Stainless Steel Strands and Lightweight Concrete for Pretensioned Concrete Girders

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Final Report B – Lightweight Concrete

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
in.	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: volumes greater than 1000 L shall be shown in m^3				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg (or "t")
TEMPERATURE (exact degrees)				
°F	Fahrenheit	5(F-32)/9 or (F-32)/1.8	Celsius	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
FORCE and PRESSURE or STRESS				
kip	1000 pound force	4.45	kilonewtons	kN
lbf	pound force	4.45	newtons	N
lbf/in^2	pound force per square inch	6.89	kilopascals	kPa

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS FROM SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
mm	millimeters	0.039	inches	in.
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
TEMPERATURE (exact degrees)				
°C	Celsius	1.8C+32	Fahrenheit	°F
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m^2	$candela/m^2$	0.2919	foot-Lamberts	fl
FORCE and PRESSURE or STRESS				
kN	kilonewtons	0.225	1000 pound force	kip
N	newtons	0.225	pound force	lbf
kPa	kilopascals	0.145	pound force per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

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16. Abstract

Benefits of lightweight concrete include reduction in the self-weight of the girder and reduction in transportation and handling costs, as well as potentially longer spans. Lightweight concrete can be produced with strength equivalent to normal-weight concrete. However, FDOT does not currently have an approved lightweight concrete mix for girders. The objective of this research was to study the implementation of lightweight concrete in girders. The following tasks were performed: a lightweight concrete mix was developed; the fresh and hardened mechanical properties were measured, lightweight concrete bridge girders were constructed, and the camber behavior of the girders was measured. At a later date, the flexural/shear behavior of girders may be studied.

The self-consolidating lightweight concrete mix that was developed for use in the girders had a design compressive strength of 10 ksi, which is higher than the 8.5-ksi strength of FDOT's standard concrete mix for girders. The 10 ksi strength was achieved 11 days after casting the test girders, and the strength at 28 days was 11.22 ksi – 12% higher than the specified strength. The measured unit weight was 0.126 k/ft^3, slightly higher than the design unit weight of 0.122 k/ft^3. The developed lightweight concrete mix satisfied FDOT's mix design requirements. The fresh properties – including slump, air content, and penetration – were evaluated before casting the concrete. The hardened properties – including unit weight, compressive strength, modulus of elasticity, splitting tensile strength, and modulus of elasticity – were evaluated by testing concrete cylinders and small beams, which were cast from the batches used to fabricate the girders. The current AASHTO LRFD equations are limited to lightweight concrete compressive strength of 10 ksi. This study investigated the applicability of AASHTO equations for lightweight concrete compressive strength higher than 10 ksi. The average measured modulus of elasticity was 4,875 ksi, which was 15% higher than the calculated value using the AASHTO equation. Because no physical test was performed on the lightweight aggregate, the K_1 factor was assumed as 1.0. The average measured splitting tensile strength of the lightweight concrete was 0.618 ksi, or $0.185\sqrt{f_c'}$. AASHTO LRFD Section 5.4.2.8 conservatively estimated the concrete density modification factor (λ). The average measured modulus of rupture was 0.895 ksi, which is 19% higher than the value calculated using the AASHTO equation. It can be concluded that the current AASHTO equations conservatively estimate the hardened materials properties of the lightweight concrete mix used in this study, which had a compressive strength higher than 10 ksi.

Five 42-ft-long AASHTO Type II girders were fabricated: two (2) used the lightweight concrete mix described above, and three (3) used normal-weight concrete. Girder cambers were monitored over time. Short-term camber measurements were compared between lightweight and normal-weight girders. The average measured cambers at 33 days were 0.605 in. and 0.688 in. for normal-weight Girders (A1, A2, and A3) and lightweight Girders (D1 and D2), respectively. Lightweight concrete girders had higher camber because of their lower elastic modulus. Long-term cambers of the lightweight girders were compared with values obtained using the PCI multiplier method and FDOT Prestressed Mathcad program v5.2. The short- and long-term cambers of lightweight girders were overestimated by both the PCI multiplier method and the FDOT program, where the PCI multiplier method was the most conservative. The average measured camber of lightweight girders at 380 days was 0.75 in., which was 67% of the calculated camber by FDOT program. The two lightweight concrete girders are currently stored at the FDOT SRC and will be experimentally tested in flexure or shear after adding a deck slab to investigate the structural behavior of high-strength lightweight concrete girders.

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EXECUTIVE SUMMARY

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The self-consolidating lightweight concrete mix that was developed for use in the girders had a design compressive strength of 10 ksi, which is higher than the 8.5-ksi strength of FDOT's standard concrete mix for girders. The 10-ksi strength was achieved 11 days after casting the test girders, and the strength at 28 days was 11.22 ksi – 12% higher than the specified strength. The measured unit weight was 0.126 k/ft^3, slightly higher than the design unit weight of 0.122 k/ft^3. The developed lightweight concrete mix satisfied FDOT's mix design requirements. The fresh properties – including slump, air content, and penetration – were evaluated before casting the concrete. The hardened properties – including unit weight, compressive strength, modulus of elasticity, splitting tensile strength, and modulus of elasticity – were evaluated by testing concrete cylinders and small beams, which were cast from the batches used to fabricate the girders. The current AASHTO LRFD equations are limited to lightweight concrete compressive strength of 10 ksi. This study investigated the applicability of AASHTO equations for lightweight concrete compressive strength higher than 10 ksi. The average measured modulus of elasticity was 4,875 ksi, which was 15% higher than the calculated value using the AASHTO equation. Because no physical test was performed on the lightweight aggregate, the K1 factor was assumed as 1.0. The average measured splitting tensile strength of the lightweight concrete was 0.618 ksi, or $0.185\sqrt{f'_c}$. AASHTO LRFD Section 5.4.2.8 conservatively estimated the concrete density modification factor (λ). The average measured modulus of rupture was 0.895 ksi, which is 19% higher than the value calculated using the AASHTO equation. It can be concluded that the current AASHTO equations conservatively estimate the hardened materials properties of the lightweight concrete mix used in this study, which had a compressive strength higher than 10 ksi.

Five 42-ft-long AASHTO Type II girders were fabricated: two (2) used the lightweight concrete mix described above, and three (3) used normal-weight concrete. Girder cambers were monitored over time. Short-term camber measurements were compared between lightweight and normal-weight girders. The average measured cambers at 33 days were 0.605 in. and 0.688 in. for normal-weight Girders (A1, A2, and A3) and lightweight Girders (D1 and D2), respectively. Lightweight concrete girders had higher camber because of their lower elastic modulus. Long-term cambers of the lightweight girders were compared with values obtained using the PCI multiplier method and FDOT Prestressed Mathcad program v5.2. The short- and long-term cambers of lightweight girders were overestimated by both the PCI multiplier method and the FDOT program, where the PCI multiplier method was the most conservative. The average measured camber of lightweight girders at 380 days was 0.75 in., which was 67% of the calculated camber by FDOT program. The two lightweight concrete girders are currently stored at the FDOT SRC and will be experimentally tested in flexure or shear after adding a deck slab to investigate the structural behavior of high-strength lightweight concrete girders.

TABLE OF CONTENTS

Disclaimer ii
SI* (modern metric) conversion factors iii
Technical report documentation page v
Acknowledgments vi
Executive summary vii
List of tables x
List of figures xi
1 INTRODUCTION 1
2 CONCRETE MIX DESIGN 1
3 GIRDER FABRICATION 2
4 MATERIAL PROPERTIES TESTING MATRIX 7
5 MATERIAL PROPERTIES TESTING RESULTS 8
5.1 Compressive strength 8
5.1 Unit weight 9
5.2 Modulus of elasticity 10
5.3 Splitting tensile strength 12
5.4 Modulus of rupture 14
6 CAMBER MEASUREMENTS 16
6.1 At casting yard 16
6.2 At FDOT SRC 18
7 CAMBER PREDICTIONS 20
7.1 PCI multiplier method 20
7.2 FDOT Mathcad program 22
8 FLEXURAL/SHEAR TESTS 22
9 SUMMARY 22
10 REFERENCES 24
APPENDIX A: DETAILED DESIGN DRAWINGS 25
APPENDIX B: FABRICATION OF LIGHTWEIGHT GIRDERS 31

LIST OF TABLES

Table 1 Concrete mixture proportions 2
Table 2 Fabrication activities schedule 4
Table 3 Field concrete test results 5
Table 4 Concrete compressive strength during the first 28 days after casting 5
Table 5 Material properties testing matrix 7
Table 6 Compressive strength test results 9
Table 7 Modulus of elasticity test results 12
Table 8 Splitting tensile strength test results 13
Table 9 Modulus of rupture test results 14
Table 10 Comparison of measured and calculated camber at transfer and erection 21

LIST OF FIGURES

Figure 1 Casting bed layout 3
Figure 2 Reinforcement layout 3
Figure 3 Slump test 5
Figure 4 Air content test 5
Figure 5 Compressive strength versus concrete age 6
Figure 6 Concrete cylinders 6
Figure 7 Compressive strength test 8
Figure 8 Failure of concrete cylinder in compression 9
Figure 9 Illustration of normal-weight and lightweight aggregates in cylinders 10
Figure 10 Installing extensometer for modulus of elasticity test 11
Figure 11 Modulus of elasticity test 11
Figure 12 Splitting tensile strength test 13
Figure 13 Tensile failure of cylinder 13
Figure 14 Modulus of rupture test 15
Figure 15 Failure of concrete beam in tension 15
Figure 16 Illustration of normal-weight and lightweight aggregates in beams 16
Figure 17 Girders at the casting yard 17
Figure 18 Laser machine at top of the girder 17
Figure 19 Adjusting the detector along the measuring ruler 18
Figure 20 Camber monitoring at the casting yard 18
Figure 21 Measuring camber at the FDOT lab 19
Figure 22 Camber monitoring at the FDOT lab 20

1 INTRODUCTION

Self-weight of girders represents a significant portion of the design load for prestressed concrete bridge girders. Self-weight can be reduced by using lightweight concrete. The key component in lightweight concrete is lightweight coarse aggregate. The use of lightweight concrete may be the solution for long girders that cannot be transported due to their heavy weight or route restrictions. Other advantages of lightweight concrete are reduced transportation and handling costs, as well as potentially longer spans.

The objective of this research program was to study the implementation of lightweight concrete in girders. The first task was to develop a high-strength lightweight concrete mix design. The second task was to measure the fresh and hardened mechanical properties of the lightweight concrete and compare results with predicted values by AASHTO equations (2017). The third task was to construct the girders. The fourth task was to compare short-term camber measurements on the normal-weight girders (Girders A) and lightweight concrete girders (Girders D), and to compare the long-term camber measurements on the lightweight concrete girders with predicted values obtained using the PCI multiplier method and Florida Department of Transportation (FDOT) Prestressed Beam Mathcad program v5.2. Another task was to study the flexural behavior of the lightweight concrete girders; however, the testing was delayed due to limited testing availability at the FDOT Structures Research Center (SRC). The girders are stored at SRC, so the testing may be done at a later date.

2 CONCRETE MIX DESIGN

Currently, FDOT does not have an approved lightweight concrete mix for bridge girders. Therefore, the authors had to develop a mix design for this research program. The process started by approaching multiple companies and researchers to assist in the development of the mix. The authors ended up working with the research team at Dura-stress, Inc., a manufacturer (precaster) of prestressed concrete components, in Leesburg, FL. The original goal was to have a self-consolidating mix with 8.5-ksi compressive strength, which is the strength of FDOT's standard mix for girders. The general rules that guided the design process were that admixtures and materials should be easily obtained by precasters and should be familiar to precasters in Florida. Several trial mixes were developed, and they were tested in both fresh and hardened states. The fresh properties included slump, air content, and penetration. The hardened property was compressive strength. The final mix had a compressive strength of 10 ksi and satisfied all the design limits requirements. The developed mix was approved by FDOT State Materials Office.

Table 1 shows the mix designs for lightweight concrete and normal-weight concrete used in the fabrication of the girders in this study. All the materials used in the two mixes were the same except that lightweight coarse aggregates were used in the lightweight mix. The proportions of the materials were slightly different. The same admixtures were used in both mixes, although the quantities differed slightly. The cement was produced by Argos. The lightweight aggregate was produced by Stalite, and the fine aggregate (sand) was supplied by Vulcan Materials Company. Separation Technologies supplied the fly ash, and all three admixtures were produced by BASF. The developed lightweight mix can be easily reproduced by any precaster in Florida.

Table 1 Concrete mixture proportions

Material	Units	Quantity	
		Lightweight	Normal weight
Type II cement	lb/yd^3	720	703
Fly ash (Type F)	lb/yd^3	170	167
Metakaolin	lb/yd^3	78	74
Stalite #67	lb/yd^3	852	-
Crushed stone #67		-	1360
Sand	lb/yd^3	1200	1202
Water	lb/yd^3	280	240
Water-cement ratio	-	0.39	0.34
Calcium Nitrite	oz/yd^3	320	320
Air entraining admixture MB AE90	oz/yd^3	0.75	0.25
Set retardant admixture, DELVO	oz/yd^3	19	28
Water-reducing admixture, Glenium 7920	oz/yd^3	65	69

3 GIRDER FABRICATION

Five 42-ft-long AASHTO Type II girders were fabricated. Three girders were cast using normal-weight concrete while the other two girders were cast with lightweight concrete. The specified concrete compressive strength for both normal-weight concrete and lightweight concrete was 10 ksi. Both mixes were self-consolidating concrete. All girders were fabricated in one bed as shown in Figure 1. All five girders had 11 0.6-in.-diameter carbon steel strands, in four layers where the strand pattern was 1:2:4:4, starting from the bottom layer. The transverse reinforcement,

Figure 2, in the lightweight girders (Girder D1 and Girder D2) was carbon steel rebar. Note that all five girders had same transverse reinforcement spacing; however, different transverse reinforcement type was used in Girders A2 and A3. Detailed drawings for all five girders are provided in Appendix A. Also, more information about transverse reinforcement type in Girders A2 and A3 can be found in Part A of this report.

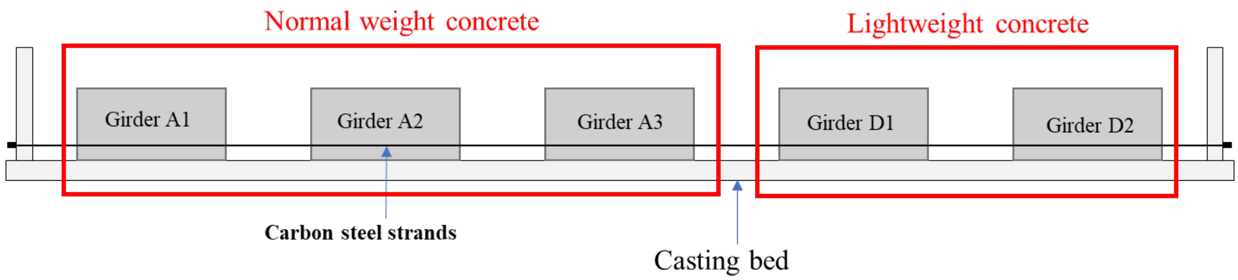

Figure 1 Casting bed layout

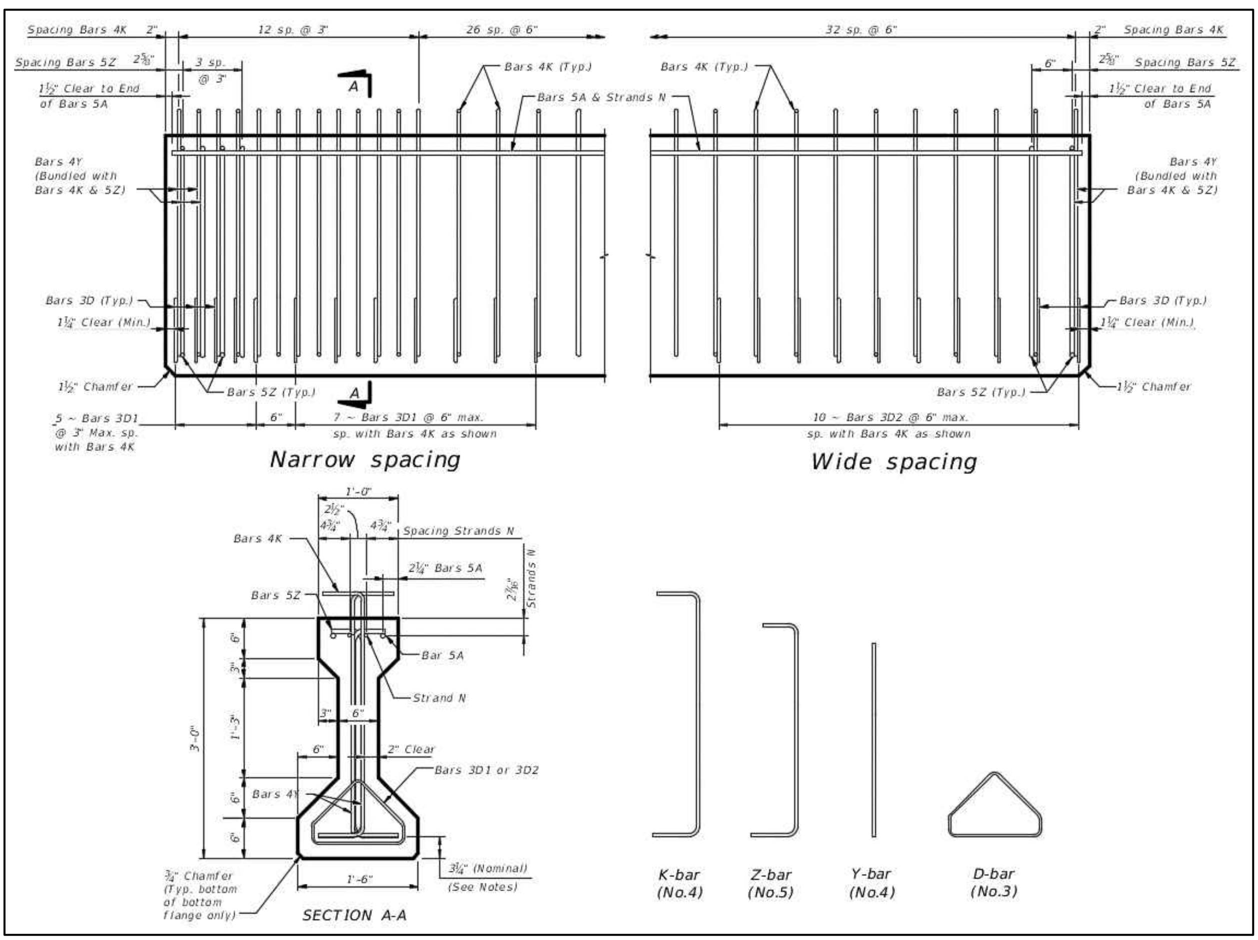

Figure 2 Reinforcement layout

Table 2 presents fabrication activities for the lightweight girders. First, carbon steel strands were run in the casting bed and then tensioned to 43.9 kips, which was 75% of ultimate strength. After tensioning the strands, confinement and stirrup reinforcement was tied, and concrete was cast. The forms were removed the next day, and strands were released two days after casting concrete. A fabrication check list, provided by Dura Stress, Inc., is included in Appendix B. More information about design and fabrication of the three girders cast with normal-weight concrete can be found in Part A of this report.

