The James River Bridge: rescue campaign for a 7 kilometer crossing

Autor(en): **Kuesel, Thomas R.**

Objekttyp: **Article**

Zeitschrift: **IABSE congress report = Rapport du congrès AIPC = IVBH Kongressbericht**

Band (Jahr): **10 (1976)**

PDF erstellt am: **26.04.2024**

Persistenter Link: https://doi.org/10.5169/seals-10411

Nutzungsbedingungen

Die ETH-Bibliothek ist Anbieterin der digitalisierten Zeitschriften. Sie besitzt keine Urheberrechte an den Inhalten der Zeitschriften. Die Rechte liegen in der Regel bei den Herausgebern.
Die auf der Plattform e-periodica veröffentlichten Dokumente stehen für nicht-kommerzielle Zwecke in Lehre und Forschung sowie für die private Nutzung frei zur Verfügung. Einzelne Dateien oder Ausdrucke aus diesem Angebot können zusammen mit diesen Nutzungsbedingungen und den korrekten Herkunftsbezeichnungen weitergegeben werden.
Das Veröffentlichen von Bildern in Print- und Online-Publikationen ist nur mit vorheriger Genehmigung der Rechteinhaber erlaubt. Die systematische Speicherung von Teilen des elektronischen Angebots auf anderen Servern bedarf ebenfalls des schriftlichen Einverständnisses der Rechteinhaber.

Haftungsausschluss

Alle Angaben erfolgen ohne Gewähr für Vollständigkeit oder Richtigkeit. Es wird keine Haftung übernommen für Schäden durch die Verwendung von Informationen aus diesem Online-Angebot oder durch das Fehlen von Informationen. Dies gilt auch für Inhalte Dritter, die über dieses Angebot zugänglich sind.

Ein Dienst der *ETH-Bibliothek*
ETH Zürich, Rämistrasse 101, 8092 Zürich, Schweiz, www.library.ethz.ch

http://www.e-periodica.ch

The James River Bridge. Rescue Campaign for a 7 Kilometer Crossing

Le pont sur la rivière James.
Campagne de sauvetage d'un pont de 7 km

Die Brücke über den James River.
Rettungsaktion für eine 7 Kilometer lange Brücke

THOMAS R. KUESEL
Partner
Parsons Brinckerhoff Quade & Douglas
New York, N.Y. 10001, USA

To design a highway bridge crossing of a 7-km-wide estuary for economical construction and minimum maintenance cost is a technical challenge. To plan construction of such a facility without any source of funds introduces some practical problems. When the project involves replacement of a 50-year-old structure that is literally falling apart, piece by piece, the problems assume some urgency. The efforts to resolve these problems are best described not as a design, but as a campaign. This, then, is a recital of the campaign to rescue the James River Bridge.

The existing bridge was constructed in 1928 as a private toll facility. It consists of a 90-meter (m) vertical lift span, 730 m of steel truss and girder spans, and 6,200 m of 13.4-m steel stringer trestle spans. Since 1949 the bridge has been part of the Virginia State Highway System, forming one of the principal highway routes across the maze of estuaries of Tidewater Virginia (see Fig. 1). Traffic has grown to 4 million vehicles per year, with a peak of 1,000 per hour in one direction.

