The Seven Mile Bridge (Knight Key Bridge
Moser Channel Bridge
Pacet Channel Viaduct)
Linking Several Florida Keys
Monroe County
Florida

HAER FL-2

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
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HISTORIC AMERICAN ENGINEERING RECORD

THE SEVEN MILE BRIDGE
(Knight Key Bridge-Pigeon Key Bridge-Moser Channel Bridge-Pacet Channel Viaduct)

Location: Spanning several Florida Keys and many miles of water this bridge is approximately 110 miles from Miami. It begins at Knight Key at the northeast end and terminates at Pacet Key at the southwest end.

UTM 487,364E / 2,732,303N 476,848E / 2,729,606N

Date of Construction: 1909-1912 as a railway bridge. Adapted as a concrete vehicular bridge on U.S. I in 1937-1938.

Present Owner: Florida Department of Transportation
Hayden Burns Building
Tallahassee, Florida 32304

Present Use: Since its conversion as a bridge for vehicles it has been in continually heavy use as U.S. I linking Miami with Key West. There is one through draw span

at Moser Channel, the connecting channel between the Atlantic Ocean and the Gulf of Mexico. It is presently scheduled to be replaced by the State with construction already underway in 1980.

Significance: At the time the Florida East Coast Railway constructed this bridge it was acclaimed as the longest bridge in the world, an engineering marvel. It was the most costly of all Flagler's bridges in the Key West Extension. Since the beginning it has served as the one and only vital link by land between Miami and Key West. The logistics of assembling labor and materials and overcoming the difficulties presented by deep water, normal tides and hurricanes attest to the engineering and management skills of those connected with its construction.

Historian: Woodrow W. Wilkins, Architect

August 1980

When the last 80-ft. steel girder was set by derrick barge No. 9 at 6:00 a.m., January 21, 1912, and when the last rail was laid at Span 36 in the Knight's Key Bridge late that Sunday afternoon, and when the last spike was driven in the early morning of January 22, 1912, the span was announced completed by Division Engineer C.S. Coe at 6:30 a.m. This was the span closing the gap over the Knight's Key trestle and thereby completing the Key West Extension of the Florida East Coast Railway. The pilot train and the Flagler Special ran over the bridge and on to Key West a few hours later (1).

The completion of the Key West Extension marked the fulfullment of a dream expressed by natives , when the editor of the Key West Gazette suggested a rail link to the mainland in 1831. The idea was given publicity in 1850 by Senator Stephen R. Mallory of Key West (2).

It remained, however, for Henry Morrison Flagler as President of the Florida East Coast Railway to make the final decision to begin the construction of the Key West Extension in 1904. The railway had reached Homestead in 1904 from which surveys to Cape Sable and Turtle Harbor were made in an effort to extend the railway to satisfactory harbor facilities. The first route which lay wholly in the Everglades was rejected as was the second survey. The decision was then made to build to Key West, 128 miles from Homestead. 14 miles were on the mainland, with the remainder stretching across the lower keys of South Florida (3).

Actual construction was begun in April 1905 under the immediate charge of Joseph C. Meredith until his death, April 20, 1909. He was succeeded by William J. Krome who carried the project to its successful completion (4).

Four principal bridges were originally planned. They were the following: The two-mile long concrete viaduct at the southern end of Long Key over water 10 to 30-ft. deep; the Seven Mile Bridge below Knight's Key over water 18 to 22-ft. deep; the Bahia Honda Bridge, slightly more than one mile long over water from 20 to 30-ft. deep; and the bridge at Boca Chica slightly more than one-half mile long (5).

Because of different conditions of water depth and wave height, different types of bridge construction were used. Concrete arch construction was used for the structures at Long Key, Boca Chica and the Pacet Channel section of the Seven Mile Bridge. The other three sections of this latter bridge are constructed of steel plate girders resting on concrete piers. At Bahia Honda steel trusses are used. Several of the minor bridges were pile trestles where the water was shallow. These were replaced by concrete arches following the 1909 hurricane (6).