Table 2 Fabrication activities schedule

Date	Activity
9/10/2018	Run strands, tension strands and tie reinforcement
9/11/2018	Set side forms
9/12/2018	Cast concrete
9/13/2018	Remove side forms
9/14/2018	Release strands

Before casting concrete, Dura-stress, Inc., field lab performed several fresh tests on the concrete batches. The fresh tests included slump, air content, water-to-cement ratio, and penetration. Slump and air content testing are shown in Figure 3 and Figure 4, respectively. Results from those tests are given in Table 3. Note that the slumps in both concrete batches were slightly higher than the design limits. Dura-stress, Inc., field lab also tested multiple concrete cylinders in compression at different days during the first 28 days after casting to measure gain in concrete compressive strength. Results of the compressive strength tests are given in Table 4. Figure 5 presents concrete compressive strength versus concrete age; note that the specified compressive strength of 10 ksi was achieved 11 days after casting concrete.

Figure 3 Slump test

Figure 4 Air content test

Table 3 Field concrete test results

Test	Truck 1	Truck 2	ASTM	Limit
Slump	31/31	31/32	C1611	24.5 in. – 29.5 in.
Air %	1	1		1 – 6
VSI	0	0		=< 1
T_{50}	2	3		2-7 seconds
Penetration (mm)	1	0	C1621	=< 2 in.

Table 4 Concrete compressive strength during the first 28 days after casting

Specimen ID	Casting day	Testing day	No. of days after casting	Compressive strength (ksi)	Avg. comp. strength (ksi)
1	9/12/2018	9/13/2018	1	5.70	5.70
2		9/14/2018	2	6.53	6.59
3				6.64	
4		9/18/2018	5	9.18	9.19
5		9/24/2018	11	10.01	10.01
6				10.00	
7		10/10/2018	28	11.30	11.22
8				11.20	
9				11.15	

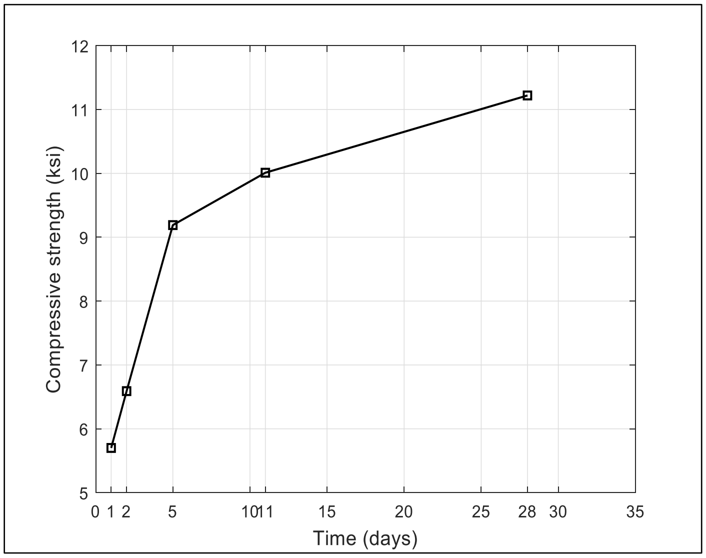

Figure 5 Compressive strength versus concrete age

In addition, several concrete cylinders and small concrete beams were taken from each concrete batch as shown in Figure 6. Some cylinders were used to measure concrete compressive and splitting tensile strengths, modulus of elasticity, and Poisson's ratio. Other cylinders will be used to measure concrete compressive strength when future flexural and/or shear tests are performed. Small concrete beams were used to measure modulus of rupture.


Figure 6 Concrete cylinders

4 MATERIAL PROPERTIES TESTING MATRIX

The material properties of hardened concrete include compressive and splitting tensile strengths, modulus of rupture, and modulus of elasticity. Fifteen cylinders and eight beams were used to determine the material properties of the lightweight concrete mix used in the fabrication of the girders. The diameter and height of the cylinders were 4 in. and 8 in., respectively. After the cylinders were filled, they were covered with lids. The length, height, and width of the beams were 12 in., 4 in., and 4 in., respectively. Beams were removed from their molds 24 hours after casting and submerged in water. Both cylinders and beams were stored at the FDOT SRC in Tallahassee, FL. Later, 546 days after casting, cylinders and beams were sent for testing at the FDOT State Materials Office (SMO) in Gainesville, FL. All specimens were tested by professional technicians following the designated ASTM testing procedure. Table 5 shows the test matrix and specimen IDs.

Table 5 Material properties testing matrix

Testing Cylinders				Testing Beams	
Specimen ID	Compressive strength ASTM C39 (2020)	Splitting tensile strength ASTM C496 (2017)	Modulus of elasticity and Poisson's ratio ASTM C469 (2014)	Specimen ID	Third point loading ASTM C78 (2018)
C1	x			B1	x
C2	x			B2	x
C3	x			B3	x
C4		x		B4	x
C5		x		B5	x
C6		x		B6	x
C7		x		B7	x
C8		x		B8	x
C9		x			
C10	x		x		
C11	x		x		
C12	x		x		
C13	x		x		
C14	x		x		
C15	x		x		

5 MATERIAL PROPERTIES TESTING RESULTS

Concrete compressive strength, unit weight, splitting tensile strength, modulus of rupture, and modulus of elasticity testing results are discussed below.

5.1 Compressive strength

A total of nine cylinders were tested in compression following ASTM C39 (2020) testing procedure. Figure 7 shows the compressive strength test apparatus. Three cylinders (C1, C2 and C3) were tested in compression only. Figure 8 shows failure of one cylinder in compression. The average compressive strength from those three cylinders was used to determine the proper load level for the modulus of elasticity test. The other six cylinders were first tested for modulus of elasticity, and then they were tested for compressive strength.

Table 6 lists the measured compressive strength for the lightweight concrete cylinders 546 days after casting; the average strength was 11.23 ksi with a standard deviation of 1.50 ksi. The average concrete compressive strength 28 days after casting was 11.22 ksi, which was 12.2% greater than the design compressive strength. The main difference between lightweight and normal-weight concretes is the use of lightweight coarse aggregate. Figure 9 shows normal-weight and lightweight cylinders after being tested in compression. The differences in the type of aggregate used in each of them is very visible.

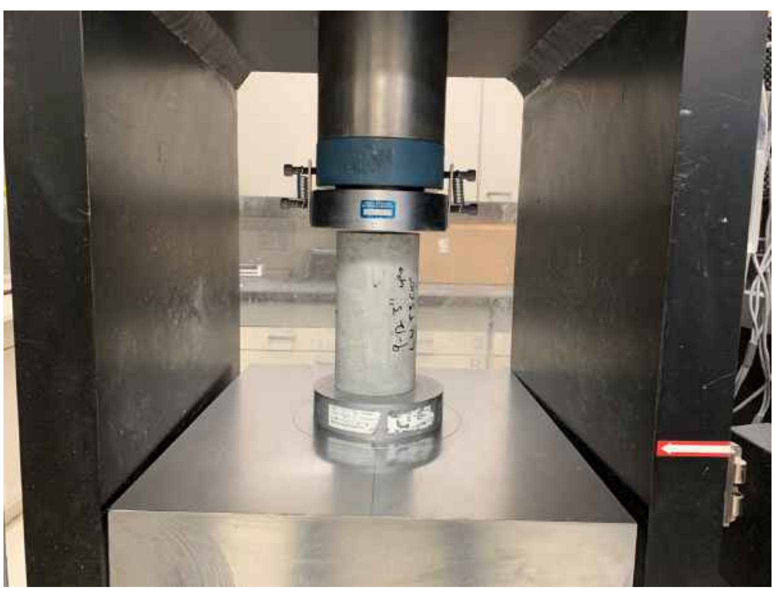

Figure 7 Compressive strength test

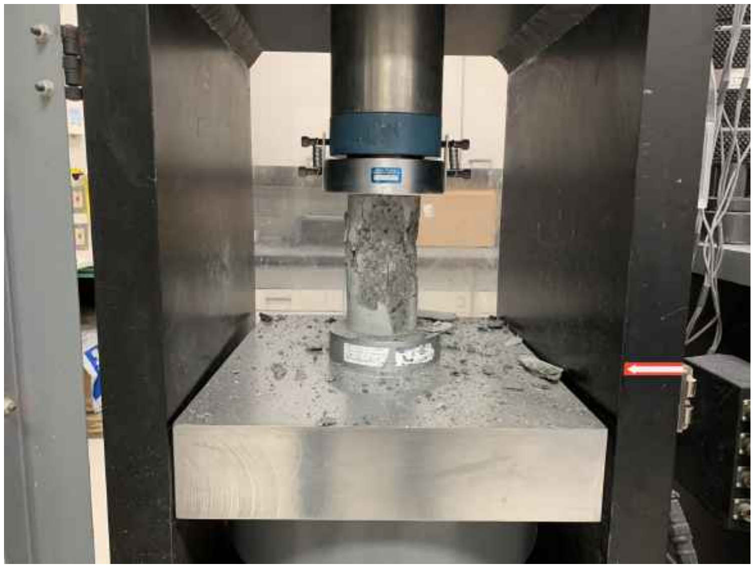
Figure 8 Failure of concrete cylinder in compression

5.1 Unit weight

The design unit weight was 122 lb/ft^3. Table 6 provides the hardened unit weight, calculated from the cylinder weights. The average measured unit weight was 126 lb/ft^3 with a standard deviation of 1.56 lb/ft^3.

Table 6 Compressive strength test results

Specimen ID	C1	C2	C3	C10	C11	C12	C13	C14	C15
Length (in.)	7.65	7.61	7.56	7.53	7.65	7.68	7.73	7.62	7.69
Diameter (in.)	4.01	4.01	4.01	4.00	4.01	4.02	4.02	4.02	4.01
Weight (g)	3207	3162	3153	3199	3209	3210	3209	3210	3145
Hardened density (lb/ft^3)	127	125	126	129	127	126	125	125	123
Max load (kips)	133	135	151	174	172	131	124	119	138
Compressive strength (ksi)	10.54	10.68	11.97	13.85	13.60	10.35	9.75	9.40	10.93

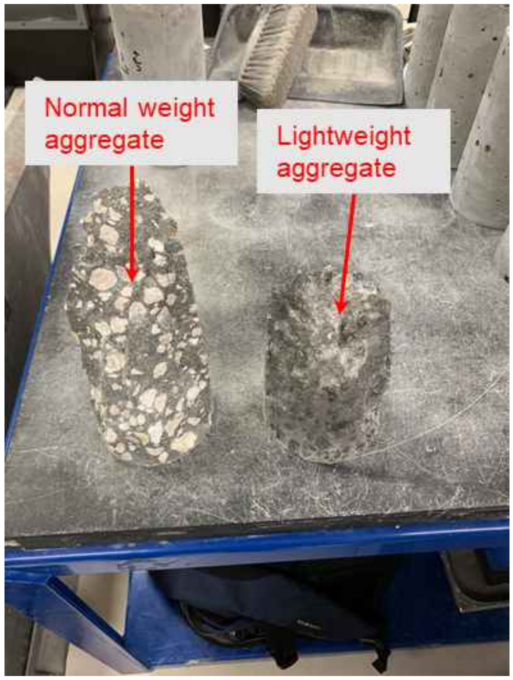

Figure 9 Illustration of normal-weight and lightweight aggregates in cylinders

5.2 Modulus of elasticity

Modulus of elasticity is another important property, which has a significant effect on camber and deflection calculations. Six cylinders were tested for modulus of elasticity following ASTM C469 (2014) test procedure. Generally, bridge girders remain in the elastic region under service conditions. The cylinders were tested 546 days after casting, which provides results comparable to service conditions. Figure 10 shows preparation of a cylinder to be tested for modulus of elasticity. Figure 11 shows a modulus of elasticity test. Results from the modulus of elasticity tests are given in Table 7. The average modulus of elasticity was 4,875 ksi with a standard deviation of 197 ksi.

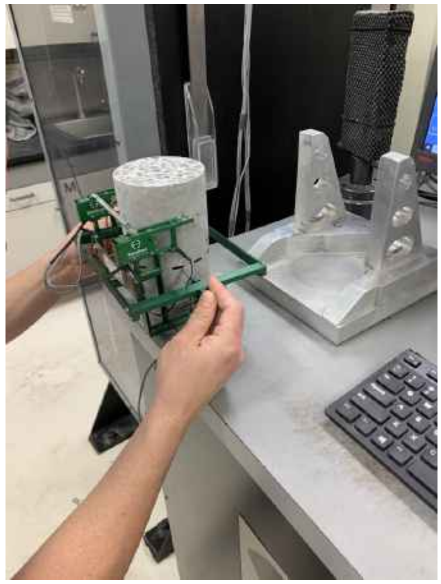

Figure 10 Installing extensometer for modulus of elasticity test

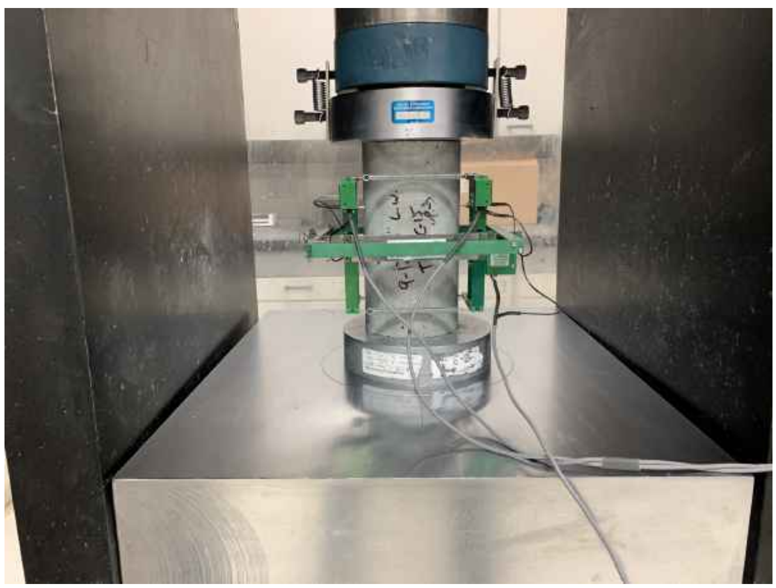

Figure 11 Modulus of elasticity test

AASHTO LRFD Section 5.4.2.4 provides the following equation to calculate modulus of elasticity of lightweight concrete with compressive strengths up to 10 ksi.

$$E_c = 120{,}000\ K_1 w_c^{2.0} {f_c'}^{0.33}$$

where

K_1 = correction factor for source of aggregate (taken as 1.0 unless determined by physical test, and approved)

w_c = unit weight of concrete (kcf)

f_c' = concrete compressive strength

The calculated modulus of elasticity using AASHTO equation was 4,231 ksi, where K_1 was assumed to be 1.0, and w_c was taken as 0.126 kcf. The calculated modulus of elasticity was approximately 87% of the average of that measured experimentally. As noted above, K_1 is a factor to adjust for type of aggregate; the higher the factor, the stiffer the aggregate. Even though K_1 was assumed as 1.0 for lightweight aggregate, the AASHTO equation for modulus of elasticity was conservative for the high-strength lightweight concrete used in this study. The calculated modulus of elasticity using design parameters (f_c' =10 ksi and w_c = 0.122 kcf) was 3,819 ksi. The average measured modulus of elasticity was 27.6% greater than that AASHTO calculated using design parameters.

Table 7 Modulus of elasticity test results

Specimen ID	C10	C11	C12	C13	C14	C15
Length (in.)	7.53	7.65	7.68	7.73	7.62	7.69
Diameter (in.)	4.00	4.01	4.02	4.02	4.02	4.01
Modulus of elasticity (ksi)	5,221	5,048	4,826	4,752	4,761	4,645
Poisson's ratio	129	127	126	125	125	123

5.3 Splitting tensile strength

Splitting tensile strength (f_{ct}) can be measured from cylinders. Six cylinders were tested for splitting tensile strength following ASTM C469 (2017) test procedure. Figure 12 shows the test setup for splitting tensile strength tests. Failure of all cylinders occurred by splitting of the cylinders into approximately identical halves as shown in Figure 13. Test results are given in Table 8, where the average splitting tensile strength was 0.618 ksi with a standard deviation of 0.075 ksi.

The splitting tensile strength (f_{ct}) is directly related to concrete compressive strength (f_c'). The relationship between splitting tensile strength and concrete compressive strength can be represented by $f_{ct} = a\sqrt{f_c'}$ where a is a factor. The measured value of the a factor using average measured concrete compressive strength was 0.185, which was lower than the a value of 0.230 specified by AASHTO LFRD Section C5.4.2.7. Note that the specified a value in AASHTO is for normal-weight concrete with compressive strength lower than 10 ksi.

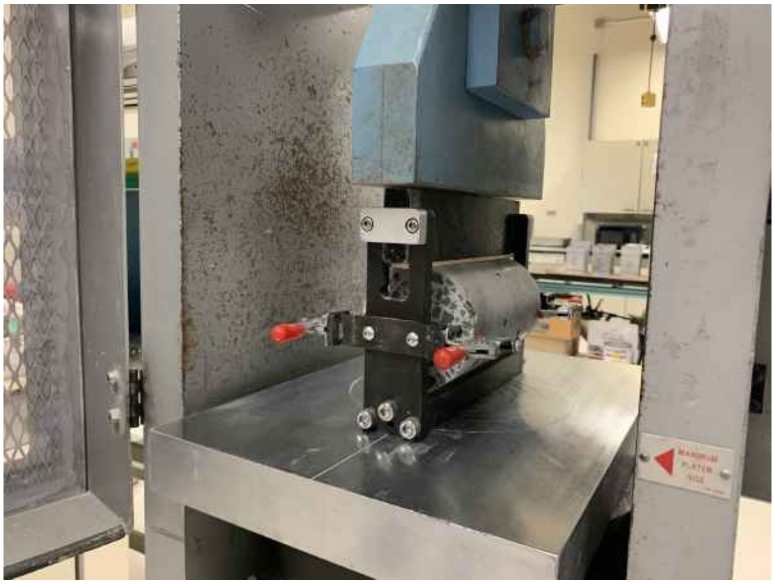

Figure 12 Splitting tensile strength test

Figure 13 Tensile failure of cylinder

Table 8 Splitting tensile strength test results

Specimen ID	C4	C5	C6	C7	C8	C9
Length (in.)	7.63	7.55	7.69	7.57	7.61	7.65
Diameter (in.)	4.01	4.02	4.02	4.00	4.01	4.01
Max. applied load (kip)	31.07	31.81	24.44	27.43	27.75	35.56
Splitting tensile strength (ksi)	0.645	0.665	0.505	0.575	0.580	0.740

AASHTO LRFD Section 5.4.2.8 provides the following equation to calculate the concrete density modification factor (λ) based on splitting tensile strength (f_{ct}) and concrete compressive strength (f_c'):

$$\lambda = 4.7 \frac{f_{ct}}{\sqrt{f_c'}} \leq 1.0$$

Using the average measured splitting tensile strength (f_{ct}) of 0.618 ksi and average measured concrete compressive strength (f_c') of 11.23 ksi, the calculated concrete density modification factor (λ) was 0.867. If the splitting tensile strength is not specified, AASHTO LRFD Section C5.4.2.8 provides a chart to determine the concrete density modification factor (λ) based on the unit weight of the mixture. For the measured unit weight of 0.126 kcf, the concrete density modification factor (λ) was found to be 0.936. Calculations indicate that the 4.7 factor in the above equation is conservative. Note that the measured compressive strength was 11.23 ksi, which was higher than the specified concrete compressive strength limit of 10 ksi for lightweight concrete according to AASHTO LRFD Section 5.4.2.6.

