Emergency standby contracts and an accelerated design-bid-build process help the New York State Department of Transportation, the Vermont Agency of Transportation and the Federal Highway Administration demolish an 80-year-old bridge, construct a temporary ferry service and erect a new bridge in just over two years.
Lake Champlain Bridge At-A-Glance

Ground breaking: June 11, 2010

Bridge open to traffic: November 7, 2011

Length: 2200 ft CL bearing @ NY abut. to CL bearing @ VT abut.

Width: 47'-4" typical approach, 55'-8" arch span

Number of lanes: 2

Traffic volume: 3500 cars per day

Total feet of cable used: Approx. 3550 ft of cable (per shop drawings)

Designer: HNTB Corporation

Sub consultants: Clough Harbour and Associates

Fitzgerald & Halliday, Inc.
The Lake Champlain Bridge, also known as the Crown Point Bridge, was a historic steel truss bridge stretching 2,187 feet across Lake Champlain and connecting the rural communities of Crown Point, N.Y., and Chimney Point, Vt. It opened in 1929 with then-New York Governor Franklin D. Roosevelt at the ribbon-cutting. Since then, the bridge has served as a vital economic link between communities, which share hospitals and fire departments, as well as a link to the past. Both the New York and Vermont shores contain several historical and archaeological sites, some dating back thousands of years.

**PROJECT SCOPING BEGINS IN FALL 2009**

In 2009, the bridge had reached 80 years of service life, and a study was to be conducted to determine the need for possible major rehabilitation or replacement. There had been a significant amount of rehabilitation and retrofit work on the original bridge over its lifetime, with the most extensive work completed in the early 1990s. Despite this major rehabilitation, deterioration was progressing rapidly both in the superstructure and the substructure elements.

In summer 2009, the bridge’s joint owners, New York and Vermont, executed a bi-state agreement to commence project scoping. Under the agreement, the New York State Department of Transportation (NYSDOT) would be responsible for advancing the project. Funding would be divided evenly between the two states with 80 percent federal support. Project oversight would be provided by the three co-lead agencies: NYSDOT, the Vermont Agency of Transportation (VTrans) and the Federal Highway Administration (FHWA). HNTB Corporation from New York City, with a team of subconsultants, was contracted to carry out project scoping, with the intent of continuing through the environmental impact study and possibly through bridge rehabilitation or bridge replacement. Project scoping through final design was estimated to take approximately five years.

On Aug. 26, 2009, the co-lead agencies and HNTB held a partnering meeting to introduce team members from NYSDOT to their counterparts at VTrans and establish lines of communication. The perfunctory “meet and greet” proved to be invaluable when the two agencies made the decision to close the bridge.

The co-lead agencies understood the importance of engaging the public early in the scoping process and had initiated public involvement as early as August 2006. The public’s perception, at that time, was that the co-lead agencies wanted to move straight to bridge replacement without first considering rehabilitation.

The bridge had become the focus of several local historians who campaigned to save the beloved structure. They were successful in getting the bridge placed on the National Register of Historic Places in 2009. While not formally listed by the time of its closure, the structure had met the eligibility requirements regarding age, integrity and significance. Thus, on Day One of the project, the preservation community became a strong advocate of saving the bridge. (See "A Spofford design," page 5 and "The bridge's historical significance," page 6.)

By the time the co-lead agencies held their first official public outreach meeting on Oct. 8, 2009, lines had been drawn. There were groups who thought it absurd to rehabilitate the aging structure and groups who considered it a great injustice to replace it. As the
co-lead agencies explained the overall project and the scoping phase, their goal was to manage expectations by informing the public of the involved federal project development and NEPA (National Environmental Protection Act). The final product, be it a rehabilitation, a replacement in the same location or a different alignment, would be years away.

During the meeting, NYSDOT officials said they currently were examining the condition of the bridge’s piers and stated upfront there could be problems with their load-carrying capacity. However, the officials reassured attendees the bridge likely would be safe and remain open throughout the five-year design process. (Bridge traffic had been restricted to one lane that summer due to steel repairs.)

In late summer 2009, NYSDOT had been progressing steel repairs to address the bridge’s more than 20 structural inspection flags issued earlier that spring. During those repairs, Department engineers noticed signs of concrete section loss just below the lake water surface. Overall, piers 5, 6, 7 and 8 exhibited the most severe deterioration of the existing concrete near the water level. Of major concern was the significant cracking in the piers and the freeze thaw induced damage to the piers, both at the bearing seats and at and below the waterline.

NYSDOT took core samples and directed HNTB to perform a complete evaluation of the piers. On Oct. 16, 2009, HNTB reported the piers’ deterioration represented a significant public safety threat. The potential of a localized failure that could cause catastrophic structural collapse could not be ruled out. NYSDOT and HNTB felt bridge closure was the only safe option.

**SUDDEN CLOSURE IS LIFE-CHANGING FOR RESIDENTS**

NYSDOT temporarily closed the bridge at 1:30 p.m. on Oct. 16, 2009, just eight days after telling the public the bridge would reopen to two lanes after truss repairs were completed. The immediate effect of the bridge’s sudden closure on local residents was tremendous, directly impacting the lives of thousands of commuters who use the crossing daily.

Lake Champlain is a 120-mile navigable waterway. The bridge, situated at the lake’s southern end, was one of three bridge crossings. Two seasonal ferry services helped to alleviate some of the burden, but they were not enough. The closest ferry, less than 20 miles south, remained open until January, and many residents chose to use it.

The only viable alternative route by road added 85 miles to commutes. The bridge’s closure separated residents from employment, medical services, childcare and family members. Farmers with fields and cattle on opposite sides of the lake could not bring in their fall harvests or tend to their livestock. Other residents were leaving home at 3 a.m. to arrive at work on time.

