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8 Accelerated Bridge Construction

8.1 General

The series of articles is intended to fit together as a unit. As much as possible, cross references are used to avoid duplication.

8.1.1 Policy overview

The monetary costs of construction can be measured in two ways. The first is the actual construction cost of the project in tax dollars. ABC projects will, in general, increase construction costs and will therefore use up more public tax dollars. The second is the monetary cost to society primarily caused by delays during construction. ABC projects will reduce construction time and thereby reduce the cost to society caused by delays. Consideration of these two factors must be kept in mind when considering the benefits of conventional versus ABC approaches to construction projects.

Iowa has used, on a limited and mostly experimental basis, ABC methods to quickly deliver bridge replacement projects. The success of these projects forms the basis of Iowa's approach which will provide consideration of ABC techniques on a more routine basis. The overall goal of Iowa's policy is to improve public safety, reduce road user costs, and provide better overall experience for the travelling public while building long lasting highway structures. By doing so, the Department is willing to recognize societal costs as real construction costs. The ABC decision-making process used in Iowa is described below. Additionally, common ABC technologies are described with an emphasis on those expected to be more frequently employed in Iowa.

8.1.2 Design information

The increase in the number of bridges built using ABC has led and will continue to lead to growth in innovation for all aspects of ABC and in bridge construction in general. Designers need to assure that newer ABC techniques are carefully thought through since many will have only seen limited use. There are a significant number of resources final designers can draw from in order to successfully complete an ABC design. These resources are covered more fully in the articles that follow, but they generally include Iowa standard details and design practices used for traditional projects, completed Iowa ABC projects, ABC projects in other states, and information found on web sites dedicated to ABC. Designers should consult the references listed under BDM 8.1.1.5 for further information.

8.1.3 Definitions

A + B Bidding is a Cost-Plus-Time bidding procedure. The low bidder is selected based on a combination of the contract bid items (A) and the time bid for construction multiplied times the daily road user cost (B). The days bid become the contract time.

Accelerated Bridge Construction (ABC) can be described in a variety of ways but is generally defined as using prefabricated bridge elements, combining elements into systems, moving a complete bridge span, or using various contracting methods to quickly deliver a project and re-open a highway to traffic.

Accelerated Project Delivery Methods (APDM) refers to fast track contracting methods such as design-build, partial design-build, and construction manager general contractor.

Calendar Day is the specified number of days for completion of the project. This is in contrast to Working Day which takes into account weather conditions that would not permit the contractor to work.

Construction Manager/General Contractor (CMGC) is an accelerated project delivery method which occupies the middle ground between the traditional design–bid–build and design–build. In a typical CMGC scenario, the owners of a project hire either a general contractor or design firm to serve as the construction manager, placing responsibility for design review, design modifications, system integration, and construction with that single contractor. CMGC allows State DOTs to remain active in the design process while assigning risks to the parties most able to mitigate them. As with the design–build approach, there are potential time savings because of the ability to undertake a number of activities concurrently.

Design-Bid-Build (DBB) is a traditional project delivery method wherein a project is designed, put out for bid to construction firms, and then built by the winning bidder.

Design-Build is an accelerated project delivery method in which the design and construction phases are combined into one contract thereby eliminating the separate bid phase in the traditional design-bid-build method which in turn allows certain aspects of design and construction to take place at the same time.

Economy of Scale refers to the repetition of the elements and processes, and how they relate to the overall cost of a project, as well as the possible savings to future projects.

Get In, Get Out, Stay Out is an FHWA initiative that reflects the desire to minimize traffic congestion caused by construction work zones and to shorten road closure times due to bridge reconstruction and replacement.

Incentive/Disincentive incorporates the daily road user traffic cost into the contract as liquidated damages (disincentive) and as an incentive. When used as an incentive the contractor receives the daily road user cost for each day they substantially complete the project or a specific phase of the project early. A maximum number of days of incentive that can be earned is specified in the contract.

Indirect Societal Costs refers to user costs associated with delays and detours, revenue loss to local businesses, livability during construction, and safety risks for users and construction personnel.

Innovative Contracting Methods typically refer to unique contracting methods such as cost plus time contracting (A+B) and best value selection (BVS), and accelerated bridge project delivery methods such as design-build, construction manager general contractor (CMGC),

Lane Rental is a contracting strategy used to improve management of temporary lane closures. The contractor is assessed an hourly or daily rental fee for each lane, or combination of lanes taken out-of-service during a project to minimize the time of the roadway restriction impacting traffic flow. The rental fee is based on hourly or daily road user costs.

Near Site Fabrication is a process of constructing prefabricated elements near the bridge construction site in order to minimize problems with shipping of large elements.

No Excuse Bonus is a modified version of an incentive. The contractor receives the bonus amount specified when they substantially complete the project or a specific phase of the project by the date listed in the proposal, however, no adjustments to the specified date is allowed for any reason regardless of who is responsible. The contractor is motivated to work around conflicts such as weather or utilities.

Prefabricated Bridge Elements and Systems (PBES) are structural components of a bridge that are built offsite, or near-site of a bridge and include features that reduce the onsite construction time and the mobility impact time that occurs when building new bridges or rehabilitating or replacing existing bridges relative to conventional construction methods. Prefabricated elements are a category of PBES which comprise a single structural component of a bridge such as deck, beam, or pier element. Prefabricated systems are a category of PBES that consists of an entire superstructure, an entire superstructure and substructure, or a total bridge that is procured in a modular manner such that traffic operations can be allowed to resume after placement.

Road User Costs are a measure of the financial impact of a construction project on the traveling public. The major contributing factors in calculating user costs are delay/detour time, average daily traffic, and the duration of the impact to users. Reduced roadway capacity, slower travel speeds, and delays in opening a new or improved facility that prevents users from gaining travel time benefits can also be included.

Self-Propelled Modular Transporter (SPMT) is a high capacity transport trailer that can lift and move prefabricated elements with a high degree of precision and maneuverability.

Substructure is any construction below the bearing seats or, in the absence of bearings, below the soffit of the superstructure.

Superstructure is any construction above the bearing seats or, in the absence of bearings, includes the soffit and any construction above the soffit.

Traditional Direct Costs refers to costs that must be financed by project dollars. These costs include construction, maintenance of traffic, design and construction of detours, right of way acquisition, project design and development, maintenance of essential services, and construction engineering.