5.4 Modulus of rupture

Modulus of rupture is important in determining the required or acceptable amount of prestress. Eight small beams were tested in flexure under three-point loading following ASTM C78 (2018) testing procedure. Figure 14 shows the test setup for the modulus of rupture test. Failure of all beams occurred within the middle span as shown in Figure 15. Test results are given in Table 9. The average modulus of rupture was 0.895 ksi with a standard deviation of 0.107 ksi. Figure 16 shows the cross section of the beams, made with normal-weight and lightweight aggregate, after being tested for modulus of rupture.

Table 9 Modulus of rupture test results

Specimen ID	B1	B2	B3	B4	B5	B6	B7	B8
Span length (in.)	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
Width (in.)	4.03	4.03	4.03	4.02	4.02	4.00	4.05	4.05
Depth (in.)	4.02	4.02	4.05	4.03	4.00	4.00	4.05	4.05
Total load (kip)	4.32	5.31	5.49	4.44	4.90	4.68	5.01	4.80
Modulus of rupture (kip)	0.795	0.980	0.995	0.815	0.915	0.875	0.910	0.875

Figure 14 Modulus of rupture test


Figure 15 Failure of concrete beam in tension

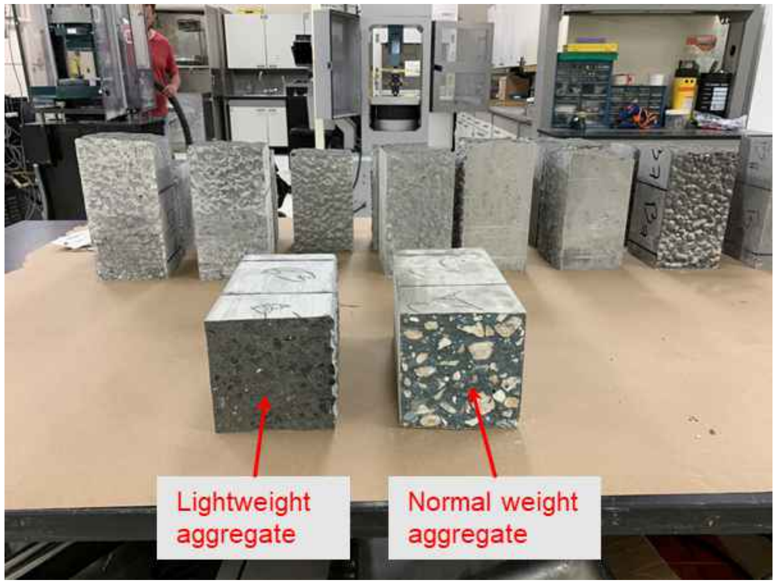

Figure 16 Illustration of normal-weight and lightweight aggregates in beams

AASHTO LRFD Section 5.4.2.6 provides the following equation to calculate modulus of rupture (f_r) of lightweight concrete with compressive strengths up to 10 ksi:

$$f_r = 0.24\,\lambda\,\sqrt{f_c'} = 0.24\,(0.936)\,\sqrt{11.23} = 0.753 \text{ ksi}$$

Comparison of the measured results with calculated results revealed that the factor value of 0.24 in the above equation underestimates the modulus of rupture for concrete compressive strength higher than 10 ksi. A factor value of 0.29 better predicts the modulus of rupture for lightweight concrete used in this study.

6 CAMBER MEASUREMENTS

6.1 At casting yard

Three self-consolidating normal-weight concrete Girders A1, A2, and A3 and two self-consolidating lightweight concrete Girders D1 and D2 were cast in the same bed. After releasing the strands, camber occurred in each girder due to effect of the prestressing. A simple method was used to measure the camber when the girders were in the casting bed. The camber was determined by measuring the distance between the casting bed and bottom fiber of the girder using a measuring tape. The measured midspan camber at the casting bed was 0.25 in. for Girder A1 and Girder A2, and 0.188 in. for Girder A3, Girder D1 and Girder D2. Then, the girders were moved from the casting bed and stored at the casting yard for 33 days. Girders were put on supports as shown in Figure 17. The distance between center of supports was approximately 38 ft.

Figure 17 Girders at the casting yard

A rotary laser level, Figure 18, was used to take camber measurements on the girders at the casting yard. The rotary laser level operates by rotating 360 degrees and sending a red laser that can be detected by a receiver. A movable receiver was attached to a graded rod, Figure 19. The receiver was adjusted along the graded rod to be aligned with the red laser to determine elevation with respect to the laser level. Elevations at the two supports and midspan were taken each time. The difference between the average elevation at the supports and midspan represents camber. Figure 20 presents the camber measurements for the first 33 days after release.

Figure 18 Laser machine at top of the girder

Figure 19 Adjusting the detector along the measuring ruler

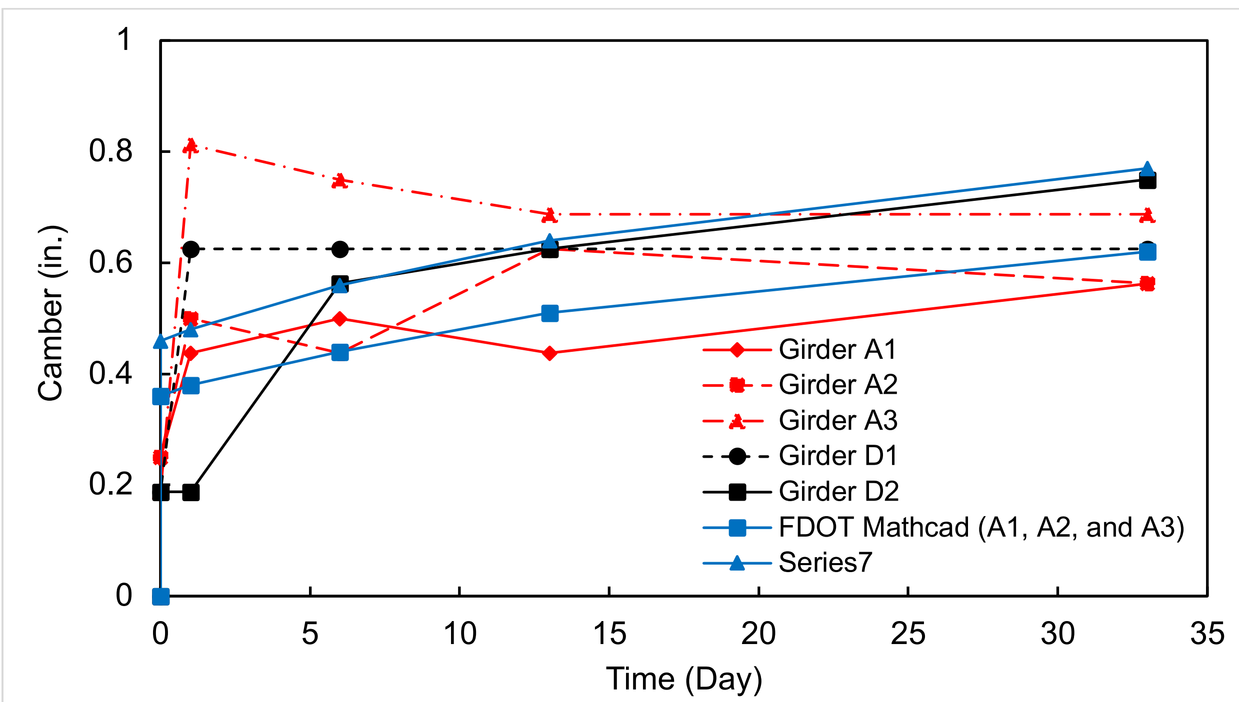

Figure 20 Camber monitoring at the casting yard

6.2 At FDOT SRC

All five girders were transported to FDOT SRC in Tallahassee, FL, 33 days after casting. When they arrived, they were put inside the lab. The three normal-weight girders (A1, A2, and A3) were tested either in shear or flexure, and no camber documentation was performed. More information about the shear and flexural testing of Girders A1, A2, and A3 can be found in Part A of this report.

After a few months of being stored in the lab, the lightweight girders (D1 and D2) were moved outside to the back yard of the lab as shown in Figure 21. Note that no camber readings were taken when the girders were inside the lab. The first camber reading at the lab was taken 303 days after casting the girders. A level device and a measuring tape were used to measure camber. First, the level device was installed. Then, elevations of the two supports and midspan were measured. At each reading, the camber was determined by calculating the difference between the average elevation at the supports and midspan. Figure 22 presents the measured camber versus time for the two lightweight girders. The final measured camber at 380 days was 0.75 in. for both girders. It can be concluded that the measured camber of lightweight girders had negligible change between erection (taken as 33 days, the age at which the girders were transported to FDOT SRC) and 380 days.

Figure 21 Measuring camber at the FDOT lab

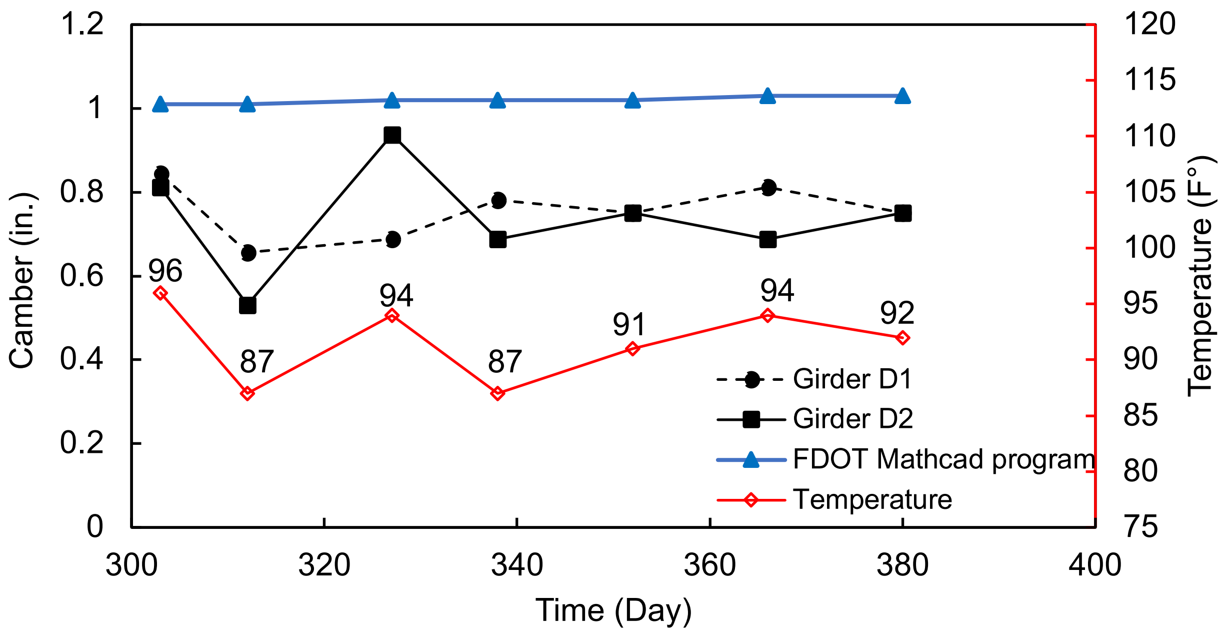

Figure 22 Camber monitoring at the FDOT lab

7 CAMBER PREDICTIONS

7.1 PCI multiplier method

The camber of the girders at transfer and at erection (taken as 33 days in this study) was calculated using an approximate method, the PCI multiplier method (2003). The procedure for camber calculation is as follows.

1. Calculate camber due to prestressing force (Δ_P)

$$\Delta_P = \frac{P_{pi}}{E_{ci} I_g}\left(\frac{e_c\, L^2}{8}\right)$$

where

P_{pi} = total prestressing force after transfer = 483.4 kips

E_{ci} = modulus of elasticity of concrete at transfer = 4,961 ksi for normal-weight concrete and 3,549 ksi for lightweight concrete

I_g = moment of inertia of girder = 50,979 in^4

e_c = eccentricity of prestressing strands = 10.49 in.

L = overall girder length = 42 ft at casting bed and 38 ft at erection

After substituting the variables into the above equation, the camber due to prestressing force (Δ_P) is 0.637 in. upward for Girders A1, A2, and A3 (normal-weight concrete) and 0.890 in.

upward for Girders D1 and D2 (lightweight concrete). Lightweight concrete girders had higher camber because of their lower modulus of elasticity.

2. Calculate camber due to self-weight (Δ_g)

$$\Delta_g = \frac{5w_g L^4}{384E_{ci}I_g}$$

where

w_g = girder self-weight = 0.384 k/ft for normal-weight concrete and 0.329 k/ft for lightweight concrete

Calculated deflections due to girder self-weight (Δ_g) at transfer and erection are 0.106 in. and 0.071 in. downward, respectively, for Girders A1, A2, and A3 (normal-weight concrete), and are 0.125 in. and 0.084 in. downward, respectively, for Girders D1 and D2 (lightweight concrete).

3. Calculate camber at transfer (Δ_{tra})

$$\Delta_{tra} = \Delta_{\mathrm{P}} - \Delta_g$$

4. Calculate camber at erection (Δ_{33_days})

$$\Delta_{33\_days} = 1.80\ \Delta_P - 1.85\ \Delta_{\mathrm{g}}$$

The PCI multiplier method was found to significantly overestimate the camber of normal-weight and lightweight girders at transfer and erection as shown in Table 10.

Table 10 Comparison of measured and calculated camber at transfer and erection

Specimen ID	At transfer (after release)			At erection (33 days)		
	Measured (in.)	PCI multiplier method (in.)	FDOT Mathcad program (in.)	Measured (in.)	PCI multiplier method (in.)	FDOT Mathcad program (in.)
Girder A1	0.250	0.530	0.360	0.563	1.014	0.620
Girder A2	0.250			0.563		
Girder A3	0.188			0.688		
Girder D1	0.188	0.765	0.460	0.625	1.447	0.770
Girder D2	0.188			0.750		

7.2 FDOT Mathcad program

FDOT Prestressed Beam Mathcad program v5.2 was used to calculate the camber of the non-composite section. The program is based on FDOT Report no. BD545-7, titled FIELD VERIFICATION OF CAMBER ESTIMATES FOR PRESTRESSED CONCRETE BRIDGE GIRDERS (Cook et al. 2005). The unit weight of concrete was the only parameter changed in the Mathcad program for the calculation of camber for lightweight concrete girders. As mentioned previously, the measured unit weight for lightweight concrete was 0.126 kcf. In the FDOT Mathcad program, a unit weight of 0.131 kcf, which includes 0.005 kcf for reinforcing materials, was used. The calculated camber by the FDOT program, for lightweight girders at 33 days, was 0.77 in., which is greater than the measured values as shown in Figure 20. As mentioned previously, the camber for the lightweight girders was monitored long-term. The calculated camber at 120 days was 0.94 in. The long-term camber was conservatively predicted by the FDOT program as shown in Figure 22.

8 FLEXURAL/SHEAR TESTS

The two lightweight concrete girders are currently stored in the back yard of the FDOT SRC in Tallahassee, FL. They will be tested either in shear or flexure after adding a deck slab to them. Tests are expected to be done in the future; no dates have been specified yet.

9 SUMMARY

A high-strength, 10 ksi, self-consolidating lightweight concrete mix was developed and used in this research program. Two 42-ft-long AASHTO Type II girders were fabricated using lightweight concrete. This study focuses on investigating the fresh and hardened properties of the developed mix. All experimental tests were conducted by professional technicians following the designated ASTM testing procedure. The fresh properties (slump, air content, and penetration) were tested before casting concrete in the bed. Several concrete cylinders and small beams were cast from the concrete batches used in the fabrication of the girders. Those cylinders and beams were used to determine the hardened properties of the concrete mixture. The hardened properties included unit weight, compressive strength, modulus of elasticity, splitting tensile strength, and modulus of elasticity. The design unit weight was 122 lb/ft^3. However, the average measured unit weight was 126 lb/ft^3. The specified compressive strength of the mixture was 10 ksi, which was achieved 11 days after casting concrete. The 28-day compressive strength was 11.22 ksi. Note that AASHTO LRFD equations regarding lightweight concrete are limited to compressive strengths up to 10 ksi. Thus, the applicability of AASHTO LRFD equations was investigated for compressive strength higher than 10 ksi.

The average measured and AASHTO calculated modulus of elasticity for lightweight concrete was 4,875 ksi and 4,232 ksi, respectively. Note that the K_1 factor in the AASHTO equation was assumed as 1.0 because no physical test was performed on the lightweight aggregate used. The higher the K_1 factor, the stiffer the aggregate. Results showed that the modulus of elasticity of the high-strength lightweight concrete was conservatively estimated by the AASHTO equation. The average measured splitting tensile strength (f_{ct}) was 0.618 ksi, which represents $0.185\sqrt{f_c'}$. The concrete density modification factor (λ) is conservatively calculated by AASHTO LRFD equation. The average modulus of rupture (f_r) was 0.895 ksi, which represents $0.29\lambda\sqrt{f_c'}$. Therefore, the AASHTO LRFD equation for modulus of rupture (f_r) was found to conservatively predict the experimental results.

Girders were monitored for camber. The measured cambers for normal-weight Girders A1, A2, and A3 at transfer were 0.250 in., 0.250 in., and 0.188 in., respectively, and at 33 days were 0.563 in., 0.563 in., and 0.688 in., respectively. The measured cambers for lightweight Girders D1 and D2 at transfer were 0.188 in. and 0.188 in., respectively, and at 33 days were 0.625 in. and 0.750 in., respectively. Both the PCI multiplier method and the FDOT program overestimated the camber of the lightweight girders, where the PCI multiplier method was the most conservative. The FDOT program was used to calculate the long-term camber of the lightweight girders. The calculated camber at 120 days and 380 days was 0.94 in. and 1.03 in., respectively. Results revealed that FDOT program overestimated the camber by approximately 37% at 380 days.

In the future, the two lightweight concrete girders will be experimentally tested to investigate the structural behavior of high-strength lightweight concrete girders.

10 REFERENCES

PCI. (2003). "PCI Bridge Design Manual", Precast/Prestressed Concrete Institute, Chicago, IL.

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AASHTO LRFD. (2017). "AASHTO LRFD Bridge Design Specifications", *8th Ed.*, American Association of State Highway and Transportation Officials, Washington, DC.

ASTM C496. (2017). "Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens", American Society for Testing and Materials, West Conshohocken, PA.

ASTM C78. (2018). "Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)", American Society for Testing and Materials, West Conshohocken, PA.

ASTM C39. (2020). "Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens", American Society for Testing and Materials, West Conshohocken, PA.

Cook, R. A., Bloomquist, D., and Sanek, J. (2005). "Field Verification of Camber Estimates For Prestressed Concrete Bridge Girders." Florida Department of Transportation, Tallahassee, FL.

APPENDIX A: DETAILED DESIGN DRAWINGS

This section contains design detailed drawings for the lightweight girders as well as other girders. The designated IDs for lightweight girders are D1 and D2. The drawings included all the information needed for construction.