After the preliminary surveys for the Extension were completed, the Company advertised for bids for its construction in many of the leading newspapers in the United States. There was only one response from a contractor who had proposed a cost-plus bid. "Flagler refused to sign

such a contract, and decided to have his own lieutenants, headed by Joseph R. Parrott, undertake the task themselves" (7).

"New methods of construction had to be devised to meet the needs in various places, and special materials, answering special purposes were brought from long distances" (8). All materials, including water for domestic and boiler use had to be brought in.

Vital to the success of the project was the assembling of the equipment and perfecting an organization under the direct supervision of Joseph C. Meredith, who had been recently employed as Constructing Engineer. Since traditional equipment for construction was unsuitable, practically all of the equipment on the original construction was floating equipment. Among other types of equipment it included launches, Mississippi River steamboats, tugs, dredges, barges, pile drivers', catamarans and derrick barges (9). In addition, there were two-story "Quarterboats" and houseboats for housing the workers. After the 1906 hurricane when 145 men were swept overboard, (10) permanent camps were established on land. An example of being forced to adapt to the conditions was when Engineer Meredith found it impossible to use ordinary dredges because of the difficulty of securing coal and fresh water. He developed a gasoline-engine excavator. It consisted of a 30-hp Otto gasoline engine operating a boom and a Hayward orange-peel bucket (11).

Eight complete construction plants were used in the field, each one comprising a unit. Each barge, 40-ft. by 70-ft. and 6-ft. 2-in. deep, was "equipped with a large size concrete mixer and engine, a 90-hp locomotive-type boiler, two derricks fitted with 50-ft. boom, clam-shell buckets and a large hopper for sand and stone" (12). Each barge was also fitted with a large centrifugal pump for removing water from the cofferdams (13). All of the floating equipment was fitted with dynamos for generating electricity since much of the work could not be interrupted by night-fall (14). The Company also maintained at Boat Key Harbor an extensive plant for maintaining and repairing its own machinery. It included boiler and machine shops, a saw-mill and an electric welding plant (15).

Another problem which the Company faced was securing and maintaining an adequate labor force, particularly for the construction of the bridges. Labor was recruited principally through employment agencies in New York and Philadelphia (16). One of the greatest recruitment difficulties was securing "all-around machinists capable of performing the diversified duties necessary" (17). Labor from the East was furnished transportation to the camps in the Keys with the expense being deducted from their wages. If a person left and if he was delinquent in this obligation, he was never forced to work out his obligation (18). However, at one time, there was a Federal indictment in charges of peonage

against Mr. Meredith, Mr. Krome and the New York employing agent. The court directed a "not guilty" verdict (19).

In addition to their salary, the men were furnished board and lodging provided by contract to the railway (20). Health care was provided in an emergency hospital in each important camp. These were in charge of two trained orderlies capable of giving first aid and treating ordinary illnesses. If an operation or extended treatment was necessary, the patient was sent with an orderly by special train to the Company's hospital at Miami or Key West. This medical and hospital service was "absolutely free of charge" whether a man had worked one day or five years (21).

The work force varied from 500 to 800 men in the early days (22). Later, particularly in the last years of rush between 3000 and 4000 men had been employed (23).

Before discussing the Seven Mile Bridge in detail, mention should be made of the Knight's Key Dock which was also vital to the construction of the Key West Extension. Because of the large amount of bridging that would be necessary below Knight's Key, it was decided to construct a temporary 75-ft. by 600-ft. dock in the Knight's Key Channel where the water was approximately 20-ft. deep (24). It was reached by a wood pile trestle which was 2000-ft. long (25). The trestle ran for some distance parallel to the Knight's Key Bridge piers under construction, eventually curving through the line of piers at Span No. 36 (Photo H-6).

The dock became the first interchange between the mid-keys and Havana. Work on it was begun in the week ending October 26, 1907 when 170 piles were driven (26). In addition to providing a location for storing crushed stone and screened gravel, the dock was equipped with a traveling bridge, rigged so that stone could be directly taken from the hold of a vessel by a clam-shell bucket, depositing the material on the dock which was central to all concrete work (27). Scheduled service to Knight's Key Dock began in February 1908 with trains meeting steamships of the P. and O. Steamship Company traveling to and from Havana (28).

