ADDENDUM NO. 2
INFORMATIONAL ITEMS

I. Existing Airfield Sign Base
II. Engineers Report
III. Pending Litigation

I. Existing Airfield Sign Base

GENERAL NOTES

DESIGN

DESIGN IS IN ACCORDANCE WITH THE FOLLOWING:

- ASCE 7, MINIMUM DESIGN LOADS FOR BUILDING & OTHER STRUCTURES - 2010 EDITION
- INTERNATIONAL CODE COUNCIL (ICC)'S INTERNATIONAL BUILDING CODE (2012)
- ACI 318-14 BUILDING CODE REQUIREMENTS FOR STRUCTURAL CONCRETE AND COMMENTARY

DESIGN DEAD LOADS INCLUDE SELF-WEIGHT OF MATERIALS AS SHOWN IN THE PLANS. NO SUPERIMPOSED DEAD LOADINGS.

DESIGN LIVE LOADS: UNIFORM LOAD OF 50 PSF
LIVE LOAD SURCHARGE

WIND:
- BASIC WIND SPEED = 200 MPH
- EXPOSURE CATEGORY = D
- TOPOGRAPHIC FACTOR = FLAT OPEN COUNTRY Kzt = 1.0
- VELOCITY PRESSURE qh = 89.7 PSF

FOUNDATION BEARING PRESSURES:
THERE IS NO SUBSURFACE EXPLORATION REPORT PRESENT. A PRESUMPTIVE LOAD-BEARING CAPACITY OF 1500 PSF FOR THE VERTICAL BEARING PRESSURE IS USED FOR THIS DESIGN. (PER TABLE 1806.2 OF THE INTERNATIONAL BUILDING CODE (2012))

ALL LOADS AND CAPACITY INDICATED ARE SERVICE (UNFACTORED) LOADS.

THE FOLLOWING ARE NOT A PART OF THIS DESIGN
1. ALL ELECTRICAL ITEMS TO BE DESIGNED BY OTHERS
2. ALL SIGN CONNECTIONS AND SIGNS TO BE DESIGNED BY OTHERS.

FOUNDATIONS

THE CONTRACTOR SHALL SAFEGUARD AND PROTECT ALL EXCAVATIONS, AND ALL EXCAVATIONS SHALL BE KEPT FREE OF WATER.

THE CONTRACTOR SHALL REFER TD THE CIVIL AND ELECTRICAL DRAWINGS FOR ALL LOCATIONS OF TRENCHES, PITS, CONDUITS, ETC. NOT SHOWN ON THE STRUCTURAL DRAWINGS.

CONCRETE

ALL CONCRETE SHALL BE NORMAL WEIGHT CONCRETE UNLESS NOTED OTHERWISE AND HAVE A DESIGN COMPRESSIVE STRENGTH AT 28 DAYS OF 4,000 PSI.

NO CONCRETE SHALL BE PLACED IN WATER.

NO CONCRETE SHALL BE PLACED UNTIL CONCRETE DESIGN MIXES HAVE BEEN SUBMITTED FOR EACH CLASS OF CONCRETE NOTED ABOVE AND HAVE BEEN APPROVED BY THE ENGINEER.

CONCRETE REINFORCEMENT STEEL

REINFORCING STEEL SHALL BE DEFORMED BARS OF INTERMEDIATE GRADE NEW BILLET STEEL CONFORMING TO CURRENT REQUIREMENTS OF ASTM A-615, GRADE 60. ALL HOOKS SHALL BE STANDARD HOOKS, UNLESS OTHERWISE NOTED.

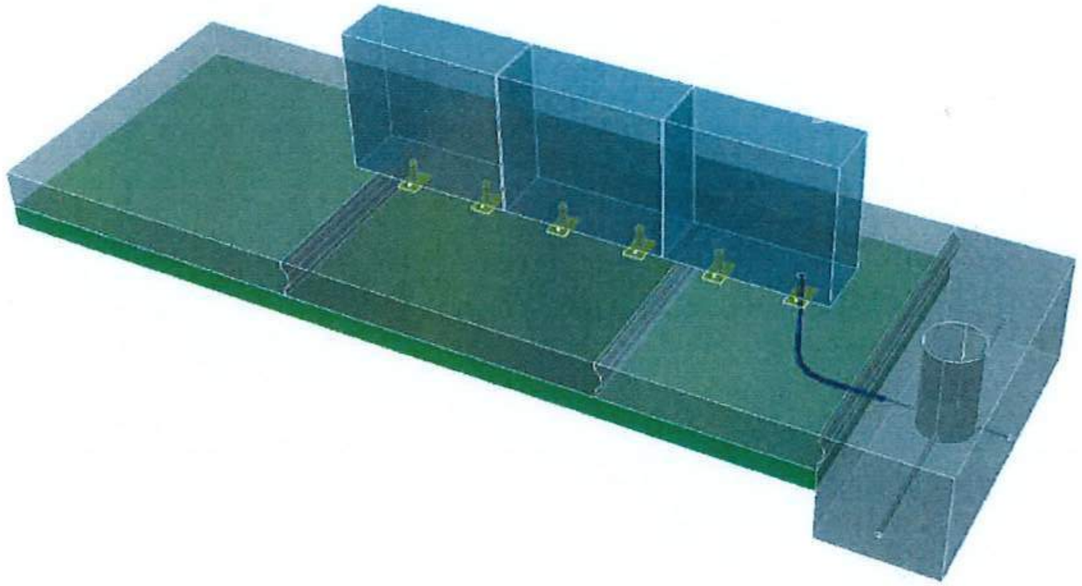
THE MINIMUM CONCRETE COVER FOR MILD TOP REINFORCEMENT WORK SHALL BE 3" FOR CONCRETE SUBJECT TO OUTDOOR ENVIRONMENT. THIS SHALL INCLUDE 2" FOR FORMED CONCRETE EXPOSED TO EARTH AND 3" FOR CONCRETE CAST DIRECTLY AGAINST EARTH.

POST-TENSIONING BARS

POST TENSIONING THREAD BARS SHALL BE 0.75 INCH DIAMETER, 80 KSI STEEL. STEEL THREAD BARS SHALL BE DESIGNED TO ALLOW THE USE OF HEAVY HEX NUTS AND COUPLERS THAT THREAD ONTO THE END OF THE DEFORMATIONS. HEAVY HEX NUTS AND COUPLERS SHALL BE OF A DESIGN AND MATERIAL RECOMMENDED BY THE BAR MANUFACTURER.

MEMPHIS INTERNATIONAL AIRPORT
MEMPHIS, TENNESSEE

STRUCTURAL PLANS
OF
FOUNDATION UNITS FOR
MEM AIRFIELD SIGNAGE REPLACEMENT



INDEX TO SHEETS

NO.	DESCRIPTION
0	TITLE SHEET
1	LOADING DETAILS 1 OF 4
2	LOADING DETAILS 2 OF 4
3	LOADING DETAILS 3 OF 4
4	LOADING DETAILS 4 OF 4
5	PRECAST SLAB MODULE DETAILS
6	PRECAST CAN MODULE DETAILS
7	MISCALLENOUS DETAILS
--	CUTSHEETS

No. 123568

11-15-2021

FAHEEM AHMAD
P.E. NO. 123568

DATE: 15 NOV 2021

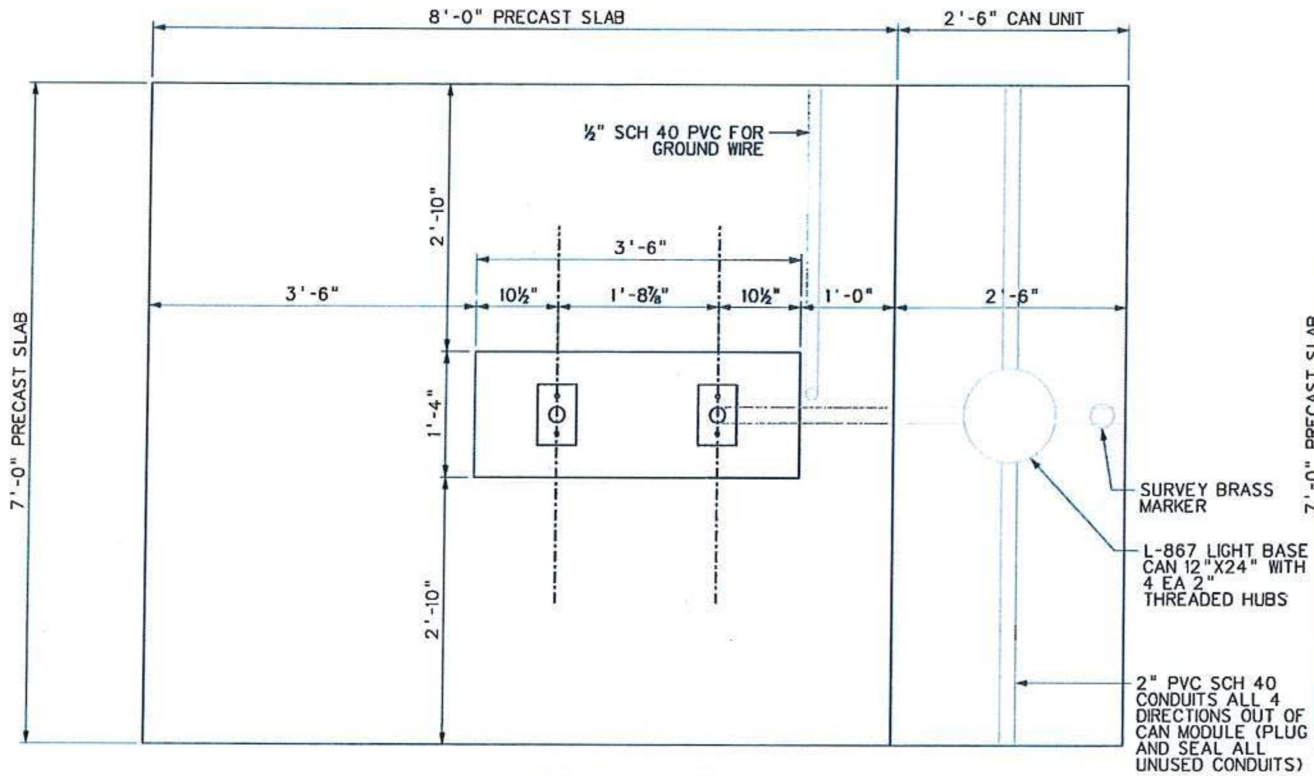
E.L. ROBINSON
ENGINEERING

5088 WEST WASHINGTON STREET
CHARLESTON, WV 25313
(304)776-7473
www. elrobinsonengineering.com

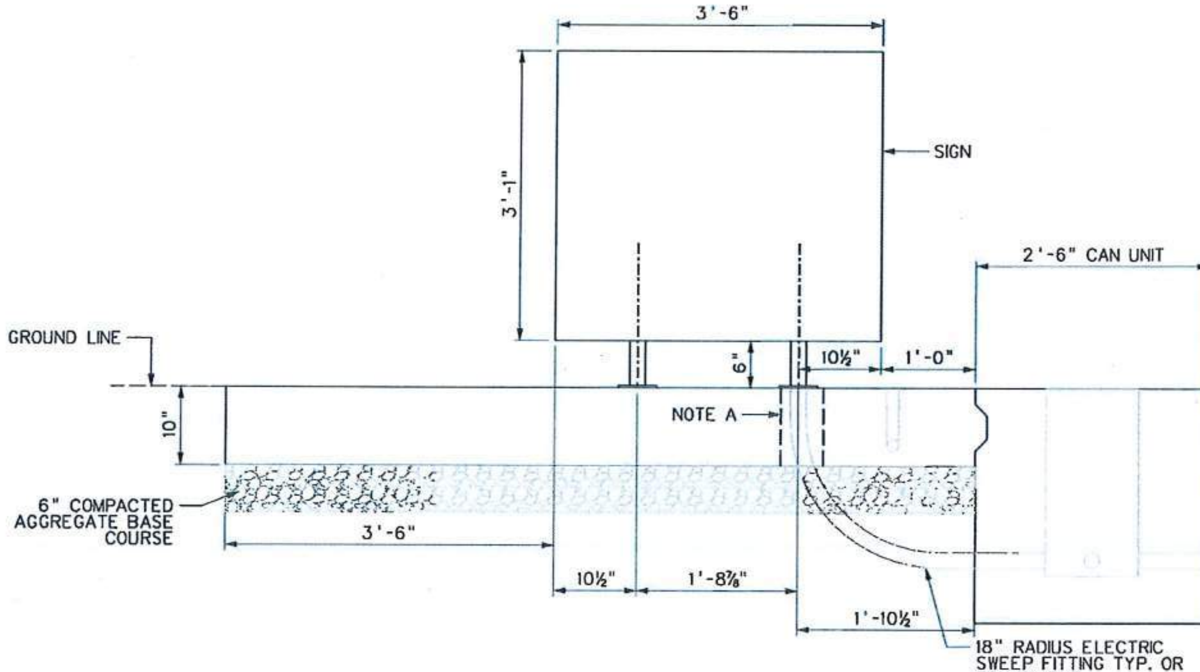
DACO
CONSTRUCTION
CO., INC.

PROVIDED AS SUPPLEMENTAL
INFORMATION ONLY

DRAWING NO.
B-0



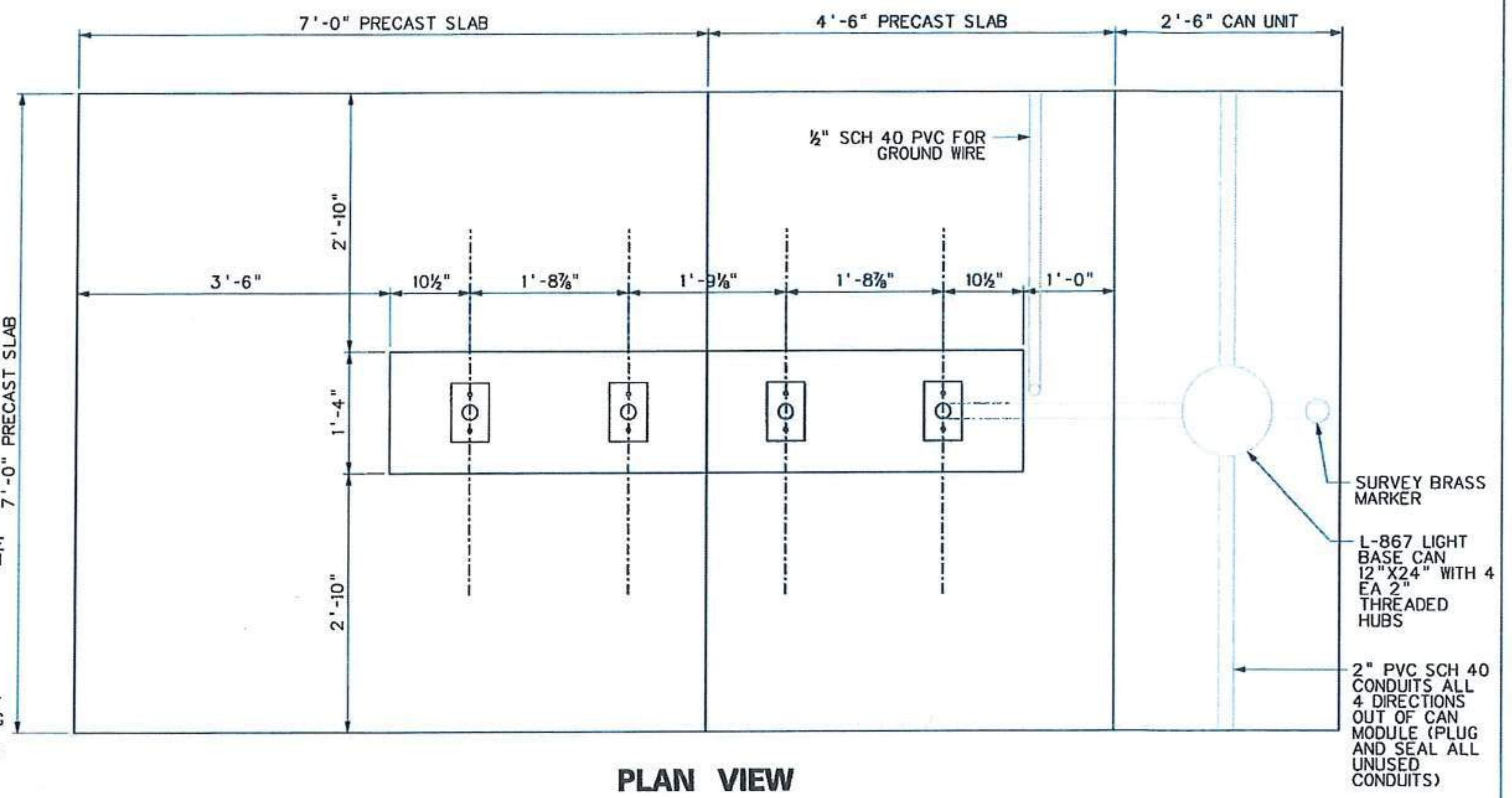
PLAN VIEW



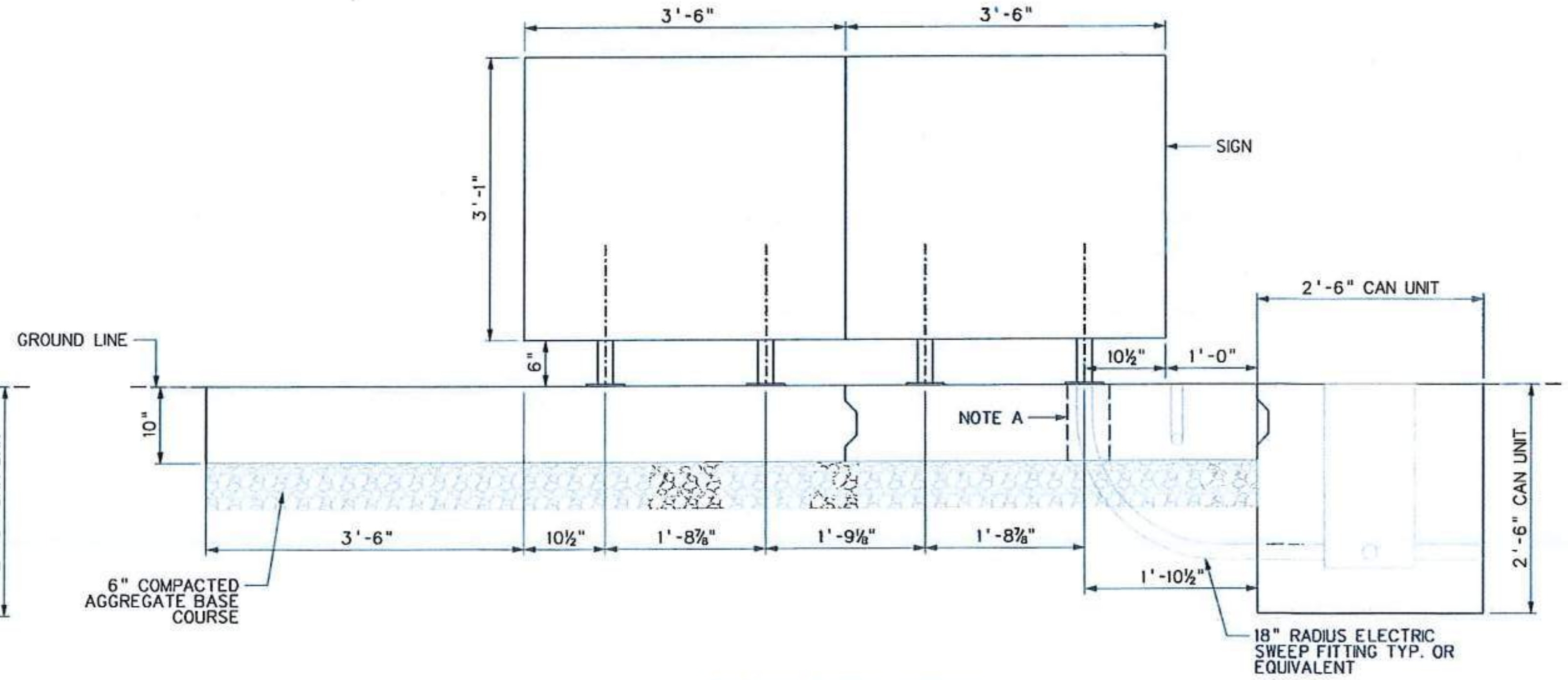
ELEVATION VIEW

NOTE A: STARTER SLAB WITH KNOCK OUT FOR CONDUITS.

