Comparative Costs of Prestressed and Conventional Construction in Trestle Spans of Florida Bridges

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● THE low terrain of Florida requires scores of exceptionally long bridges because of its flat slopes, broad flood plains of inland rivers, and the many wide tidal-bays and sounds separating the mainland from the highly developed beaches. Construction of new structures and replacement of old ones is a continuing procedure. Many of these bridges have over-all lengths more appropriately expressed in miles than in linear feet, but most of them are essentially very simple structures. Water depths and foundation conditions are such that, generally, adequate support for light spans can be provided by bents of friction or point bearing piles. This has resulted in many short trestle spans. The Florida bridge of great length is usually a series of dozens of identical, short, simply-supported trestle units.

Simplification and economical detailing of trestle construction is under constant study in the Florida road department. Any possibility resulting in cost savings in simple bridge building is worth considering as a small saving on a single span if applied to a large number of spans amounts to an important sum. For approximately four years, prestressed concrete has repeatedly resulted in substantial economies in the longer bridges with many identical spans and, lately, in the shorter structures.

Until recently, standard trestle spans up to about 45 ft in length, constructed near the coast with exposures to salt-laden spray and atmosphere, have usually been of reinforced concrete T-beam type. Composite I-beam concrete-deck spans were standard for longer spans and for less critical exposures on inland bridges. Spans with prestressed members are currently being used as substitutes for both of these conventional types. All prestressed construction to data has been composite and simply supported with the precast-prestressed beam carrying all dead load and the beam-slab combination resisting live load.

Many structural and maintenance advantages can be claimed for prestressed construction, but it has been used in Florida work only on a basis of contract cost competition with one of the conventional types. To date, in every case, the prestressed alternate has won the competition on every job on which it was allowed. Experience has been so consistently good that the policy of designing alternate types is being abandoned for projects on which prestressed members are applicable. Recently, no bid was offered on the conventional types for several important jobs with keen competition.

The use of prestressed members in Florida bridges began in 1951 when a design was allowed in competition with two conventional types for 3½ miles of trestle in the lower Tampa Bay bridge. The prestressed design was bid at a saving of about 4 percent. Little prestressed planning was done for a period of about two years during which time the Tampa job was tested and evaluated and found to justify both the structural computations and the contractor's cost estimates.

In 1953, there was an acceleration in prestressed planning occasioned by the design of several long trestle bridges and by the establishment of several large pretensioning plants. The latter development is of special significance as these yards have facilities for making many types and sizes of members economically in large or small quantities; therefore, the use of prestressed members is practical and economical for the small jobs requiring only a few parts.

The design of prestressed beams has been standardized insofar as possible. Figure 1 shows three sizes of beams designed to accommodate all loadings and all span lengths from 25 to 60 ft. In each size, the cross-section and end block details remain constant for various lengths, and lateral spacing in the structure is varied to satisfy the requirements of span and loading.

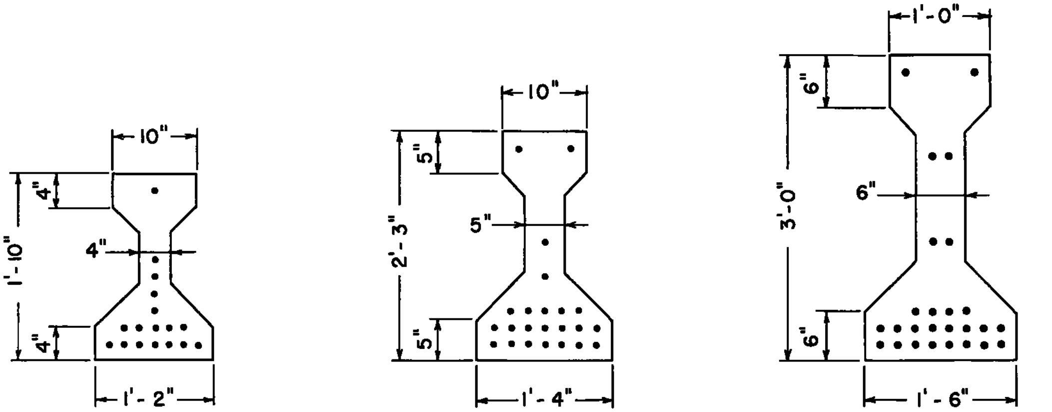

Figure 1. Standard pretensioned beams.

Standard beams for post-tensioning, as shown in Figure 2, have been developed for spans of 45 to 72 ft. These beams are an extension of the original design used for beams of the lower Tampa Bay bridge. They are also used with the combined method of stressing where the straight tendons are pretensioned and the draped tendons are post-tensioned.

Table 1 shows the bidding on ten typical projects of varied type, over-all length, and individual span length. A first cost differential, although of variable percentage, has been a consistent characteristic of bidding on these and all other jobs on which a prestressed design was offered. The superstructure cost includes all items above the substructure to, but not including, the handrail. The area upon which the cost per square foot is based includes the clear area of roadway and walks between the inside faces of railings.

