

HERBERT C. BONNER BRIDGE

Structural Condition Assessment



Bridge #270011, Oregon Inlet, Dare County



FINAL REPORT

21, December 2006

A&O Project No.: 2006_007

Prepared for:

NCDOT Bridge Maintenance Unit
4809 Beryl Road, Raleigh,

Alpha & Omega Group, PC
4911 Green Road, Suite 107
Raleigh, NC 27616



ALPHA & OMEGA GROUP
CIVIL & STRUCTURAL ENGINEERS

WJE | ENGINEERS
ARCHITECTS

LOCHNER
ENGINEERS AND PLANNERS

KO & ASSOCIATES, P.C.
Consulting Engineers

HERBERT C. BONNER BRIDGE

Structural Condition Assessment

Bridge #270011, Oregon Inlet, Dare County

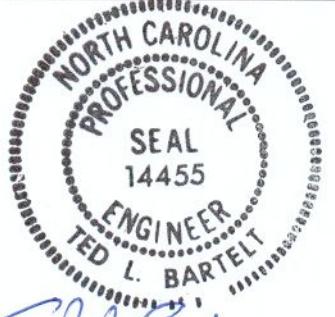
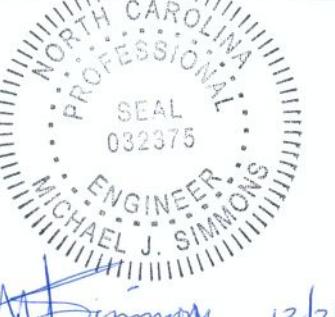
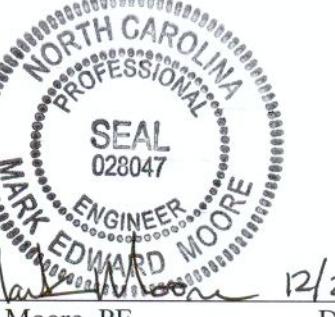
 Ted L. Bartelt, PE Alpha & Omega Group, PC Project Management	 Charles Craycraft, PE H. W. Lochner, Inc. High Level Span Assessment
 Mike Simmons, PE H. W. Lochner, Inc. Underwater Assessment	 Morris Israelnaim, PE Ko and Associates, PC Approach Span Assessment
 Mark Moore, PE WJE Eng. and Arch., PC Concrete Testing and Assessment	

Table of Contents

Table of Contents	i
List of Tables	iv
List of Figures	v
Executive Summary	1
Introduction	11
Consultant Team and Scope of Work	11
Description of the Bonner Bridge	12
Site Location	12
Superstructure	12
Substructure	13
Approach Spans	13
High Level Spans	14
NBIS Bridge Inspection	16
Overview	16
Findings	16
Superstructure	16
Rail, deck and joints	16
Prestressed girders, cored slabs and bearings	17
Continuous Steel Girders and Bearings	18
Fishing Catwalks	18
Substructure	19
Bent caps, columns and pile caps	19
Bent Piles (above water surface)	20
Crutch Bents	20
Fender System	20
Quantification of Deterioration by Span/Bent	20
Detailed Visual Inspection	21
Methodology	21
Delamination Surveys	21
Crack Survey and Mapping	21
Visual Inspection – Approach Spans (Bents and Spans)	23
Detailed Visual Inspection of Approach Bents	26
Detailed Visual Inspection of Approach Spans	30
Visual Inspection – High Level Spans (Bents and Spans)	34
Detailed Visual Inspection of High Level Bents	34
Detailed Visual Inspection of High Level Spans	37
Underwater Assessment	40
Overview	40
Methodology	40
Summary of Findings	41
Testing Program	43
Field Testing Methodology	43
Field Testing Findings	46
Coring	46
Half- Cell Corrosion Measurements	46

