Designing & Building the Sagadahoc Bridge Between Bath & Woolwich, Maine

Using a carefully planned and implemented design-build approach led to on-time project completion and with costs on-budget.

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In 1927, the Carlton Bridge was constructed as a steel truss lift bridge to carry U.S. Route 1 and adjacent railroad lines (owned by the Maine Department of Transportation) over the Kennebec River between Bath and Woolwich, Maine. Vacationing motorists seeking Maine coastal tourist destinations and the growth of Bath Iron Works (located in Bath, adjacent to the bridge site — a major shipbuilder contractor and Maine's largest employer) contributed significantly to the 25,000 vehicles per day that crossed the Kennebec River on the Carlton Bridge. Seasonal traffic flows, daily shift changes at Bath Iron Works and frequent openings to allow marine traffic to pass in the river caused significant traffic congestion and unacceptable traffic delays on the narrow two-lane bridge.

To alleviate the congestion and the delays, the state began planning in the early 1990s for a wider structure capable of carrying four lanes of traffic. Through a consensus-building process with the neighboring communities, it was agreed in 1996 that a new bridge would be built parallel to the Carlton Bridge. By that time, $38 million in federal funding that had been targeted for the project was at risk. The funding would expire by October 1997 if it were not committed to the project. There was insufficient time for a conventional design, bid and build process; in addition, it was understood that delays would contribute to high user costs associated with the severe traffic congestion in Bath and Woolwich. As a result, the Maine Department of Transportation (DOT) decided to explore a design-build method of project delivery in order to obtain the $38 million in federal funding and to quickly resolve the increasing traffic burden.

This project would be Maine DOT's first use of the design-build approach.

At that time Maine law required low-bid competition. The Maine legislature, however, at the request of Maine DOT, approved a statutory change to allow design-build for the new bridge project in Bath–Woolwich. Maine DOT, with direct involvement of the Federal Highway Administration (FHWA), reviewed the design-build selection processes that had been used by other state DOTs. Maine DOT used this information to create a state-of-the-art design-build selection process that incorporated the best features from other states and added special improvements to fit its project expectations. A key improvement was the idea of a "value based selection." This improvement was intended to incorporate elements of owner control over the product by weighting the technical merit of a design-builder's concept with price.

During construction, Maine DOT engaged the local community to name the new bridge. Through a public voting process, the new bridge was named the Sagadahoc Bridge, for the county where the bridge is located and for the Native American tribe that historically lived in the area.

Maine Design-Build Approach

Selection of a design-build team for the new Sagadahoc Bridge started in the fall of 1996 with a national advertisement for expressions of interest (EOI) from interested parties. Seven teams responded. Four of those teams were selected to further respond to a defined request for proposal (RFP). Maine DOT offered a $60,000 stipend to each team that submitted a responsive proposal. Each team was to submit a price bid and an enhanced technical proposal that included a set of preliminary bridge plans.

Maine DOT identified key required design criteria in its RFP, including:

- established horizontal and vertical alignments;
- deck/roadway configuration (number of lanes, shoulders, sidewalks, barriers);
- approximate abutment stations (with defined allowable deviation);
- allowable superstructure types (steel or concrete box girders);
- allowable river foundation types (piles or drilled shafts);
- maximum number of allowable piers in the river and area of allowable river bottom impacts (based on pre-determined hydraulic, environmental and navigational requirements); and,
- maximum number of expansion joints.

Prior to advertising this project, Maine DOT concluded all environmental clearances and obtained permits from the United States Coast Guard and the Army Corps of Engineers. These efforts included establishing minimum required navigational clearances under the bridge and maximum allowable area of river channel impacts due to construction and permanent foundations. By establishing a higher vertical profile for the proposed alignment, the need for a costly lift span or movable bridge section was eliminated.

Maine DOT created contract documents for this project with the intent of aligning risk with control. Contract risks were assigned to the design-build team, along with commensurate controls. The owner's supplemental boring program was an example of the efforts made to align control with risks. The project RFP allowed teams to propose pier locations that did not correspond to the exact positions where soil borings had been extracted in the original geotechnical exploration studies. Each team was allowed to request a maximum of ten additional exploratory borings in the river, along with an opportunity to request tests of their own choosing associated with this supplemental foundation exploration. Maine DOT then combined the requests and performed an additional exploratory program at its own expense. This supplemental geotechnical program was expedited so that the results were provided to the proposing teams in sufficient time to be incorporated into their design concepts and bid pricing. Each design-build team was assigned the risks of the geotechnical site conditions and control of managing those risks by allowing them the opportunity to direct additional exploratory work and testing. Maine DOT retained risks related to hazardous wastes, archeological finds and buried man-made obstructions.

The level of owner involvement in inspection efforts associated with the warranty items was also reduced in accordance with the relative control and risk assigned to the design-builder. Since the design-build team would be ultimately responsible for warranty item performance, the inspection of those items was also its responsibility.

A financial incentive/penalty program of approximately $1 million was offered through a performance specification that addressed concrete properties of permeability, strength, air entrainment and reinforcing steel clearances. The design-build team was assigned control of designing and monitoring the concrete mix since the team assumed the risks associated with the incentive/disincentive program. In addition, financial incentives of $3,000 per day (to a maximum of $1 million) were offered for early completion of construction. Conversely, a liquidated damages penalty of $4,500 per day was established, should the contractor exceed the scheduled completion date.

The RFP documents were crafted to balance design considerations without hindering the creativity and talents of the proposing design-build teams. Additional needs of the owner that were prescribed in the RFP included:

- granite masonry pier protection for all river piers (Maine DOT had successful experience with this approach in protecting piers at the water level from abrasive ice floes and the significant salt water tides that are common on the Kennebec River);
- trapezoidal box beams of either weathering steel or concrete to address aesthetic and long-term serviceability needs; and,
- epoxy-coated steel and corrosion inhibitor admixtures for long-term durability.

Each design-build team was allowed flexibility in choosing significant design parameters such as pier locations, span lengths, traffic and construction staging, and minor adjustments in roadway geometry, within prescribed limits.

Prescribing these items in the RFP resulted in the owner's specific expectations being met, without making the proposing teams guess owner preferences. It was the intention of the owner to encourage an economical bid price by reducing the uncertainty on the project requirements.

Maine DOT received separate technical and price proposals from each team in July 1997. The first evaluation step was to verify that each technical proposal responded to all required criteria. Of the four proposals submitted, two were found to contain flaws and were categorized as non-responsive and not eligible for further consideration. The corresponding price proposals (bids) were returned to these teams unopened. The flaws included proposed superstructure and river foundation types that were not allowed, along with geometry deviations not in compliance with the alignments established in the RFP. The teams with unresponsive proposals relinquished the $60,000 stipend.

A diverse committee of nineteen members then evaluated the two remaining technical proposals. The committee consisted of:

- Nine Maine DOT members — two bridge design, two construction, one bridge maintenance, one geotechnical, two traffic, one environmental services;
- Four FHWA members — one each from bridge design/construction/maintenance, highway geometrics/safety, traffic/safety and materials/maintenance;
- One peer state member from the Texas DOT (with expertise in bridge design and construction);
- Two local members, one each from the City of Bath and the Town of Woolwich;
- One University of Maine engineering professor;
- One state historic preservation officer; and,
- One private architect consultant.

