Introduction

The team of Alpha & Omega Group, P.C. (A&O), H. W. Lochner, Inc. (Lochner), Wiss, Janney, Elstner, Associates, Inc. (WJE), and Ko and Associates, P.C. (Ko) was selected by the Bridge Maintenance Unit of the North Carolina Department of Transportation to perform an in-depth structural condition assessment of the Herbert C. Bonner Bridge which spans the Oregon Inlet from Bodie Island to Pea Island along the Cape Hatteras National Seashore in Dare County. The structural condition assessment included a visual condition survey, material sampling by means of concrete coring, non-destructive field testing, laboratory controlled testing, and structural analyses. The tests performed included corrosion potential, ultrasonic pulse velocity measurements, petrographic examination of selected core samples, chloride ion content analyses, concrete compression testing, and laboratory carbonation testing of the concrete. This report presents the results of the assessment, testing, and analyses and includes discussions of the current condition of the bridge in comparison to the original design and the current design loading of vehicles that travel North Carolina roadways.

The routine 2-year National Bridge Inspection Standards (NBIS) bridge inspection was also performed by A&O during the same time frame. Information reported in the NBIS Bridge Inspection Report was utilized to assist with the development of recommendations for repairs to extend the service life of the structure by ten (10) years.

Consultant Team and Scope of Work

A&O was individually tasked with performing a **routine biennial bridge inspection of the Bonner Bridge according to National Bridge Inspection Standards (NBIS)** down to the water surface, inclusive of the pile caps. An underwater NBIS bridge inspection, from the water surface down, was not included in the scope of work. Underwater NBIS inspections are routinely performed by NCDOT personnel. However, an underwater assessment was performed by Lochner for the purposes of the in-depth structural condition assessment.

The purpose of the in-depth structural condition assessment was to supplement the NBIS Bridge Inspection, determine the current condition of the bridge, identify structural deficiencies, determine load carrying capacities of the structural components, develop repair recommendations, and provide an engineer's opinion of construction costs to keep the bridge open and functional at current design loads until the year 2016 (a 10-year service life.)

The overall project was divided into four main tasks:

Task 1: Perform the NBIS bridge inspection throughout the entire length of the bridge
Task 2: Perform an assessment of the high level spans (Spans 129-166)
Task 3: Perform an assessment of the approach spans (Spans 1-128B and Spans 167-204)
Task 4: Conduct a field load test with the assistance of NCDOT

The primary area of responsibility of each team member was as follows:

A&O: NBIS bridge inspection, overall project management and coordination of in-depth assessment, quantification of deficiencies, and assembly of repair recommendations and cost estimates.

Lochner: Structural analysis of the bents in the high level spans, steel superstructure analysis, underwater assessment of the substructure piles, and assisting with development of repair recommendations and cost estimates.

WJE: Concrete strength testing, corrosion potential testing, ultrasonic pulse velocity measurements, petrographic examinations, chloride analysis, carbonation testing, and assisting with repair recommendations and cost estimates for both the high level and approach spans.

Ko: NBIS load rating; structural analyses of the approach span bents, crutch bents, and assisting with the development of repair recommendations and cost estimates.

Description of the Bonner Bridge

(Overall plan view and profile of the bridge is located in Appendix B)

Site Location

The Bonner Bridge traverses the Oregon Inlet in Dare County, North Carolina. The structure is oriented north-south and extends from Bodie Island on the north to Pea Island on the south. The bridge structure is 12,864'-9" long and begins at End Bent 1 at Sta. 25+78.88 (on Bodie Island) and ends at End Bent 2 at Sta. 154+43.62 (on Pea Island). The contract for construction of the Bonner Bridge was awarded to McLean Contracting Company, Baltimore, MD on February 15, 1962. Construction of the bridge was completed on April 7, 1964.

Superstructure

Along the entire length of the bridge, the overall superstructure width of 33'-3" and roadway width of 28'-0" are maintained constant. With the exception of the three steel spans between Bents 143 and 146, the bridge cross-section typically consists of four prestressed concrete girders spaced 8'-0" apart supporting a 7.25" thick cast-in-place reinforced concrete bridge deck. The typical bent spacing is 61'- 6" which results in a girder span of 59'-7".