Ultrasonic Pulse Velocity Testing	49
Laboratory Testing	53
Compressive Strength Tests.....	53
Ultrasonic Pulse Velocity Measurements on Cores	55
Petrographic Examination	56
Methods	56
Girders	56
Core 17 - Span 132, Girder 4	56
Core 138 - Span 162, Girder 3	58
Pile Caps	59
Core 120 - Bent 150 Pile Cap.....	59
Core 103 - Bent 145 Pile Cap.....	62
Bridge Deck	64
Core 114 - Span 150, Mid-span Deck	64
Core 93 - Span 132, Mid-span Deck	65
Core 90 - Span 130, Mid-span Deck	68
Core 137 - Span 162, Mid-span Deck	69
Columns	71
Core 104 - Bent 145 Middle Column	71
Core 117 - Bent 150 Middle Column	73
Chloride Analysis.....	75
Concrete Quality.....	78
Effects of Corrosion Activity	79
Load Test of Spans 186 and 189	85
Summary of Findings.....	85
Structural Analysis.....	86
Methodology	86
Approach Span Bent Structural Analysis Per Plans	86
Analysis of Approach Span Bents per Inspection Findings.....	91
High Level Bent Structural Analysis.....	94
Analysis of High Level Bents per Plans	94
Computer Model (STAAD).....	95
Analysis Results: High Level Bents per Plans	96
Analysis of High Level Bents per Inspection Findings	97
Model Revised per Inspection Findings.....	97
Analysis Results: High Level Bents per Inspection Findings	97
Prestressed Concrete AASHTO Girders (Spans 1-143 & 147-204).....	100
Concrete Slab	100
45" AASHTO Girders.....	101
Results per Plan	101
Analysis per Inspection Findings	101
Model Revised per Inspection Findings	101
Results per Inspection Findings	101
Welded Steel Plate Girder Spans	101
Welded Steel Plate Girders.....	102
Concrete Slab	102
Results per Plan	102
Model Revised per Inspection Findings	103
Results per Inspection Findings	103

Repair Recommendations	104
Alternative Repair Methods	105
Narrative and Sketches of Proposed Repairs	105
Spall/Delamination Repairs.....	106
Crack Repair.....	107
Pile Repairs	107
Penetrant Sealer.....	107
Concrete Girder Spans.....	107
Narrative and Sketch of Proposed Repairs	107
Concrete Slab	107
45" AASHTO Girders	108
High Level Spans	108
Narrative and Sketch of Proposed Repairs	108
Concrete Slab	108
Welded Steel Plate Girders.....	109
Bearings.....	109
End Diaphragms and Lateral Bracing	109
Girders.....	109
Recommendations.....	109
Summary of Opinions of Construction Costs.....	112
Discussion of Repair Costs	112
Unit Construction Cost Estimates	113
Repair Grouping	116
Repair Summary Tables in Order of Grouping	117
Group A - Pile Jacketing and Expansion Joints.....	117
Group B - High Level Bent Repairs	117
Group B - Supplemental Caps For Bents 196, 197, & 198.....	118
Group B - Approach Bent Repairs.....	118
Group C - Superstructure Repairs - Steel Spans	119
Group C - Superstructure Repairs – AASHTO Girder Spans.....	119
Group D - Superstructure Repairs – Deck and Painting Steel Girders	120
Conclusion	121

Appendices

- Appendix A - Glossary of Terms
- Appendix B - Sketches of Existing Conditions (A&O)
- Appendix C - Quantification of Cracks, Spalls and Delaminations (A&O)
- Appendix D - Concrete Materials Condition Assessment Report (WJE)
- Appendix E - Load Test Report (WJE)
- Appendix F - High Level Bent Assessment Calculations (Lochner)
- Appendix G - Underwater Assessment Report (Lochner)
- Appendix H - Computer Model Types for Approach Spans (Ko)
- Appendix I – Approach Bent Analysis Calculations (Ko)