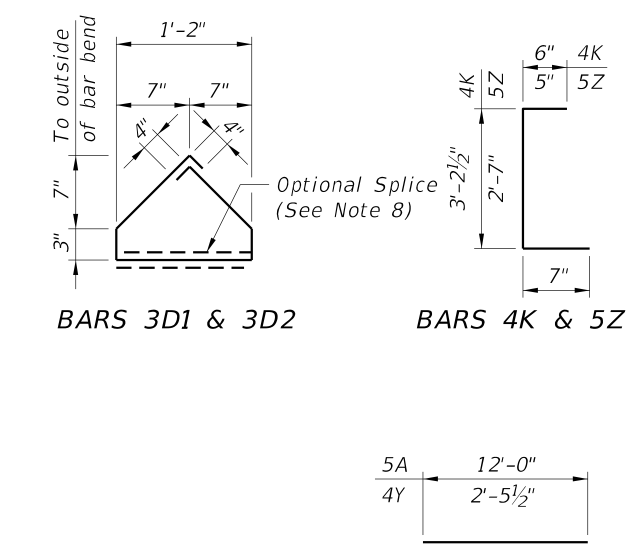
BEAM NOTES

1. Work Bar Bending Diagrams provided on this sheet with Index 415-001 for Beams A1, A3, B3, C1, C3, D1 and D2. Work Bar Bending Diagrams provided on this sheet with Developmental Design Standards Index D21310 for Beams A2, B2 and C2.
2. All bar bend dimensions are out-to-out.
3. Concrete cover: 2 inches minimum.
4. Strands N: 3/8" Ø minimum, stressed to 10,000 lbs. each. Strands N shall be Carbon Steel Strands.
5. Place one (1) Bar 4K or 5Z at each location. Alternate the direction of the ends for each bar.
6. Tie Bars 4K and 5Z to the fully bonded strands in the bottom or center row (see "STRAND PATTERN" on the Table of Beam Variables Sheet).
7. Place Bars 3D1 in beam END 1, and Bars 3D2 in beam END 2.
8. Contractor Options:
   A. Bars 3D1 and 3D2 may be fabricated as a two-piece bar with a 1'-0" minimum lap splice of the bottom legs.
9. Cut wedges and Prestressing Strands at the end of the beam without damaging the surrounding concrete. See "STRAND CUTTING DETAIL."
10. Provide material certifications to FDOT Structures Research Center.
11. Carbon Steel and Stainless Steel reinforcing bars shall be Grade 60 per Specification Section 931.
12. GFRP reinforcing bars shall be in accordance with Specification Section 932.
13. Researchers and FDOT personnel shall be allowed to instrument the beams and monitor them during detensioning. Time required for instrumenting is approximately one day per casting bed setup.

BILL OF REINFORCING STEEL FOR ONE BEAM ONLY

MARK	NOTE NUMBERS	SIZE	NUMBER REQUIRED	LENGTH
A	—	5	4	12'-0"
D1	8	3	12	3'-11¾"
D2	8	3	10	3'-11¾"
K	5 & 6	4	80	4'-3½"
N	4 & 9	3/8" Ø Strand	2	42'-5"
Y	—	4	6	2'-5½"
Z	5 & 6	5	6	3'-7"

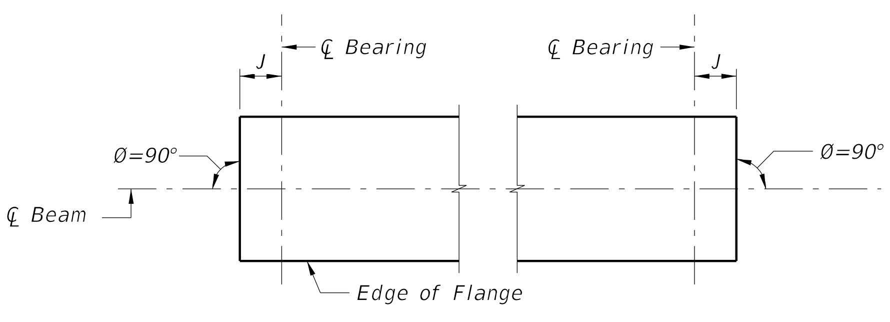
BENDING DIAGRAMS (See Notes 1 & 2)



BARS 3D1 & 3D2

BARS 4K & 5Z

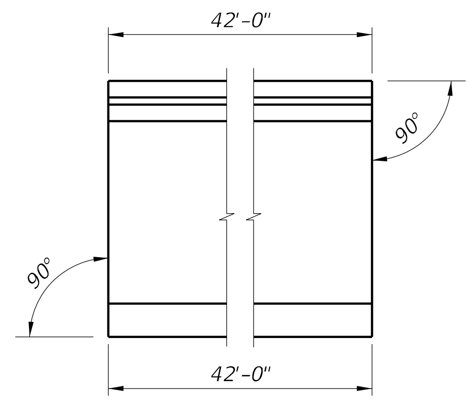
BARS 5A & 4Y



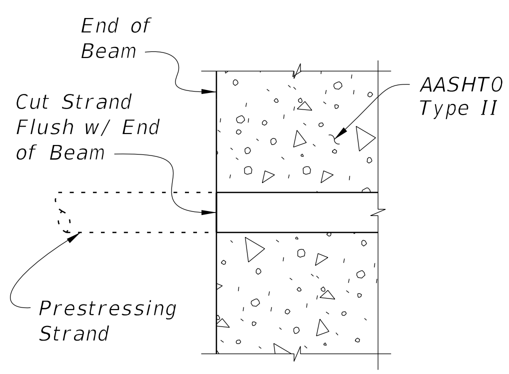
END 1

END 2

PLAN VIEW
CASE 1
(Standard Orientation for New Construction)



END ELEVATION
CONDITION 1
(Dim P = 0.0)



TYPICAL SECTION
SHOWING CUT STRAND

STRAND CUTTING DETAIL

REVISIONS					
DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION

26

DRAWN BY: JKF 12/17
CHECKED BY: VAY 12/17
DESIGNED BY:
CHECKED BY:

STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION

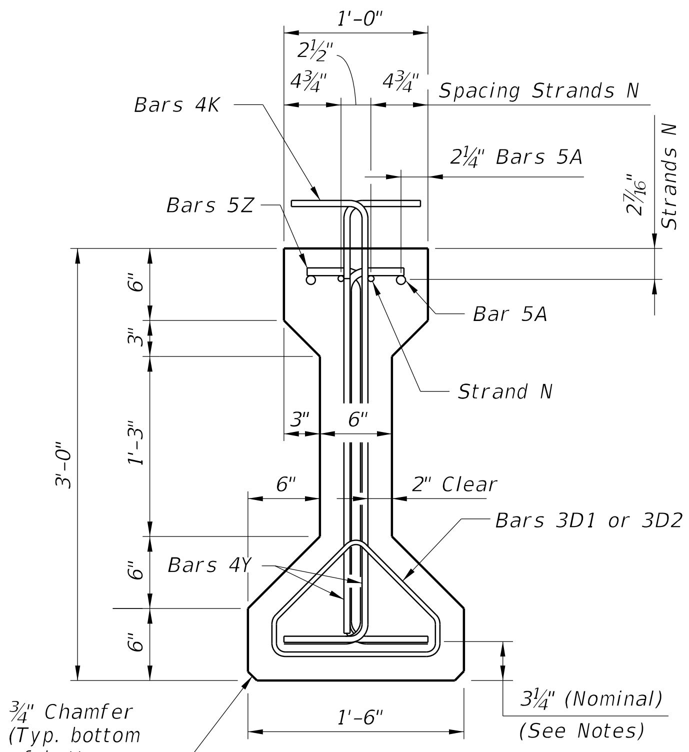
ROAD NO.	COUNTY	FINANCIAL PROJECT ID

SHEET TITLE: AASHTO TYPE II BEAM - DETAILS AND NOTES

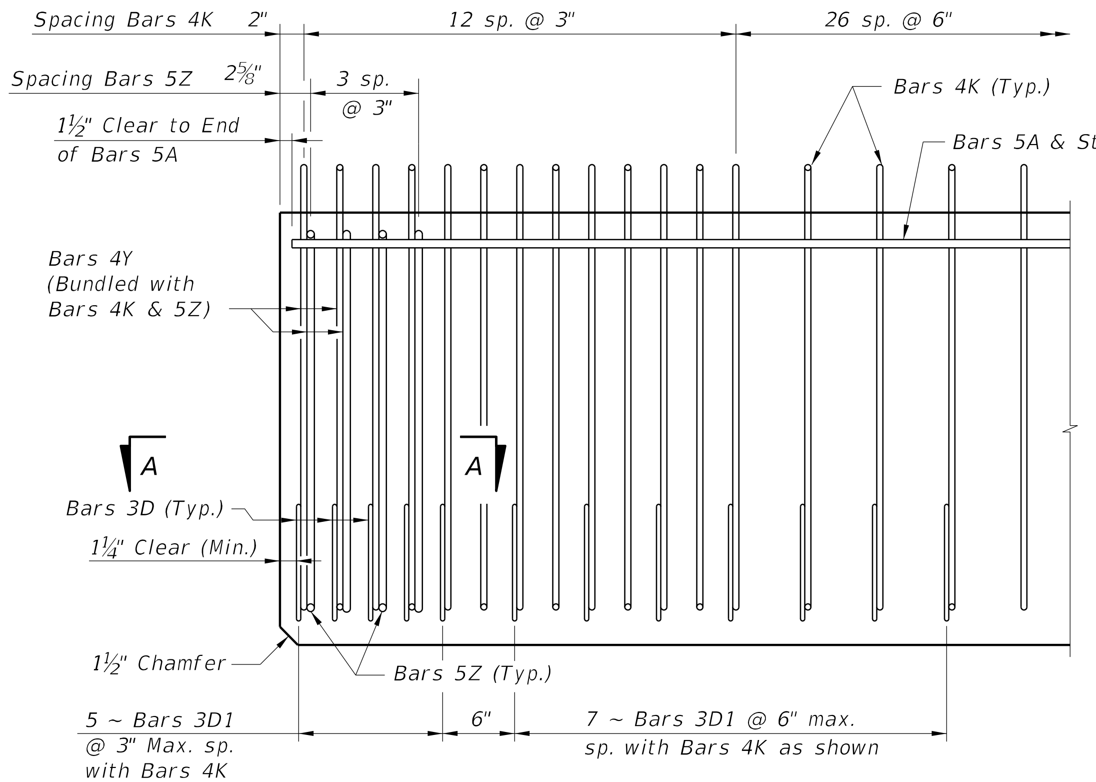
PROJECT NAME: Stainless Steel Strands for Pretensioned Concrete Girders

REF. DWG. NO.

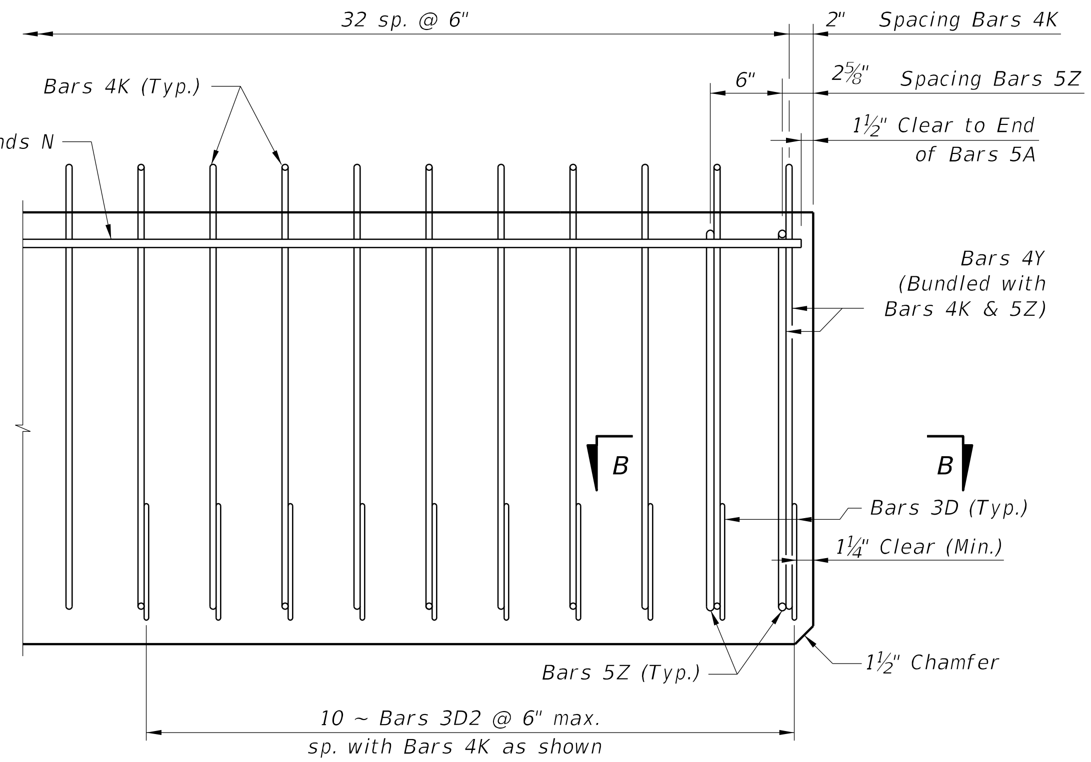
SHEET NO. 1



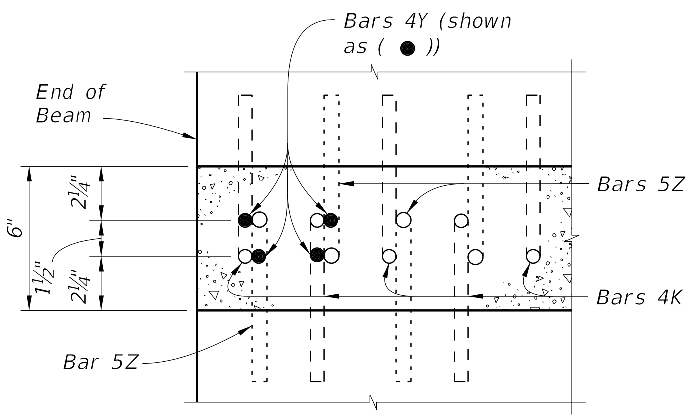
END VIEW



ELEVATION AT END 1 OF BEAM
(Flanges Not Shown For Clarity)



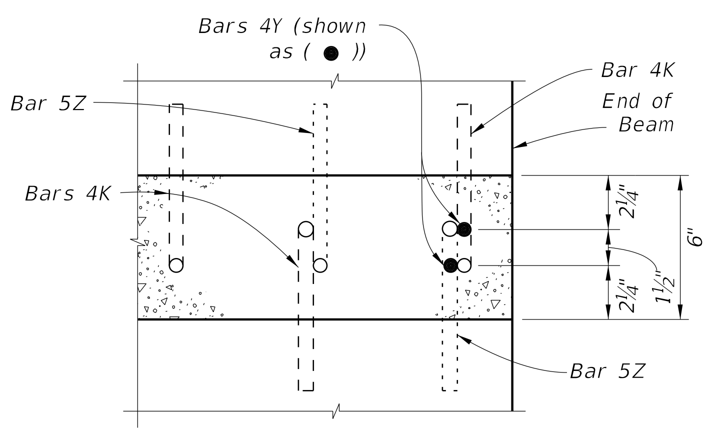
ELEVATION AT END 2 OF BEAM
(Flanges Not Shown For Clarity)



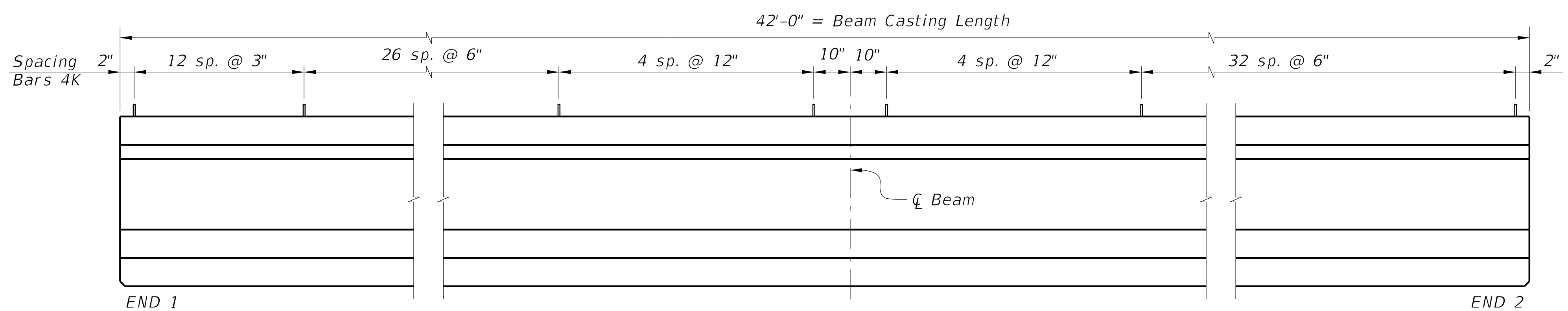
SECTION A-A
(Showing Bars 4K, 4Y & 5Z Only)

NOTES:
Work this Sheet with the AASHTO Type II Beam - Table of Beam Variables.

For referenced notes, see Sheet 1.



SECTION B-B
(Showing Bars 4K, 4Y & 5Z Only)



ELEVATION

GIRDERS A1, A2, A3, B2, B3, C1, C2, C3, D1 & D2

REVISIONS					
DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION

27

DRAWN BY: JKF 12/17	STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION			SHEET TITLE: AASHTO TYPE II BEAM - DETAILS	REF. DWG. NO.
CHECKED BY: VAY 12/17					
DESIGNED BY:	ROAD NO.	COUNTY	FINANCIAL PROJECT ID	PROJECT NAME: Stainless Steel Strands for Pretensioned Concrete Girders	SHEET NO.
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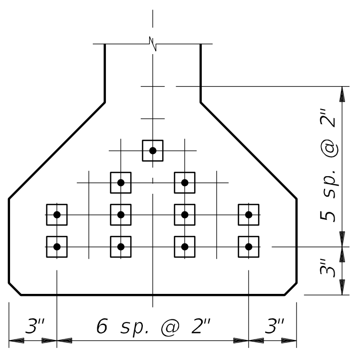
$USER$ $DATE$ $TIME$ $FILE$

AASHTO TYPE II BEAM - TABLE OF BEAM VARIABLES

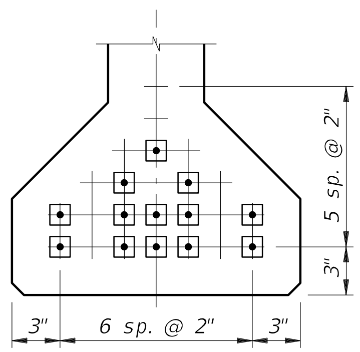
LOCATION		CONCRETE PROPERTIES			MATERIALS FOR BARS 4K, 4Y, 5Z 3D1, 3D2 & 5A	STND. PTRN. TYPE	END ELEV. COND.	PLAN VIEW CASE		BRG. PLATE MARK		END OF BEAM & BEARING DIMENSIONS					
SPAN NO.	BEAM NO.	CLASS	STRENGTHS (psi)									ANGLE Ø		DIM P	DIM J	DIM K1	DIM K2
			28 Day	Release				END 1	END 2	END 1	END 2	END 1	END 2				
	A1	NWC	10000	6000	CARBON STEEL	3	1	1	1	–	–	90°	90°	–	–	–	–
	A2	NWC	10000	6000	GFRP	3	1	1	1	–	–	90°	90°	–	–	–	–
	A3	NWC	10000	6000	STAINLESS STEEL	3	1	1	1	–	–	90°	90°	–	–	–	–
	B2	NWC	10000	6000	GFRP	1	1	1	1	–	–	90°	90°	–	–	–	–
	B3	NWC	10000	6000	STAINLESS STEEL	1	1	1	1	–	–	90°	90°	–	–	–	–
	C1	NWC	10000	6000	CARBON STEEL	2	1	1	1	–	–	90°	90°	–	–	–	–
	C2	NWC	10000	6000	GFRP	2	1	1	1	–	–	90°	90°	–	–	–	–
	C3	NWC	10000	6000	STAINLESS STEEL	2	1	1	1	–	–	90°	90°	–	–	–	–
	D1	LWC	10000	6000	CARBON STEEL	3	1	1	1	–	–	90°	90°	–	–	–	–
	D2	LWC	10000	6000	CARBON STEEL	3	1	1	1	–	–	90°	90°	–	–	–	–

NOTES:

1. Work this Sheet with Sheets 1 and 2.
2. Use Carbon Steel Strands for Beams A1, A2, A3, D1 and D2. Use Stainless Steel Strands for Beams B2, B3, C1, C2 and C3.
3. For Beams B2, B3, C1, C2 and C3, FDOT will supply an adequate length of Stainless Steel Strand to extend length of casting bed and additional length as needed for stressing.
4. Return unused Stainless Steel Strand to FDOT Structures Research Center.
5. FDOT will cut Stainless Steel Strand samples from the beginning, middle and end of spool as needed for testing purposes.
6. Use Normal Weight Concrete (NWC) for Beams A1, A2, A3, B2, B3, C1, C2 and C3.
7. Use Light Weight Concrete (LWC) for Beams D1 and D2.
8. Beams B2, B3, C1, C2 and C3 may be cast with one set of 13 strands in the casting bed. This will require sheathing of two strands for the entire beam length for Beams B2 and B3.



