The Dame Point concrete cable-stayed bridge

Autor(en): **Loizias, Marcos P. / McCabe, Raymond J.**

Objekttyp: **Article**

Zeitschrift: **IABSE reports = Rapports AIPC = IVBH Berichte**

Band (Jahr): **64 (1991)**

PDF erstellt am: **17.07.2024**

Persistenter Link: https://doi.org/10.5169/seals-49349

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

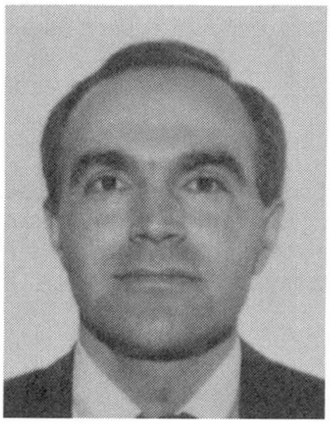
http://www.e-periodica.ch

The Dame Point Concrete Cable-Stayed Bridge

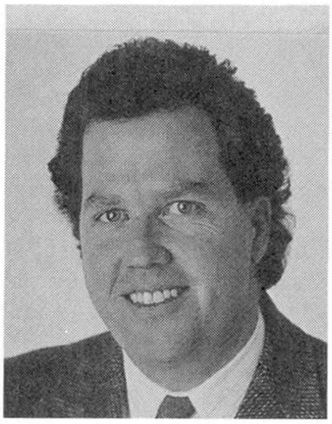
Le pont haubané en béton de Dame Point

Die Dame-Point-Schrägseilbrücke mit Betonträger

Marcos P. LOIZIAS
Assist. Chief Eng.
HNTB
New York, NY, USA



Raymond J. McCABE
Assoc. and Chief Eng.
HNTB
New York, NY, USA



SUMMARY

The Dame Point Bridge is a concrete cable-stayed structure with a center span of 400 m and flanking spans, each 200 m long. The bridge utilizes concrete towers and concrete deck consisting of edge girders, floorbeams and deck slab. Each edge girder is supported by a vertical plane of stay cables in a harp-like configuration. The cables consist of thread bars pressure-grouted within steel pipes. All post-grouting loads are carried by the composite action of bars and steel pipe.

RESUME

Le pont de Dame Point est une structure haubanée en béton avec une portée centrale d'env. 400 m et des portées latérales d'env. 200 m chacune. Ce pont comporte des mâts et un tablier en béton; l'ossature de ce dernier est constituée par des poutres de rive et des poutrelles sous dalle formant tablier. Un faisceau vertical de haubans configuré en forme de harpe supporte chacune des poutres de rive. Les câbles sont formés par des barres filetées logées à l'intérieur de tubes d'acier injectés sous pression. Toutes les charges appliquées après l'opération d'injection sont reprises par l'action combinée des barres et des tubes d'acier.

ZUSAMMENFASSUNG

Die Dame-Point Brücke ist eine seilabgespannte Betonkonstruktion mit einer Mittelspannweite von rund 400 m und Seitenspannweiten von je 200 m. Die Pylon und der gesamte Brückenträger bestehen aus Stahlbeton. Die Randträger werden von Seilen in einer Ebene (Harfenanordnung) gehalten. Die Kabel sind durch injizierte Stahlhüllrohre geschützt. Alle nach dem Injizieren aufgebrachten Lasten wirken auf diesen Verbundquerschnitt.

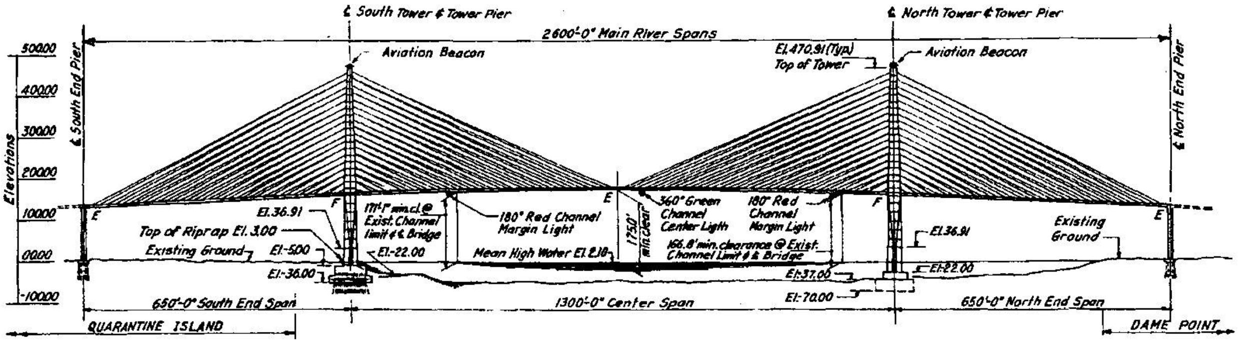


FIGURE 1 - ELEVATION

1. INTRODUCTION

The Dame Point Bridge is a 3.2 Km-long, high-level bridge structure crossing the navigation channel of the St. Johns River at Jacksonville, Florida. The main river spans of the bridge consist of the longest concrete cable-stayed structure in the Western Hemisphere, a 792.6m long three-span cable-stayed bridge with a center span of 396.3m and flanking spans, each 198.15m long.