A Declaration of Emergency was issued on Oct. 20, 2009, by Vermont Secretary of Transportation David Dill, and a State Disaster Emergency was declared under Executive Order No. 28 by New York Gov. David A. Paterson on Oct. 21, 2009.

The co-lead agencies and the HNTB design team immediately began simultaneously assessing and developing contract drawings for emergency repairs to the bridge, evaluating the possibility of building a new bridge on another alignment.

**Results of pier core samples**

NYSDOT took core samples from Pier 5 of the existing bridge. These cores verified 30-percent section loss in the exterior portions of the piers. Qualitatively, this equated to 18 inches of deteriorated concrete around the pier’s perimeter. Similar severity of section loss later was observed at piers 6, 7 and 8. Repair contracts—beginning as early as 1945—had been let for the piers and bearings. This in and of itself is critical to understanding the existing conditions of the piers. It is highly unusual for concrete and bearing repairs to take place on a bridge that is only 15 years old, as the Lake Champlain Bridge was in 1945. In fact, the previous concrete repairs had masked some of the structural deterioration to the piers and bearings.

Upon discovering the extensive pier deterioration, NYSDOT and HNTB determined that an immediate in-depth analysis of the piers was warranted. The piers’ deterioration represented a significant public safety threat given the potential that a localized failure could cause catastrophic structural collapse. Given the structure’s height above water and the depth of the lake, a catastrophic collapse could result in multiple fatalities. With the information furnished by the HNTB design team, NYSDOT and VTrans concluded it was too dangerous to leave the bridge open to traffic given the level of uncertainty and potential for abrupt failure.
and identifying the location where a temporary ferry could be constructed.

Residents were furious at the unexpected closure and at the Oct. 27 and Oct. 28 packed-house public meetings they demanded an alternative way to cross the lake. The co-lead agencies had considered building a temporary bridge, but rejected it due to the high cost and the time to construct (at least six months).

As short-term mitigation, NYSDOT and VTrans negotiated subsidies for two existing ferry services, which allowed commuters to cross the lake for free. In addition, several shuttle bus services, with corresponding park-and-rides, were created on both sides of the lake.

**TEMPORARY FERRY SYSTEM BUILT IN THREE MONTHS**

On Oct. 30, 2009, a multi-agency meeting attended by representatives from New York and Vermont was held to discuss the possibility of constructing a temporary ferry just south of the bridge location. Due to the historical and archaeological significance of the area, cooperation from all involved agencies was imperative from the beginning of the planning process.

Agencies, such as the New York and Vermont State Historic Preservation Offices (SHPO), Adirondack Park Agency, Vermont Fish and Wildlife, Army Corps of Engineers and numerous others were involved from the early stages in an effort to familiarize those involved with the project background, possible historical and environmental effects, and the need to expedite the approval and permitting phases. Coordination between involved agencies proved successful, and on Nov. 11, 2009, FHWA, New York and Vermont granted National Environmental Policy Act (NEPA) approval for the proposed temporary ferry project in both states.

As design details became available, NYSDOT's two emergency standby contractors mobilized to the future site of the temporary ferry service in New York. One contractor completed the work on the approach to the ferry service while the other completed the waterborne work. VTrans held a special letting to bring on a contractor to perform the work in Vermont. All of this work took place in the midst of a harsh New England winter. On Feb. 1, 2010, the temporary ferry began operation three and one-half months after the bridge’s closure. Operating the temporary ferry service cost NYSDOT and VTrans an average of $24,250 daily. It ran 24 hours, seven days a week.

Meanwhile, as short-term mitigation efforts were under way, more test results and alarming findings from an underwater inspection were discovered. The week after bridge closure, a diving inspection was performed to gather additional information on the piers' condition below water. At Pier 5, a horizontal crack was discovered below lake level that appeared to extend through the full cross section of the unreinforced concrete pier. In the days following, numerous cracks, up to 3/8 inches wide, were found in the inspected piers. Upon completion of underwater inspections of Piers 5, 6, 7 and 8, cracks were found in all piers. It was believed that lateral movement cracked the

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“A Spofford design

The original Lake Champlain Bridge held an important place in the evolution of continuous trusses and the practice of bridge engineering in the United States. The Lake Champlain Bridge was an early design of a continuous truss and its chief designer, Charles M. Spofford, was influential and active in the analysis, design and construction of such structures. His book titled Theory of Continuous Structures and Arches, published in 1937, discussed in detail the design aspects of the continuous truss bridge. This structural form was a clear early innovation in the design of continuous trusses, and Spofford’s role in its development cannot be argued.
unreinforced piers, forming a hinge that allowed the piers to ‘rock’ with fluctuating temperatures. The original design excluded reinforcing because of the iron ore inclusion in the concrete. The continual lake fluctuations and freeze thaw cycles proved to be the critical demise of this design.

REPLACEMENT BECOMES THE ONLY VIABLE OPTION
Both short-term and long-term repair strategies for pier strengthening and pier replacement were evaluated. The cost of temporary repairs to the piers, resulting in a four- to five-year service life, was estimated at more than $20 million. An overall rehabilitation of the bridge with a targeted 50-year service life was estimated at $85 million.

To perform those repairs, crews would have to underpin the structure and such operations, coupled with high winds, cold weather and lake ice, could further destabilize the structure. The risk for personnel was too great. Further, if the bridge collapsed, pieces of uncontrolled size could become lodged in deep lake mud, making extraction extremely difficult, expensive and time-consuming. A final Safety Assessment Report, prepared by HNTB and submitted on Dec. 3, 2009, recommended immediate and controlled demolition.

With strengthening or retrofitting neither adequate nor cost-effective, the co-lead agencies relayed the findings and conclusions to their respective governors, and on Nov. 9, 2009, both elected officials announced plans to demolish the bridge, construct a temporary ferry service and build a replacement bridge on an accelerated schedule.

