Large Eyebar Suspension Bridge in South America

Span of 1,114 Feet Under Construction in Brazil Has Chain of Eyebars with New Form of Stiffening Truss

A COMBINED highway and railway bridge under construction at Florianopolis, in the province of Santa Catharina, Brazil, connecting the island on which the city is located with the mainland, represents the first application of modern eyebar-chain construction to suspension bridges. It is no less interesting because of its unusual stiffening truss construction, which, in connection with the use of eyebars for the chain and the unloaded backstays, results in a high degree of rigidity and economy. Because of its long main span, nearly 1,114 ft., this structure will take rank among the largest suspension bridges in existence. It was designed by Robinson and Steinman, of New York, as consulting engineers for Byington and Sundstrom, of São Paulo, Brazil, contractors for the bridge.

In the original design for the crossing, whose span is controlled very closely by the conditions of the site (see the location plan), a wire-cable suspension bridge was contemplated. This design had a parallel-chord stiffening truss with hangers at all panel points. When, however, the American Bridge Co. made a tender of heat-treated eyebars under a guarantee of 75,000 lb. per square inch minimum elastic limit, permitting a working stress of 50,000 lb. per square inch to be used in the chain, the structure was redesigned to take advantage of eyebar construction, with the result of showing a distinct economy in total cost and permitting the stiffness of the main span to be increased very greatly. The eyebar-chain design, shown in the drawings, is now being carried out.

Special Features—From the design details on p. 593 it will be seen that the towers are two-column steel bents with battered legs and with line bearing at the base, while the stiffening trusses have curved top chords so disposed as to give maximum depth at the quarter-points, the top chord in the middle section being formed by the suspension chain itself. This novel combination of chain and truss yields large savings in steel due to the elimination of the middle half of the top-chord and other members, and to the more economical truss outline in which the depth conforms to the variation in bending moments along the span. The traffic requirements are satisfied by a 28-ft. clear roadway width, which fixed the truss spacing at 33½ ft. Accordingly the cross-section involves no features beyond the ordinary. The backstays are unloaded, going down directly to masonry anchorages, one of which is on rock while the other is carried by a pile foundation including both vertical and batter piles. The approaches are steel viaducts with spans of 185 ft. directly adjacent to the towers.

Loading—The loadings assumed for the design of the various parts of the structure vary from 1,850 lb. per lineal foot of bridge for the chain and 2,000 lb. for the trusses (the latter with 10 per cent impact) to a 6-ton truck or 60 lb. per square foot (with 25 per cent impact) on the roadway stringers, and a 50-ton electric locomotive followed by 2,000 lb. per lineal foot (50 per cent impact) on the railway stringers. Wind was taken at 25 lb. per square foot on the suspension bridge and 30 lb. on the viaduct, and the temperature variation was taken at the moderate amount of 30 degrees rise or fall, in conformity with local climatic conditions. In comparison with these figures it may be noted that the total dead load is 4,370 lb. per lineal foot of main span, or about 4,000 lb. for structure and deck excluding the water main which extends along one side of the roadway.

With this loading the greatest allowable stresses were set at 50,000 lb. per square inch for the eyebars of the main chain, and 20,000 lb. per square inch in the stiffening trusses. Some margin below these amounts was maintained, however, and the final stresses in the chain do not exceed 46,500 lb. per square inch, and those in the trusses 18,500 lb. per square inch, as calculated by the ordinary, approximate method. In the case of the stiffening trusses, additional margin is represented by the difference between analyses of the structure by the ordinary method and by the more exact or deflection method; the latter showed considerably lower stresses, by about 25 to 30 per cent, but no reduction in section was made to suit these stresses. The reduction in the chain stress was made possible by the smaller weight of the combination stiffening truss of variable depth as compared with the parallel-chord truss. The floor framing has its bending stresses limited to 17,000. In all the analyses, the value of the modulus of elasticity of the truss steel was taken at 29,000,000 lb. per square inch and that of the eyebars was taken at 27,000,000 lb.

MAIN FEATURES OF EYEBAR-CHAIN SUSPENSION BRIDGE, FLORIANOPOLIS, BRAZIL.

