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HISTORY OF ABC IMPLEMENTATION IN U.S.

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ABSTRACT

Accelerated bridge construction implementation in the U.S. has been significantly advanced due to the leadership of state DOTs in partnership with the Transportation Research Board, the American Association of State Highway and Transportation Officials, the Federal Highway Administration, and academic and industry partners. This paper provides a history of those collaborative efforts.

INTRODUCTION

The advancement of accelerated bridge construction (ABC) implementation in the U.S. has itself accelerated in recent years. The current speed of this advancement is due to the leadership of the state DOTs in collaboration with the Transportation Research Board (TRB), the American Association of State Highway and Transportation Officials (AASHTO), the Federal Highway Administration (FHWA), and academic and industry partners.

Before discussing the history of ABC implementation in the U.S., however, it is best to first define ABC. According to FHWA (1), "ABC is bridge construction that uses innovative planning, design, materials, and construction methods in a safe and cost-effective manner to reduce the onsite construction time that occurs when building new bridges or replacing and rehabilitating existing bridges." This reduced onsite construction time is achieved without reducing quality, to open a cost-effective long-lasting bridge to traffic with increased safety and reduced traffic disruption during construction.

ABC in planning may include early environmental clearance and permitting as well as right-of-way acquisition and utility relocation prior to advertising the project, and the use of innovative contracting strategies such as A+B bidding and incentive/disincentive clauses. ABC in design typically includes prefabricated bridge elements, and in recent projects the prefabrication of entire superstructure systems has become more common. ABC in design may also include geotechnical engineering enhancements such as mechanically-stabilized earth walls, lightweight backfill, and geo-synthetic reinforced soil (GRS) abutments. ABC materials may include high performance steel, high performance concrete, ultra-high performance concrete, and fiber reinforced polymers among other innovative materials. ABC in construction may include use of innovative equipment such as self-propelled modular transporters to move superstructure spans into place, or the innovative use of existing equipment such as hydraulic jacks to laterally slide superstructure spans into place.

While various ABC technologies can be used in all phases of bridge construction, the use of prefabricated bridge elements and systems (PBES) is typical in ABC projects. According to FHWA (1), "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 occur when building new bridges or rehabilitating or replacing existing bridges relative to conventional construction methods." The "E" in PBES is for prefabricated **E**lements; an "element" is a single structural component of a bridge such as a full-depth prefabricated deck, a modular decked beam, or a prefabricated substructure. For beams to be considered prefabricated elements under the current PBES definition they must be abutting; the use of abutting beams eliminates the majority of deck forming which would otherwise require a separate construction step. The "S" in PBES stands for prefabricated **S**ystems; a "system" consists of an entire superstructure, an entire superstructure and substructure, or a total bridge that is fabricated offsite or near-site. The prefabricated system is then rolled, launched, slid, lifted, or otherwise transported into place, having the deck and, if possible, the parapets in place such that no separate construction phase is required after placement.

This paper focuses mainly on PBES because PBES technologies are used in most ABC projects.

RESEARCH

The foundation for successful implementation is successful research, and the contribution of research to the advancement of ABC implementation has been significant. TRB and state Departments of Transportation (DOTs), through their sponsorship of research administered by TRB, have been leaders in the advancement of ABC research from the beginning.

TRB National Cooperative Highway Research Program

In 1985 TRB's National Cooperative Highway Research Program (NCHRP) published a synthesis report on PBES (2). For the synthesis, a prefabricated element was defined as "a part of a bridge that is fabricated or assembled away from its final position and used to minimize design effort, onsite construction time, or disruption or environmental impact in the vicinity of the site." A prefabricated system was defined as "a combination of prefabricated bridge elements." The most common elements were the prestressed concrete I-beam, precast and prestressed box beam, precast and prestressed channel, and precast slab span. Newcomers at that time were the steel stay-in-place form, prestressed concrete subdeck and full-depth panels, and precast parapet. Structural steel beams were not considered PBES, and the box beam and slab span were most frequently used on low-volume roads. At the time of the 1985 synthesis, approximately 15 percent of the bridges in the U.S. contained PBES. The primary reasons for use of prefabricated elements were to reduce first cost and to accelerate construction. Subsequent to the 1985 definition of elements and systems, prestressed concrete I-beams and other spread-beam shapes have become conventional construction as was the case for structural steel beams at that time.

