AASHTO Technology Implementation Group

Nomination of Technology Ready for Implementation

2010 NOMINATIONS DUE BY FRIDAY, SEPTEMBER 11, 2009

Sponsor	*Nominations <u>must</u> be submitted by an AASHTO member DOT willing to help promote the technology.*	1. Sponsoring State DOT: Maine		
		2. Name: Kenneth Sweeney		
		Title: Director, Bureau of Project Development		
		Mailing Address: 16 State House Station		
		City: Augusta	State: Maine	Zip Code: 04333-0016
		E-mail: ken.sweeney@maine.gov	Phone: 207-624-3400	Fax: 207-624-3401
		3. Date Submitted:		
		4. Is the Sponsoring State DOT willing to promote this technology to other states by participating on a Lead States Team supported by the AASHTO Technology Implementation Group? Please check one: ☒ Yes ☐ No		
Technology Description (10 points)	*The term "technology" may include processes, products, techniques, procedures, and practices.*	5. Name the technology: Hybrid Composite Beam (HCB)		
		6. Please describe the technology: The "Hybrid-Composite Beam" (HCB), is a new type of structural member developed for use in bridges and other structures. The HCB is comprised of three main sub-components that are a shell, compression reinforcement and tension reinforcement. In the preferred embodiment, the shell is comprised of a fiber reinforced plastic (FRP) box beam. The compression reinforcement consists of concrete which is pumped into a profiled conduit (generally an arch) within the beam shell. The tension reinforcement consists of carbon, glass or steel fibers anchored at the ends of the compression reinforcement. The HCB basically combines the strength and stiffness of conventional concrete and steel with the lightweight and corrosion advantages of advanced composite materials. What results is a new alternative for rebuilding our nation's infrastructure with state-of-the-art sustainable structures.		
		7. If appropriate, please attach photographs, diagrams, or other images illustrating the appearance or functionality of the technology. (If electronic, please provide a separate file.) Please check one: ☒ Yes, images are attached. ☐ No images are attached.		
State of Development (30 points)	*Technologies must be successfully deployed in at least one State DOT. The TIG selection process will favor technologies that have advanced beyond the research stage, at least to the pilot deployment stage, and preferably into routine use.*	8. Please describe the history of the technology's development. The technology was invented by John Hillman, PE, SE of Wilmette, IL in 1996. Mr. Hillman was able to validate the concept through a Type 1 IDEA Grant from the Transportation Research Board (TRB), High-Speed Rail - Innovations Deserving Exploratory Analysis (HSR-IDEA) Project. This grant facilitated the fabrication and successful testing of the first HCB and led to a Type 2 IDEA grant co-funded by HSR and NCHRP. The Type 2 Grant resulted in the construction of the world's first composite railroad bridge. The bridge was deployed on the Heavy Tonnage Loop - (HTL-FAST Loop) at TTCI in Pueblo, CO in November 2007. Since this time, the bridge has been subjected to over 95 Million Gross Tons of heavy axle, Class 1 Railroad loading with no change in performance. The success of the IDEA projects led to the construction of the first two permanent highway bridges utilizing the HCB. These include the High Road Bridge over Long Run Creek in Lockport Township, IL and the Route 23 Bridge over Peckman Brook in Cedar Grove, NJ. Both of these bridges were constructed with funds from FHWA - IBRD Awards. In 2007, Mr. Hillman established HC Bridge Company, LLC to further develop, license, market, deploy and support HCB technology. To date, Mr. Hillman has secured and spent over $1.4 million dollars for research and development of this technology from various sources and programs. The High Road Bridge was recognized in April 2009 with a National "Grand Award" at the ACEC-Engineering Excellence Awards. This is the top category nationally and limited to the top eight civil engineering projects in the country. HCB technology has also been recognized as one of the top 25 inventions by Modern Marvels - Invent Now Competition and it was recognized by Popular Science Magazine as one of the top 10 Inventions of 2008.		

9. For how long and in approximately how many applications has your State DOT used this technology?

To date the Maine Department of Transportation has finished prototype testing and is currently having HCB's fabricated for the 8-span, 540 foot long Knickerbocker Bridge in Boothbay, ME. When completed, this will be the longest composite bridge in the world and to our knowledge, the first multi-span composite bridge made continuous for live load over the supports. Previous installations include the 57-foot High Road Bridge by the Illinois Department of Transportation in Aug 2008, and the Route 23 in Cedar Grove, NJ by the NJDOT to be completed in Oct 2009. Missouri DOT has already committed to building a 3-span bridge as part of the Safe and Sound Project in 2010 and BNSF Railroad has committed to the first revenue service RR bridge in 2010. Several other states have also expressed an interest in HCB bridges.