This eyebar-suspension bridge has a span of 1,113 ft. 9 in., which makes it one of the longest suspension bridges ever built. Note the unusual stiffening trusses with use of suspension chain in combination.

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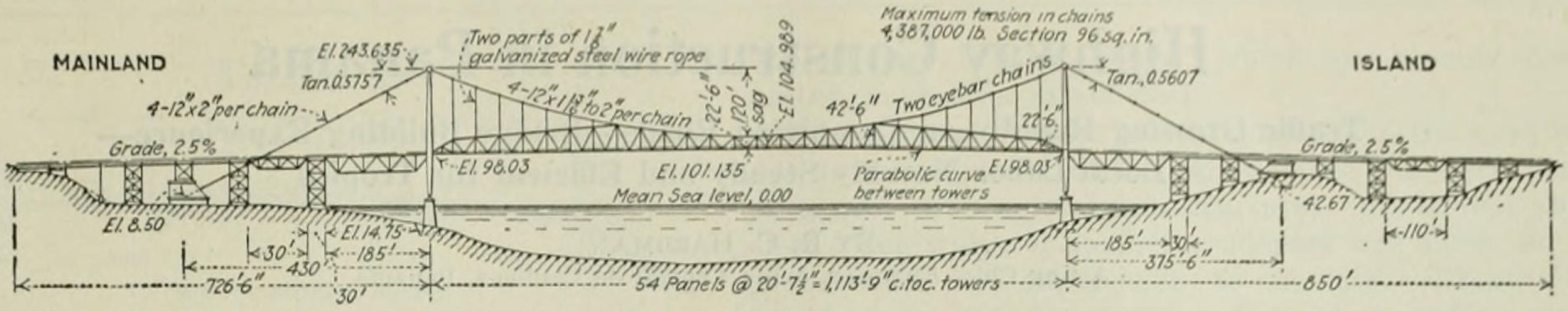
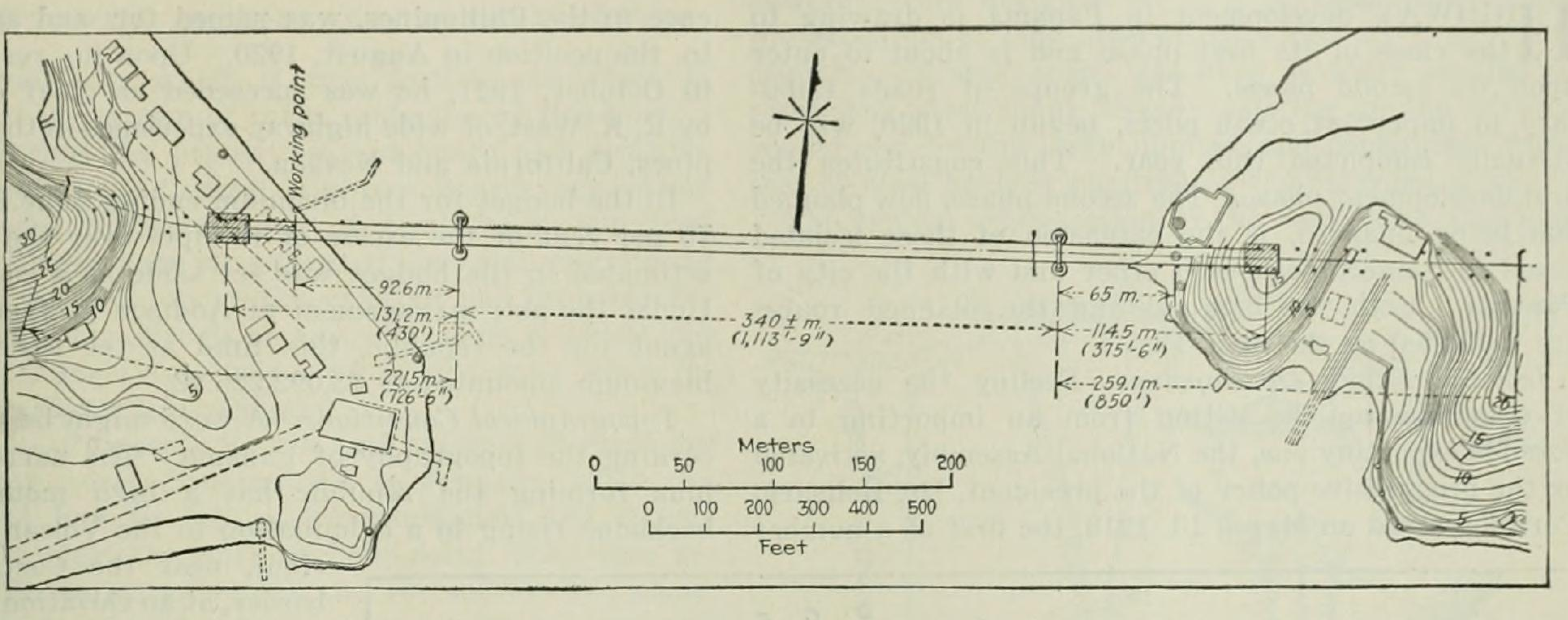
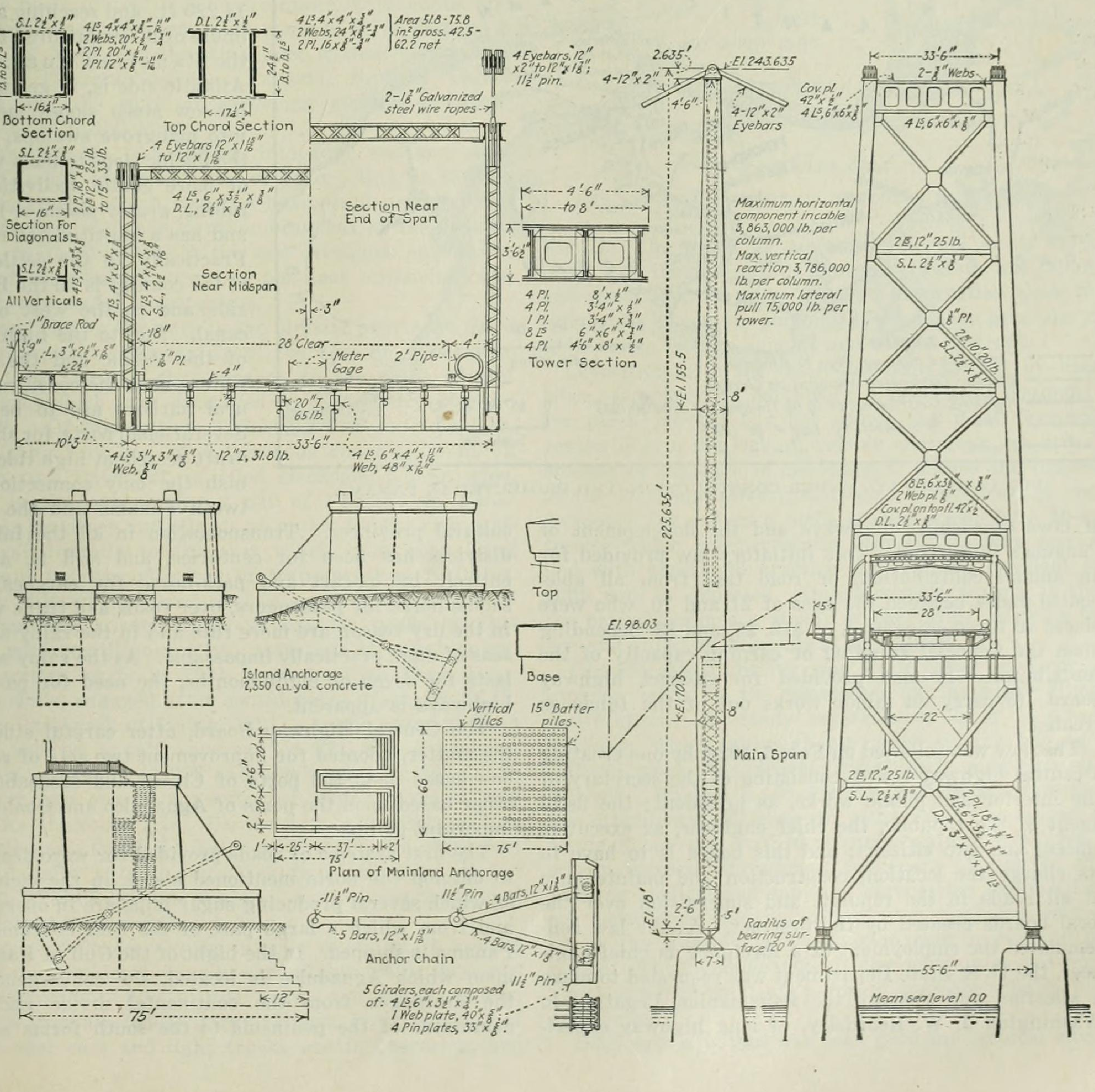
The two chains consist each of four eyebars 12 in. wide, from anchorage to anchorage. The eyebars of the backstays are 2 in. thick, while those of the main span range from 2 in. to 1$\frac{13}{16}$ in., with chain section ranging from 96 to 87 square inches. Steel-rope suspenders are used, consisting of two parts of 1⅞ in. galvanized steel wire rope socketed to clevis attachments at the top chords of the trusses.