In 2003, almost two decades later, a second NCHRP synthesis on PBES was published (3). Its focus was to compile existing information on the use of new and innovative PBES in bridge construction, rehabilitation, and replacement relative to design effort, onsite construction time, lane closure time, and environmental impact. The synthesis found that, in the intervening years since the 1985 synthesis, new systems had been developed to prefabricate decks, superstructures, and substructures, with an interest in the development of totally prefabricated systems that could accelerate construction time and further minimize traffic disruption. Reasons for using PBES included faster construction, minimized construction delay and lane closure time, and improved safety at the bridge site. Initial cost and lack of standardization were reported as significant disadvantages for PBES, with the lack of standardization often resulting in higher construction costs.

Throughout the years state DOTs have requested research projects to advance specific ABC technologies and, thereby, advance nationwide ABC implementation. NCHRP research projects that have focused on ABC technologies include full-depth precast concrete deck panel systems, precast bent cap systems for seismic regions, and connection details for adjacent precast concrete box beam bridges. Ongoing NCHRP projects include PBES tolerances, dynamic effects of bridge moves, and the development of a recommended AASHTO guide specification for ABC design and construction (4).

TRB Second Strategic Highway Research Program

In 2005, the U.S. Congress authorized the second Strategic Highway Research Program (SHRP2) as a short-term research program to investigate underlying causes of highway crashes and congestion. SHRP2 was conducted under a memorandum of understanding between AASHTO, FHWA, and TRB and began work in early 2006 with five years of funding and nine years to complete the research (5).

The work of SHRP2 was guided by an oversight committee and four technical coordinating committees, one in each of the four focus areas of safety, renewal, reliability, and capacity. The renewal focus area housed the ABC research conducted under this initiative. The renewal goal was to develop design and construction methods that cause minimal disruption and produce long-lived facilities to renew the aging highway infrastructure.

Several ABC-related products have been developed under the renewal focus area. Currently the most noted ABC renewal product is the toolkit developed under the R04 research project, “Innovative Bridge Designs for Rapid Renewal” (6). The toolkit includes standard design details, specifications, and concepts; recommended specification language; a guidebook; and design examples.

Additional Research

A number of state DOTs, the FHWA, and several academic and industry organizations have also taken the lead to individually or jointly sponsor ABC-related research to help advance the state-of-the-practice. For example, the Oregon DOT led a pooled-fund project to develop a decision tool to help determine whether a project is a good candidate for ABC; this tool is now used in a number of states. Another example is FHWA’s extensive research on ultra-high performance concrete connections for PBES.

In 2013 the Research and Innovative Technology Administration under the U.S. Department of Transportation provided funding to establish and operate the ABC University Transportation Center (ABC-UTC) at Florida International University in consortium with Iowa State University and the University of Nevada at Reno. Current research efforts at the ABC-UTC include precast bridge railing, seismic connection details, and compiling ABC projects and research into databases for ready access by bridge professionals in their work to advance ABC implementation (7).

The products developed in these research initiatives have helped ensure good constructability and long-term performance of ABC technologies.

EARLY YEARS OF NATIONWIDE IMPLEMENTATION

In 1996 work toward a national accelerated construction initiative began following the publication of TRB Special Report 249, *Building Momentum for Change* (8)**,** which recommended creation of a strategic forum to promote accelerated construction in highway infrastructure. Bridges, as part of the highway infrastructure, were part of this national initiative.

TRB Task Force on Accelerating Innovation in the Highway Industry

In response to TRB Special Report 249, in 1999 the TRB Task Force on Accelerating Innovation in the Highway Industry (A5T60) was created to facilitate the removal of barriers to innovation, advocate continuous quality improvement and positive change, enhance safety and mobility, encourage development of strategies that generate beneficial change, and create a framework for informed consideration of innovation (9). In 2000 the TRB A5T60 Task Force conducted a two-day workshop in Washington, DC to explore issues associated with accelerating highway construction.

Accelerated Construction Technology Transfer Workshops

Findings from the 2000 TRB-sponsored workshop were shared with the newly-formed AASHTO TIG and FHWA. In 2002 the TRB A5T60 Task Force, AASHTO TIG, and FHWA co-sponsored pilot Accelerated Construction Technology Transfer (ACTT) workshops in Indiana and Pennsylvania with focus on accelerating the construction of upcoming major highway projects in those states.

