

ABSTRACT

EVALUATION OF MODULAR PRESS-BRAKE-FORMED TUB GIRDERS WITH UHPC JOINTS

The Short Span Steel Bridge Alliance (SSSBA) is a group of bridge and culvert industry leaders (including steel manufacturers, fabricators, service centers, coaters, researchers, and representatives of related associations and government organizations) who have joined together to provide educational information on the design and construction of short span steel bridges in installations up to 140 feet in length. From within the SSSBA technical working group, a modular, shallow press-brake-formed steel tub girder was developed. This new technology consists of cold-bending standard mill plate width and thicknesses to form a trapezoidal box girder. The steel plate can either be weathering steel or galvanized steel, each an economical option. Once the plate has been press-brake formed, shear studs are then welded to the top flanges. A reinforced concrete deck is then cast on the girder in the fabrication shop and allowed to cure, becoming a composite modular unit. The composite tub girder is then shipped to the bridge site, allowing for accelerated construction and reducing traffic interruptions.

The use of prefabricated bridge elements and systems has led to the recognition that durable connections are the key components in this type of construction. An ultra-high performance concrete (UHPC), which is a steel fiber reinforced, portland cement-based product with advantageous fresh and hardened properties is used for creating robust connections between the prefabricated components. The use of the UHPC as a joint media is becoming more popular during bridge construction. However, the majority of the prefabricated bridge elements and systems are of traditional structural shapes. Therefore, structural performance of the UHPC joint connecting prefabricated composite tub girders needs to be evaluated.

The scope of this project was to test a bridge model system comprised of two composite modular press-brake-formed tub girders connected with an UHPC joint. This was accomplished by, constructing two modular units and joining them with an UHPC joint. The system was then fatigue loaded simulating 75-year traffic conditions in a rural environment. A Service II limit state moment was induced into the system at predetermined numbers of cycles in order to monitor performance of the specimen. Data obtained from strain gages installed on the webs and bottom flanges was used to determine the actual moments induced into the system, as well as the load distribution factors. Experimental results were used to evaluate reliability of the longitudinal UHPC joint in a composite tub girder system.

TABLE OF CONTENTS

ABSTRACT	II
TABLE OF CONTENTS	III
LIST OF TABLES	VI
LIST OF FIGURES	VII
CHAPTER 1:INTRODUCTION.....	1
1.1 BACKGROUND / OVERVIEW.....	1
1.2 PROJECT SCOPE & OBJECTIVES	2
1.3 REPORT ORGANIZATION	2
CHAPTER 2:LITERATURE REVIEW	4
2.1 INTRODUCTION	4
2.2 ACCELERATED BRIDGE CONSTRUCTION.....	4
2.3 PREFABRICATED BRIDGE ELEMENTS AND SYSTEMS	5
2.4 SUBSTRUCTURES.....	6
2.4.1 Precast Abutments	6
2.4.2 GRS-IBS Substructure System	7
2.4.3 2.4.2 GRS-IBS Substructure System	7
2.5 SUPERSTRUCTURES.....	10
2.5.1 Link Slab.....	10
2.5.2 I-93 Fast 14.....	11
2.6 ULTRA-HIGH PERFORMANCE CONCRETE (UHPC).....	12
2.6.1 Background.....	13
2.6.2 UHPC Properties	13
2.6.3 Previously Conducted Research	14
2.7 FOLDED STEEL PLATE GIRDER WITH UHPC CLOSURE POURS ON GRS ABUTMENT.....	15
2.8 SUMMARY	16
CHAPTER 3:SLAB EDGE TREATMENT METHODS	17

3.1 INTRODUCTION	17
3.2 SHEAR-KEY DETAIL DESIGN	17
3.3 RETARDER PRODUCT	19
3.4 FORMWORK PREPARATION.....	19
3.5 SLAB EDGES TREATMENT	24
3.6 CONCLUSION.....	27
CHAPTER 4: EXPERIMENTAL TESTING.....	28
4.1 INTRODUCTION	28
4.2 OVERVIEW OF THE TEST SPECIMEN	28
4.2.1 Specimen Properties and Dimensions	28
4.3 LAYOUT OF STRAIN GAGES.....	30
4.4 TEST SPECIMEN ASSEMBLY	32
4.4.1 Support Assembly.....	32
4.4.2 Concrete Formwork	34
4.4.3 Reinforcing Bars Placement	36
4.4.4 Formwork Coating.....	37
4.4.5 Concrete Deck Pour	38
4.4.6 Shear-Keys Surface Treatment	41
4.5 UHPC JOINT POUR	42
4.5.1 Concrete Formwork	42
4.5.2 UHPC Joint Pour	46
4.6 LOAD CONFIGURATION	53
4.7 LOAD MAGNITUDE DETERMINATION	55
4.7.1 Load Determination Overview	55
4.7.2 Magnitude of Applied Loads	56
4.7.3 Number of Cycles	56
4.8 TESTING PROCEDURE.....	57
4.8.1 Testing Procedure Overview	57
4.9 CONCRETE DECK FAILURE	58
4.10 SUMMARY	63

CHAPTER 5: EXPERIMENTAL TESTING RESULTS	64
5.1 INTRODUCTION	64
5.2 CONCRETE STRENGTH	64
5.2.1 Deck Concrete	64
5.2.2 UHPC Compressive Strength	65
5.3 MOMENT CALCULATION	65
5.3.1 Gage Configuration	65
5.3.2 Linear Regression Algorithm	67
5.3.3 Calculation of Induced Moment	70
5.3.4 Total System Moment.....	71
5.4 DISTRIBUTION FACTORS	87
5.5 DEFLECTIONS	88
5.6 SUMMARY	89
CHAPTER 6: PROJECT SUMMARY AND CONCLUDING REMARKS	90
6.1 PROJECT SUMMARY	90
6.2 RECOMMENDATIONS FOR CONTINUED RESEARCH	90
REFERENCES	91
APPENDIX A: LOADING CALCULATIONS	94
APPENDIX B: GAGE DATA	100