The Seven Mile Bridge comprises four sections combined into one continuous bridge. It begins at the northeast end with the Knight's Key Bridge moving toward the southwest over the Pigeon Key Bridge, the Moser Channel Bridge and the Pacet Channel Viaduct, respectively. During construction and immediately thereafter they were jointly referred to as the Knight's Key Bridge although correspondence, reports and drawings referred to them as separate entities. In January 1911 it was called the Knight's Key - Little Duck Key Bridge when the following statistics were presented. The total length, 35,600-ft; elevation above water, 17 to 31-ft; length of steel spans, 80-ft; and the diameter of concrete arches, 35-ft. The lengths of the separate components are also given as follows: Knight's Key Channel Bridge, 6800-ft; Pigeon Key Bridge, 5900-ft; Moser Channel Bridge, 13,800-ft;

and the Pacet Channel Viaduct, 9100-ft. "all framing one continuous structure" (29). The lengths are obviously rounded-off. It should be noted that these figures were stated approximately one year before the Extension was completed.

Two months later, additional information on the Knight's Key Bridge was recorded with the following facts: 316 plate girder spans on piers, 80-ft. center to center; 19 plate girder spans, 59-ft. 9-in., center to center on piers; 1 draw span, 253-ft. 6-in.; center to center of end pins and 264-ft. 4-in. center to center of end piers; 210 arches with 35-ft. clear span on piers 43-ft. center to center (30). Also in May 1912, the entire continuous structure was called Knight's Key Bridge (31). And in 1913, after distinguishing between bridges as steel spans resting upon pier and viaducts consisting of concrete arch construction a report gives what is probably more accurate lengths as follows: Knight's Key Bridge, 6803-ft.; Pigeon Key Bridge, 5935-ft.; Moser Channel Bridge, 13,947-ft.; and Pacet Channel Viaduct, 9035-ft.; total length, 35,720-ft. (32). These references serve to establish that the historical name for the Seven Mile Bridge was for a long time the Knight's Key Bridge. As far as can be determined, one of the earliest public references to the now popular name, the Seven Mile Bridge, was made in 1953 (33).

Having distinguished between the historical name and the popular name of the structure, it should be noted that the

Henry Morrison Flagler Museum, Palm Beach, contains hundreds of original drawings and blueprints conveniently grouped in rolls under the names of the four segments. There are also numerous blueprints of shop drawings by the American Bridge Company which fabricated the steel. Unfortunately, the Florida East Coast Railway drawings give no clues to the designers of the bridge or any of its parts.

Since the field conditions which were met differed between some, if not all, of the four segments, methods and systems of construction are necessarily found to differ also. This report will, therefore, recognize there facts and treat each separately.

After the rails had reached Knight's Key, 83 miles below Homestead, in December 1907 (34), work was carried on simultaneously at various parts of the Seven Mile Bridge. For example, the Construction Report for the week end July 31, 1909, notes, among other categories of work, that pilings were driven for 88 piers at Knight's Key Bridge and for 26 piers at Moser Channel Bridge (35).

The Knight's Key Bridge

This bridge is 6803-ft. long. In the week ending August 15, 1908, a work camp was established in Pigeon Key and one barge of material was discharged for construction of a cement storage house (36). The initial work on the Knight's Key Bridge itself occurred during the week ending January 2, 1909

when "Pile driver #1 has been engaged in driving two lines of dolphins for holding plant equipment while engaged at work" (37). By the end of the following week, in addition to driving anchor piles and fender piles for six piers, pile driver #6 had all of the south line of dolphins driven down to the intersection with the Knight's Key trestle. Also three complete sets of cofferdams which were loaded at Long Key were delivered (38). For the week ending February 6, 1909, one month after the initial dolphins were driven, cofferdams #5, 6 and 7 were lowered into place, seals were placed at piers #3, 4, 5 and 6, cofferdam #2 had been pumped out and cleaned and the piling cut off. Additionally, during that week, four pier forms were constructed at Pigeon Key and ready to be placed in the first four cofferdams (39). Thus did the rapid pace of work continue until the last pier on the Knight's Key Bridge was completed at 5:00 p.m., July 28, 1909, five months and one day after the completion of the first pier which was finished at 3:00 a.m., February 27, 1909 (40).