8.1.4 Abbreviations and notation

A+B, cost plus time contracting
AADT, average annual daily traffic
ABC, accelerated bridge construction

ADT, average daily traffic
ADTT, average daily truck traffic
AHP, analytic hierarchy process
APDM, accelerated project delivery methods
BSB, Bridges and Structures Bureau
CIP, cast-in-place
CMGC, construction manager general contractor
DB, the Design Bureau
DBB, design-bid-build
EDC, every day counts
EPS, expanded polystyrene
FHWA, Federal Highway Administration
GEC, Geotechnical Engineering Circular
GRS-IBS, Geosynthetic reinforced soil integrated bridge system
I/D, Incentive/Disincentive
Iowa DOT, Iowa Department of Transportation
LEB, Location and Environment Bureau
LRFD, load and resistance factor design
MDT, multi-disciplined team
MSE, mechanically stabilized earth
P10L, designation for the LRFD pile bent standard [BSB SS P10L], which replaces the P10A pile bent standard
PBES, prefabricated bridge elements and systems
PPCB, pretensioned prestressed concrete beam
RSB, rolled steel beam
SCC, self-consolidating concrete
SIP, stay-in-place
SPMT, self-propelled modular transporters
TS&L, type, size, and location
UHPC, ultra-high performance concrete

8.1.5 References

8.1.5.1 Direct

Throughout the ABC section there may be direct references to specific portions of standards and publications. Direct references are included in brackets [ ] using the abbreviations given below.

Although the latest editions are listed below there may be some circumstances in which referenced documents have been prepared on the basis of previous editions.

[AASHTO division article, table, or figure] refers to AASHTO *Standard Specifications for Highway Bridges, 17th Edition (2002)* with current errata changes - design, seismic design, or construction division with article, table, or figure number.

[AASHTO-LRFD article, table, or figure] refers to *AASHTO LRFD Bridge Design Specifications, 5th Edition (2010)* with article, table, or figure number.

[BDM article, table, figure, or note] refers to *LRFD Bridge Design Manual* with article, table, figure, or plan note number. (Available on the Internet at http://www.iowadot.gov/bridge/manuallrfd.htm)

[IDOT SS article] refers to Iowa Department of Transportation *Standard Specifications for Highway and Bridge Construction, Series 2009* with article number. (Available on the Internet at: http://www.iowadot.gov/erl/index.html)

8.1.5.2 Indirect

Indirect references are general and infrequent sources of information that usually are not linked with specific article or section numbers.

Culmo, M. P., *Accelerated Bridge Construction - Experience in Design, Fabrication and Erection of Prefabricated Bridge Elements and Systems*, CME Associates Inc., FHWA-HIF-12-013, November 1, 2011. (Available on the Internet at: http://www.fhwa.dot.gov/bridge/abc/docs/abcmanual.pdf)

Emulating Cast-in-Place Detailing in Precast Concrete Structures, ACI 550.1R-01, September 2001. (Available on the Internet at: http://mahabghodss.net/NewBooks/www/web/digital/standard/ACI/Part%206/550.1R-01.pdf)

Decision-Making Framework for Prefabricated Bridge Elements and Systems (PBES), FHWA-HIF-06-030, May 2006

Manual on the Use of Self-Propelled Modular Transporters to Remove and Replace Bridges, FHWA-HIF-07-022, June 2007

Culmo, M. P., *Connection Details for Prefabricated Bridge Elements and Systems*, CME Associates Inc., FHWA-IF-09-010, March 2009.

Doolen, T., A. Saeedi, S. Emami, *Accelerated Bridge Construction (ABC) Decision Making and Economic Modeling Tool*, Final Report, Project TPF-5(221), Oregon State University, 2011. (Available on the Internet at https://rosap.ntl.bts.gov/view/dot/23739)

8.1.5.3 Web sites

Web site references are general, but frequent sources of information. General web site references are included in brackets [ ] using the abbreviations given below. If a specific web page is referenced the link to the website will be provided in brackets.

[AASHTO TIG SPMT webpage] refers to AASHTO Technology Implementation Group SPMT webpage (Available on the Internet at: http://tig.transportation.org/Pages/SelfPropelledModularTransporters.aspx)

[FHWA ABC webpage] refers to FHWA - Accelerated Bridge Construction webpage (Available on the Internet at: http://www.fhwa.dot.gov/bridge/abc/index.cfm)

[FHWA EDC webpage] refers to FHWA - The Every Day Counts Initiative webpage (Available on the Internet at: http://www.fhwa.dot.gov/everydaycounts/)

[FHWA HFL webpage] refers to FHWA - Highways For Life webpage (Available on the Internet at: http://www.fhwa.dot.gov/hfl/)

[FIU ABC Center webpage] refers to Florida International University (FIU) – Accelerated Bridge Construction Center webpage (Available on the Internet at: http://www.abc.fiu.edu/)

[IDOT ABC webpage] refers to Iowa DOT’s Research and Investigations webpage (Available on the Internet at: http://www.iowadot.gov/bridge/index.htm#)

[ODOT ABC webpage] refers to Ohio DOT’s Build Bridges Faster, Smarter, Better webpage (Available on the Internet at: http://www.dot.state.oh.us/Divisions/Engineering/Structures/standard/Maintenance/Pages/SI9.aspx)

[PCA ABC webpage] refers to PCA ABC webpage (Available on the Internet at: http://www.cement.org/bridges/br_abc.asp)

[UDOT ABC webpage] refers to Utah DOT's ABC webpage (Available on the Internet at: http://www.udot.utah.gov/main/f?p=100:pg:0:::1:T,V:1991,)

[WSDOT ABC webpage] refers to Washington DOT's ABC webpage (Available on the Internet at: https://wsdot.wa.gov/engineering-standards/design-topics/accelerated-innovative-bridge-construction

8.1.5.4 Iowa ABC projects

A number of projects in Iowa have used various ABC technologies. Most of these ABC projects are listed in Table 8.1.5.4 by bridge design number and county with the exception of the Wapello project which lists the county project number. The table also lists the various components that have been used for each project. Most of the components are prefabricated bridge elements or systems, but at least one project also included an innovative contracting method combined with staged construction. A number of these projects have plans, photographs, reports, papers, and power point presentations available on the Iowa DOT Bridges and Structures Bureau website [IDOT ABC webpage].

Table 8.1.5.4. ABC Experience at Iowa DOT

ABC Components	**703 O' Brien**	**106 Boone (Mackey Bridge)**	**106 Madison**	**305 Marion**	**508 Pottawattamie (CB 24th)**	**208 Bremer**	**109 Buena Vista**	**210 Washington**	**111 Pottawattamie (Keg Creek)**	**L-#39--73-90Wapello (Waffle Deck)**	**113 Cass (Massena)**
Approach pavement	X					X		X	X		
Abutment wings							X		X		X
Integral abutments		X	X				X				
Semi-integral abutments									X		X
Drilled shafts									X		
Pile bents		X									
Frame piers									X		
T-piers											
Box beams			X				X				
PPCB + diaphragms		X								X	X
RSB + diaphragms											
Full depth precast deck		X			X					X	
Rails											
RSB + deck + rail									X		
Paving notch repair				X							
A + B contracting					X						
Staged construction					X						
I/D contracting							X		X		X
Slide-in bridge constr.											X
UHPC									X	X	
Post-Tensioning		X			X						
Grouted splice coupler									X		

8.2 Decision making

8.2.1 Bridge replacement projects

Except for emergency projects the typical approach to evaluating projects for acceleration is multi-phased involving a concept team consisting of DOT staff from multiple Bureaus including the District, BSB, DB, LEB and other Bureaus as necessary. The general decision making process for selecting ABC projects is illustrated in the ABC Decision Process Flowchart in Figure 8.2.1-1.