Following the success of the three initial workshops, the A5T60 Task Force turned the national accelerated construction initiative over to the AASHTO TIG and FHWA. The AASHTO TIG and FHWA then co-sponsored ACTT workshops in over half of the 50 states. In each workshop the ACTT process was applied to a specific project or corridor. A multidisciplinary team of national transportation experts worked with local agency professionals to evaluate all aspects of the project from the perspectives of multiple skill sets. Those skill sets included innovative financing and contracting; right-of-way, utilities, and railroad coordination; environment; geotechnical, materials, and accelerated testing; traffic engineering safety, and intelligent transportation systems; structures; public relations; construction; roadway and geometric design; and long-life pavements and maintenance. By the end of each ACTT workshop, participants had developed recommendations to reduce roadway construction time and enhance safety and quality with cost-effective solutions (9).

AASHTO TIG PBES Lead States Team and SCOBS Technical Committee for Construction

The AASHTO TIG, a leader in the ACTT initiative and now evolved into the AASHTO *Innovation Initiative* (10), was created in 2000 and consisted of State DOT and FHWA executives. The TIG was formed to identify and champion the implementation of a select few ready-to-use technologies each year; these technologies were selected because they were considered likely to yield significant economic or qualitative benefits to the users. The TIG vision was an environment for rapid acceptance and implementation of high-payoff innovative technologies, with a focus on technologies under the Standing Committee on Highways (SCOH) for implementation among AASHTO member agencies, local agencies, and industry.

In 2001 the AASHTO TIG selected precast concrete bent caps for nationwide implementation and created a Lead States Team composed of bridge engineers from various state DOTs, FHWA, and industry to expand the use of precast concrete bent caps in bridge design and construction nationwide. The TIG approved the Lead States Team's proposal to expand the focus to all PBES to further ABC implementation. From 2001 to 2004 the PBES Lead States Team, in partnership with the FHWA, championed PBES to bridge owners and other stakeholders across the country. Its various activities included PBES articles, presentations, sessions, workshops, brochures, videos, and a website for technology transfer that included PBES projects, publications, and research information.

The PBES Lead States Team was sunset in 2004, and FHWA imported the PBES Lead States Team web content to its website for continued technology transfer. AASHTO transferred the PBES Lead State Team's leadership role to the AASHTO Subcommittee on Bridges and Structures (SCOBS). The SCOBS Chair designated the Technical Committee for Construction (T-4) as the focal point for ABC, with FHWA and industry working in partnership with T-4 to continue ABC implementation.

AASHTO/FHWA/TRB International Scan on Prefabricated Bridge Elements and Systems

Also during 2004 AASHTO, FHWA, and TRB co-sponsored an international scan on PBES in Japan and Europe (11). The scan team recommended the following technologies for nationwide implementation:

- Movement systems – self-propelled modular transporters and other bridge installation systems (horizontal skidding or sliding, longitudinal launching floating, rotating, and vertically lifting);
- Superstructure systems – the Poutre Dalle system (inverted tee-beam with composite cast-in-place topping), partial-depth concrete decks prefabricated on steel or concrete beams, U-shaped segments with transverse ribs;
- Deck systems – full-depth prefabricated concrete decks, deck joint closure details, hybrid steel-concrete deck systems, multiple-level corrosion protection systems; and
- Substructure systems – SPER system (Sumitomo Precast form for resisting Earthquakes and for Rapid construction).

One of the first implementation projects resulting from the scan was a 2006 overnight replacement of a superstructure over an interstate using self-propelled modular transporters, with just hours of impact to motorists on the interstate (12). Scan team members and other bridge owners have continued work to implement the scan team's various recommended PBES technologies in the years following the scan.

National PBES/ABC Conferences

National conferences focused on PBES for ABC also contributed significantly through the years to advance successful ABC implementation. The first national PBES conference was held in February 2003 in St. Louis, Missouri. Co-sponsored by AASHTO, FHWA, and the MidWest Transportation Consortium, this first conference drew over 200 bridge professionals, with almost half the participants being bridge engineers from State highway agencies. Participants also included representatives from AASHTO and

FHWA, professional associations, contractors, suppliers, and academia. Presentations included case studies, perspectives on bridge construction needs, and details related to specific prefabricated elements and systems including deck panels, bent caps, piers, and superstructures (13). The second national PBES conference, co-sponsored by AASHTO, FHWA, the Midwest Transportation Consortium, and Rutgers, was held in September 2004 in New Brunswick, New Jersey.

The third and subsequent national ABC conferences have been coordinated by Atorod Azizinamini at the University of Nebraska-Lincoln and then Florida International University in Miami. The December 2004 FHWA Steel Bridge Conference was held in San Antonio, Texas with focus on high performance steel bridges and ABC. In December 2005 the FHWA ABC Conference was held in San Diego, California. In March 2008 the ABC – Highways for LIFE Conference was held in Baltimore, Maryland. In April 2010 the FHWA Bridge Engineering Conference: Highways for LIFE and ABC was held in Orlando, Florida. In December 2014 the ABC-UTC hosted its first National ABC Conference in Miami, Florida, followed by its second National ABC Conference in December 2015, also in Miami. In collaboration with FHWA, state DOTs, TRB, and the bridge industry, these national ABC conferences bring the bridge community together to share best ABC practices across the country.

