaff103/>> (Last accessed: March 30, 2014)

Note: This website is planned to contain the entire ABC related work in the US.

Webinar training sessions that can be accessed from:

<<http://www.fhwa.dot.gov/everydaycounts/technology/bridges/pbeswebinartraining/>> (Last accessed: March 30, 2014)

Future publications: Planning and Policy, Engineering Materials, and Construction Contracting (expected summer 2014)