



## Program Progress Performance Report University Transportation Centers

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# **ACCOMPLISHMENTS**

## **What are the major goals and objectives of the program?**

The broad goals and objectives of the Tier I Accelerated Bridge Construction University Transportation Center (ABC-UTC) are to advance the frontier of Accelerated Bridge Construction (ABC); develop new ABC knowledge; effectively transfer the state-of-the-art ABC knowledge to the profession; develop a next-generation ABC workforce; and collaborate with the Federal Highway Administration (FHWA), the American Association of State Highway and Transportation Officials (AASHTO), Departments of transportation (DOTs), other UTCs, and the transportation profession to make ABC the best solution for design, repair and construction of the nation's aging bridge infrastructure in line with U.S. DOT's strategic focus on State of Good Repair.

Specific goals and objectives of the ABC-UTC can be broken into three general categories:

### **Research**

- Extend principles of ABC to the repair, replacement and preservation of bridges, including multi-hazards and seismic issues.
- Enhance the service life of bridges constructed using principles of ABC by emphasizing design for service life (at the design stage), preservation, and timely maintenance.
- In collaboration with other UTCs develop traffic safety systems specifically for modular bridge construction for all traffic levels.
- Develop next generation bridge systems that are best suited for ABC applications.
- Building on existing knowledge, develop the next generation of decision-making tools for better communication among stakeholders, which should assess the merits of various construction processes and visualize the entire life span of bridges in a seamless manner from birth to recycling.
- Develop new and innovative ideas and applications for use of advanced materials, such as Ultra High-Performance Concrete in ABC.
- Investigate use of robotics in bridge construction
- Facilitate adaptation of high-speed rails, by developing ABC solutions specific to high speed rails
- Investigate ABC solutions for addressing challenges imposed by climate change
- Develop new knowledge to extend the application of ABC in seismic areas.

### **Education and Workforce Development**

- Become the educational focal point for advancing principles of ABC.
- Develop and nationally distribute K-12 educational materials related to bridge engineering, and ABC in particular, for educating and attracting future generations of transportation and sustainability engineers.
- Develop educational materials that could be used in academia at both undergraduate and graduate levels for explaining fundamental and advanced topics in ABC.
- Develop and deliver continuing education opportunities on ABC for practicing engineers across the country.

- Train graduate students knowledgeable in implementation of ABC in practice
- Train high school teachers by providing them with tools that they can incorporate into their curriculum to teach bridge engineering with an especial focus on ABC.

### Technology Transfer

- Become a national repository and focal point for assisting federal, state, and local agencies on matters related to ABC.
- Educate the current and next generation of engineers on when and how to effectively use ABC technologies.
- Lower the cost of utilizing ABC technologies by conducting outreach activities at the local, regional, and national levels that include the dissemination of research results.
- Develop implementable tools that follow the form and function of AASHTO-type publications.
- Conduct webinar and national conferences.

### What was accomplished under these goals?

Meetings and correspondences among the partner universities were held during the reporting period to track progress in different tasks, using a matrix that included a list of planned tasks. Progress in different tasks related to research, education and workforce development, and technology transfer was discussed during these meetings between ABC-UTC directors, associate directors, graduate students and key researchers.

Following is a description of various tasks by three main categories that are research, workforce development, and technology transfer.

### Research

ABC-UTC aims to carry out research in close association with federal and state agencies and bridge industry. During the reporting period, technical advisory committee (TAC) was established for research projects that were selected based on input of ABC-UTC Advisory committee, AASHTO T-4 and AASHTO T-3 Committees. The technical advisory committee consists of professionals from FHWA, state DOT and industry. These professionals were carefully selected for each research projects based on their experience that was closely related to the ABC-UTC research projects. Meetings were held with TAC to discuss ABC-UTC research projects.

Following table provides a list of research projects, technical advisory committee members for each project and progress made in the project during the reporting period.

Project #	Research Project Title	TAC Members	Progress (October 1, 2017 – March, 31 2018)
FIU-1	Compilation of all ABC research that is ongoing and completed	Ahmad Abu-Hawash, Iowa DOT	The ABC Research Database continues to be populated and advertised.

Project #	Research Project Title	TAC Members	Progress (October 1, 2017 – March, 31 2018)
	Recommended by AASHTO T-4		
FIU-2	Compilation of ABC solutions	Ahmad Abu-Hawash, Iowa DOT	The ABC Project Database continues to be populated and advertised.
FIU-3	Estimating total cost of bridge construction using ABC and conventional methods of construction	Mary Lou Ralls Newman, Ralls Newman, LLC	Project has been completed.
FIU-4	Development of Manual for Enhanced Service Life of ABC Bridges	Bruce Johnson, Oregon DOT; Ali Maher, Rutgers University; Hamid Ghasemi, FHWA; Carlos Duart, CDR Maguire	<p>The structural conditions of a closure joint were replicated under a flexure test for a unit width.</p> <p>48 beam specimens were cast and tested to failure. Observations were recorded.</p> <p>Numerical study including several details with different parameters are currently under investigation."</p>
FIU-5	Alternative ABC Connections Utilizing UHPC	Bruce Johnson, Oregon DOT; Bijan Khaleghi, Washington DOT; Tom Ostrom, Caltrans; Elmer Marx, Alaska DOT	Six more specimens with different parameters with one layer of UHPC have been cast to investigate the effect of rebar size and overlap length and general behavior of the connection.
FIU-6	Extending Application of SDCL to ABC (Phase II – Experimental):	Bruce Johnson, Oregon DOT; Bijan Khaleghi, Washington DOT; Tom Ostrom, Caltrans; Elmer Marx, Alaska DOT	A repair method using Ultra High Performance Concrete was examined in a specimen incorporating SDCL detail. The developed seismic SDCL details was evaluated under cyclic loading first, then the damaged specimen was repaired and tested. The test results show increase in strength and ductility of the column, however the capacity protected SDCL detail remained undamaged.

