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Long box girders lifted for record span

Contractors have completed the world’s longest box girder bridge lift, jacking two pairs of twin 958-ft girders 171 ft over Guanabara Bay between Rio de Janeiro and suburban Niteroi. With these huge haunched girders in place atop 197-ft-high piers, the contractors are now preparing to lift the final 577-ft drop-in section 230 ft to complete the main span of the three-span continuous steel structure.

“This is the kind of tricky job that never has been done before,” said Richard Thorp, an engineer with the contractors. A specially designed jacking assembly suspended from the cantilevered ends of the long side span girders will raise the final section.

The $138-million bridge, which is 8.5 miles long, includes a record 984-ft-long orthotropic steel box girder span flanked by 656-ft side spans, designed by Howard, Needles, Tammen & Berge noff International, Inc., Kansas City, Mo., and post-tensioned concrete box girder approach spans, designed by Escritorio de Engenharia Antonio Alve de Noronha Ltda., Brazil.

Each pair of the 958-ft-long girder sections forms a side span and 98 ft of an approach span, and cantilevers 203 ft into the main spans, leaving a 577-ft gap for the final section (see drawing facing page).

A joint venture of Redpath, Dorman Long Ltd., Bedford, England, and the Cleveland Bridge and Engineering Co., Ltd., Darlington, England, working in association the Montreal Engenharia S.A., of Rio de Janeiro, jacked the two long pairs of box girders on a specially designed jacking system attached to ring girders circling the piers. Lifting the first pair of girders, one on each side of the piers, was completed in only three and one-half days.

Jacking assembly. The jacking columns were made up of steel sections, 30 ft long, with welded shear plates that have the lower corners beveled off. The jacking columns are bolted to the sides of the piers.

A pinned assembly consisted of two, double-action, 496-ton-capacity hydraulic jacks, a short armed yoke to provide footing on the shear plate while raising the box girders and a longer armed steel latch to provide support from the shear plates while the yoke is being raised for the next step in the lifting operation.

The assemblies, one for each jacking column, attached to the ring girders that encircle the piers. On each of the main piers, where the haunched sections of the girders rest, the contractor bolted two jacking columns to each side. On each of two side piers where the box girders taper, only two jacking columns were needed.

The contractors fabricated all of the steel box girders on an island near the Niteroi side of the bridge. The island had a straight quay that was extended on a steel pile jetty so it would be long enough to assemble the 958-ft-long box girders. Each box, 22.5 ft wide, is haunched at the main piers and tapers to 25 ft at mid-span.

Workmen first fabricated the 577-ft-long twin box girder for the gap in the main span on camber blocks.

When the girder was completed, the contractors jacked it up from the cam ber blocks and moved it sideways out past the edge of the quay to rest on concrete jetties. This section, weighing about 4,200 tons, was stored for one year, then used as a barge to float the long haunched sections to the lift assemblies.

Workmen then assembled the 958-ft-long haunched girders. Each pair was assembled as a complete twin box cross section, but after it was completed, workmen separated it along the longitudinal center line into two single box structures. They laterally moved the first box, weighing 2,480 tons, from the quay onto the concrete jetties.

Long girder lift. While this work was being done, the contractors prepared the first two piers, 2 miles away in the bay, to receive the side spans. Workmen installed the steel box ring girders around the base of each pier and erected the steel jacking columns up the end faces of each pier.
The big box girders rested on steel wedges for sliding off when they reached the top of the pier. In a test lift, four bearings were raised to the top and set in place on the piers. When the ring girder reached the top of the piers, workmen slid the box girder off and onto the bearings.

**Main span spectacular.** Lifting of the 577-ft main span section 230 ft from the water by the suspended jacking columns will be the most spectacular if not the biggest part of the job in placing the steel superstructure. The same jacking columns used on the completed lifts will be suspended from steel bearings on the ends of the cantilevered ends of the haunched girders.

The 2-in.-thick shear plates are welded to the column sections. The jacking assemblies—a yoke and latch each—are to be mounted in the ends of the center spans. Platforms will be placed underneath so observers can check the action.