TYPE (1) 11 STRANDS



TYPE (2) 13 STRANDS

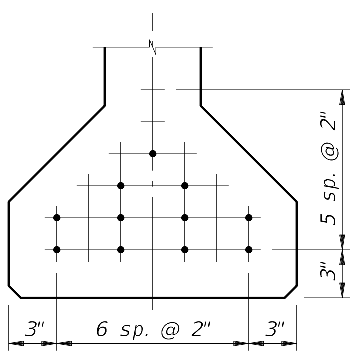
STRAND DESCRIPTION: Use 0.6" Diameter, Stainless Steel Strands. Area per strand equals 0.2328 sq. in.

STAINLESS STEEL STRAND PATTERNS

STRAND STRESSING LEGEND

- • – Strands stressed at 43.9 kips each.
- ⊡ – Strands stressed at 37.2 kips each.

NOTE: ALL STRANDS FULLY BONDED.



TYPE (3) 11 STRANDS

STRAND DESCRIPTION: Use 0.6" Diameter, Grade 270 Low-Relaxation Carbon Steel Strands. Area per strand equals 0.217 sq. in.

CARBON STEEL STRAND PATTERNS

REVISIONS					
DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION

28

DRAWN BY: JKF 12/17
CHECKED BY: VAY 12/17
DESIGNED BY:
CHECKED BY:

STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION

ROAD NO.	COUNTY	FINANCIAL PROJECT ID

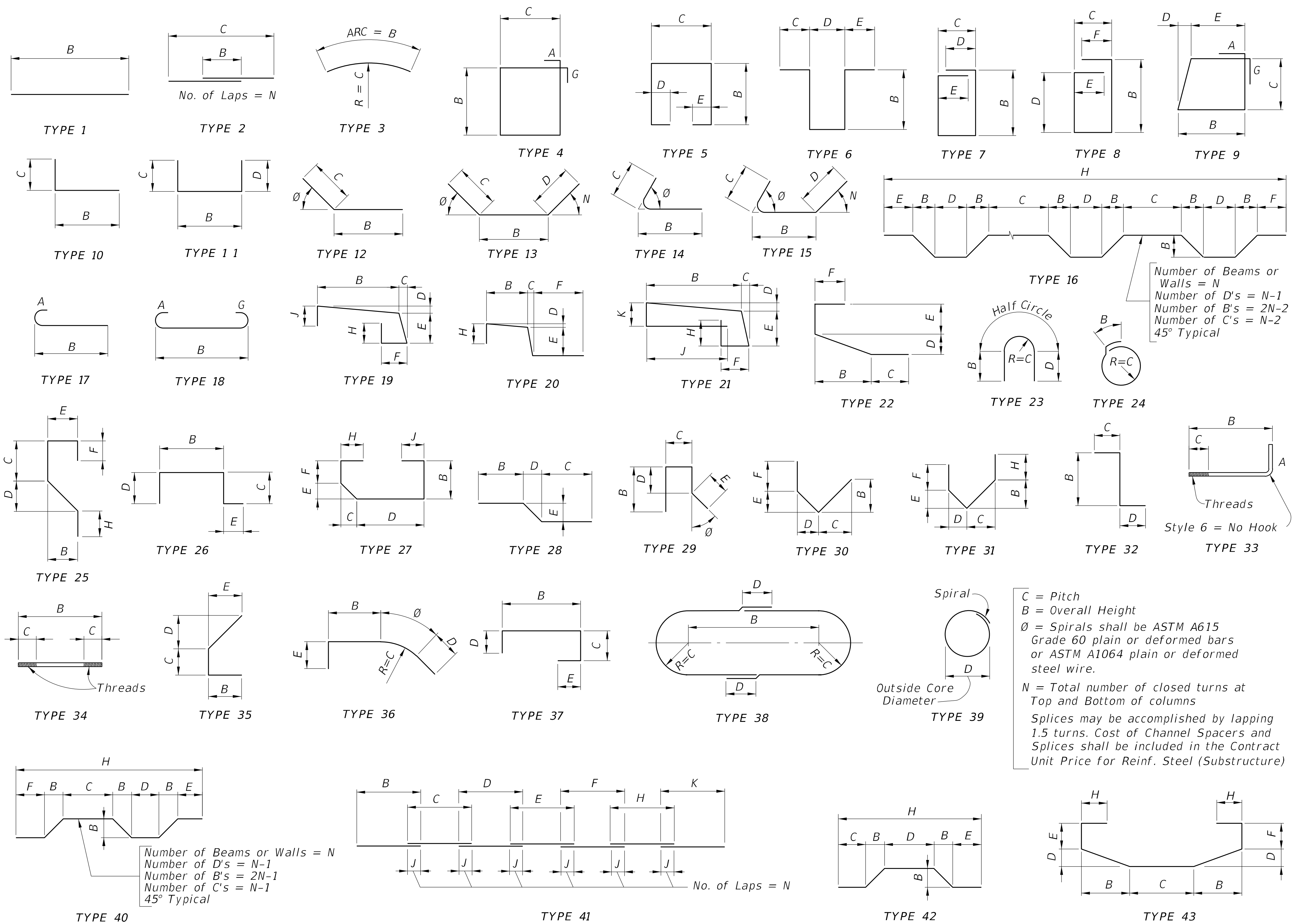
SHEET TITLE: AASHTO TYPE II BEAM - TABLE OF BEAM VARIABLES

REF. DWG. NO.

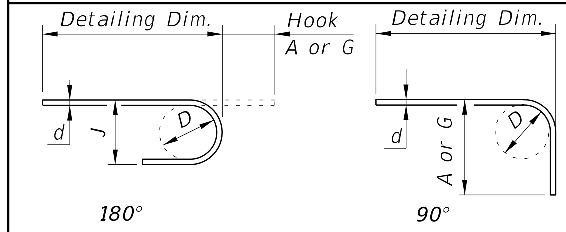
PROJECT NAME: Stainless Steel Strands for Pretensioned Concrete Girders

SHEET NO. 3

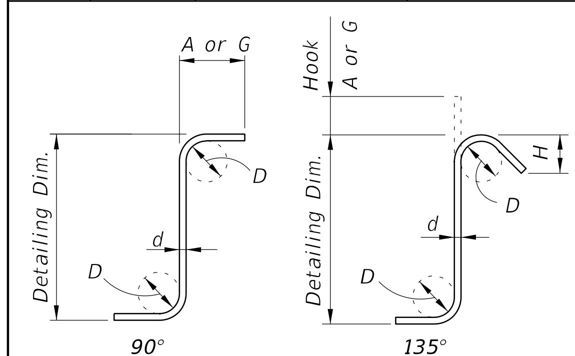
$USER$ $DATE$ $TIME$ $FILE$



HOOK DETAILS



BAR SIZE	D	180° HOOKS		90° HOOKS
		A OR G	J	A OR G
#3	2¼"	5"	3"	6"
#4	3"	6"	4"	8"
#5	3¾"	7"	5"	10"
#6	4½"	8"	6"	1'-0"
#7	5¼"	10"	7"	1'-2"
#8	6"	11"	8"	1'-4"
#9	9½"	1'-3"	11¾"	1'-7"
#10	10¾"	1'-5"	1'-1¼"	1'-10"
#11	12"	1'-7"	1'-2¾"	2'-0"
#14	18¼"	2'-3"	1'-9¾"	2'-7"
#18	24"	3'-0"	2'-4½"	3'-5"
STYLE		1		3



STIRRUPS (TIES SIMILAR)

STIRRUP & TIE HOOK DIMENSIONS

BAR SIZE	D	90° HOOKS	135° HOOKS	
		A or G	A or G	H *
#3	1½"	4"	4"	2½"
#4	2"	4½"	4½"	3"
#5	2½"	6"	5½"	3¾"
#6	4½"	1'-0"	8"	4½"
#7	5¼"	1'-2"	9"	5¼"
#8	6"	1'-4"	10½"	6"
STYLE		4	5	

STYLE 6 = NO HOOK

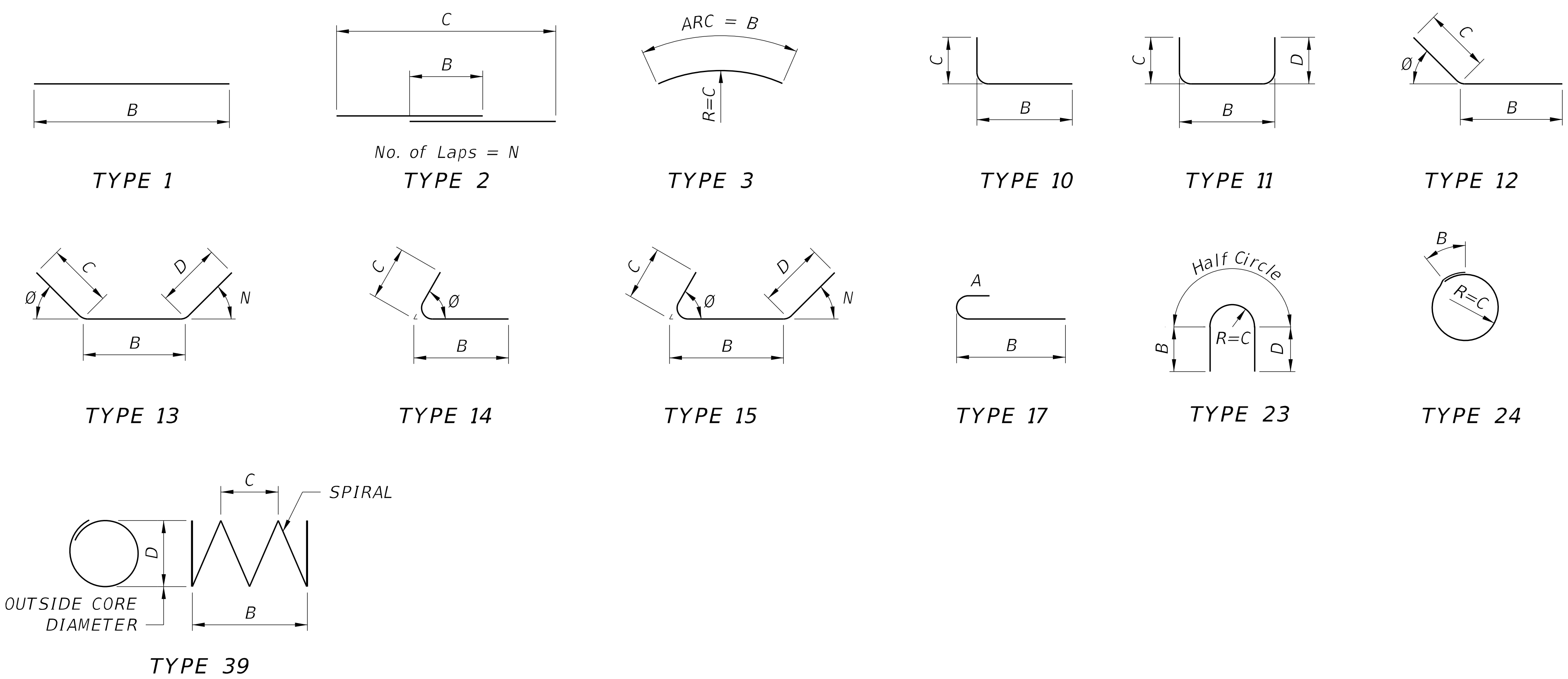
* Dimension is approximate.

Hook Styles Detailed on this sheet are for Illustration Only.

Actual Hook Style for any particular bar will be shown under A or G Heading on REINFORCING BAR LIST sheet(s) in Structures Plans.

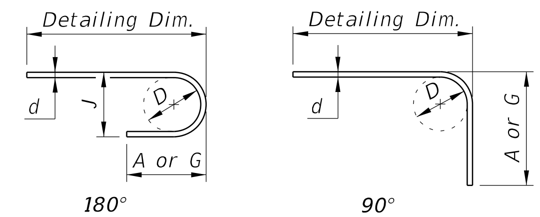
All Dimensions are out-to-out.

NOTE: For Bar Dimensions See REINFORCING BAR LIST Sheet(s) in Structures Plans.



SINGLE BAR BENDING DETAILS

FRP REBAR HOOK DETAILS



BAR SIZE	D	180° HOOKS		90° HOOKS
		A or G	J	A or G
#2	3"	4½"	3½"	4¾"
#3	4½"	6¾"	5¼"	7⅛"
#4	4½"	8¼"	5½"	8¾"
#5	4½"	9¾"	5¾"	10⅝"
#6	4½"	11½"	6"	1'-0"
#7	6"	1'-1½"	7¾"	1'-2"
#8	6"	1'-3"	8"	1'-4"
STYLE		1		3

NOTES

GENERAL
All dimensions are out-to-out.
For Bar Dimensions See REINFORCING BAR LIST Sheet(s) in Structures Plans.

SPIRALS (TYPE 39 BARS)

C = Pitch
B = Overall Height
N = Total number of closed turns at Top and Bottom of spiral
Splices = 1.5 turns
Include spiral splice in the Contract Unit Price for FRP Reinforcing.

HOOKS

All dimensions are approximate.
Hook Styles Detailed on this sheet are for Illustration Only. Actual Hook Style for any particular bar will be shown under A or G Heading on REINFORCING BAR LIST sheet(s) in Structures Plans.

APPENDIX B: FABRICATION OF LIGHTWEIGHT GIRDERS

This section contains information about fabrication of the girders. All girders were fabricated at Dura-Stress, Inc., casting yard in Leesburg, FL. Dura-Stress provided fabrication check lists, which included the following:

1. Measured concrete fresh properties
2. Stress information
3. Rebar material/mechanical properties
4. Strand stress calculations
5. Pre-pour production sheet
6. Concrete mix designs
7. Concrete batch tickets
8. Casting bed diagram
9. Concrete compressive strength

CHECK LIST

✓	TABLE SHEET	JOB #	B1789
✓	STRESS	FDOT #	TEST BEAM
✓	REBAR/SPIRAL	PRODUCT TYPE	TYPE II
✓	STRESS CALCS	MARK #	1-D1, 1-D2, 1-A3, 1-A2, 1-A1
✓	STRESS RESULTS	SERIAL #	LW1 - LW5
✓	PREPOUR	BED #	31N
✓	BATCH TICKETS	MIX DESIGN	LIGHTWEIGHT (10,000 mix) 05-2056 (10,000 mix)
✓	CASTING DIAGRAM		

	Check Off!
Cast Date:	9-12-18
Entered in Great Production:	Jancy
Entered in MAC (initials)	N/A
Scanned:	
Ready To File:	

Sample #'s TEST01

TABLE SHEET

PROJECT NO. : B1789 TEST BEAM

PRODUCT : TYPE II

BED # : 31 N

DATE CAST : 9/12/18

SERIAL NOs : LW1 - LW2

MIX DESIGN : LIGHTWEIGHT

CLASS : (10,000 MIX)

MIX DESIGN TOLERANCES

SLUMP : 24.5-29.5 | AIR : 1-6 | AGG CORR FACTOR : 0.9

RELEASE : 6000 PSI | SHIP: 10,000 psi | PENATRATION: 25MM Max

OF REL. CYL'S : 10 | MADE FROM RANDOM# 1 | W/C : RATIO 0.3

CY TOTAL : 7.98

DAY 1:

DAY 2:

Retested

SAMPLE #	LOT # / LAB #	AIR TEMP/ TIME	CONC. TEMP	T50	SLUMP	VSI	PEN.	AIR %	BUCKET VOLUME	MEASURE WEIGHT	MEASURE WITH CONCRETE	W/C RATIO
Q.C.	INITIAL	79/801	99	4 sec	26/27	0	2mm	9.0	.25	8.40	37.95	.27
	2nd Truck	81/829	99	2 sec	31/32	0	1mm	1.0	.25	8.40	40.35	.27
18TEST01	R#1	83/855	100	3 sec	31/31	0	0mm	1.	.25	8.40	40.25	.27
	TRUCK #3											
	R#1											
	TRUCK #											

	R-1	R-	R-
LOT SIZE	8		
LOAD NUMBER	LW1 - LW2		
SERIAL NUMBER			
TEST LOAD NUMBER			

TESTING TECH: ES/KK

REMARKS :

Q/C NOTIFIED BATCH PLANT

Time: 8:30am
Temp:
Taken by:

1 DAY POUR: ✓
2 DAY POUR:
OTHER:

STRESS INFORMATION SLIP

F.D.O.T. PROJECT YES NO (CIRCLE ONE)

DATE 9-10-18

INITAL TENSION 5,000

JOB# 1789

NUM OF STRAND 11

FINAL TENSION ~13,900

BED# 31

JACK#

PAK# OR COIL# 002829.009
002900.004

LIST MARK#S 1-D1, 1-D2, 1-A3, 1-A2, 1-A1

PRODUCT TYPE Girt 2

TYPE OF CABLE .6

MUST BE SIGNED BY PERSON FILLING OUT SLIP: Kevin Walker

WILL NOT BE PROCESSED WITHOUT ALL PROPER INFORMATION AND SIGNATURE !

Stress Prepared by: Janet
Checked by:

Setup prepared by: Janet
Checked by:

6,000 psi - 10,000 psi
no sheathing

REBAR REPORT

JOB #	B1789
BED #	31N
MARK #	1-D1, 1-D2, 1-A3, 1-A2, 1-A1
TYPE OF PRODUCT	GIRT 2

BAR SIZE	3	HEAT #	BR18120076879
BAR SIZE	4	HEAT #	BR1810121101
BAR SIZE	5	HEAT #	~~1-7579136~~ ID 7578475, (5214503702)? HT
BAR SIZE		HEAT #	
BAR SIZE		HEAT #	
BAR SIZE		HEAT #	
BAR SIZE		HEAT #	
BAR SIZE		HEAT #	

STRAIGHT BIL OLADING - NOT NEGOTIABLE

NUCOR
NUCOR STEEL BIRMINGHAM, INC.

Nucor Steel Birmingham, Inc.
3900 NE 10TH Way
Pompano Beach, FL 33064
954-942-9400

Rebar

Page: 1 of

Bill of Lading N
507382 Rev 0
PICKED: 07-06-2018 12:17 PM
PRINT: 6-Jul-201812:44 PM

SOLD TO: 000
DURA-STRESS INC
PO BOX 490779
LEESBURG, FL 34749
(352) 787-1422

RECEIVED
JUL 09 2018
DURA-STRESS, INC.