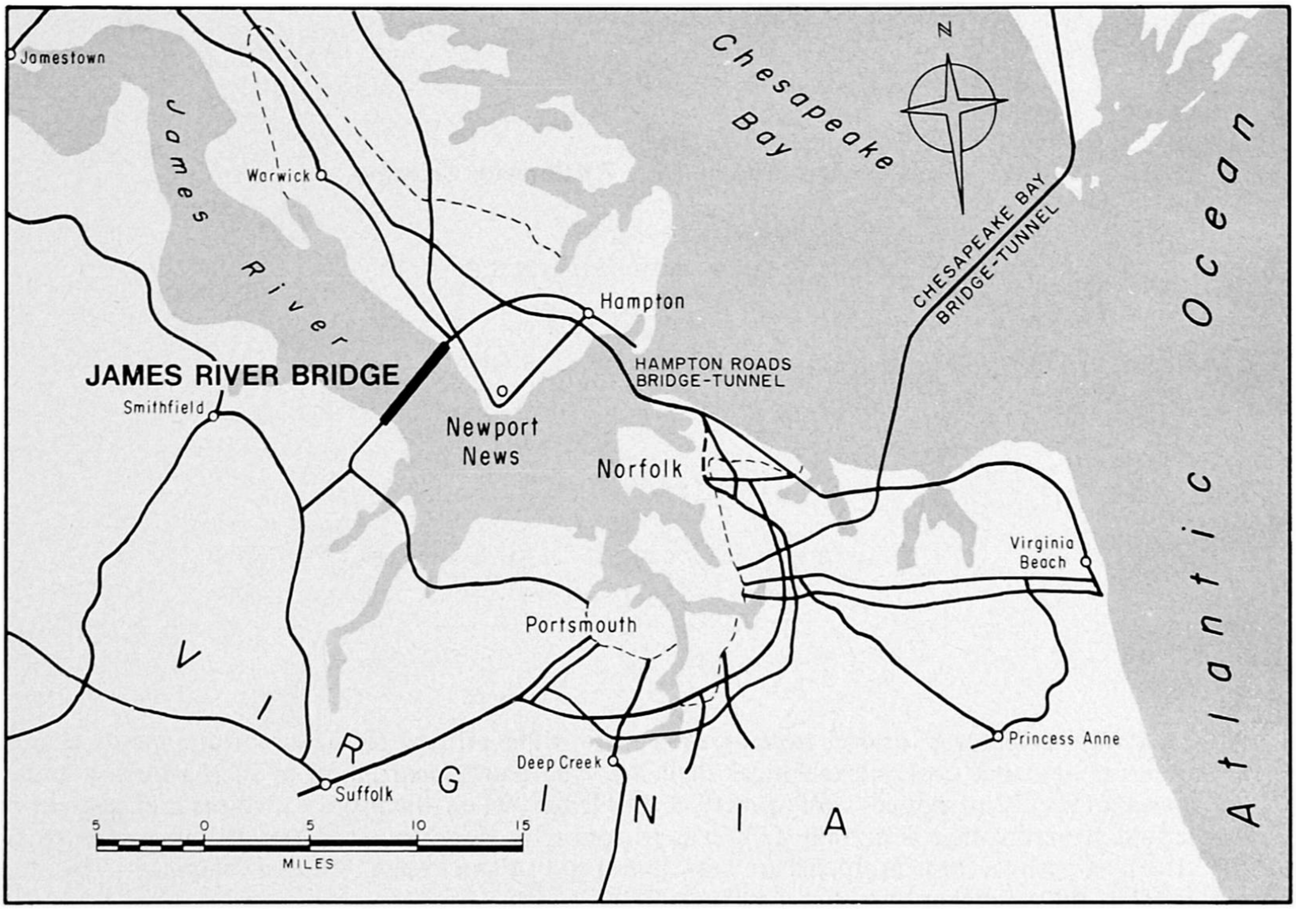
By the 1960s the 6.7-m-wide roadway had become seriously obsolescent, particularly with no facilities for handling breakdowns anywhere in the 7-km bridge length. Beyond this, physical deterioration of the structure was accelerating alarmingly, primarily from exposure to a salt-laden marine environment. Figures 2 and 3 show typical conditions on the trestle spans. There was serious concern that the bridge might actually collapse, and its replacement became a priority project of the Virginia Department of Highways.

Unfortunately, there was no money. All federal aid and state matching funds were committed to other projects of even higher priority. The $60 million cost of a new four-lane bridge was simply out of the question.

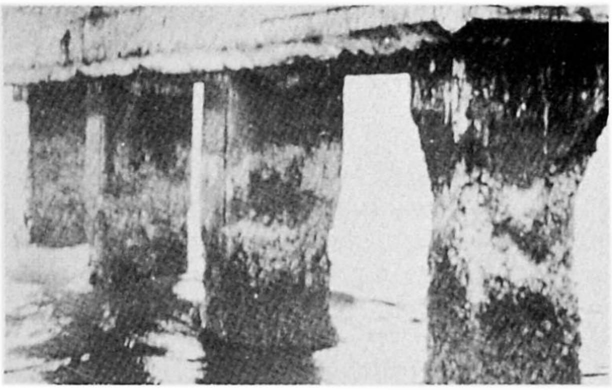
The only potential financing source was the Reserve Maintenance Fund of the Virginia Toll Bridge and Ferry System, to which the James River Bridge belongs. This could yield sufficient money for emergency repairs, and over a period of years might accumulate enough to start the reconstruction. But it was scheduled to go out of existence in 1976, when the completion of the federally financed Second Hampton Roads Bridge-Tunnel Crossing would trigger the removal of tolls throughout the system, redemption of bonds, and reversion of all reserve funds to the general State treasury. And in the most optimistic view, this fund might yield barely one-third of the money required for the new bridge.