The four jacks at one end of the box girder will be interconnected. The two assemblies of four jacks at the other end, will work independently, giving the lift the equivalent of three-point support. An additional horizontal jacking system will be used to move the side spans horizontally to compensate for changes in length caused by temperature variations.

When the main span box girder section, which has 6.5-ft draught, is lifted out of the water, the girder will assume a virtually stable shape. On reaching the top, tie bolts will pull the top flanges together and close a 2-in. gap.

The contractors will install transverse tackle to maintain lateral stability and control the plumb of the jacking columns, making sure the load does not go askew. Steel cables will run from winches on top of the side spans above to the far ends of the load. The tackle will be operated on the cantilevered ends above and controlled from the central control panel on the box girder section. In addition, damping gear will be installed from the cantilevered ends of the side spans to damp out aerodynamic oscillation.

Thorp says, "The job consists of lifting a floating moving unit, weighing 4,200 tons, on rigidly fixed jacking columns at a time when we will have considerable deflection in the side spans and the unit. The cantilevers will deflect 5 ft at the initial stage as the box girder comes out of the water. We will have to contend with thermal changes during the jacking operations. Once out of the water, the span will assume a virtually stable shape. We will have to allow for wind conditions sidewise and endwise."

While the lifting operation so far has gone without a hitch, the project has had big problems on the foundation work. Eight men died in March, 1970, when a test pile assembly collapsed as workmen were preparing it for a 2,200-ton load test (ENR 4/9/70 p. 34). After this accident, the original joint venture contractors encountered difficulties in placing the foundation, and construction was finally stopped in late 1970.

The Brazil Transport Ministry, which then created a special agency called ECEX to complete the project, contracted with a new joint venture to complete the foundation work. ECEX is now eager to complete the bridge by January.
Trusses of museum will carry both

... portions of roof and some displays

The National Air and Space museum, a structure designed to house and memorialize man's swiftest vehicles, has started rising from the ground 27 years after Congress authorized it.

In 1946, Congress passed the bill establishing a National Air Museum in Washington, D.C. Congress then waited until 1971 to appropriate $1.9 million to redesign a dormant plan for a by-then renamed National Air and Space Museum.

Then it became the task of Gyo Obata of Hellmuth, Obata and Kassabaum, Inc. (HOK), St. Louis architect-engineers to design a structure that would both fit a $40-million budget and the character of the Mall, the greensward that stretches 2 miles from the U.S. Capitol to the Washington Monument and on to the Lincoln Memorial.

For the price, the government and the user, The Smithsonian Institution, will obtain a 685 x 235-ft structure containing within its 85-ft height two main levels of display area and offices, library and dining rooms on the third and topmost level. A below-grade garage will provide space for 550 cars. All told, the building will contain 550,000 sq ft, down from the originally proposed structure of about 800,000 sq ft.

The structure, started in November, 1972, under a construction management contract awarded Gilbane Building Co., Providence, R.I., consists of seven modular bays, four of them marble-faced, and three enclosed in glass.

Each of the glass-sheathed bays, 115 ft wide by 120 ft deep and 65 ft high, will display their framing as well as the exhibits of historic airplanes, space craft and launching vehicles. Each open bay, enclosed by double-glazed clear insulating glass, is framed by five triangular tubular steel trusses, that in effect form a half-bent rising 62.5 ft at the front wall and extending back 120 ft to conventional column and beam framing at the rear.

Structural engineer LeMessurier Associates, Inc., Cambridge, went to the tubular truss design to provide a light appearing frame, but one capable of carrying the weight of aircraft that will be suspended from the roof supports.

The building's walls are 2.5 ft thick, providing space for HVAC ducting and piping for an automatic fire suppression system. In event of fire or smoke conditions, the air handling systems are designed to change their operating mode to maintain negative pressure in a fire area, while fresh air is supplied to exit areas. Construction is scheduled for completion in the spring of 1975.