The decision making process involves one basic stage with an optional second stage.

The concept team will initially assess the applicability of ABC to bridge construction projects based on the ABC rating score. The ABC rating score acts as a filter by ranking the suitability of bridge replacement candidates for ABC based on a set of measures. The ABC rating score and the first stage decision making based on the score are addressed in BDM 8.1.2.1.1.

Bridge projects identified as potential ABC candidates in the first stage of the decision making process may use the optional second stage or proceed directly to the third stage. The optional second stage should be used when a project is borderline or where a very large and costly project is being considered and a more rigorous evaluation is desired to determine if ABC is appropriate. The optional second stage evaluation involves the use of the ABC AHP decision making software tool as described in BDM 8.1.2.1.2. The concept team can use the results of the software analysis to further determine if ABC alternatives should be developed in conjunction with traditional alternatives as part of the concept.

The Project Delivery Division Director and BSB Advisory Team must approve any ABC candidates before they are further developed as part of a concept. The BSB Advisory Team will consist of the Bridge Engineer, Assistant Bridge Engineer, Chief Structural Engineer, Preliminary Bridge Unit Leader, and a Preliminary Bridge Engineer. The BSB Advisory Team will prioritize the list of ABC candidates and establish recommendations to the Project Delivery Division Director. At this point in the decision making process the focus will be on evaluating Division resources in terms of funding and staffing. Viable candidates for ABC may be deferred or rejected due to scheduling issues or the lack of program funding. If approval is given, then a traditional option and an ABC option will be fully developed as part of the concept. Developing the ABC option will require the concept team to consider, among other things, viable approaches to contracting methods, structural placement techniques, and the use of prefabricated elements and systems in order to ensure the project can be constructed in the construction time allotted. See BDM 8.1.2.1.3 for additional details about ABC concept development. Once all the alternatives have been reviewed the concept team may include an ABC approach as the recommended alternative in the final concept letter that is sent out for review to various Bureaus and the District. If there is general concurrence with the ABC option as the recommended approach, then the project-specific ABC approach will be further developed in a TS&L plan by the Preliminary Bridge Design Unit.

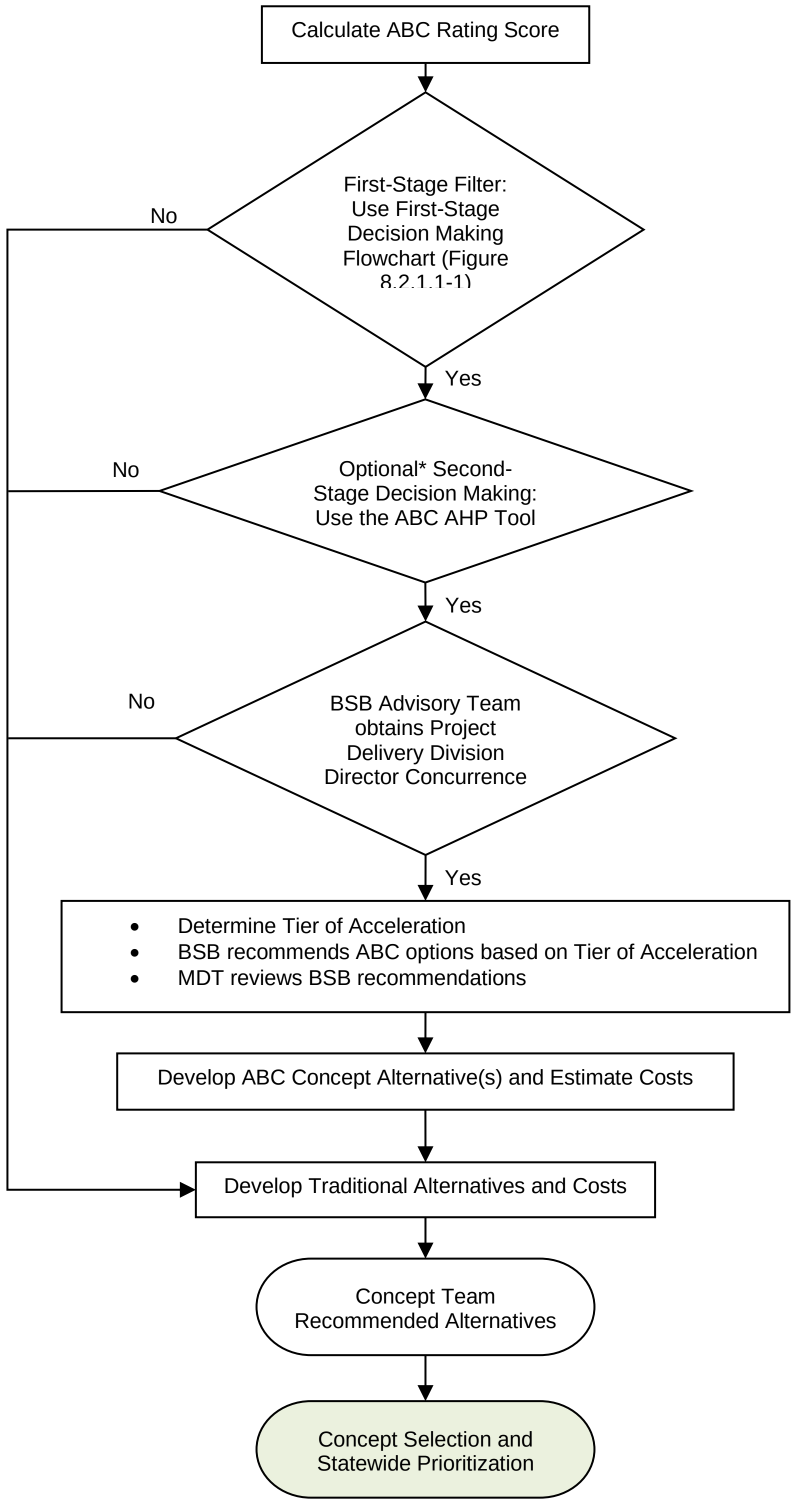


Figure 8.2.1-1. ABC Decision Process Flowchart
* This step may be eliminated as discussed in 8.2.1

8.2.1.1 First stage decision making – ABC rating score

During the first stage of the decision making process the concept team will assess the applicability of ABC to bridge construction projects using the ABC Decision Making Flow Chart illustrated in Figure 8.2.1-1. The main tool to assist the concept team in their decision to take a project to the second stage in the decision making process is the ABC rating score.