10. What additional development is necessary to enable routine deployment of the technology?

To date, at least one full size prototype HCB for each project has been successfully tested in the laboratory, including fatigue loading and loading to failure. Although through the course of development Mr. Hillman has developed limit states design methodologies for the design and analysis of the HCB, additional work is required to develop AASHTO code specification recommendations and/or a Guide Specification for HCB technology. The results of this research will also lead to commercial grade design and analysis software that will simplify design and specification of HCB bridges by other engineers and DOT's. Additionally, broader scale deployment of the technology will create the economies of scale to drive down fabrication costs and make the HCB cost competitive on a first cost basis with conventional concrete and steel structures.

11. Have other organizations used this technology? Please check one: ☒ Yes ☐ No

If so, please list organizations and contacts.

Organization	*Name*	*Phone*	*E-mail*
New Jersey DOT	Richard Dunne	609-530-2557	richard.dunne@dot.state.nj.us
Illinois DOT	Ralph Anderson	217-782-2124	ralph.anderson@illinois.gov
Missouri DOT	Pete Rahn	573-751-4622	pete.rahn@modot.mo.gov
Association of American Railroads	Duane Otter	719-584-0594	duane_otter@aar.com

Payoff Potential (30 points)

Payoff is defined as the combination of broad applicability and significant benefit or advantage over other currently available technologies.

12. How does the technology meet customer or stakeholder needs in your State DOT or other organizations that have used it?

The HCB provides an optimized structural element for reconstruction of our nation's infrastructure that offers the following benefits:

- LIGHTWEIGHT - 1/10th the weight of concrete and 1/3rd the weight of steel.
- SAFER – Internal redundancy and serviceability design result in capacities that greatly exceed code requirements, coupled with infinite fatigue life.
- REDUCED CARBON FOOTPRINT – Beams use 80% less cement, one of the largest contributors to the carbon footprint. They also require 75 to 80% fewer trucks for shipping and smaller cranes for erection for reduced emissions.
- CONGESTION RELIEF – Lighter, modular bridge system allows for "Accelerated Bridge Construction" and reducing traffic congestion during construction.
- SUSTAINABLE – No painting, rusting, cracking, spalling or alkali-silica reactions (ASR) results in a sustainable technology that provides for "100+ Year Service Life".

13. What type and scale of benefits has your DOT realized from using this technology? Include cost savings, safety improvements, transportation efficiency or effectiveness, environmental benefits, or any other advantages over other existing technologies.

Specific benefits of the technology can be realized from the construction of the High Road Bridge in IL. The bridge consisted of six beams, each 58-feet long. Because each beam weighed less than 4,000 lbs, all six beams could be shipped on one truck. Had these been precast concrete beams, it would have required six trucks instead of one. The contractor was also able to erect the beams with a 30 ton utility crane instead of a 150 to 200 ton crane. The HCB's will not rust or spall and therefore require little or no maintenance. The HCB's are designed to satisfy deflection requirements, subsequently the beams generally exhibit strength capacity 30 to 60% beyond the code specified demand, resulting in safer structures. Lastly, in high seismic regions, an HCB superstructure will result in 60% less mass than a concrete structure, resulting in reduced seismic forces and a superstructure that can maintain an elastic response due to the resilient characteristics of the fiber reinforced plastic materials.