Following the decision to close and replace the bridge, the massive program was divided into four separate independent projects:

1. Short-term mitigation of public transportation
2. Temporary ferry system design and construction
3. Bridge demolition
4. New bridge design and construction

Each of the four projects was executed simultaneously but managed independently by separate NYSDOT and VTrans personnel.

NYSDOT OPTS FOR D2B2 PROCESS
To expedite development and delivery of the new bridge, NYSDOT decided to complete design on a compressed schedule with the traditional, linear functions of final design, bid packaging, advertisement and permitting performed concurrently. The process, known as dynamic design-bid-build (D2B2), was

The bridge’s historical significance
The New York approach to the bridge, located in Adirondack Forest Preserve, includes remains of two 18th century forts, Fort St. Frederic and Fort Crown Point. In addition, the bridge originally was tolled and the historic toll house is located just south of the bridge approach road, with a 19th century lighthouse and campground farther to the south.

At the Vermont approach, there are remains of an 18th century French fort under the first span and the historic Chimney Point Tavern, also listed on the National Register of Historic Places, to the south. Additionally, artifacts dating back more than 7,500 years have been found at the Chimney Point Historic Site, directly adjacent to the bridge.
executed at an unprecedented speed, shaving years off conventional approaches.

Unlike Vermont, the state of New York did not have design-build legislation in place at the time of bridge closure. New York State had considered creating design-build legislation but decided letting would be quicker under standard procedures. Pursuing a design-build contract would require roughly two months for a request for proposal process once design approval was granted. Using design-build, the anticipated earliest start date for detailed design would have been April 2010.

The D2B2 process encouraged early collaboration between contractors and designers via a separately bid contract, while still following New York State’s contracting rules and regulations. The HNTB design team had an existing contract with NYSDOT for project scoping, and NYSDOT took advantage of that contract to advance final design. Rather than begin design-build in April, NYSDOT delivered the final bid documents the first week of April 2010.

THE FORMER BRIDGE IS DEMOLISHED
Due to the structure’s instability and fragility, explosives were determined to be the most effective method of demolition. The co-lead agencies were interested in having the bridge down as quickly as possible to avoid the structure falling down on its own, which would have made removal extremely difficult and likely would have delayed construction of the new bridge.

The demolition required coordination with numerous regulatory agencies. The historic bridge’s Section 106 Programmatic Agreement, executed in record time, included requirements for protecting the surrounding historic/archeological resources and for commemorating the former bridge.

Design approval of the demolition was received on Dec. 8, 2009. The structure was demolished on Dec. 28, 2009. Debris removal began immediately. By the end of April 2010, 95 percent of the former bridge had been extracted from the lake, allowing the main navigation channel to be reopened.

FIVE-YEAR DESIGN PROCESS CONDENSED TO FIVE MONTHS
The public involvement process started in mid-December 2009. An intensive schedule consisting of a six-day review process was established. It included meetings with the historic consulting parties, a public advisory committee (PAC) meeting, as well as a series of public information meetings to introduce the proposed bridge replacement alternatives.

The PAC was formed prior to project scoping. It was a 20-member group comprised of elected officials and representatives from various interest groups and public agencies. The PAC’s role was to meet with NYSDOT, VTrans, FHWA and HNTB team representatives periodically to provide input, ideas and concerns regarding the bridge during project development.

Armed with five preliminary bridge design alternatives furnished by HNTB, NYSDOT officially began the design review process on Dec. 10, 2009, with a meeting of the co-lead agencies, the HNTB design team and the historic consulting parties. A 30-day review process was required per Section 106 regulations, and the process began with this meeting. The lead design agencies presented the five proposed bridge alternatives to the historic consulting parties. The benefits and shortcomings of each bridge type were presented for discussion.

Benefits of D2B2

• Helps eliminate years from delivery of major projects by overlapping traditional linear functions such as planning, design, permitting, advertising and construction phases.

• Sends projects to construction sooner, which creates jobs and spurs economic activity.

• Can potentially save tens of millions of dollars on statewide multi-year bridge programs, with the savings used to complete other backlogged projects.

• Uses existing state contracting practices, so agencies remain in control.

• Reduces cost to users and surrounding businesses by minimizing travel delays.
During this meeting, discussions were held directly between the consulting party representatives and the structural engineers designing the bridge in an effort to alleviate possible concerns or issues that could arise during the 30-day review process. The meeting was attended by FHWA, SHPO, NYSDOT and VTrans to mediate the discussions and provide input when needed. This smaller group allowed for productive dialogue between the design team and the consulting parties. Additionally, concerned individuals had the opportunity to identify issues to be addressed during design, such as historical and archeological impacts associated with an increased bridge footprint.

During this meeting, the design team was able to explain the risks and drawbacks associated with replacing the bridge with another truss bridge, as well as discussing the potential benefits of using a more modern bridge type. At this point in the process, the consulting parties began to move away from the initial shock of the bridge demolition and embraced the concept of constructing a new bridge.

The following day, Dec. 11, 2009, members of FHWA, NYSDOT, VTrans and the HNTB design team met with the PAC to reveal the five bridge types being considered for bridge replacement. For the bridge type selection meetings, the PAC was expanded to include additional members of the public interested in the project, including planners, business representatives, historians, preservationists, transit representatives, as well as local high school students, who would be future users of the bridge. This expanded group was referred to as the PAC+.

The PAC+ provided feedback on the five bridge replacement alternatives and showed an overwhelming support for the network tied arch bridge. Many felt the bridge, however, lacked fluidity, and indicated the transition from arch span to standard steel girders was too abrupt.

The original bridge type alternatives

Prior to the official design review, the HNTB design team presented the co-lead agencies with five bridge alternatives deemed the most feasible and appropriate for the proposed location and use. A sixth, and ultimately the final design, emerged during the review process.

