

Sebastian Inlet Bridge

by W. E. Dean*

A new design in long span precast prestressed concrete highway bridges has resulted from particular topographic conditions at Florida's Sebastian Inlet. The crossing on State Road A-1-A is located on the east coast, about midway of the peninsula and only 200 yards from the Atlantic Ocean. The inlet connects the Ocean and Indian River through a jetty-protected channel 600 feet wide crossing the narrow coastal barrier island. It is the only natural opening for a reach of 110 miles. The normal tidal range of about 2½ ft. and the large reservoir of the 1 to 3 mile wide Indian

River produce currents of 6 to 8 fps at every tide cycle.

Channel criteria prescribed by the Corps of Engineers required a main span 180 feet long for a square bridge to cross the 30° skewed channel. Vertical clearance is 40 ft. above mean sea level. With its proximity to the open ocean, the structure will be subject to constant exposure to wind-driven salt-laden spray. This condition presents a severe corrosion problem for a steel structure. Several similarly located structures along the Florida coast require almost constant maintenance to provide a questionable protection for steel surfaces.

The topography and criteria resulted in the following principal considerations for design:

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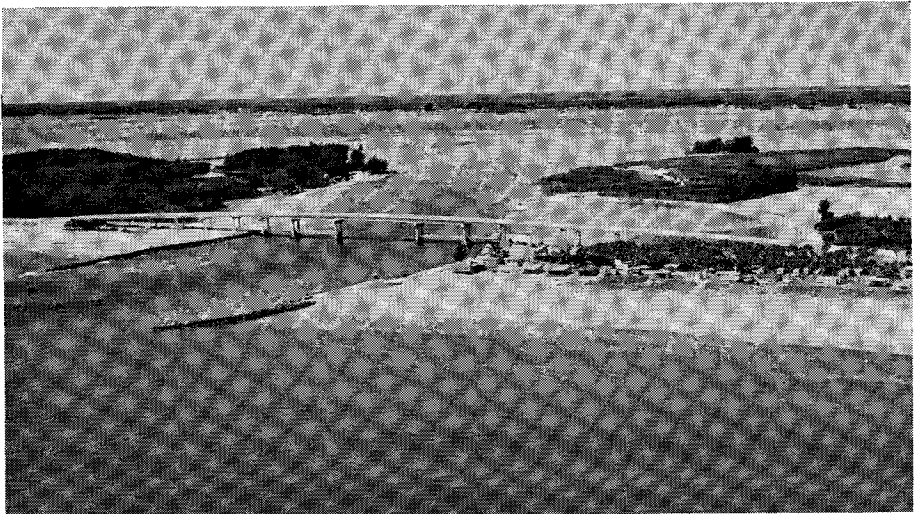


Fig. 1—Sebastian Inlet Bridge

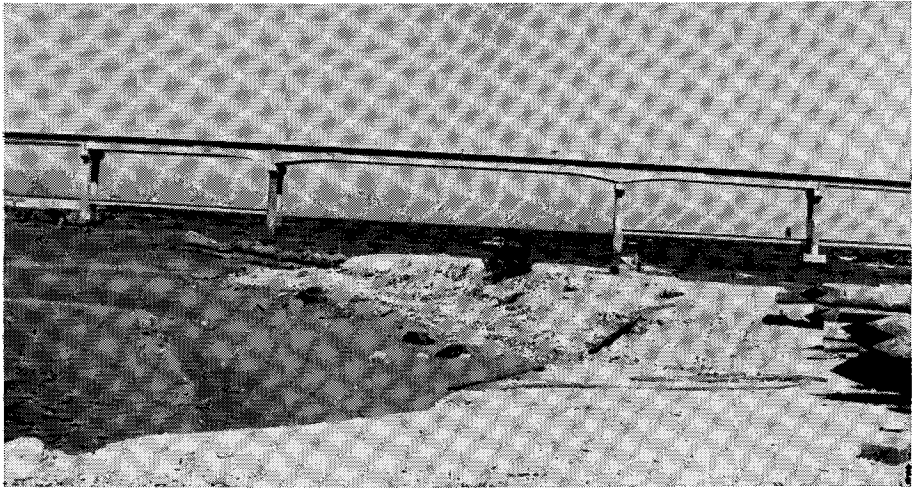


Fig. 2—Channel Spans of Sebastian Inlet Bridge

1. The owner desired a structure that would require minimum maintenance for the severe exposure and corrosion potential.
2. Use of the channel by vessels required that it be kept open for the entire construction period.
3. Swift currents and consequent navigational hazards precluded constriction of the channel opening by falsework.