Project #	Research Project Title	TAC Members	Progress (October 1, 2017 – March, 31 2018)
FIU-7	A Predictive Computer Program for Proactive Demolition Planning	James Corney, Utah DOT	Comprehensive literature review has been made during the period regarding the relevant research efforts to simulate bridge demolition process using discrete mechanical analysis techniques. The current task is working on the code development by implementing required numerical analysis components.
FIU-8	Corrosion Durability of Reinforced Concrete Utilizing UHPC for ABC Applications	FDOT	Initial experiments assessing corrosion macrocell current development for steel in dissimilar conventional and ultra-high performance concretes were made. Further testing for those concretes in saturated conditions were made. Samples to assess chloride penetration in cold joints for dissimilar conventional and ultra-high performance concretes were being developed.
FIU-9	Extending Maximum Length of the Folded Steel Plate Girder Bridge System (FSPGBS), exceeding 100 ft. with capability to Incorporate Camber	NSBA	The numerical work to develop the connection detail was completed. Several details are identified. Two Folded Plate Girders, each 57 ft long were shipped to Tampa steel for fabricating first test specimen using the flange detail connection. The test specimen is expected to be ready for testing by August of 2018. Plan is to test the first detail and based on result select the second detail to be tested.
FIU-10	NDT Methods Applicable to Health Monitoring of ABC Closure Joints	Ahmad Abu-Hawash, Iowa DOT; Steve Womble, FDOT, D7	In this period, based on an extensive literature search, common closure joints were categorized into five groups with distinctive geometric and physical features. Observed and presumed defects for each group was also identified. Concurrently, NDT methods applicable to bridge inspection were reviewed and among them, a set of promising methods were identified. These methods were evaluated according to their effectiveness, efficiency and ease of use for health monitoring of closure joints. In the next period, etiology of defects in closure joints will be investigated and

Project #	Research Project Title	TAC Members	Progress (October 1, 2017 – March, 31 2018)
			the promising NDT methods will be evaluated also for their application to specific types of defects and joints, taking into account the etiology.
FIU-11	Performance Comparison of In-Service, Full-Depth Precast Concrete Deck Panels to Cast-in-Place Decks	Ahmad Abu-Hawash, Iowa DOT; James Corney, Utah DOT; Bruce Johnson, Oregon DOT	Literature review is near completion. Survey was developed and distributed. Survey results are being collected, compiled, and analyzed.
FIU-12	Use of Drones in ABC	Atorod Azizinamini, FIU; Ibrahim Tansel, FIU	"Relevant literature review has been performed.  Type of drone and applications to ABC have been identified. "
ISU-1	Development of Crash-Tested Prefabricated Bridge Railings  Recommended by AASHTO T-4	Ahmad Abu-Hawash, Iowa DOT; Tim Fields, Connecticut DOT	Research progress during October 1, 2017 to March 31, 2018 for the Development of Prefabricated Concrete Bridge Railings includes drafting and revising the final report. The final report is being reviewed with finalized test results. Due to conducting multiple tests, data required additional effort to carefully process the data so that project outcomes can be accurately communicated. Corrections have been made within the results in respect to the initial conditions and the results will be presented as if performed in a continuous manner.
ISU-2	Material Design and Structural Configuration of Link Slabs for ABC Applications	Ahmad Abu-Hawash, Iowa DOT; Michael Nop, Iowa DOT; Wisconsin DOT; and Michael P. Culmo, CME Associate	Preliminary mixtures of small ECC batches were prepared based on a popular ECC mix design reported in the literature called ECC-M45. The preliminary mixtures were intended for us to get a feel for how ECC behaves during mixing and in the fresh state. It was found that pseudo strain hardening in flexure could be achieved with ECC made with local mortar sand. Two gradations of silica sand have been obtained for ECC ductility testing. It is expected that a finer sand gradation will produce more ductile ECC mixtures and this will be investigated to develop a highly ductile ECC pre-cast ABC link slab.

Project #	Research Project Title	TAC Members	Progress (October 1, 2017 – March, 31 2018)
ISU-3	Investigation of Macro-Defect Free Concrete for ABC including Robotic Construction	Ahmad Abu-Hawash, Iowa DOT; Sean Perfetti, Caterpillar	This project is complete and the final report has been posted on the website.
ISU-4	An Integrated Project to Enterprise-Level Decision Making Framework for Prioritization of Accelerated Bridge Construction	Ahmad Abu-Hawash, Iowa DOT	A Mixed-integer programming computation platform is developed that is capable of prioritizing the bridge selection at the network-level while optimizing the best construction strategies at the project-level. A test bed network is generated and the developed computational framework has been implemented. A final report is generated and currently being revised and reviewed by the team members.
ISU-5	Inspection and QA/QC for ABC Projects	Ahmad Abu-Hawash, Iowa DOT; Hoda Azari, FHWA; Shane Boone, BDI)	A thorough literature review is in progress. This effort is focused upon identifying promising techniques to use for ABC applications. The evaluation techniques that are currently being explored include audio-visual, acoustic-seismic, electro-magnetic, electro chemical, and radiographic methods. These technologies may not all be prioritized for ABC applications, but are included nonetheless for completeness. In addition to the literature review, a field demonstration of airborne GPR was performed on a bridge that was constructed using ABC. The capabilities of the technology were noted and will be included in the project findings.
ISU-6	Integral Abutment Details for ABC Projects, Phase II	Brent Phares, ISU; Travis Hosteng; ISU; Behrouz Shafei; ISU; Jim Nelson, Iowa DOT  Ahmad Abu-Hawash, Iowa DOT; Mike Nop, Iowa DOT; Logan Wells, Iowa DOT; Mike LaVoilette; HDR; Elmer Marx, Alaska DOT; Mike Culmo, CME; William Oliva, Wisconsin DOT; James	Three details were designed and approved by the project Technical Advisory Committee (TAC) and construction on the specimens has been ongoing in the Iowa State Structural laboratory, which is being documented in depth. Preparations for the testing setup of one specimen are being started now, and the flowability test for the unique Ultra High Performance Concrete (UHPC)-Joint Connection Detail will be conducted soon as well. Away from the lab, ANSYS models are being started as to give a validation of lab test results and easier methods for adjusting and testing future connection detail revisions. The