The structure carries a 6-lane divided highway at a maximum grade of 5 percent. Each of the two divided roadways is 13.26m wide from curb to curb, consisting of three 3.66m lanes, a 1.37m outside shoulder and a 0.91m inside shoulder. The two roadways are separated by a concrete median barrier that has been designed to be removable and facilitate an additional lane.

The length and height of the center span satisfies navigation clearances of 381m horizontal and 53.4m vertical.

2. DETAILS OF THE BRIDGE STRUCTURAL SYSTEM

2.1 General Description

Figure 1 shows a general elevation of the cable-stayed bridge.

The bridge is of segmental concrete construction. It is comprised of two massive reinforced concrete towers which provide anchorage to an array of steel stay cables that support the roadway deck. The roadway deck (Fig. 2) consists of a slab supported by concrete floorbeams that frame into longitudinal edge girders. Each edge girder is supported by a vertical plane of stay cables in a harp-like configuration.

The edge girders frame monolithically into the two towers 396.3m apart, essentially fixing the bridge at those points. The superstructure is hinged at the center of the center span by means of vertical bearings provided to transfer vertical loads resulting from live load. Horizontal shear locks are provided at the center of center span and end piers to transfer wind forces. In addition, deck expansion joints are provided at those locations to accommodate longitudinal movement of the superstructure.

2.2 Superstructure

The reinforced concrete edge girder is 2.44m wide and varies in depth from 1.52m to 1.85m in the deck units adjacent the towers where the compression from the cable thrust forces becomes greatest. The girder has been designed in conjunction with the deck slab to resist the local and global bending moments from dead and live loads as well as the compression force from the cables.

Post-tensioned transverse floorbeams, spaced at 5.34m on centers, connect the edge girders and support the deck slab. The slab varies in thickness from 22.9 cm to 55.9 cm in the deck units of highest compression. The slab is normally reinforced concrete except it is post-tensioned in areas where the cable thrust forces are not yet distributed over the whole deck width.

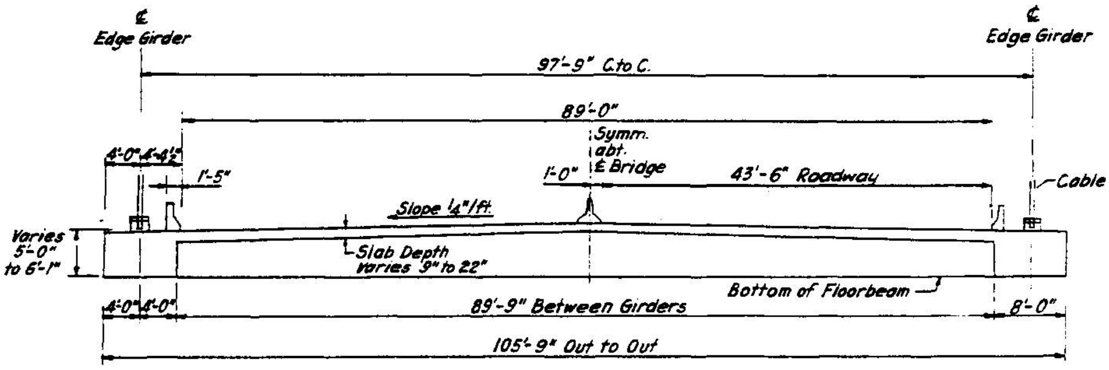


FIGURE 2 - CROSS SECTION

2.3 Towers

Each tower (Fig. 3) consists of vertical concrete pylons in each cable plane, 29.8m center to center and extending 92m above the roadway level. The pylons are of varying solid cross-section above the roadway and of octagonal hollow cross-section below. The concrete tower serves as an anchorage for the stay cables and transmits the superstructure forces to the foundation.

The north tower foundation consists of a footing that sits on top of a 10.0m thick concrete seal that is supported directly on marl with an allowable bearing pressure of 575 kN per square meter. The south tower is supported on 704 HP 14x117 steel piles, driven into substrata of stiff sandy clay. The south footing sits on top of a 4.6m thick concrete seal. The allowable design pile load is 1150 kN per pile. The tower foundations are illustrated in Fig. 4.