1. Long span steel girder bridge
2. Concrete segmental bridge
3. Steel composite cable stay bridge
4. Concrete extradosed bridge
5. Network tied arch bridge
6. Modified network tied arch bridge
Vermont Historic Preservation Officer Scott Newman suggested extending the arch design below the bridge deck to better reflect the design of its historic predecessor. Working late into the night, the HNTB design team created a sixth option based on the late-breaking idea. It featured a network tied arch main span, supported by triangular rigid frame elements at each end of the arch. The new design, a “modified” network tied arch, was unveiled on Dec. 12, 2009, during three back-to-back public information meetings at Ticonderoga, N.Y. The sessions drew more than 600 attendees.

Each attendee was given a questionnaire and asked to vote for his or her preferred bridge type, as well as include any feedback or comments for the new bridge. Additionally, an online survey was conducted for members of the public unable to attend the meetings. More than 3,000 online surveys were completed. There was an overwhelming level of support for the sixth alternative, the modified network tied arch.

Team members listened to the public’s concerns, and presented a brand-new design in response. This process restored public trust that had been lost earlier. In two months, attendees had gone from chastising the team to applauding them. They showed acceptance of the process and a strong consensus for the new design concept. The overall level of trust and cooperation enabled the remainder of the design phase to progress as expeditiously as was needed to meet the project schedule. On Dec. 15, 2009, the PAC reconvened to make a formal recommendation of the modified network tied arch alternative to the Commissioner of NYSDOT and the Secretary of VTrans.

**PERMITTING, NEPA REDUCED FROM YEARS TO MONTHS**

The NEPA process for the new bridge began in early October 2009. With the emergency situation, the co-lead agencies resolved to reduce the timeframe of the necessary environmental process, which traditionally can take upwards of 5+ years to complete for a project of this complexity. As a result of the co-lead agencies’ efforts and those of the other federal and state regulatory agencies involved, the environmental process was successfully completed in an astonishing four months.

The National Environmental Policy Act of 1969 (NEPA) calls for an examination and consideration of impacts of a proposed transportation action, in this case the replacement of the bridge, on sensitive resources. Because of potential impacts to environmental resources and the need for transportation improvements, a balanced decision making process is utilized that considers a range of factors of both impacts to the resources and the transportation needs. The NEPA process requires that a new bridge undergo one of three different forms of an environmental review: categorical exclusion (CE), an environmental assessment (EA), or an environmental impact study (EIS). The level of review is dependent upon the level of impact the proposed project would have on environmental resources and/or the level of uncertainty as to whether there is a significant impact. Of the three, the CE is the least complex and the EIS is the most complex.

To meet the four-month goal, the co-lead agencies first decided to construct the replacement structure along the same alignment as the original bridge. This reduced the NEPA process to a “Categorical Exclusion with Documentation” and expedited the environmental review process from years to weeks. Similar strategies throughout the design process minimized delays to the greatest extent practical, while still meeting current project development practices.

Second, as mentioned earlier, NYSDOT managed the demolition, new bridge design and temporary ferry construction separately to eliminate confusion. Each task had independent design and management teams to expedite the process.

Third, due to the area’s environmental, historical and archaeological sensitivity, numerous permits were required in each state. The new bridge itself did not qualify for emergency relief because the temporary ferry service relieved some of the burden. Therefore, the new bridge design project was required to follow typical design project requirements, including the previously discussed NEPA environmental review process, all permitting required for a new bridge, and the formal NYSDOT bidding process.

To expedite this process while still following FHWA and NYSDOT guidelines, the FHWA arranged a federal regulatory agency summit on Jan. 12, 2010. Federal agencies that would have a role in the project participated, and all agreed on permitting requirements, process and project timeline. Collaboration within the agencies
The Section 106 Programmatic Agreement

Section 106 of the National Historic Preservation Act mandates that historic preservation must be considered during the planning process of any project that receives federal funding and may impact a historic property. Under Section 106, historic properties affected by a project must be identified and the effects of the project on the historic property must be evaluated in an attempt to avoid or mitigate those effects. A Section 106 Programmatic Agreement is an accord between project partners that outlines how they will comply with federal historic preservation requirements.

continued through the permitting phase, including approvals needed from the U.S. Coast Guard, the U.S. Army Corps of Engineers, USFWS, NY & VT DEC (endangered species consultation), various agencies for Clean Water Act provisions, as well as coordination with the St. Regis Mohawk Tribe and cultural resource agencies (SHPO). The collaborative efforts by FHWA, NYSDOT, VTrans and their respective agencies were critical in acquiring all required permits and documentation to progress bridge construction.

Because the new Lake Champlain Bridge was to traverse a navigable waterway, U.S. Coast Guard involvement was required. On Jan. 12, 2010, NYSDOT and HNTB met with the Coast Guard to explain the design concept, describe the project’s expedited nature, verify Coast Guard requirements for navigational clearance, ensure understanding of necessary permit applications, and explain the various project constraints that would affect the navigation channel.

From these discussions, a 75-foot vertical and 300-foot lateral navigational clearance was established. The new bridge permit application process began immediately following the meeting. This direct contact with the Coast Guard greatly expedited the permit application process, and the local ‘Notice to Mariners’ was posted by mid-March 2010.

Because of effective communication between agencies, and the high level of cooperation that resulted, all permits required for the new bridge were in place before the contract was awarded on May 27, 2010.