Project #	Research Project Title	TAC Members	Progress (October 1, 2017 – March, 31 2018)
		Corney, Utah DOT; Atorod Azizinamini, FIU	progress to be made in the near future is to complete construction, testing, and analysis of all three connection details and use those results to refine the ANSYS models, which will all lead to a final report continuously being added to with progress in the project.
ISU-7	Development of Guidelines to Establish Effective and Efficient Timelines and Incentives for ABC	Ahmad Abu-Hawash, Iowa DOT; Mathew Haubrich, Iowa DOT	The database of ABC projects (105 projects) has been scoured to estimate the relationship between construction cost-technique. A first draft of a survey has been developed for the contractors and DOTs and will be distributed after finalization. The goal of the survey (followed by phone interviews) is to collect a clear insight on the cost-time relations for different construction techniques.
UNR-1	Development and Seismic Evaluation of Pier Systems w/ Pocket Connections and Hollow PT/UHPC Columns	Bijan Khaleghi, Washington DOT; Elmer Marx, Alaska DOT; Tom Ostrom, Caltrans	This project has been completed.
UNR-2	Shake Table Studies of a Bridge System with ABC Connections:	Bijan Khaleghi, Washington DOT; Elmer Marx, Alaska DOT	The construction all the elements and sub-elements were completed, and the bridge model was assembled in the shake table lab. Instrumentation of the bridge began. The shake table tests are scheduled for April 2018.
UNR-3	Analytical Investigations and Design Implications of Seismic Response of a Two-Span ABC Bridge System	Bijan Khaleghi, Washington DOT; Elmer Marx, Alaska DOT; Tom Ostrom, Caltrans	Preliminary preparation of the computer model began. Bulk of the research will be conducted after testing of the bridge system.
UNR-4	Durable UHPC Columns with High-Strength Steel	Elmer Marx, Alaska DOT; Tariq Masroor, Caltrans	This project has two experimental tasks. The first is the preliminary characterization of UHPC confinement using 2x4 and 3x6 cylinders. The second task is to test UHPC columns with high strength steel. About 40 UHPC cylinders have been cast and will be tested in the next quarter.



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			For the UHPC column tests, the design has been finalized and the research team is waiting for a bid to start the construction of the specimens and also waiting to receive the high strength steel that will be used in the tests. The construction is expected to be early summer and testing will be late summer/early fall.

### Education and Workforce Development

The following table lists different tasks related to workforce development provides a brief description of each task, identifies the lead institution for each task, and states the progress made in each task during the reporting period.

Task #	Brief Description of Task	Lead Institution	Progress (October 1, 2017 – March, 2018)
WD-1	<b>Student Education:</b> Each ABC-UTC consortium member will be expected to mentor a minimum of one graduate student for each \$50,000 to \$75,000 in project work.	ALL (FIU, ISU, UNR)	In this period, a total of 31 graduate students are working on ABC-UTC related research projects. 17 at FIU, 6 at ISU and 8 at UNR.
WD-2	Increasing the number of research assistantship opportunities for graduate students.	ALL (FIU, ISU, UNR)	In this period ISU added 2 students, UNR added 2 students, and FIU had 6 additional students.
WD-3	Upgrading course content in the areas of structural engineering and construction engineering/management to include modules on the use of ABC topics.	UNR	In this period, ABC seminars previously posted and the related video clips were maintained.
WD-4	Developing online courses and making progress towards the development of fully online degree programs.	FIU	FIU and ISU continue to develop materials to move some courses online.
WD-5	<b>Mentorship Program</b> – Development of a mentoring program where students are put in direct contact with industry representatives who are active in the field of accelerated bridge construction.	FIU, ISU, UNR	The following professionals from industry have been mentoring ABC-UTC students on research during this reporting period: <ul style="list-style-type: none"> <li>• Michael LaViolette, HDR</li> <li>• Mike Culmo, CME</li> <li>• Finn Hubbard, Fish &amp; Associates</li> <li>• Dr. Reza Farimani, Thornton Tomasetti</li> </ul>

Task #	Brief Description of Task	Lead Institution	Progress (October 1, 2017 – March, 2018)
			<ul style="list-style-type: none"> <li>• Dr. Francesco Russo, Michael Baker Jr., Inc.</li> <li>• Dr. Jawad Gull, HDR</li> <li>• Dr. Ardalan Sherafati, BlueScope Construction.</li> <li>• Nathan Johnson, Kleinfelder Engineering</li> <li>• Claudia Pulido, Kiewit Infrastructure Engineers</li> <li>• Mark Reno, Quincy Engineering</li> <li>• Ashkan Vosooghi, AECOM</li> </ul> <p>All three center partners are actively encouraging productive mentorship relationships between graduate students and former graduate students and professionals.</p>
WD-6	<p><b>Graduate Student Seminars</b> – Each graduate student will be required to give a technical presentation at the conclusion of their research study. These presentations will be delivered electronically as part of the ABC-UTC technology transfer activities.</p>	ISU	<p>These seminars continue to be offered quarterly as “Research Seminars”. Seminars were delivered in November 2017 and January 2018 and were attended by 607 and 540 sites from around the world, respectively, with multiple attendees at many of the sites.</p> <p>These seminars are recorded and archived on the ABC-UTC website for future viewing.</p>
WD-7	Encourage one-on-one interaction with industry.	ISU Lead; ALL (FIU, ISU, UNR)	<p>Opportunities for graduate and undergraduate students is being encouraged through the mentorship program, the internship program, and the graduate student seminar program. Additionally, all project technical advisory committees include numerous members of the technical community.</p>
WD-8	<p><b>Internship Program-</b> All three consortium members will develop an undergraduate research internship program.</p>	UNR Lead; ALL (FIU, ISU, UNR)	<p>All three partner universities have hired undergraduate students as interns on ABC-UTC research projects. 4 undergraduate students are supported through internships and are actively involved in research during the past reporting period.</p>
WD-9	<p><b>Educational Modules-</b> Develop three educational modules, in the form of print and videos, for K-12 with focus on developing age-appropriate programs.</p>	UNR	<p>Educational modules are being developed by ISU in cooperation with local Iowa elementary school. The four-week educational module has daily, one-hour lesson plans introducing students to engineering, bridge engineering, and ABC.</p>