2.4 Stay Cables

Each edge of the superstructure is supported from the tower pylons with 144 stay cables that slope upward in a vertical plane from the edge girder. At the edge girder anchorage, the cables are spaced at 5.34m, so that a single cable supports a typical edge girder segment. At the tower anchorage, the cables are arranged in pairs, vertically along the centerline of the pylon in the center span side and horizontally in the end span side. This arrangement allows the cables to cross each other and to be anchored at the far side of the tower, thus transferring their loads into the vertical tower by compression only.

The cables consist of grade 1040 Dywidag thread bars pressure grouted within steel pipes. All bars are 32mm diameter, however the number of bars per cable varies from 7 to 9 in accordance with the final cable force. The steel pipe section varies from 16.8 cm to 21.9 cm depending on the number of contained bars. The cable anchorages have been designed such that prior to grouting, the bar tendons alone resist the dead load of the structure. The bars are anchored by standard Dywidag anchor nuts bearing on anchor disk and plate. The steel pipe is anchored separately in front of the anchor disk by rivet studs bearing against the grout, which in turn transfers the load to the concrete. All loads applied after grouting, i.e., live load and wearing surface, are carried by the composite of action bar tendons and steel pipe. The rivet pipe anchorage is such that the post-grouting forces are transferred directly to the concrete, preventing thus any fluctuating loads from reaching the fatigue-sensitive nut anchorage of the bars.

3. BASIC ANALYSIS AND DESIGN PARAMETERS

3.1 Analysis

The primary longitudinal system of the bridge was analyzed on a two-dimensional model for each of the cable planes. A space frame model was used for the wind analysis. Non-linear analysis was used to further refine the design and properly account for (1) the non-linear response of cables, (2) the non-linear response of the deck girder and tower pylon when they are subjected to compressive loads and bending moments simultaneously, (3) the non-linear effect of live load that includes the moment due to the dead load thrust acting on the live load displacement.

The floor system was analyzed using partial length finite element models of slab, floorbeams and edge girders under vertical loads and simulated forces from the primary longitudinal system. A second order analysis was used to design the transverse tower frame under transverse loads and cable forces from the primary longitudinal system. The tower stability was checked by convergence of a second-order analysis for factored loads.

3.2 Design

The concrete members of the bridge were designed in accordance to the Load Factor Design Method (as outlined in AASHTO).

The stay cables were designed by the Service Load Method. The static and dynamic design of the stay cables was made for axial loads (N) and the bending stresses (M) near the anchorages that result from angle changes caused by cable sag changes, geometry changes from joint displacement and change of angle due to rotation of girder and tower. The allowable cable element stresses used for static and dynamic design were as follows:

	Static		Dynamic	
	N	N+M	N	N+M
Cable Bars	.6 Fu	.8 Fy	110	190
Anchorage Pipe (A615)	-	.55 Fy	--	248
Cable Pipe (A53)	.55 Fy	--	110	--

4. CONSTRUCTION

4.1 Substructure

The construction of the tower foundations required braced cofferdams and tremie seals. For the south tower, 704 HP 14x117 steel piles were driven 24.4m below the waterline in sand and marl. After dewatering the cofferdam, the footing and then the concrete pedestal were cast.

The tower pylons were built by the conventional lift-by-lift method using steel forms. For a typical lift, formwork was advanced upward and reinforcing placed by tower cranes located adjacent to each tower. Concrete was delivered to the site in ready-mix trucks, barged to the towers and placed by buckets from the tower cranes. The roadway strut and pier table were constructed on steel falsework. After prestressing the six floorbeams of the pier table, the first four pairs of short stay cables, pre-assembled to full length on shore, were installed by threading them downward through openings in tower and edge girder. Stressing these cables lifted the pier table off the supporting falsework.

4.2 Superstructure

After construction of the pier table, the balanced cantilever construction of the superstructure began, extending outward from each tower, alternately in each direction, one section at a time. Each segment was cast using a form traveller that rolled along both edges of the previously cast segments. A typical segment was 32m wide and 5.34m long and consisted of a concrete slab, floorbeam and two edge girders. Approximately 92 to 134 cubic meters of concrete was needed for each segment.

The contractor constructed both cantilevers simultaneously, using four form travellers. The form traveller was designed as a lightweight H-shaped steel framework with a 4.1m high truss supporting each edge girder and a connecting cross truss supporting the forms for the floorbeam and deck slab. Two C-shaped frames running on rollers on the bridge surface carried the form traveller during the time it was jacked forward to the next segment. In this position, the form traveller was supported at the front by an extension of the erected cable, vertical hanger bars in the rear, and diagonal bar tendons counteracting the horizontal component of the stay cable anchorage force.

