NUCOR® SKYLINE

CASE STUDY

# Substructure Redesign for the Route 4 Bridge over Sprout Brook

City of Paramus, Bergen County, NJ

## A value-engineering design
Lichtenstein Consulting Engineers, Inc.
2001

After 70 years of use, the New Jersey Paramus Route 4/17 interchange reached saturation, carrying traffic volumes of 280,000 vehicles/day. In 1998, the New Jersey Department of Transportation invited bids for the reconstruction of the interchange. The 50 million dollar construction contract required the replacement of several structures, including the Route 4 bridge over Sprout Brook. Although quite modest in terms of its span of 48 feet, the structure carries 13 lanes and is 209 feet wide.

The replacement bridge was originally designed to include the construction of deep cast-in-place concrete abutments and wingwalls on piled footings. Construction of these units would have required extensive cofferdams, excavation and dewatering to accommodate pile driving operations and construction of the proposed footings. The State's Contractor, Bishop-Sanzari-Creamer, JV of Hackensack, NJ in conjunction with Lichtenstein Consulting Engineers, Inc., of Paramus, NJ proposed a value engineering process through the NJDOT. The value engineering solution eliminated the need for cofferdams by utilizing a tied-back steel sheet pile system capped with concrete to form the abutment and wingwalls.

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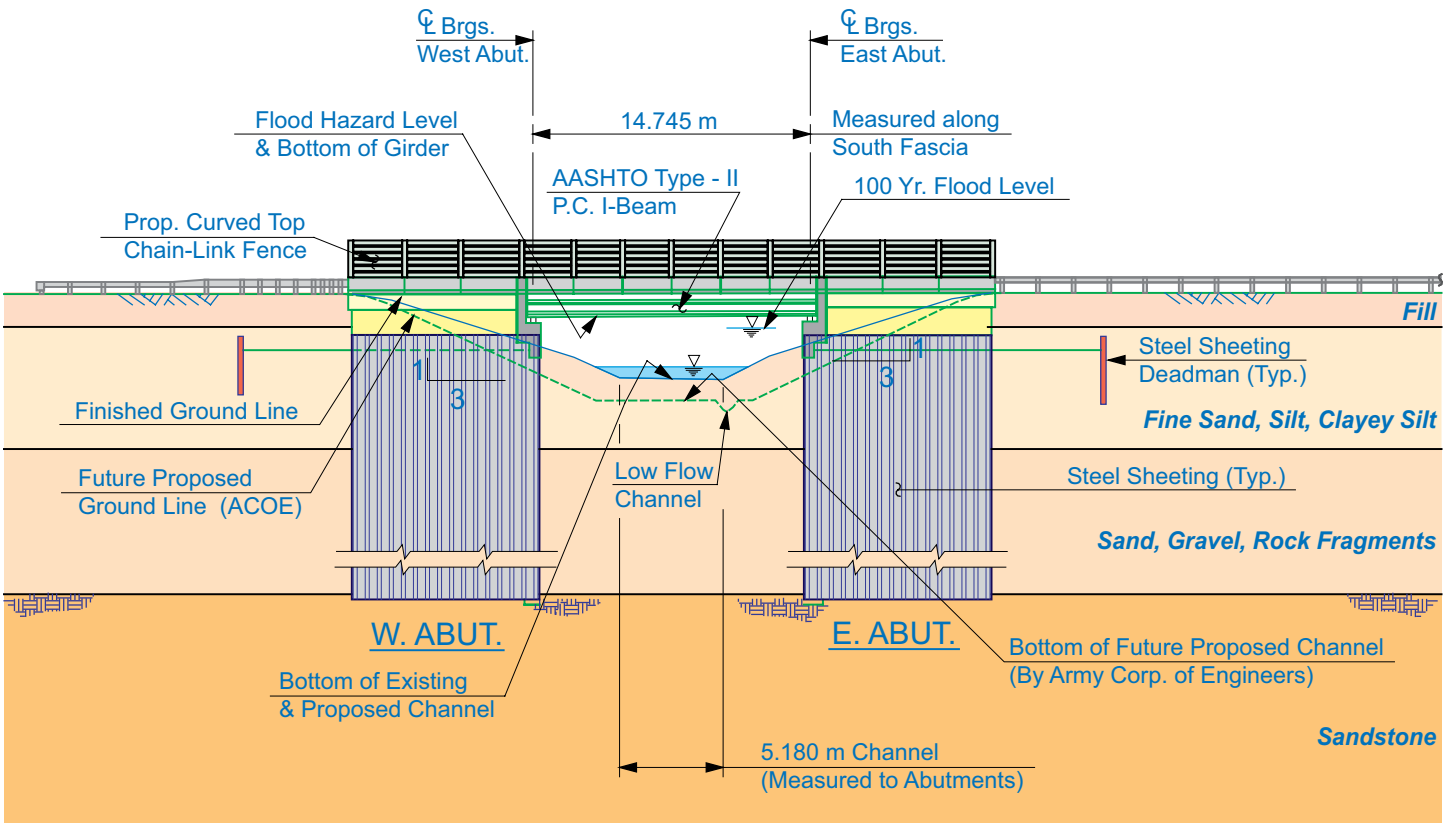