Under these constraints, the rescue campaign evolved in four phases:

1. Repairs to hold the old bridge together while a construction fund was accumulated.



1. James River Bridge Location



2. Necked pile caps damaged by age and salt water

3. Deteriorated riding surface temporarily repaired with poured asphalt

2. Initial construction of a new 6.2-km two-lane trestle, with temporary crossover connections to the old 800-m channel crossing.

3. Addition of the four-lane channel crossing.

4. Addition of the second two-lane trestle to complete the full four-lane facility.

The timing of Phase 2 was critical – it had to be deferred until sufficient funds were accumulated but had to be completed before 1976 when the source of funds would disappear. The repairs of Phase 1 had to be sufficient to maintain the structure safely until its replacement parts were completed, but not so extensive as to deplete the funds being accumulated for reconstruction. And everything had to be done during a period of unpredictably escalating construction costs.

The key to the success of the campaign was the observation that 90 percent of the trouble with the old bridge was contained in the 6.2-km trestle, but only one-third of the reconstruction cost was needed to replace this with a new two-lane structure.

The campaign thus developed with two objectives:

1. To manage and conserve the limited available resources to implement Phases 1 and 2.

2. To plan Phases 3 and 4 to minimize life cycle costs of the facility, including both capital construction costs and maintenance and operation costs..

The critical deterioration of the old trestle structure was concentrated in the concrete within the tidal zone and on the undersides of the pile caps and roadway deck. In these areas salt penetration had caused extensive spalling and softening of concrete and exposure and rusting of reinforcing steel. Many of the concrete piles were necked down alarmingly (see Fig. 2). Two thousand five hundred piles were repaired (after chipping away all deteriorated concrete) by encasing them in cylindrical concrete jackets placed within gasketed water-tight cofferdam forms. Eroded concrete on the underside of the deck, and the side and bottom surfaces of the pile bent caps, which had been most exposed to salt spray, was also chipped away and repaired with pneumatically projected mortar.

Fortunately, the structural steel was in relatively good condition, and it was decided that it could be maintained for the required duration with minimal isolated reinforcement, plus maintenance painting. Systematic repairs were necessary for the concrete disphragms joining the steel stringers at the ends of each span. Thirty percent of these diaphragms were cracked, and were reinforced with steel channels and brackets. The concrete deck surface was badly cracked, but it was decided to spend the available money on structural repair to the under-surface rather than cosmetic repair to the top surface. The cracks were, therefore, sealed with poured asphalt (see Fig. 3), and the crazy quilt patched riding surface served as a constant reminder that Phase 1 was a temporary program.