In addition to the required NEPA documentation, a programmatic agreement was executed as part of the National Historic Preservation Act, Section 106 process. NYSDOT used programmatic agreements for the new bridge and demolition of the former bridge to expedite the traditional Section 106 process. The programmatic agreement was contracted between FHWA, New York State Historic Preservation Office, New York State Department of Environmental Conservation, Vermont State Historic Preservation Office, Advisory Council on Historic Preservation, NYSDOT and VTrans. The agreement included provisions for environmental and archaeological compliance during the construction phase, as well as measures for mitigation and restoration to the lands affected by bridge construction. Additionally, actions to commemorate the original Lake Champlain Bridge were required to mitigate the loss of the historic structure. The agreement was incorporated into the final design contract documents to emphasize the historical, archaeological and environmental sensitivities of the project, as well as make the contractor aware of its responsibilities during construction.

PRELIMINARY DESIGN COMPLETED IN SIX WEEKS

Preliminary engineering began on Dec. 16, 2009. The design team worked closely with NYSDOT, VTrans and the FHWA and held early technical coordination meetings. For example, the overall design concept was presented to the co-lead agencies on Jan. 6, 2010, for feedback and comment. Preliminary drawings were distributed at the meeting that included proposed geometry, typical bridge sections and conceptual details for primary structural members. The meeting set the necessary design criteria, established the roadway cross section and identified the new structure’s functional needs.

Design issues were brought up for discussion and critical decisions were made prior to beginning final design. All required groups were involved in the Jan. 6 meeting, and those not present were able to acquire preliminary drawings. The co-lead agencies took a proactive approach to ironing out major design issues as early as possible. There was no room in the schedule for changing direction or modifying the basic design concepts once final design began, thus engaging all involved agencies was critical in making conceptual design decisions.

The mandatory 30-day review period required by the Section 106 process ended on Jan. 14, 2010. That same day, New York and Vermont announced that the modified network tied arch bridge concept would be progressed into final design. Once the new bridge programmatic agreement was finalized at the end of January, the preliminary design phase was able to be finalized.

The new bridge preliminary design and NEPA process was approved by the FHWA on Feb. 5, 2010.

PROJECT ADVERTISED AT 75-PERCENT COMPLETED PLANS

A primary strategy in the expedited D2B2 process was to deliver to interested contractors as much information as possible as early as possible. This allowed contractors to understand the type
of construction and to begin identifying and contacting subcontractors. It also gave them more time to plan site access and construction sequencing, given the environmental and historical sensitivities.

Included in NYSDOT contracts are “Special Notes” that offer additional project-specific information and clarification to the contractor. Special Notes in the Lake Champlain Bridge contract included:

- Construction access at the site.
- A full copy of the Section 106 Programmatic Agreement.
- An explanation of the deliverables scheduled under the modified design-bid-build contract.
- Structural clarifications, such as guidelines for mass concrete placement, metalizing and arch erection.
- Permitting and environmental monitoring required during construction.
- Vibration monitoring, also required for the historic structures adjacent to the site.

Contractor participation and input was a critical component during the design process, for not only was the design expedited, but the construction schedule was accelerated, as well. On Feb. 1, 2010, roughly two weeks following the start of final design, a contractor review meeting was held at NYSDOT offices. Interested contractors and subcontractors were invited to attend a presentation by the design team. A question-and-answer session followed the presentation in an attempt to have contractors provide feedback to the design team. A set of 30-percent plans was distributed to all attendees for additional information. To handle contractor questions and concerns, an e-mail address was made available on NYSDOT’s website to interested bidders.

Establishing a detailed schedule of deliverables early in the design process greatly contributed to the success of the Lake Champlain Bridge project. In an unprecedented move, the co-lead agencies agreed to make the 75-percent contract documents available online for bid to interested contractors on March 1, 2010 — two and one half weeks before official advertisement of 75-percent plans on March 17, 2010.

A pre-bid meeting, with 95-percent contract plans and specifications, was held on March 29, 2010, to provide additional information to interested contractors. The HNTB design team delivered the 95-percent plans just 10 weeks after initiating final design. The major addendum was a full swap-out of the 432-sheet plan set. Details not critical to bid, including camber and haunch tables, bar lists and load rating tables, would be delivered to the winning contractor at contract award. The proposed schedule, although expedited, still followed required time regulations per NYSDOT’s standard bid process and maximized the amount of time that contractors had to prepare their bids.

Construction commenced with a groundbreaking ceremony on June 11, 2010 and continued through November, 2011.
During the pre-bid meeting, NYSDOT provided a project overview, discussed design philosophy, suggested construction staging/sequencing and answered questions. Similar to the Feb. 1, 2010, meeting, design team members presented the advanced bridge design, specifically pointing out changes or additions to the 75-percent bidding documents. Contractors also had the opportunity to ask the design team questions to clarify bid documents and constructability issues.

Eight bids were received and publicly opened on April 15, 2010, six months after NYSDOT had closed the bridge and three months after final design began. Flatiron Constructors, Inc., the low bidder, came in at $69.6 million, 2 percent under engineer’s estimate. All things considered, the expedited D2B2 process progressed faster than a conventional design-build. The co-lead agencies and FHWA had condensed a five-year design process into five months with the bridge itself being designed in three and one-half months.

The construction contract was awarded on May 27, 2010. Both state’s governors attended the groundbreaking ceremony on June 11, 2010.

PROJECT MAINTAINS MOMENTUM DURING CONSTRUCTION

Several strategies were put in place to maintain project momentum during construction. For example, the co-lead agencies established a 16-month construction schedule and included in the contract an incentive/disincentive clause to open the bridge to traffic within 500 days of award. The estimated incentives were set at $30,000 per day (equal to the projected cost of operating the temporary ferry service), with a maximum of 50 days or $1.5 million. Disincentives, which would cost the contractor $30,000 for each day work extended beyond the deadline, had no cap.

Accelerating construction was the driving factor in the bridge’s design. The center arch span was fabricated off-site, floated in and lifted 75 feet into place and attached. The pre-assemble-and-lift scheme allowed the contractor to construct the center arch span and approach spans simultaneously, reducing the overall construction schedule.