The ABC rating score is a numerical value from 0 to 100 indicating the viability of bridge construction projects for considering ABC concepts. The higher the score the more suited a project is for ABC. The ABC rating score has been categorized into two ranges. Bridges with a score of 50 or more are automatically further evaluated for consideration of ABC techniques. Bridges with a score of less than 50 will only be evaluated further at the request of the District who may be aware of unique circumstances, such as a critical environmental issue, that may make the project suitable for ABC.

The ABC rating score is based on a set of measures which include AADT, Out of Distance Travel, User Costs, and Economy of Scale. The measures are based on National Bridge Inventory (NBI) records as coded according to the Structure Inventory and Appraisal (SI&A) guide. Each measure is scored based on a set of criteria. The measure scores are multiplied by a weight factor to account for their relative importance. The individual weighted measure scores are then summed together to form an overall weighted score which can have a maximum value of 165. The overall weighted score is then normalized to a 100 point scale to become the ABC rating score. The measures are described below:

- Average annual daily traffic (AADT) - This is a measure of the amount of traffic traversing the bridge site. Use a value equal to the total number of vehicles (AADT) on the bridge plus 25% of the AADT for the roadway under the bridge if applicable. This measure has a weight of 10.

AADT score	AADT criteria
0	No traffic impacts
1	Less than 5000
2	5000 to less than 10,000
3	10,000 to less than 15,000
4	15,000 to less than 20,000
5	20,000 or more

- Out of distance travel (OODT) - This is a measure of the impact that a project has on vehicles when the construction site is closed to traffic. OODT is the additional distance traveled along a detour in miles for traffic when a bridge is closed due to construction. This measure has a weight of 10.

OODT score	OODT criteria
0	No OODT
1	Less than 5 miles
2	5 miles to less than 10 miles
3	10 miles to less than 15 miles
4	15 miles to less than 20 miles
5	20 miles or more

- Daily road user costs (DRUC) - This is a measure of the daily financial impact of a construction project on the traveling public. The major contributing factors in calculating user costs are OODT and AADT on the bridge. The standard method the Department has for calculating user costs is the formula:

$$\text{DRUC (\$)} = (\text{AADT} + 2 * \text{ADTT}) * (\text{OODT}) * (\text{Mileage Rate})$$

The mileage rate is currently set at 37.5 cents per mile (2016). Average daily truck traffic (ADTT) is counted at three times the amount of other traffic. This measure has a weight of 10.

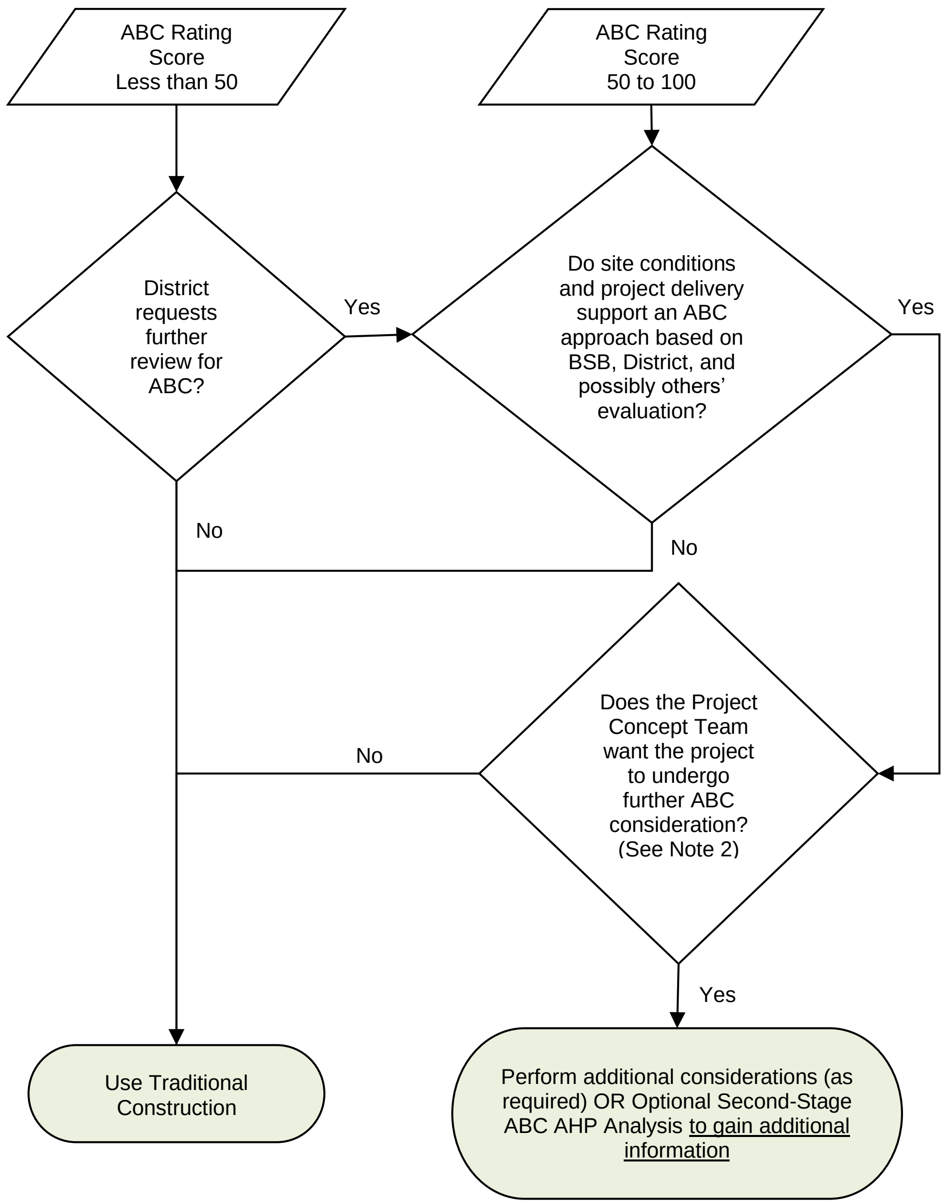
DRUC score	DRUC criteria
0	No DRUC
1	Less than $10,000
2	$10,000 to less than $50,000
3	$50,000 to less than $75,000
4	$75,000 to less than $100,000
5	$100,000 or more

- Economy of scale (EOS) - This measure accounts for the repetition of the elements and processes, and how they relate to the overall cost of a project, as well as the possible savings to future projects. The total number of spans is used in order to account for repetition of substructure elements as well as superstructure elements. This measure has a weight of 5.