ELEVATION

The constructed substructure consisted of a cast-in-place concrete cap type abutment supported on high strength interlocking steel sheet piling driven to refusal. The wingwalls were of similar construction. The abutment and wingwalls were tied-back with high strength rods attached to a deadman system located under Route 4. The top of the sheet piles was embedded 1'-0'' into the abutment cap and designed to support the full axial load in combination with the lateral earth pressures. A seismic design was performed as per the requirements of the original Contract plans and current AASHTO specifications.

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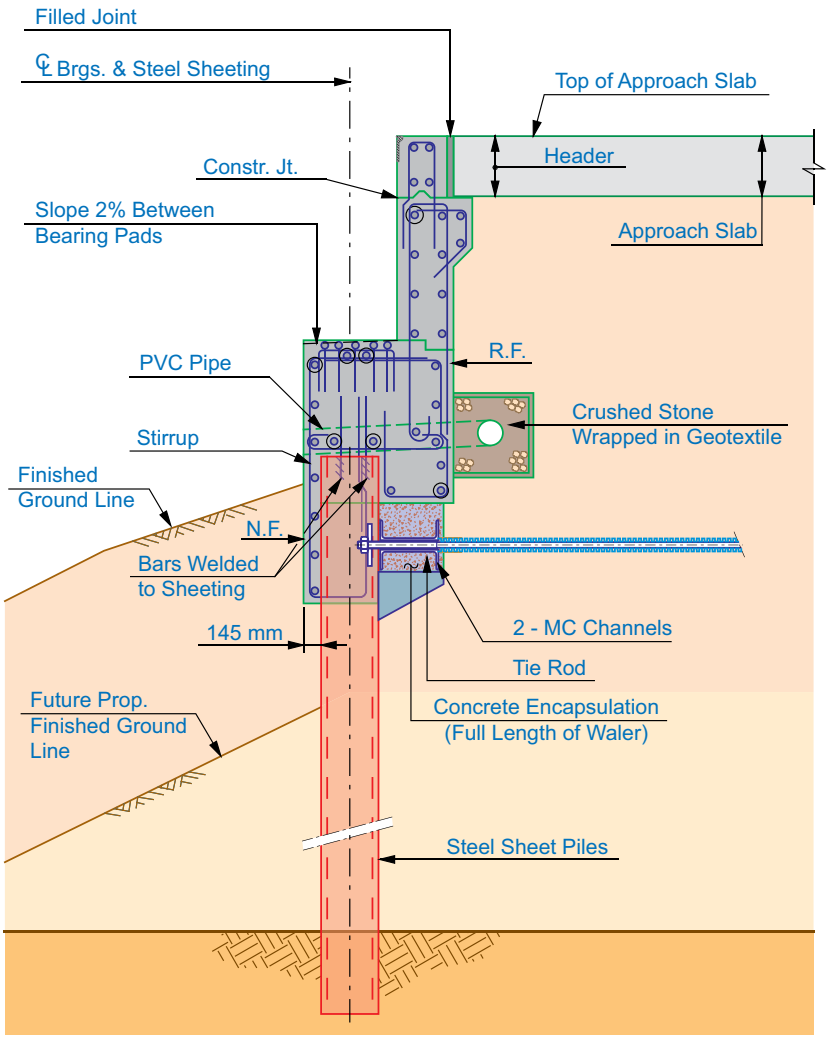