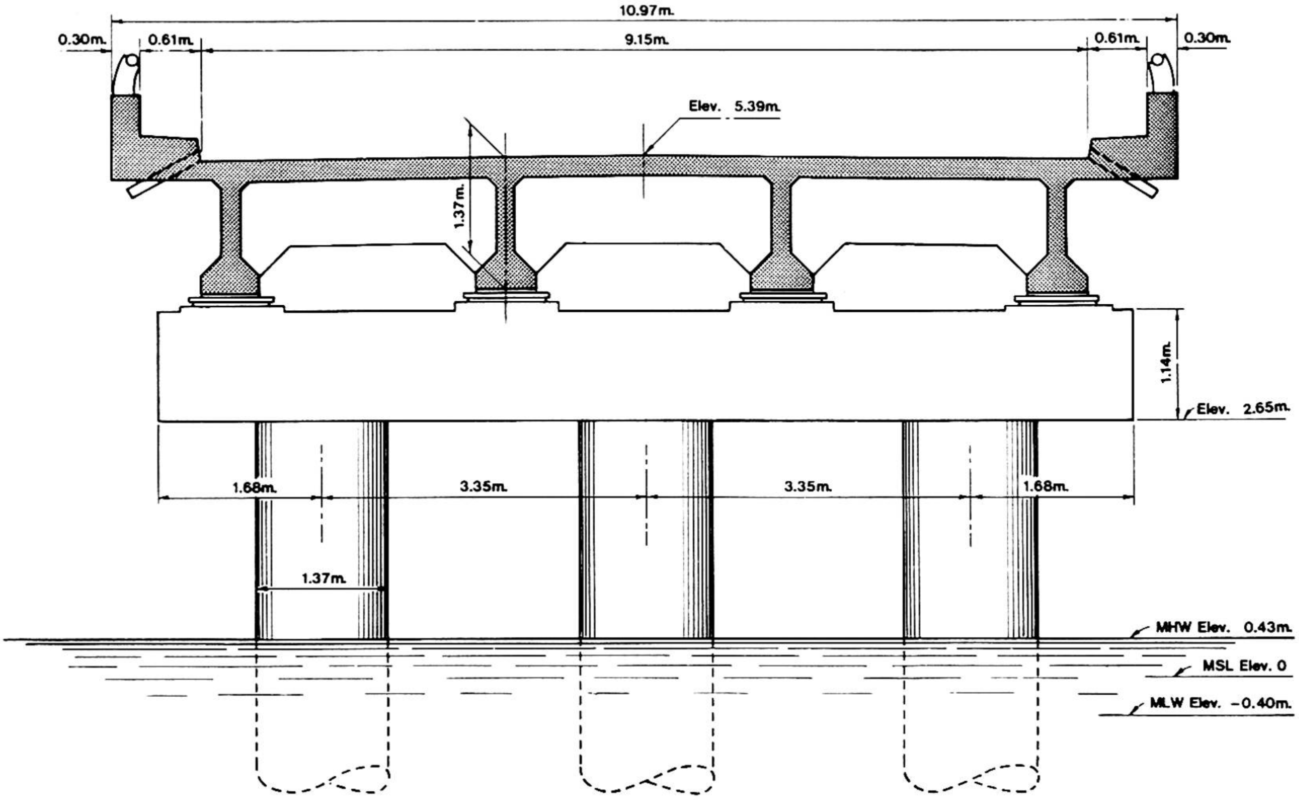
The design of Phase 2 had two objectives: to minimize initial construction costs of the new trestle structure and to eliminate the sources of deterioration that had been observed in the old bridge. Both objectives were served by designing a completely prefabricated structure of prestressed concrete, which minimized costly field labor on the exposed river site, and secured dense, crack-free concrete produced under factory-controlled conditions.

The cross section of the new trestle (see Fig. 4) features a 9.15-m-wide roadway with two 0.6-m safety walks and solid concrete parapets. The roadway affords sufficient width for two-way traffic past a stalled vehicle. The deck is composed of monolithic units 23 m long, consisting of four longitudinal beams, four transverse diaphragms, and a 20 cm deck slab. The entire unit weighed 230 tons.

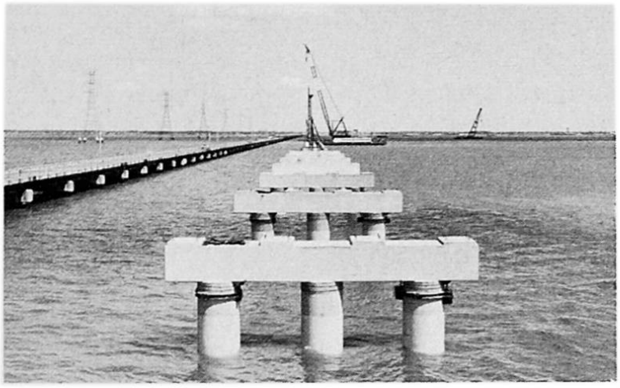
The safety walks and parapets were omitted from the precast monolith, and subsequently poured in situ. This eliminated any problems of aligning parapet and railing sections in adjacent spans, and facilitated installation of conduit and pullboxes for the roadway lighting system. Fortuitously, this also avoided a serious construction delay when a shortage of conduit developed.