EOS score	EOS criteria
0	1 span
1	2 or 3 spans
2	4 or 5 spans
3	6 spans or more

There are two additional measures which will automatically generate a minimum ABC Rating Score of 50 if the calculated score is less than 50. The first determining factor for receiving an automatic score of 50 is if the out of distance travel for the detour is 30 or more miles. This much out of distance travel was considered sufficiently long that some consideration ought to be given to ABC techniques. The second factor for receiving a score of 50 is if the structure is an interstate bridge.

The ABC rating scores for all state bridges will be made available in the Structure Inventory and Inspection Management System (SIIMS). Ultimately knowledge and judgment among the various Bureaus must be used to establish the suitability of a particular project for ABC even though the ABC rating score helps to establish the most likely candidates.



Note 1: The District may determine that some projects with an ABC Rating Score of less than 50 should still be considered for ABC based on factors such as long detours, environmental issues, safety issues, lost local business revenue, critical structure for emergency route, etc. In these cases, the District may submit specific projects to undergo a review to see if site conditions and project delivery will support an ABC approach and, ultimately, if the project will proceed to the second-stage of the decision making process.

Note 2: The Project Concept Team may want to exclude some projects from further consideration of ABC. Two of the main reasons for excluding projects for further evaluation are limited funds for ABC and limited staffing hours to perform the evaluations. These reasons may dictate that a smaller set of the more viable ABC projects only be considered in the second-stage of the decision making process. Additionally, as experience with choosing ABC projects progresses it may be clear that some projects are not suitable based on the ABC AHP criteria even without running the software.

Figure 8.2.1.1-1. ABC Decision Flowchart

8.2.1.2 Optional second stage decision making – Analytical hierarchy process tool

The ABC AHP Decision Making Software is used in the Department's optional second stage decision making process. The software tool was developed at Oregon State University through a multi-state pooled fund project conducted under the leadership of the Oregon DOT. This software allows for the qualitative analysis of various construction alternatives based upon user selected criteria and sub-criteria. Such a qualitative assessment does not require detailed cost data for specific alternatives. Rather, general ABC concepts can be compared against general traditional construction approaches. It is, however, critical that the decision making committee have intimate knowledge of site and geographic specifics. It is, therefore, critical that input be sought from all disciplines and interested parties and Bureaus.

The ABC AHP Decision Making Software was developed with five general categories of criteria to be considered during analysis. These five categories provide mechanisms to assess different options with metrics that are important and specific to each site. The five categories are:

- Direct Costs
- Indirect Costs
- Schedule Constraints
- Site Constraints
- Customer Service

Each of the above listed criteria has sub-criteria for which each alternative will be assessed. The sub-criteria and its definition are listed below:

- Direct Costs
  - Construction – This factor captures the estimated costs associated with the construction of the permanent structure(s) and roadway. This factor includes premiums associated with new technologies or innovative construction methods. Premiums might result from factors such as contractor availability, materials availability, and contractor risk. It may include incentive/bonus payments for early completion and other innovative contracting methods.
  - Maintenance of Traffic – This factor captures the maintenance of traffic (MOT) costs at the project site. MOT costs may impact preference due to its impact on total costs. This factor includes all costs associated with the maintenance of detours before, during, and after construction. Examples of this factor include: installation of traffic control devices, maintenance of detour during construction including flagging, shifting of traffic control devices during staged construction, restoration associated with the temporary detours upon completion of construction.
  - Design and Construct Detours – This factor captures the costs to design and construct temporary structures and roadways to accommodate traffic through the project site.
  - Right of Way – This factor captures the cost to procure Right of Way (ROW). This factor includes either permanent or temporary ROW procurements/easements.
  - Project Design and Development – This factor captures the costs associated with the design of permanent bridge(s) and costs related to project development based on the construction method.
  - Maintenance of Essential Services – This factor captures the costs associated with the need to provide essential services that may be impacted by the construction method selected. Examples of this factor include: alternate routes or modes of transportation to provide defense, evacuation, emergency access to hospitals, schools, fire station, law enforcement, etc. This criterion is for situations where measures need to be implemented beyond those already considered in the "MOT" and "Design and Construct Detours" criteria.
  - Construction Engineering – This factor captures the costs associated with the owner's contract administration for the project.

  - Inspection, maintenance, and preservation – This factor captures the life cycles costs associated with the inspection, maintenance, and preservation of individual bridge elements.

- Indirect Costs
  - User Delay – This factor captures costs of user delay at a project site due to reduced speeds and/or off-site detour routes.
  - Freight Mobility – This factor captures costs of freight delay at a project site due to reduced speeds and/or off-site detour routes.
  - Revenue Loss – This factor captures lost revenues due to limited access to local businesses resulted from limited or more difficult access stemming from the construction activity.
  - Livability During Construction – This factor captures the impact to the communities resulting from construction activities. Examples include noise, air quality, and limited access.
  - Road Users Exposure – This factor captures the safety risks associated with user exposure to the construction zone.
  - Construction Personnel Exposure – This factor captures the safety risks associated with worker exposure to the construction zone.
- Schedule Constraints
  - Calendar or Utility or Railroad, or Navigational – This factor captures the constraints placed on the project that might impact the timing of construction as a result of weather windows, significant or special events, railroad, or navigational channels.
  - Marine and Wildlife – This factor captures the constraints placed on the project by resource agencies to comply with marine or wildlife regulations. Examples include in-water work windows, migratory windows, and nesting requirements.
  - Resource Availability – This factor captures resource constraints associated with the availability of staff to design and oversee construction. For example, additional time constraints may exist if a project must be outsourced.
- Site Constraints
  - Bridge Span Configurations – This factor captures constraints related to bridge span configurations. This element may impact owner preference regarding bridge layout, structure type, or aesthetics.
  - Horizontal/Vertical Obstructions – This factor captures physical constraints that may impact construction alternatives. Examples include bridge next to fixed objects such as tunnels, ROW limitations, sharp curves or steep grades, or other urban area structures that constrain methods and/or bridge locations.
  - Environmental – This factor captures the constraints placed upon the project by resource agencies to minimize construction impacts on natural resources including marine, wildlife, and flora.
  - Historical – This factor captures historical constraints existing on a project site.
  - Archaeological Constraints – This factor captures archaeological constraints existing on a project site.
- Customer Service
  - Public Perception – This factor captures both the public's opinion regarding the construction progress and their overall level of satisfaction.
  - Public Relations – This factor captures the costs associated with the communication and management of public relations before and during construction.

Typically, if the concept team members opt to perform the ABC AHP analysis, they will perform the process as a group to take advantage of the diverse experience of the team. District staff can offer intimate knowledge of local site constraints, community concerns, and other relevant information that may not be available to Central Complex staff. While Central Complex staff with expertise in various phases of project development, planning, design, contract letting, construction, etc. can provide the data needed for the analysis.