ABUTMENT SECTION

The existing geometry and superstructure design of the project remained unchanged, thereby maintaining the established profile and waterway opening. As noted the design eliminated the need for deep cofferdams, piles, concrete footings and walls as well as significantly reducing the amount of excavation to the existing channel. This resulted in less impact to the environment. Only minor modifications to the existing permits were needed. The project requirements called for a 75 year design life and also took into account proposed future dredging operations to be performed by the Army Corp. of Engineers.

By utilizing the sheet pile - cap system, there was a substantial reduction in the amount of pile driving since all the H-piles required in the cast-in-place design were eliminated. Not only were cofferdams for the abutments not needed but the permanent sheeting installed for the abutments was less in linear footage quantity than that required for the temporary cofferdams. The reduction in pile driving expedited the construction of the structure and reduced the potential for damage to adjacent structures due to vibration. The AZ 36 sheet piles for the abutments and wingwalls and the AZ 13 for the deadman system were supplied by Skyline Steel LLC.

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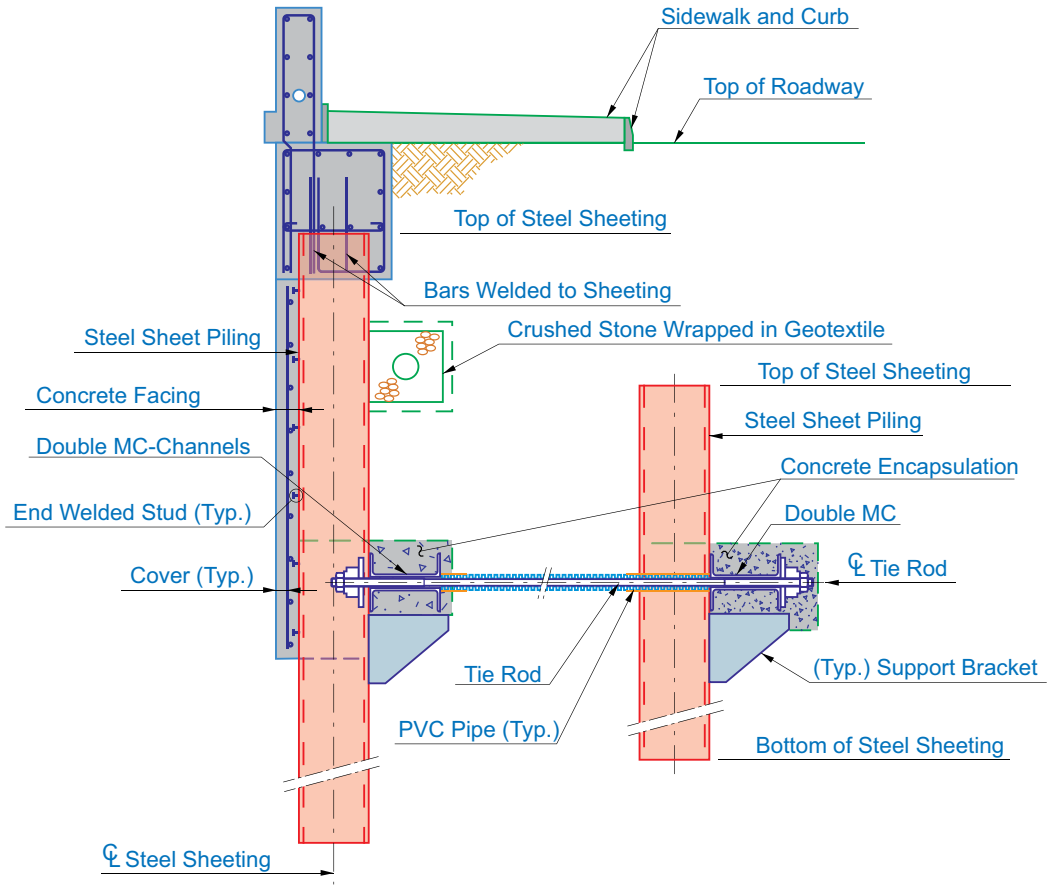


WINGWALL SECTION

The sheet piles were installed with a vibratory hammer with the last several feet advanced with an impact hammer to refusal.