SIZE 3, 1 MOD LOADING DETAILS



PLAN VIEW



ELEVATION VIEW

NOTE A: STARTER SLAB WITH KNOCK OUT FOR CONDUITS.

SIZE 3, 2 MOD LOADING DETAILS

FAHEEM AHMAD
No. 123568

11-15-2021

REVISION NUMBER	SHEET NUMBER	REVISIONS	DATE	BY

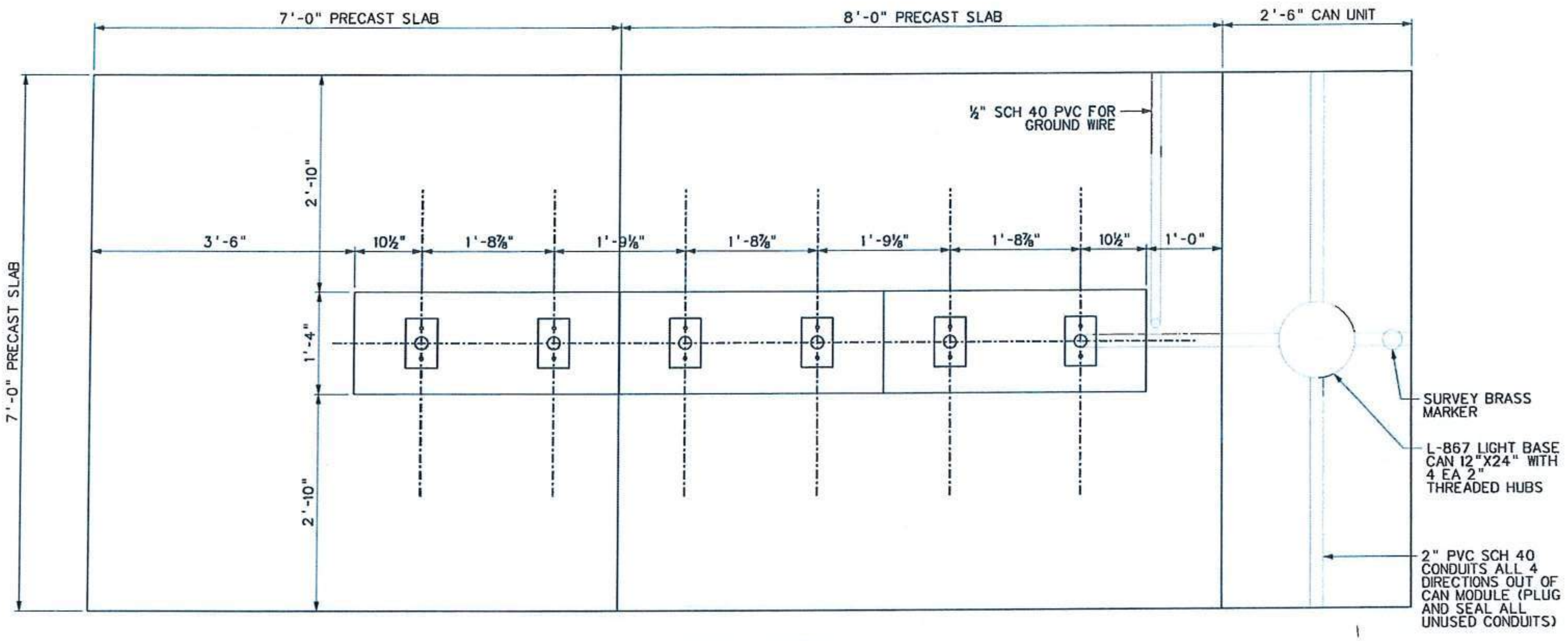
DACO CONSTRUCTION CO., INC.

E.L. ROBINSON ENGINEERING
5088 Washington Street West
Charleston, West Virginia 25313
Phone: 304-776-7473 Fax: 304-776-6426
www.elrobinsonengineering.com

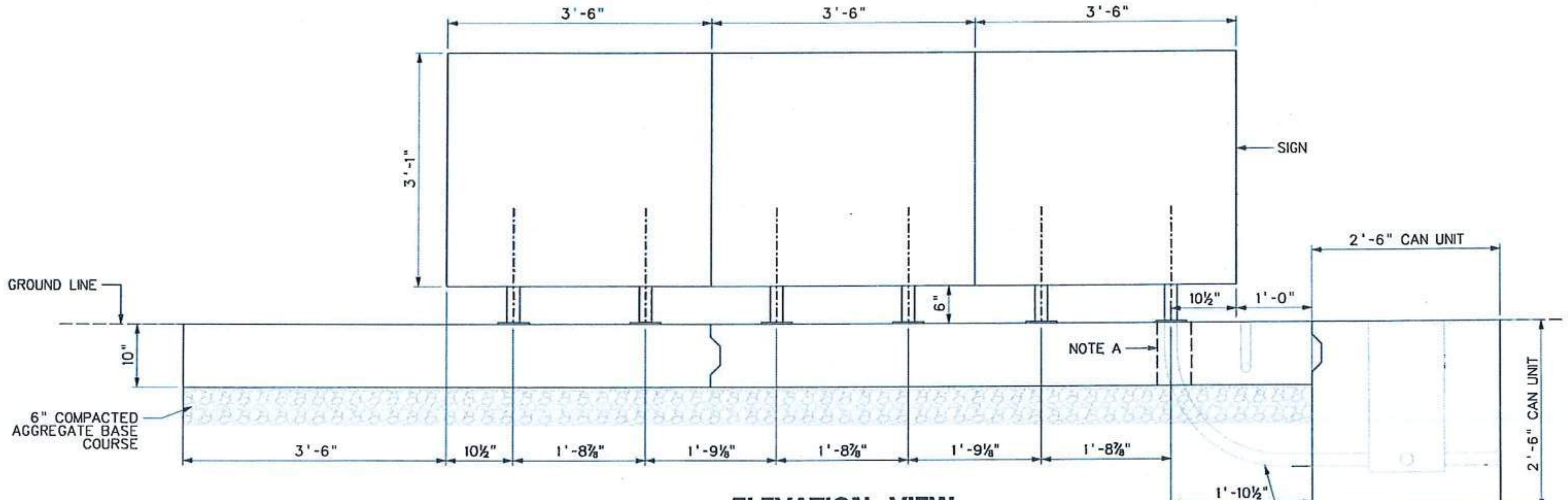
DESIGNED BY: KMD
CHECKED BY: FA
DRAWN BY: KMD
CHECKED BY: FA
DATE: 15 NOV 2021
SHEET NO. **B-1**

MEMPHIS INTERNATIONAL AIRPORT
MEMPHIS, TENNESSEE

MEM AIRFIELD SIGNAGE REPLACEMENT
SIGN LAYOUT 1 OF 4



PLAN VIEW



ELEVATION VIEW

NOTE A: STARTER SLAB WITH KNOCK OUT FOR CONDUITS.

SIZE 3, 3 MOD LOADING DETAILS

FAHEEM AHMAD
No. 123568

11/15/2021

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DACO CONSTRUCTION CO., INC.

E.L. ROBINSON ENGINEERING
5088 Washington Street, West
Charleston, West Virginia 25313
Phone: 304-776-7473 Fax: 304-776-6426
www.elrobinsonengineering.com

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CHECKED BY: FA
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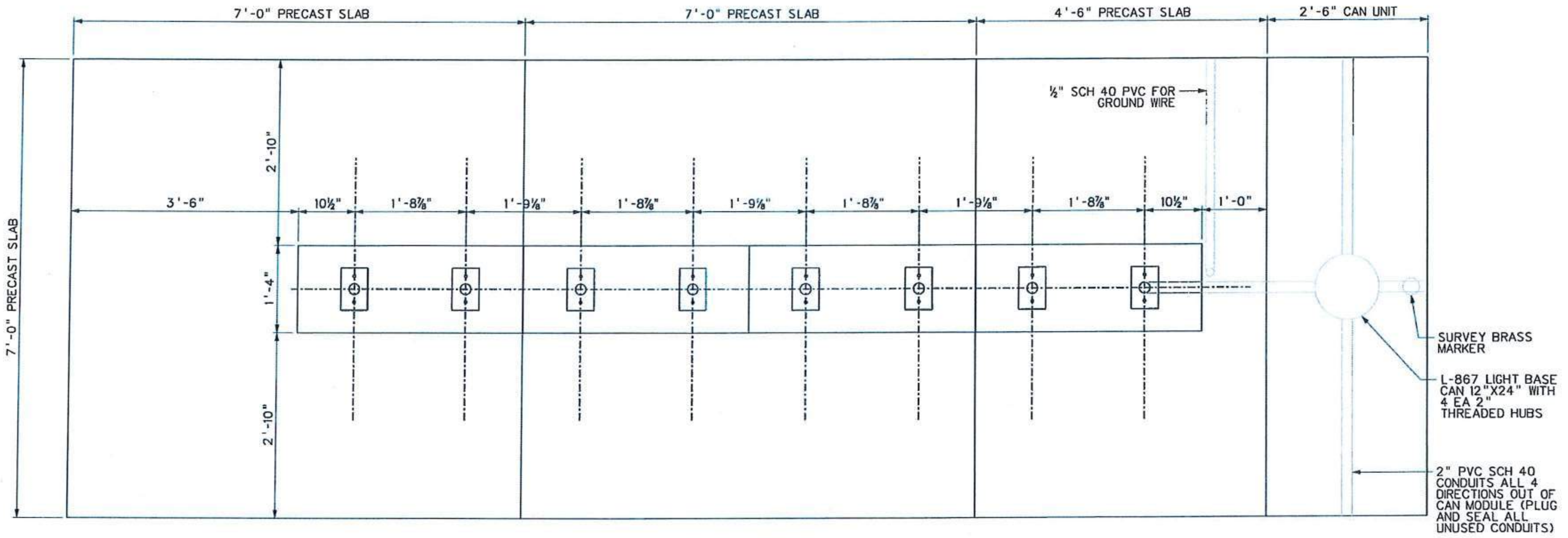
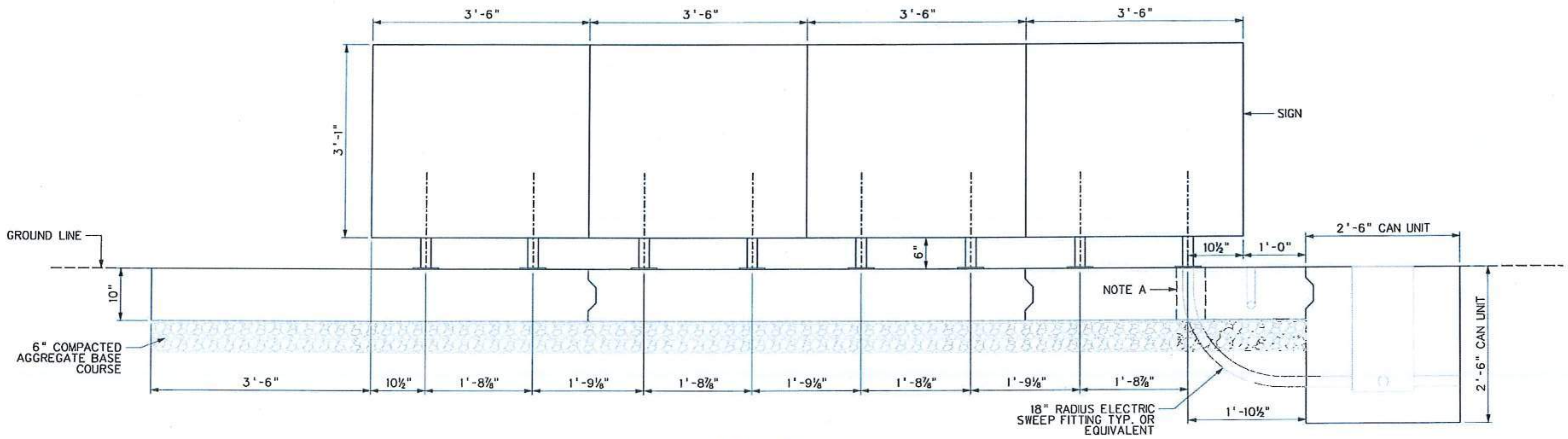
MEMPHIS INTERNATIONAL AIRPORT
MEMPHIS, TENNESSEE

MEM AIRFIELD SIGNAGE REPLACEMENT
SIGN LAYOUT 2 OF 4



PLAN VIEW



ELEVATION VIEW

NOTE A: STARTER SLAB WITH KNOCK OUT FOR CONDUITS.

SIZE 3, 4 MOD LOADING DETAILS

FAHEEM AHMAD
No. 123568

11/15/2021

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DACO CONSTRUCTION CO., INC.

E.L. ROBINSON ENGINEERING
5088 Washington Street West
Charleston, West Virginia 25313
Phone: 304-776-7473 Fax: 304-776-6426
www.elrobinsonengineering.com

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CHECKED BY: FA
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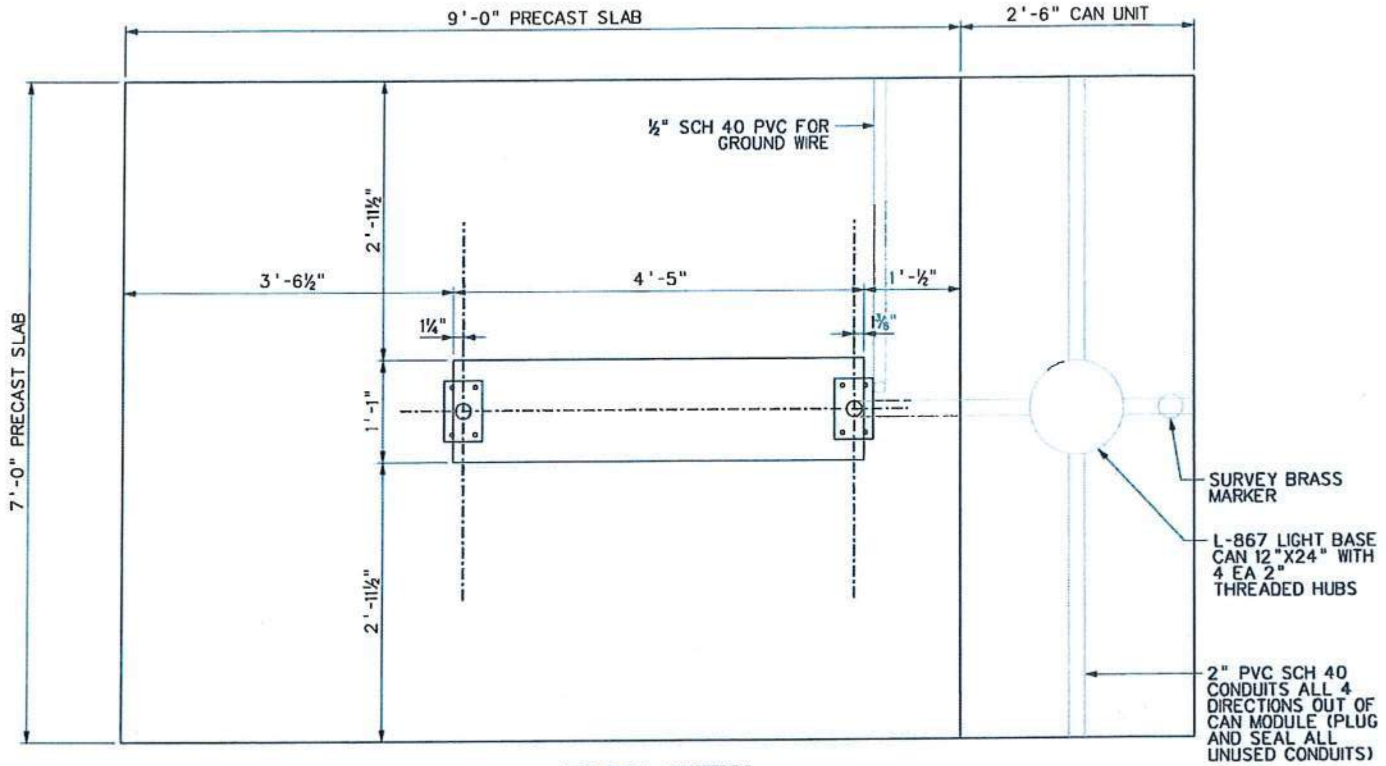
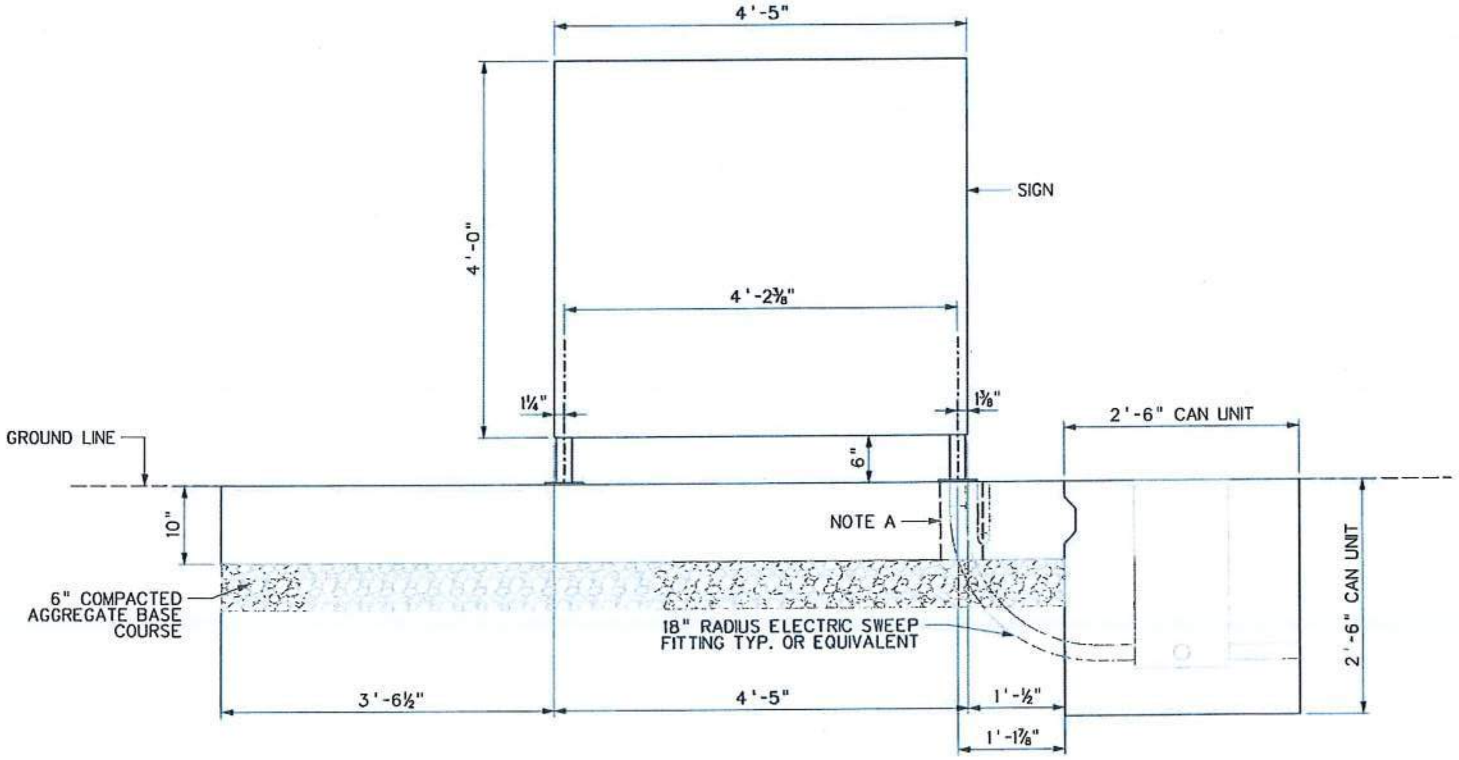
MEMPHIS INTERNATIONAL AIRPORT
MEMPHIS, TENNESSEE

MEM AIRFIELD SIGNAGE REPLACEMENT
SIGN LAYOUT 3 OF 4



PLAN VIEW



ELEVATION VIEW

NOTE A: STARTER SLAB WITH KNOCK OUT FOR CONDUITS.