FHWA Innovative Bridge Research and Construction/Deployment Programs

Bridge owners must accept the inherent risks associated with the incorporation of bridge innovations. Requiring bridge owners to also accept the additional costs of first use of these innovations can push them toward using existing technologies because of their limited budgets. An additional funding source to cover the incremental cost increase that occurs in the first use of an innovation is, therefore, critical for widespread implementation of innovation. The previous FHWA Innovative Bridge Research and Construction (IBRC) and Innovative Bridge Research and Deployment (IBRD) programs addressed bridge owners' need for additional funding. Many bridge technologies were implemented as a result of having this additional funding, including a number of ABC technologies.

RECENT INITIATIVES

The early years of ABC implementation set a good foundation for subsequent programs that have been initiated to promote more widespread use of ABC technologies and help ensure successful implementation.

FHWA Highways for LIFE Program

In 2005 the U.S. Congress funded FHWA's Highways for LIFE (HfL) pilot program. The term "LIFE" was an acronym to represent the need to advance Longer-lasting highway infrastructure using Innovations to accomplish the Fast construction of Efficient and safe highways and bridges (14). The three HfL goals were to improve safety during and after construction, to reduce congestion caused by construction, and to improve the quality of highway infrastructure. HfL advanced a business model that focused on setting customer-based performance goals and achieving the best solutions to meet those goals; encouraged a culture that routinely invites proven, market-ready innovation and rapidly adopts new practices; and emphasized effective technology deployment and improved ways to more quickly get innovation into mainstream use (15).

From 2006 to 2012 the HfL program provided funding to construct a number of bridges that incorporated ABC technologies. Those technologies include various modular decked beams, precast abutments, precast piers, and superstructure span replacements using self-propelled modular transporters and lateral slide technologies. HfL summary reports provide detailed documentation of these ABC projects (16).

AASHTO / TRB U.S. Domestic Scan Program

In 2007 AASHTO member states funded NCHRP Project 20-68A, the U.S. Domestic Scan Program. The program plans and manages the execution of domestic technology scans that each focus on a single technical topic (17). AASHTO and NCHRP identify scan topics based on suggestions submitted by state

DOTs and FHWA. Several domestic scans have addressed topics that help to advance ABC implementation. The two scans specifically focused on ABC were 07-02, “Best Practices in Accelerated Construction Techniques,” and 11-02, “Best Practices Regarding Performance of ABC Connections in Bridges Subjected To Multi-Hazard and Extreme Events.”

FHWA Every Day Counts Initiative

In 2009 FHWA launched its *Every Day Counts* (EDC) initiative to more quickly identify and deploy market-ready innovations in highway infrastructure to speed project delivery, improve road safety, and protect the environment (18). FHWA is working with state, local, and industry partners to deploy the technologies and develop performance measures to gauge their success.

Since its beginning the EDC initiative has assisted in the development of a significant number of projects employing ABC technologies. In 2010 the EDC Round One (EDC-1) bridge innovations were PBES and geosynthetic reinforced soil-integrated bridge systems (GRS-IBS). In 2011-2012 over a thousand bridges were built in an accelerated manner using some form of PBES technology. In 2012 the EDC-2 bridge innovations were PBES, GRS-IBS, and lateral slide technologies. In 2013-2014 the number of bridges built with PBES technologies increased significantly. In 2014 the eleven EDC-3 innovations include GRS-IBS and Ultra-high Performance Concrete (UHPC) Connections for Prefabricated Bridge Elements.

In 2011 FHWA established the Center for Accelerating Innovation to provide national leadership on deploying transportation innovation (19). The Center houses the EDC initiative and products from the HfL program. The Center for Accelerating Innovation is also helping get the word out about current funding programs that are available to bridge owners to encourage ABC implementation.

SHRP2 Implementation

In 2012, Congress authorized additional funding to support SHRP2 implementation activities coordinated by FHWA, AASHTO, and TRB (20). In 2013, FHWA and AASHTO prioritized and scheduled products from the SHRP2 research program for implementation based on industry needs, available funding, product readiness, and anticipated benefits. The SHRP2 R04 toolkit (6) is included in this implementation effort.