These conditions combined to indicate that a precast-prestressed girder system, placed without the use of falsework in the channel span, would provide the ideal solution.

There are several prestressed concrete plants in the area with ready access by barge to the bridge site. These plants produce all of the AASHO-PCI standard prestressed concrete I-sections. It was logical to develop a design that would utilize the equipment, beds and procedures of these plants to the fullest possible extent.

The layout adopted consisted of a bridge 1,548 ft. long with $\pm 5\%$ grades connected by a crest verti-

cal curve of 1,200 ft. (Fig. 1). Crown grade at the bridge ends is Elev. +23 and at center of channel is Elev. +47. Roadway width is 28 ft. plus safety walks 2 ft. wide each side. Design live load is H20-S16. From both bridge ends there are 8 simple spans of 73 ft. using 5 Type III AASHO-PCI beams each. For three spans at the center of the bridge a design was developed with span lengths of 100 ft.-180 ft.-100 ft.

The substructure is of conventional rigid frame concrete bents. Foundation material is soft coquina rock at rather shallow depths providing an ideal condition for use of composite concrete-steel foundation piles. Footings for water piers were set at Elev. +1 for ease of construction except for the two main piers which were founded below the channel bottom and constructed in open cofferdams. Stub type concrete abutments are used at the bridge ends.

The three main spans are an anchor-cantilever unit with four lines of girders at 8 ft.-6 in. lateral spac-

ing. The 100 ft. anchor spans have girders 65 ft. long extending from the terminal piers to splice points, then 65-ft. girders extending from the splice points across the channel piers and cantilevering 30 feet beyond. The center drop-in girders are 120 ft. long to make up, with the cantilever arms, the 180-ft. channel span (Fig. 2). Both the girders and deck slab for the center drop-in section are of lightweight structural concrete weighing 120 pounds per cubic foot maximum. Girders and deck for the 100-ft. anchor spans and 30-ft. cantilever arms are of conventional concrete. The only falsework required consisted of a bent at each of the splice points in the anchor spans, thus leaving the channel entirely unobstructed at all times except for a few hours during actual setting of the drop-in girders.

The 120-ft. drop-in girders and the 65 ft. girders at the ends of the anchor spans are 6 ft. deep (Fig. 3). The bottom flange and width of web of these members is identical with the AASHO-PCI Type IV beams. The top flange is identical with the bottom. They were designed to be stressed by pretensioning, using ½-in. cable tendons, and can be produced on any of several available Type IV beds.

The anchor-cantilever members are special I-sections varying in depth from 6 ft. at the ends to 9 ft. at the support (Fig. 3). These members were designed to be stressed by post-tensioning, using parallel tendons of 18 wires 0.196 in. in diameter with Freyssinet-type anchors. Job specifications permitted the producer to vary the type of tendons and method of prestressing provided the magnitude and center of gravity of the stressing

force was compatible with values shown on the plans. Using this specification allowance, the producer elected to prestress these members entirely by pretensioning with ½-in. high-strength cables.

With girder depths of 9 ft. at the piers and 6 ft. in the center, the depth to span ratios are $\frac{1}{20}$ at the haunch and $\frac{1}{30}$ at the crown. These depths compare very well with usual proportions for long span steel plate girders.

In the original design, it was anticipated that the 65 ft. anchor-cantilever members would be handled from their ends. Handling stresses would have been resisted by partial stressing at the plant combined with mild steel reinforcing in the top and bottom flanges. Following erection, the stressing would have been completed. As constructed, with all stressing done at the plant by pretensioning, it was necessary to handle the members from pick-up points located near their centers.