SIZE 4, 1 MOD LOADING DETAILS

FAHEEM AHMAD
No. 123568

11/15/2021

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DACO CONSTRUCTION CO., INC.

E.L. ROBINSON ENGINEERING
5088 Washington Street, West
Charleston, West Virginia 25313
Phone: 304-776-7473 Fax: 304-776-6426
www.elrobinsonengineering.com

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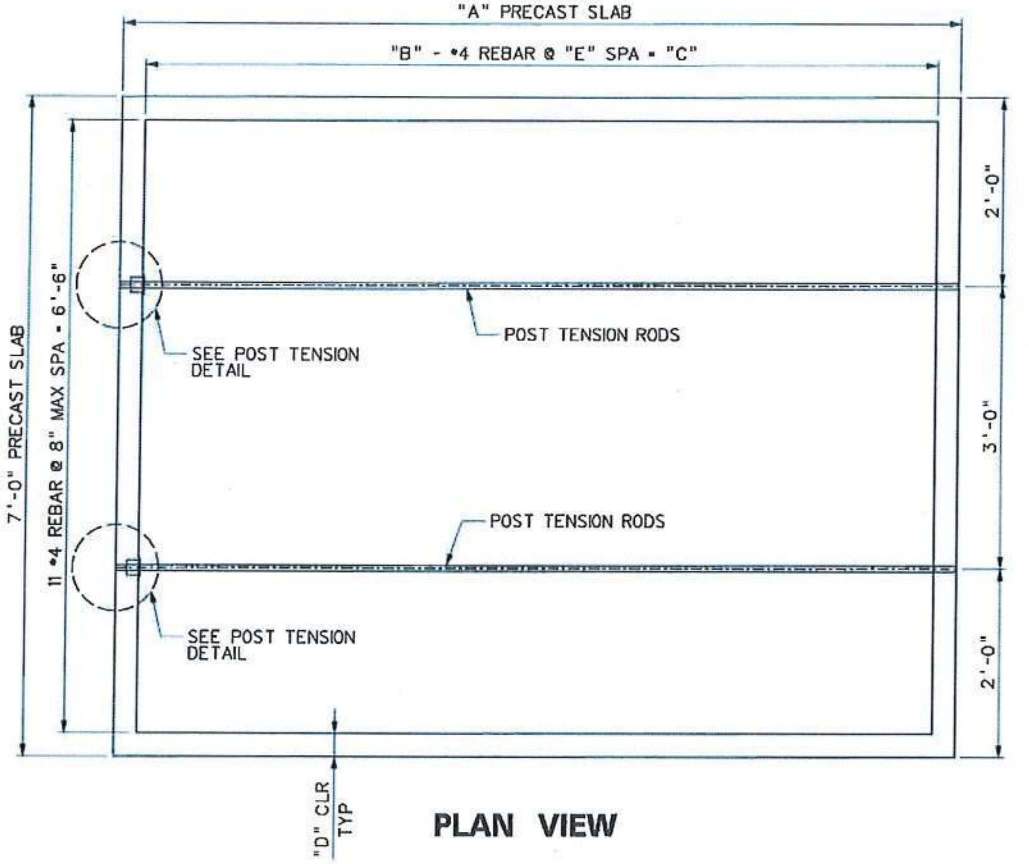
CHECKED BY: FA
DATE: 15 NOV 2021
SHEET NO. **B-4**

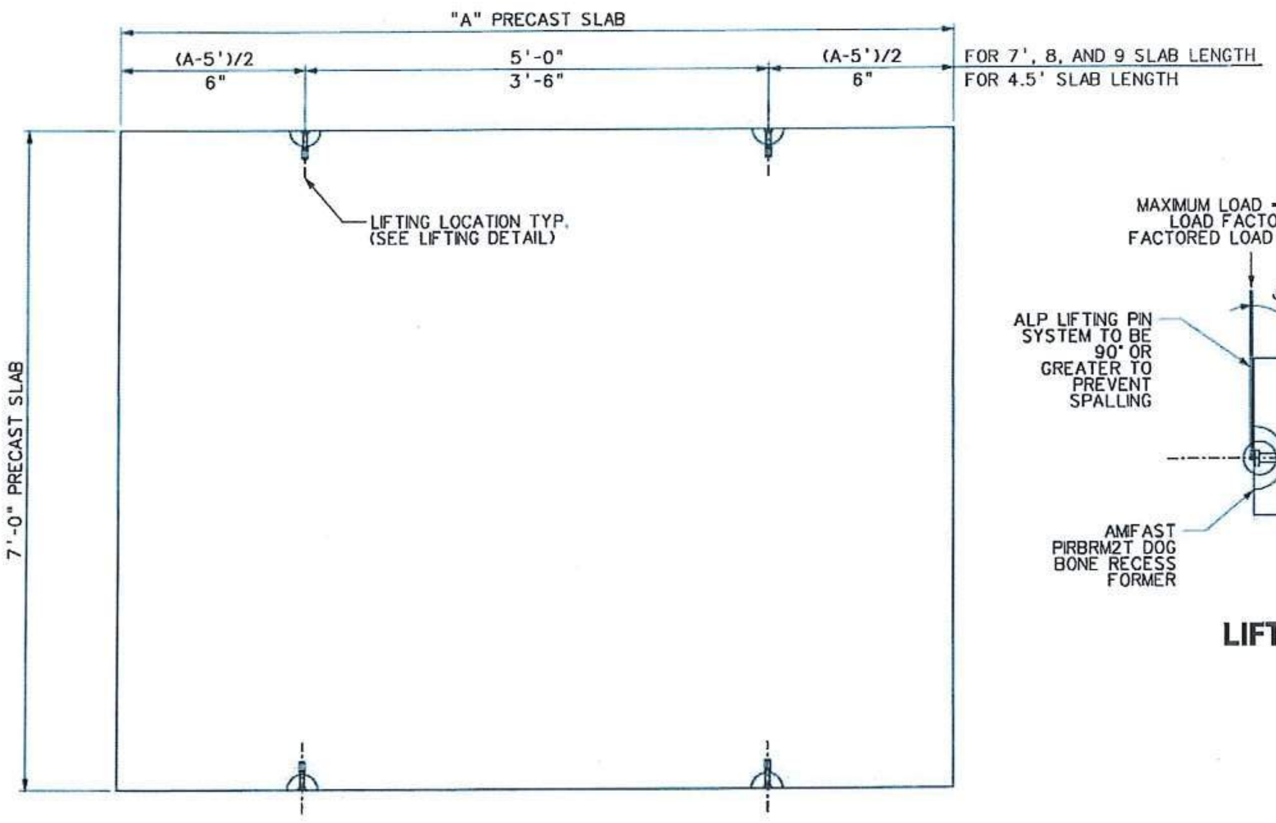
MEMPHIS INTERNATIONAL AIRPORT
MEMPHIS, TENNESSEE

MEM AIRFIELD SIGNAGE REPLACEMENT

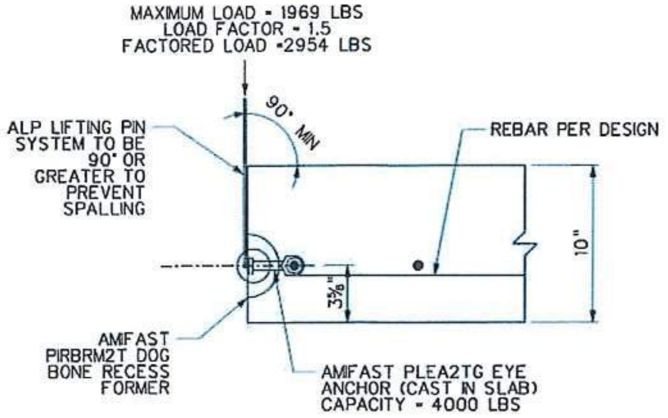
SIGN LAYOUT 4 OF 4



PLAN VIEW



LIFTING LOCATION

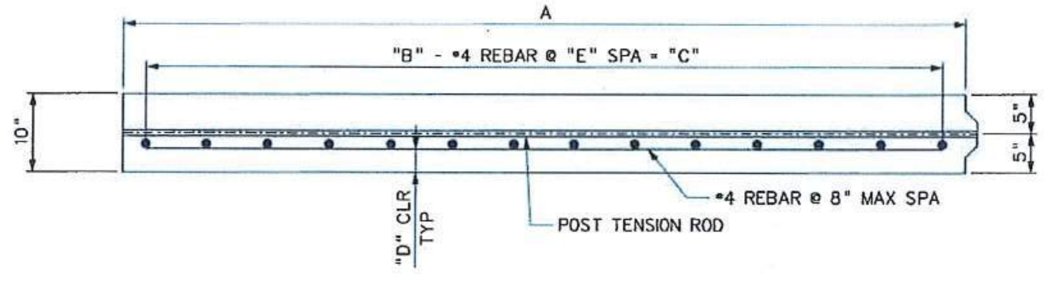


LIFTING DETAIL

PRECAST SLAB WEIGHTS						
SLAB	LENGTH (FT)	WIDTH (FT)	THICKNESS (IN)	UNIT WEIGHT (LBS/FT)	WEIGHT (LBS)	WEIGHT PER ANCHOR
1	4.5	7	10	150	3938	984
2	7	7	10	150	6125	1531
3	8	7	10	150	7000	1750
4	9	7	10	150	7875	1969

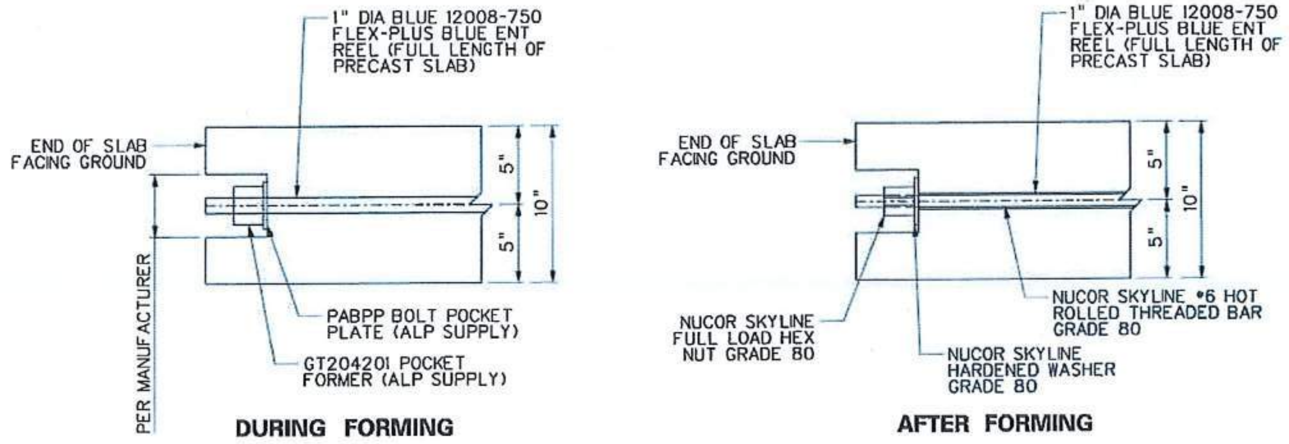
NOTES

1) ALL ASSEMBLY ITEMS SHOWN ON THIS SHEET MAY BE SUBSTITUTED BY EQUIVALENT.
2) POST TENSIONING PER MANUFACTURERS RECOMMENDATION.



ELEVATION VIEW

A (FT)	B	C (FT)	D (IN)	E (IN)
4.5	7	4	3	8.000
7	10	6.5	3	8.667
8	12	7.5	3	8.182
9	13	8.5	3	8.500



POST TENSION DETAILS

FAHEEM AHMAD

11/15/2021

REVISION NUMBER	SHEET NUMBER	REVISIONS	DATE	BY

DACO CONSTRUCTION CO., INC.

E.L. ROBINSON ENGINEERING
5088 Washington Street, West
Charleston, West Virginia 25313
Phone: 304-776-7473 Fax: 304-776-6426
www.elrobinsonengineering.com

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CHECKED BY: FA
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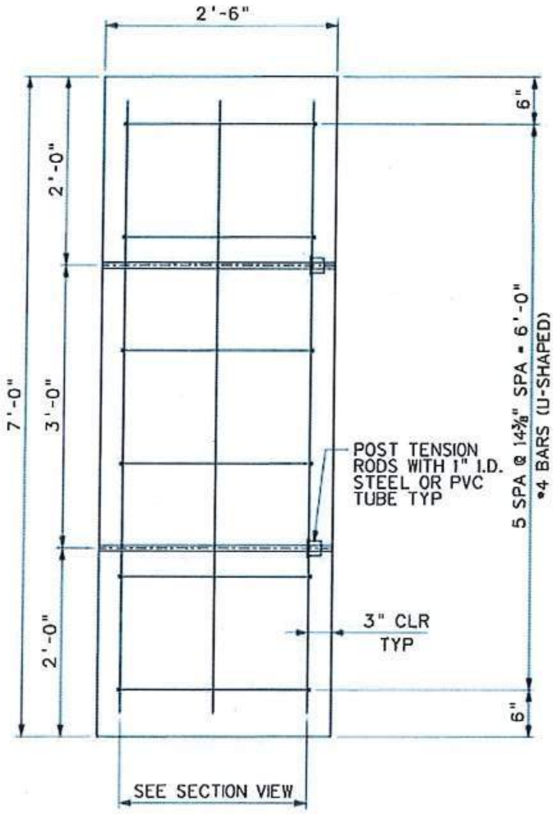
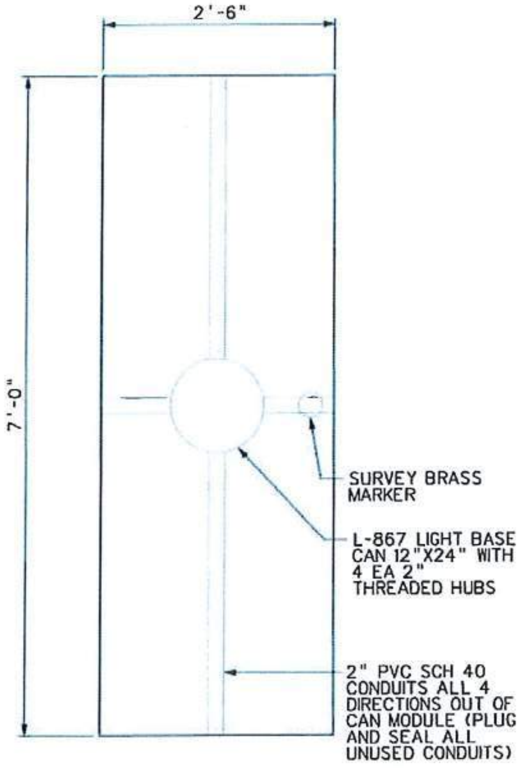
CHECKED BY: FA
DATE: 15 NOV 2021
SHEET NO. **B-5**

MEMPHIS INTERNATIONAL AIRPORT
MEMPHIS, TENNESSEE

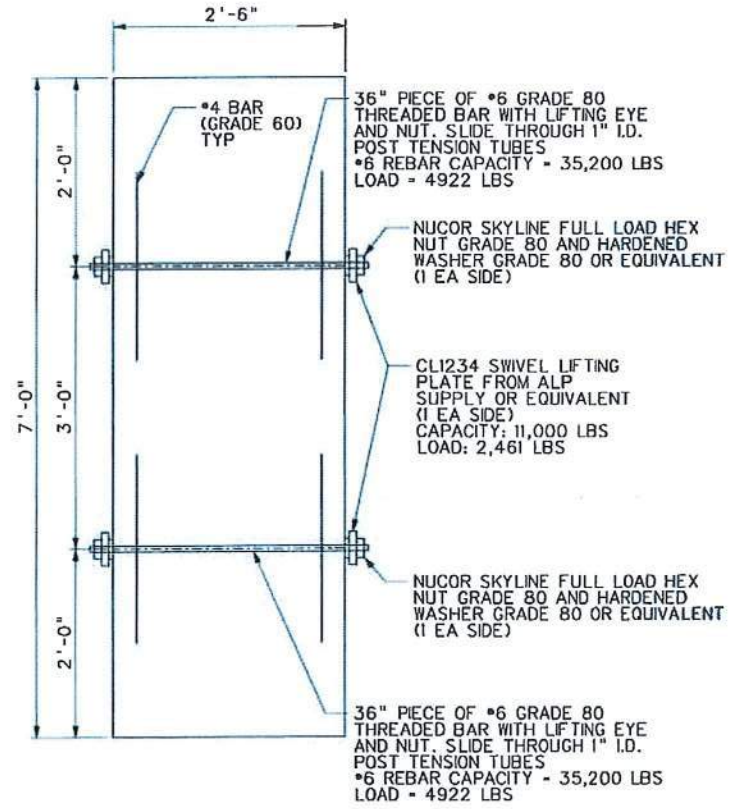
MEM AIRFIELD SIGNAGE REPLACEMENT
PRECAST SLAB MODULE DETAILS



PLAN VIEW



MISCALLENOUS DETAILS

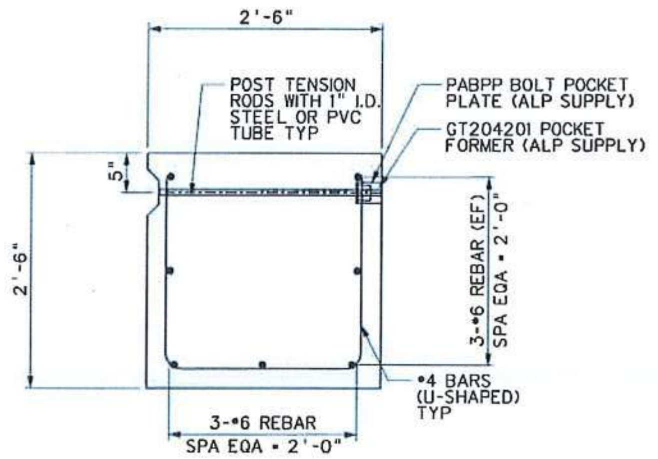


LIFTING LOCATIONS

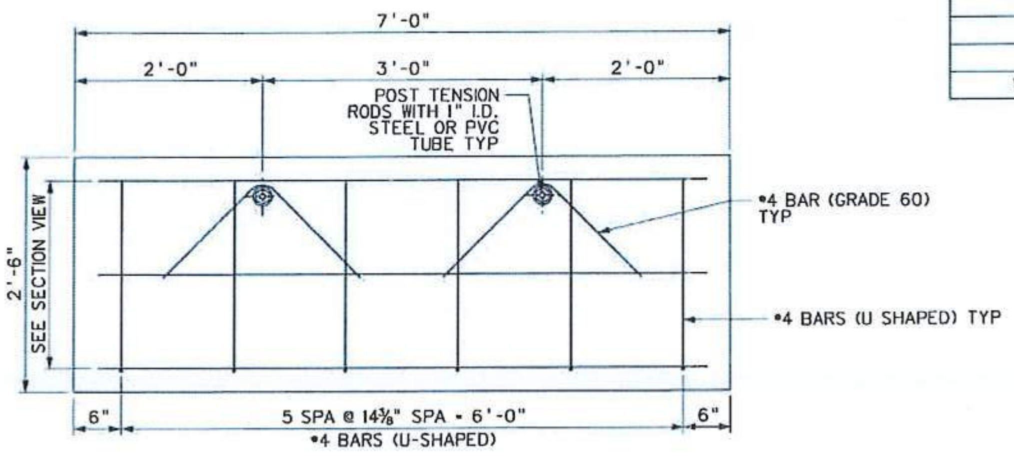
PRECAST SLAB WEIGHTS						
SLAB	LENGTH (FT)	WIDTH (FT)	THICKNESS (IN)	UNIT WEIGHT	WEIGHT (LBS)	
CAN	2.5	7	30	150	6563	
LOAD FACTOR					1.5	
FACTORED WEIGHT					9844	LBS
NUMBER OF #6 GRADE 80 REBAR					2	EA
WEIGHT PER #6 GRADE 80 REBAR					4922	LBS
NO OF CL1234 SWIVEL LIFTING PLATE					4	EA
WEIGHT PER CL1234 SWIVEL LIFTING PLATE					2461	LBS

LIFTING NOTES

1) A 36" PIECE OF #4 GRADE 60 REBAR OVER THE POST TENSION TUBE. TOP REBAR TO LAY TIGHT ON POST TENSION TUBE.
2) POST TENSION CONDUITS SHALL BE 1" INTERNAL DIAMETER, STEEL OR PVC.
3) BRASS SURVEY MARKER SHALL BE PLACED ON THE CAN UNIT. ALL REQUIREMENTS FOR THE SURVEY MARKER SHALL BE IN ACCORDANCE WITH THE CONTRACT PLANS.