Two pilot projects were sponsored as part of the R04 research project to demonstrate the use of the R04 toolkit. In 2011 the US 6 Bridge over Keg Creek in Iowa was the first pilot project to be showcased; the three-span bridge consists of modular decked beam elements connected with field-cast UHPC joints, supported on a precast concrete substructure, and was installed during a two-week closure. The second pilot project was the I-84 Bridge over Dingle Ridge Road in New York State, showcased in 2013; single-span replacements were constructed adjacent to the existing pair of bridges and then slid laterally into place following demolition of the existing bridges during weekend closures of the interstate. Currently a number of ABC bridges are being constructed in the R04 implementation phase.

Industry Involvement

Industry partners have been a critical component of effective ABC implementation. A number of general contractors have provided their perspectives at national forums to help stakeholders understand how ABC construction can be streamlined and further improved. General contractors have also proposed ABC technologies on a number of conventional projects because those technologies provided benefit in their operations. Also, innovative project delivery methods such as design-build and construction manager/general contractor (CMGC) have also been effective tools in the implementation of ABC.

TRB ABC Subcommittee

In 2013, TRB approved the creation of the ABC Subcommittee (AFF10-3) under its General Structures Committee (AFF10). The Subcommittee conducted its inaugural meeting during the TRB 2014 Annual Meeting in Washington, DC. The Subcommittee has created a national ABC research tracking tool which identifies and categorizes approximately a hundred ABC/PBES-related research projects that are completed, ongoing, or initiated.

Publications and Websites

FHWA has taken the lead in sponsoring a number of publications which have been critical to empowering state DOTs as they incorporate ABC into their programs and work to cut design time and overall project costs. The 2006 ABC decision framework helps engage state DOT bridge engineers in developing decision guides with their own priorities for implementing ABC projects. The document helps change the practice and paradigm of project decision-making by engaging bridge engineers early in the project development planning stage. Another example is FHWA's 2007 manual on the use of self-propelled modular transporters; it provides support and guidance that documents the bridge system move as a proven success. Similarly, the 2009 connection details manual is another critical tool that state DOTs had requested; it provides a compilation of ABC connection details in use across the US. This manual was followed with the 2011 ABC manual to further assist bridge owners in their ABC implementation; the ABC manual provides an overview of ABC from planning through construction. These guidance documents are available on FHWA's ABC website (1), and more resources are being developed for subsequent posting. By delivering these publications, FHWA demonstrates that it is serious about PBES for ABC and is at the table to help bridge owners be successful in their ABC implementation.

A number of state DOTs have developed their own ABC websites as they work to implement ABC in their states. Foremost in this effort is Utah, the first DOT to program ABC as a standard practice.

In addition, a database of information on constructed ABC projects has replaced the TIG PBES database previously imported to FHWA's website when the TIG's PBES Lead States Team sunset in 2004. Beginning in 2011, the National ABC Project Exchange was created as part of an AASHTO, FHWA, and state DOT collaboration. The project exchange is a national repository of ABC projects that includes detailed documents on ABC/PBES projects that have been successfully built within the US. The detailed information includes contract plans, specifications, bid tabs, schedule, photos, and a project summary report. The database is in the process of being moved to the ABC-UTC website for ready access by users.

CONCLUSION

Typically the use of ABC has consisted of trying a specific ABC technology for its first use in a state but not necessarily with the intent to standardize the use of that technology, assuming its use was successful, on subsequent projects. Significant efforts to more effectively implement ABC nationwide have been undertaken since the 2003 NCHRP synthesis reported that the lack of standardization often results in higher construction costs.

Many players are responsible for the successful implementation of the variety of ABC technologies in use today. AASHTO and its members, TRB, and FHWA have collaborated in multiple ways to address the needs for reduced motorist impact, improved safety, and more reliable travel times through the increasing number of work zones required to renew the nation's aging bridge inventory. State DOTs have provided leadership in response to user needs. TRB has responded with leadership in ABC research. FHWA has provided the broad national view, leadership, research, and in particular has assisted with obtaining additional funding and technical assistance so critical to effective implementation of innovation. Academia and industry, through their support of bridge owner needs and their individual and joint research and implementation efforts, assure the continued successful and effective advancement of ABC implementation in the U.S. More standardization and construction cost savings are products of these collaborative efforts.

An overarching conclusion for those responsible for mainstream innovation deployment is that dedication, resources, and time are needed to make wholesale change in the state-of-the-practice. Each project and each technical contribution, however small, moves the bridge community forward in the implementation of an innovation. No better example exists than accelerated bridge construction.

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