The heavy lift offered other advantages:

- Construction crews had easier access building the center span on the ground rather than over water.
- The modified design’s delta frame provided more clearance, making it easier to lift and fit than the originally proposed “unmodified” network tied arch design.
- Once the arch was in position, precast deck panels were used instead of traditional cast-in-place decking. This eliminated the need for extensive formwork and lengthy cure times associated with cast-in-place decks.
- Both the heavy lift operation and precast concrete deck required little to no interruption in the navigation channel. In fact, a 200-foot

On Aug. 26, 2011, the center arch span was floated two miles down the lake to be lifted into place.
navigation channel remained open for the duration of construction.

In addition to design details and methodologies, other means of expediting construction were written into the bid documents. Explicit turnaround times for shop drawing reviews and answering contractors’ requests for information were to be adhered to by the design team and the co-lead agencies. Further, engineers from the design team were on-site to facilitate improved coordination and communication between NYSDOT’s engineer-in-charge, the contractor and the design team.

Other construction accelerators included:
- Shop-applied metalizing (vs. field-applied)
- Symmetrical design for ease of steel fabrication and concrete forming
- Temporary causeways, created for demolition, were kept open for the bridge contractor

**HEAVY LIFT IS SUCCESSFUL**

At sunrise on Aug. 26, 2011, coincidentally the 82nd anniversary of the original bridge’s opening, the eight-story-tall, 402-foot center arch span began its two-mile float to the construction site. It was carried by two barge assemblies and accompanied by tugboats and the United States Coast Guard and various police agency boats provided the escort/security during the move and lift.

Keeping the arch stable during the float was the most critical part of the erection sequence. Knowing the tension in each cable would change as the arch was transported and then lifted, HNTB designed the structure so cable tension could vary, depending on the load applied to the structure.

Erdman Anthony, the contractor’s erection engineer for the lift, simulated the load cases to ensure that while it was being pushed by the barges, and certainly during the lift, the changing cable forces remained at safe levels.

When the arch span arrived at the bridge site later that morning, onlookers, thrilled with the progress they were witnessing, had populated the shoreline to see the spectacle of a 1.8 million-pound steel arch go airborne.

Flatiron suspended the arch span by four strand jacks, one stationed at each corner of the unfinished bridge. Then, crews began the patient work of

“When we muster our resources and point in the right direction, we can achieve tremendous accomplishment. There is a natural tendency for adversarial relationships under these circumstances. This project proves we can do a much better job of gaining alignment among resource agencies and reviews.”

— Ted Zoli
National Chief Bridge Engineer, HNTB

The center arch span was maneuvered into place, suspended by four strand jacks and hoisted 75-feet to its final position.
hoisting the massive structure into place, chipping away at the 75-foot journey in 18-inch increments.

Erdman Anthony not only monitored the amount of force each of the four strand jacks carried to keep them as balanced as possible but also displacement to make sure the four corners of the arch span remained as level as possible.

Fit-up of arch span to approach spans happened late that night as crews bolted the cross beams into place. By the end of the following day, the bridge was essentially whole.

AGENCIES IDENTIFY BEST PRACTICES

Determining a cost savings has been difficult because of the project’s uniqueness. The expedited nature of the project saved millions of dollars in some areas, especially studies, engineering and design, which typically can take years, but the project’s emergency nature generated more expenses in other areas, such as the fast-tracked bridge demolition, subsidizing the existing ferry services and building a temporary ferry.

There are aspects of the project the co-lead agencies would have done differently in retrospect, but there were many things done right.

For this project, the individual best practices can be collectively grouped under New York’s D2B2 process and FHWA’s “Every Day Counts” initiative. FHWA’s “Every Day Counts” initiative is intended to identify and deploy innovation aimed at shortening project delivery, enhancing the safety of our roadways and protecting the environment.

Best practices under EDC and D2B2 include:

- **Robust communication with the public.** NYSDOT distributed 17 e-mail blasts in a 10-week period to a list of nearly 3,000 people, and dedicated one, high-level team member to maintaining public communication and responding to every incoming e-mail message. A special website was monitored continually and updated with additional information for potential bidders. Also, a webinar of the contractor review meeting was available to interested contractors who were unable to attend the meeting at NYSDOT’s offices.

- **High-level support.** The co-lead agencies secured high-level support for the project at every state and federal agency involved with the project. In fact, during the scoping phase, NYSDOT attempted to streamline communications by appointing a lead federal division for each agency. Between the Vermont and New York FHWA offices, for example, the New York division office assumed the lead, which corresponded with NYSDOT’s role as project lead. It proved to be an extremely efficient tactic, also adopted by the New York division of the U.S. Coast Guard. Had the tactic been replicated with other agencies, NYSDOT most likely would have saved significantly more time. However, because of the project’s emergency status, the effort to streamline other points of contact never materialized.

- **Technology application.** Assessing the condition of the former Lake Champlain Bridge was the first time HNTB has deployed accelerometers and tilt meters to identify a structure’s behavior and fragility. The technology provided NYSDOT with actual measurements of the piers under temperature and thermal cycles and was critical in helping NYSDOT make its decision to close the bridge.

- **3-D renderings.** NYSDOT anticipated significant fit-up problems during construction because of the complex steel structure, especially on the arch. However, it came together better than expected. At one point, Flatiron was requesting steel.
shipments for the arch every other day. Within a few days of starting construction of the arch, the contractor was requesting shipments daily because the steel was fitting together so well. The ease of construction is a testament to both the fabricator, High Steel Structures, Inc., and the quality of the 3-D modeling.