ELEVATION VIEW



SECTION VIEW

FAHEEM AHMAD
No. 123568

11/15/2021

REVISION NUMBER	SHEET NUMBER	REVISIONS	DATE	BY

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5088 Washington Street West
Charleston, West Virginia 25313
Phone: 304-776-7473 Fax: 304-776-6426
www.elrobinsonengineering.com

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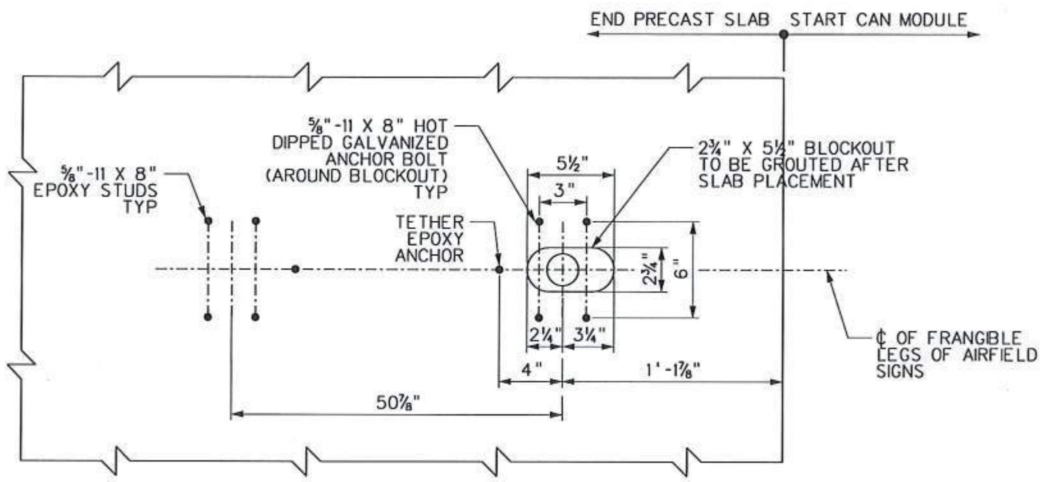
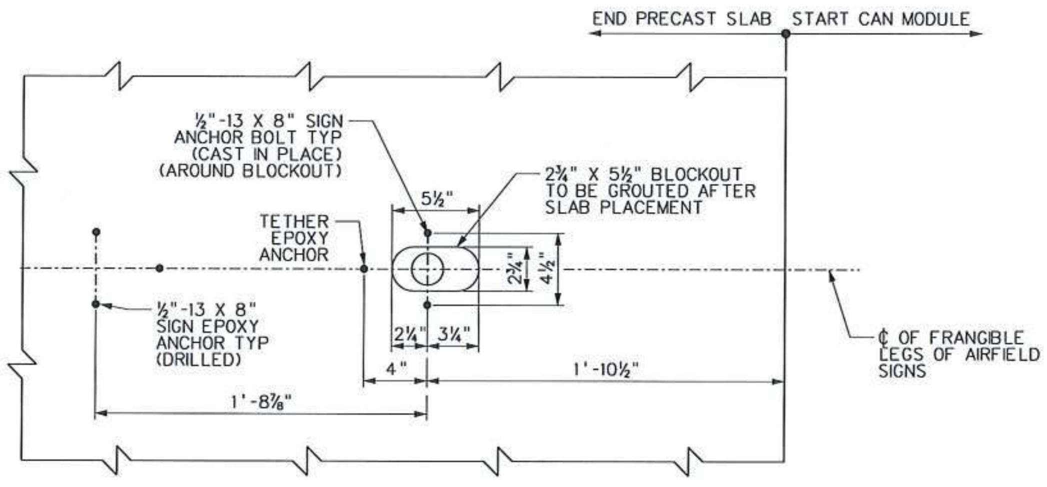
SHEET NO. B-6

MEMPHIS INTERNATIONAL AIRPORT
MEMPHIS, TENNESSEE

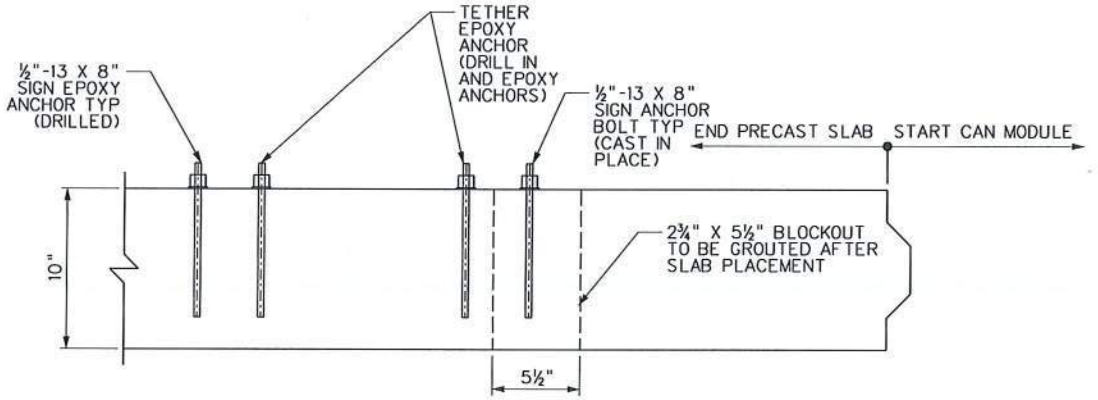
MEM AIRFIELD SIGNAGE REPLACEMENT
PRECAST CAN MODULE DETAILS



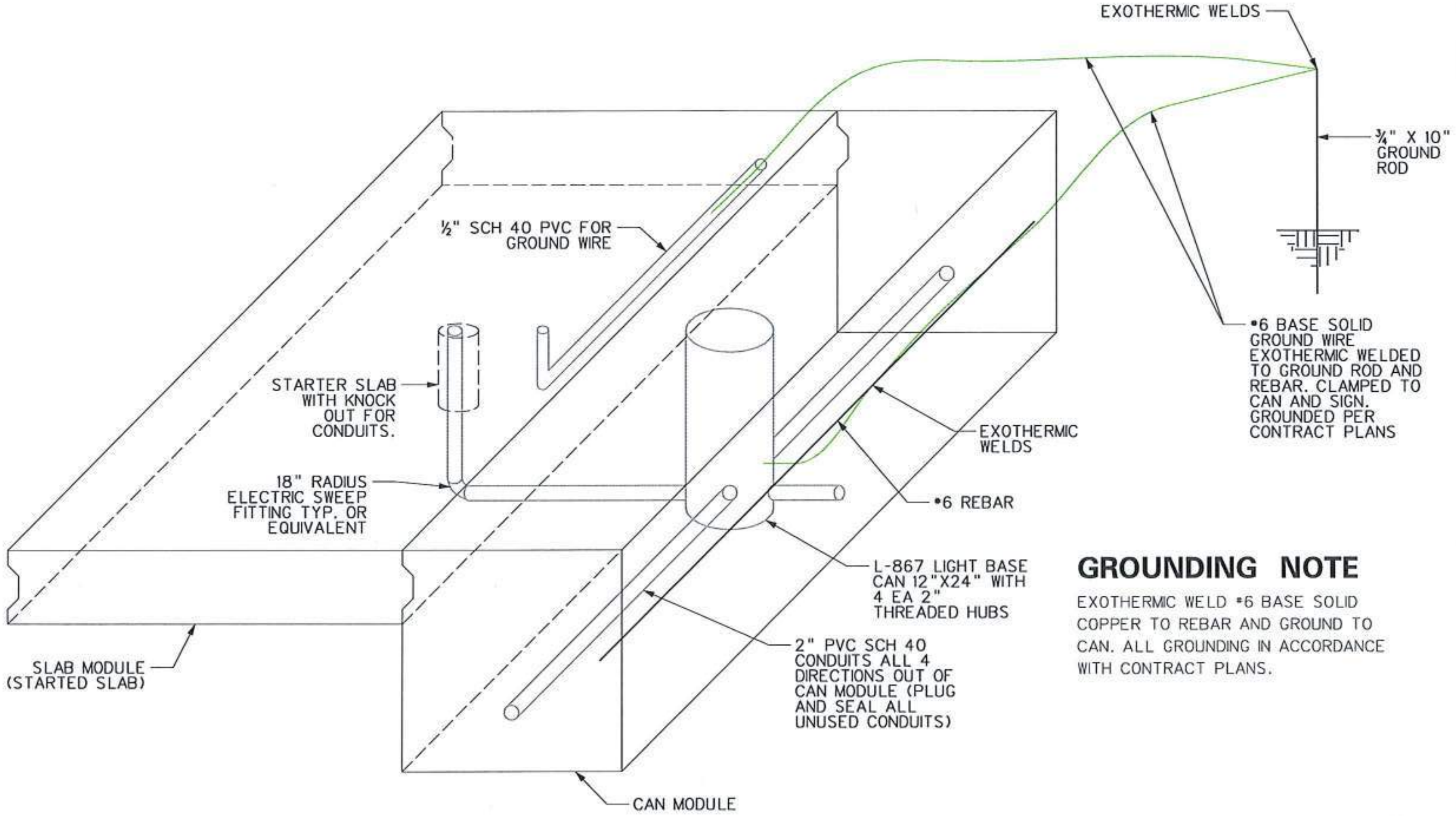
PLAN VIEW
SIZE 4 SIGNS – MOD 1



PLAN VIEW
SIZE 3 SIGNS – ALL MODS



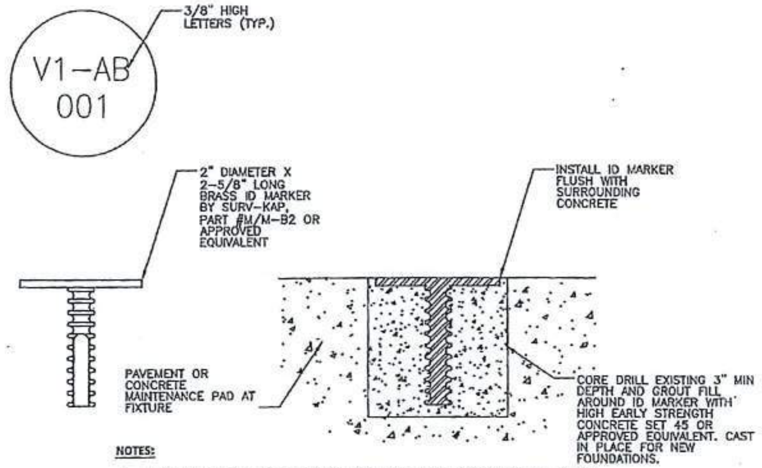
ELEVATION VIEW
SIZE 3 MOD SHOWN, SIZE 4 SIMILAR



GROUNDING DETAILS

GROUNDING NOTE

EXOTHERMIC WELD •6 BASE SOLID COPPER TO REBAR AND GROUND TO CAN. ALL GROUNDING IN ACCORDANCE WITH CONTRACT PLANS.



NOTES:

1. PROVIDE PROPOSED NUMBERING SCHEME TO RPR FOR APPROVAL PRIOR TO LABELING.
2. THE COST OF FLUSH MOUNTED AIRFIELD LIGHTING FIXTURE ID MARKER IS INCIDENTAL TO THE RESPECTIVE AIRFIELD GUIDANCE SIGN.
3. INSTALL FLUSH MOUNTED AIRFIELD FIXTURE ID MARKERS APPROVED BY THE RPR.

SIGN FOUNDATION ID MARKER (FLUSH MOUNTED)

ALL DETAILS SHOWN ON THIS SHEET ARE FOR INFORMATION ONLY.

REVISION NUMBER	SHEET NUMBER	REVISIONS	DATE	BY

DATE: 15 NOV 2021
SHEET NO. **B–7**

MEMPHIS INTERNATIONAL AIRPORT
MEMPHIS, TENNESSEE

MEM AIRFIELD SIGNAGE REPLACEMENT
MISCALLENOUS DETAILS

Flex-Plus® Blue™ ENT

Ⓤ LISTED E73317

is a nonmetallic flexible raceway for use in walls, floors, and non-plenum ceilings. It's lightweight, hand bendable, and free from sharp edges, which reduces installation time and saves money.

See pages 31–32 for technical information.

Options:

- Sizes 1/2" through 2"
- Colors:
  - Yellow color for communication circuits and signaling cable
  - Red color for fire alarm circuits
  - Blue color for power circuits
- Packaging: Coils or Reels

Standard Stock – Reels

	Color	Part No.	Nom. I.D.	Nom. O.D.	Pull Tape	Min. Bend Radius	Reel Size (F x W)	Reel Type (W=Wood)	Reel Length	Reel Wt. (lbs.)	Wt. per 100 ft. (lbs.)
1/2"	Blue	12005AK-001	.56	.84	Empty	6"	36" x 24"	W	1500	40	10
	Yellow	1205AKY-001	.56	.84	Empty	6"	36" x 24"	W	1500	40	10
	Red	1205AKR-001	.56	.84	Empty	6"	36" x 24"	W	1500	40	10
3/4"	Blue	12007AA-001	.76	1.05	Empty	6"	36" x 24"	W	1000	40	14
	Yellow	1207AAY-001	.76	1.05	Empty.	6"	36" x 24"	W	1000	40	14
	Red	1207AAR-001	.76	1.05	Empty	6"	36" x 24"	W	1000	40	14
1"	Blue	12008-750	1.00	1.315	Empty	6"	36" x 24"	W	750	40	20
	Yellow	12008Y-750	1.00	1.315	Empty	6"	36" x 24"	W	750	40	20
	Red	12008R-750	1.00	1.315	Empty	6"	36" x 24"	W	750	40	20
1 1/4"	Blue	12009-750	1.402	1.66	Empty	7"	48" x 32"	W	750	90	19
1 1/2"	Blue	12010-750	1.554	1.90	Empty	8 1/4"	48" x 32"	W	750	90	39
	Yellow	12010Y-750	1.554	1.90	Empty	8 1/4"	48" x 32"	W	750	90	39
2"	Blue	12011-500	2.030	2.375	Empty	9 1/2"	48" x 32"	W	500	90	32
	Red	12011R-500	2.030	2.375	Empty	9 1/2"	48" x 32"	W	500	90	32
	Yellow	12011Y-500	2.030	2.375	Empty	9 1/2"	48" x 32"	W	500	90	32

→ Example only - Any Plastic tube will work

*1-1/4" - 2" available in yellow & red, made to order; consult factory.

Standard Stock – Coils

	Color	Part No.	Nom. I.D.	Nom. O.D.	Pull Tape	Min. Bend Radius	Coil Length (ft.)	Wt. per 100 ft. (lbs.)
1/2"	Blue	12005-200	.56	.84	Empty	6"	200	10
	Yellow	12005Y-200	.56	.84	Empty	6"	200	10
	Red	12005R-200	.56	.84	Empty	6"	200	10
3/4"	Blue	12007-100	.76	1.05	Empty	6"	100	14
	Yellow	12007Y-100	.76	1.05	Empty	6"	100	14
	Red	12007R-100	.76	1.05	Empty	6"	100	14
1"	Blue	12008-100	1.00	1.315	Empty	6"	100	22
	Yellow	12008Y-100	1.00	1.315	Empty	6"	100	22
	Red	12008R-100	1.00	1.315	Empty	6"	100	22

10 ft. Lengths

	Color	Part No.	Nom. I.D.	Nom. O.D.	Std. Ctn. Qty.	Std. Ctn. Wt. (lbs.)
1/2"	Blue	12005-UPC	.56	.84	10 ft.	1.02
3/4"	Blue	12007-UPC	.76	1.05	10 ft.	1.46
1"	Blue	12008-010	1.00	1.315	10 ft.	2.93

NOTE: The solid blue color of ENT conduit is a registered trademark of Carlon.
ENT may show color deterioration in direct sunlight over an extended period of time. It is suggested that all ENT products not be stored outside. Since this product is not intended for use outdoors, it should not be exposed to extended periods of direct sunlight.

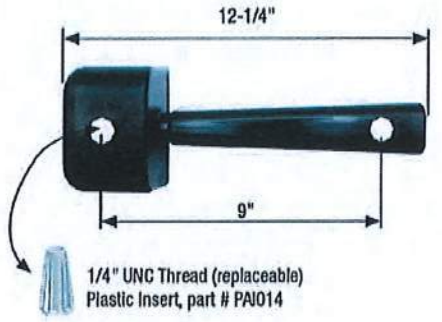
DOVETAIL ANCHOR SLOT - FOAM FILLED

Dovetail Anchor Slots come in standard 26 gauge, mill galvanized finish in 10' lengths. Custom gauges and finishes available upon request.

Part Number	Gauge	Finish	Length	Feet / Bundle
MCDAS26	26	Mill Galvanized	10'	250'

PA INSERT® BOLT POCKET FORMER SYSTEM

The PA Insert® Bolt Pocket Former System is used primarily for box culverts to bolt two culverts together. This reusable former creates a void which provides a cast-in space for the bolt connection. The former lasts over 50 pours and utilizes a steel plate to eliminate spalling of the concrete. Threaded Insert Locators can be used to hold it in place. The Steel Plates and Bolts are installed with it and remain with the precast element after the Former is removed. Magnetic version is available. See www.alpsupply.com for more information.