Scores for the categories were compiled with a maximum possible aggregate technical proposal score of 100 points (see Table 1). Each committee member scored only the items within their expertise.

TABLE 1.
Category Scoring Weight

1. Understanding Scope of Work 10%
2. Quality of Design 17%
3. Durability 20%
4. Maintainability 12%
5. Navigational Vertical Clearance 1%
6. Quality of Schedule 5%
7. Community Impacts 5%
8. Aesthetics 5%
9. Quality of Construction 10%
10. Maintenance of Traffic 15%

The bid openings began by announcing the technical scores from the committee for each bidder. The public opening and reading of the two price proposal bids followed. An overall "best-value" rating was computed as the lump sum bid price divided by the corresponding technical score. From this computation each teams' technical and price proposal resulted in an effective price per technical score point. The project was awarded to the team with the lowest effective price per technical score point.

Winning Team Proposal

The successful team consisted of a general contractor and a lead designer. The expense for developing the winning proposal was carried primarily by the contractor and the lead designer, with contributions from several other team members, which was partially offset by the $60,000 stipend. This design-build team had both the highest technical score (92) and the lowest price ($46.6 million). In contrast, the competing team's unsuccessful proposal had a bid price of $51.3 million for a steel box girder bridge and received a technical score of 76. Table 2 summarizes these resulting selection parameters and overall "best-value" rating.

Examination of these results reveals that the competitor would have needed to decrease their bid by more than $12 million in order to overcome the lower technical score.

The entire design-build selection process required only ten months from September 1996 to July 1997. Maine DOT's decision to use the design-build process allowed the State of Maine to successfully secure federal funding for the project by the October 1997 deadline and to aggressively address the traffic congestion issue.

Quality Assurance/Quality Control

The design-build process was structured so that Maine DOT performed a quality assurance role, and the design-build team provided quality control. These responsibilities were defined in the RFP requirements and the construction contract.

The quality assurance role extended to the design and construction components of the project. The design review involved only concepts and contract compliance, without performing calculations and was performed by a consultant retained by Maine DOT. Maine DOT retained a second consultant to monitor construction scheduling, with a focus on claims avoidance. This monitoring program

TABLE 2.
Design-Build Team Proposal Comparison

Team	Bid Price	Technical Score	Best-Value Rating*
1	$46.6 million	92	$506,500
2	$51.3 million	76	$675,000

Note: * Calculated as bid price divided by technical score to determine $ per technical point.

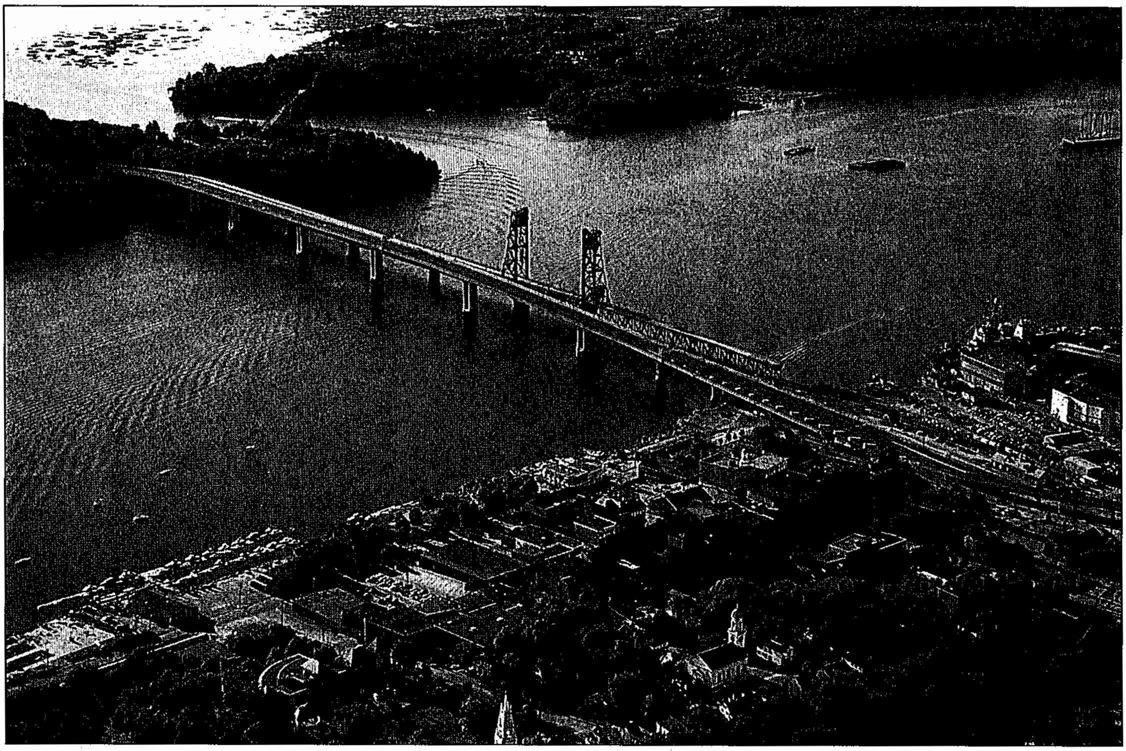

FIGURE 1. An aerial view of the new Sagadahoc Bridge.

was executed through site visits and reports on the general progress and quality of the completed project.

Design quality control was provided by the designer through an independent review performed by another team from the same company, located in a separate design office. Design-build team field representatives managed construction quality control. A detailed quality control manual, prepared by the design-build team and submitted for Maine DOT approval, provided guidance. The manual included descriptions of testing and documentation procedures. Throughout the project, the design-build team performed all material testing, construction inspection and quality control documentation. To close out the project in conformance with project requirements, the design-build team submitted to Maine DOT a record of complete quality control documentation including plans, specifications, calculations, working drawings, test results and certifications.

Maine DOT required a warranty on the specialty features of the bridge, including:

- A five-year warranty for structural bearings, sign and light supports, sign panels, luminaries, pavement and granite pier construction.
- A ten-year warranty for bridge deck expansion joints and the deck waterproofing membrane.

Design Decisions & Influences

The general contractor and lead designer worked closely to develop and evaluate various economical design schemes and alternatives, based on constructibility and schedule considerations. These concepts were also developed in conformance with the specific conditions as described in the owner's RFP documents. The design-build team focused on exceeding Maine DOT expectations. It was understood that any extra value offered by the team would be favorably reflected in the technical evaluation and selection scoring of the team's proposal.