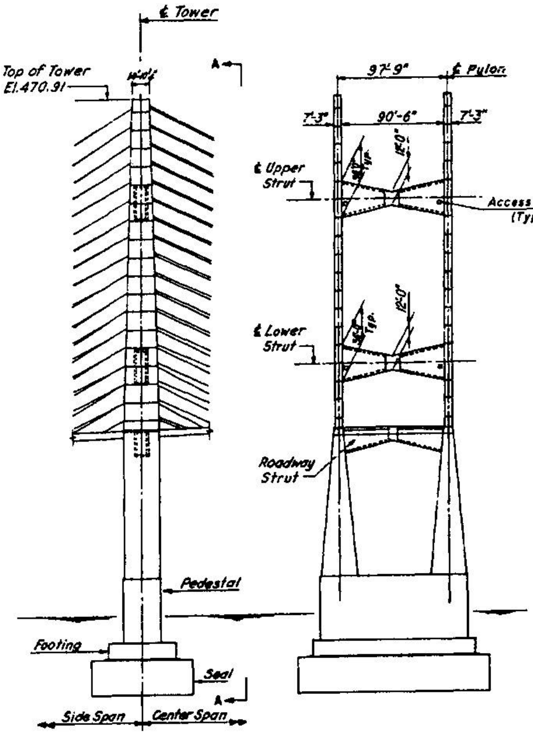
The typical cycle of constructing the side span segments E(n) and center span segments M(n) was as follows:

1. Advance the form traveller to position for casting segment E(n).
2. Erect the two cables for the segment by first anchoring on tower side and then connecting cable extension to the form traveller. Stress cables to a specified force.
3. Position formwork and place reinforcement. Cast concrete in edge girders, floor beam and slab.
4. Repeat steps 1 through 3 for segment M(n).
5. Disconnect the cable extension to the form traveller and stress the cable anchored in segment E(n) to the required force.
6. Lower the form traveller and advance to next segment.
7. Repeat steps 5 and 6 for segment M(n).

This cycle was repeated alternately left and right at each tower until the last edge girder segment over the end pier was to be cast. At this stage, the end span form traveller was connected to the end pier to allow casting of the edge girder and tie down to the end pier. Casting the remaining deck section completed the end span closure. When both halves of the bridge reached this stage, some cables were adjusted to vertically match the free ends of both cantilevers, the gap was bridged by one of the form travellers, and the center closure was cast. Final cable adjustments were then made to assure correct cable forces and deck geometry.

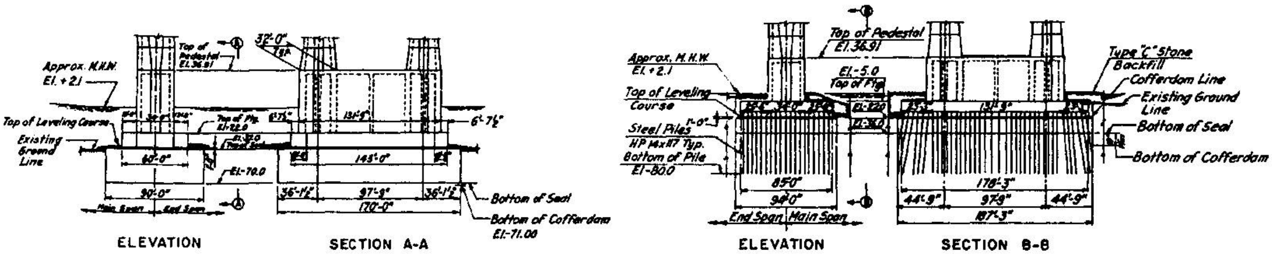
Thirty-five cantilever segments were built on each side of the towers for a total of 140 segments. At several stages of the cantilever construction, cable adjustments were necessary to correct the geometry of the structure. Although most segments were built in a seven-day cycle, some segments towards the end of construction were completed in only four days.

Grouting of the cables, setting of the median barriers, asphalt surfacing of the deck and installation of the cable damping system completed the construction of the bridge. The Dame Point Bridge was opened to traffic in March 10, 1989.



ELEVATION SECTION A-A

FIGURE 3 - TOWER ELEVATION



ELEVATION SECTION A-A
NORTH TOWER PIER

ELEVATION SECTION B-B
SOUTH TOWER PIER

FIGURE 4 - TOWER FOUNDATIONS

ACKNOWLEDGEMENTS

OWNER: The Jacksonville Transportation Authority, Jacksonville, Florida
DESIGNER: Howard Needles Tammen & Bergendoff (HNTB), New York, NY
CONTRACTOR: Pensacola Construction Co. of Kansas City, Missouri, and the Tyger Construction Co. of Spartansburg, South Carolina, with DSI Dywidag Systems International, USA, and DRC Consultants Inc., New York, NY
CONSTRUCTION SUPERVISION: Sverdrup Corporation and Howard Needles Tammen & Bergendoff