Special design attention was given to eliminating creep deflection of the deck units to preclude "humping" of the spans over a prolonged service period, so that the roadway surface will remain smooth without requiring addition of a topping course. This was accomplished by arranging the prestressing tendons so that the unit stress under dead load plus prestress was uniform across the section at all points. Long-term creep will thus produce a uniform shortening of the span (estimated to be about 12 mm in 23 m), without bending deflection. The additional tendons necessary to accomplish uniform stressing added about 1½ percent to the cost of the trestle structure, compared to a design for strength only, without creep control.

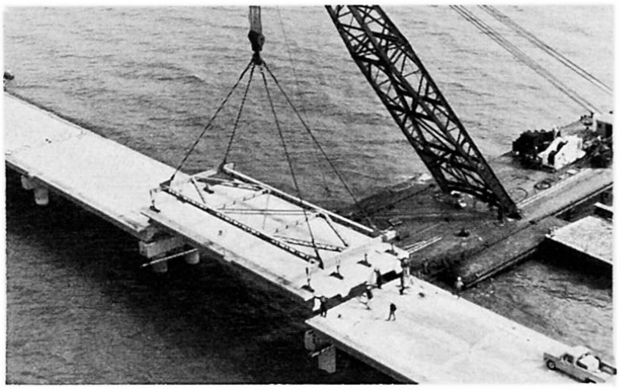
Open joints of 2.5 cm are provided across the full section of each pile bent support, to accommodate structural flexure of the simple span deck units, thermal expansion, and erection clearance for the installation of the precast monoliths. Short pipe sections through the deck slab at the gutter lines form scuppers to convey roadway drainage off the deck away from the open joints and pile bents.