Task #	Brief Description of Task	Lead Institution	Progress (October 1, 2017 – March, 2018)
WD-10	<b>Summer Teacher Program-</b> Each consortium member will develop a two-day-long summer camp for elementary, middle and high school teachers to familiarize them with basics of transportation engineering in general and principles of bridge engineering and ABC in particular.	FIU, ISU, UNR	Summer activities are being planned for each university. Including a summer teacher workshop and parent-child bridge engineering camp at FIU.
WD-11	<b>Online e-Zine Go-</b> ISU will publish quarterly articles in the online “e-zine Go!” related to the ABC-UTC’s mission.	ISU	No additional articles were published in the previous reporting period. All previously posted articles are archived on the e-Zine Go! website.
WD-12	Offer travel scholarship with emphasis on traditionally underrepresented students	All (FIU, ISU, UNR)	Travel scholarships were offered for students to attend and present at the TRB 97 <sup>th</sup> Annual Meeting Travel, National ABC conference and the March 2018 ACI conference.
WD-13	Make presentations on transportation careers at major minority institutions and conferences.	All (FIU, ISU, UNR)	Previously prepared video presentations are housed on the ABC-UTC website.

## Technology Transfer

The following table lists different tasks related to technology transfer provides a brief description of each task, identifies the lead institution for each task, and states the progress made in each task.

Task #	Brief Description of Task	Lead Institution	Progress (October 1, 2017 – March, 2018)
T2-1	<p><b>AASHTO Subcommittee on Bridges and Structures (SCOBS) Meeting:</b> ABC-UTC Director and key research team members will be attending the annual AASHTO meetings and, where needed and possible, will brief the related committees on research findings by giving technical presentations.</p>	All (FIU, ISU, UNR)	The Annual TRB meeting was held in January 2018 in Washington, DC and was attended by the director. Preparations are underway for PIs to attend and give presentations at the June 2018 AASHTO SCOBS Annual Meeting in Burlington, VT
T2-2	<p><b>National Committee Meetings:</b> Each ABC-UTC consortium member will be expected to attend at least 3 meetings of national committees each year (other than annual AASHTO meetings) and give technical presentations.</p>	All	Several ABC-UTC research presentations were given during the January 2018 TRB Annual Meeting in Washington, DC. Also a representative from the partner universities attend and presented at the American Concrete Institute bridge seismic committee meetings in Los Angeles, CA, in October 2017 and in Salt Lake City, UT, in March 2018. (UNR)
T2-3	<p><b>Journal Publications:</b> Each ABC-UTC consortium member will be expected to prepare and submit a minimum of two journal publications, in high impact journals, for each research project as lead.</p>	All	<p>The following papers were submitted or/and accepted:</p> <p>Zhang*, N. and Alipour, A. "Application of novel recovery techniques to enhance the resilience of transportation networks" Transportation Research Record: Journal of the Transportation Research Board (In Press).</p> <p>Dopko, M., Najimi, M., Shafei, B., Wang, X., Taylor, P., and Phares, B. (2018) Flexural performance evaluation of fiber reinforced concrete incorporating multiple macro-synthetic fibers, Transportation Research Board Annual Meeting, January 7-11, Washington, DC.</p> <p>Dopko, M., Najimi, M., Shafei, B., Wang, X., Taylor, P., and Phares, B. (2018) Assessment of strength and restrained shrinkage behaviors on micro-carbon fiber</p>

Task #	Brief Description of Task	Lead Institution	Progress (October 1, 2017 – March, 2018)
			<p>reinforced concrete with binary chemical admixtures, Transportation Research Board Annual Meeting, January 7-11, Washington, DC.</p> <p>Kise, S., A. Mohebbi, M. Saiidi, T. Omori, R. Kainuma, K. Shrestha, and Y. Araki, "Mechanical Splicing of Superelastic Cu-Al-Mn Bars with Headed Ends," accepted, Journal of Smart Materials and Structures.</p>
T2-4	<p><b>Outreach:</b> Each ABC-UTC consortium member will be expected to participate in a minimum of two outreach activities each year. Ideally, one outreach activity would be geared toward a national audience and one would be geared toward regional audiences.</p>	FIU, ISU and UNR	<p>All universities have been active in outreach and assisting local and national agencies to learn about ABC. Key researchers at all three institutions routinely give presentations at national conferences. Dr. Azizinamini has given several presentations on ABC at national gatherings and more are planned.</p>
T2-5	<p><b>ABC strategic plan:</b> In collaboration with AASHTO T-4 Technical Committee on Construction, a strategic implementation plan will be developed to promote and support the use of ABC across the U.S.</p>	All	<p>The ABC-UTC continues to collaborate with the AASHTO SCOBS Technical Committee for Construction (T-4) in support of the T-4 strategic plan.</p>
T2-6	<p><b>Collaboration with bridge groups:</b> The research team will work with other bridge groups such as the FHWA Long-Term Bridge Performance Program.</p>	All	<p>The ABC-UTC continues to coordinate with bridge owners on project submissions to the ABC Project Database, with eight projects in AZ, MN, OH, and PA added during this reporting period.</p>
T2-7	<p><b>Provide bridge owners with tools to implement ABC as a standard practice:</b> Research team will convene meetings of select practicing engineers and bridge owners to assist them in the implementation of ABC as a standard practice.</p>	FIU	<p>The Proven Advanced Technologies initiative was renamed Implemented Advanced Technologies. Participation in this initiative was revamped to require innovations that have at least one project included in the ABC-UTC Project Database and have been presented in an ABC-UTC monthly webinar featured presentation. A workshop on these technologies was presented in December 2017 at the National ABC Conference in Miami.</p>

