procedural adjustments were required during fabrication. During detensioning of the first pair of girders, three strands prematurely ruptured. It is thought that elastic shortening of the concrete girder as the strands were detensioned caused increased tension, calculated to be 80% of the tensile strength and 57% of the minimum specified rupture strain of stainless steel strand. It is possible that the beam formwork or the pretensioning bulkheads may have caused local stress concentrations in the strand, leading to brittle failure. To rectify the safety and girder durability issues, the second set of beams were redesigned. In these beams, the middle 16 of 54 total strands (the last strands detensioned) were only pretensioned to 58% of f_{pu}. There was sufficient leeway in the design to keep the same number of strands—the beams were initially designed for zero tension under service loads and then revised to limit the service tension in the concrete to 0.3 ksi per AASHTO LRFD specifications Table 5.9.2.3.2b-1 for components with bonded tendons subjected to severe corrosive conditions. The second set of beams was detensioned without issue.

The existing dry-laid granite causeways of the 1926 bridge were constructed for a 20-ft roadway and were too narrow to support the 30-ft roadway leading up to the new superstructure. The new roadway is carried by approach spans that span the causeways with center-to-center bearing span lengths of 53 ft 9 in. (north approach) and 30 ft 3 in. (south approach). Supported by the existing abutments and by new concrete grade beams, the approach spans each consist of eight butted 2-ft 7-in.-deep by 4-ft 0-in.-wide reinforced precast concrete beams with 5-ksi concrete design strength supporting an 8-in.-thick cast-in-place concrete topping slab. The approach beams are conventionally reinforced with Grade 100 high-chromium, low-carbon steel meeting the requirements of ASTM A1035. No prestressing was used in the components of the approach spans. The contract gave the contractor the option of fabricating the nonprestressed concrete components.

Substructure

The gravity abutments from the 1926 bridge were rehabilitated to support the proposed superstructure. Bedrock is shallow at the site, and exposed bedrock outcrops are prevalent adjacent to the north approach causeway and in the channel. Borings taken through the abutments indicated that the north abutment had been founded on cleaned bedrock while portions of the south abutment had been founded on native till soils. To mitigate future settlement and undermining, the south abutment was underpinned with micropiles. Eight micropiles, each with an 11.875-in.-diameter casing and a no. 18 central reinforcing bar, were installed in 14-in.-diameter cored holes in the south abutment. The annulus around the micropile casing was tremie-grouted with a permeating grout. The grouting process also served to permeate and fill nearby holes, voids, and wide cracks within the existing abutments.

For both abutments, the loose bedding mortar between courses of stones was removed and replaced with cementitious mortar. Mortar joints in the tidal zone were sealed with epoxy caulking rated for saltwater inundation. Where possible, this work was done in the dry by working around the tidal elevations, and underwater work was completed with dive crews at slack tide. The concrete abutment caps were demolished and replaced with hammerhead cast-in-place concrete abutment caps to accommodate the wider roadway width of the proposed superstructure. The roadway profile was also raised to accommodate sea-level rise and to improve the vertical geometry of the bridge and roadway.

The approach spans are supported on one end by the rehabilitated abutments and on the other end by micropile-supported, cast-in-place concrete grade beams installed beyond the limits of the existing stone retaining walls.

Conclusion

In November 2023, a significant milestone was reached: the new superstructure was opened to the traveling public, and in June 2024, the project reached completion. The use of durable precast concrete with corrosion-resistant reinforcement will provide a low-maintenance facility in this challenging location. The completed project provides sufficient roadway width to safely accommodate pedestrian and vehicular traffic while maintaining the historic abutments and approach

AESTHETICS **COMMENTARY**

by Frederick Gottemoeller

Small bridges deserve thoughtful design, too. This is especially true if they overlook visual spectacles, such as a reversing waterfall that draws whitewater kayakers and crowds of spectators during the summer months, or if they include historic, memorable, and still-capable structural features, such as granite-faced gravity abutments.

Thoughtful design requires consulting project stakeholders, including members of the community that surrounds the project, uses it every day, and takes pride in its appearance and setting. Doing so pays direct benefits. For one thing, it creates community understanding of the structural imperatives driving the need to replace or repair the structure. For another, it uncovers seemingly inconsequential enhancements that mean so much to a community and will determine the acceptance of the structure by future generations. At the Falls Bridge in Blue Hill, Maine, these enhancements included the decorative steel railing, stamped and colored shoulder pavement, and color coating of the precast concrete beams so that the arched concrete fascia panels stand out.

The decision to preserve and reuse the granite abutment walls was especially inspired. While observing the daily tidal cycle, spectators' attention is drawn to the supports of the bridge. Over the walls' almost 100-year life, the stone has stood up to the daily stress of nature. This is a testament to the stone's authenticity, durability, and obvious strength. The granite impresses in a way that no formliner-created "stone" can. It also extends the memory of the original bridge into the future. Blue Hill's Falls Bridge will continue to be a source of community pride for another 100 years.