With an emergency project, there is little time for the design process’ typical mistake and correction cycle. The best approach in this situation is to draw and model the bridge in 3-D because it provides more answers than questions. The HNTB design team created 3-D renderings of every major aspect of the bridge. These 3-D renderings were critical to gaining buy-in from the state historic preservation offices. The precise renderings helped the various resource agencies understand how very little the bridge’s touchdown points would affect the historically and environmentally sensitive surroundings. And, with the 3-D models, the design team was able to produce design plans much faster.

• **Condensed bid process.** Collapsing the traditional three months between project specifications and estimates to six weeks proved to be another critical acceleration method.

• **An aggressive four-part quality assurance/quality control process:**

  1. **Collaboration.** The collaboration among the co-lead agencies, consulting parties, permitting agencies, the design team and the public was unprecedented and is perhaps the single-most important factor in successfully expediting the bridge design process.

  2. **Communication.** In order to keep lines of communication open, NYSDOT, VTrans, FHWA and HNTB participated in twice weekly interagency conferences during the design phase. Design questions, issues and review comments were addressed. All parties maintained awareness of recent changes, design decisions and any other developments that could alter the design documents. In addition to collaboration with the design team, conference calls between the co-lead agencies were held every Monday, Wednesday and Friday. They were imperative to the success of the expedited bridge design process.

  3. **Drawings and specifications reviews.** NYSDOT created separate review teams for the approach roadway and structural drawings. The members of these review teams at NYSDOT, VTrans and FHWA understood that the HNTB design team would submit new, updated or completed drawings by noon each Monday and Thursday. The review teams were given 24 hours to provide comments to NYSDOT’s Deputy Project Manager, who then would compile comments and deliver them to HNTB by close of business that same day. This process permitted all drawings in the contract plan set to be reviewed by each of the co-lead agencies prior to plans, specifications and estimates delivery. Any comments requiring further discussion would be addressed during the semi-weekly conference calls mentioned above.

  4. **Working sessions with the design team.** These multi-day working sessions allowed the co-lead agencies to effectively address any design issues directly with the design team. The design team was able to effectively communicate thoughts and ideas through sketches, props and other visuals that typical conference calls or periodic meetings could not employ effectively. Efficient, effective decision-making during these working sessions greatly streamlined the overall design process.

• **Constructability reviews.** A NYSDOT construction representative attended three different working sessions to provide input and to help modify design elements where appropriate to expedite construction. Minimizing construction duration was a driving factor in the design of the replacement bridge. Furthermore, the construction representative was an important link within NYSDOT as the project progressed from design to construction. Significant changes were made in the design as a result of those reviews.

• **A value engineering review.** During the first three-day working session in January, design plans were reviewed by an outside consultant. HNTB presented the 30-percent plans on Jan. 11, 2010, and the value engineering team had 48 hours to complete its review of the documents and present its findings to NYSDOT, VTrans and FHWA representatives on Jan. 13, 2010.

• **A transparent public review process.** The co-lead agencies established a relationship with the PAC early on, was open with the public and forthcoming with information, and showed respect for the

“The level of collaboration and communication throughout this project has been unprecedented and is the primary reason we were able to accomplish so much in such a short time. I am so proud of how quickly we were able to construct such a beautiful new bridge and reestablish the vital link between the two states.”

— Mary E. Ivey
Regional Director, NYSDOT Region 1
former bridge throughout the process before proposing the new bridge. This demonstrated the value of public input to the co-lead agencies and the design team. Additionally, by adding a sixth bridge type alternative based on the PAC+ comments, the co-lead agencies and design team demonstrated their willingness to listen and adapt to the public’s needs and desires.

- Dividing the project into smaller projects. Dividing the bridge replacement project into four individually managed projects, eliminated confusion and expedited the environmental permitting process.
- An aggressive deliverables plan. The co-lead agencies met with the HNTB design team early in the project to chart delivery timeframes for public meetings, design reports, plans, specifications, estimates and amendments to meet the April letting. NYSDOT worked closely with its headquarters to ensure the deadlines could be met.

LESSONS LEARNED AND BEST PRACTICES
With an emergency mandate to reestablish the link between the two rural communities, the need for a quick response was a given. Contractors say the best jobs are the ones they receive in the fall because they have the winter to prepare for work in the spring. Due to the need for speed on this project, interested contractors were giving a basic design scheme on Feb. 1, 2010, to help them in preparing their bids. Just two months later, NYSDOT let the job and it was awarded to Flatiron in May. As a result, there was minimal time for prep work and almost no time for error, making the accelerated timeline the biggest challenge of this project. When a $70-million bridge is designed in three months, there will certainly be some overlooked details.

“We had a great relationship with our counterparts at NYSDOT. Our Director Rich Tetreault had a fantastic relationship with Bob Dennison, NYSDOT’s chief engineer. They were on a one-on-one basis. Many times, when we couldn’t agree on something, the two just picked up the phone and worked it out.”

— Dan Landry
VTrans Project Manager
Many of the challenges the co-lead agencies encountered below are a result of accelerating the project. Others are simply lessons learned in the ongoing work of bridge building.

**Lessons Learned**

- **Underwater obstructions** were one of the challenges the co-lead agencies faced while installing the drilled shafts. Pier 5 resulted in the biggest setback. Mitigation of those obstructions delayed the project by two months. Some preventative measures were taken. The co-lead agencies staged the work, so the new bridge’s piers were offset from the old ones in hopes of avoiding any remains. Further, crews used sonar, ground-penetrating radar and probes to locate partially submerged chunks of the demolished bridge. However, sonar and radar only allowed them to see a little more than five feet into the yogurt-like lake bed. Some chunks of the demolished bridge were embedded 15 feet or deeper. Tighter specifications that put more responsibility on the contractor to mitigate footing obstructions may have reduced the owner’s cost to keep the project on schedule.