Before discussing the steel super-structure of the Knight's Key Bridge, the materials and methods of the sub-structure, i.e., the cofferdams, the pilings, the seals and the piers which were mentioned in the Construction Reports, above, should be described in order to appreciate the unprecedented engineering problems and solutions connected with the bridge.

"The below-water construction of arches and piers is the same. Not only must these supports rest upon solid rock, but the engineers determined that they must be immovably anchored to it" (41). "The purpose of the piling was three-fold: first, to afford foundation should any erosion of the rock occur: second, to act as an anchor against any tendency to overturning or lateral displacement and third, to act as an exploratory probe. It happened several times that cavaties in the rock were encountered that has been missed by the sounding outfits" (42). At Knight's Key, four varieties of lime rock were encountered (43).

Once the location of the piers had been determined wood cofferdams were floated into place. They were constructed of four portable wood sections. Two 24-ft. by 60-ft. lighters, rigged as a catamaran were used in this operation. They were equipped with a 10-ton derrick placed at diagonally opposite corners. Weighing from eight to twelve tons when assembled, braced and caulked, the cofferdam was run out on three trucks on track timbers between the barges, lowered into position and secured. Then the layer of sand on top of the rock bottom was pumped out by a large centrifugal pump (44). These cofferdams were re-used many times. After they had been secured a steel punch was driven into the rock to make places for the creosoted piles. 24 of them were used as anchors for each pier (45).

After the piles had been driven, the next operation was to pour the seal. This was a "footing course of concrete from 3 to 5-ft deep" deposited by tremie and allowed to set" (46). German Alsen cement was used for all underwater concrete with American Alsen, Alpha and Vulcanite cements being used above the high tide line (47). This was mixed with gravel from Mobile and sand from Bear Cut near Miami (48). Besides forming a solid and compact union between the piles and the rock, the seals served to make the cofferdam practically water tight. The cofferdams were then pumped dry and the protruding piles were sawed off below the ordinary low tide line (49).

The form for the pier base was then put in place. It was built up of German concrete to a point a few inches above the tide level. This concrete was allowed to set for seven days, after which the water was admitted and the cofferdam was removed (50). In filling the forms with concrete several reinforcing rods were left out to allow two men to stay in the pier form to work the concrete and to allow the spout to be placed for pouring the concrete. The remaining rods were placed after the concrete reached the top of the pier (51).

The forms for the upper part of the pier were then placed. The reinforcing rods were also placed and the remaining concrete laying done at the same time (52). There is a note on the back of a photograph (W-32 which is not submitted herewith) in the Henry Morrison Flagler Museum,

Palm Beach which states " the Knight's Key piers placed 80-ft centers, 22-ft. above mean high water, measuring 7-ft. 4-in by 16-ft. on top". The construction report for the week ending July 31, 1909, states that pilings had been placed for 88 piers and cofferdams had been set for 86 piers. Upper forms were set for 85 piers and upper shafts concreted for 85 piers (53). The above descriptions are typical methods of construction (Photo H - 5, 11, 12, 13, 20, 21, 22, 23, 24 and 27).

The superstructure of the Knight's Key Bridge was composed of 80-ft. deck steel plate girders (54). Because of the depth of the water at Knight's Key Channel it was decided to use the steel girders instead of concrete arches as at Long Key. These girders furnished by the American Bridge Company are 8-ft. high and weigh 41½-tons each (55).

It is interesting to note that Henry Flager, who was 75 when he made the decision to build the Key West Extension, had continually maintained an interested and active role in its construction. He made numerous suggestions which were not always followed. The size of the steel girders is an example. In a letter from him in Palm Beach to William J. Krome on February 25, 1910, he suggested that all bridges should be built of thicker steel and not over 5 or 6-ft. in height to better withstand hurricanes and reduce the surface area exposed to corrosion (56). Some years earlier while in New York he wrote a letter to Joseph C. Meredith on June 20,

1905, insisting that the girder walls should be 2 to 3-ft. higher than the top of the rails to prevent derailed trains from falling into the water (57).