The design expedient that limits the weight of members, simplifies prestressing operations and makes this girder system practical for pre-cast construction is the splice in each of the anchor spans. This splice is centered at the inflection point for dead load moment. Maximum moment at the splice is limited to approximately ± 1200 ft.-kips due to moving live load, which can readily be accommodated by mild steel reinforcing at top and bottom of the section. There being no particular necessity for prestressing through the splice, joining of the sections is accomplished by a length of cast-in-place concrete enclosing protruding and lapped reinforcing bars. The 65-ft. anchor members are prestressed for positive moment only, the anchor-cantilevers for neg-

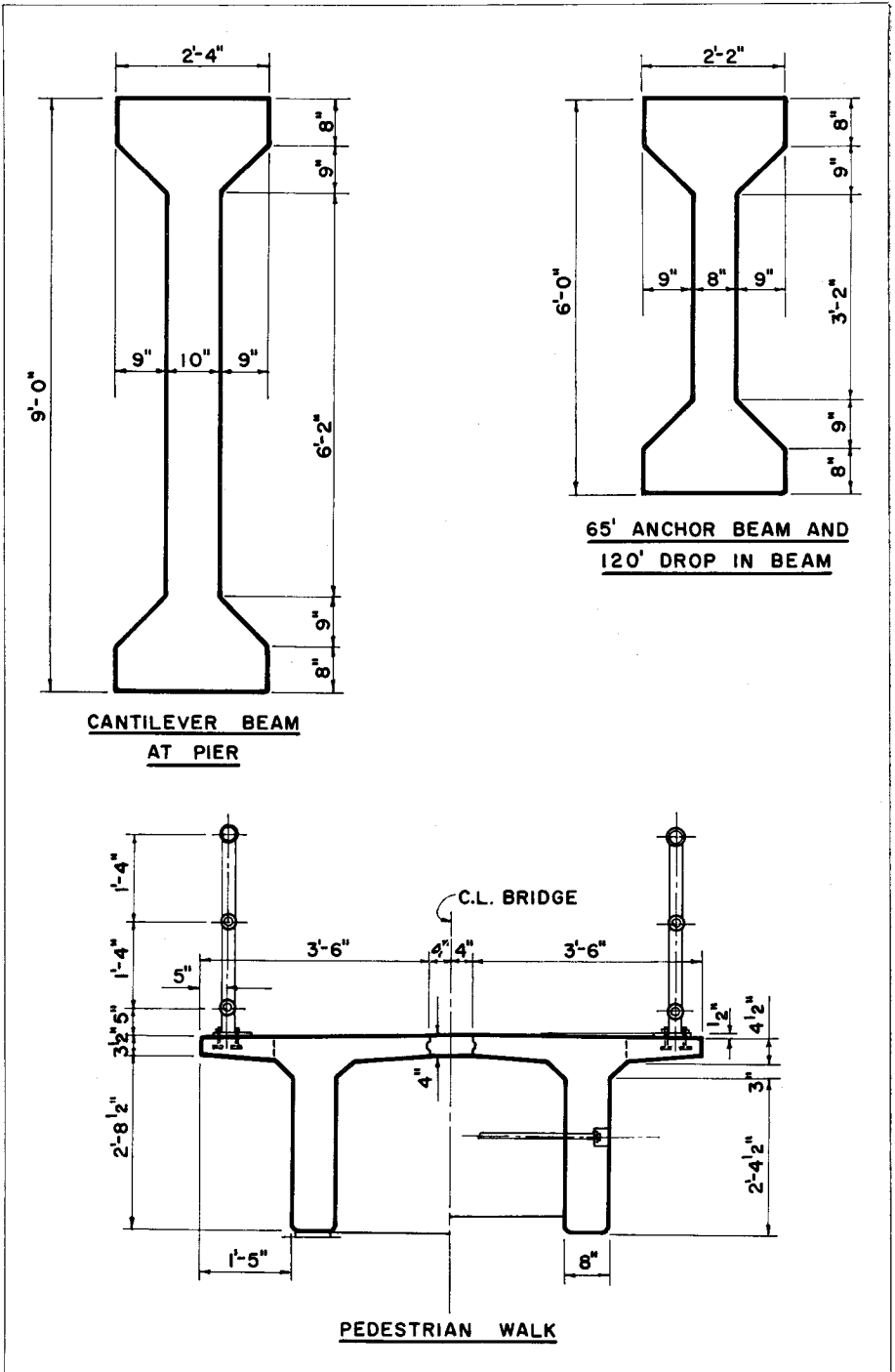


Fig. 3—Typical Sections

ative moment only with the splice furnishing a satisfactory transition between bending in the sagged and humped directions.