The new Sagadahoc Bridge is a 2,792-foot-long twelve-span structure (see Figure 1). The superstructure consists of:

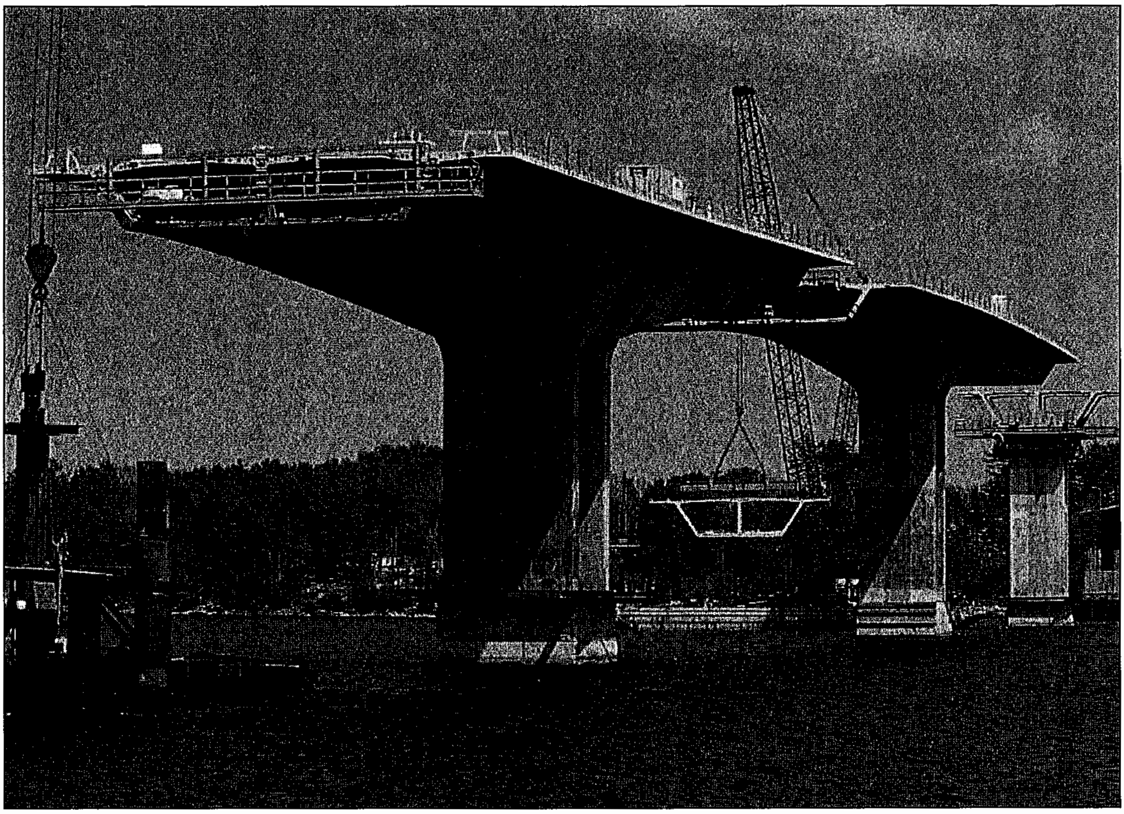

FIGURE 2. Precast balanced cantilever segmental erection.

- *Woolwich approach:* three cast-in-place 184-foot, two-cell trapezoidal box girder spans on a 650-foot horizontal curve, with a constant deck width of 69 feet and a constant superstructure depth of 9 feet.
- *Main span unit:* six precast two-cell trapezoidal box girder spans (west to east span lengths of 262, 420, 380, 331, 331 and 203 feet), a constant deck width of 69 feet and a variable superstructure depth from 20 feet at the main piers to 9 feet at midspan.
- *Bath approach:* three cast-in-place 164-foot four-cell trapezoidal box girder spans, a flared deck width (69 to 120 feet) and a constant superstructure depth of 9 feet.

The use of multiple foundation types is an example of the benefits that evolve from a design-build process where the designer and builder interact to optimize the contractor's resources and scheduling conditions.

The river foundations consisted of four 8-foot-diameter shafts under the main piers and three 8-foot-diameter shafts under the side piers. The shafts were capped with rectangular footings from 31 to 36 feet in width and 12 feet in height, supporting twin wall columns. Both abutments, and three of the four land-based piers, were founded on spread footing widths of approximately 14 to 28 feet and heights from 6 to 8 feet, bearing directly on sound rock. One pier (land-based Pier 12 on the Woolwich approach) was founded on H-piles due to a localized variability in the rock strata. This footing incorporated forty HP360 x 132 piles, each approximately 22 feet long.

Maine DOT identified in the RFP that only driven piles or drilled shaft foundations could be used in the river. Spread footings in the river were not allowed due to scour concerns and maximum impact area agreements with environmental agencies. Long span lengths were explored by the team in order to limit the number of expensive deep-water piers constructed in the river. The decision to use a record 420-foot-long precast segmental main span over the navigation channel evolved from the interest in limiting river foundation construction.

The design team chose to use large 8-foot-diameter drilled shafts for piers in the river. The primary reason was that the shafts are secured with rock sockets and provide stability for the long unbraced lengths associated with an extreme design event using potential full scour. In addition, choosing shafts for foundations benefited the schedule, because doing so allowed foundations to be placed quickly before winter. Under Maine DOT directives, spread footings were permissible on land, where the team chose to utilize them. The close proximity of sound rock near the ground line made this option feasible and economical.

In the RFP, Maine DOT required that a concrete or steel trapezoidal box girder section be used for the superstructure. The design-build team determined that a concrete superstructure would be more economical than steel, based on lower delivered material costs and reduced on-site construction time with winter weather constraints. It was further decided to combine a precast main span unit over the river with cast-in-place approach spans on each end as the optimum design.

Use of a precast unit over the river minimized operations over water and allowed precast activities to continue through the winter, benefiting the project schedule. The balanced cantilever method of erecting the precast segments was the most economical technique for constructing the long spans over the river (see Figure 2). Concurrently, cast-in-place spans over land accommodated the flared deck. It also allowed for the convenient staging of construction that would help when shifting traffic from the existing bridge to the new bridge and would eliminate the need for large land-based cranes.

The single 69-foot-wide two-cell box girder was selected for the superstructure to reduce by 50 percent the segment precasting and erection operations needed for separate parallel single-wall box girders. The trade-off was the need for lifting equipment with slightly larger capacity to handle the heavier segments (a maximum weight of 100 tons). Another benefit of using one wide single-box superstructure was a reduction in the required number of piers by 50 percent. Fewer piers make for a less cluttered and more aesthetically pleasing substructure. Additional design decisions were developed through coordination between the designer and builder that improved constructibility. These design considerations included twin-wall piers and a special foundation-forming system described as a "lost" cofferdam.

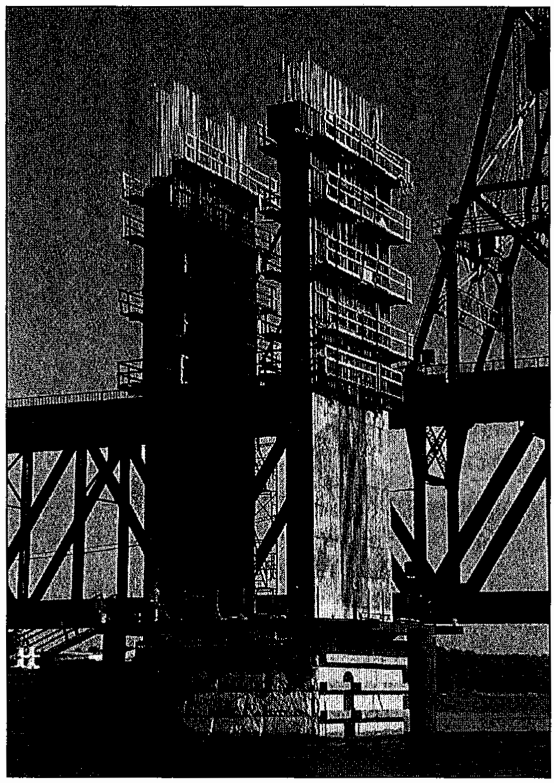

FIGURE 3. Twin wall piers provide structural flexibility.