In the initial evaluation the concept team will compare an ABC option with a traditional option. This exercise may be repeated with modified design concepts as often as deemed necessary. It is expected that the initial run will take about two hours.

8.2.1.3 Concept development

For bridge replacement projects the construction process needs to accommodate traffic. The conventional methods of handling traffic normally result in a detour, temporary bridge with a bypass/runaround, crossovers, or staged construction. Each of these methods can have a significant impact on construction and user costs as well as worker and motorist safety. ABC seeks to address these issues by significantly shortening the duration of two time metrics:

- Onsite construction time – Any period of time from when a contractor alters the project site location until all construction-related activity is removed. This includes, but is not limited to, the removal of maintenance of traffic items, construction materials, equipment, and personnel.
- Mobility impact time - Any period of time the traffic flow of the transportation network is reduced due to onsite construction activities.

Of the two time metrics mobility impact time is the most important since it directly affects the traveling public. In general, for bridge replacement projects the Iowa DOT considers five tiers with respect to complete road closure:

- Tier 1 – Traffic impacts within 24 hours
- Tier 2 – Traffic impacts within 3 days
- Tier 3 – Traffic impacts within 2 weeks
- Tier 4 – Traffic impacts within 3 months
- Tier 5 – Traffic impacts greater than 3 months

When selecting ABC candidates, it is important to determine the mobility impact time because it has a significant effect on what ABC techniques are used and what the project cost will be. Tier 1 and 2 will generally require entire bridge superstructures to be placed as a unit. Tier 3 and some tier 4 projects will tend to favor the use of prefabricated bridge elements. Tier 4 and 5 projects are much more likely to use traditional construction methods within an accelerated construction timeline.

The concept team has the responsibility to determine the level of acceleration that is warranted for a specific site. Once the appropriate acceleration tier has been selected BSB will then recommend ABC concepts to achieve the desired acceleration. In some cases, it will be desirable to collaborate with local contractors and fabricators before fully developing an ABC concept alternative. Collaboration to provide input on the project concept options will be handled by means of a multi-disciplined team (MDT). The MDT would consist of bridge designers (assigned to the project if possible), a representative from the respective District, Construction and Material Bureau, and selected industry contractors. This team would provide input to the identified concept options in the approach to the specific projects and guide the designers in the most viable option(s). This team could be scheduled to meet on a quarterly basis for review and discussion of project concepts.

8.2.2 Emergency projects

Emergency repair or replacement projects will typically be the result of extreme events such as flood damage, fire, roadway vehicle impact, and waterway vessel collision. Less common events could also include terrorist activities and unanticipated structural failures due to regular or accelerated wear under typical operating conditions. Regardless of the cause of the emergency the goal behind any emergency project is to quickly restore the affected portion of the transportation network back to full capacity.

Due to the immediate need imposed by an emergency the decision making process will not typically follow the process outlined above. Relatively common emergency project procedures for damage to overpasses by vehicles with overheight loads are addressed in BDM 8.1.10. These procedures may also be useful for other small-scale emergencies. Large scale or uncommon emergencies may require an emergency response team to be assembled from various Bureaus in order to expedite a project.

Prequalified design consultants and contractors may also be brought in on an on-call basis in order to develop a response plan. Involvement from other agencies such as the U.S. Army Corps of Engineers may also need to be quickly established. Depending on the nature and extent of the emergency it may be necessary to have Department personnel on call for 24 hours per day, 7 days per week.

Some of the keys to mitigate losses and ease the inconvenience to the travelling public include quick response times with respect to the following: stabilizing damaged structures to prevent further damage to property and injury to traveling public, providing the required construction equipment and manpower for rescue and recovery efforts, establishing detour routes, and making the detour information available to the general public as quickly as possible to ease traffic congestion.

In order to expedite design and construction schedules a thorough damage assessment must be quickly performed in order to establish the scope of the project and to allow any demolition and damage removal to begin immediately. Using established contracting methods and procedures will speed up the contract negotiation process and avoid future contract disputes. Traditional contracting methods, such as cost plus time and materials, and lump sum, and innovative contracting methods such as A+B bidding have an appropriate role in different situations. Incentive and disincentive clauses are also very effective in motivating design firms, contractors, and material suppliers to complete the work.

Modifying time-based specifications for concrete to the maturity method is also very important to expedite emergency projects.

8.2.3 Repair and rehabilitation projects

In principle, projects that involve deck or superstructure replacement could be constructed with ABC techniques much in the same way that bridge replacement projects are handled. Other projects affecting traffic flow, such as approach slab replacements, deck overlays, joint repairs, and other bridge repairs could also be accelerated. Projects of these types will be addressed by the Burau on case-by-case basis and discussed with the District.

8.3 Technologies

There are a variety of available ABC technologies which are classified under five different headings:

- Foundation and wall elements
- Rapid embankment construction
- Prefabricated bridge elements and systems (PBES)
- Structural placement methods
- Fast track contracting

The first four components focus primarily on methods designed to accelerate the actual on-site bridge construction. The fifth technology is primarily concerned with accelerating project delivery by the use of contracting methods and language.

The purpose of this article is to not only describe some of the common technologies that are used nationwide, but also to highlight those technologies that are more likely to be commonly used in Iowa. Some of the technologies listed in the sections that follow have already been used in Iowa projects, but there are others that have not yet been tried that the Department believes may have more potential application in Iowa. This article should not be viewed as setting forth the only available options or the only options that may be considered.

8.3.1 Foundation and wall elements

Some ABC techniques for foundation and wall elements that have been used around the nation are briefly described below.

- Continuous flight auger (CFA) piles

  Conventional construction of deep foundation elements, such as drilled shafts, is typically a multi-step process. Installation of a CFA pile combines these steps into a single, continuous process. CFA piles are characterized by drilling a hollow-stem auger into the ground to form the pile's diameter. Sand-cement grout or concrete is pumped into the hole as the auger is removed, eliminating the need for temporary casing or slurry. After the auger is removed, reinforcement is installed. [For additional details see GEC No. 8 "Design And Construction Of Continuous Flight Auger Piles" at http://www.fhwa.dot.gov/engineering/geotech/pubs/gec8/.] Approval from BSB and the Design Bureau's Soil Unit should be sought before using CFA piles on a state project since the technology is new to Iowa.