The erection of the girders was begun by contract with Terry and Tench who used a derrick car for the operation. When the Florida East Coast Railway assumed the work with Company forces after the contractor defaulted, the work was done by floating derricks at a much quicker pace. (Photo H-18). Each girder was anchored to the piers with 16 bolts, four to each pier (58). The first span was erected on August 21, 1909 at the east abutment between piers #1 and 2 (59). (Photo H-25).

The last deck plate girder was set by Barge #9 between piers #36 and 37 at 6:00 a.m., Sunday morning, January 21, 1912 (60). This event marked the completion of all steel and concrete spans in the Extension. All spans except at pier #36 had been placed during the week ending January 29, 1910, two years earlier (61). The delay in closing this span is explained by the fact that the Knight's Key trestle ran under this gap. The trestle and the dock were necessary for the completion of all the bridges.

Once the girders were bolted into place, 10-in. by 12-in. by 11-ft. cross ties were clamped to the bridge with railroad hooks. These sawed oak ties were laid six inches apart, held to the girders by hook bolts (62). Conventional track gauge rails, weighing 70 lbs. per yard were set 29-ft.

9-in. above mean low tide. The last rail was laid at Span #36 on Sunday, January 21, 1912, and the last spike was driven in the early morning, January 22, 1912 (63).

Although the effect of normal forces of nature were of primary concern from the initial concept and planning of the project, anticipated but unscheduled natural forces created the greatest havoc. One of these forces, the 1935 hurricane did in fact cause the eventual demise of the Key West Extension. Prior to that the greatest loss of life and equipment occurred in the 1906 hurricane following a false alarm in 1905. After that, when approaching storms were reported from Washington, the land equipment was protected and the floating equipment was taken to shallow water and sunk. It was more economical to raise it and repair it (64). Although the storms of 1909 and 1910 were more severe there was relatively little loss of life and equipment (65).

The hurricane of October 11, 1909 not only caused extensive damage to the Knight's Key Bridge, only a month after the first steel girder had been erected, but it appears to have caused the default of the contractor. It was in this storm that five steel girders were blown entirely off their piers. They were numbers 41, 50, 57, 68 and 69. All but the last had the bracing in place and were bolted. A considerable number of other spans were shifted from 1-in. to 18-in. on the piers. This was reported in the Weekly Construction Report for the week ending October 16, 1909 (66). Thereafter

there ensued a battle between the Company and the contractor.

During the storm four barges of girders went aground at Pigeon Key, one of them containing draw bridge material broke loose and went into the Knight's Key trestle and sank. Thus the greater part of the draw bridge material was lost overboard. The contractor also lost the erection traveler which was resting on the last span and carrying spans 68 and 69. The contractor disclaimed responsibility for plant and material lost (67). The Company claimed that the lost girders were due to the carelessness of the contractor who had failed to put in the required anchor bolts, using only two to each girder at the time of the storm (68). Although the firm had contracted to erect the Knight's Key and the Moser Channel bridges and the draw at Moser Channel (69), they abandoned the work. The construction report for the week ending October 23, 1909 states that the contractor resumed work on Monday but decided to abandon the contract on Tuesday night. "They did no other work except what was necessary to recover and prepare their plant for shipment" (70). On November 2, 1909, "James Parker, Terry and Tench businessman on the Knight's Key Bridge left for New York with several bridgemen. Really the whole force has left" (71). During the week ending December 4, 1909 wrecking crews picked up 4 of the 5 spans lost overboard. They were found to be so badly twisted that they were no longer fit for use on the bridge (72).