The twin wall piers deliver the benefits of improved structural flexibility for a long bridge length between expansion joints, stability for the overturning cantilever moment and a wide pier table for beginning balanced cantilever construction (see Figure 3). An innovative construction method using a precast concrete floating "lost" cofferdam was developed to minimize the expense of building a full-depth cofferdam in the 40-foot-deep water

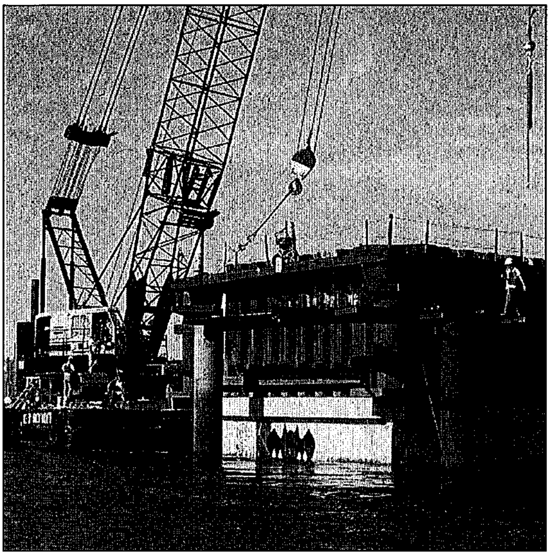

FIGURE 4. Precast concrete "lost" cofferdam with removable steel frame.

around the river piers (see Figure 4). (It was labeled as "lost" because this floating cofferdam did not contribute to the structural capacity of the foundation, but it remains still in place.)

Long-term durability of the bridge was enhanced with several special design features. Maine DOT required that the pier bases be clad with granite for protection from ice floes (a proven technique). In addition, the faces of the pier bases were sloped to encourage the breaking of ice floes, thereby allowing a reduction in the corresponding design loads. The concrete superstructure incorporated 6,000 psi concrete with fly ash to decrease permeability and with calcium nitrite for corrosion resistance. The superstructure is longitudinally post-tensioned along with transverse post-tensioning in the deck. This bi-axial state of pre-compression provided enhanced durability. The deck was further protected with a replaceable asphalt wearing surface over a waterproof membrane.

The citizens of Bath and Woolwich were deeply involved throughout the design-build process. The two communities were interested in both the functional and visual qualities of their new bridge. The design-build team encouraged community involvement by offering a design charette during the fast-tracked design phase. The local communities enthusiastically embraced this offer. Through this process of public involvement, the charette participants selected specialty lighting for the piers, decorative light fixtures on the deck and textured finishes with color-stained concrete for the piers and superstructure. Community pride, fostered through the use of this public involvement process, was evident at the day-long grand opening celebration.

Construction Process

Construction of the Sagadahoc Bridge began in the fall of 1997. Construction was influenced by site-specific challenges, including the severe Maine winter weather, significant tidal flows in the Kennebec River and the need to stage construction to transfer traffic from the old bridge to the new bridge.

Construction began with the Woolwich approach footings and abutments, installation of drilled shafts for Piers 3 through 9 and the concurrent assembly of a casting yard along the Bath waterfront, within view of the bridge site. The 8-foot-diameter drilled shafts were constructed in permanent casings that extended through sediment layers in the riverbed and keyed into the underlying rock strata. Sockets were drilled into the rock and the shafts were poured with tremies in the wet holes. The first drilled shaft was poured for the project in March 1998 and all of the twenty-two required shafts were completed within eight months (see Figures 5 & 6).

Eight steel pipes were installed in each shaft in order to conduct cross-hole sonic log testing of the as-constructed shaft integrity. Two shafts also incorporated an Osterberg-cell (O-cell) for subsequently measuring the load capacity of the drilled shaft. However, the cross-hole sonic log testing was not a contract requirement. This testing was provided by the design-build team under the quality control program and as an extra benefit to the owner to verify the integrity of the shafts. The O-cell load tests were performed in accordance with the contractual requirement specified by the Maine DOT. The contract required that a load test be performed for each different bearing material used in the foundations. The design-build team used the load test program

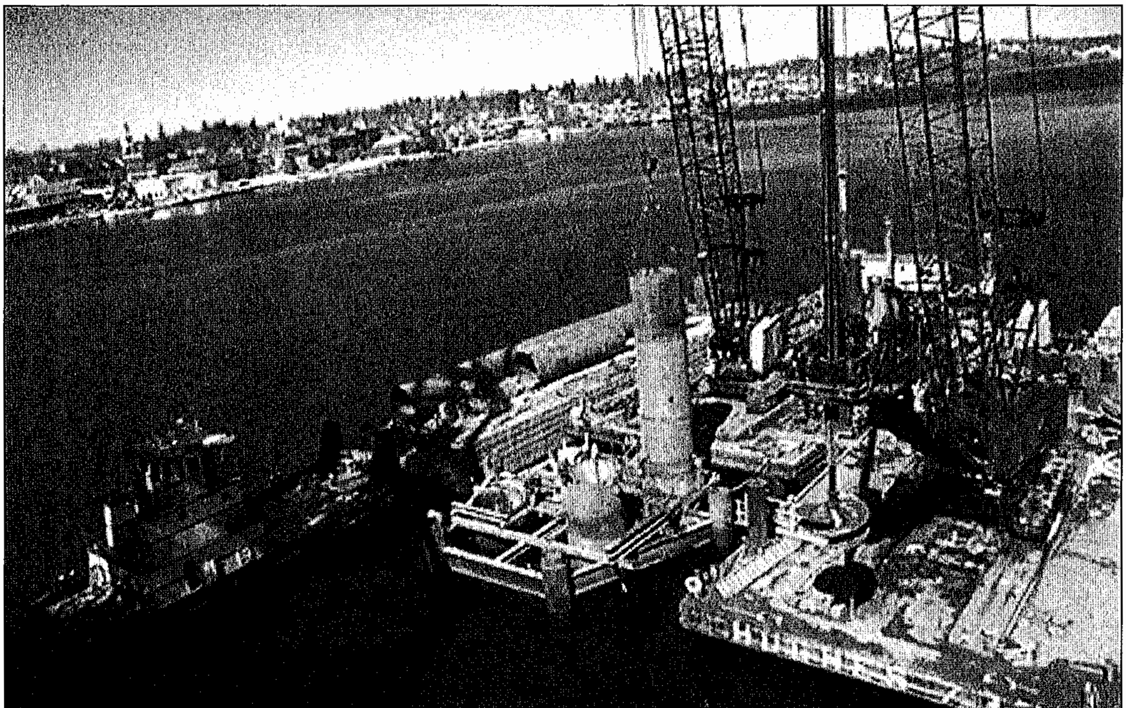

FIGURE 5. Eight-foot-diameter drilled shaft foundations being socketed into bedrock.

to identify increased design capacities and reduce rock socket lengths. The intent was to successfully proof test the 8-foot-diameter production drilled shafts, without actually reaching the ultimate capacity of the shaft.