		14. Please describe the potential extent of implementation in terms of geography, organization type (including other branches of government and private industry) and size, or other relevant factors. How broadly might the technology be deployed? There are approximately 600,000 bridges in the National Bridge Inventory, of which over 150,000 are functionally obsolete or structurally deficient. Of these 600,000 bridges, over 90% have spans of 100-feet or less. With the exception of a few highly skewed bridges or those requiring tight radius curved steel girders, the HCB can cost effectively be utilized for the majority of these bridges. The HCB is particularly beneficial in geographic locations subject to heavy salt applications for cold weather, salt fog, brakish water as well as regions of high seismicity. The HCB can also be deployed in a prefabricated bridge system with the concrete arch and deck already in place, lending itself to "Accelerated Bridge Construction" in congested urban environments. It is applicable to both highway and railroad bridge construction. Further, the HCB lends itself to structural framing and roof panels in buildings housing corrosive materials, such as water treatment plants and chemical processing facilities. There have also been numerous inquiries and ongoing developments using the HCB for pier and wharf structures by the Coast Guard and other industries with heavy load, deep water handling facilities.
Market Readiness (30 points)	*The TIG selection process will favor technologies that can be adopted with a reasonable amount of effort and cost, commensurate with the payoff potential.*	15. What actions would another organization need to take to adopt this technology? Although there are unique characteristics to the structural behavior of the HCB, sufficient information is available in the current AASHTO and AREMA design codes with respect to quantifying the demand and the capacity based on the limit states for reinforced concrete, that would allow a practicing structural engineer to safely design and specifiy a structure using HCB's with minimal guidance. HC Bridge Company, LLC will provide support and guidance to organizations interested in adopting this technology for the design and deployment of an HCB structure. HC Bridge also provides field support to contractors to help understand the methods of installation and concrete placement. However, because every aspect of the HCB has been intentionally developed to be interchangeable with conventional beams and construction equipment, both from a design and installation standpoint, the learning curve for deployment of this technology is almost negligible. With a modest investment in design guides and specifications for fabrication and erection, this technology can be deployed with little or no guidance from HC Bridge.
		16. What is the estimated cost, effort, and length of time required to deploy the technology in another organization? The length of time required by another organization to deploy this technology is the same as it would be for the reconstruction or deployment of any new bridge in the owner's inventory. It's simply a matter of providing for a direct substitution of the HCB for a conventional concrete or steel beam. HC Bridge can either provide a signed and sealed design or provide the guidance for the organization to perform their own design. The fabrication capacity already exists under license agreements between HC Bridge and qualified fabricators. However, the cost for a fabricator to establish a manufacturing facility for HCB's is on the order of 20% of what it would cost to build a new precast concrete facility, due to the mitigation of stressing equipment, batch plants and heavy lifting equipment. The primary cost for deployment of this technology on a grand scale resides in educating the organizations and making them aware of this technology through a well thought out marketing effort.
		17. What resources—such as technical specifications, training materials, and user guides—are already available to assist deployment? HC Bridge has compiled a significant amount of information to assist in the deployment of the HCB. This includes numerous research and test reports from the IDEA Program and prototype testing, sample plans and detailed special provisions for fabrication and erection of HCB's prepared in a standard DOT format, PowerPoint presentations, design spreadsheets and literally hundreds of photographs and videos of fabrication, testing and installation of HCB projects completed to date.

		18. What organizations currently supply and provide technical support for the technology? HC Bridge Company, LLC is currently the most comprehensive source for technical support of this technology. Additional technical support has been provided by the AEWC at the University of Maine and Eriksson Technologies, who is currently working with HC Bridge to develop commercial grade design software to assist engineers in specifying HCB as an alternative framing system.
		19. Please describe any legal, environmental, social, intellectual property, or other barriers that might affect ease of implementation. The HCB technology is currently protected by US Patents 6,145,270 and 7,562,499, that which are assigned to HC Bridge Company, LLC. HC Bridge also has patents pending in the European Union Countries as well as seven other countries. Currently Harbor Technologies, Inc. of Brunswick, ME, is licensed to manufacture HCB technology in the US. Despite the proprietary nature of this technology, the transportation industry provides for cost controls through competition with conventional building materials. No regulatory, environmental or social risks have been identified.
Submit Completed form to		***http://transportation1.org/tig_solicitation/Submit.aspx***

Fig 1 - 2008 ACEC Grand Award Winner – High Road Bridge over Long Run Creek First permanent HCB Highway Bridge funded by FHWA – IBRD Award

Fig 2 – April 2009 - Prototype Test Beam for Knickerbocker Bridge in Boothbay, ME.
33-inch deep HCB with 7-inch deck, 70-foot long was load tested to 2M cycles with ultimate capacity having:
Operating Rating Factor = 3.48
Inventory Rating Factor = 2.68

Fig 3. June 2009 **-** Route 23 Bridge in Cedar Grove, NJ. Ritacco Construction sets 31-foot x 6-foot HCB using excavator.

Fig 4. Nov 2007 – TTCI, Pueblo, CO. World's first Composite Railroad Bridge, constructed with HCB's developed with funding from TRB, High Speed Rail-IDEA Program. Endurance testing to date includes over 95 million gross tons (MGT) of heavy axle railroad loading.