SHIP TO: 010
DURA-STRESS INC
11325 COUNTY RD 44E
LEESBURG, FL 34788
(352) 787-1422

SCANNED
7-9-18

Freight Mode: Truck

Subject to section 7 of the te and conditions of this bill of lac if this shpment is to be delive to the consignee without recou on the consignor, the consig shall sign the following stateme

The carrier may decline to m delivery of this shipment with payment of freight and all ot lawful charges.

NUE
(Signature of Consignor)

Freight Charges are PREPAID unless marked collect.
CHECK BOX IF COLLECT:
To Be Prepaid

CUSTOMER NO.	CUSTOMER ORDER NUMBER	OUR ORDER NUMBER	SHIPPER NUMBER	TERMS
10099	See Below	See Below	P1-41856	Prepaid

SHIP VIA	VEHICLE NUMBER	ROUTING
Fast Florida Freight	109 Julio	

NO. OF BUNDS.	NO. OF PIECES	DESCRIPTION	PRODUCT CODE	WEIGHT
		SPECIAL INSTRUCTIONS ALL BUNDLES MUST HAVE TAGS ALL MATERIAL MUST BE CLEAN/NO PITTING/NO RUST DOT INSPECTION AS TRUCK ARRIVES ALL DELIVERIES B/4 2:00 FRIDAYS B/4 10 AM ****SPECIAL TIE WIRE TAGGING**** FAST FLORIDA DELIVERY NEEDED 7/10 AM - PRELOAD 7/9	2 Tags missing	
9	3024	10/#3 Rebar 40' A615M GR420 (Gr60) OUR ORDER NUMBER - 360655/1 CUSTOMER PO# - 13289 SOUTHSIDE	900000104804200	45,477
		Tag# 1 : BR1812076878 Heat #: BR18103079 Lot #: BR1810307901	Pieces: 336	5,053
		Tag# 2 : BR1812076879 Heat #: BR18103079 Lot #: BR1810307901	Pieces: 336	5,053
		Tag# 3 : BR1812076880 Heat #: BR18103079 Lot #: BR1810307901	Pieces: 336	5,053
		Tag# 4 : BR1812076887 Heat #: BR18103079 Lot #: BR1810307901	Pieces: 336	5,053
		Tag# 5 : BR1812076888 Heat #: BR18103079 Lot #: BR1810307901	Pieces: 336	5,053
		Tag# 6 : BR1812076889 Heat #: BR18103079 Lot #: BR1810307901	Pieces: 336	5,053
		Tag# 7 : BR1812076857 Heat #: BR18103080 Lot #: BR1810308001	Pieces: 336	5,053
		Tag# 8 : BR1812076868 Heat #: BR18103080 Lot #: BR1810308001	Pieces: 336	5,053
		Tag# 9 : BR1812076871 Heat #: BR18103080 Lot #: BR1810308001	Pieces: 336	5,053
		Total Tags: 9	Total Pieces: 3024	45,477

Brandon Wilkes

ENTERED SEP 07 2018

Name of Carrier **Fast Florida Freight** Carrier's No. **109 Julio**
RECEIVED, subject to the terms and conditions of this Bill of Lading.
AT

If the shipment moves between two ports b a carrier by water, the law requires that the bill c lading shall state whether it is "carrier's weight" o "shipper's weight".

The property described above in apparent good order, except as noted (contents and condition of contents of packages unknown), marked, consigned, and destined as indicated above, which said carrier (the word carrier being understood throughout this contract as meaning any person or corporation in possession of the property under the contract) agrees to carry to its usual place of delivery at said destination, if on its route, otherwise to deliver to another carrier on the route to said destination. It is mutually agreed that every service to be performed hereunder shall be subject to all the terms and conditions of this bill of lading. THIS BILL OF LADING IS NOT SUBJECT TO ANY CLASSIFICATION OR TARIFFS, WHETHER INDIVIDUALLY DETERMINED OR FILED WITH ANY FEDERAL OR STATE REGULATORY AGENCY, EXCEPT AS SPECIFICALLY AGREED TO IN WRITING BY THE SHIPPER AND CARRIER.

The agreed-on declared value of the property is hereby specifically stated by the shipper to be no exceeding

per

Carrier Certification:
Carrier acknowledges receipt of the property described above in good order and condition.
Per

Shipper hereby certifies that he is familiar with all the terms and conditions of this bill of lading, including those on the back hereof, and the said terms and conditions are hereby agreed to by the shipper and accepted for itself and its assigns

CHAR2\1458684v1

SOLD TO: DURA-STRESS INC
PO BOX 490779
LEESBURG, FL 34749-

NUCOR

NUCOR STEEL BIRMINGHAM, INC.

CERTIFIED MILL TEST REPORT

Page: 1

Ship from:

MTR #: 0000182011
Nucor Steel Birmingham, Inc.
3900 NE 10TH Way
Pompano Beach, FL 33064
954-942-9400

SHIP TO: DURA-STRESS INC
11325 COUNTY RD 44E
LEESBURG, FL 34788-

Date: 6-Jul-2018
B.L. Number: 507382
Load Number: 41856

Material Safety Data Sheets are available at www.nucorbar.com or by contacting your inside sales representative.

NBMG-08 January 1, 2012

LOT # / HEAT #	DESCRIPTION	PHYSICAL TESTS: YIELD P.S.I.	TENSILE P.S.I.	ELONG % IN 8"	BEND	WT% / DEF	CHEMICAL TESTS: C / Ni	Mn / Cr	P / Mo	S / V	Si / Cb	Cu / Sn	C.E.
	ALL BUNDLES MUST HAVE TAGS ALL MATERIAL MUST BE CLEAN/NO PITTING/NO RUST DOT INSPECTION AS TRUCK ARRIVES ALL DELIVERIES B/4 2:00 FRIDAYS B/4 10 AM												
PO# =>	13289 SOUTHSIDE												
BR1810307901 BR18103079	Nucor Steel - Birmingham Inc 10/#3 Rebar 40' A615M GR420 (Gr60) ASTM A615/A615M-16 GR 60 AASHT O M31-15	69,700 481MPa	107,500 741MPa	11.0%	OK	-2.7% .026	.34 .14	1.22 .22	.012 .032	.037 .005	.24 .001	.30	
PO# =>	13289 SOUTHSIDE												
BR1810308001 BR18103080	Nucor Steel - Birmingham Inc 10/#3 Rebar 40' A615M GR420 (Gr60) ASTM A615/A615M-16 GR 60 AASHT O M31-15	75,500 521MPa	110,900 765MPa	13.0%	OK	-2.9% .026	.34 .12	1.32 .24	.017 .033	.049 .006	.21 .001	.29	

I hereby certify that the material described herein has been manufactured in accordance with the specifications and standards listed above and that it satisfies those requirements. .
1.) Weld repair was not performed on this material.
2.) Melted and Manufactured in the United States.
3.) Mercury, Radium, or Alpha source materials in any form have not been used in the production of this material.

QUALITY ASSURANCE: George Milius

George P. Milius, Jr.

STRAIGHT BILL OF LADING - NOT NEGOTIABLE

NUCOR
NUCOR STEEL BIRMINGHAM, INC.

Nucor Steel Birmingham, Inc.
2060 Avenue A
KISSIMMEE, FL 34758
321-219-0191

Bill of Lading No.:
502262 Rev 0

PICKED: 04-12-2018 11:21 AM
PRINT: 12-Apr-201811:36 AM

RECEIVED APR 12 2018 DURA-STRESS, INC

SENT APR 13 2018 Kelly Kelly

SOLD TO: 000

DURA-STRESS INC
PO BOX 490779
LEESBURG, FL 34749
(352) 787-1422

SHIP TO: 010

DURA-STRESS INC
11325 COUNTY RD 44
LEESBURG, FL 34788
(352) 787-1422

Freight Mode: Truck

Subject to section 7 of the terms and conditions of this bill of lading if this shpment is to be delivered to the consignee without recourse on the consignor, the consignor shall sign the following statement:

The carrier may decline to make delivery of this shipment without payment of freight and all other lawful charges.

NUE

(Signature of Consignor)

Freight Charges are PREPAID unless marked collect.

CHECK BOX IF COLLECT: ☐

To Be Prepaid

CUSTOMER NO.	CUSTOMER ORDER NUMBER	OUR ORDER NUMBER	SHIPPER NUMBER	TERMS
10099	See Below	See Below	01-114348	Prepaid

SHIP VIA	VEHICLE NUMBER	ROUTING
FREEDOM TRUCKING	1 DENNIS	

NO. OF BUNDS.	NO. OF PIECES	DESCRIPTION			PRODUCT CODE		WEIGHT
		SPECIAL INSTRUCTIONS ALL BUNDLES MUST HAVE TAGS ALL MATERIAL MUST BE CLEAN/NO PITTING/NO RUST DOT INSPECTION AS TRUCK ARRIVES ALL DELIVERIES B/4 2:00 FRIDAYS B/4 10 AM					
9	1701	13/#4 Rebar 40' A615M GR420 (Gr60) OUR ORDER NUMBER - 358732/2 CUSTOMER PO# - 11811 SOUTHSIDE			900000134804200		45,450
		Tag# 1 : BR1812030844	Heat #: Lot #:	BR18101207 BR1810120701	Pieces:	189	5,050
		Tag# 2 : BR1812030796	Heat #: Lot #:	BR18101209 BR1810120901	Pieces:	189	5,050
		Tag# 3 : BR1812030772	Heat #: Lot #:	BR18101210 BR1810121001	Pieces:	189	5,050
		Tag# 4 : BR1812030778	Heat #: Lot #:	BR18101210 BR1810121001	Pieces:	189	5,050
		Tag# 5 : BR1812030781	Heat #: Lot #:	BR18101210 BR1810121001	Pieces:	189	5,050
		Tag# 6 : BR1812030782	Heat #: Lot #:	BR18101210 BR1810121001	Pieces:	189	5,050
		Tag# 7 : BR1812030759	Heat #: Lot #:	BR18101211 BR1810121101	Pieces:	189	5,050
		Tag# 8 : BR1812030764	Heat #: Lot #:	BR18101211 BR1810121101	Pieces:	189	5,050
		Tag# 9 : BR1812031001	Heat #: Lot #:	BR18101288 BR1810128801	Pieces:	189	5,050
		SCANNED Total Tags:	9		Total Pieces:	1701	45,450

ENTERED SEP 06 2018

Name of Carrier FREEDOM TRUCKING Carrier's No. 1 DENNIS
RECEIVED, subject to the terms and conditions of this Bill of Lading.
AT _______________

The property described above in apparent good order, except as noted (contents and condition of contents of packages unknown), marked, consigned, and destined as indicated above, which said carrier (the word carrier being understood throughout this contract as meaning any person or corporation in possession of the property under the contract) agrees to carry to its usual place of delivery at said destination, if on its route, otherwise to deliver to another carrier on the route to said destination. It is mutually agreed that every service to be performed hereunder shall be subject to all the terms and conditions of this bill of lading. THIS BILL OF LADING IS NOT SUBJECT TO ANY CLASSIFICATION OR TARIFFS, WHETHER INDIVIDUALLY DETERMINED OR FILED WITH ANY FEDERAL OR STATE REGULATORY AGENCY, EXCEPT AS SPECIFICALLY AGREED TO IN WRITING BY THE SHIPPER AND CARRIER.

If the shipment moves between two ports by a carrier by water, the law requires that the bill of lading shall state whether it is "carrier's weight" or "shipper's weight".

The agreed-on declared value of the property is hereby specifically stated by the shipper to be not exceeding

_______________ per _______

Carrier Certification:

Carrier acknowledges receipt of the property described above in good order and condition.

Per Dennis [signature]

Shipper hereby certifies that he is familiar with all the terms and conditions of this bill of lading, including those on the back hereof, and the said terms and conditions are hereby agreed to by the shipper and accepted for itself and its assigns.

CHAR2\1458684v1

STRAIGHT BILL OF LADING - NOT NEGOTIABLE

NUCOR
NUCOR STEEL BIRMINGHAM, INC.

Nucor Steel Birmingham, Inc.
2060 Avenue A
KISSIMMEE, FL 34758
321-219-0191

Bill of Lading No.:
502262 Rev 0

PICKED: 04-12-2018 11:21 AM
PRINT: 12-Apr-201811:36 AM

SOLD TO: 000

DURA-STRESS INC
PO BOX 490779
LEESBURG, FL 34749
(352) 787-1422

SHIP TO: 010

DURA-STRESS INC
11325 COUNTY RD 44E
LEESBURG, FL 34788
(352) 787-1422

Freight Mode: Truck

Subject to section 7 of the terms and conditions of this bill of lading if this shpment is to be delivered to the consignee without recourse on the consignor, the consignor shall sign the following statement:

The carrier may decline to make delivery of this shipment without payment of freight and all other lawful charges.

NUE
(Signature of Consignor)

Freight Charges are PREPAID unless marked collect.

CHECK BOX IF COLLECT: ☐

To Be Prepaid

CUSTOMER NO.	CUSTOMER ORDER NUMBER	OUR ORDER NUMBER	SHIPPER NUMBER	TERMS
10099	See Below	See Below	O1-114348	Prepaid

SHIP VIA	VEHICLE NUMBER	ROUTING
FREEDOM TRUCKING	1 DENNIS	

NO. OF BUNDS.	NO. OF PIECES	DESCRIPTION	PRODUCT CODE	WEIGHT
		SPECIAL INSTRUCTIONS ALL BUNDLES MUST HAVE TAGS ALL MATERIAL MUST BE CLEAN/NO PITTING/NO RUST DOT INSPECTION AS TRUCK ARRIVES ALL DELIVERIES B/4 2:00 FRIDAYS B/4 10 AM		
9	1701	13/#4 Rebar 40' A615M GR420 (Gr60) OUR ORDER NUMBER - 358732/2 CUSTOMER PO# - 11811 SOUTHSIDE	900000134804200	45,450
		Tag# 1 : BR1812030844 Heat #: BR18101207 Lot #: BR1810120701	Pieces: 189	5,050
		Tag# 2 : BR1812030796 Heat #: BR18101209 Lot #: BR1810120901	Pieces: 189	5,050
		Tag# 3 : BR1812030772 Heat #: BR18101210 Lot #: BR1810121001	Pieces: 189	5,050
		Tag# 4 : BR1812030778 Heat #: BR18101210 Lot #: BR1810121001	Pieces: 189	5,050
		Tag# 5 : BR1812030781 Heat #: BR18101210 Lot #: BR1810121001	Pieces: 189	5,050
		Tag# 6 : BR1812030782 Heat #: BR18101210 Lot #: BR1810121001	Pieces: 189	5,050
		Tag# 7 : BR1812030759 Heat #: BR18101211 Lot #: BR1810121101	Pieces: 189	5,050
		Tag# 8 : BR1812030764 Heat #: BR18101211 Lot #: BR1810121101	Pieces: 189	5,050
		Tag# 9 : BR1812031001 Heat #: BR18101288 Lot #: BR1810128801	Pieces: 189	5,050
		Total Tags: 9	Total Pieces: 1701	45,450

Duplicate 25

Name of Carrier FREEDOM TRUCKING Carrier's No. 1 DENNIS
RECEIVED, subject to the terms and conditions of this Bill of Lading.
AT ______________________________ , ______________

The property described above in apparent good order, except as noted (contents and condition of contents of packages unknown), marked, consigned, and destined as indicated above, which said carrier (the word carrier being understood throughout this contract as meaning any person or corporation in possession of the property under the contract) agrees to carry to its usual place of delivery at said destination, if on its route, otherwise to deliver to another carrier on the route to said destination. It is mutually agreed that every service to be performed hereunder shall be subject to all the terms and conditions of this bill of lading. THIS BILL OF LADING IS NOT SUBJECT TO ANY CLASSIFICATION OR TARIFFS, WHETHER INDIVIDUALLY DETERMINED OR FILED WITH ANY FEDERAL OR STATE REGULATORY AGENCY, EXCEPT AS SPECIFICALLY AGREED TO IN WRITING BY THE SHIPPER AND CARRIER.

If the shipment moves between two ports by a carrier by water, the law requires that the bill of lading shall state whether it is "carrier's weight" or "shipper's weight".

The agreed-on declared value of the property is hereby specifically stated by the shipper to be not exceeding

______________ per ______

Carrier Certification:

Carrier acknowledges receipt of the property described above in good order and condition.

Per Dennis Lutes

Shipper hereby certifies that he is familiar with all the terms and conditions of this bill of lading, including those on the back hereof, and the said terms and conditions are hereby agreed to by the shipper and accepted for itself and its assigns.

CHAR2\1458684v1

SOLD TO: DURA-STRESS INC
PO BOX 490779
LEESBURG, FL 34749-

NUCOR

NUCOR STEEL BIRMINGHAM, INC.

CERTIFIED MILL TEST REPORT

Page: 1

Ship from:

MTR #: 0000168857
Nucor Steel Birmingham, Inc.
2060 Avenue A
KISSIMMEE, FL 34758
321-219-0191

SHIP TO: DURA-STRESS INC
11325 COUNTY RD 44E
LEESBURG, FL 34788-

Date: 12-Apr-2018
B.L. Number: 502262
Load Number: 114348

Material Safety Data Sheets are available at www.nucorbar.com or by contacting your inside sales representative.

NBMG-08 January 1, 2012

LOT # / HEAT #	DESCRIPTION	PHYSICAL TESTS: YIELD P.S.I.	TENSILE P.S.I.	ELONG % IN 8"	BEND	WT% / DEF	CHEMICAL TESTS: C / Ni	Mn / Cr	P / Mo	S / V	Si / Cb	Cu / Sn	C.E.
	ALL BUNDLES MUST HAVE TAGS ALL MATERIAL MUST BE CLEAN/NO PITTING/NO RUST DOT INSPECTION AS TRUCK ARRIVES ALL DELIVERIES B/4 2:00 FRIDAYS B/4 10 AM												
PO# => BR1810120701 BR18101207	11811 SOUTHSIDE Nucor Steel - Birmingham Inc 13/#4 Rebar 40' A615M GR420 (Gr60) ASTM A615/A615M-16 GR 60 AASHTO M31-15	66,400 458MPa	102,200 705MPa	12.0%	OK	-4.3% .033	.39 .12	.91 .18	.011 .036	.035 .005	.20 .017	.45	
PO# => BR1810120901 BR18101209	11811 SOUTHSIDE Nucor Steel - Birmingham Inc 13/#4 Rebar 40' A615M GR420 (Gr60) ASTM A615/A615M-16 GR 60 AASHTO M31-15	67,400 465MPa	98,200 677MPa	11.0%	OK	-4.0% .034	.41 .14	.81 .14	.014 .032	.050 .004	.20 .016	.36	
PO# => BR1810121001 BR18101210	11811 SOUTHSIDE Nucor Steel - Birmingham Inc 13/#4 Rebar 40' A615M GR420 (Gr60) ASTM A615/A615M-16 GR 60 AASHTO M31-15	61,500 424MPa	92,800 640MPa	11.0%	OK	-4.2% .036	.38 .12	.83 .18	.016 .039	.050 .004	.18 .016	.33	
PO# => BR1810121101 BR18101211	11811 SOUTHSIDE Nucor Steel - Birmingham Inc 13/#4 Rebar 40' A615M GR420 (Gr60) ASTM A615/A615M-16 GR 60 AASHTO M31-15	65,900 454MPa	97,300 671MPa	10.0%	OK	-3.6% .034	.40 .11	.84 .14	.013 .037	.046 .004	.22 .016	.32	

I hereby certify that the material described herein has been manufactured in accordance with the specifications and standards listed above and that it satisfies those requirements.
1.) Weld repair was not performed on this material.
2.) Melted and Manufactured in the United States.
3.) Mercury, Radium, or Alpha source materials in any form have not been used in the production of this material.