The first O-cell test location was selected at Pier 6 as representative of the rock strata found at the locations of the shafts for Piers 3 through 6, where the highest shaft capacity was expected. An 8-foot-diameter production drilled shaft was installed at Pier 6 with a 7.5-foot-diameter rock socket of approximately 12 feet in length, based on the AASHTO design method for computing allowable shaft capacities. The O-cell load tests were used to check the design by loading the actual test shaft to approximately three times the design load. Once the loading was completed, the shaft was unloaded and reloaded to approximately two times the design load to ensure the structural integrity of the shaft for use as a production shaft.

Ultimate design values for shaft capacity were computed using an AASHTO method for estimating capacity with design parame-

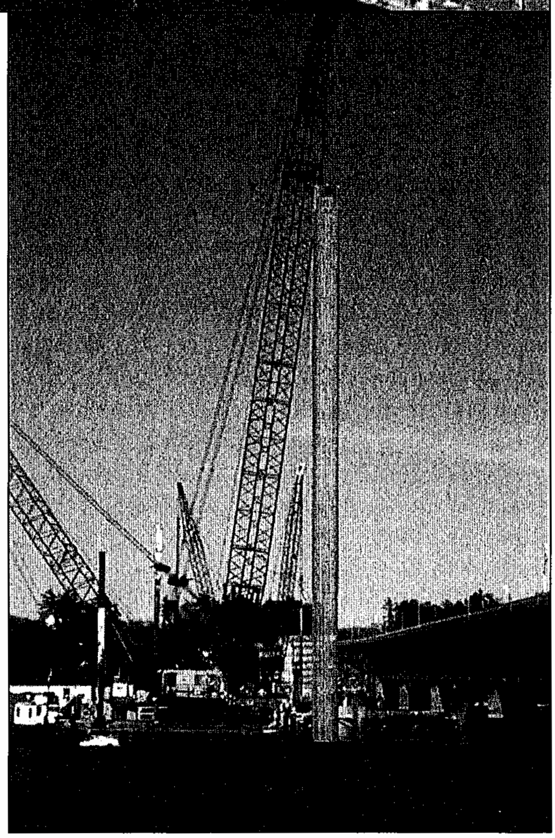

FIGURE 6. First use of large-diameter drilled shafts in Maine (up to 145 feet long).

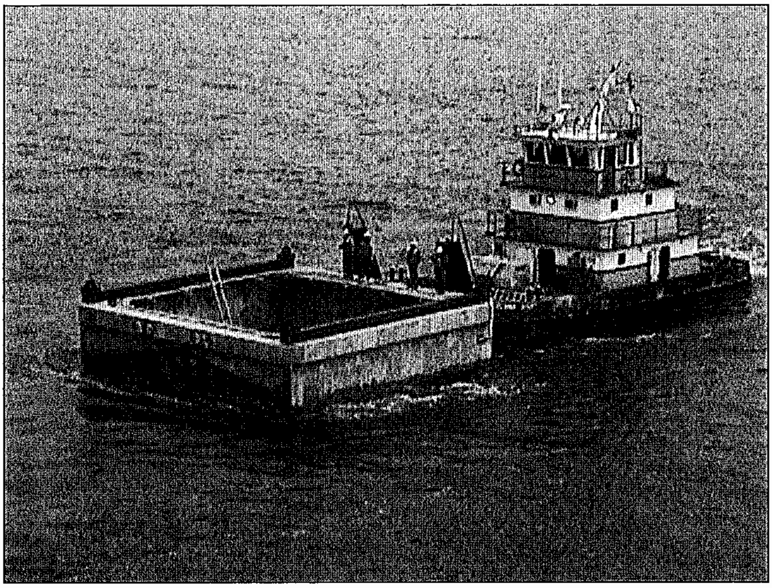

FIGURE 7. Delivery of the unique floating cofferdam.

ters based on an evaluation of subsurface data and laboratory tests from the exploration program. A safety factor of 2.5 was used to determine the rock socket lengths in association with estimated ultimate design values for side shear resistance and end bearing. This AASHTO design method provided an estimate of 17.2 ksf of allowable ultimate unit side resistance capacity and 275 ksf of ultimate end bearing capacity.

Since the O-cell load test applies an equal upward and downward force on the rock socket, the maximum downward load applied during the test did not approach the ultimate end bearing capacity of the shaft. Therefore, the design-build team could not determine an actual ultimate end bearing value from this load test. However, the load test did proof the shaft to three times the design load.

An actual unit side shear of 37.6 ksf was recorded from the O-cell test on the Pier 6 shaft. Examination of the data indicated that this value was close to the estimated ultimate unit side capacity of 41.8 ksf. Using these O-cell load test results indicated that the side resistance capacity of the shaft that was higher than what was estimated under the AASHTO method by a factor of 2.4 for this particular large-diameter drilled shaft and type of bearing material. It was also found that the fractured rock within the upper 8 feet at this shaft location (typically assumed to provide very little capacity under the AASHTO method) in reality contributed significantly to actual side shear resistance. However, this layer of fractured rock was conservatively disregarded in computing the design capacity.

A second load test location was selected by the design-build team to represent the rock strata that were expected to offer the least shaft capacity. A location at Pier 7 was chosen to represent the foundation design parameters for Piers 7 through 9. The 8-foot-diameter production drilled shaft at this Pier 7 test location was installed with a 7.5-foot-diameter rock socket of approximately 19 feet in length, determined using the AASHTO drilled shaft design method. This design method provided an estimated 13 ksf of ultimate unit side resistance capacity and 275 ksf of ultimate end bearing capacity.

Also since this second load test applied equal upward and downward forces on the rock socket, the maximum loads applied during the test did not approach either the ultimate side shear or end bearing capacity of the shaft. Therefore, the design-build team could not determine an actual ultimate side shear or end bearing value from this load test. However, this second O-cell load test was used to successfully proof test the design by loading the actual Pier 7 test shaft to approximately three times the design load.

The second load test results indicated an ultimate unit side resistance in excess of 19 ksf. Using this actual load test result indicated that the side resistance capacity of the shaft that was 1.5 times higher than the conservative estimate developed under the AASHTO method for this particular large-diameter drilled shaft and type of bearing material.

Using load tests was a valuable tool for optimizing and verifying the foundation design. Results from the initial load test were used to increase the estimated design capacity and economically reduce rock socket lengths for the remaining drilled shaft foundations on the project. The second load test verified the design optimization decisions used on Piers 7 through 9 that were based on results from the first load test.

The floating "lost" cofferdams were each precast on a barge anchored in the Kennebec River at the casting yard. To allow the cofferdams to float, each cofferdam was fitted with steel caps bolted over the individual openings for extension of the drilled shafts through the bottom slab of the precast form. The barge was then floated downriver to the Bath Iron Works facility where two permanent shipbuilding cranes worked in tandem to lift each 300-ton precast cofferdam and place them in the river (see Figure 7). A temporary steel extension was attached to the cofferdams, prior to their being guided into position by tugboat. Once positioned over the completed drilled shafts, the cofferdams were submerged to plan elevation and aligned with the shafts using a temporary frame located around the perimeter of the system as a template. A seal was placed in the bottom of the form and the footing was constructed. The top of footing is located just below the historical low-water mark in the river and the bottom of cofferdam matches the top of drilled shaft elevations.