The erection scheme is shown in Fig. 4. In each anchor span, the 35-ton anchor and 42-ton anchor-cantilever girders were erected on the piers and falsework bents with their ends 4 ft.-3 in. apart. Had the original plan of post-tensioning the anchor-cantilever members been used, this separation would provide sufficient space for jacks. After concrete in the splices and connecting diaphragms reaches strength of 3500 psi, the 51-ton, 120-ft. drop-in girders are placed between the two cantilevers, then the deck slabs follow in the indicated sequence.

Support for the drop-in span is provided by end daps in the anchor-cantilever and 120-ft. drop-in girders. Reactions and shearing stresses are accommodated by a heavy system of vertical stirrups combined with diagonal bars.

Shoes at all support points on the piers and at the ends of the cantilevers consist of curved pintle plates for fixed bearings and self-lubricating plates allowing for longitudinal motion and rotation at the expansion ends.

One unusual incidental on this project is the provision of pedestrian walks underneath the bridge deck extending from each jetty to the near channel pier. Sebastian Inlet is famous as a passageway for thousands of fish between the Atlantic Ocean and Indian River. It is a matter of common experience on similar Florida bridges that the public is going to use them for fishing piers regardless of restrictive regulations and policing. For this bridge, as a matter of public relations, the Florida Road Department

decided to provide a place for fishing in comfort and safety for both the anglers and motorists. Struts between pier shafts provided simple means of support for walks 10 ft. above average water level, an ideal elevation for fishing.

The walks—2 spans of 100 feet and 3 of 73 feet—are 7 ft.-8 in. wide. They are made up of 2 precast-pretensioned Lin Tee sections with 3 ft.-6 in. flanges joined by a cast-in-place closure 8 in. wide (Fig. 3). Aluminum handrails and navigation warning lights are provided along each side for safety of fishermen and boats.

Concrete strengths for the superstructure were specified as follows:

Anchor and Cant. Sections (145 lbs./cu. ft.)

Concrete for Beams

$$f'_{ci} = 4,000 \text{ psi}$$

$$f'_c = 5,000 \text{ psi}$$

Concrete for Deck Slabs

$$f'_c = 4,000 \text{ psi}$$

Drop-in Section (120 lbs./cu. ft. max. wt.)

Concrete for Beams

$$f'_{ci} = 5,000 \text{ psi}$$

$$f'_c = \text{Unspecified}$$

Concrete for Deck Slabs

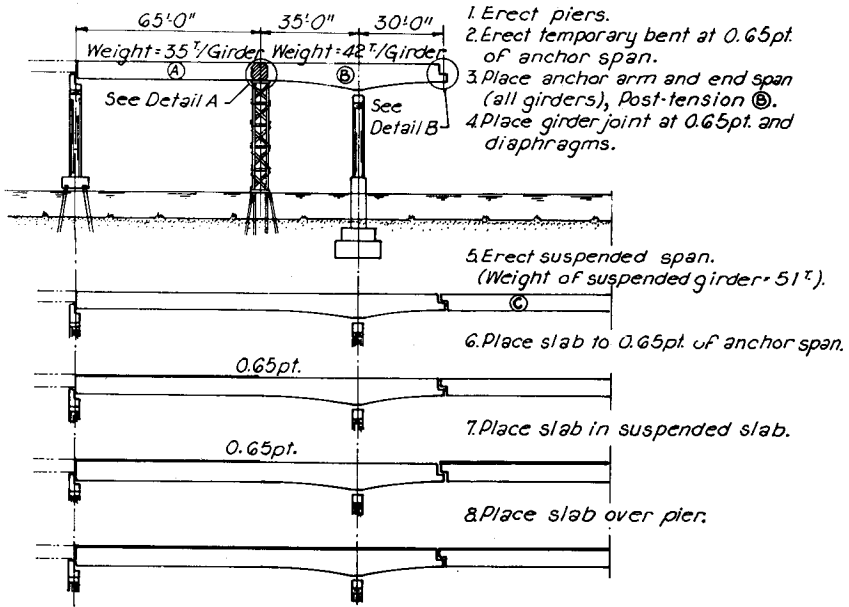
$$f'_c = 4,000 \text{ psi}$$

Splice Concrete (145 lbs./cu. ft.)