QUALITY ASSURANCE: George Miljus

George P. Miljus Jr.

SOLD TO: DURA-STRESS INC
PO BOX 490779
LEESBURG, FL 34749-

SHIP TO: DURA-STRESS INC
11325 COUNTY RD 44E
LEESBURG, FL 34788-

NUCOR

NUCOR STEEL BIRMINGHAM, INC.

CERTIFIED MILL TEST REPORT

Ship from:

MTR #: 0000168857
Nucor Steel Birmingham, Inc.
2060 Avenue A
KISSIMMEE, FL 34758
321-219-0191

Date: 12-Apr-2018
B.L. Number: 502262
Load Number: 114348

Material Safety Data Sheets are available at www.nucorbar.com or by contacting your inside sales representative.

NBMG-08 January 1, 2012

LOT # / HEAT #	DESCRIPTION	PHYSICAL TESTS					CHEMICAL TESTS						
		YIELD P.S.I.	TENSILE P.S.I.	ELONG % IN 8"	BEND	WT% / DEF	C / Ni	Mn / Cr	P / Mo	S / V	Si / Cb	Cu / Sn	C.E.
PO# =>	11811 SOUTHSIDE												
BR1810128801 BR18101288	Nucor Steel - Birmingham Inc 13/#4 Rebar 40' A615M GR420 (Gr60) ASTM A615/A615M-16 GR 60 AASHTO M31-15	62,700 432MPa	90,900 627MPa	13.0%	OK	-3.7% .036	.38 .10	.83 .11	.009 .042	.045 .004	.22 .014	.32	

I hereby certify that the material described herein has been manufactured in accordance with the specifications and standards listed above and that it satisfies those requirements.
1.) Weld repair was not performed on this material.
2.) Melted and Manufactured in the United States.
3.) Mercury, Radium, or Alpha source materials in any form have not been used in the production of this material.

QUALITY ASSURANCE: George P. Miljan, Jr.

Strand-Tech Manufacturing
PO Box 2220
Summerville SC 29484
USA

Phone:: 843-873-3331
Fax: 843-873-3776

STM
STRAND-TECH MANUFACTURING

Pack Slip: 71855

Packing Slip

Page: 1 of 1

Ship To:	Sold To:
DURA-STRESS, INC 11325 CR 44 EAST LEESBURG FL 34788	DURA-STRESS, INC 11325 CR 44 EAST LEESBURG FL 34788
RECEIVED	
Phone: AUG 29 2018	Phone:
Fax:	Fax: SCANNED 8-29-18
Email: DURA-STRESS, INC.	Email:

Ship Date: 8/28/2018 F.O.B.: FOB Summerville

Ship Via: MOL TRUCKING

CUSTOMER SPECIFICATIONS

☐ No Covers	☑ Load to Side	☑ Certify with Domestic Statement
☑ Tarped	☐ Load Down Center	☑ P.O. No. Must Appear on Packing Slip
☐ Spaced for Straps	☐ Load Eye to the Sky	☐ Representative Curve
		☐ Chemical Analysis

Shipments must be 7 pack shipments. Packs must be with no welds 1/13/2014 10:33> They can only take delivery of truckloads between the following hours! Monday � Thursday 7:00 am to 3:30 pm Friday- 7:00 am to 12:00 pm If a driver arrives before 7:00 am they can use the West gate at the traffic light for overnight or early parking.

Line **Part Number / Description** **Planned Qty**

Sales Order: 60816 **Your PO:** 12875

Salesperson(s): Aldo Bassi

Line 1 Rel 39 66,500 FT

4600.270.D Back Order Qty: 3,148 FT

.600 7 WIRE 270 LOW RELAXATION

ENTERED AUG 29 2018

Lot	Shipped Qty	Net Weight
002829.009	9,066 FT	6,709 LB
002829.011	9,057 FT	6,702 LB
002900.001	9,110 FT	6,741 LB
002900.004	9,053 FT	6,699 LB
002900.005	9,063 FT	6,707 LB
002900.006	9,069 FT	6,711 LB
002900.007	8,934 FT	6,611 LB

Total Qty: 63,352 FT **Total Net Weight:** 46,880 LB

STM
STRAND TECH MANUFACTURING

CUSTOMER:	DURASTRESS, INC	DATE:	08/28/2018
LOCATION:	LEESBURG, FL 34788	CERTIFICATION NUMBER:	QA71855
PURCHASE ORDER:	12875	CERTIFICATION STANDARD:	ASTM A 416/A416M

PRODUCT DESCRIPTION

.600" (15.24 mm) DIAMETER 270 (1860) GRADE LOW RELAXATION SEVEN WIRE STRAND

COIL IDENTIFICATION

COIL #'S	HEAT #
002829.009	82325S
002829.011	82325S
002900.001	82329S
002900.004	82329S
002900.005	82329S
002900.006	82329S
002900.007	82329S

TESTS AND SAMPLE INFORMATION

ATTACHED ARE ACTUAL TEST RESULTS FOR SAMPLES TAKEN FROM THE MATERIAL BEING PROVIDED. ADDITIONAL TESTS AND MANUFACTURING DATA AVAILABLE AS REQUIRED BY ASTM. ROD HEAT AND CHEMISTRY INFORMATION ON FILE.

COMMENTS

Prestressed concrete strand identified on this certification was produced by Strand Tech Martin Inc. and meets the requirements for "Domestic Origin" as defined by the Surface Transportation Act of 1978, and amended 1982, and meets all of the requirements set forth in Federal Highway Administration rules and regulations with regard to "Domestic Origin." All materials listed above was produced and fabricated in the United States of America. Meets certification ASTM A416/A416M

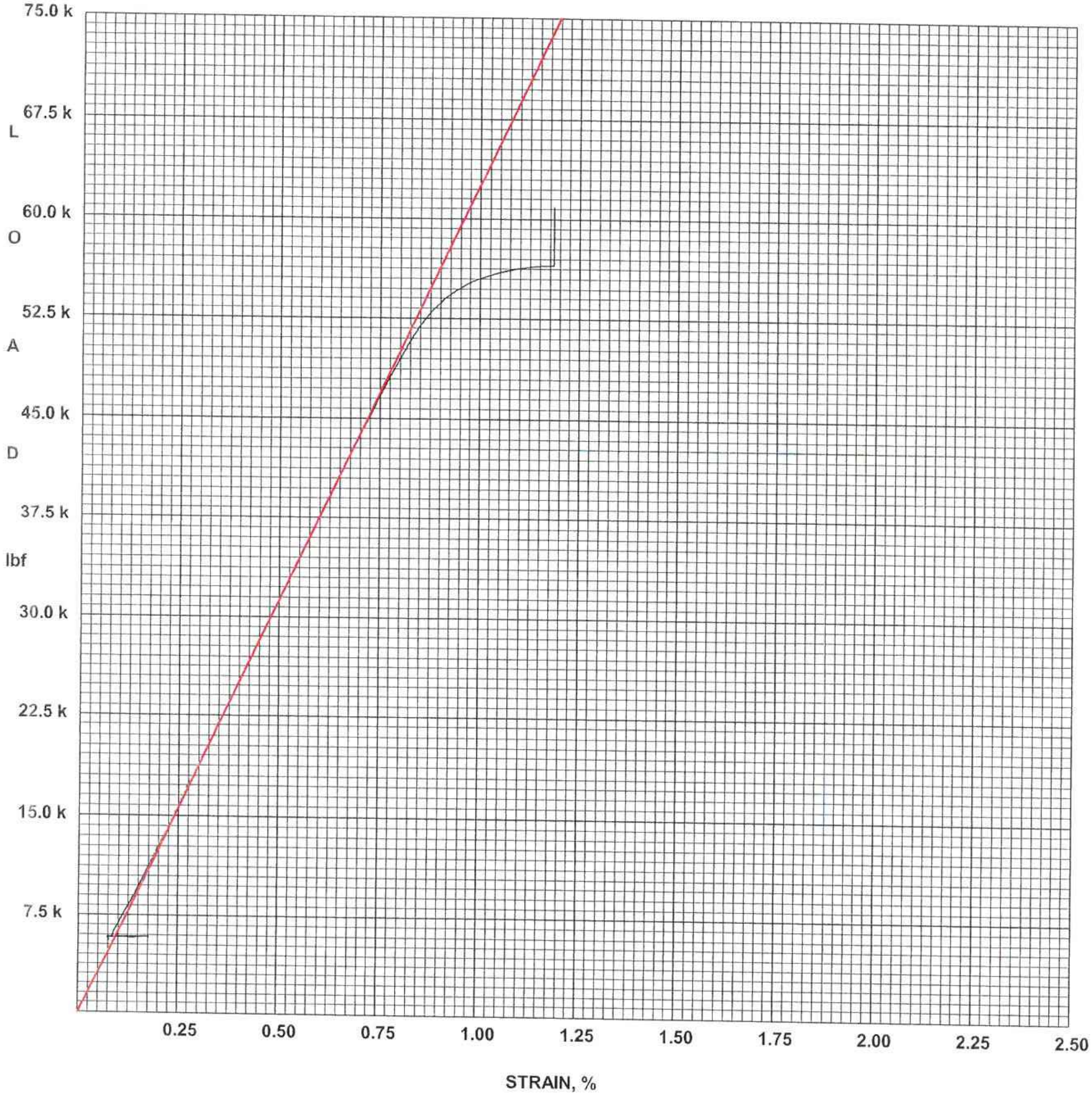
COMMENTS

"THE MATERIAL DESCRIBED IN THIS CERTIFICATION WILL BOND TO CONCRETE OF A NORMAL STRENGTH AND CONSISTENCY IN CONFORMANCE WITH THE PREDICTION EQUATIONS FOR TRANSFER AND DEVELOPMENT LENGTH GIVEN IN THE ACI/ AASHTO SPECIFICATIONS."

STRAND-TECH MARTIN, INC.
P.O. BOX 2220
SUMMERVILLE, SC 29484
TOLL FREE (877) 783-3305

CERTIFICATION PREPARED BY:

CHRIS LEWIS



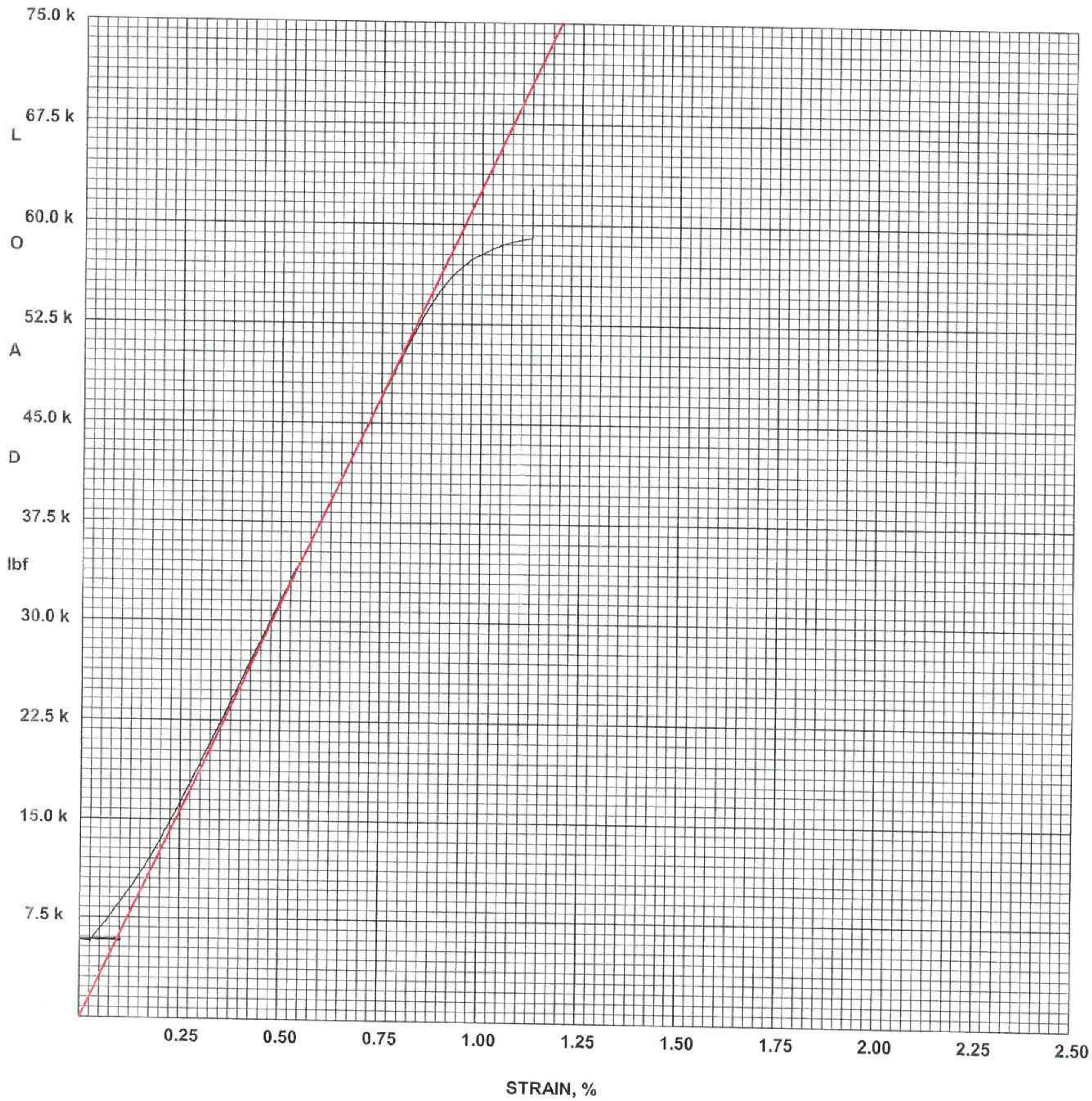
Strand-Tech Manufacturing, Inc.
Manufacturer of PC Strand & Wire
258 Deming Way
Summerville, SC 29483

7-Wire Strand ASTM A416

Test Date	08/16/2018
Size	.600" 270 LR
Lot:	002829
Sample:	05
Heat Number:	82325S
Test #:	1
Tested By:	203 AW
Ultimate, lbf:	60900
Ultimate, kN:	271
Load @, lbf:	55500
Load @, kN:	247
Elongation, %:	6.33
Nominal Area, in²:	0.217
Nominal Area, mm²:	140
Actual, in²:	0.2184
Actual, mm²:	140.91
Strand Diameter, in:	0.604
Modulus, Mpsi:	28.7
Modulus, MPa:	197700
Minimum, in:	0.0098

002829.009
002829.011

Aug 16, 2018 6:26:39 AM
SN: 205440-R3 V7.02.10



Strand-Tech Manufacturing, Inc.
Manufacturer of PC Strand & Wire
258 Deming Way
Summerville, SC 29483

7-Wire Strand ASTM A416

Test Date	08/26/2018
Size	.600" 270 LR
Lot:	002900
Sample:	01
Heat Number:	82329S
Test #:	1
Tested By:	203 AW
Ultimate, lbf:	62700
Ultimate, kN:	279
Load @, lbf:	57800
Load @, kN:	257
Elongation, %:	5.29
Nominal Area, in²:	0.217
Nominal Area, mm²:	140
Actual, in²:	0.2186
Actual, mm²:	141.03
Strand Diameter, in:	0.604
Modulus, Mpsi:	28.7
Modulus, MPa:	197800
Minimum, in:	0.0093

002900.001
002900.004
002900.005
002900.006
002900.007

Aug 26, 2018 6:39:17 AM
SN: 205440-R3 V7.02.10

9/10/2018 7:58

PRODUCT
GIRT 2
MARK #
1-D1, 1-D2, 1-A3, 1-A2, 1-A1

JOB#:	B1789	
DATE:	9/10/2018	
BED #:	31N	
JACK #		
STRAND SIZE	.600 7W 270 LR ASTM A416	
COIL/PACK/REEL #	002829009-0	0
0	002900004-0	0
0	0	0
	0	0
BED LENGTH (L):	3811.375	0
STRAND SIZE: (A)	0.2170	0
FINAL TEN. (P)	43900	0
PRE TEN. : (Pi)	5000	0
M.O.E. (E):	28.70	0
		0
		0

CORRECTION INFO.	
Number of cable #	11
Exp. Conc temp @ Placement:	85
Ambient temperature(at):	73
Abutment rotation (ar): N/A	0
Live end seating (les):	0.2362
Dead end slippage (des):	0.08858
anchorage movement:	0.375

ELONGATION

delta.a.t (Ptxdb/Pb)=	0
delt.(Pi x L)/(A x E) =	3.0599
delta'b.(PxL)/(AxE)=	23.8062
delta'bed shortning (bs/2)+(bs/#strand)=	0.2216

GROSS ELONG. 24.353

NET ELONG.	24 1/8

RANGE + 2.5%	24 11/16
RANGE - 2.5%	23 1/2

FORCE ADJUSTMENTS

Pb (P - Pi) =	38900
Pt(=	0
Par (arxAxE)/(L)=	0
Ples(lesxAxE)/(L)=	385.9578
Pdes no adj. required	0
Pbs (dbsxAXE)/(L)=	362.101
TOTAL FORCE ADJ.	748.0588
ADJUSTED FORCE =	39648.0588

JACKING FORCE = 44648

TOTAL ADJ. FORCE	44648

AASHTO MAX = 46872

RANGE +2.5% =	45764
RANGE -2.5% =	43532

31N

2 ←

DURA-STRESS INC.
STRAND STRESS REPORT

DATE:	9/10/2018	ITEM NO'S:	GIRT 2 MARK #
PROJECT NO.	B1789		1-D1, 1-D2, 1-A3, 1-A2, 1-A1
PRODUCT	GIRT 2		
BED NO.	31N		
NO. OF CABLE: 1/8	11		JACK CAL DATES: T-12/11 8 1
TECHNICIAN. 1/8		Ambient temperature(at): 73	AMBIENT TEMP: 80
DATE: 9-10-18			JACK # : T-12
		CABLE TYPE:	.600 7W 270 LR ASTM A416

CHUCK SLIPPAGE	
LIVE	DEAD
3/8 3/8 1/4 1/4	1/8 1/8 1/8 1/8
AVERAGE:	AVERAGE:
TOTAL:	

FINAL TENSION	44648 (44650)
FINAL ELONGATION	24 1/8
+2.5%	24 11/16
- 2.5%	23 1/2
AASHTO MAX =	46872

IF TARGET = AASHTO ELONGATION MAY NOT WORK

	GAUGE	ELO		GAUGE	ELO		GAUGE	ELO		GAUGE	ELO		GAUGE	ELO		GAUGE	ELO		GAUGE	ELO
1	44700	24 1/4	12			23			34			45			56			67		
2	44650	24	13			24			35			46			57			68		
3	44650	24	14			25			36			47			58			69		
4	44650	24	15			26			37			48			59			70		
5	44650	24	16			27			38			49			60			71		
6	44650	24	17			28			39			50			61			72		
7	44650	24	18			29			40			51			62			73		
8	44650	24 1/4	19			30			41			52			63			74		
9	44650	24	20			31			42			53			64			75		
10	44650	24 1/4	21			32			43			54			65			76		
11	44650	24	22			33			44			55			66			77		