Because the new Sagadahoc Bridge layout overlapped the old Carlton Bridge at the Bath approach, construction of the new abutment and cast-in-place superstructure was staged to accommodate the transfer of traffic (see Figure 8). After completing the north half of the first span on the Bath approach, traffic was transferred from the Carlton Bridge onto the Sagadahoc Bridge. Then the approach spans of the Carlton Bridge were demolished and the remainder of the new abutment and first span were completed in a second phase. This sequencing required designing the post-tensioning layouts and construction details for an overlap of both longitudinal and transverse tendons between the first and second phase of the superstructure. The lower level of the Carlton Bridge remains in place to allow for rail traffic across the old bridge. The lift span remains in a raised position until those times when rail traffic requires it to be lowered.

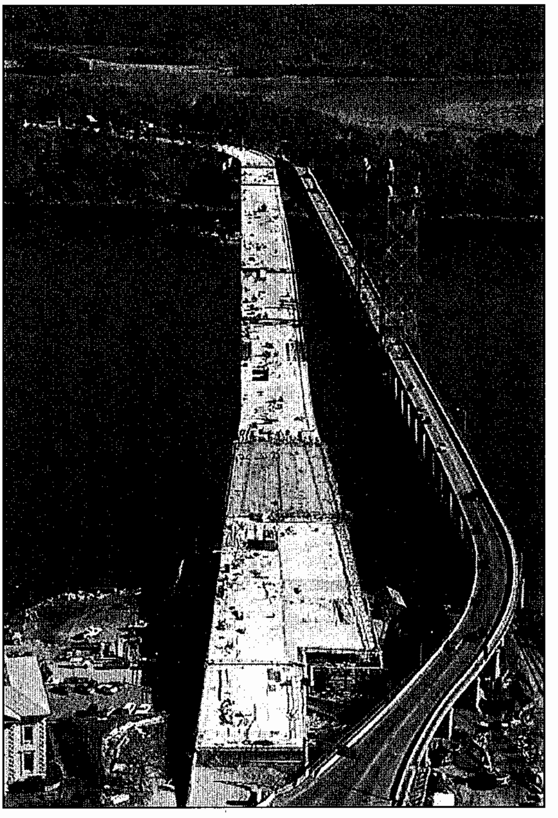

FIGURE 8. The overlapping footprint at the Bath abutment was handled by building the first span in two phases.

The general contractor established the casting yard for the precast main span unit on vacant property along the Bath waterfront, within view of the bridge site (see Figure 9). This property was stabilized to support the casting machine and other heavy equipment. A heated enclosure was constructed around the segment casting bed to allow precasting operations to continue year round. Segments were stored at the casting site prior to erection.

The general contractor cast the first superstructure segment in May 1998 and the last of 202 total main span segments in September 1999 (see Figure 10). The first precast superstructure segment was then erected in September 1998. The final segment was placed in November 1999.

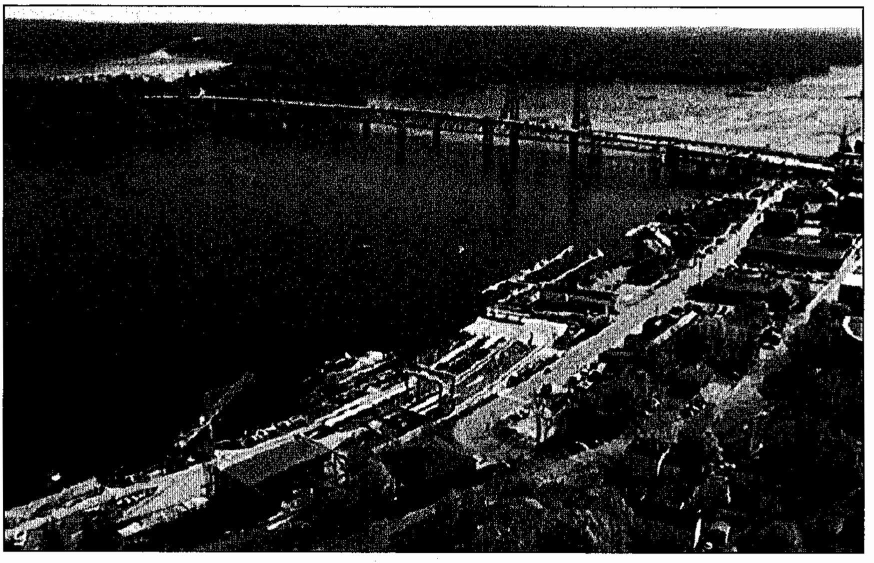

FIGURE 9. The casting yard established adjacent to the bridge site.

process began by constructing a pier table on top of the twin wall piers. A special adaptation of the technique was used to minimize the pier segment weights. Precast segments were erected on top of the twin walls to each side of the twin wall piers (see Figure 12 on page 50). The diaphragm segment was cast in place between the precast elements. The precast segments were then incrementally placed and secured by post-tensioning bars and tendons on alternating sides of the pier table.

The balanced cantilever method for precast segmental erection was used to construct the spans over the river. The segments were delivered by barge from the adjacent casting yard and lifted into place with a barge-mounted crane (see Figure 11). The balanced cantilever

Both the Woolwich and Bath approaches are concrete multi-cell box girder superstructures that were cast in place on falsework. The first superstructure placement for the Woolwich approach was performed in August 1998 and casting was complete within five months. The first placement for the three-span, variable-width Bath approach unit occurred in May 1999 and was completed within six months.

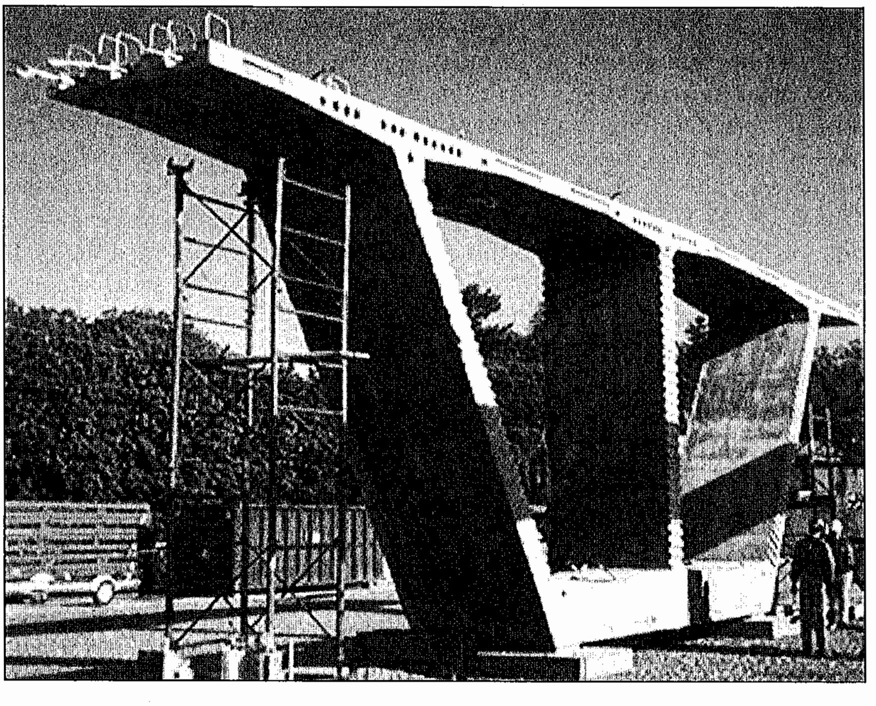

FIGURE 10. Precast segments were 69 feet wide with a variable depth of 9.333 feet to 19 feet 7 inches.