The cost savings associated with the value engineering proposal was slightly over $200,000 and was shared equally between the State and the Contractor. Implementation of the value engineering proposal expedited the completion of the structure. This area of Route 4 was opened to its final traffic pattern 10 weeks ahead of its anticipated schedule. Although used in Europe for many years, at the time of construction, this was the second project in the State of New Jersey to utilize this type of design. The first application of this system in New Jersey was the Broadway Bridge in Camden County, also prepared by Lichtenstein Consulting Engineers, Inc.

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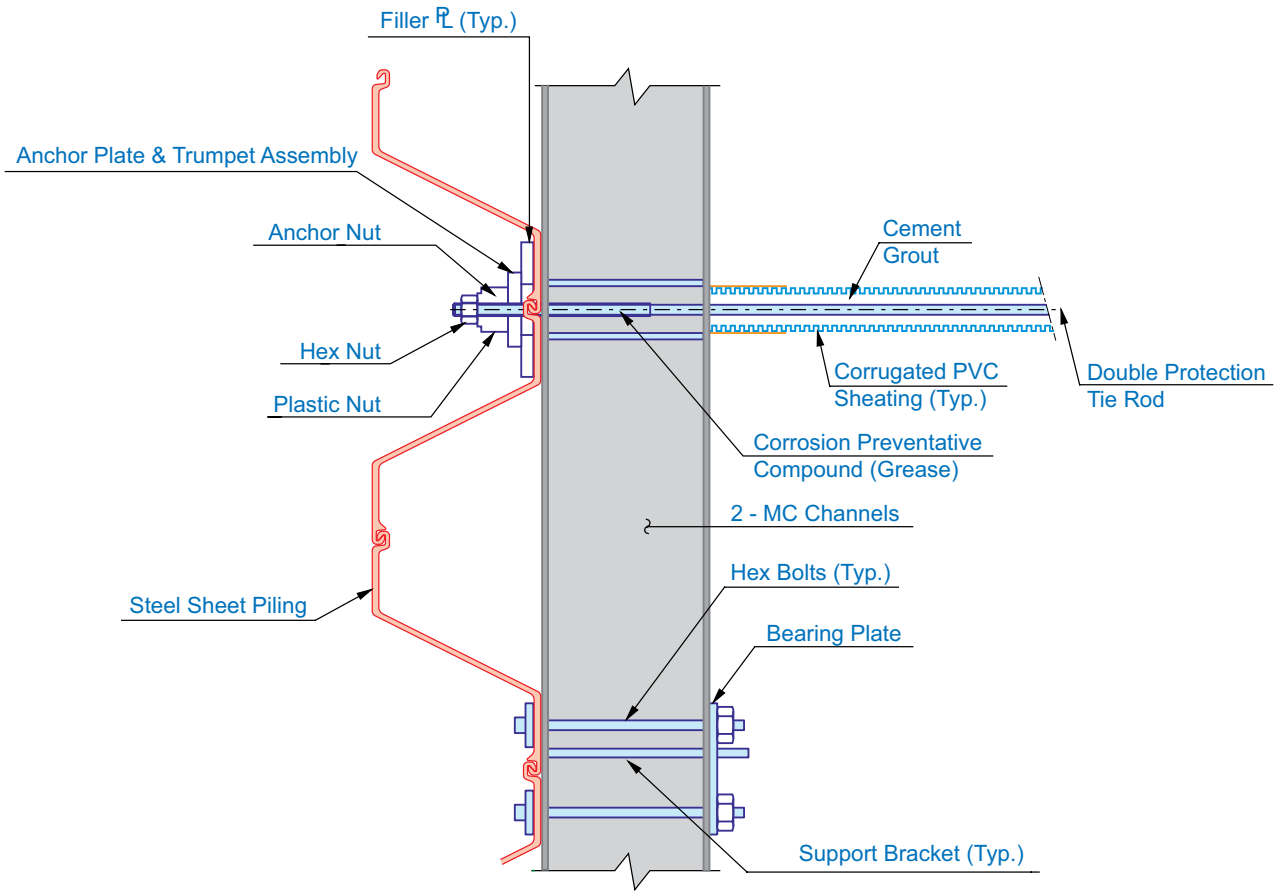