- Geosynthetic reinforced soil integrated bridge system (GRS-IBS)
  A method of foundation installation that combines the foundation, abutment, and approach into one composite material.GRS -IBS technology uses alternating layers of compacted granular fill material and fabric sheets of geotextile reinforcement to provide support for the bridge. The internal soil is typically retained by non-structural modular block wall facing elements in order to prevent erosion. GRS-IBS also provides a smooth transition from the bridge onto the roadway, and alleviates the "bump at the bridge" caused by uneven settlement between the bridge and approach roadway. The technology offers unique advantages in the construction of small bridges. A number of county bridges in Iowa have been built using this technology. One state-owned bridge on IA 3 near Pocahontas (FHWA 040101, Maint. No. 7606.0S003) has also been built. Some of the benefits of this system include reduced construction time and cost, simple construction using common equipment and materials with non-specialized labor, and flexible design that can accommodate utilities and unforeseen site conditions. This technology is generally recommended for grade crossings, but has been used extensively for stream crossings. For stream crossings, additional consideration must be given to the protection of the GRS perhaps by using a sheet pile facing. [For additional information see http://www.fhwa.dot.gov/everydaycounts/technology/grs_ibs/publications.cfm.]
- Prefabricated pier cofferdams
  Several methods for cofferdams have been developed, such as driven steel sheeting and framing systems combined with underwater tremie concrete. Prefabrication can be used to facilitate the casting of pile cap footings. Pier box forms have been developed that can be floated into position and hung from the piles or drilled shafts.
- Retaining walls
  There are various ABC retaining wall systems that can be used. One of the more common systems that have been available for some time is mechanically stabilized earth (MSE) walls.

Some ABC techniques for foundation elements that have particular application in Iowa include pile bents and drilled shafts. Pile bents in combination with precast bent caps may be a good fit for some ABC projects because the bents can be installed relatively quickly once the existing structure is demolished. In general, larger capacity piles are used in order to limit the number of piles required at each pile bent. Drilled shafts are particularly suitable for ABC projects if they can be installed before the road is closed and the existing structure is demolished. In general, drilled shafts are used over other foundations types because they have a small footprint and can support significant axial loads.

- Pile options for pile bent piers without encasement
  - Galvanized steel H-piles
    For shorter bridges over streams with minimal debris or ice flow, galvanized steel H-piles may be substituted for individually encased piles for pile bent piers. The substitution allows the contractor to drive the piles and place a precast concrete bent cap without having to form and pour the individual encasements.
  - Concrete-filled steel pipe pile or prestressed concrete pile
    For shorter bridges over streams with minimal debris or ice flow, it may be desirable to use concrete-filled steel pipe piles or prestressed concrete piles for a pile bent pier not requiring full encasement. Displacement piles may require considerably less length of pile than H-pile.
- Drilled shafts
  In some cases, drilled shaft foundations may be installed just outside the limits of the existing structure before the existing structure is removed and the road closed. Once the shafts are in place the road is closed and the existing structure removed which allows the rest of the substructure to be quickly constructed using precast elements. This ABC technique is

suitable when the existing structure is relatively narrow and the replacement structure is only moderately wider. The limiting factor for this technique may be the weight of the precast cap which typically must span and support the full width of the new bridge between two columns. The weight of the cap may be mitigated somewhat through the use of prestressing, post-tensioning, and voids.

8.3.2 Rapid embankment construction

Some ABC techniques for rapid embankment construction that have been used around the nation are briefly described below.

- Expanded Polystyrene (EPS) Geofoam – A lightweight (1-2 lbs/ft^3) embankment fill system comprised of large blocks of expanded polystyrene. EPS Geofoam is not intended to structurally support the bridge abutment but can eliminate or reduce the amount of pre-load settlement an abutment may have otherwise experienced. [For additional information see http://www.fhwa.dot.gov/engineering/geotech/improvement/.]
- Accelerated Embankment Preload Techniques – Stone columns or wick drains have been used to accelerate the removal of water from underlying clay soil layers to allow for consolidation.
- Column Supported Embankment Technique – A method of constructing an embankment over compressible soils that involves installation of closely spaced piles or stone columns through the compressible soils. Once in place, multiple layers of geosynthetic reinforced soils are placed over the columns to support the new embankment.

8.3.3 Prefabricated bridge elements and systems

Prefabricated Bridge Elements – The most common form of ABC involves connecting prefabricated elements at the site to form a bridge. The items below are not meant to be an exhaustive list, but only cover some of the more common ABC elements and considerations.

- Materials – A wide variety of materials with various benefits for different elements can be used in ABC projects. Particularly important are materials used in connections between precast concrete deck elements due to the significant potential for cracking followed by deterioration due to chloride infiltration. For connections careful consideration should be given to the use of corrosion resistant reinforcing steel, durable non-shrink grouts, self-consolidating concrete (SCC) and ultra-high performance concrete (UHPC). Additionally, UHPC is also able to achieve a full moment connection with smaller closure pours. A combination of quality materials with compressive stress due to post-tensioning can have a significant effect on increasing the longevity of decks.
- Beams – Prefabricated steel and concrete beams have been used for many years in traditional construction techniques. Prestressed concrete beams, rolled steel beams, and plate girders may be placed quickly as simple spans. Beam continuity for live load, which is beneficial for beam weight reduction and crack reduction in decks at the pier, can often still be achieved for accelerated projects. Adjacent butted precast beam systems consisting of double tees, deck bulb tees, box beams, etc., though not commonly used in Iowa, can be advantageous to ABC.
- Decks – Forming, placing reinforcement, pouring, curing, and stripping cast in-place decks is one of the more time-consuming aspects in bridge construction. There are a number of approaches to circumvent the lengthy traditional process. The more common approaches include stay-in-place (SIP) corrugated steel forms, partial-depth precast concrete deck panels, and full-depth precast concrete deck panels. BSB approval should be sought to use SIP forms and partial depth precast panels since they typically have been limited to rural highways with limited ADT counts (i.e. BDM 5.2.1.1 and 5.2.4.3).
- Modular superstructure elements – The main benefit of modular components is that the deck is already attached to the beams eliminating the need for grouted shear pockets which are common for full-depth precast deck panels. Modular systems are often limited to shorter spans around 100’ due to shipping limits and a maximum weight of 150 kips due to limited crane capacities. For this reason, lighter rolled steel beams tend to be more favorable for modular construction. Continuity for multi-span bridges is often accommodated with modular systems.
- Substructure pier elements – Caps, column, and footing (spread or pile supported) precast elements for open frame piers are typically joined using grouted sleeve reinforcing bar couplers.

The weight of these elements should be no larger than 150 kips. Prestressing, post-tensioning, and voids may be used to reduce weight. Prefabricated wall piers are not as common due to weight limitations. Pile bents, not requiring concrete pile encasement, but consisting of steel shell piles, prestressed piles, or galvanized steel H-piles and precast caps can often be quickly constructed.