One of the problems which the Company faced was the protection of the steel spans from rust. They had set up a test rack at Marathon in which test plates, coated with different plates, were placed. It was found that the Company's standard paint was as efficient as any (73). Regarding the effect of the sea-water on concrete, the Company found that shortly after being exposed to the water a scaling-off occurred to a depth of 1/16-in. on the part of the concrete between the limits of low and high tide, which was about 18-in. After the scaling-off took place a marine growth formed on the parts exposed to the weather which served to protect the concrete from further damage (74).

There is one final word in the design for hurricanes: "They (the engineers) have built these Viaducts of stone and steel to withstand a wind pressure four hundred per cent greater than has ever been recorded in this latitude" (75). In fact, very little damage was suffered by them in 1909.

The Pigeon Key Bridge

Being a continuation of the Knight's Key Bridge there were no differences in the material and method of construction, except for the fact that when the bridge crossed this tiny island, the foundation piers were on solid land. (Photos H-32 and H-40). This bridge is a 5935-ft. link in the Seven Mile Bridge. Since one of the major work camps was located on Pigeon Key (76) there was a trestle leading on to it.

The Moser Channel Bridge

This continuation of the Pigeon Key Bridge is 13,947-ft. in length. Except for the draw span, the materials and methods of construction are the same as at the Knight's Key Bridge. The cost of this segment was listed for tax purposes in 1913 as $1,146,984.00 whereas the total cost of all four bridges were listed as $2,735,022.00. These costs reflect only an approximate distribution of heavy items of expenditure (77).

The draw span is the draw in the Seven Mile Bridge, located somewhat south of the center of a 5-mile stretch of plate girders. Specifically there are 55 80-ft. plate girder spans, then to 19 59-ft. 9-in. spans and 119 80-ft. spans north of the draw. South of the draw are 142 80-ft girder spans followed by two miles of concrete viaduct construction (78). Most of the shorter plate girders are used in the two degree curved portion of the bridge, about a mile north of the draw (79).

By July 17, 1909, foundation piles were driven for 15 piers and seals were placed for 4 (80), and during the week ending August 14, 1909, the cofferdam was set for pier number 31, the pivot for the draw span (81). By September 4, 1908, the lower form for the pivot pier had been concreted (82). (Phote H-13).

The October 1909 hurricane caused the following damage to work on this section, anchor pilings for two piers, coffer-dams for seven piers, seals for six piers, one lower and one

upper form. Practically all of the equipment being used was either sunk or went aground (83). Eight girders, comprising 4 spans had been raised into position during the week ending January 22, 1910 (84), with the last steel span being erected in the week ending April 15, 1911 (85). Structural steel for the draw bridge trusses had been erected during the week ending January 7, 1911 (86). Track-laying was carried on southward from the Moser Channel drawbridge and north from Bahia Honda Key simultaneously (86) during the week ending December 30, 1911 (87). Selected drawings and details of the Moser Channel Bridge are included herewith (Photos H-11, 12, 13, 15, 16 and 17).

The through truss draw span was 253-ft. 6-in. A draw span was originally planned to be placed in the Bahia Honda Bridge. The United States Government directed that the draw be placed, instead, over Moser Channel which was a direct passage connecting the Atlantic and the Gulf of Mexico (88).

The Pacet Channel Viaduct

This true concrete viaduct consists of 210 arches with a 35-ft. clear span and 43-ft. center to center spacing of piers (89). It is 9035-ft. long, terminating the Seven Mile Bridge at its southern most end. The concrete arches meet the Moser Channel steel girders approximately two miles north of Little Duck Key (Photos H-3 and H-36).

Form work for the arches was begun during the week ending January 21, 1911 and two weeks later pile driving for the piers had begun (90). By June 24, 1911, 39 arch forms had been placed, 29 arches had been concreted, 13 spandrel walls and 9 arch forms had been removed (91). Concrete work had been completed by December 23, 1911 (92).

The method of construction of the arches at Long Key, which is described below, was followed in the Pacet Channel Viaduct (93). The method for driving the piles, setting cofferdams, pouring concrete seals and concreting the pier forms were as described for the steel bridges. However, the "work on the arches was practically independent of the work on the piers, and was conducted with different men, different barges, and to some extent different materials" (94). As explained earlier the difference in materials was the fact that American cement was permitted in work above high tide.