- **The 10-foot-wide precast deck panels** provided an effective method for loading the arch in a more controlled manner. However, unforeseen issues during fabrication arose mostly due to the lifting detail. Additionally, the panels did not butt up against each other. In between each of the 32 panels is a two-foot closure pour. Each of the gaps had to be filled with reinforcing steel, post-tensioning ducts had to be connected, and crews had to shoot sheer studs in between them. The takeaway here is that precast deck panels can be time-saving, but they are detailed intensive.

- **There were questions with erection sequencing and procedures — what was intended, what was possible and where the demarcation line lies between a designer’s responsibility and a contractor’s responsibility for working out details.**

- **Building the center arch span off-site at ground level was easier, faster and safer than trying to construct it over water. Moving and lifting it wasn’t overly complicated. However, in retrospect, giving more consideration during the design phase to property easements for the build site of the center arch span would have been helpful. For federal land procurement reasons, the FHWA asked NYSDOT not to specify in documentation a site for building the arch. In hindsight, doing so might have alleviated a significant amount of negotiating and permitting for the contractor.**

- **There were multiple issues with reinforcement, which is not uncommon in a contract, but with this project, the rebar seemed to be even more challenging. For example: The pier shapes were challenging to build. More complicated shapes require extensive rebar detailing. In an accelerated design process, it is essential that designers recognize that some construction processes are**
more time-consuming. Ideally, more time and flexibility could have been allowed in the schedule. Additionally, working closer with the steel reinforcing fabricator during construction may have reduced the problems experienced in the field and reduced claims.

- The lake water proved to be an unexpected issue. NYSDOT specified a somewhat permeable curtain, which was ineffective in controlling turbidity. So, the co-lead agencies were forced to purchase a much more expensive, impermeable curtain. Because two states were involved in the project, there also were two different Departments of Conservation involved with slightly different requirements. For example: New York allowed pH within a certain band (no more than 1.5 pH higher or lower) of the background pH. Vermont had a strict minimum and maximum pH level. In cases such as this, better coordination between each state’s Department of Conservation is helpful to mitigation differences.

- The amount of electrical work on the bridge wasn’t particularly significant. The bridge has only minor aesthetic lighting and no overhead street lights; however, electrical issues arose throughout the project. To avoid confusion and possible delays, it is important to integrate the electrical work needed to support the lighting earlier in the design process.

- The project’s environmental permitting process required an on-site environmental monitor. In retrospect, the co-lead agencies would have preferred someone whose role was similar to that of safety personnel. The monitor would help the owner and contractor avoid problems and accidents, keep the project on track and resolve problems when they occur rather than simply identify problems as they occurred. Also, the reporting mechanism was inefficient since the environmental monitor did not report to the owner’s representative, NYSDOT.

- Getting the contractor’s equipment to the bridge construction site was a challenge. The contractor originally had planned to use the ferry slips, but needed the ferry operator’s permission to use them, which understandably placed the ferry company in a conflicting position. As an alternative solution, Flatiron lined up barge after barge until they stretched from the shore to the main span piers of the structure. Crews then drove the concrete trucks over the barges and out to the work site in the middle of the lake. In hindsight, it should not have been assumed the ferries would cooperate, or the rules of operation should have been agreed to in advance of construction.

Best Practices
- Having the HNTB design team on-site and accessible during construction, meant that questions could be answered on the fly and problems could be addressed immediately or proactively avoided.

- This project used traditional cofferdams and watertight enclosures to construct the foundations. In shallower water, crews used conventional driven sheet pile cofferdams. In deeper water, watertight enclosures were used to allow the contractor to work in the dry. These enclosures were more like bathtubs with holes in the bottoms that sit on top
“We could not have accomplished this project without the professionalism and dedication of the design team of HNTB, Fitzgerald & Halliday and Clough Harbour. They gave it their all. They sacrificed their nights, weekends and holidays. Many consultants would have reacted in a similar fashion, but I can’t imagine any team putting forth a greater effort than the team we had.”

— James C. Boni, PE
Project Manager, NYSDOT

of shafts driven into place. Thus, crews only had to dewater six or eight feet as opposed to dewatering all the way down to the bottom of the deep lake. The bottoms of the enclosures were precast and became a permanent part of the piers. Only the walls were ultimately removed. Crews put concrete collars over the shafts, which worked as stoppers, and then the precast bed of the cofferdam sat on top of those collars. The whole procedure worked extremely well.

• This project involved two archeological entities, one from each state. Each was on site, monitoring the project. They were reasonable but sensitive to the area and were extremely easy to work with. As an aside, the co-lead agencies found the missing 1731 fort that was presumed to be in Vermont but had never been located. It was able to be documented and preserved.

• In addition to their aesthetics, the five-story-tall delta frames anchoring either end of the center arch shortened the main span and made the center arch span construction and lift easier. They did require a temporary support and rigging system making them more difficult to build.

BRIDGE BECOMES A MODEL FOR SUCCESS

The new Lake Champlain Bridge is composed of eight spans with one network tied arch signature span. Total bridge length is set at 2,200 feet with seven approach spans measuring up to 250 feet and a 402-foot-long network tied arch signature span. A minimum vertical clearance of 16 feet, 6 inches is provided at the bridge curb with vertical clearance increasing toward the center of the roadway.

Together with VTrans, the FHWA and the HNTB design team, NYSDOT developed a plan to demolish the original truss bridge in just over two months and to design and construct a new signature crossing within 20 months. Because of the expedited D2B2 process, the design was completed on a compressed schedule with the traditional, linear functions of bid advertisement, contract packaging and permitting performed concurrently. The teamwork between the two states and numerous local and federal agencies allowed for a collaborative, cooperative process.

The Lake Champlain Bridge Replacement Project serves as a model for success in communication and cooperation among various agencies and interest groups, resulting in significant time- and cost-savings to the public.