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T2-8	<b>Supplier input:</b> Suppliers that specialize in products suitable for making ABC more efficient will be consulted on their products and systems; as appropriate, ABC-UTC will assist suppliers in assembling and/or acting as an independent body that evaluates the products (similar to HITEC).	All	The ABC-UTC continues its development of a process to provide an independent perspective on the recently renamed Implemented Advanced Technologies.
T2-9	<b>Data dissemination through partnership:</b> Several existing resources will be utilized for data dissemination, such as a) DOT/RITA research clusters and b) NEEShub, which is established by the NSF George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES).	All	Nothing new to report.
T2-10	<b>Offices of technology transfer:</b> As appropriate, cooperative agreements will be developed with industries for eventual marketing of products developed through research studies conducted by the ABC-UTC. At the request from an individual researcher, industry partner or the ABC-UTC Director, it will be determined if there is a merit to develop a patent based on research outcomes.	All	Several patents have been developed based on research outcomes.
T2-11	<b>Three forms of publication:</b> ABC-UTC publications will be of three forms, each serving a different purpose: (1) journal articles, (2) conference papers; and (3) research reports.	All	A new journal papers were submitted and preparation of other papers began.

Task #	Brief Description of Task	Lead Institution	Progress (October 1, 2017 – March, 2018)
T2-12	<b>Technical briefs:</b> Every ABC research project will have a one-page (front and back) technical brief of the pertinent details that will be sent out via e-news to a larger transportation community.	All	Description of each ABC-UTC research project has been posted on ABC-UTC website. <a href="http://www.abc-utc.fiu.edu">www.abc-utc.fiu.edu</a>
T2-13	<b>Dedicated website:</b> Currently the FIU ABC Center has a website ( <a href="http://www.abc.fiu.edu">www.abc.fiu.edu</a> ). With enhancements, this website will become the official site of the ABC-UTC.	All	The dedicated ABC-UTC website ( <a href="http://www.abc-utc.fiu.edu">http://www.abc-utc.fiu.edu</a> ) continues to be updated with the latest research, workforce development, and technology transfer activity.
T2-14	<b>Periodic e-newsletter (ABC Talk):</b> An online newsletter (ABC Talk) will be published to present the highlights of ABC-UTC activities. The availability of the newsletter will be communicated through resources available to AASHTO, FHWA, and TRB.	All	Nothing new to report.
T2-15	<b>Printed newsletter:</b> Annually, a hard copy version of the select articles from e-newsletter (ABC Talk), summarizing the highlights of ABC-UTC activities, will be published	All	The 2017 Highlights Report is under development.
T2-15a	<b>Webcasting and video Clips:</b> Selected tests will be webcast, and video clips of critical parts of selected tests will be developed.	All	We continue to webcast select tests.
T2-16	<b>Social media:</b> Researchers will actively participate in professional social media such as Facebook, Twitter, and LinkedIn.	All	ABC-UTC have continued using Hootsuite to coordinate and market all webinars, seminars, events, and any other large events hosted by ABC-UTC via Facebook, Instagram, Twitter, and LinkedIn.

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T2-17	<p><b>Statewide or region-wide continuing education courses:</b> Three short courses, each four hours long, will be developed: a short course on basic principles of ABC and overview (FIU), a short course on issues related to seismic (UNR), and a short course on use of principles of ABC in small communities (ISU). The materials for each course will be developed for presentation on the web to DOTs and consulting engineers across the country. The course materials will be archived for future use.</p>	FIU	Efforts are underway to systematically educate state DOT's on the implementation of ABC.
T2-18	<p><b>In-depth web conference training:</b> Specific featured presentation topics from the planned monthly webinars will be expanded to 3- to 4-hour in-depth web conference training to assist practitioners in developing a better understanding of the specific topics.</p>	FIU	<p>The archive for the 2017 In-Depth Web Training was completed (<a href="https://abc-utc.fiu.edu/technology-transfer/in-depth-web-training-archive/">https://abc-utc.fiu.edu/technology-transfer/in-depth-web-training-archive/</a>).</p> <p>Plans are underway for the 2018 In-Depth Web Training, currently scheduled for Tuesday, September 4. The topic will be the Vermont Agency of Transportation's programmatic implementation of ABC.</p>
T2-19	<p><b>Monthly ABC webinars:</b> The current FIU ABC center monthly webinars, attracting 3000 to 5000 participants, will be continued. Webinars will be archived for subsequent viewing.</p>	FIU	The ABC-UTC conducted a monthly webinar with featured presentation in each of the six months of this reporting period, with registered sites ranging from 762 to 870. Details are available on the Monthly Webinar Archives at <a href="https://abc-utc.fiu.edu/events/webinar-archives/">https://abc-utc.fiu.edu/events/webinar-archives/</a> .
T2-20	<p><b>ABC Conferences:</b> In coordination with FHWA, state DOTs, and industry, a national ABC conference will be organized each year.</p>	FIU	The ABC-UTC sponsored the 2017 National ABC Conference, held December 6-8 in Miami. Over 600 participants attended the general session and 34 technical sessions consisting of 119 thirty-minute presentations. Details are available



Task #	Brief Description of Task	Lead Institution	Progress (October 1, 2017 – March, 2018)
			in the Conference Archives at <a href="https://abc-utc.fiu.edu/technology-transfer/conferences/2017-national-accelerated-bridge-construction-conference/">https://abc-utc.fiu.edu/technology-transfer/conferences/2017-national-accelerated-bridge-construction-conference/</a> .
T2-21	<b>Annual workshop:</b> An annual 1.5-day technical workshop on ABC topics of current concern will be held at FIU. FIU held its first such ABC workshop in December 2012 with more than 40 attendees. There will be a registration fee and the event will be self-supporting.	FIU	The ABC-UTC sponsored 11 half-day pre-conference workshops on December 6 in Miami, prior to the 2017 National ABC Conference. Details on these workshops can be viewed in the Conference Archives at <a href="https://abc-utc.fiu.edu/technology-transfer/conferences/2017-national-accelerated-bridge-construction-conference/">https://abc-utc.fiu.edu/technology-transfer/conferences/2017-national-accelerated-bridge-construction-conference/</a> .