Minimizing the impact of severe Maine winters by precasting the superstructure of the main span unit

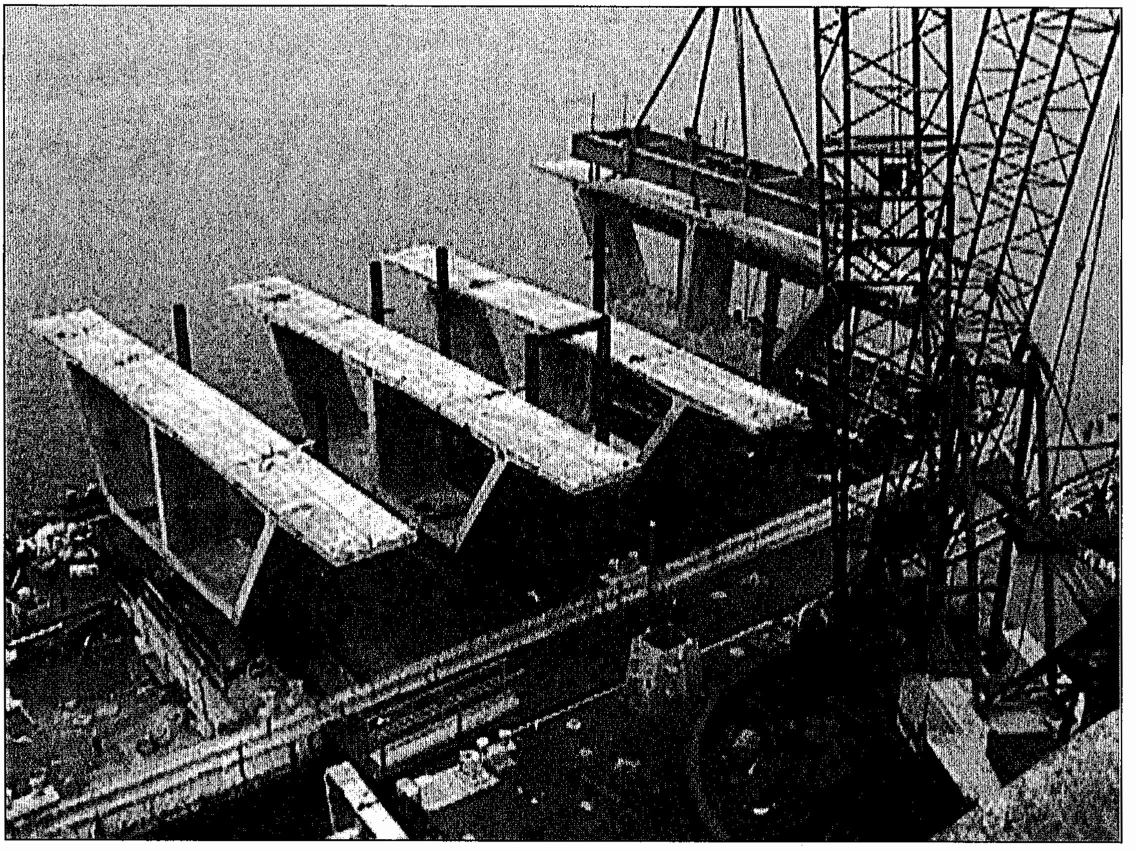

FIGURE 11. Segments were delivered by barge from the precasting site to the site.

contributed to the timely transfer of traffic in May 2000 and completion of the project by August 1, 2000 (see Figure 13 on page 51). The project was completed thirty days early, earning the general contractor a completion bonus of $90,000. In addition, a maximum bonus of approximately $1 million was earned for achieving the concrete quality performance goals. Mixing precast and cast-in-place technologies for the bridge superstructure optimized the overall schedule and provided a quality product.

Appraisal of Finished Product

The State of Maine successfully accomplished its objective of securing federal funding to construct the highest quality new Sagadahoc Bridge for the least price. This project's outcome directly resulted from Maine DOT's use of a customized value-based process for selecting the design-build team. Attention to the following details in the RFP and design-build documents contributed to the successful realization of Maine DOT's objective.

- *Emphasis on a good quality control plan.* The quality control documents set contractual standards and expectations for the design-build team's construction practices. These documents directly influenced product quality and the working relationship between the owner and design-build team field representatives. This project presents a positive example of the importance of attention to quality control. The thoroughness of a responsive design-build team's quality control plan was significantly weighted in the technical scoring.
- *Balance of owner needs with design-build team creativity.* It is preferable for owners to explicitly identify desired items in the RFP, while remaining open to design-build team creativity. This approach involves yielding some control over the