Calculations of the deflections of the structure show that under live-load on one-half the span, the quarter-point deflection is only about 13 in., or 1/1,000th of the span, while under full-span loading the center deflection is about 17 in. or about 1/800th of the span. These extraordinarily low values result from the following factors: the use of eyebars in the chains, with their greater section and resulting greater dead weight and reduced elongation; the unloaded backstays; the great depth of stiffening truss at the quarter-points, about double the depth of the originally-planned parallel-chord truss; the large chord-section of the stiffening trusses in the middle portion, where the chains serve as chords; and the novel combination of chain and truss whereby full live-load produces tension instead of compression in the middle half of the top-chord.

Construction and fabrication are now under way and the bridge is expected to be completed by the end of next year.


MAINLAND
ISLAND
Maximum tension in chains 4,387,000 lb. Section 96 sq.in.
El.243.635
Two parts of 1⅞" galvanized steel wire rope
Tan.0.5757
4-12"x2" per chain
4-12"x1⅞" to 2" per chain
Two eyebar chains
Tan.0.5607
Grade, 2.5%
El. 98.03
El. 101.135
El. 104.989
Parabolic curve between towers
Mean Sea level, 0.00
El. 8.50
El. 14.75
42.67
54 Panels @ 20'-7½" = 1,113'-9" c. to c. towers
726'-6"
430'
185'
375'-6"
850'


Working point
92.6 m.
131.2 m. (430')
221.5 m. (726'-6")
340 ± m. (1,113'-9")
65 m.
114.5 m. (375'-6")
259.1 m. (850')
Meters
0 50 100 150 200
0 100 200 300 400 500
Feet


Bottom Chord Section
Top Chord Section
Section For Diagonals
All Verticals
Section Near Midspan
Section Near End of Span
4 Eyebars, 12" x 2" to 12" x 1⅞"; 11½" pin.
2-1⅞" Galvanized steel wire ropes
28' Clear
Meter Gage
2' Pipe
33'-6"
Tower Section
Maximum horizontal component in cable 3,863,000 lb. per column.
Max. vertical reaction 3,786,000 lb. per column.
Maximum lateral pull 75,000 lb. per tower.
El. 243.635
4-12"x2" Eyebars
El. 155.5
El. 98.03
El. 70.5
Main Span
Radius of bearing surface 120"
Mean sea level 0.0
55'-6"
Top
Base
Island Anchorage 2,350 cu. yd. concrete
Vertical piles
15° Batter piles
Plan of Mainland Anchorage
Anchor Chain
5 Bars, 12" x 1⅞"
4 Bars, 12" x 1⅞"
11½" Pin
5 Girders, each composed of: 4 Ls 6" x 3½" x ¾", 1 Web plate, 40" x ⅝", 4 Pin plates, 33" x ⅝"
75'
12'