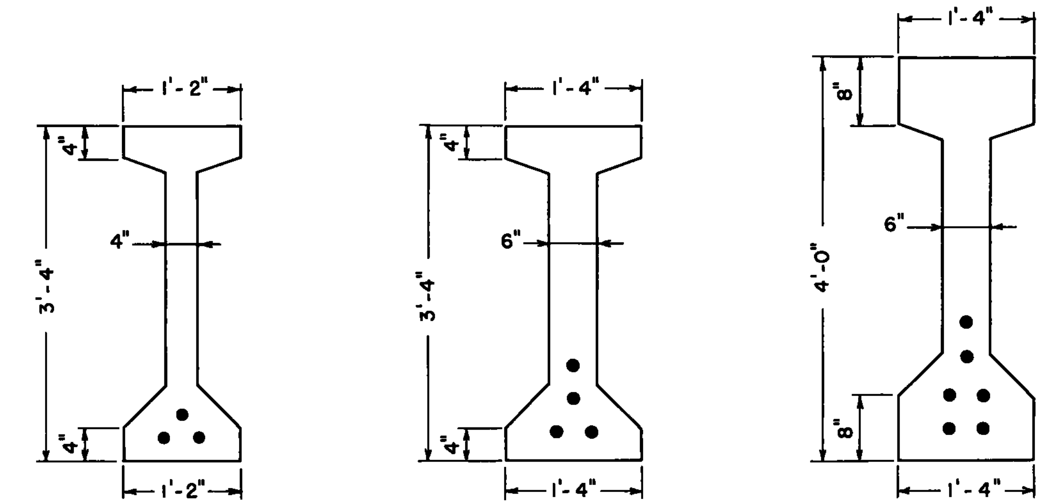

Figure 2. Post-tensioned beams, cross-sections at mid span.

TABLE 1

Bridge	No. and Length of Spans	Roadway Width	Walks	Type of Stressing	Superstructure Costs Per Lin Ft of Bridge	Superstructure Costs Per Sq Ft of Bridge	Alternate Type	Alternate Cost per Sq Ft	Date of Bids
Lower Tampa Bay	363 at 48'	28'	2 at 3'	Post.	$116.69	$3.43	Reinf T	$3.53	195
Cortez	50 at 48'	24'	2 at 5'	Combine	180.00	3.18	Reinf T	3.38	1954
Escambia River	71 at 36'	28'	2 at 2'	Pre	94.45	2.95	Reinf T	3.26	1954
Hillsborough River	8 at 53'	28'	2 at 2'	Pre	116.98	3 66	I Beam	4.66	1954
Upper Tampa Bay	252 at 48'	26'	2 at 1'-6"	Post.	87.96	3.03	Reinf T	3.59	1954
	20 at 72'	26'	2 at 1'-6"	Post.	166.67	5.75	I Beam	5.75	1954
Myakka Valley (6 bridges)	25 at 25'	24'	2 at 1'-6"	Pre	90.41	3.35	Reinf T	3 44	1955
Palm River	10 at 36'	56'	2 at 5'	Pre	314.77	4.77	Reinf T	4.85	1955
	1 at 45'	56'	2 at 5'	Pre	351.11	5 32	Reinf T	5.59	1955
Anclote River	7 at 45'	28'	2 at 3'	Pre	144.44	4 25	Reinf T	No bid	1955
Manatee River	30 at 66'	56'	2 at 2'	Post.	272.75	4.55	I Beam	7.32	1955
Palma Sola	72 at 48'	24'	2 at 5'	Post.	110.00	3.24	Reinf T	No bid	1955

A 106-mile section of the Florida Turnpike is now under construction from Miami north. Engineers for the turnpike commission have adopted the road department's standard pre-tensioned beams as alternates for I-beams for all structures on which they are applicable. As of December 15, 1955, bids have been received for 22 bridges on which the alternate was allowed. The bridges are principally grade separations or small structures of three or four spans with individual span lengths of 35 to 55 ft. On 9 of the bridges no bid was received for the I-beam alternate. On the remaining 13, the prestressed alternate was bid low in every case for a total saving of $93,000.

Some design features which tend to limit construction with prestressed beams are curves, warps, skews or other geometric requirements which result in highly variable lengths and shapes. Members for such specialized construction can often be best furnished through the fabricating facilities of the steel industry. In Florida, prestressed beams have not been used in spans skewed more than 20 degrees.

Pretensioning, with the reinforcement in a constant position on a bed several hundred feet long, is ideal for production line manufacture and minimizes the cost of stressing operation. Post-tensioning with part of the tendons draped to offset the variable dead load moment is more efficient. Relative savings between the two methods will vary between different jobs and different contractors. Limited experience on fairly large jobs has indicated that, for spans of more than 45 ft, the extra labor in stressing the draped tendons is more economical than the extra material required when all tendons are straight.

The limiting economic span length for this simply-supported composite construction is also difficult to define. Table 1 shows that a 72-ft span was bid at the same price with prestressed beams and with I-beams in 1954. This span was near the point of equal first cost for the prices prevailing at that time. Recent increases in the delivered price of fabricated steel have definitely increased this economic length. Bids for 1955 indicated a cost differential of steel above prestress of about 50 percent in 66-ft spans. These bids were by different contractors, and superstructure items other than the beams were involved. Possibly, any span in which the length would not be economically impractical for simply supported I-beams would be practical with precast-prestressed beams.

Prestressing, which was little more than an interesting probability five years ago, has become a firmly established practice and one that will become increasingly important in bridge and building construction.