**What opportunities for training and professional development has the program provided?**

- Educational modules
- Monthly webinars
- In-depth webinars
- Web-based research seminars
- Various presentations to AASHTO, TRB, other national and international conferences, website, and conference publications.
- Youtube channel for video clips of the tests was maintained and updated.
- Youtube posting of general aspects of ABC seismic connections was maintained and updated.

**How have the results been disseminated?**

The results will be disseminated by followings:

- Educational modules
- Monthly webinars
- In-depth webinars
- Web-based research seminars
- Various presentations to AASHTO, TRB, other national and international conferences, website, and conference publications.
- Youtube channel for video clips of the tests was maintained and updated.
- Youtube posting of general aspects of ABC seismic connections was maintained and updated.

## **What do you plan to do during the next reporting period to accomplish the goals and objectives?**

Several summer camps and workshops are being planned for the summer. These activities will target K-12 teachers, students, and families.

## **Publications, conference papers, and Presentations**

Salazar J, Abyaneh R, Katz A, Kim H, Yousefpour H, Garber D, Hrynyk T, Bayrak O, "Benefits of Using 0.7-inch Strands in Precast, Pretensioned Girders: A Parametric Investigation," **PCI Journal**, Volume 62, Issue 6, November-December 2017.

Chitty F, Freeman C, and Garber D, "Development of UHPC Joint Detail for Florida Slab Beam Bridge," **2018 PCI Convention and National Bridge Conference**, Student Research I (EDU2), Denver (CO), February 2018.

Chitty F, Freeman C, and Garber D, "Analysis of efficient prestressed concrete superstructures for short-span bridges for accelerated construction," **TRB 97<sup>th</sup> Annual Meeting**, Concrete Bridge Topics, Part 3 (Part 1, Session 346; Part 2, Session 413), Washington, D.C., January 2018.

Chitty F, Freeman C, and Garber D, "Development of longitudinal joint details for Florida Slab Beam incorporating Ultra-High-Performance Concrete," **TRB 97<sup>th</sup> Annual Meeting**, Longitudinal Deck-Level Connections for Accelerated Bridge Construction, Washington, D.C., January 2018.

Garber D, "The Strut-and-Tie Method: A Way to Design Any Concrete Member (Overview and Recent Developments)," **2018 Tom Maze Transportation Seminar**, Iowa State, invited speaker.

Garber D, "ABC-UTC Research Database," **TRB 97<sup>th</sup> Annual Meeting**, ABC Joint Subcommittee (AFF00[2]) meeting, January 2018.

Garber D, "Demolition Requirements for Bridge Construction Projects – Best Practices Guidelines (Phase I)," **2017 National ABC Conference**, ABC Solutions, December 2017.

Garber D, "Compilation of ABC Solutions," **2017 National ABC Conference**, ABC Solutions, December 2017.

Garber D and Rezaei N, "Compilation of ABC Solutions: ABC Project and Research Databases," **11<sup>th</sup> University Transportation Centers Spotlight Conference: Rebuilding and Retrofitting the Transportation Infrastructure**, Rehabilitating and Restoring the Current System (poster session), September 2017.

Azadeh Jaber Jahromi, Alireza Valikhani and Atorod Azizinamini. "Toward Development of Best Practices for Closure Joints in ABC Projects", *Transportation Research Record: Journal of the Transportation Research Board* No. 18-05330. 2018.

Azadeh Jaber Jahromi, Morgan Dickinson Valikhani, Alireza and Atorod Azizinamini. "Assessing Structural Integrity of Closure Pours in ABC Projects", *Transportation Research Record: Journal of the Transportation Research Board* No. 18-05307. 2018.

Azadeh Jaber Jahromi, Alireza Valikhani and Atorod Azizinamini. "The best practice for closure joints in ABC projects". Western Bridge Conference 2017.

Azadeh Jaber Jahromi, and Atorod Azizinamini. "Experimental investigation of longitudinal closure pour detail for prefabricated slabs used in modular construction", Transportation Research Record, ABC Workshop 2017.

Azadeh Jaber Jahromi, Alireza Valikhani and Atorod Azizinamini. "New Longitudinal Joint Detail using Normal Strength Concrete". National Accelerated Bridge Construction Conference, Miami, 2017.

Azadeh Jaber Jahromi, Alireza Valikhani and Atorod Azizinamini. "The best practice for closure joints in ABC projects". UTC spotlight conference 2017.

Alireza Valikhani, Azadeh Jaber Jahromi, and Atorod Azizinamini. "Retrofitting Damaged Bridge Elements Using Thin Ultra High Performance Shell Elements". Transportation Research Record: Journal of the Transportation Research Board No. 17-02047. 2017.

Azadeh Jaber Jahromi and Atorod Azizinamini "Design Provision of ABC Closure Pour Using Hooked Bar, Florida International University, Research Day 2017.

Mardanpour P, Izadpanahi E, Rastkar S, Fazlzadeh SA, Hodges DH. Geometrically Exact, Fully Intrinsic Analysis of Pre-Twisted Beams Under Distributed Follower Forces. AIAA Journal. 2017 Oct 16:1-3.

Mardanpour P, Izadpanahi E, Rastkar S, Lorente S, Bejan A. Design of High Aspect-Ratio Aircraft: The Flow of Stresses and Aeroelastic Stability. [Submitted to AIAA]

Mardanpour P, Izadpanahi E, Rastkar S, Zisis I, Fazlzadeh SA. Nonlinear time domain and stability analysis of beams under partially distributed follower force. [Accepted at Acta Mechanica Solida Sinica]

Shafieifar, Mohamadreza, Mahsa Farzad, and Atorod Azizinamini. "New Connection Detail to Connect Precast Column to Cap Beam Using UHPC in ABC Applications". Transportation Research Record: Journal of the Transportation Research Board 2018.

Shafieifar, Mohamadreza, Mahsa Farzad, and Atorod Azizinamini. "Experimental and numerical study on mechanical properties of Ultra High Performance Concrete (UHPC)." Construction and Building Materials 156 (2017): 402-411.

