



La Plata River Bridge

Both the substructure and superstructure of this 2550 ft (777 m) long bridge were successfully bid using a precast prestressed concrete alternate design. As a result, the contractor saved the owner about \$1 million in construction costs and cut construction time by over a year. The bridge crosses the La Plata River and is located between the towns of Toa Baja and Dorado in Puerto Rico.

The bridge has 21 spans, each span being 121 ft (36.9 m) long. The deck area is 116,194 sq ft (10800 m²).

The superstructure consists of 105 modified AASHTO VI beams. This modified section is 2 in. (51 mm) thinner than the standard AASHTO VI section, thus creating a section with a higher efficiency ratio requiring less prestressing force for actual loads. Using this section, the design resulted in a saving of one beam per span.

The substructure uses a combination of 54 in. (1372 mm) circular reinforced concrete columns on 12 x 12 in. (305 x 305 mm) prestressed concrete pile foundations at twelve piers, and 54 in. (1372 mm) hollow cylindrical prestressed concrete pile columns at nine other piers.

Special beam finite element models were used to simulate the effects of the prestressing force and the behavior of the external loads acting in the thinner section of the modified beam. Three-dimensional finite element programs simulated the piles interacting with the different soil layers under a group of external loads. Other programs were used for the analysis and design of the hollow cylindrical prestressed pile columns interacting with the internal reinforced concrete core.

The Department of Transportation permitted the contractor and consultants to submit alternate designs based on the original design. This was the first time that alternate designs were allowed in Puerto Rico. The winning alternate design was prepared by Behar-Ybarra and Associates for the contractor.

The precast prestressed concrete alternate design made it possible for this 2550 ft (777 m) long 21-span bridge to be built 14 months ahead of schedule with a 20 percent savings in construction costs.

The original design proposed a superstructure consisting of six AASHTO VI beams per span with a cast-in-place deck (see original cross section). However, the alternate design (see new cross section) used a modified AASHTO VI beam, which requires less prestressing force than the standard AASHTO VI beam for the same external loads. Consequently, one beam per span was saved because the modified section has a larger efficiency ratio and could be used at a greater center-to-center spacing than the standard section. Also included in the alternate design were prestressed concrete deck panels as an integral part of the structural slab. Again, this feature saved both construction time and money.

The original bridge substructure design included reinforced concrete pier walls on HP steel pile foundations, with 75 tons (68 t) capacity each.

These pier walls were variable in height and had to accommodate requirements for a channel to be built sometime in the future. The channel excavation was not part of this construction contract and, therefore, improperly increased the cost of the substructure since nine of the pier walls had footings below the channel bottom.

The alternate design used a combination of 54 in. (1372 mm) prestressed concrete hollow cylindrical pile columns at nine piers, and 54 in. (1372 mm) reinforced concrete columns on 12 x 12 in. (305 x 305 mm) prestressed concrete pile foundations, with 100 tons (91 t) capacity each, at twelve other piers.

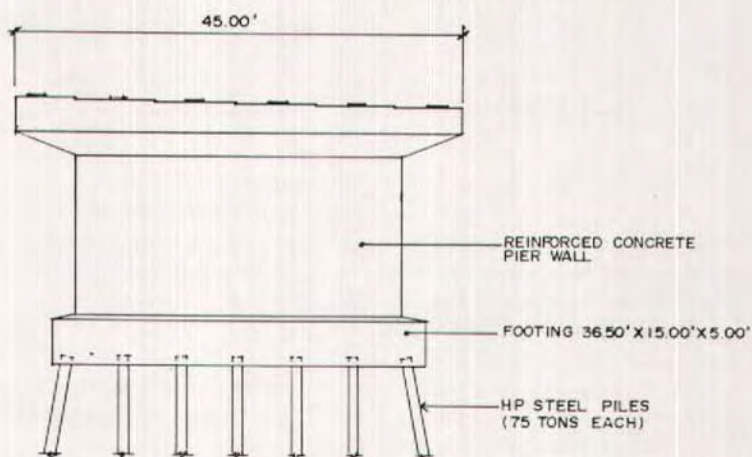
Precast Prestressed Concrete Components Used in Superstructure and Substructure.

Superstructure:

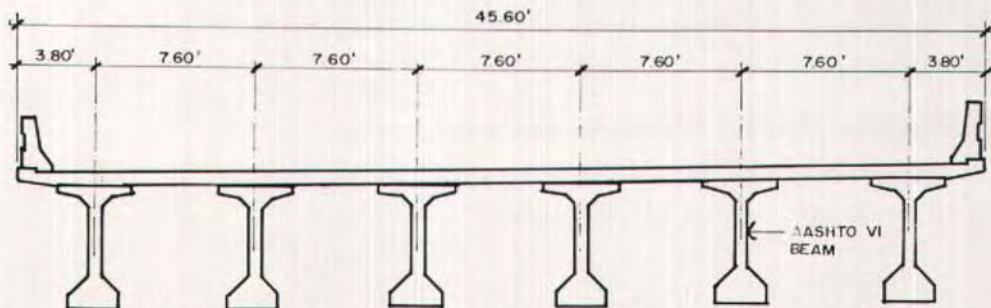
- 105 modified AASHTO VI prestressed concrete beams, 121 ft (36.9 m) long. Section has a 6 in. (152 mm) web, 40 in. (1016 mm) top flange and 26 in. (660 mm) bottom flange.
- 2120 prestressed concrete deck panels, each 6 x 6.5 ft (1.83 x 1.98 m).