4. Trestle cross section of new bridge design



5. Newly installed piles and caps for replacement roadway

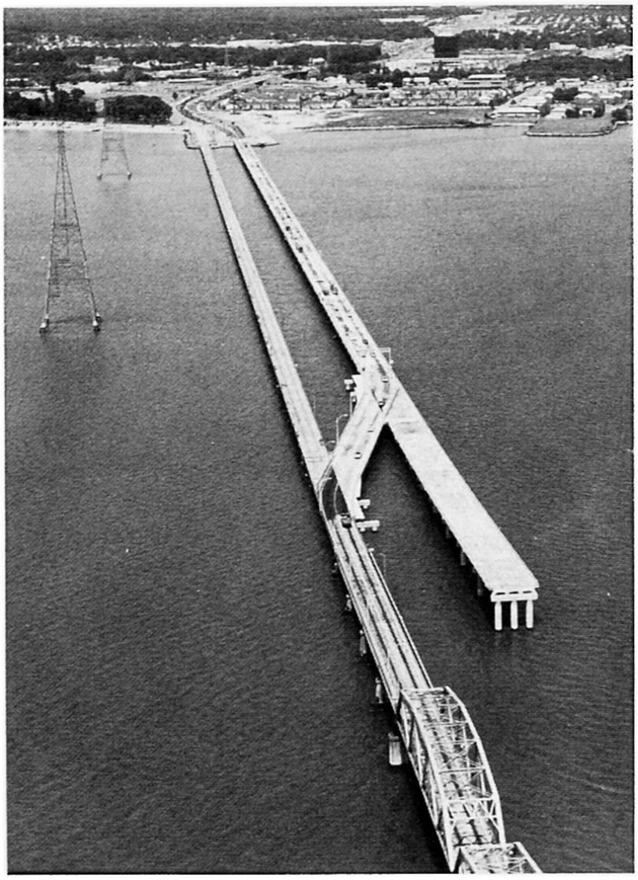


6. A span of new roadway being set in place

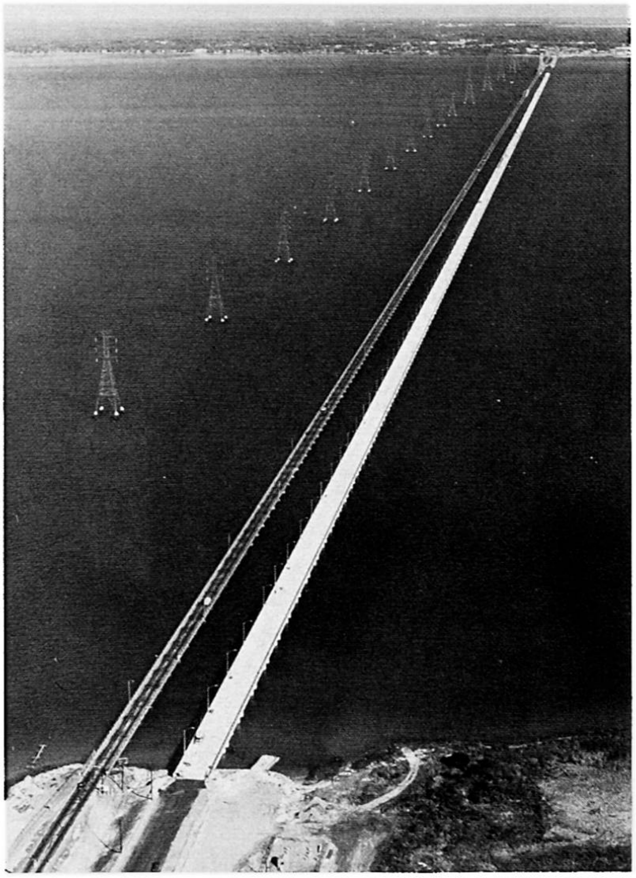
For the trestle foundations, precast, prestressed, cylindrical concrete piles were chosen. They have a diameter of 1.4 m and a wall thickness of 13 cm. Cast by a rotary centrifugal process, they have an exceptionally dense and smooth surface for resistance to salt water erosion. Over a 3-m height through the tidal zone they are further protected by an epoxy coating applied at the casting yard. The pile sections were precast in 5.2-m lengths, and joined by 16 prestressing cables to form individual piles up to 52 m long, weighing as much as 60 tons.

Three piles were connected by a precast, reinforced concrete cap to form a pile bent. The piles were filled with sand to furnish resistance against impact by small fishing vessels which abound in the area. A hollow void was left in the tops of the piles after they were cut off to a uniform elevation. The precast caps were fitted with three prongs of reinforcing steel that projected into the pile tops. After the caps were adjusted to grade and levelled, the voids were filled with concrete placed through vertical holes provided through the caps over each pile. The trestle substructure was thus established with a maximum propirtion of dense, high quality concrete and a minimum of site labor and materials.

The piles were set in prebored holes jetted into the alluvial river bottom, and then driven to a bearing stratum to develop a capacity of 180 tons each, in addition to the pile weight. Capacity was



7. Old and new bridges shown during construction with crossover in operation



8. Aerial view of parallel crossings from south approach looking north

confirmed by a series of 360-ton load tests. In granular soils, capacity was attained with only short driving. In silt and clay soils, it was necessary to drive the piles as much as 12 m. This required special precautions to avoid driving a plug of soft soil up inside the cylindrical pile, creating internal bursting pressures which could split the pile.

To minimize the effects of salt water spray on the deck units and pile caps, the crown of the new roadway was established at 5 m above mean high water (1.1 m higher than the old trestle). This places the bottom of the pile caps 2.2 m above mean high water. The selection of 3-pile bents was made to preserve stability in the event that any one pile was severely damaged by a collision.

Successful construction of the project is attributable to the availability and utilization of heavy marine equipment capable of handling and placing the 60-ton piles and 230-ton deck units within the close tolerances required to secure proper fit of the precast elements. The accuracy of final assembly is a tribute to the care and skill of the construction contractor, Tidewater-Raymond-Kiewit, and to the precaster, Bayshore Concrete Products Corporation.

The 6.2-km new trestle structure was completed and joined to the old channel crossing by temporary crossover structures in September 1975, at a cost of approximately $17 million, well within the available funds for Phase 2. This has permitted retiring the old trestle structure, and has eliminated 90 percent of the safety hazards of the crossing.

Design of Phase 3, the new channel crossing, has been completed, and construction is scheduled to start in the fall of 1976, when sufficient funds will become available. The old channel crossing consisted of a 90-m vertical lift span furnishing a 15-m vertical clearance in the down position. The new crossing is also a vertical lift, but the span has been increased to 126 m to provide a 106-m-wide navigation channel, and the vertical clearance was set at 18.3 m, which is estimated to reduce the required number of openings by over 50 percent.