Mohamadreza Shafieifar, Mahsa Farzad, Atorod Azizinamini. "A comparison of existing analytical methods to predict the flexural capacity of Ultra High Performance Concrete (UHPC) beams." Construction and Building Materials 172 (2018): 10-18.

Shafieifar, Mohamadreza, Mahsa Farzad, and Atorod Azizinamini. "New Connection Detail to Connect Precast Column to Cap Beam Using UHPC in ABC Applications". TRB Washington D.C 2018.

Mahsa Farzad, Shafieifar, Mohamadreza, and Atorod Azizinamini. "Accelerated Retrofitting of Bridge Elements Subjected to Predominantly Axial Load Using UHPC Shell". TRB Washington D.C 2018.

Shafieifar, Mohamadreza, Mahsa Farzad, and Atorod Azizinamini. "Alternative ABC Connection Using UHPC". 2017 UTC Spotlight Conference, Washington, D.C., 2017.

Shafieifar, Mohamadreza, Mahsa Farzad, and Atorod Azizinamini. "Alternative ABC Connection Using UHPC". Western Bridge Engineers 2017, Oregon, 2017.

Farhangdoust, S., Mehrabi, A.B., and Almosawi, S.F., "NDT Methods Applicable to Health Monitoring of ABC Closure Joints.", 27<sup>th</sup> Research Symposium, ASNT, March 27-29, 2018, Orlando, FL.

Zhang<sup>+</sup>, N. and Alipour, A. "Application of novel recovery techniques to enhance the resilience of transportation networks" Transportation Research Record: Journal of the Transportation Research Board (In Press).

Dopko, M., Najimi, M., Shafei, B., Wang, X., Taylor, P., and Phares, B. (2018) Flexural performance evaluation of fiber reinforced concrete incorporating multiple macro-synthetic fibers, Transportation Research Board Annual Meeting, January 7-11, Washington, DC.

Dopko, M., Najimi, M., Shafei, B., Wang, X., Taylor, P., and Phares, B. (2018) Assessment of strength and restrained shrinkage behaviors on micro-carbon fiber reinforced concrete with binary chemical admixtures, Transportation Research Board Annual Meeting, January 7-11, Washington, DC.

Mohebbi, A., M. Saiidi, and A. Itani, "Seismic Design of Precast Piers with Pocket Connections, CFRP Tendons, and ECC/UHPC Columns," International Journal of Bridge Engineering, Special Issue: Experimental and Analytical Investigations with Emerging Bridge Design Methods, October 2017, pp. 99-123.

Saiidi, M., "Bridge Columns with Engineered Cementitious Composites (ECC) and Ultra High Performance Concrete (UHPC) under Seismic Loads," Keynote Presentation, 2nd International and 6th National Conference on New Materials and Structures, Yazd, Iran, October 2017.

Saiidi, M., and A. Mohebbi, "Development and Seismic Evaluation of Pier Systems with Pocket Connections and UHPC Columns," Research Webinar Series, Accelerated Bridge Construction-University Transportation Center, November 2017.

Saiidi, M., "New Paradigm in Earthquake Engineering of Bridges- Resilient, Fast, Recyclable," Mexican National Academy of Engineering Induction Ceremony, Mexico City, Mexico, November 2017.

Saiidi, M., "Seismic Damage Susceptibility of Bridge Piers with Different High Performance Cementitious Materials in Plastic Hinges," Keynote Address, Second International Bridge Seismic Workshop, Shanghai, China, November 2017.

Mohebbi, A., M. Saiidi, and A. Itani, "Seismic Response of a Precast with Pocket Connections and ECC/UHPC Plastic Hinge," Presented at Session 4, Earthquake-Resistant ABC, National Accelerated Bridge Conference, Miami, Florida, December 2017.

Shoushtari, E., M. Saiidi, A. Itani, and M. Moustafa, "Shake Table Studies of a Two-Span Steel Girder Bridge Incorporating ABC Connections," Presented at Session 4, Earthquake-Resistant ABC, National Accelerated Bridge Conference, Miami, Florida, December 2017.

Mohebby, A., M. Saiidi, and A. Itani, "Seismic Response of an ABC Two-Column Bent Using Advanced Materials," Poster Presentation, National Accelerated Bridge Conference, Miami, Florida, December 2017.

Shoushtari, E., M. Saiidi, A. Itani, and M. Moustafa, "Shake Table Studies of a Two-Span Steel Girder Bridge Incorporating ABC Connections," Poster Presentation, National Accelerated Bridge Conference, Miami, Florida, December 2017.

Saiidi, M., A. Mohebby, and A. Itani, "Raising Performance Standards in Post-Earthquake Serviceability of Precast Columns and Piers with Advanced Materials," Annual Meeting, Pacific Earthquake Engineering Research Center, Berkeley, California, January 2018.

## Website(s) or other Internet site(s)

- **ABC-UTC Website (<https://abc-utc.fiu.edu/>)**: The ABC-UTC website was redesigned and recreated to create a more functional and user-friendly site to house all ABC-related materials. The website is host to all of the webinars, in-depth web training, student seminars, and short courses that have been hosted by the center. These videos are all available for free to users. The site also has all information, progress reports, final reports, and other resources related to all of the ABC-UTC research projects.
- **ABC Project and Research Database (<http://utcdb.fiu.edu/>)**: As part of two separate ABC-UTC research projects, an ABC Project and Research Database website and the online database was created. This database contains information related to ABC-related projects and research. The website interface allows users to easily search and access this information and also gives users the ability to propose enter in new projects and research for consideration in the official database.
- **Technical Training Certificate Delivery System (<https://abc-utccerts.fiu.edu/>)**: This site and system allow for the webinar, graduate student seminar, and other technical training event certificates of participation to be created and delivered to attendees and participants. The system also creates an online database of all user certificates, which allows participants to access all past certificates of attendance.
- UNR YouTube channel to host shake table testing of bridges

## Technologies or techniques

FIU has envisioned an innovative approach for rapid retrofit of bridges, exhibiting corrosion activities using thin shells of UHPC and robotic construction. A provisional patent is prepared for submission.