Part Number	Description	Weight (lbs)
PABPF	Bolt Pocket Former	1.15
PABPFM	Bolt Pocket Former - Magnetic	1.55
PABPP	Bolt Pocket Plate, HDG	0.95
PABPIK	Installation Kit, Plated	4.90

EACH CONNECTION REQUIRES:

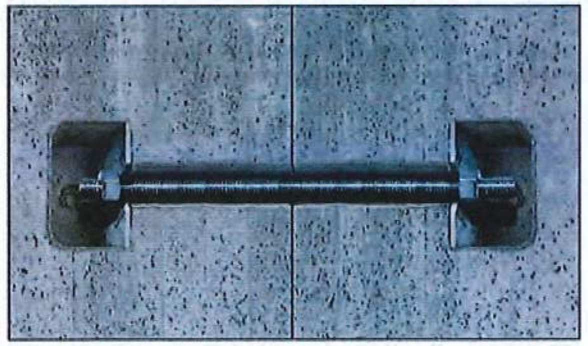
2 X BOLT POCKET FORMERS
(Reusable)

+

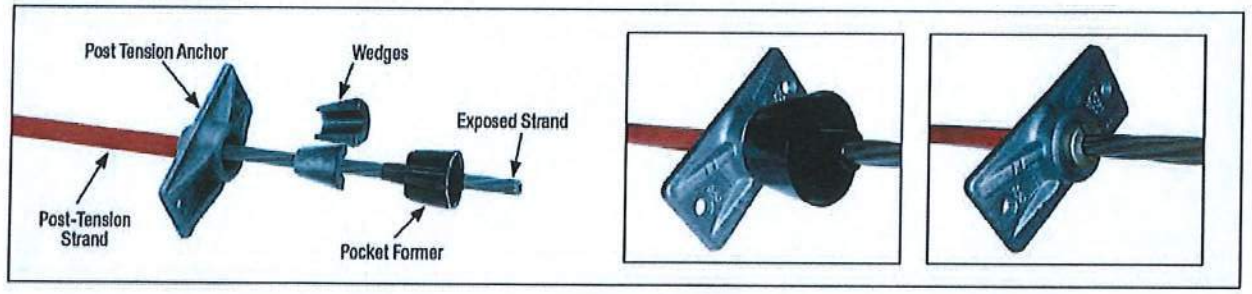
2 X BOLT POCKET PLATES

+

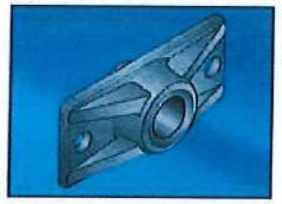
1 X INSTALLATION KIT



POST-TENSIONING COMPONENTS



GENERAL TECHNOLOGIES, INC.



POST TENSION ANCHOR

Part Number	Strand Size
GT201751	1/4", 3/8", 7/16", 1/2", 1/2" Special
GT201201	1/2" Jumbo, 0.6", 0.6" Special

GENERAL TECHNOLOGIES, INC.

2-PART WEDGE

Part Number	Strand Size
GT201115	1/2", 1/2" Special
GT201602	0.6", 0.6" Special

GENERAL TECHNOLOGIES, INC.

POCKET FORMER

Part Number	Strand Size	Weight
GT204751	1/2"	1.0 oz.
GT204201	0.6"	2.1 oz.

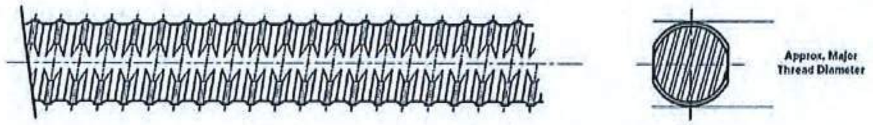
GENERAL TECHNOLOGIES, INC.

HAND WEDGE SETTER TOOL

Part Number	Weight
SL 400580	2.45 lbs

Reinforcing Steel Grade Fully Threaded Bar

Hot Rolled Threaded Bar and Accessories†



Grade 80 ksi Yield Strength / 100 ksi Ultimate Strength							
Bar Designation	Grade	Nominal Diameter in mm	Min. Net Area Thru Threads in² mm²	Min. Ultimate Strength kips	Min. Yield Strength kips	Thread Orientation	Max. Length ft m
#6	80	¾ 20	0.44 284	44 196	35.2 157	Left Hand	60 18.3
#7	80	⅞ 22	0.60 387	60 267	48.0 214	Left Hand	60 18.3
#8	80	1 25	0.79 510	79 351	63.2 281	Left Hand	60 18.3
#9	80	1 ⅛ 28	1.00 645	100 445	80.0 356	Left Hand	60 18.3
#10	80	1 ¼ 32	1.27 819	127 565	101.6 452	Left Hand	60 18.3
#11	80	1 ⅜ 35	1.56 1006	156 670	124.8 555	Left Hand	60 18.3
#14	80	1 ¾ 45	2.25 1452	225 1001	180.0 801	Right Hand	60 18.3
#18	80	2 ¼ 55	4.00 2581	400 1779	320.0 1423	Right Hand	60 18.3
#20	80	2 ½ 64	4.91 3168	491 2184	392.8 1747	Right Hand	60 18.3

Hot rolled threaded bars conform to the physical and chemical requirements of ASTM A615 Grade 80 ksi "Standard Specification for Deformed Carbon Steel Bars for Concrete Reinforcement".

Grade 100 ksi Yield Strength / 115 ksi Ultimate Strength							
Bar Designation	Grade	Nominal Diameter in mm	Min. Net Area Thru Threads in² mm²	Min. Ultimate Strength kips	Min. Yield Strength kips	Thread Orientation	Max. Length ft m
#11	100	1 ⅜ 35	1.56 1006	179.4 798	156.0 670	Left Hand	60 18.3
#14	100	1 ¾ 45	2.25 1452	258.6 1150	225.0 1001	Right Hand	60 18.3
#18	100	2 ¼ 55	4.00 2581	460.0 2046	400.0 1779	Right Hand	60 18.3
#20	100	2 ½ 64	4.91 3168	564.7 2512	491.0 2184	Left Hand	60 18.3

Hot rolled threaded bars conform to the physical and chemical requirements of ASTM A615 Grade 100 ksi "Standard Specification for Deformed Carbon Steel Bars for Concrete Reinforcement".

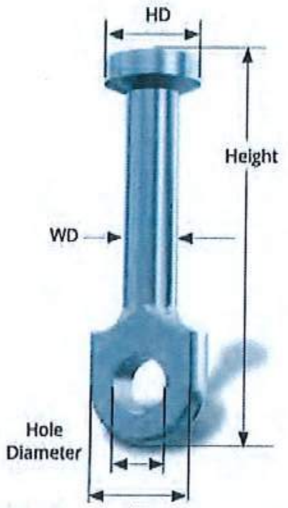
over

Please note: As we continuously improve the design of our products, product details are subject to change.

Eye Anchor

The Eye Anchor is an economical and high strength insert for the lifting and handling of precast elements. It is similar to the Dog Bone Anchor.

The Eye Anchor has an eye at the foot where tension bars can be looped through the insert. It is most beneficial when lifting thin slabs of lightweight concrete or elements requiring lifting at low compressive strengths (<2000 psi). The Eye Anchor provides maximum capacity when utilizing a tension bar and cast at the center of the panel.



PLEA4TG

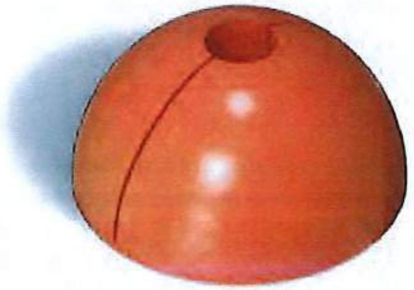
Item #	Size (T)	Height	A	HD	WD	Hole Diameter	Weight (lbs)	Lifting Eye	Recess Former	SWL	Safety Factor	UML/T
						Eye Anchor						
PLEA1TG	1T	2 9/16	7/8	3/4	3/8	3/8	.14	PLLE1T	PLDBRM1T	2000	4:1	8000
PLEA2TG	2T	3 9/16	1 1/4	1	9/16	4/8	.35	PLLE2T	PLDBRM2T	4000	4:1	16000
PLEA4TG	4T	5 1/2	1 3/4	1 7/16	3/4	6/8	.90	PLLE4T	PLDBRM4T	8000	4:1	32000
PLEA8TG	8T	7 1/16	2 5/16	1 13/16	1 1/8	1 1/8	1.1	PLLE8T	PLDBRM8T	16000	4:1	64000
PLEA20TG	20T	9 13/16	3 1/4	2 13/16	1 9/16	1 4/8	6.9	PLLE20T	PLDBRM20T	40000	4:1	160000

Material	High Strength Steel	SWL	Safe Working Load
Finish	HDG	UML/T	Ultimate Mechanical Load in Tension (lbs)

Dog Bone Recess Former

Recess Former for use with PROLIFT Dog Bone Anchors.

Item #	Size (T)	Material	Weight (lbs)	Color
		PROLIFT Dogbone Recess Former		
PLDBRM1T	1T	Rubber	.14	Blue
PLDBRM2T	2T	Rubber	.26	Yellow
PLDBRM4T	4T	Rubber	.55	Orange
PLDBRM8T	8T	Rubber	1.1	Green
PLDBRM20T	20T	Rubber	2.22	Black



PLDBRM4T

Lifting Eye

PLLE4T

Item #	Size (T)	Weight (lbs)	SLL	Safety Factor	UML/T
		Lifting Eye			
PLLE1T	1T	2.11	2600	5:1	13000
PLLE2T	2T	3.76	5000	5:1	25000
PLLE4T	4T	8.34	10000	5:1	50000
PLLE8T	8T	20.53	20000	5:1	100000
PLLE20T	20T	41.18	40000	5:1	200000

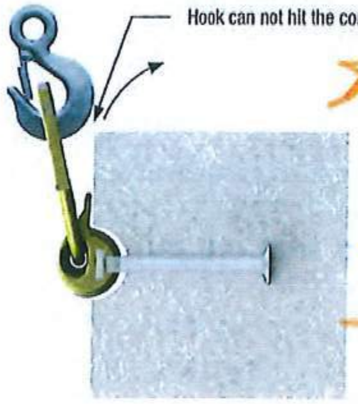
SLL	Safe Lifting Load
UML/T	Ultimate Mechanical Load in Tension (lbs)

The Lifting Eye is a high strength steel lifting accessory for use with Dog Bone anchors. The Lifting Eye consists of a lifting body and a high strength ball which connects to the Dog Bone anchor. A key feature is the quick connect bail that can rotate freely through 180° degrees under load. Additionally, the spherical head, or lifting eye, has the ability to rotate 360° degrees while under load.

Inspection and maintenance of the Lifting Eye is recommended before each use. The Lifting Eye may experience excessive wear, unexpected damage, bending, twisting, misuse, or overloading during its usable lifetime which can reduce the lifting eye's rating load. Any evidence of wear that exceeds the degree of wear based on its age and typical use suggests that the lifting eye be replaced. Lifting eyes should be used with anchors from the same manufacturer.

EDGE LIFTING OF SLABS AND WALL PANELS

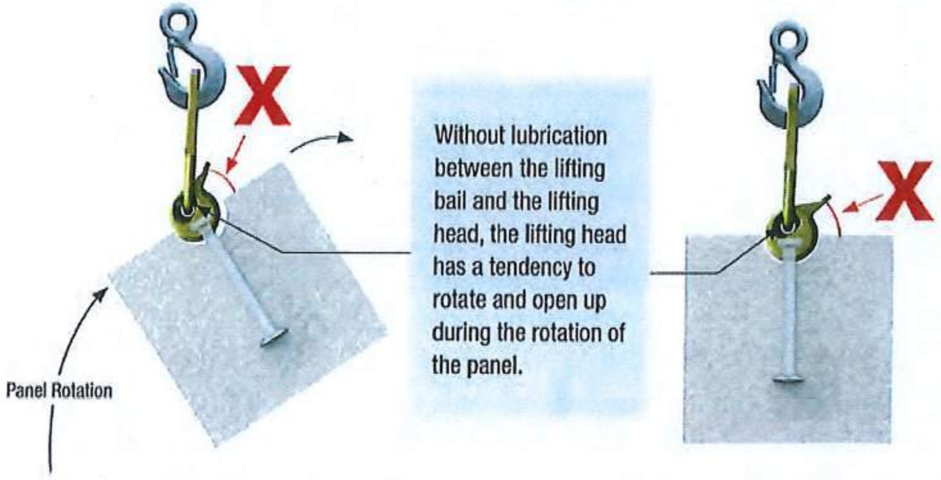
1



10" should Qualify as thicker panel.

The Lifting Pin System is **not typically recommended** for lifting in the edge of thin wall panels or slabs due to the system's low shear capacity in that application. For thin panels, the ALP Supply® QUIKLIFT® System should be used. In thicker panels and slabs, the ALP Supply® Lifting Pin System can be used to rotate slabs or panels, but users should monitor the orientation of the lifting head in relation to the direction of load. Without proper lubrication of the lifting head, it can start to disengage from the lifting anchor as the panel is rotated up. This is due to the friction of the lifting head and the bail.

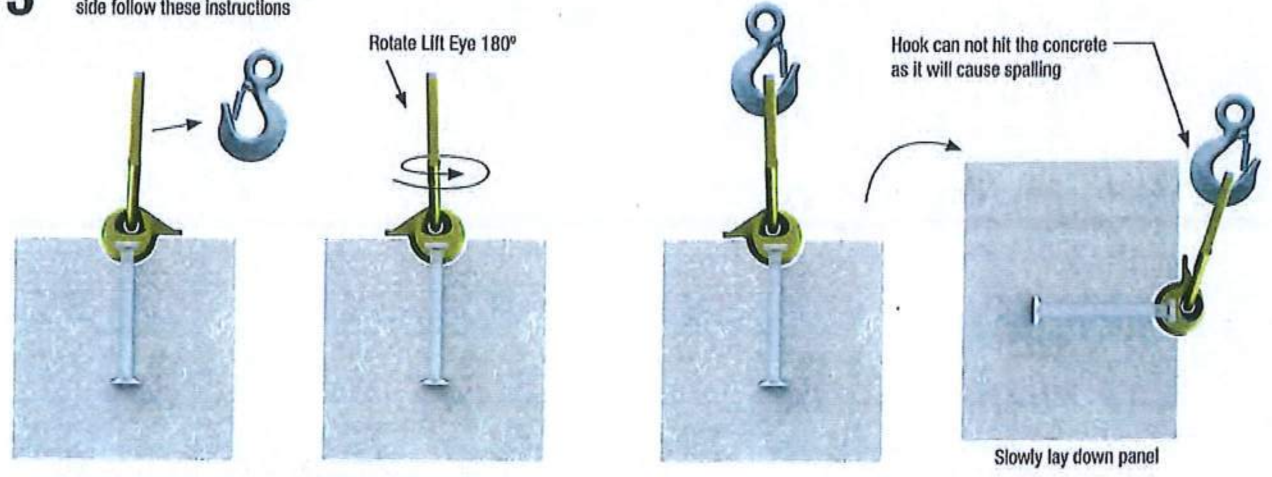
2



Without lubrication between the lifting bail and the lifting head, the lifting head has a tendency to rotate and open up during the rotation of the panel.

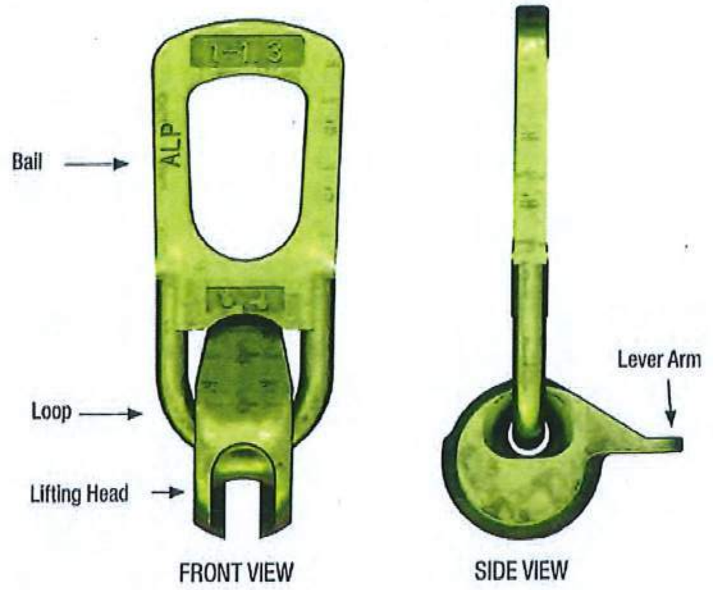
3

If laying panel down on opposite side follow these instructions



It may be necessary to disengage the lifting eye from the hook

ALP® LIFTING EYE TERMINOLOGY AND INSPECTION



INSPECT ALL LIFT EYES FOR THE FOLLOWING:

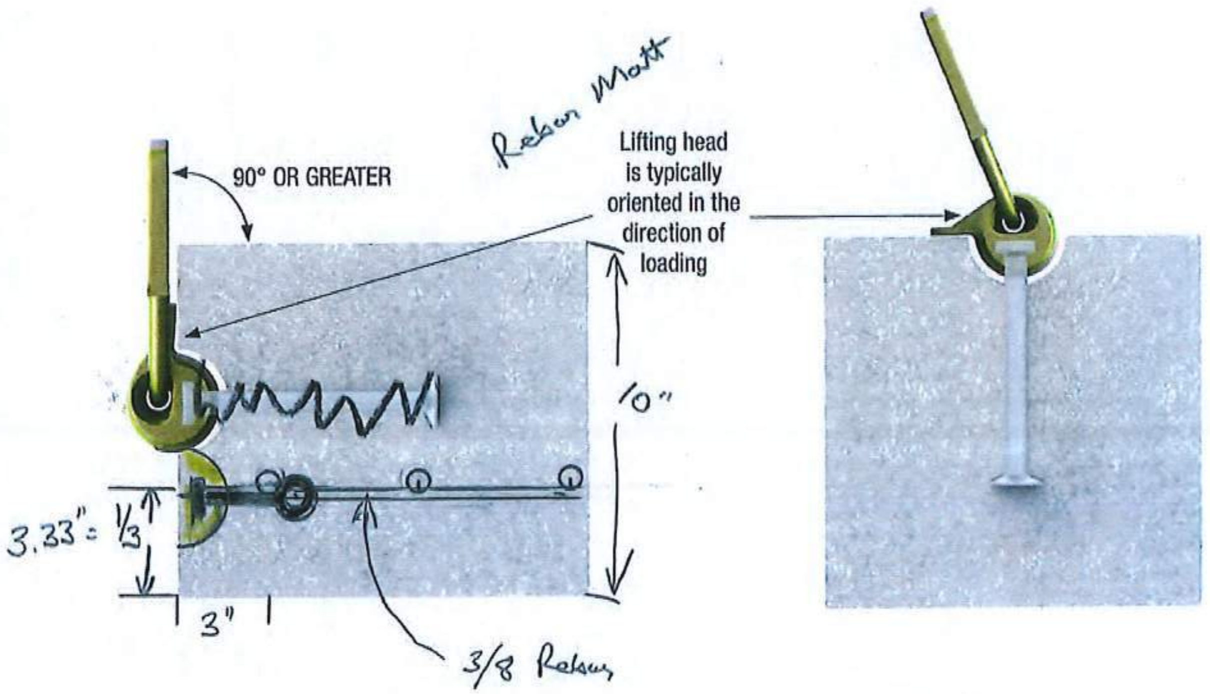
- Inspect the Bail and Lifting Head for cracks.
- Inspect the Bail and Loop for any bends.
- Inspect and remove from service if there are signs that excessive external heat was applied to any parts.

WHEN TO REMOVE LIFT EYES FROM SERVICE:

- If the Bail has been bent.
- If a weld has been fractured.

See ALP Supply® website for Inspection and Maintenance Guidelines for routine inspection of lifting hardware.