- Abutment elements – Iowa prefers to use integral abutments whenever feasible. Integral abutments can generally make use of a precast cap for the beams to sit on, but would still typically require a closure pour for the connection between the beams and abutment. Semi-integral abutments also use a precast cap for the beams to rest on, but typically it is possible to attach the backwall to a superstructure modular unit thereby eliminating the closure pour. Precast wings can also be incorporated into the system, but will typically require a closure pour.
- Approach pavement – Precast approaches have been successfully used on a number of Iowa projects. In general, it is better to bridge the distance from the abutment notch to a sleeper slab rather than placing the precast element directly on the subgrade. The primary reason for this is the difficulty with compacting the subgrade so that the element sits firmly on it.
- Precast culverts and modular arches – These systems have been available for a number of years.

Prefabricated Bridge Systems – Major bridge portions may be prefabricated and moved into place. Typical placement methods are covered in the next article. These systems are ordinarily used for short duration, tier 1 or 2, road closures. Typical systems include:

- Complete superstructures
- Superstructures with integral piers
- Complete bridges

8.3.4 Structural placement methods

Structural placement of prefabricated bridge systems is often achieved by one of the following four methods.

- Self-Propelled Modular Transporters (SPMTs) – A set of high capacity, highly maneuverable transport trailers that can be connected transversely or longitudinally to carry and place entire bridge structures. SPMTs are often used when multiple structures are being replaced within a relatively short distance along a corridor. The individual structures may then be fabricated at one location, called a bridge farm, and then transported and installed at their final locations. [For additional information see AASHTO TIG SPMT webpage.]
- Longitudinal Launching – A bridge placement method that requires the bridge superstructure to be constructed in a launching pit behind one or both abutments and then moved into place by jacking longitudinally out over the spans. This method is often used over deep gorges, busy navigation channels, or in environmentally sensitive areas. [For additional information see “Bridge Construction Practices using Incremental Launching” at http://onlinepubs.trb.org/onlinepubs/archive/NotesDocs/20-07(229)_FR.pdf.]
- Horizontal Skidding or Sliding – A bridge system movement method that involves lateral sliding or skidding of the new or existing structure. The most common procedure requires the erection of the new bridge superstructure to take place parallel to the old bridge. Once complete, the old bridge is demolished, the new substructure is installed, and the new superstructure is slid or lifted into place. Another method may call for the substructure for the new bridge to be constructed under the old bridge, the old bridge slid out of the way, and the new bridge slid into place. Alternatively, a temporary alignment may be built, the existing bridge slid laterally onto temporary supports for the temporary alignment and the new structure built along the final alignment.
- Other Heavy Lifting Equipment and Methods:
    - Strand Jacks – A system that pulls elements up vertically using cables. This system is often used to place structures that are shipped in on barges.
    - Climbing Jacks – A system that pushes elements up vertically using hydraulic jacks.
    - Pivoting – A system that involves rotating the prefabricated bridge into place on vertical or transverse axis.
    - Transverse or Longitudinal Gantry Cranes

8.3.5 Fast track contracting

8.3.5.1 Accelerated project delivery

Traditional design-bid-build (DBB) methods require design and construction to take place sequentially. Accelerated project delivery (APD) methods generally allow design and construction to take place concurrently thereby requiring less time to complete a project. Additionally, the early involvement of a contractor allows the design to more readily take into account the most likely ABC construction techniques. APD methods are usually achieved by using one of the three methods below:

- Design-Build – A performance based bridge contracting method which allows final design and construction to occur simultaneously. In Design-Build, the owner relinquishes control of the design and construction process as well the risk associated. [For additional information see http://www.fhwa.dot.gov/construction/cqit/desbuild.cfm.]
- Partial Design-Build – A bridge contracting method which gives contractors enough guidance on bridge type, size, and location to competitively bid the project, but allows the Design-Builder to finish the design process while initial construction is performed.
- Construction Manager/General Contractor (CMGC) – A bridge contracting method similar to design build except for the owner's contracted involvement. In CMGC, the owner is part of the design team and does not relinquish control or risk. [For additional information see http://www.fhwa.dot.gov/construction/cqit/cm.cfm.]

Innovative contracting methods such as design build and CMGC, which are promoted by the Every Day Counts initiative, are not currently considered in Iowa.

8.3.5.2 Contracting provisions

There are number of contracting provisions that may be used on ABC projects.

- Best Value Selection – A selection process that combines a bid or quote with an evaluation of the contractor's proposal which typically includes credentials and experience. This contracting method is typical for design build or CMGC bridge projects.
- A+B and A+B+C Bidding – A+B or "price + time" bidding includes a base bid price (the "A" component) for the contracted work as well as a monetary value based on time to complete the project (the "B" component). The "B" component is often tied to road user costs. See IDOT SS 1112 for more information on A+B bidding in Iowa. A+B+C bidding will generally include monetary value associated with meeting important project milestones. Once again the value of the "B" and "C" components is often tied to road user costs. In general, the awarded amount for the contract is limited to the "A" component, but the best value is determined based on the sum of the components.
- Continuity of the Construction Process – Contracting provisions can be used to limit the amount of days a worksite is inactive. An example of this would be to limit the project construction to a certain number of workdays. Contractors are charged for workdays regardless of whether the construction site is active or not except when weather or outside causes are the source of the inactivity.
- Incentive/Disincentive (I/D) Clauses – A contract provision used to financially compensate or assess damages to a contractor for time spent on project construction. I/D clauses are typically tied to road user costs. A cap is often placed on the maximum incentive value. See Section 1111 of the Standard Specifications for more information on I/D bidding in Iowa. [For additional information see http://www.fhwa.dot.gov/construction/contracts/t508010.cfm.]
- Warranties – A time based guarantee typically used for specific project items such as concrete pavements, bridge painting, and bridge expansion joints. Warranties were not permitted on Federal-aid projects until 1995. Warranties are most often used on design build projects where owners have less control over the quality control procedures.
- Lane Rental – A contracting provision that involves charging the contractor for the amount of time a lane is out of service. This forces a contractor to be aware of roadway user impacts during construction and the bidding process.

8.4 Quality control

The IDOT Standard Specifications often specify construction tolerances for component dimensions and component placement. The tolerances in the Specifications may not be suitable for proper fit up between prefabricated bridge elements and placement of prefabricated bridge systems. Additionally, the Specifications may not address construction tolerances that are important to the successful implementation of a particular ABC technology.

For example, IDOT SS 2501.03.I and L specify construction tolerances for pile driving. However, an ABC project which makes use of precast bent caps supported on piles should specify tolerances for the final position of the pile heads in the plans. This will ensure the precast cap can be placed over the pile heads without interference. If pile tolerances are particularly tight consideration should also be given to requiring the use of a template in the plans in order to ensure proper pile positioning.

8.4.1 Certification

Reserved

8.4.2 Inspection

Reserved

8.5 Details

Reserved

8.6 Costs

Reserved