For purposes of this report, the bridge structure has been separated into the following sections corresponding to Figures 1, 2, and 3:

Section A: Between End Bent 1 and Bent 8, which consists of 8 spans, the bridge profile is on a 1.4% grade and is at an elevation of 21.65' at Bent 8. Elevations for the bridge are measured at the left gutter 14' from the centerline of the

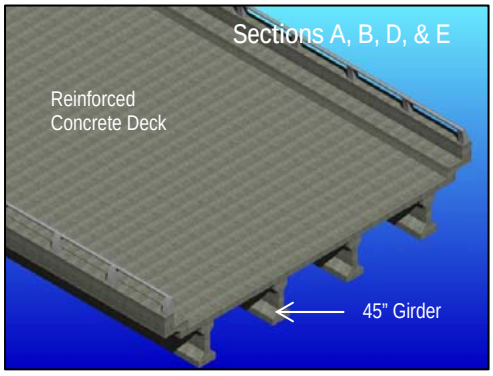

Figure 1.

bridge. El. 0.0' is referenced to mean low tide. From Bent 8 to Bent 122, the grade of the bridge structure is 0.0% at elevation 21.65'. (Fig. 1)

Section B: Between Bent 122 and Bent 143, the structure has a 4% grade and rises to an elevation of 83.35' midway between Bents 144 and 145. (Fig.1)

Section C: Between Bents 143 and 146, the bridge superstructure has spans of 160', 180' and 160' and consists of four continuous steel plate girders. These girders are typically 6' deep at Bents 143 and 146, and haunched to a depth of 8'-9" at Bents 144 and 145. Span 145 (between Bents 144 and 145) spans the navigational channel. (Fig. 2)

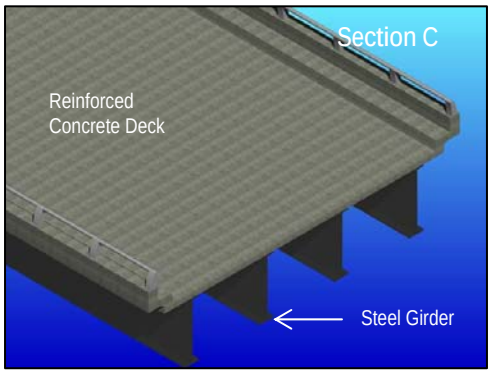

Figure 2.

Section D: Between Bent 146 and Bent 167, the structure has a -4% grade and descends to El. 21.65' at Bent 167. (Fig. 1)

Section E (south approach spans): From Bent 167 to Bent 186, the grade of the bridge is 0.0% at elevation 21.65'. From Bent 186 to End Bent 2, the grade of the bridge is -2% and descends to El. 11.80' at End Bent 2. (Fig. 2)

In October 1990, a dredge impacted a section of the Bonner Bridge requiring replacement of the bridge between Bent 123 and Bent 129. In this section, the AASHTO girders and roadway slab were replaced with twelve (12) 1'-9" deep x 3'-0" wide prestressed precast concrete cored slabs. Five (5) damaged bents were removed and replaced with seven (7) new bents to reduce these span lengths to 46'-1½". Bituminous concrete (asphalt) was placed on top of the cored slabs to provide a replaceable wearing surface and to help seal the joints between the twelve cored slab units that make up the width of the superstructure. The reinforced concrete curbs, parapets, and metal rail on the replaced spans match those on the older spans.

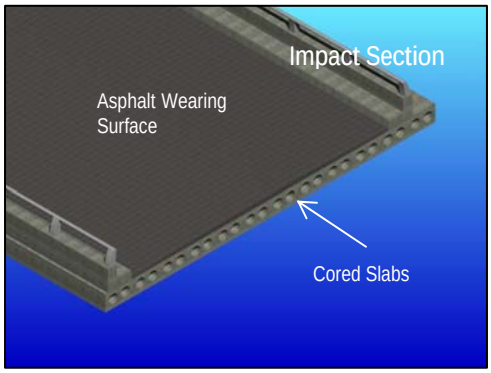

Figure 3.

Substructure

Approach Spans

The substructure of the bridge consists of a series of pile bents which support the AASHTO girders. Between End Bent 1 and Bent 123, and between Bent 167 and End Bent 2, the typical pile bent cap is 3' wide, 2'-6" deep and 28'-6" long. The pile bent cap is supported by six (6) 22" octagonal prestressed concrete piles. In addition, every fourth bent contains four longitudinally battered piles and serves as a brace bent, providing additional longitudinal support to the bridge as a whole.

Due to concerns about the stability of the bridge, crutch bents were added to Bents 108 through 123 and Bents 173 through 186. In 1980 additional crutch bents were added to Bents 167 through 172 and Bents 187 through 200.

The 1990 dredge impact damaged Bents 124 through 128, and these bents were replaced by new pile bents now labeled Bents 124 through 128B.

High Level Spans

From Bent 129 to Bent 166 inclusive, the substructure consists of reinforced concrete post-and-beam bents which support the AASHTO girders as well as the steel main spans. The bents vary in height to accommodate the profile of the bridge and are one, two, or three stories high. The bents typically consist of prestressed concrete piling, a pile cap, a web wall, two columns, from zero to two struts, and a bent cap. Typical details for the bents from Bent 129 to Bent 166 are shown in Table 1 and Figure 4.