ALP® LIFTING EYE GENERAL USE



1" = .195

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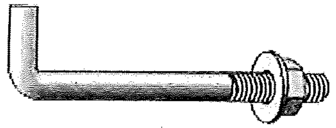
Product catalog » Anchoring products » Anchor bolts w/ nuts and washers » Hot dipped galvanized steel » Coarse (standard) thread » 1/2"-13

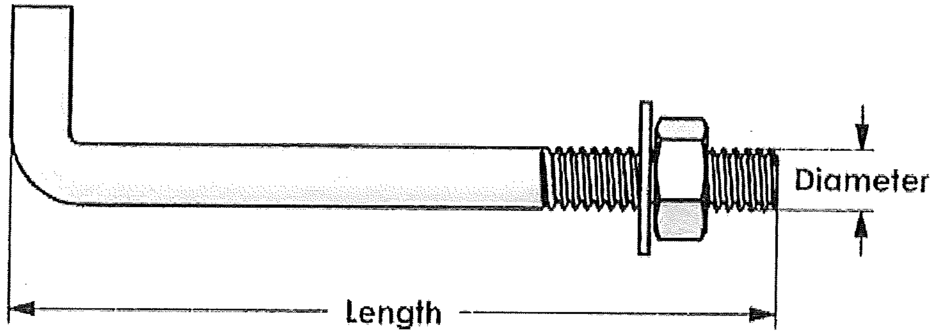


Anchor bolts w/ nuts and washers, Hot dipped galvanized steel, 1/2"-13 x 8"

Prod. #	Length	Each price	Bag price	Bulk price	Buy
10900	8"	$2.30 / ea	$40.35 / 25	$367.00 / 250	

Cost of all entered products: **$0.00**

Product Images



Product details

Bolt Depot Product #:	10900
Units:	US
Category:	Anchoring products
Subcategory:	Anchor bolts
Material:	Steel
Plating:	Hot dipped galvanized
Thread direction:	Right hand
Thread density:	Coarse
Diameter:	1/2"
Thread count:	13
Length:	8"
Comes with washers:	Yes
Comes with nuts:	Yes
Plating specification:	A153

See also

Safety glasses

Bolt Depot branded apparel and safety gear.

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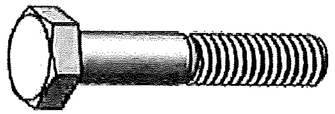
Product catalog » Hex bolts » Hex bolts » Hot dipped galvanized steel » Coarse (standard) thread » 1/2"-13



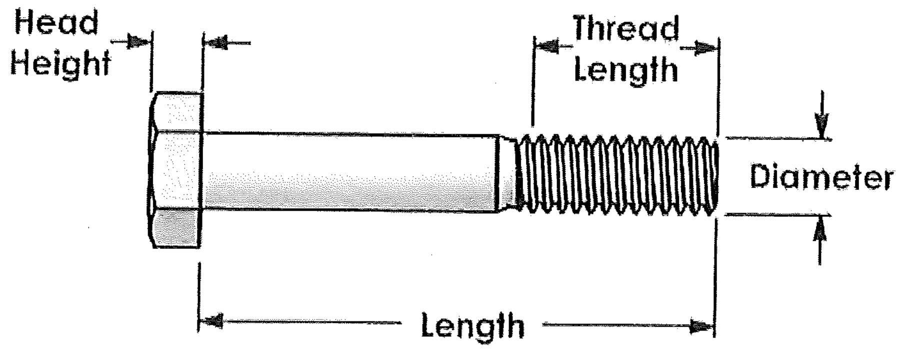
Hex bolts, Hot dipped galvanized steel, 1/2"-13 x 8"

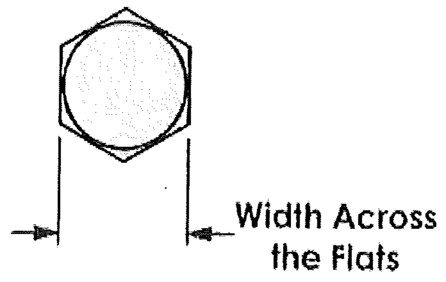
Important Note: Due to the plating thickness, only hot dipped galvanized nuts should be used on hot dipped galvanized hex bolts.

Prod. #	Length	Each price	Bag price	Bulk price	Buy
80	8"	$1.68 / ea	$33.39 / 25	$283.00 / 250	

Cost of all entered products: **$0.00**

Product Images





Product details

Bolt Depot Product #:	80
Units:	US
Category:	Hex bolts
Subcategory:	Hex bolts
Material:	Steel
Plating:	Hot dipped galvanized
Thread direction:	Right hand
Thread density:	Coarse
Diameter:	1/2"
Thread count:	13
Length:	8"
Length tolerance:	+0.12" / -0.16"
Head style:	Hex
Drive type:	External hex
Plating specification:	ASTM A153
Head height Min:	0.302"
Head height Max:	0.323"
Width across the flats:	3/4"
Fully threaded:	No
Thread length Min:	1-1/2"
Dimensional standard:	ASME B18.2.1

Additional information

US bolt thread length table

US Hex bolt sizes

ⓘ Head/Wrench size table

ⓘ US hex bolt recommended torque

Matching Products

Prod. #	Description		Buy
2617		**Hex nuts, Hot dipped galvanized steel, 1/2"-13** A standard six sided nut.	$0.27 / ea $8.68 / 50 $73.60 / 500
15969		**Top lock nuts, Hot dipped galvanized steel, 1/2"-13** A style of prevailing torque lock nut. Also called tri-loc. This style of lock nut deforms the threads of the mated fastener.	$0.30 / ea $10.78 / 50 $94.90 / 500
2990		**USS flat washers, Hot dipped galvanized steel, 1/2"** USS pattern is the most common type of flat washer.	$0.21 / ea $16.76 / 100 $148.00 / 1000
2984		**Lock washers, Hot dipped galvanized steel, 1/2"** Split lock washers place tension against a nut after tightening, to help prevent loosening.	$0.16 / ea $10.23 / 100 $91.80 / 1000

See also

Metric hex bolts

A bolt with a six sided head.

ECONOMICAL EPOXY FOR THE TRANSPORTATION INDUSTRY

Adhesive HIT-RE 10
technical supplement

HY-10

RE-10 = 14.25
HY-10 = 17.24
HIT-1 = 27.50.

Mortar system


HIT-RE 10 cartridge


HAS threaded rods


Rebar

PRODUCT DESCRIPTION

HIT-RE 10 is the newest addition to Hilti's best in class chemical anchor portfolio. This adhesive is engineered to satisfy demanding jobsite conditions for transportation doweling and anchoring at an economical price. HIT-RE 10 is ideal for roadways, bridges, railways and runway projects.

The Hilti HIT-RE 10 Adhesive Anchoring System is an injectable two-component epoxy adhesive. The two components are kept separate by means of a dual-cylinder hard plastic cartridge with an attached manifold.

HIT-RE 10 comes packaged in a new 19.6 oz. hard cartridge that integrates seamlessly with the HDM 500 manual dispenser and HDE 500 A-22 battery-powered dispenser. The automatic dosing feature provides productivity and easy installation on the jobsite. As with every Hilti anchoring product, HIT-RE 10 comes with the sales and technical service support you have come to expect from Hilti.

Product features

The Hilti HIT-RE 10 Adhesive Anchoring System may be used with fully threaded rod or deformed reinforcing bar installed in uncracked concrete. The primary features of the HIT-RE 10 Adhesive Anchoring System are:

- Suitable for post-installed rebar and threaded rod anchoring applications
- Long working time allows flexible installation
- Suitable for un-cracked concrete
- Meets requirements of ASTM C881, Type I, II, IV and V, Grade 3, Class A, B, and C
- Mixing tube provides proper mixing, helps eliminate measuring errors and minimizes waste
- Contains no styrene and virtually odorless
- Installation base material temperature range from 41°F to 104°F. For curing time based on base material temperature see the Instructions For Use

MATERIAL SPECIFICATIONS

Table 1 - Material properties of fully cured HIT-RE 10

Bond Strength ASTM C882 2 day cure 14 day cure	21.2 Mpa 23.1 Mpa	3,070 psi 3,350 psi
Compressive Strength ASTM D6951	88.1 Mpa	12,780 psi
Compressive Modulus ASTM D6951	5,380 Mpa	0.78 x 10^6 psi
Tensile Strength 7 day ADTM D638	53.2 Mpa	7,720 psi
Elongation at break ASTM D638	1.30%	1.30%
Heat Deflection Temperature ASTM D648	58°C	137°F
Absorption ASTM D570	0.06%	0.06%
Linear Coefficient of Shrinkage on Cure ASTM D2566	0.0007	0.0007

Hilti HIT-RE 10 Adhesive with Hilti HAS threaded rod

Figure 3 – HAS threaded rod installation conditions

Permissable base materials	Permissable concrete conditions		Permissable drilling method
			
Uncracked concrete	Dry concrete	Water saturated concrete	Hammer drilling with carbide tipped drill bit

Table 14 - Hilti HAS Threaded Rod Installation Specifications when installed with HIT-RE 10 adhesive system

Setting information		Symbol	Units	Nominal rod diameter, (in.)						
				3/8	1/2	5/8	3/4	7/8	1	1-1/4
Nominal bit diameter		d_0	in.	7/16	9/16	3/4	7/8	1	1-1/8	1-3/8
Effective minimum embedment		$h_{ef,min}$	in. (mm)	2-3/8 (60)	2-3/4 (70)	3-1/8 (79)	3-1/2 (89)	3-1/2 (89)	4 (102)	5 (127)
Effective maximum embedment		$h_{ef,max}$	in. (mm)	7-1/2 (190)	10 (250)	12-1/2 (310)	15 (380)	17-1/2 (440)	20 (500)	20 (500)
Minimum diameter of fixture hole	through-set		in.	1/2	5/8	13/16[1]	15/16[1]	1-1/8[1]	1-1/4[1]	1-1/2[1]
	preset		in.	7/16	9/16	11/16	13/16	15/16	1-1/8	1-3/8
Installation Torque		T_{inst}	ft-lb. (N-m)	15 (20)	30 (41)	60 (81)	100 (136)	125 (169)	150 (203)	200 (271)
Minimum concrete thickness		h_{min}	in. (mm)	h_{ef} + 1-1/4 > 4 (h_{ef} + 30 > 100)		$h_{ef} + 2d_0$				
Minimum edge distance[2]		c_{min}	in. (mm)	1-7/8 (48)	2-1/2 (64)	3-1/8 (79)	3-3/4 (95)	4-3/8 (111)	5 (127)	5-5/8 (143)
Minimum anchor spacing		s_{min}	in. (mm)	1-7/8 (48)	2-1/2 (64)	3-1/8 (79)	3-3/4 (95)	4-3/8 (111)	5 (127)	5-5/8 (143)

[1] Install using (2) washers. See Figure 5.

[2] Edge distance of 1-3/4-inch (44mm) is permitted provided the installation torque is reduced to 0.30 T_{inst} for 5d<s<16 in. and to 0.5T_{inst} for s>16-in.

Figure 4 - Hilti HAS threaded rods

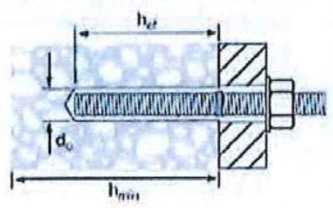


Figure 5 - Illustration with (2) washers

Table 15 - Hilti HIT-RE 10 design information with HAS threaded rods per ACI 318-14 Ch. 17 [1]

Design parameter		Symbol	Units	Nominal rod diameter (in.)						
				3/8	1/2	5/8	3/4	7/8	1	1-1/4
Nominal anchor diameter		d_a	in. (mm)	3/8 (9.5)	1/2 (12.7)	5/8 (15.9)	3/4 (19.1)	7/8 (22.2)	1 (25.4)	1-1/4 (31.8)
Effective minimum embedment[7]		$h_{ef,min}$	in. (mm)	2-3/8 (60)	2-3/4 (70)	3-1/8 (79)	3-1/2 (89)	3-1/2 (89)	4 (102)	5 (127)
Effective maximum embedment[7]		$h_{ef,max}$	in. (mm)	7-1/2 (190)	10 (254)	12-1/2 (318)	15 (381)	17-1/2 (445)	20 (508)	20 (508)
Minimum concrete thickness[7]		h_{min}	in. (mm)	$h_{ef}+1\text{-}1/4>4$ $(h_{ef}+30 \geq 100)$		$h_{ef} + 2d_0$[6]				
Critical edge distance		c_{ac}	in.	$c_{ac} = h_{ef} \cdot \left(\frac{\tau_{k,uncr}}{1160}\right)^{0.4} \cdot \left[3.1-0.7 \cdot \frac{h}{h_{ef}}\right]$; $\left(\frac{h}{h_{ef}}\right)$ need not be larger than 2.4 $\tau_{k,uncr}$ need not be taken as greater than: $\tau_{k,uncr} = \frac{k_{uncr}\sqrt{h_{ef} \cdot f'_c}}{\pi \cdot d_a}$						
			mm.	$c_{ac} = h_{ef} \cdot \left(\frac{\tau_{k,uncr}}{8}\right)^{0.4} \cdot \left[3.1-0.7 \cdot \frac{h}{h_{ef}}\right]$; $\left(\frac{h}{h_{ef}}\right)$ need not be larger than 2.4 $\tau_{k,uncr}$ need not be taken as greater than: $\tau_{k,uncr} = \frac{k_{uncr}\sqrt{h_{ef} \cdot f'_c}}{\pi \cdot d_a}$						
Minimum edge distance[2]		c_{min}	in. (mm)	1-7/8 (48)	2-1/2 (64)	3-1/8 (79)	3-3/4 (95)	4-3/8 (111)	5 (127)	5-5/8 (143)
Minimum anchor spacing		s_{min}	in. (mm)	1-7/8 (48)	2-1/2 (64)	3-1/8 (79)	3-3/4 (95)	4-3/8 (111)	5 (127)	5-5/8 (143)
Effectiveness factor for uncracked concrete		$k_{c,uncr}$[4]	-	24						
Strength reduction factor for tension, concrete failure modes		$\phi_{c,N}$	-	0.65						
Strength reduction factor for shear, concrete failure modes		$\phi_{c,V}$	-	0.70						
Characteristic bond stress in uncracked concrete[5]		$\tau_{k,uncr}$	psi (N/mm²)	1,246 (8.6)	1,191 (8.2)	1,136 (7.8)	1,082 (7.5)	1,029 (7.1)	974 (6.7)	864 (6.0)
Permissable installation conditions	Strength reduction factor for tension, bond failure modes, dry concrete	Anchor category	-	2	2	3	3	3	3	3
		$\phi_{b,dry}$	-	0.55	0.55	0.45	0.45	0.45	0.45	0.45
	Strength reduction factor for tension, bond failure modes, water saturated concrete	Anchor category	-	2	2	3	3	3	3	3
		$\phi_{b,ws}$	-	0.55	0.55	0.45	0.45	0.45	0.45	0.45

[1] Design information in this table is based on testing in accordance with ACI 355.4.

[2] Edge distance of 1-3/4-inch (44mm) is permitted provided the rebar remains un-torqued.

[3] For all design cases, $\psi_{c,N}$ = 1.0. The appropriate coefficient for breakout resistance for uncracked concrete ($k_{c,uncr}$) must be used.

[4] Values provided for post-installed anchors under Condition B without supplementary reinforcement as defined in ACI 318-14 17.3.3. For cases where the presence of supplementary reinforcement can be verified, the reduction factors associated with Condition A may be used. Temperature range B: Maximum short term temperature = 130°F(55°C), maximum long term temperature = 110°F(43°C). Short term elevated concrete temperatures are those that occur over brief intervals, e.g., as a result of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.

[5] Bond strength values corresponding to concrete compressive strength f'_c = 2500 Psi. For concrete compressive strength, f'_c, between 2500 Psi and 8000 Psi, the tabulated characteristic bond strength may be increased by a factor of $(f'_c/2500)^{0.15}$

[6] d_0 = drilled hole diameter, see figure 4.

[7] See Figure 4.

Table 16 - Hilti RE 10 adhesive design strength with concrete / bond failure for threaded rod in uncracked concrete [1,2,3,4,5,6,7,8]

Nominal anchor diameter in.	Effective embedment in. (mm)	Tension - ΦN_n				Shear - ΦV_n			
		f'_c=2500 psi (17.2 Mpa) lb (kN)	f'_c=3000 psi (20.7 Mpa) lb (kN)	f'_c=4000 psi (17.2 Mpa) lb (kN)	f'_c=6000 psi (41.4 Mpa) lb (kN)	f'_c=2500 psi (17.2 Mpa) lb (kN)	f'_c=3000 psi (20.7 Mpa) lb (kN)	f'_c=4000 psi (17.2 Mpa) lb (kN)	f'_c=6000 psi (41.4 Mpa) lb (kN)
3/8	2-3/8 (60)	1,915 (8.5)	1,955 (8.7)	2,010 (8.9)	2,095 (9.3)	2,440 (10.9)	2,485 (11.1)	2,560 (11.4)	2,665 (11.9)
	3-3/8 (86)	2,725 (12.1)	2,775 (12.3)	2,855 (12.7)	2,975 (13.2)	6,935 (30.8)	7,065 (31.4)	7,270 (32.3)	7,570 (33.7)
	4-1/2 (114)	3,635 (16.2)	3,700 (16.5)	3,810 (16.9)	3,965 (17.6)	9,250 (41.1)	9,420 (41.9)	9,695 (43.1)	10,095 (44.9)
	7-1/2 (190)	6,055 (26.9)	6,165 (27.4)	6,345 (28.2)	6,610 (29.4)	15,415 (68.6)	15,695 (69.8)	16,155 (71.9)	16,825 (74.8)
1/2	2-3/4 (70)	2,830 (12.6)	2,880 (12.8)	2,965 (13.2)	3,090 (13.7)	7,205 (32.0)	7,335 (32.6)	7,550 (33.6)	7,860 (35.0)
	4-1/2 (114)	4,630 (20.6)	4,715 (21.0)	4,855 (21.6)	5,055 (22.5)	11,785 (52.4)	12,005 (53.4)	12,355 (55.0)	12,865 (57.2)
	6 (152)	6,175 (27.5)	6,285 (28.0)	6,470 (28.8)	6,740 (30.0)	15,715 (69.9)	16,005 (71.2)	16,470 (73.3)	17,155 (76.3)
	10 (254)	10,290 (45.8)	10,480 (46.6)	10,785 (48.0)	11,230 (50.0)	26,190 (116.5)	26,675 (118.7)	27,450 (122.1)	28,590 (127.2)
5/8	3-1/8 (79)	3,135 (13.9)	3,195 (14.2)	3,290 (14.6)	3,425 (15.2)	9,280 (41.3)	9,940 (44.2)	10,230 (45.5)	10,650 (47.4)
	5-5/8 (143)	5,645 (25.1)	5,750 (25.6)	5,920 (26.3)	6,165 (27.4)	17,565 (78.1)	17,890 (79.6)	18,410 (81.9)	19,175 (85.3)
	7-1/2 (191)	7,530 (33.5)	7,665 (34.1)	7,890 (35.1)	8,215 (36.5)	23,420 (104.2)	23,850 (106.1)	24,550 (109.2)	25,565 (113.7)
	12-1/2 (318)	12,545 (55.8)	12,780 (56.8)	13,150 (58.5)	13,695 (60.9)	39,035 (173.6)	39,750 (176.8)	40,915 (182.0)	42,605 (189.5)
3/4	3-1/2 (89)	4,015 (17.9)	4,090 (18.2)	4,210 (18.7)	4,385 (19.5)	11,000 (48.9)	12,050 (53.6)	13,095 (58.2)	13,635 (60.7)
	6-3/4 (171)	7,745 (34.5)	7,960 (35.4)	8,310 (37.0)	8,830 (39.3)	24,090 (107.2)	24,760 (110.1)	25,850 (115.0)	27,475 (122.2)
	9 (229)	10,325 (45.9)	10,610 (47.2)	11,080 (49.3)	11,775 (52.4)	32,120 (142.9)	33,015 (146.9)	34,470 (153.3)	36,630 (162.9)
	15 (381)	17,210 (76.6)	17,685 (78.7)	18,465 (82.1)	19,625 (87.3)	53,535 (238.1)	55,020 (244.7)	57,450 (255.5)	61,050 (271.6)
7/8	3-1/2 (89)	4,455 (19.8)	4,580 (20.4)	4,780 (21.3)	5,080 (22.6)	11,000 (48.9)	12,050 (53.6)	13,915 (61.9)	15,805 (70.3)
	7-7/8 (200)	10,025 (44.6)	10,300 (45.8)	10,755 (47.8)	11,430 (50.8)	31,185 (138.7)	32,050 (142.6)	33,465 (148.9)	35,560 (158.2)
	10-1/2 (267)	13,365 (59.5)	13,735 (61.1)	14,340 (63.8)	15,240 (67.8)	41,580 (185.0)	42,735 (190.1)	44,620 (198.5)	47,415 (210.9)
	17-1/2 (445)	22,275 (99.1)	22,895 (101.8)	23,900 (106.3)	25,400 (113.0)	69,300 (308.3)	71,220 (316.8)	74,365 (330.8)	79,025 (351.5)
1	4 (102)	5,510 (24.5)	5,660 (25.2)	5,910 (26.3)	6,280 (27.9)	13,440 (59.8)	14,725 (65.5)	17,000 (75.6)	19,540 (86.9)
	9 (229)	12,395 (55.1)	12,735 (56.6)	13,300 (59.2)	14,130 (62.9)	38,555 (171.5)	39,625 (176.3)	41,370 (184.0)	43,965 (195.6)
	12 (305)	16,525 (73.5)	16,980 (75.5)	17,730 (78.9)	18,840 (83.8)	51,405 (228.7)	52,830 (235.0)	55,160 (245.4)	58,620 (260.8)
	20 (508)	27,540 (122.5)	28,305 (125.9)	29,550 (131.4)	31,405 (139.7)	85,680 (381.1)	88,055 (391.7)	91,935 (408.9)	97,700 Tqable 16
1-1/4	5 (127)	7,635 (34.0)	7,845 (34.9)	8,190 (36.4)	8,705 (38.7)	18,785 (83.6)	20,575 (91.5)	23,760 (105.7)	27,085 (120.5)
	11-1/4 (286)	17,175 (76.4)	17,655 (78.5)	18,430 (82.0)	19,585 (87.1)	53,440 (237.7)	54,920 (244.3)	57,340 (255.1)	60,940 (271.1)
	15 (381)	22,900 (101.9)	23,535 (104.7)	24,575 (109.3)	26,115 (116.2)	71,250 (316.9)	73,225 (325.7)	76,455 (340.1)	81,250 (361.4)
	20 (508)	30,535 (135.8)	31,385 (139.6)	32,765 (145.7)	34,820 (154.9)	95,000 (422.6)	97,635 (434.3)	101,940 (453.4)	108,335 (481.9)

[1] See Section 3.1.8 of Hilti Product Technical Guide 17 Volume 2 for explanation on development of load values.