## Inventions, patent applications, licenses

FIU is working on following innovative ideas for which patent application will be filed:

- Sandwich Folded Girder System
- Innovative connection for ABC Bridges.

- THIN UHPC shell for rapid retrofiting
- Extending the maximum length of Folded Plate Steel Bridge System to 110 ft. using an innovative connection detail.

### **Other products**

UNR prepared promotional video clips for engineering recruitment events.

## **PARTICIPANTS & COLLABORATING ORGANIZATIONS**

### **What organizations have been involved as partners?**

- Atorod Azizinamini, Florida International University
- Saidi Saiidi, University of Nevada, Reno
- Brent Phares, Iowa State
- Terry Wipf, Iowa State University

## **Industry Partners and Collaborators**

### **ABC-UTC Advisory Committee Members**

The ABC-UTC has an Advisory Committee that provides recommendations on ABC-UTC operations. The ABC-UTC also has advisory boards that provide recommendations under each of its focus areas of Research, Workforce Development, and Technology Transfer. Additionally, advisory panels and committees make recommendations on specific projects or activities. The members of the Advisory board can be found by visiting <https://abc-utc.fiu.edu/about-us/advisory-members/>

## **IMPACT**

### **What is the impact on the development of the principal discipline(s) of the program?**

The ABC-UTC has now become the focal point for ABC at national level. Many designers are contacting ABC-UTC for help and getting started in use of ABC. ABC-UTC is continuing providing an excellent service to bridge profession and assisting U.S. DOT through its research, education and workforce development and technology transfer activities. ABC-UTC is taking a national lead in ABC area and has established a very good working relation with FHWA and AASHTO T-4 that is responsible for developing the national roadmap for State DOTs for implementing ABC. The Director of ABC-UTC was also elected to be liaison between the TRB ABC committee and ABC-UTC. These connections and activities are allowing ABC-UTC to better fill the knowledge gap, especially in the research, technology transfer and workforce development areas. ABC-UTC has also made major accomplishments in developing a close working relationship with State DOTs. Twenty-six States have Co-sponsored the 2014 National ABC Conference, thirty State DOTs have sponsored the 2015 National ABC Conference and to date 31 state DOTs have co-sponsored the 2017 National ABC Conference to be held on December of 2017 at Hyatt Regency Hotel in Miami, FL. The State DOT engineers of sponsoring State DOTs work very closely with

ABC-UTC director to develop the conference program. The connection created with State DOT bridge engineers will greatly facilitate the implementation of ABC-UTC work.

About 25% of the 607,000 bridges in our inventory are substandard and need repair or replacement. This fact continues to elevate the impact ABC-UTC is having on bridge profession.

## **What is the impact on other disciplines?**

Delivering transportation programs in a safe and economical manner is at the heart of any public agencies' mission. ABC-UTC's activities go beyond just building bridges that are constructed quickly. The introduction of time element into construction activities result in significantly enhancing the public and worker safety. It enhances the mobility and therefore help save energy and be environmentally responsible. Assisting the U.S. DOT, ABC-UTC is playing a role in helping to deliver a high quality transportation program to society.

## **What is the impact on physical, institutional, and information resources at the university or other partner institutions?**

The establishment of ABC-UTC has allowed obtaining many additional resources for the faculties, active in ABC areas at FIU and partner universities. In 2015, FIU's Provost provided ABC-UTC a faculty line. As a result ABC-UTC hired Dr. Armin Mehrabi, who is a specialist in long span bridges. He joined the ABC-UTC on January pf 2017. More importantly, on October 13, 2016, President and Provost at FIU, after a yearlong intensive evaluation of all major research activities at FIU, selected five research areas within FIU to be designated as preeminent programs. It is with great pleasure to state that Bridge Engineering and ABC-UTC was selected as one of the five research preeminent areas. Greater resources will be available to ABC-UTC as a result of being named preeminent program.

In summary, the establishment of ABC-UTC at FIU by U.S. DOT has provided this great institution with an excellent platform to better educate our students and help the profession while working shoulder to shoulder with U.S. DOT.

## **What is the impact on technology transfer?**

The ABC-UTC monthly webinars are proving to be the most effective means of transferring the knowledge to the profession. Having 3000 to 4000 bridge professional participate in each monthly webinars are unparalleled. The 2014 National ABC conference was co-sponsored by 26 states who actively participated in this event. The 2015 National ABC Conference was Co-Sponsored by 30 States and 2017 Conference sponsored by 32 states. ABC-UTC was successful in developing major travel scholarship program that allowed more than 200 state bridge engineers to attend each National ABC Conferences (2014, 2015 and 2017). These activities are providing opportunities for effective communications with State DOTs and bridge professionals, making the task of Technology transfer much easier.

Many State DOTs seek our help in organizing a workshop that is aimed at educating consultants and contractors in their areas about ABC.

## **What is the impact on society beyond science and technology?**

Increasing safety, enhancing mobility, being environmentally responsible, building bridges that are resilient and sustainable are important consequences of using ABC. The major goal of ABC-UTC is to make the ABC the method of choice for bridge replacement and retrofit and in future to call it BC. This, in turn, will improve the mobility and save the society in many different ways. One of the most important contributions of ABC to society is reducing the number of accidents and therefore significantly enhancing the safety. A single accident could cost taxpayers millions in litigation and legal expenses.

## **CHANGES/PROBLEMS**

### **Changes that have a significant impact on expenditures**

No changes

### **Actual or anticipated problems or delays and actions or plans to resolve them**

No changes

### **Significant changes in use or care of human subjects, vertebrate animals, and/or biohazards**

No changes

### **Change of primary performance site location from that originally proposed**

No changes

## **SPECIAL REPORTING REQUIREMENTS**

Financial report and documents will be sent by Department of Research at Florida International University.

### **Completed by:**

**Florida International University:** Atorod Azizinamini

**Iowa State University:** Brent Phares, Terry Wipf

**University of Nevada, Reno:** Saiid Saiidi, A. Itani