WALER PLAN
(Abutment & Wingwall)

The permanent steel piling abutments and wingwalls were designed in accordance with AASHTO Standard Specifications for Highway Bridges and included provisions for seismic events. Due to deep scour depths, the abutment design height (top of roadway to bottom of stream) had to be increased to approximately 27 feet. The steel piling abutment and wingwall included one row of tiebacks which developed resistance from a deadman system also constructed of steel sheet piling. A double corrosion protection system was used on the tierods to meet design life requirements.

The sheet piling was installed to within a few feet of the rock-line using a vibratory hammer and then driven to refusal with an impact hammer. The vertical capacity of the steel piling was limited to the structural capacity of the steel section. This more than exceeded the design vertical load of 15.5 kip/linear foot transmitted from the superstructure.

The abutment design considered combinations of both vertical and lateral loads and accounted for p-delta effects resulting from deflection and out-of-plumbness. The analysis also considered both static and seismic conditions resulting in bending moments of 45 kip-ft/ft and 150 kip-ft/ft respectively.

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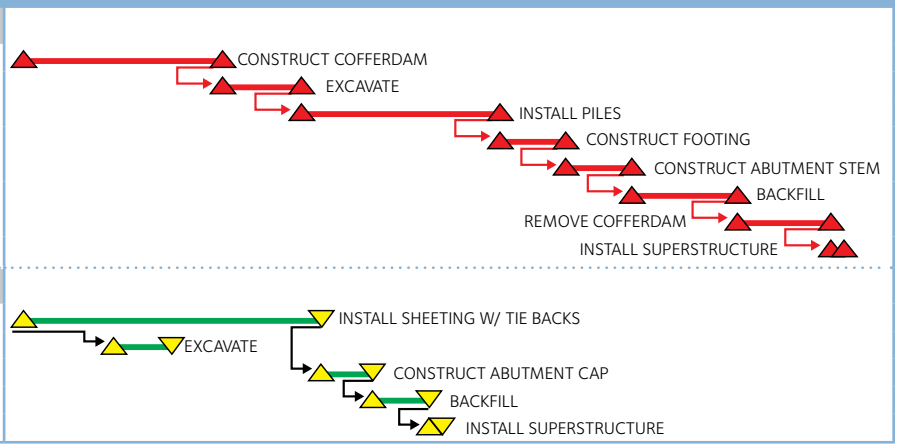
## Construction Schedule

| ACT ID | DESCRIPTION | ORIG DUR |
|---|---|---|
| **CONCRETE ABUTMENT** | | |
| CA1000 | CONSTRUCTION COFFERDAM | 40 |
| CA1010 | EXCAVATE | 20 |
| CA1020 | INSTALL PILES | 40 |
| CA1030 | CONSTRUCT FOOTING | 10 |
| CA1040 | CONSTRUCT ABUTMENT STEM | 10 |
| CA1050 | BACKFILL | 20 |
| CA1060 | REMOVE COFFERDAM | 16 |
| CA1070 | INSTALL SUPERSTRUCTURE | 1 |
| **SHEET PILE ABUTMENT** | | |
| SPA1000 | INSTALL SHEETING W/ TIE BACKS | 80 |
| SPA1010 | EXCAVATE | 10 |
| SPA1040 | CONSTRUCT ABUTMENT CAP | 10 |
| SPA1050 | BACKFILL | 10 |
| SPA1070 | INSTALL SUPERSTRUCTURE | 1 |

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