[2] See Section 3.1.8.6 of Hilti Product Technical Guide 17 Volume 2 to convert design strength value to ASD value.

[3] Linear interpolation between embedment depths and concrete compressive strengths is not permitted.

[4] Apply spacing, edge distance, and concrete thickness factors in tables 18-23 as necessary. Compare to the steel values in table 17. The lesser of the values is to be used for the design.

[5] Data is for maximum short term temperature = 130°F (55°C), maximum long term temperature = 110°F (43°C). Short term elevated concrete temperatures are those that occur over brief intervals, e.g., as a result of diurnal cycling. Long term concrete temperatures are roughly constant over significant periods of time.

[6] Tabular values are for dry concrete or water-saturated concrete conditions.

[7] Tabular values are for short term loads only. For sustained loads including overhead use, see Section 3.1.8.8 of Hilti Product Technical Guide 17 Volume 2.

[8] Tabular values are for normal weight concrete only. For lightweight concrete multiply design strength by λ_a as follows: For sand-lightweight, λ_a = 0.51. For all-lightweight, λ_a = 0.45.

Table 18 - Load adjustment factors for 3/8-in. diameter threaded rods in uncracked concrete [1,2,3]

3/8-in. uncracked concrete	Spacing factor in tension f_{AN}				Edge distance factor in tension f_{RN}				Spacing factor in shear [4] f_{AV}				Edge distance in shear ⊥ Toward edge f_{RV}				Edge distance in shear ∥ To edge f_{RV}				Concrete thickness factor in shear [5] f_{HV}			
Embedment in h_{ef} (mm) Spacing (s) / edge distance (ca) / concrete thickness (h), - in (mm)	2-3/8 (60)	3-3/8 (86)	4-1/2 (114)	7-1/2 (191)	2-3/8 (60)	3-3/8 (86)	4-1/2 (114)	7-1/2 (191)	2-3/8 (60)	3-3/8 (86)	4-1/2 (114)	7-1/2 (191)	2-3/8 (60)	3-3/8 (86)	4-1/2 (114)	7-1/2 (191)	2-3/8 (60)	3-3/8 (86)	4-1/2 (114)	7-1/2 (191)	2-3/8 (60)	3-3/8 (86)	4-1/2 (114)	7-1/2 (191)
1-3/4 (44)	n/a	n/a	n/a	n/a	0.43	0.32	0.23	0.13	n/a	n/a	n/a	n/a	0.29	0.11	0.08	0.05	0.43	0.21	0.16	0.10	n/a	n/a	n/a	n/a
1-7/8 (48)	0.61	0.59	0.57	0.54	0.45	0.33	0.24	0.14	0.58	0.54	0.53	0.52	0.32	0.12	0.09	0.05	0.45	0.24	0.18	0.11	n/a	n/a	n/a	n/a
2 (51)	0.62	0.60	0.57	0.54	0.46	0.34	0.24	0.14	0.58	0.54	0.54	0.53	0.35	0.13	0.10	0.06	0.46	0.26	0.19	0.12	n/a	n/a	n/a	n/a
3 (76)	0.68	0.65	0.61	0.57	0.60	0.42	0.31	0.18	0.62	0.56	0.55	0.54	0.65	0.24	0.18	0.11	0.60	0.42	0.31	0.18	n/a	n/a	n/a	n/a
3-5/8 (92)	0.71	0.68	0.63	0.58	0.69	0.48	0.35	0.20	0.65	0.58	0.56	0.55	0.86	0.32	0.24	0.14	0.69	0.48	0.35	0.20	0.78	n/a	n/a	n/a
4 (102)	0.73	0.70	0.65	0.59	0.76	0.52	0.38	0.22	0.67	0.59	0.57	0.55	1.00	0.37	0.28	0.17	0.76	0.52	0.38	0.22	0.82	n/a	n/a	n/a
4-5/8 (117)	0.77	0.73	0.67	0.60	0.88	0.59	0.43	0.25	0.69	0.60	0.58	0.56		0.46	0.34	0.21	0.88	0.59	0.43	0.25	0.88	0.63	n/a	n/a
5 (127)	0.79	0.75	0.69	0.61	0.96	0.64	0.46	0.27	0.71	0.61	0.59	0.56		0.51	0.38	0.23	0.96	0.64	0.46	0.27	0.91	0.65	n/a	n/a
5-3/4 (146)	0.84	0.78	0.71	0.63	1.00	0.73	0.53	0.31	0.74	0.62	0.60	0.57		0.63	0.47	0.28	1.00	0.73	0.53	0.31	0.98	0.70	0.64	n/a
6 (152)	0.85	0.80	0.72	0.63		0.77	0.56	0.32	0.75	0.63	0.61	0.58		0.67	0.51	0.30		0.77	0.56	0.32	1.00	0.72	0.65	n/a
7 (178)	0.91	0.85	0.76	0.66		0.89	0.65	0.38	0.79	0.65	0.62	0.59		0.85	0.64	0.38		0.89	0.65	0.38		0.77	0.70	n/a
8 (203)	0.97	0.90	0.80	0.68		1.00	0.74	0.43	0.83	0.67	0.64	0.60		1.00	0.78	0.47		1.00	0.74	0.43		0.83	0.75	n/a
8-3/4 (222)	1.00	0.93	0.82	0.69			0.81	0.47	0.86	0.69	0.65	0.61			0.89	0.53			0.81	0.47		0.86	0.79	0.66
10 (254)		0.99	0.87	0.72			0.93	0.54	0.92	0.71	0.68	0.63			1.00	0.65			0.93	0.54		0.92	0.84	0.71
12 (305)		1.00	0.94	0.77			1.00	0.65	1.00	0.76	0.71	0.65				0.86			1.00	0.65		1.00	0.92	0.78
14 (356)			1.00	0.81				0.75		0.80	0.75	0.68				1.00				0.75			0.99	0.84
16 (406)				0.86				0.86		0.84	0.78	0.70								0.86			1.00	0.90
18 (457)				0.90				0.97		0.88	0.82	0.73								0.97				0.95
24 (610)				1.00				1.00		1.00	0.92	0.80								1.00				1.00
30 (762)											1.00	0.88												
> 48 (1219)												1.00												

[1] Linear interpolation not permitted

[2] Shaded area with reduced edge distance is permitted provided the installation torque is reduced to 0.30 T_{max} for 5d < s < 16-in. and to 0.5 T_{max} for s > 16-in.

[3] When combining multiple load adjustment factors (e.g. for a four-anchor pattern in a corner with thin concrete member) the design can become very conservative. To optimize the design, perform anchor calculation using design equations from ACI 318 Chapter 17.

[4] Spacing factor reduction in shear applicable when $c < 3^{*}h_{ef}$. f_{AV} is applicable when edge distance, $c < 3^{*}h_{ef}$. If $c \geq 3^{*}h_{ef}$, then $f_{AV} = f_{AN}$.

[5] Concrete thickness reduction factor in shear, f_{HV}, is applicable when edge distance, $c < 3^{*}h_{ef}$. If $c \geq 3^{*}h_{ef}$, then $f_{HV} = 1.0$.

Table 19 - Load adjustment factors for 1/2-in. diameter threaded rods in uncracked concrete [1,2,3]

1/2-in. uncracked concrete	Spacing factor in tension f_{AN}				Edge distance factor in tension f_{RN}				Spacing factor in shear [4] f_{AV}				Edge distance in shear ⊥ Toward edge f_{RV}				Edge distance in shear ∥ To edge f_{RV}				Concrete thickness factor in shear [5] f_{HV}			
Embedment in h_{ef} (mm) Spacing (s) / edge distance (ca) / concrete thickness (h), - in (mm)	2-3/4 (70)	4-1/2 (114)	6 (152)	10 (254)	2-3/4 (70)	4-1/2 (114)	6 (152)	10 (254)	2-3/4 (70)	4-1/2 (114)	6 (152)	10 (254)	2-3/4 (70)	4-1/2 (114)	6 (152)	10 (254)	2-3/4 (70)	4-1/2 (114)	6 (152)	10 (254)	2-3/4 (70)	4-1/2 (114)	6 (152)	10 (254)
1-3/4 (44)	n/a	n/a	n/a	n/a	0.40	0.27	0.20	0.12	n/a	n/a	n/a	n/a	0.11	0.07	0.05	0.03	0.22	0.14	0.11	0.06	n/a	n/a	n/a	n/a
2-1/2 (64)	0.61	0.59	0.57	0.54	0.48	0.32	0.23	0.14	0.55	0.54	0.53	0.52	0.19	0.12	0.09	0.06	0.37	0.25	0.18	0.11	n/a	n/a	n/a	n/a
3 (76)	0.64	0.61	0.58	0.55	0.54	0.35	0.26	0.15	0.57	0.55	0.54	0.53	0.25	0.16	0.12	0.07	0.49	0.32	0.24	0.15	n/a	n/a	n/a	n/a
4 (102)	0.68	0.65	0.61	0.57	0.66	0.41	0.30	0.18	0.59	0.57	0.55	0.54	0.38	0.25	0.19	0.11	0.66	0.41	0.30	0.18	0.59	n/a	n/a	n/a
5 (127)	0.73	0.69	0.64	0.58	0.82	0.48	0.36	0.21	0.61	0.58	0.57	0.55	0.53	0.35	0.26	0.16	0.82	0.48	0.36	0.21	0.66	n/a	n/a	n/a
6 (152)	0.77	0.72	0.67	0.60	0.98	0.57	0.42	0.24	0.63	0.60	0.58	0.56	0.70	0.46	0.34	0.21	0.98	0.57	0.42	0.24	0.72	0.63	n/a	n/a
7 (178)	0.82	0.76	0.69	0.62	1.00	0.66	0.49	0.28	0.65	0.62	0.60	0.57	0.88	0.58	0.43	0.26	1.00	0.66	0.49	0.28	0.78	0.68	n/a	n/a
8 (203)	0.86	0.80	0.72	0.63		0.76	0.56	0.32	0.67	0.63	0.61	0.58	1.00	0.71	0.53	0.32		0.76	0.56	0.32	0.84	0.73	0.66	n/a
10 (254)	0.95	0.87	0.78	0.67		0.95	0.69	0.41	0.72	0.67	0.64	0.60		0.99	0.74	0.44		0.95	0.69	0.41	0.93	0.81	0.74	n/a
11-1/4(286)	1.00	0.92	0.81	0.69		1.00	0.78	0.46	0.75	0.69	0.65	0.61		1.00	0.88	0.53		1.00	0.78	0.46	0.99	0.86	0.78	0.661
12 (305)		0.94	0.83	0.70			0.83	0.49	0.76	0.70	0.66	0.62			0.97	0.58			0.83	0.49	1.00	0.89	0.81	0.682
14 (356)		1.00	0.89	0.73			0.97	0.57	0.81	0.73	0.69	0.64			1.00	0.74			0.97	0.57		0.96	0.87	0.737
16 (406)			0.94	0.77			1.00	0.65	0.85	0.76	0.72	0.66				0.90			1.00	0.65		1.00	0.93	0.788
18 (457)			1.00	0.80				0.73	0.89	0.80	0.75	0.67				1.00				0.73			0.99	0.836
20 (508)				0.83				0.81	0.94	0.83	0.77	0.69								0.81			1.00	0.881
22 (559)				0.87				0.89	0.98	0.86	0.80	0.71								0.89				0.924
24 (610)				0.90				0.97	1.00	0.90	0.83	0.73								0.97				0.965
30 (762)				1.00				1.00		1.00	0.91	0.79								1.00				1.000
36 (914)											0.99	0.85												
> 48 (1219)											1.00	0.97												

[1] Linear interpolation not permitted

[2] Shaded area with reduced edge distance is permitted provided the installation torque is reduced to 0.30 T_{max} for 5d < s < 16-in. and to 0.5 T_{max} for s > 16-in.

[3] When combining multiple load adjustment factors (e.g. for a four-anchor pattern in a corner with thin concrete member) the design can become very conservative. To optimize the design, perform anchor calculation using design equations from ACI 318 Chapter 17.

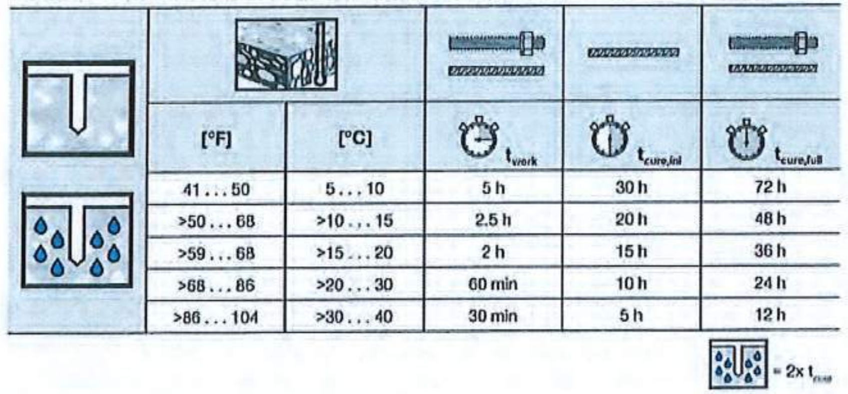
[4] Spacing factor reduction in shear applicable when $c < 3^{*}h_{ef}$. f_{AV} is applicable when edge distance, $c < 3^{*}h_{ef}$. If $c \geq 3^{*}h_{ef}$, then $f_{AV} = f_{AN}$.

[5] Concrete thickness reduction factor in shear, f_{HV}, is applicable when edge distance, $c < 3^{*}h_{ef}$. If $c \geq 3^{*}h_{ef}$, then $f_{HV} = 1.0$.

INSTALLATION INSTRUCTIONS

Installation Instructions For Use (IFU) are included with each product package. They can also be viewed or downloaded online at www.hilti.com (US) and www.hilti.ca (Canada). Because of the possibility of changes, always verify that downloaded IFU are current when used. Proper installation is critical to achieve full performance. Training is available on request. Contact Hilti Technical Services for applications and conditions not addressed in the IFU.

Figure 6 – HIT-RE 10 adhesive cure and working time (approx.)



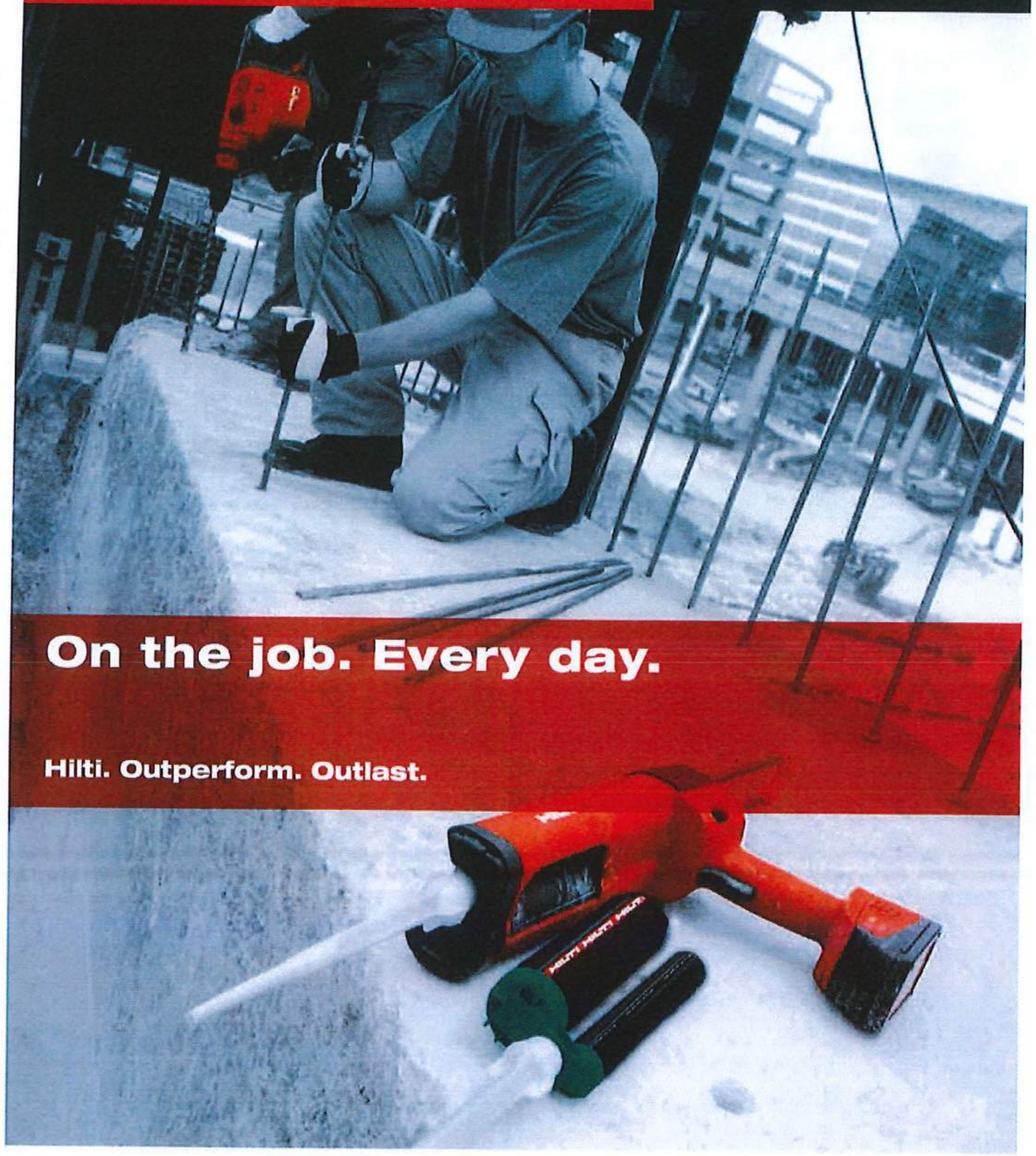
[°F]	[°C]	t_{work}	$t_{cure,ini}$	$t_{cure,full}$
41 . . . 50	5 . . . 10	5 h	30 h	72 h
>50 . . . 68	>10 . . . 15	2.5 h	20 h	48 h
>59 . . . 68	>15 . . . 20	2 h	15 h	36 h
>68 . . . 86	>20 . . . 30	60 min	10 h	24 h
>86 . . . 104	>30 . . . 40	30 min	5 h	12 h

= 2x t_{cure}

ORDERING INFORMATION

Description	Package contents
HIT-RE 10 (19.6 fl. oz./580 ml)	Includes (1) cartridge with (1) mixer and filler tube
HIT-RE 10 (19.6 fl. oz./580 ml) MC	Includes (1) Master Carton with (12) cartridges with mixers and filler tube
HIT-RE 10 (19.6 fl. oz./580 ml) 18MC	Includes (18) Master Cartons with (12) cartridges each and mixers and filler tube
HIT-RE 10 (19.6 fl. oz./580 ml) (9MC) + HDM 500	Includes (9) master cartons with (12) cartridges each with (1) mixer and filler tube and (1) HDM 500 Manual dispenser
HIT-RE 10 (19.6 fl. oz./580 ml) (18MC) + HDM 500	Includes (18) master cartons with (12) cartridges each with mixers and filler tube and (1) HDM 500 Manual dispenser
HIT-RE 10 (19.6 fl. oz./580 ml) (18MC) + HDE 500	Includes (18) master cartons with (12) cartridges each with mixers and filler tube and (1) HDM 500 Battery dispenser

HIT-HY 10 PLUS
Adhesive Anchor



On the job. Every day.