11
9 10
6 8 7 5
2 4 3 1

31N

9/12/2018 9:34

]

PRODUCT		
TYPE II		
MARK #		
TEST		

JOB#:	B1789	
DATE:	9/12/2018	
BED #:	54M	
JACK #		
STRAND SIZE	.6 ST TEST	
COIL/PACK/REEL #	D430001-1D	0
0	0	0
0	0	0
	0	0
BED LENGTH (L):	3021.5	0
STRAND SIZE: (A)	0.2328	0
FINAL TEN. (P)	37200	0
PRE TEN. : (Pi)	5000	0
M.O.E. (E):	24.40	0
		0
		0

CORRECTION INFO.	
Number of cable #	13
Exp. Conc temp @ Placement:	85
Ambient temperature(at):	85
Abutment rotation (ar): N/A	0
Live end seating (les):	0.3438
Dead end slippage (des):	0.1093
anchorage movement:	0.625

ELONGATION

delta.a.t (Ptxdb/Pb)=	0
delt.(Pi x L)/(A x E) =	2.6596
delta'b.(PxL)/(AxE)=	17.128
delta'bed shortning	
(bs/2)+(bs/#strand)=	0.3606

GROSS ELONG. 17.942

NET ELONG.	17 9/16

RANGE + 2.5%	18
RANGE - 2.5%	17 1/8

FORCE ADJUSTMENTS

Pb (P - Pi) =	32200
Pt(=	0
Par (arxAxE)/(L)=	0
Ples(lesxAxE)/(L)=	646.3326
Pdes no adj. required	0
Pbs (dbsxAXE)/(L)=	677.9161
TOTAL FORCE ADJ.	1324.2487
ADJUSTED FORCE =	33524.2487

JACKING FORCE = 38524

TOTAL ADJ. FORCE	38524

AASHTO MAX = 46560

RANGE +2.5% =	39487
RANGE -2.5% =	37561

54M

DURA-STRESS INC.
STRAND STRESS REPORT

TYPE II

ITEM NO'S:	MARK #
	TEST

DATE:	9/12/2018
PROJECT NO.	B1789
PRODUCT	TYPE II
BED NO.	54M
NO. OF CABLE:	13
TECHNICIAN.	
DATE:	

Ambient temperature(at): 85

JACK CAL DATES: ____________________

AMBIENT TEMP: ____________________

JACK # : ____________________

CABLE TYPE: .6 ST TEST

CHUCK SLIPPAGE			
LIVE		DEAD	
AVERAGE:		AVERAGE:	
TOTAL:			

FINAL TENSION	38524
FINAL ELONGATION	17 9/16
+2.5%	18
- 2.5%	17 1/8

AASHTO MAX = 46560

IF TARGET = AASHTO ELONGATION MAY NOT WORK

GAUGE	ELO	GAUGE	ELO	GAUGE	ELO	GAUGE	ELO	GAUGE	ELO	GAUGE	ELO	GAUGE	ELO
1		12		23		34		45		56		67	
2		13		24		35		46		57		68	
3		14		25		36		47		58		69	
4		15		26		37		48		59		70	
5		16		27		38		49		60		71	
6		17		28		39		50		61		72	
7		18		29		40		51		62		73	
8		19		30		41		52		63		74	
9		20		31		42		53		64		75	
10		21		32		43		54		65		76	
11		22		33		44		55		66		77	

54M

PREPOUR PRODUCTION SHEET

JOB# B1789
F.D.O.T.# TEST BEAM
CAST DATE

PRODUCT TYPE II
BED# 31 N
MIX # LIGHTWEIGHT (10,000 mix) 05-2056

COMMENT KEYS / = OK, O = ACCEPTABLE, X = NOT ACCEPTABLE

SERIAL #'S	LW1	LW2	LW3	LW4	LW5	
MARK #'S	D1	D2	A3	A2	A1	
DATE:	9-10-18	9-10-18	9-10-18	9-10-18	9-10-18	
INSPECTOR:	KS					
WIDTH	O	O	O	O	O	
LENGTH	O	O	O	O	O	
HEIGHT	O	O	O	O	O	
CABLE HOLES	O	O	O	O	O	
"L" BAR HOLES	O	O	O	O	O	
CHAMFER	O	O	O	O	O	
SKEW	NA					
INSERTS	NA					
BLOCK OUTS	NA					
FORM CLEANNESS	O	O	O	O	O	
PLATES FORM FACE	NA					

COMMENTS

SERIAL #'S	LW1	LW2	LW3	LW4	LW5	
MARK #S	D1	D2	A3	A2	A1	
DATE:	9-10-18	9-10-18	9-10-18	9-10-18	9-10-18	
INSPECTOR:	KS					
REINFORCEMENT	O	O	O	O	O	
STEEL SPACING	O	O	O	O	O	
PLATES	NA					
CLEARANCE	O	O	O	O	O	
LINER	O	O	O	O	O	
LIFTING LOOPS	O	O	O	O	O	
SHEATHING	NA					

COMMENTS

SERIAL #'S	LW1	LW2	LW3	LW4	LW5	
MARK #S	D1	D2	A3	A2	A1	
INSPECTOR:	KS					
DATE :	9-11-18	9-11-18	9-11-18	9-11-18	9-11-18	
DROP IN PLATES	NA					
BLOCK OUTS	NA					
INSERTS	NA					
HEADERS	O	O	O	O	O	
LENGTH	O	O	O	O	O	
FORMS	O	O	O	O	O	

COMMENTS

CONCRETE MIX DESIGN
05-2056

Producer: Dura-Stress, Inc.	Class VI (8500 PSI) / Self-Consolidating	Effective Date: 7/16/2018
Aggregrate Correction Factor: 0.9	Environment: Extremely Aggressive	Hot Weather

Source of Materials

Product	Quantity		Production Facility
921: Cement - Type II (MH)	703	Pound(s)	CMT29 - Suwannee American Cement - Branford, FL
929: Fly Ash - Class F	167	Pound(s)	FA01 - Separation Technologies - Crystal River, FL
929: Metakaolin	74	Pound(s)	MK03 - BASF Middle Georgia
901: C12 - #67 Stone	1340	Pound(s)	10645 - VULCAN MATERIALS COMPANY
902: F01 - Silica Sand (Concrete)	1180	Pound(s)	11057 - VULCAN MATERIALS COMPANY
MasterAir AE 90 (MB-AE 90) [924-000-014 - Admixture for Concrete - Air Entraining]	2.36	FL OZ	BASF Construction Chemicals, LLC
MasterSet DELVO (Delvo) [924-003-021 - Admixture for Concrete Type D]	28	FL OZ	BASF Construction Chemicals, LLC
MasterGlenium 7920 [924-001-070 - Admixture for Concrete Type A]	57	FL OZ	BASF Construction Chemicals, LLC
MasterLife CI 30 (Rheocrete CNI) [924-009-002 - Admixture for Concrete - Corrosion Inhibiting]	320	FL OZ	BASF Construction Chemicals, LLC
Water	34.1	GAL	
Water	284	LB	

Calculated Values

Theoretical Unit Weight	139.9	PCF
Theoretical Yield	26.99	CF
Water Contributed from Admixture(s)	18.1	LB

Mix Design Limits*

Slump Flow = 27 +/- 2.5 in

Water to Cementitious Materials Ratio <= 0.32

Slump Flow Cut Off Time <= 12 min

**See Contract Documents for Limits not displayed*

Producer Data

Method of measuring	Pressure Meter
Air Content - Pressure	1.7 %
Temperature	95 degree F
Slump Flow	26.5 in
J-Ring Slump Flow	27.0 in
Passing Ability	0.5 in
Static Segregation	11.0 %
Average Chloride Content	0.196 lbs/yd^3
Water to Cementitious Materials Ratio	0.31
Age	13 Days
Compressive Strength	10,860 PSI
Slump Flow Cut Off Time	12 min
Age	21 Days
Surface Resistivity	37.56 kOhm-cm
Density (Unit Weight	144.2 lbs/ft^3
VSI	0
T<sub>50<sub>	3.0 seconds
Penetration Depth (Pd)	1 mm

Special Use Instructions:

Company: DURA STRESS INC

Date: 8/15/2018

Trial #: Florida State University DOT Spec.

Batch Size	
cy.	1
cu. ft.	1.2

Class Special 10000PSI Metakaolin CNI

470

1.20 V2

0.396 V1

	0.080578512	
Sand/Agg Ratio	0.449	
W/C	0.39	
W/CM	0.289	0.29
Total Cementicious	968.00	
Fly Ash	17.6	
Total Mass	3300	

	Lbs.	Type	Spg.	Volume
Cement	720	SAC	3.15	3.66
Fly Ash	170	Sep.Techn.	2.2	1.24
#67	852	Vulcan	1.52	8.98
#89	0	Vulcan	2.42	0.00
Sand	1200	Vulcan	2.63	7.31
Metakaolin	78		2.5	0.50
Water	280	Water	1	4.49
Air	3%		0	0.81
Theo Unit We	122.25		Total	26.99

27.99

Trial Weights		
Cement	32.00	lbs
Fly Ash	7.56	lbs
#67	39.65	lbs
#89	0.00	lbs
Sand	55.04	lbs
Metakaolin	3.47	lbs
Water	7.96	lbs

sts Per T	st Per Yard
	$ -
	$ -
	$ -
	$ -
	$ -
	$ -

	oz/cwt		oz/cy	oz/truck
MasterAir AE-	0.25		2.42	2.42
MasterGleniu	6		58.08	58.08
Delvo	3		29.04	29.04
MasterSure Z	0		0.00	0.00
MasterLife CI	0		320.00	0.00

576

ml / Trial		
MasterAir AE-	3.18	ml
MasterGleniu	76.30	ml
MasterSet R9	38.17	ml
MasterSure Z	0.00	ml
MasterLife CI	14.22	oz

	$ -
	$ -
	$ -
	$ -
	$ -
Total	$ -	$ -

98 97

Add. Water +/-	
Slump	
30 Min	
60 Min	
Air %	
Unit Weight	
Amb. Temp.	
Concrete Temp.	
Int set	

2.80

Moisture Trial Mix		
Stone #1	4.7%	1.78
Stone #2	0.0%	0.00
Sand #1	3.2%	1.71
Sand #2	0.0%	0.00
	Total	3.49

b

Water from CI 30 1.00

****

Job: 31-10KLWAGG Date: Sep 12, 2018 Start:07:26 Disch:07:48
Operator: W62342488 Duration/Wait: 20:04/3:55 Batch#:41849 Mixer#: 1
Mix: 10KLW Mix Name: 10K psi LIGHTWEIGHT
Required: 12.00 Batched: 6.00
Amount: 6.00 CY

1 BW

PreWet: 70%

Material	Bin	Moist/ABS%	Design	Target	Actual		%Err	*Note	Jogs
STALITE 0.5	3	5.20/0.00	852	5378	5340	Lb	-0.7	-----	34
SAND 11-057	1	4.00/0.00	1200	7488	7440	Lb	-0.6	-----	1
SUWANEE	3		720	4320	4320	Lb	0.0	-----	1
STI FLYASH	4		170	1020	1025	Lb	0.5	-----	2
gLENIUM 7920	4		65.00	390.00	388.00	Oz	-0.5	-----	
DELVO	2		19.00	114.00	112.00	Oz	-1.8	-----	
MB AE90	1		0.75	4.50	6.00	Oz	33.3	-----	
Prewet				620	615	Lb	-0.8	-----	
Water				271	264	Lb	-2.6	-----	
Prewet Mixing			0:01		0:01	s			
Dry Mixing			0:01		0:01	s			
Wet Mixing			2:00		2:00	s			
Total Moisture:			240	1440	1429	Lb	-0.8		
Water/Cement:			0.270	0.267					

+468 lb metamax

+1920 oz CNI (C130)

****

Job: 31-10KLWAGG Date: Sep 12, 2018 Start:07:54 Disch:--:--
Operator: W62342488 Duration/Wait: 25:52/3:20 Batch#:41851 Mixer#: 1
Mix: 10KLW Mix Name: 10K psi LIGHTWEIGHT *ABORTED*
Required: 12.00 Batched: 12.00
Amount: 6.00 CY
PreWet: 70%

2 BW

Material	Bin	Moist/ABS%	Design	Target	Actual	%Err	*Note	Jogs
STALITE 0.5	3	5.20/0.00	852	5378	5360 Lb	-0.3	-----	22
SAND 11-057	1	4.00/0.00	1200	7488	7460 Lb	-0.4	-----	3
SUWANEE	2		720	4320	4355 Lb	0.8	-----	7
STI FLYASH	4		170	985	970 Lb	-1.5	-C---	5
gLENIUM 7920	4		65.00	390.00	388.00 Oz	-0.5	-----	
DELVO	2		19.00	114.00	112.00 Oz	-1.8	-----	
MB AE90	1		0.75	4.50	6.00 Oz	33.3	-----	
Prewet				620	616 Lb	-0.6	-----	
Water				270	270 Lb	0.0	-F---	
Prewet Mixing			0:01		0:01 s			
Dry Mixing			0:01		0:01 s			
Wet Mixing			2:00		0:09 s			
Total Moisture:			240	1440	1438 Lb	-0.1		
Water/Cement:			0.270	0.270				

.27

+ 46816 meter

+ 1920 oz CNI

****

Job:	31-10KLWAGG	Date: Sep 12, 2018	Start:08:40 Disch:08:51	
Operator:	W62342488	Duration/Wait: 10:46/1:00	Batch#:41852	Mixer#: 1
Mix:	10KLW	Mix Name: 10K psi LIGHTWEIGHT		
Required:	12.00	Batched: 12.00		
Amount:	6.00 CY			
PreWet: 70%				

(3)rd

Material	Bin	Moist/ABS%	Design	Target	Actual	%Err	*Note	Jogs
STALITE 0.5	3	5.20/0.00	852	5378	5380 Lb	0.0	-----	7
SAND 11-057	1	4.00/0.00	1200	7488	7600 Lb	1.5	O----	2
SUWANEE	2		720	4320	4370 Lb	1.2	O----	7
STI FLYASH	4		170	970	980 Lb	1.0	-C---	2
gLENIUM 7920	4		72.00	432.00	432.00 Oz	0.0	-----	
DELVO	2		12.00	72.00	70.00 Oz	-2.8	-----	
Prewet				641	632 Lb	-1.4	-----	
Water				284	275 Lb	-3.2	-----	
Prewet Mixing			0:01		0:01 s			
Dry Mixing			0:01		0:01 s			
Wet Mixing			1:00		1:55 s			
Total Moisture:			245	1470	1465 Lb	-0.3		
Water/Cement:			0.275	0.274				

.27

+ 46816 meta

+ 1920 CNI (C130)

BEAM PLACEMENT DIAGRAM

JOB NO.: B1789
FDOT NO.: TEST BEAM
MIX DESIGN: LIGHTWEIGHT (10,000 Mix) / 05-2056

BED: 31 N
PRODUCT: TYPE II

INSPECTOR: JCB/DB
TEST LOAD(s):
TOTAL YARDS: 19.5

DATE CAST: 9-12-18

COVERED? ☐ OR CUR. COMPOUND ☐
CUR EXP DATE ☐

1 2 3

S/N	LW1	LW2	LW3	LW4	LW5	
MARK	D1	D2	A3	A2	A1	
	Truck #4 767 - AIR High Rejected (9) Truck #5 765 - 838 - 8:46 AIR - 1	Truck #6 767 - 906 Air = 1.	767 - 636 - IN Full Truck #1	767 - 648 OUT 1 1/2 yd From Truck #1 Truck #2 765 - 650 IN Full	765 - 705 OUT Truck #2 3yd Truck #3 767 7:16 IN 7:21 OUT 1 1/2 yds	
	LIGHTWEIGHT	LIGHTWEIGHT	05-2029	05-2029	05-2029	

W/C MAX 4 0.3 5

READY MIX TRUCK(S) MEET QCM BATCH PLANT CRITERIA

E

W

PROJECT NO.: B1789 TEST BEAM

BED #: 31 N

DATE DETENSIONED: 9-14-18

DATE CAST: 9-12-18

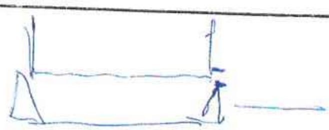
TYPE: TYPE II

CYLINDER PSI: 6532/6641 - LW mix. 9023/8922 - 2054 mix

REQUIRED RELEASE: 6000 PSI

SERIAL NO.:	LW1	LW2	LW3	LW4	LW5	
MARK NO.:	D1	D2	A3	A2	A1	
SIDE LENGTH RIGHT:	42'-1/8"	42'-1/8"	42'-1/4"	42'-1/4"	A1	
SIDE LENGTH LEFT:	42'-1/8"	42'-1/8"	42'	42'	42'-1/8"	
AVG. LENGTH:	42'-1/8"	42'-1/8"	42'-1/8"	42'	42'-1/8	
DESIGN LENGTH :	42' 0"	42' 0"	42' 0"	42' 1/8"	42'-1/8"	
				42' 0"	42' 0"	
HORIZONTAL ALIGNMENT						
CAMBER (INCH)	0 / 3/16	0 / 3/16	0 / 1/4	0 / 1/4	0 / 3/16	

REMARKS:



DURA-STRESS Inc.

28- DAY BREAKS

ASTM C-39

W42206367 (BW) K40050077 (KK) T52017368 (DT)

Great Production____ DuraNet____ Poles____ MAC____ Faxed ✓

DATE BROKE: 10/10/2018
DATE CAST: 9/12/2018

Job #	Bed	R #	Sample #	Dia. 1 Inches	Dia. 2 Inches	Avg. Dia. Inches	Cylinder Length	Area Inches	Load English	PSI	Avg. PSI	Type of Breaks	Tech.
	4U	9B	16U	3.99	3.99	3.99	8.00	12.504	119330	9544		4	KK
				3.99	3.99	3.99	8.00	12.504	121770	9739	9650	3	KK
				3.99	3.99	3.99	8.00	12.504	120950	9673		5	KK
			PC	4.00	4.00	4.00	8.00	12.566	126440	10062		5	KK
				4.00	4.00	4.00	8.00	12.566	127920	10180	10090	5	KK
				4.00	4.00	4.00	8.00	12.566	126030	10029		5	KK
B1789	31		TEST 01-1	4.04	4.04	4.04	8.00	12.819	145890	11381		5	KK
05-2056				4.04	4.04	4.04	8.00	12.819	147100	11475	11450	5	KK
				4.04	4.04	4.04	8.00	12.819	147180	11481		5	KK
B1789	31		TEST 01	4.04	4.04	4.04	8.00	12.819	144890	11303		5	KK
LIGHT				4.04	4.04	4.04	8.00	12.819	143620	11204	11220	5	KK
WEIGHT				4.04	4.04	4.04	8.00	12.819	142990	11155		5	KK
B1679	18SW	R1	18I4A43Q	4.03	4.04	4.04	7.98	12.819	144460	11269		6	KK
POLES			18-141	4.04	4.04	4.04	8.00	12.819	146220	11407	11380	5	KK
				4.04	4.04	4.04	8.01	12.819	146920	11461		5	KK
DOT	25	R1	18DOTA169Q	4.04	4.04	4.04	8.00	12.819	155130	12102		5	KK
				4.03	4.05	4.04	8.01	12.819	154520	12054	12130	5	KK
				4.04	4.04	4.04	8.00	12.819	156720	12226		6	KK

Manager's Signature: [signature]

REVISION 4-25-17