Substructure:

- At twelve piers, a total of 176 prestressed concrete piles, 12 x 12 in. (305 x 305 mm) in section and 75 ft (22.9 m) long each.
- At nine other piers, a total of 27 hollow cylindrical prestressed concrete pile columns with 54 in. (1372 mm) exterior diameters and 44 in. (1118 mm) interior diameters. The pile columns have a total length of 96 ft (29.3 m), with almost 50 ft (15.2 m) above the ground level serving as pier columns supporting the superstructure beams directly above.

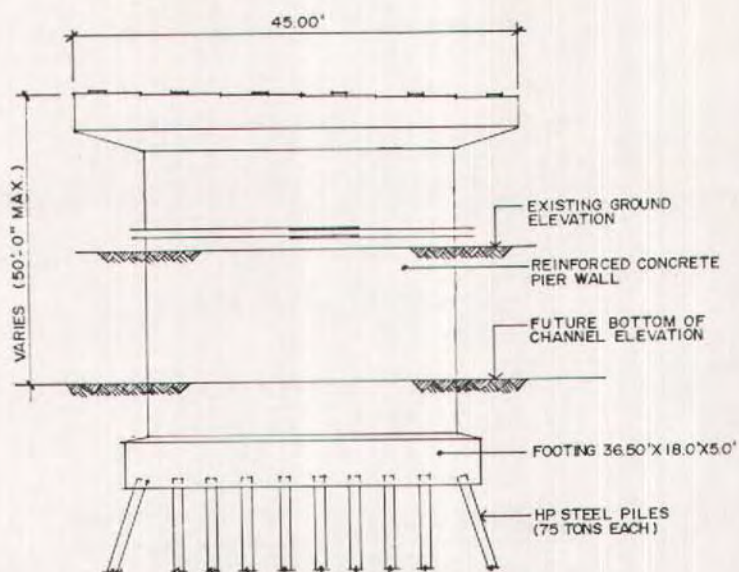


**SHORT PIER ELEVATION
(GROUND PIERS)**

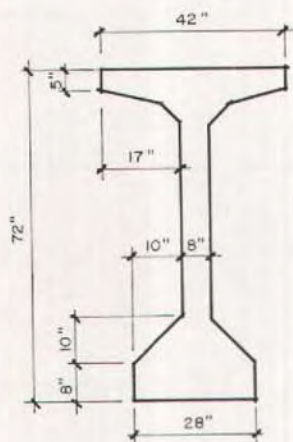


TYPICAL ROADWAY CROSS SECTION

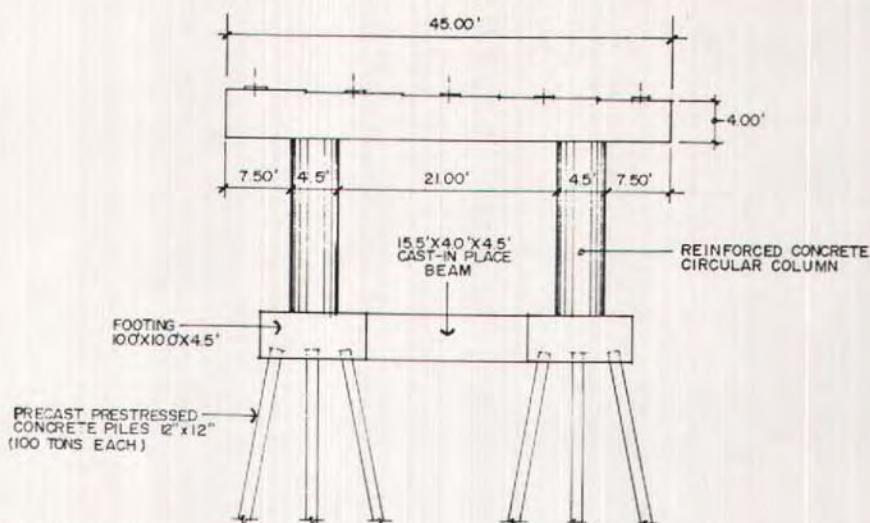
ORIGINAL DESIGN
2,550 FT. CONCRETE BRIDGE