References

- Alpha & Omega Group 2006 NBIS Bridge Inspection Report

List of Tables

Table 1. Details of Approach Bents and High Level Bents	15
Table 2. (deleted)	
Table 3. Preliminary inspection and rating of high bent structures	22
Table 4a. Half-cell potential measurements for the inspected high bents.....	47
Table 4b. Half-cell potential measurements for the inspected high bents	48
Table 5. Half-cell potential measurements for the inspected approach bents.....	49
Tables 6a. UPV measurements for the inspected high bents	50
Tables 6b. UPV measurements for the inspected high bents.....	51
Tables 6c. UPV measurements for the inspected high bents	52
Table 7. UPV measurements for the inspected approach bents	53
Table 8. Summary of compressive strength tests.....	54
Table 9. Chloride contents	77
Table 10: Concrete core testing summary for all cores tested	81
Table 11 – Structural models and the bents they represent.....	87
Table 13: Flexural Analysis	92
Table 14: Shear Analysis	92
Table 15: Flexural and Shear Analysis - Crutch Bents	93
Table 16: Pile End Bearing Capacity	93
Table 17: Representative Models.....	94
Table 19: Flexural Analysis	98
Table 20: Flexural Analysis	98
Table 21: Shear Analysis	98
Table 22: Column Analysis	99
Table 23: Pile End Bearing Capacity	99

List of Figures

Figure	Title	Page
1	Section A, B, D, & E	12
2	Section C	13
3	Impact Section	13
4	High Level Bent	14
5	The various pile bent configurations of the inspected pile bents.	24
6	The various pile bent configurations of the inspected pile bents, continued.	25
7	Typical UPV and Half Cell testing locations on the single frame bents.	43
8	Typical UPV and Half Cell testing locations on the two frame bents.	44
9	Typical UPV and Half Cell testing locations on the three frame bents.	45
10	Typical UPV and Half Cell testing locations on the pile bents.	46
11	Comparison of Compressive Strength to UPV.	55
12	Adhesion crack partially surrounding coarse aggregate particle. Millimeter scale.	58
13	Weathered coarse aggregate particle. Internal cracking (red arrow) unrelated to aggregate reactivity (ASR). Blue arrow shows adhesion crack. Millimeter scale.	59
14	On drying, salt crystals appeared on the lapped concrete surface near the outside end of the core.	61
15	Mottled paste color in the vicinity of a porous limestone aggregate particle. Dark gray paste (red arrows) was hard and dense.	61
16	Paste alteration at the outside end of Core 103. Millimeter scale.	63
17	Air entrainment in Core 103.	63
18	Microcrack extending from the outside surface through a limestone aggregate particle (between red arrows). Millimeter scale.	65
19	Discolored, carbonated paste at the top of Core 93. Millimeter scale.	67
20	Discolored, carbonated paste at the bottom of Core 93. Millimeter scale.	67
21	Small voids near the bottom surface of the concrete were lined or filled with secondary carbonate deposits. Millimeter scale.	69
22	Pores in a coarse aggregate particle near the top surface of Core 137 contain soft, clay-like deposits. Millimeter scale.	70
23	Coralline limestone coarse aggregate particle in Core 137 containing well preserved coral fragments. Millimeter scale.	71
24	Carbonate crystals line a shell cavity within a limestone coarse aggregate particle.	72
25	An adhesion crack (arrows) partially encircles a coarse aggregate particle in Core 104. Millimeter scale.	73
26	Paste discoloration at the outside end of Core 117. The dark gray layer at the surface was slightly eroded exposing sand grains.	74
27	Secondary carbonate deposits coat the outside fracture surface 1.2 to 2.6" from the outside surface. This morphology characterizes open-space filling, and was not considered to be a "cause" of fracturing.	75
28	Sampling methodology for chloride tests.	75
29	Chloride levels by depth in core.	78
30	STAAD computer model live load calculation parameters.	95
31	AASHTO standard truck loading.	96
32	Cross section of AASHTO girder span section.	100
33	NCDOT Standard Truck T5A.	100

34	Welded steel plate girder section.	102
35	Typical spall/delamination repair.	106
36	Typical Slab Repair	108
37	Typical Girder Repair	108
38	Typical Slab Repair	109
39	Approach bent cap additional support.	111