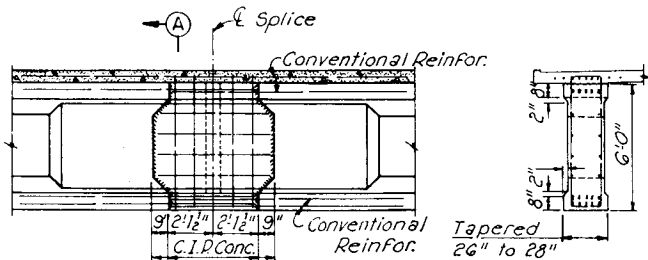
$$f'_c = 3,500 \text{ psi at time of erection of drop-in beams}$$

$$f'_c = 4,000 \text{ psi}$$

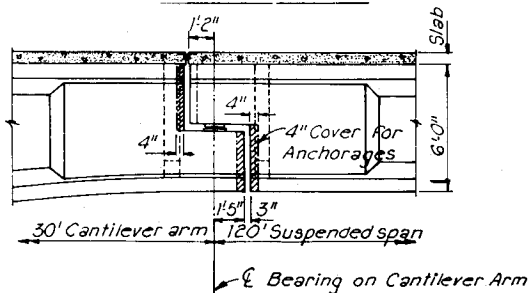
The reason for the high transfer strength of the beams with lightweight concrete is as follows: A loss of prestress 50% higher than with conventional concrete was assumed; that is for pretensioning, a loss of 52,500 psi rather than the usual 35,000 psi. This made transfer the critical stress condition. Using a cement factor of 8 bags per cubic yard, sand fine aggregate, Solite coarse aggregate, curing by moisture and without artificial heat, 5,000 psi strength was reached in 4 or 5 days. Cylinders made for 28



ERECTION SCHEME



DETAIL "A" SPLICE



DETAIL "B" BEAM SEAT

Fig. 4—Erection Plan

day and 90 day tests averaged in excess of 6,000 and 7,000 psi respectively.

A research program at the structural laboratory of the University of Florida using approximately the same mix and including shrinkage and creep tests has indicated that these loss assumptions were unduly conservative.

Bids for the project were received by the Florida Road Department on July 30, 1963. Prices per linear foot for girders in the three main spans were \$50 per ft. for the 120-ft. drop-in, \$50 per ft. for the 65-ft. anchors and \$80 per ft. for the 65-ft. anchor-cantilevers. The average cost per square foot of complete superstructure in the 100 ft.-180 ft.-100 ft. spans (girders, deck, curbs, parapets, handrail) is \$11.68 per square foot which cost indicates a substantial economy in comparison

with the first cost of any commonly used alternate type of similar span length.

Contractor for the project was Cleary Brothers Construction Co. of West Palm Beach, Florida. All prestressed concrete members were furnished by Juno Prestressors Inc., a Cleary Brothers subsidiary company. The project was designed for the Florida Road Department by Howard, Needles, Tammen & Bergendoff, Consulting Engineers.

Sebastian Inlet Bridge was financed entirely by local funds, without any Federal Aid participation; however, plan details, design computations and job specifications were submitted to the Bureau of Public Roads as they were developed. The Bureau checked the entire design and approved a similar design for a large Federal Aid bridge presently under construction