The piers having been completed, the arch ring was assembled in the place where it was to be used first. When it was removed, it was floated forward intact to the next location (95). The piers were of sufficient section to carry the thrust of the arches to which they were anchored. Two sets of 3/4-in. reinforcing rods were used, one set imbedded in the concrete near the soffit, passing from pier to pier and the other imbedded in the outer portion of the arch, also extending from pier to pier (96).

After the pier had hardened, the arch centers were set for placing the arch rings. At Long Key, the arch center consisted of five wood trusses, spaced 4-ft. across and lagged up with 3-in. material, the whole being supported on two five-pile vents 28-ft. apart. The centers were held in position by oak wedges (97). As the form work was put in place, steel rods were set and spliced to the rods in the pier, wired so that the concrete pouring would not displace the steel. As the arch ring was concreted, lagging for the back of the arch was carried up on temporary bracing so that the crown could be poured and not run off. The centers remained in position until the spandrel walls had been placed and set (98). The temporary bracing and lagging was removed before constructing the spandrel walls. Then the form work for the walls was set in place and wired together and the steel rods in the arch were spliced to the rods protruding from the pier (99). (Photo H-26).

"The concrete was placed in the arch ring and the spandrel wall at the same time, being commenced over a pier and carried out on each side thereof over the adjacent arch centers. Thus, an arch ring would be built in two operations, the first consisting of placing the concrete from one pier to a point about one-third of the distance around the arch ring, and the second beginning at the other pier and completing the other two-thirds of the arch. The place where

these two operations formed a joint was selected to insure the least deflection of the forms during the placing of the concrete due to loading" (100). While the concrete was being placed it was worked by men between the forms. After the concrete had hardened, it was kept wet for 10 days. Then the space between the spandrels was filled with broken stone ballast in which the cross ties were imbedded (101). (Photo H-47). "To avoid expansion cracks the arches were put in alternately ... The arch is so designed that little dependence is placed on the reinforcement. This is true of all concrete structures on the entire line, as it was not thought wise to take any chances of corrosion of the reinforcement from the salt water, and weight was desired to withstand the action of the waves" (102). The ends of each arch, where they met on piers, were joined by dove-tailing to permit expansion and contraction (103).

The Overseas Highway

It appears that the Key West Extension was never a paying proposition with an estimated cost of over $20,000,000 (104). It served Key West for 22 years until the fateful Labor Day hurricane in 1935. Prior to this the Company had already gone into Receivership with Mr. W.R. Keenan, Jr., Flagler's brother-in-law and President of the Florida East Coast Railway, and Mr. S.M. Loftin, the Company's General Counsel appointed as co-receiver in 1931. Net losses between

1928 and 1931 had been $6,000,000 with maintenance in the Extension alone at $3000 per mile of track per year (105).

After the hurricane of 1935 which washed away such a great number of miles of embarkment and track, the receivers decided to abandon the Extension south of Florida City (106). One Flagler estimate to rebuild the sixteen miles of damaged tracks was $1,800,000. A Federal court at Jacksonville was told it would cost $2,940,000 (107). The system was sold to the state of Florida for $640,000 (108).

Previously, the union of Key West to the mainland had begun as early as 1924 when the Monroe County Commission had broached the idea of an overseas highway to the Dade County Commission. The Monroe County residents had already voted a $300,000 bond issue for this to parallel the railroad in 1923 (109). Dade County completed its highway to the county line and Monroe County had completed a highway throughout the length of the Keys except for 40 miles of "water gap". This part of the travel was accomplished by ferries with slips at Lower Matecumbe and No Name Key (110). The highway utilizing the ferries was opened January 12, 1928 (111). Monroe County had spent $3,970,000 for its road to the mainland. Army engineers had estimated that at least $7,500,000 would be required to bridge the "gap". Then the Overseas Highway Bridge Corporation was organized to request a loan from the Reconstruction Finance Corporation for $10,700,000 . On

October 12, 1932. The Bridge Commission was asked to dissolve and reorganize as the Monroe County Toll Bridge Commission, which was approved by an enabling act by the State of Florida (112).