A fixed, high-level crossing was considered as an alternative to the adopted design, but the required 44-m vertical clearance would have resulted in a long, high structure of expensive elements. In addition to an estimated $20 million extra capital expenditure for the complete four-lane project, this layout would have precluded the half-width construction of 1.5 km of the trestle approaches, and required maintaining a corresponding length of deteriorated old trestle in service until the completion of Phase 3. Finally, the energy cost of requiring all highway traffic to climb an additional 30 m was judged to be more objectionable than the relatively infrequent delays attributable to opening the movable span.

Phase 3 was designed as a full four-lane crossing for the main channel span and its foundations, with two-lane approaches connecting to the Phase 2 trestle structure. It was judged to be inadvisable from an operating viewpoint to have two separate, adjacent two-lane movable spans, and such a design would have involved a substantial cost premium for the overall project. Construction funds for a two-lane channel crossing could not have been obtained any sooner than those for a four-lane facility, so there was no scheduling advantage to splitting Phase 3.

Phase 3 is currently scheduled to be completed in 1979, permitting the full retirement of the old structure. Funding of Phase 4 is not yet scheduled, but on the presumption that this will be accomplished by 1980, the duration of the James River Bridge Campaign will have been 25 years.

One oddment remains. Despite fiscal and administrative constraints, the campaign to construct the new bridge has proceeded on a logical basis. Demolition of the old structure, however, promises to cause no end of controversy. The James River and the Hampton Roads estuary are prime fishing and shellfish grounds, and all schemes proposed to date for demolition and disposal of the old structure (particularly the solid masonry piers of the channel crossing) have aroused spirited environmental objections. It appears that it might become necessary to mount a new campaign.

SUMMARY

The campaign to replace a 50-year-old bridge without sufficient funds involved (1) temporary rehabilitation and maintenance, (2) construction of 6.2 km of two-lane trestle spans, (3) construction of 800-m, four-lane channel crossing, and (4) addition of parallel two-lane trestle. Design of the new structure includes a completely prefabricated trestle featuring dense crack-free concrete, epoxy protection for concrete piles, extra tendons to eliminate creep deflection, and 3.5-m underclearance to reduce salt spray erosion. Phases 1 and 2 have been completed, solving 90 percent of safety and maintenance problems with expenditure of one-third of total project funds.

RESUME

La campagne de reconstruction d'un pont cinquantenaire avec des fonds insuffisants a comporté: 1) Remise en état temporaire et entretien, 2) Construction d'un viaduc de 6.2 km, et à 2 voies, 3) Construction sur une longueur de 800 m d'une travée à 4 voies et 4) Addition d'un passage parallèle et à 2 voies. Le projet de la nouvelle structure prévoit des piles en béton, des câbles de précontrainte supplémentaires pour lutter contre le fluage et un tirant d'air de 3.5 m pour réduire l'érosion due au sel. Les phases 1 et 2 ont été exécutées, résolvant ainsi 90 % des problèmes de sécurité et d'entretien, et dépensant 1/3 des fonds du projet.

ZUSAMMENFASSUNG

Die Aktion, eine 50 Jahre alte Brücke ohne genügende Geldmittel zu ersetzen, erfolgte in mehreren Phasen: 1) Provisorische Wiederherstellung und Unterhalt, 2) Konstruktion eines zweispurigen, 6,2 km langen Viaduktes, 3) Konstruktion einer 800 m langen Brücke über den Schiffahrtskanal, und 4) Konstruktion eines zweiten parallelen Viaduktes. Die neue Brücke wurde als vollständig vorfabrizierter Viadukt entworfen, mit dichtem, rissfreiem Beton, Epoxy-Schutz für die Betonpfähle, zusätzlichen Vorspannkabeln zum Ausgleich der Kriechverformungen und mit 3,5 m Lichtraum zur Verringerung des Salzwasserangriffes. Die Phasen 1 und 2 sind fertiggestellt. Mit dem Aufwand eines Drittels der gesamten Baukosten wurden 90 % der Sicherheits- und Unterhalts-Probleme gelöst.