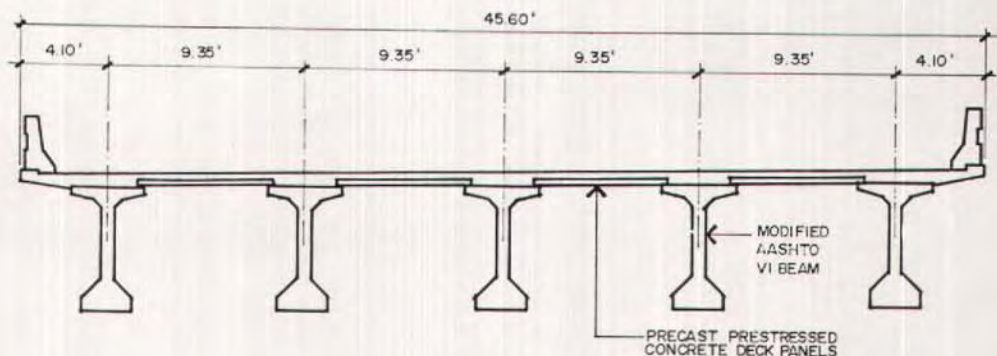
**TALL PIER ELEVATION
(CHANNEL PIERS)**



AASHTO VI BEAM SECTION

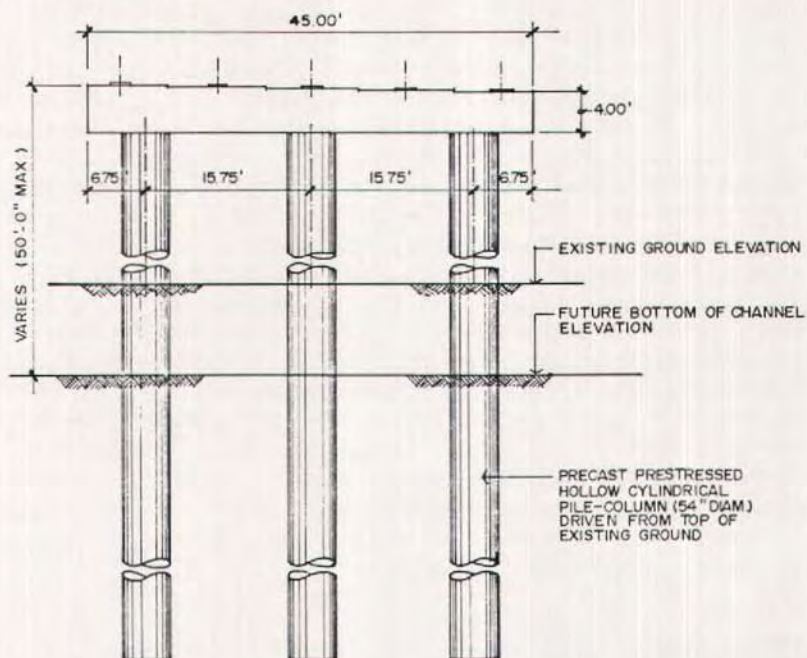


SHORT PIER ELEVATION
(GROUND PIERS)

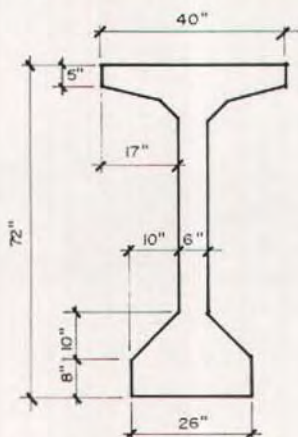


TYPICAL ROADWAY CROSS SECTION

ALTERNATE DESIGN
2,550 FT. PRESTRESSED CONC. BRIDGE



**TALL PIER ELEVATION
(CHANNEL PIERS)**



**MODIFIED AASHTO VI
BEAM SECTION**

These pile columns were used at the locations where the future channel will be located, serving as columns with 50 ft (15.2 m) heights above the future channel bottom and driven from the top of the existing ground. This resulted in economizing the enormous amount of excavation that was required in the original design to accommodate the pier wall foundations, located below the future channel bottom.

At twelve other piers where the existing ground surface did not need to be altered, the 54 in. (1372 mm) circular columns represented the better solution. These piers used 12 x 12 in. (305 x 305 mm) prestressed concrete piles with a higher load capacity than the steel piles used in the original design. Therefore, a fewer number of piles were required by properly arranging their layout and having a lighter superstructure above. This scheme decreased the dead load and the seismic forces acting on the structure, since the bridge is in a severe earthquake zone.

By using an all precast prestressed design alternate from the bottom up—54 in. (1372 mm) hollow cylindrical pile columns, 12 in. (305 mm) square piles, modified AASHTO VI beams, and deck panels—construction time was cut by 14 months, almost 40 percent of the total estimated time. The original proposed bridge was bid at over \$5 million. However, this winning alternate was done for about \$1 million less—a savings of 20 percent. The final unit cost amounted to about \$39 per sq ft.

This design demonstrates that a proper combination of precast prestressed concrete structural members can result in an economical, maintenance-free bridge which is highly competitive with other construction materials.

The bridge was completed in December 1985 and, during the last two years, the structure has been operating with total satisfaction.



Credits

Owner: Puerto Rico Highway Authority, Department of Transportation, San Juan, Puerto Rico.

Engineers: Behar-Ybarra and Associates, Bridge Engineers, Catano, Puerto Rico.
(Engineers in charge: Bernardo Deschapelles; Elias Behar-Ybarra.)

Contractor: Redondo Construction Corporation, San Juan, Puerto Rico.

Precast Prestressed Concrete Manufacturer: Puerto Rico Bridge Corporation, Catano, Puerto Rico.