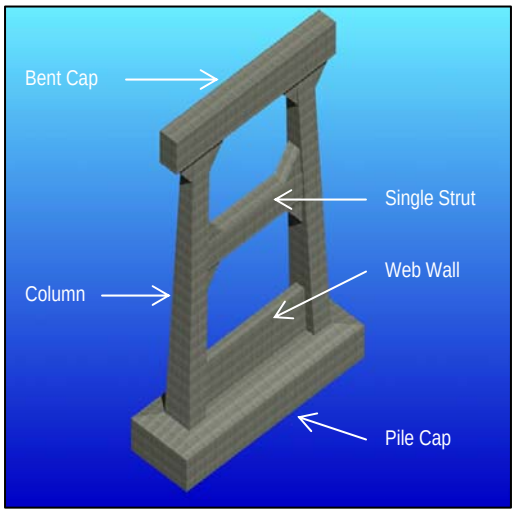

Figure 4.

Table 1. Details of Approach Bents and High Level Bents

Bent No.	Piles	Pile Cap	Column Size	Bent Cap Size
EB1-121 (normal)	6	3’-0”x 28’-6”x 2’-6”	na	na
EB1-121 (normal)	7	3’-0”x 42’-0”x 2’-6”	na	na
EB1-121 (battered)	7	3’-0”x 28’-6”x 2’-6”	na	na
EB1-121 (battered)	8	3’-0”x 42’-0”x 2’-6”	na	na
122-128, 161-166	6	3’-0” x 28’-6” x 2’-6”	na	na
129, 160	10	9’-0” x 31’-0” x 4’-3”	3’-0” x 4’-0” at bottom 3’-0” x 2’-6” at top	3’-6” x 3’-0” x 28’-2”
130, 159	12	10’-0” x 32’-0” x 4’-3”	3’-0” x 4’-2” at bottom 3’-0” x 2’-6” at top	3’-6” x 3’-0” x 28’-2”
131, 158	12	10’-0” x 32’-0” x 4’-3”	3’-0” x 4’-3.25” at bottom 3’-0” x 2’-6” at top	3’-6” x 3’-0” x 28’-2”
132, 157	12	10’-0” x 32’-0” x 4’-3”	3’-0” x 4’-5” at bottom 3’-0” x 2’-6” at top	3’-6” x 3’-0” x 28’-2”
133, 156	12	10’-0” x 32’-0” x 4’-3”	3’-0” x 4’-7” at bottom 3’-0” x 2’-6” at top	3’-6” x 3’-0” x 28’-2”
134, 155	12	10’-0” x 32’-0” x 4’-3”	3’-0” x 4’-8.75” at bottom 3’-0” x 2’-6” at top	3’-6” x 3’-0” x 28’-2”
135, 154	12	10’-0” x 32’-0” x 4’-3”	3’-0” x 4’-10.5” at bottom 3’-0” x 2’-6” at top	3’-6” x 3’-0” x 28’-2”
136, 153	12	11’-0” x 33’-0” x 4’-3”	3’-0” x 5’-0.5” at bottom 3’-0” x 2’-6” at top	3’-6” x 3’-0” x 28’-2”
137, 152	12	11’-0” x 33’-0” x 4’-3”	3’-0” x 5’-2.25” at bottom 3’-0” x 2’-6” at top	3’-6” x 3’-0” x 28’-2”
138, 151	15	13’-6” x 35’-0” x 4’-3”	3’-0” x 5’-4.25” at bottom 3’-0” x 2’-6” at top	3’-6” x 3’-0” x 28’-2”
139, 150	15	13’-6” x 35’-0” x 4’-3”	3’-0” x 5’-6” at bottom 3’-0” x 2’-6” at top	3’-6” x 3’-0” x 28’-2”
140, 149	15	13’-6” x 35’-0” x 4’-3”	3’-0” x 5’-8” at bottom 3’-0” x 2’-6” at top	3’-6” x 3’-0” x 28’-2”
141, 148	15	13’-6” x 35’-0” x 4’-3”	3’-0” x 5’-9.5” at bottom 3’-0” x 2’-6” at top	3’-6” x 3’-0” x 28’-2”
142, 147	15	13’-6” x 35’-0” x 4’-3”	3’-0” x 5’-11” at bottom 3’-0” x 2’-6” at top	3’-6” x 3’-0” x 28’-2”
143, 146	21	16’ x 35’-0” x 4’-3”	3’-6” x 6’-9.375” at bottom 3’-6” x 3’-6” at top	3’-6” x 4’-0” x30’-0”
144, 145	40	18’-0” x 36’-0” x 4’-9”	4’-6” x 6’-7.625” at bottom 4’-6” x 4’-0” at top	5’-0” x 4’-0” x 30”
167-EB2 (normal)	6	3’-0”x 28’-6”x 2’-6”	na	na
167- EB2 (normal)	7	3’-0”x 42’-0”x 2’-6”	na	na
167- EB2 (battered)	7	3’-0”x 28’-6”x 2’-6”	na	na
167- EB2 (battered)	8	3’-0”x 42’-0”x 2’-6”	na	na