After the 1935 hurricane, the Federal Public Works program gave the Bridge Commission $600,000 outright and the Reconstruction Finance Corporation gave a $3,600,000 loan to convert the abandoned bridges and viaducts to highway bridges, the loan to be repaid out of tolls collected (113).

The water gap bridges were converted to a modern highway by Engineer B.M. Duncan. Among the names of early contractors and suppliers of the period were S.J. Groves and Sons, Minnesota; Wisconsin Bridge and Iron Company, Milwaukee, Wisconsin; W.D. Horne of Homestead; Florida East Coast Welding Company of Key West; Charley Toppino of Homestead; Holden Wood, Inc. of Miami; M.G. Comer Bridge and Foundation Company of Miami; and Cosco Products of Birmingham, Alabama (114).

Conversion of the bridges was started on November 28, 1936 (115). The 14-ft. width of Flagler's bridges was stretched to handle two lanes of traffic by using 22-ft to 25-ft I beams. On the concrete bridges, slots were cut into each of the abutments to receive the steel beams. Then the slots were cemented over to encase the steel beams into a solid concrete foundation. Wood forms for concrete slabs, 10-in. thick were built between the beams which were spaced 10-ft.

apart. Before the concrete was poured the space between the cantilevered beams was further strengthened by steel braces. Hence there are three separate sections in the concrete deck. These are the width of the original bridge in the center flanked by the concrete overhangs on each side. Each bridge has a 9-in. high curbing and concrete guard rails except at the Knight's Key Bridge where steel guard rails are used (116).

Construction on the steel bridges differed to the extent that blocks of steel one and a quarter inch thick were welded into the girders and the steel beams were then placed across the bridge and welded into these blocks. The beams were further reinforced by a steel brace extending from the bottom of the girder and welded under the end of the beam. Construction of the concrete decking was the same (117).

On March 29, 1938, the ribbons formally opening the complete Overseas Highway were cut at 9:00 a.m. at the Pigeon Key Bridge, by Senorita Ida Rodriguez, daughter of the Cuban consul in Key West. There was a second ribbon cutting at Lower Matecumbe (118) in the afternoon.

Photocopies and negatives submitted with State Project Number 99900-3573, Historical Documentation of the Seven Mile Bridge by Woodrow W. Wilkins. (Note: Unless otherwise noted, photographs are undated; Also, identification numbers of locations, where available are listed in parentheses).

Footnotes

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(22) Wm. Mays Venable, "The Long Key Viaduct", The Engineering Record, November 23, 1907, p. 560.

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(25) Carlton J. Corliss, "Recollections of An Extension", FEC Collection, Henry Morrison Flagler Museum, Palm Beach, Florida (typewritten).

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(30) Ibid., p. # 26007, March 7, 1912.

(31) Patterson, The Florida East Coast Railway, The Key West Extension.

(32) Ibid., #28269, April 5, 1913.

(33) Carlton J. Corliss, Building Out to Sea (specs given at Lexington, Kentucky to the Mississippi Valley Historical Association, May 8, 1953) (typewritten).

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(35) "Weekly Construction Reports"

(36) Ibid.

(37) Ibid.

(38) Ibid.

(39) Ibid.

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(42) Patterson, The Florida East Coast Railway, The Key West Extension.

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(49) Chapin, Official Souvenir, p. 15.

(50) Ibid.

(51) Carver, Concrete Viaducts on the Key West Extension, p. 425.

(52) Ibid.

(53) Weekly Construction Reports

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(63) Corliss, Historical Notes of the Key Vaca Area.

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(80) Weekly Construction Reports

(81) Ibid.

(82) Ibid.

(83) Ibid.

(84) Ibid.

(85) Ibid.

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(90) Weekly Construction Report

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(92) Ibid.

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(96) Ibid, p. 558.

(97) Carver, Concrete Viaducts on the Key West Extension, p. 425.

(98) Ibid. p. 425-426.

(99) Ibid., p. 426.

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