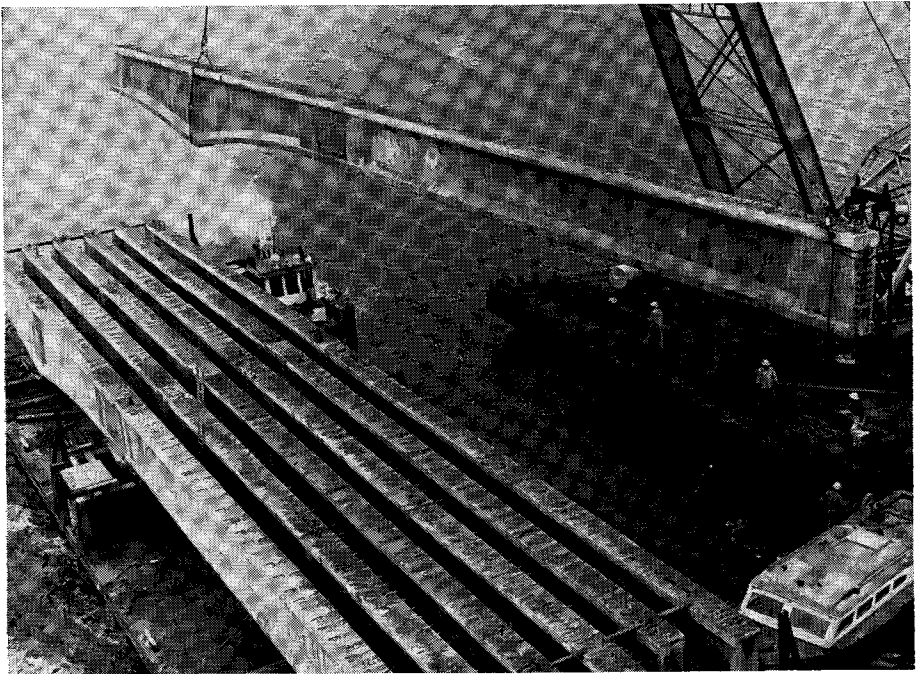


Fig. 5—Precast Prestressed Girders for Dupont Bridge after Being Spliced on Barge

on U.S. Highway 98 over East St. Andrews Bay near Panama City, Florida. This bridge has the same length of main spans as the Sebastian Bridge but will carry 4 lanes of traffic. Unit costs for both the girders and complete spans were substantially less than for Sebastian. Girder prices, per linear foot, were \$40 for the 120-ft. drop-ins, \$41 for the 65-ft. anchors and \$65 for the anchor-cantilevers. For the main span superstructures complete, the average cost per square foot was \$9.60.

One interesting contrast in erection procedure developed between the Sebastian and Panama City bridges. The contractor for the latter bridge has available some unusually large hoisting equipment. By reason of the availability of this equipment, the contractor chose to splice the anchor and the anchor-cantilever members at the production plant, transport them to the bridge site by barge and hoist the spliced assembly into place, thus saving the cost of the erection bents and reducing the cost of splicing. (Fig. 5)

With this general type of structure, many variations of span length and arrangement are possible. The maximum practical span length will be limited by the size and weight of members that can readily be transported and hoisted into place. Using this general layout, a main span length of 200 ft. is possible with the maximum weight of individual members at about 60 tons.

The Sebastian Inlet Bridge was completed and opened to traffic on February 12, 1965. The girder system has been placed on the Panama City Bridge. On neither job has any unanticipated hitch or difficulty developed in erection. One unusual

construction hazard was experienced on the Sebastian Bridge in that the partially erected and temporarily braced girder system, without slab or diaphragms, stood through two Florida hurricanes of last fall. Wind gusts in excess of 100 mph were experienced with no damage whatever; a splendid testimonial to the contractor's foresight and the effectiveness of his temporary shoring. One can only speculate on what might have happened under these circumstances to a girder system of similar vertical dimensions and less weight.

A bridge of this general type to cross New River on Interstate Highway I-95 in Fort Lauderdale, Florida is presently under design in the Orlando office of the Consulting Engineers. The main spans will be in lengths of 100 ft.-150 ft.-100 ft. constructed on a 45° skew. All concrete will be of standard weight, 150 pounds per cubic foot. The drop-in and anchor beams will be standard AASHTO-PCI Type IV sections, with the length of drop-in as 100 ft. The haunched anchor-cantilever member will vary from 4 ft.-6 in. at the ends (the depth of the Type IV beam) to 7 ft.-6 in. at the piers.

While all bridges so far designed with this girder system have been for sites affording water transportation from casting yard to bridge, there is no reason why job site production by post-tensioning would not be entirely practical. The proven economies thus far shown for this type of structure indicate that a similar girder system for similar layouts with length of main span up to about 200 ft. are deserving of consideration in any area in which prestressed concrete structural systems are used.