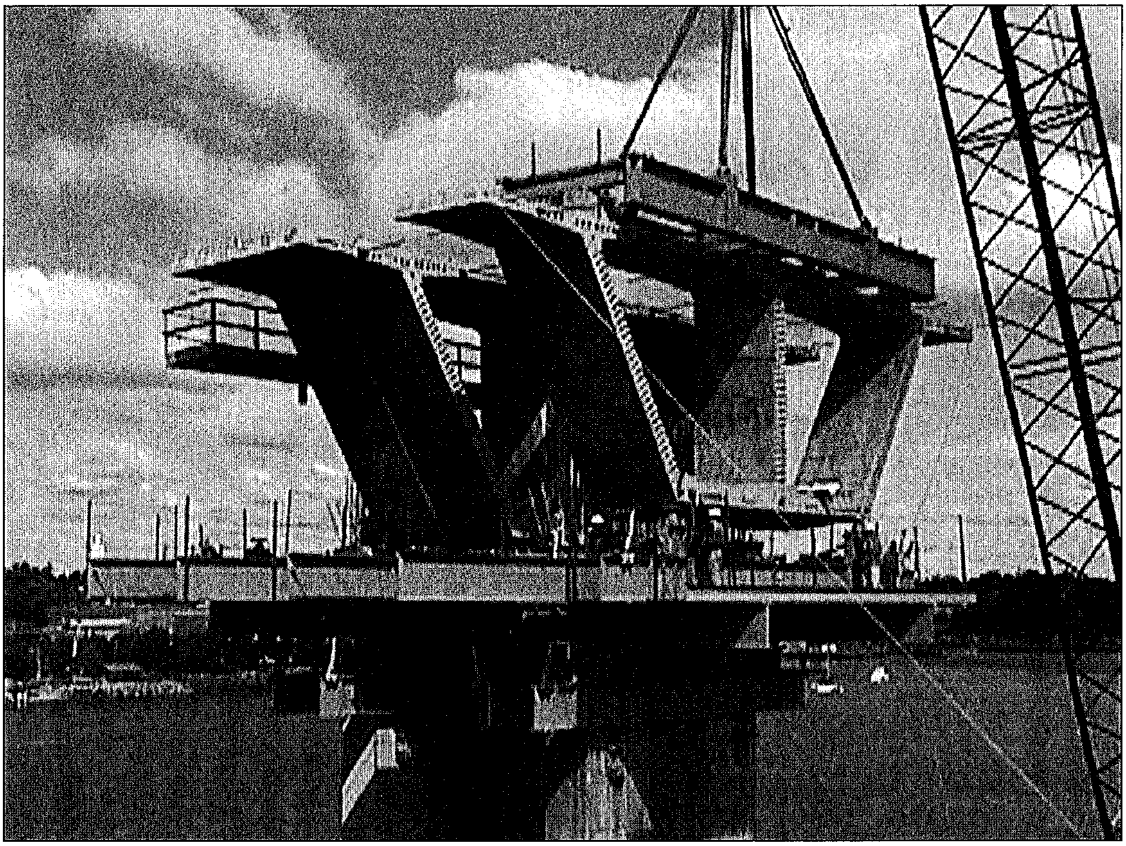

FIGURE 12. Precast segments with cast-in-place diaphragms for pier tables.

design and construction process since the design-build team will be implementing the design and construction at a fast pace. The owner's expectations were met by fully defining the performance specifications as part of the RFP. By releasing control of design details that are not explicitly defined in the RFP, the owner encouraged the possibility for a creative outcome. Given this freedom, the design-builder could introduce an innovative new construction method or design consideration that could then be incorporated by the owner into future projects.

- *Unbiased selection process.* The selection process must be unbiased and comprehensive to fairly and accurately assess and score the proposals. One reason for the success of this project is that the owner defined explicit RFP requirements and then objectively evaluated the proposals based on the submitted proposals' responsiveness to these specific requirements.
- *Explicit monetary incentives/penalties.* This program was successful in motivating the design-build team to provide outstanding materials. The design-build team focused on achieving the defined concrete strength, air entrainment and reinforcing clearances in order to receive financial incentive payments. This program served as a successful method for the owner to obtain quality in the project.
- *Providing a fair contract.* Balancing risk with control is critical to the working relationship between the owner and the design-build team. This balance intrinsically reduces the probability of claims.

As part of the design-build contract, warranty inspections have been performed as prescribed at two and four years after the completion of construction. These warranty

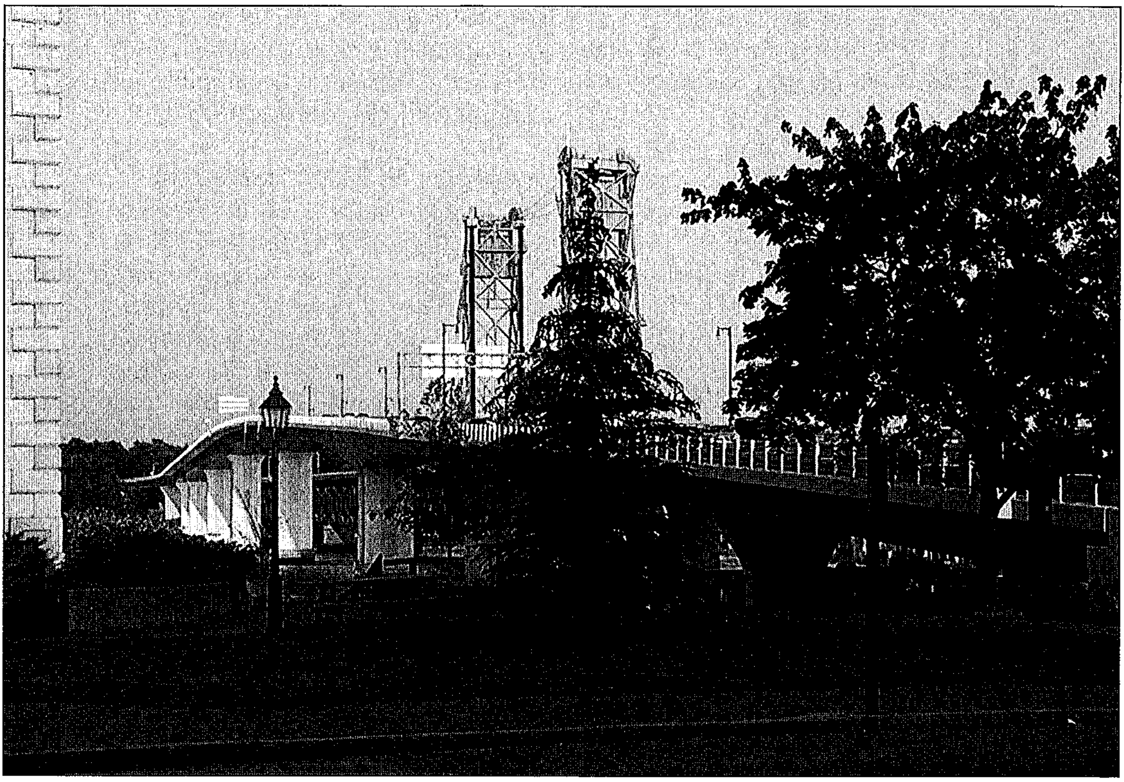

FIGURE 13. A view of the completed Sagadahoc Bridge.

inspections were performed in September 2002 and August 2004 by Maine DOT, along with representatives from the design-build team. After four years of exposure to a wide range of traffic, weather and tidal fluctuations, the inspections confirmed that the structure was in excellent condition.

The design-build team successfully delivered a high-traffic capacity, durable bridge on time and within budget that will provide many years of service. As a bonus, the State of Maine and the local communities are benefiting from the recognition and aesthetic pleasure of this bridge, which has been commended through the following awards:

- 1999 Northern New England Concrete Promotion Association Outstanding Concrete Construction Award;
- 2000 American Council of Engineering Companies, Colorado Chapter Grand Conceptor Award;
- 2001 National Council of Structural Engineering Associations Award of Merit; and,
- 2001 Design Build Institute of America Design Build Excellence Award, Civil (more than $15 million).

ACKNOWLEDGMENTS — *The design-build team for this project consisted of general contractor Flatiron Structures, LLC, with headquarters in Longmont, Colorado, and the lead designer, FIGG Bridge Engineers, Inc., with headquarters in Tallahassee, Florida. The FIGG design effort was led from the firm's Denver, Colorado, office. There were many designers, sub-contractors and material suppliers that contributed to the design-build team. Some of the supporting firms and their responsibilities were: Case Foundations Co. — drilled shaft installation; Libby Steel, Inc. — reinforcing steel placement; S. Williams Concrete, Inc. — concrete supplier; Pike Industries, Inc. — asphalt contractor; A D Electric, Inc. — signing and lighting contractor; A D Rossi, Inc. — traffic rails and waterproof membrane; DSI USA, Inc. — post-tensioning supplier; Ben C. Gerwick, Inc. — cofferdam design; Pine Tree Engineering — roadway and traffic engineering; Law Engineering &*

Environmental Services, Inc. — geotechnical engineering; Bartlett Engineering — electrical engineering; and The Mintz Lighting Group — specialty lighting consultant.

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