Hilti. Outperform. Outlast.

An economical solution for multiple base materials.

HIT-HY 10 PLUS Adhesive Anchoring System

Hilti has you covered with the latest addition to the anchoring portfolio: The new Hilti HIT-HY 10 PLUS Adhesive Anchor System. This new adhesive can be used in a variety of base materials including concrete, grouted CMU, hollow brick and CMU*. HIT-HY 10 PLUS is an economical solution when an ICC Evaluation Report is not required and the versatility makes it great for many jobsite conditions. It is a high-value, everyday adhesive that is easy to dispense with the same dispensers as the rest of the Hilti adhesive portfolio (MD 2500 manual dispenser and ED 3500-A battery dispenser).

Order Information

Description	Package Contents	Qty of Foil Packs	Item No.
HIT-HY 10 PLUS (11.1 fl oz/330 ml)	Includes 1 foil pack with 1 mixer and 3/8" filler tube per pack	1	00422710
HIT-HY 10 PLUS (16.9 fl oz/330 ml)	Includes 20 foil packs with 1 mixer and 3/8" filler tube per pack	20	00422711

Composite Mesh Sleeves for Hollow Masonry and Brick Material

Description	For use with:	Qty	Item No.
Mesh Sleeve HIT-SC 12x50	1/4" dia. rods	20	00375979
Mesh Sleeve HIT-SC 12x85	1/4" dia. rods	20	00375980
Mesh Sleeve HIT-SC 16x50	5/16", 3/8" dia. rods and 5/16" HIT-IC rods	20	00375981
Mesh Sleeve HIT-SC 16x85	5/16", 3/8" dia. rods and 5/16" HIT-IC rods	20	00375982
Mesh Sleeve HIT-SC 18x50	1/2" dia. rods	20	00360485
Mesh Sleeve HIT-SC 18x85	1/2" dia. rods	20	00360486

Applications

- Slab extension through doweling
- Sign, fence or awning attachment to masonry or concrete
- Scaffolding, pipe or fixture attachment to masonry or concrete
- Small hole filling where anchors have been removed

Outperform and Outlast

- Works in a variety of base materials acting as a universal anchor adhesive
- Cures in approximately 45 minutes at 70°F providing quick installation times to finish the job earlier
- Achieve various embedment depths by combining mesh sleeves to customize lengths in hollow base materials
- Rebar and threaded rod tested in a wide variety of depths and diameter sizes to solve the application needs on a jobsite

Technical Data	HIT-HY 10 PLUS
Product	Hybrid Urethane Methacrylate
Base material temperature	32° F to 104° F (0° C to 40° C)
Diameter range	3/8" to 3/4"

Package volume
- Volume of HIT-HY 10 PLUS 11.1 fl oz/330 ml foil pack is 20.1 in³
- Volume of HIT-HY 10 PLUS 16.9 fl oz/500 ml foil pack is 30.5 in³

*For hollow brick and CMU, composite sleeves are required. See catalog for full ordering information.

HIT-HY 10 PLUS Adhesive Anchor System

1.1 Product Description

Hilti HIT-HY 10 PLUS is a new hybrid adhesive mortar combining resin, hardener, cement and water. It's formulated for fast curing and easy installation in a wide range of solid and hollow concrete and masonry base material with temperatures during installation from 32°F (0°C) up to 104°F (40°C). HIT-HY 10 PLUS is styrene free and virtually odorless.

HIT-HY 10 PLUS Adhesive Anchor System is easy to use in a wide variety of applications. The system consists of a side-by-side self opening adhesive cartridge which fits all Hilti MD and ED dispensers, a mixing nozzle which comes with every cartridge, and either a threaded rod or rebar (purchased separately).

HIT-HY 10 PLUS is designed for fastenings into solid base materials, such as concrete, and is also suitable for fastening into base materials containing voids and holes such as hollow block and clay brick with holes when used with a screen tube.

Features	Benefits
For virtually all base materials	Good performance from one product for many applications
Reusable	Open cartridges may be stored for up to 20 days by leaving the mixer attached
Easy to use	Low dispensing forces
Suitable for dry and saturated base materials	Application versatility
Suitable for in-service temperatures up to 122°F (long term) and 176°F (short term)	Flexibility for use in demanding environments

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1.2 Material Specifications

Material Specifications	Mechanical Properties			
	f_y ksi (MPa)		min. f_u ksi (MPa)	
Standard threaded rod, ASTM A 36, 9SMNPB36K and/or 9SMN36K conforming to DIN 1651.	36	(248)	58	(400)
HAS-E Rod material meets the requirements of ISO 898 Class 5.8	58	(400)	72.5	(500)
HAS-H Rod material meet the requirements of ASTM A 193 Grade B7	105	(724)	125	(862)
Stainless HAS rod material meets the requirements of ASTM F 593 (AISI 304) Condition CW 3/8"-5/8"	65	(448)	100	(689)
Stainless HAS rod material meets the requirements of ASTM F 593 (AISI 304) Condition CW 3/4"	45	(310)	85	(586)
HAS-E Standard Nut Material meets the requirements of SAE J995 Grade 5				
HAS Stainless Steel Nut material meets the requirements of ASTM F 594				
HAS-E Carbon Steel and Stainless Steel Washers meet dimensional requirements of ANSI B18.22.1 Type A Plain				
HAS Stainless Steel Washers meet the requirements of AISI 304 or AISI 316 conforming to ASTM A 240				
HAS-E Standard Washers meet the requirements of ASTM F 884, HV				
All HAS-H and HAS-E rods, nuts & washers are zinc plated to ASTM B 633 SC 1				

1.3 Technical Data

HIT-HY 10 PLUS Allowable Bond/Concrete Capacity and Steel Strength for HAS / Threaded Rods in Normal Weight Concrete [1,2,3,4]

Anchor Diameter in. (mm)	Embedment Depth in. (mm)	HIT-HY 10 PLUS Allowable Bond/Concrete Capacity		Allowable Bolt Strength[4]			
		$f'_c \geq 2500$ psi (≥17 MPa)		HAS-E Standard Carbon Steel		HAS-SS AISI (304/316) Stainless Steel	
		Tensile lb (kN)	Shear lb (kN)	Tensile lb (kN)	Shear lb (kN)	Tensile lb (kN)	Shear lb (kN)
3/8 (9.5)	2-1/4 (57)	750 (3.3)	1325 (5.9)	2640 (11.7)	1360 (6.0)	3645 (16.2)	1880 (8.4)
	3-3/8 (86)	1985 (8.8)	3135 (13.9)				
	4-1/2 (114)	2140 (9.5)	4820 (21.4)				
1/2 (12.7)	3 (76)	1405 (6.2)	2730 (12.1)	4700 (20.9)	2420 (10.8)	6480 (28.8)	3340 (14.9)
	4-1/2 (114)	3530 (15.7)	5570 (24.8)				
	6 (152)	4295 (19.1)	8575 (38.1)				
5/8 (15.9)	3-3/4 (95)	1925 (8.6)	4065 (18.1)	7340 (32.6)	3780 (16.8)	10125 (45.0)	5215 (23.2)
	5-5/8 (143)	4290 (19.1)	8580 (38.2)				
	7-1/2 (191)	5715 (25.4)	11430 (50.8)				
3/4 (19.1)	4-1/2 (114)	2740 (12.2)	6065 (27.0)	10570 (47.0)	5445 (24.2)	12390 (55.1)	6385 (28.4)
	7-1/2 (191)	5880 (26.2)	11760 (52.3)				
	9 (229)	7055 (31.4)	14110 (62.8)				

[1] Concrete/bond values above to be compared to the steel value. The lesser of the values is to be used for the design.
[2] Allowable concrete tension and shear capacity based on the Strength Design method.
[3] All values based on holes drilled with the specified carbide bit.
[4] Steel strength as defined in AISC Manual of Steel Construction (ASD):
Tensile - 0.33 x F_u x Nominal Area
Shear - 0.17 x F_u x Nominal Area

HIT-HY 10 PLUS Anchor Spacing and Edge Distance Guideliness for Normal Weight Concrete [1]

Spacing
Tension and Shear
$s_{min} = 3.0\ h_{ef}$

Edge Distance
Tension and Shear
$c_{min} = 2.0\ h_{ef}$

[1] Minimum anchor spacing and edge distance necessary to have no reduction in anchor capacity, where h_{ef} is the effective embedment of the anchor.

TIGERSUPPLIES

« Back | Surveying Equipment >> Field Supplies >> Monuments and Accessories

AdirPro 791-02 2" Flat Brass Survey Marker

By AdirPro | MFR#: 791-02 | TIGER#: TS68362

1 Review Write a Review Ask a Question

ADIRpro AUTHORIZED DEALER

Propose Survey Marker

Highlights

- Stem length of 2"
- Head thickness: 1/8"
- Ribbed shank to prevent loosening
- Shank area: 0.4 sq. in
- Non-glare finish for easy visibility
- Allows hand stamping in the field
- Solid brass construction

More Product Details What's Included

List Price: ~~$17.95~~

$7.26

You Save: $10.69 - 60%

- **Select Head Diameter & Style**

○ 1-3/8" Flat
○ 2" Domed
● 2" Flat
○ 2" Flat (6-Pack)
○ 3" Flat (DISCONTINUED)
○ 3" Flat (6-Pack) (DISCONTINUED)

1 Add to cart

IN STOCK
Free Shipping (USA)
Ships Out Within: 24 - 48 Hours
Shipping Date By: 11/10/2021

⚠ **California Proposition 65 Warning.** This product can expose you to chemicals including lead, which are known to the State of California to cause cancer and birth defects or other reproductive harm. For more information go to www.P65Warnings.ca.gov

Overview Features In The Box Specifications Warranty/Return
Customer Reviews

Overview for the 791-02 2" Flat Brass Survey Marker

The AdirPro Brass Survey Marker is a durable marker that can be installed in freshly poured concrete or inserted into a drilled hole to be held in by epoxy. Made of solid brass material, it is tough and long-lasting. Its non-glare, yellow gold finish ensures easy visibility making it ideal for construction and surveying applications.

This survey marker by AdirPro features a flat or domed head with 1/8-inch thickness. It is available in 1-3/8-inch, two-inch, or three-inch head diameter and is equipped with a two inches long stem. It has a shank area of 0.4 square inches. To prevent unnecessary turning or loosening, it features a ribbed shank.

The AdirPro Brass Survey Marker can be hand-stamped in the field. It also includes a one-year manufacturer's warranty for guaranteed reliable service.

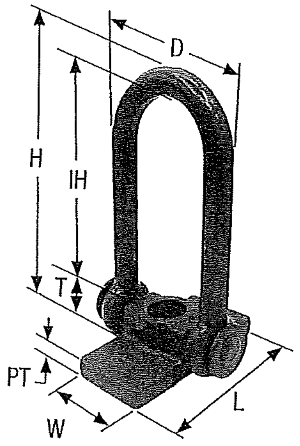
Configuration Options

The AdirPro Brass Survey Marker comes in three head sizes and two style options to suit most surveying and construction needs. Please select your preference from the menu above.

- **791-01: 1-3/8" Flat Head**
- **791-04: 2" Domed Head**
- **791-02: 2" Flat Head**
- **791-02-6: 2" Flat Head (6-Pack)**
- **791-03: 3" Flat Head**
- **791-03-6: 3" Flat Head (6-Pack)**

4.7 ★★★★★
Google
Customer Reviews

CL-12 SINGLE SWIVEL LIFT PLATE

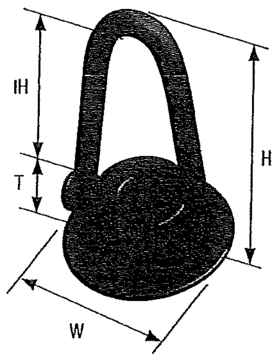


Manufactured from forged steel and designed for use with single lifting inserts for either face lifting or edge lifting applications. The SWL is achieved provided that it has full bearing on smooth, flat concrete, and a washer installed underneath the bolt head. Note that this Swivel Lifting Plate is designed for use only with 3/4" or 1" bolt diameters.

SINGLE SWIVEL LIFT PLATE DIMENSIONS AND LOAD CHART

Part Number	Bolt Diameter	H Overall Height	IH Inside Height	L Length	W Width	D	T Thickness	PT - Plate Thickness	Minimum Bolt Length	5:1 SWL (lbs)	Weight (lbs)
CL1234	3/4"	8-1/8"	5-7/8"	5"	2-1/2"	4-1/4"	1-1/2"	9/16"	4"	11,000	5.68
CL1201	1"	8-1/8"	5-7/8"	5"	2-1/2"	4-1/4"	1-1/2"	9/16"	5"	11,000	5.53

CL-26 DOUBLE SWIVEL LIFT PLATE



Lifting Plate will permit rotation of the ball in the direction of the applied load. The bail portion will rotate a full 360° in a horizontal plane and will swivel 180° in a vertical place. Designed for use only with 1", 1-1/4" and 1-1/2" coil bolts.

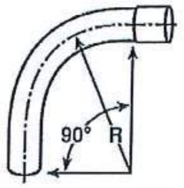
DOUBLE SWIVEL LIFT PLATE DIMENSIONS AND LOAD CHART

Part Number	Bolt Diameter	H Overall Height	IH Inside Height	W Width	T Thickness	5:1 SWL (lbs)	Weight (lbs)
CL261	1"	8-1/2"	5-1/2"	5"	1-29/32"	10,000	8.63
CL26114	1-1/4"	9"	5-1/2"	7"	2-3/8"	15,000	16.94
CL26112	1-1/2"	9"	5-1/2"	7"	2-3-8"	15,000*	16.79

* Higher capacity swivel lift plate available upon request.

Prime Conduit, Inc.

Schedule 40 PVC Elbows – 90° Special Radius



Part Number	Trade Size	Type	Radius"B"	EACH UPC
UA9CF	1"	PLAIN END	18"	670648067101
UA9CFB	1"	BELL END	18"	670648227239
UA9DF	1"	PLAIN END	24"	670648067415
UA9DFB	1"	BELL END	24"	670648227314
UA9EF	1"	PLAIN END	30"	670648067255
UA9EFB	1"	BELL END	30"	670648079470
UA9FF	1"	PLAIN END	36"	670648067323
UA9HF	1"	PLAIN END	48"	670648067453
UA9CG	1-1/4"	PLAIN END	18"	670648227253
UA9CGB	1-1/4"	BELL END	18"	670648196504
UA9DG	1-1/4"	PLAIN END	24"	670648068061
UA9DGB	1-1/4"	BELL END	24"	670648196559
UA9EG	1-1/4"	PLAIN END	30"	670648067309
UA9EGB	1-1/4"	BELL END	30"	670648055009
UA9FG	1-1/4"	PLAIN END	36"	670648067507
UA9FGB	1-1/4"	BELL END	36"	670648196702
UA9HG	1-1/4"	PLAIN END	48"	670648067460
UA9BHB	1-1/2"	BELL END	12"	670648967296
UA9CH	1-1/2"	PLAIN END	18"	670648067125
UA9CHB	1-1/2"	BELL END	18"	670648196511
UA9DH	1-1/2"	PLAIN END	24"	670648067118
UA9DHB	1-1/2"	BELL END	24"	670648196566
UA9EH	1-1/2"	PLAIN END	30"	670648067316
UA9EHB	1-1/2"	BELL END	30"	670648055184
UA9FH	1-1/2"	PLAIN END	36"	670648068139
UA9FHB	1-1/2"	BELL END	36"	670648196719
UA9HH	1-1/2"	PLAIN END	48"	670648067477
UA9CJ	2"	PLAIN END	18"	670648067408
UA9CJB	2"	BELL END	18"	670648196528
UA9DJ	2"	PLAIN END	24"	670648967166
UA9DJB	2"	BELL END	24"	670648196573
UA9EJ	2"	PLAIN END	30"	670648067170
UA9EJB	2"	BELL END	30"	670648196641
UA9FJ	2"	PLAIN END	36"	670648067187
UA9FJB	2"	BELL END	36"	670648196726
UA9HJ	2"	PLAIN END	48"	670648067194
UA9HJB	2"	BELL END	48"	670648196818
UA9JJ	2"	PLAIN END	72"	670648227741
UA9CK	2-1/2"	PLAIN END	18"	670648067149
UA9CKB	2-1/2"	BELL END	18"	670648196535
UA9DK	2-1/2"	PLAIN END	24"	670648167214
UA9DKB	2-1/2"	BELL END	24"	670648196580
UA9EK	2-1/2"	PLAIN END	30"	670648067224
UA9EKB	2-1/2"	BELL END	30"	670648196658
UA9FK	2-1/2"	PLAIN END	36"	670648067231
UA9FKB	2-1/2"	BELL END	36"	670648196733
UA9HK	2-1/2"	PLAIN END	48"	670648067248
UA9HKB	2-1/2"	BELL END	48"	670648196825
UA9CL	3"	PLAIN END	18"	670648067156
UA9CLB	3"	BELL END	18"	670648196542
UA9DL	3"	PLAIN END	24"	670648227383
UA9DLB	3"	BELL END	24"	670648196597
UA9EL	3"	PLAIN END	30"	670648227420
UA9ELB	3"	BELL END	30"	670648196665
UA9FL	3"	PLAIN END	36"	670648067286
UA9FLB	3"	BELL END	36"	670648196740
UA9HL	3"	PLAIN END	48"	670648067293
UA9HLB	3"	BELL END	48"	670648196832
UA9IL	3"	PLAIN END	60"	670648183269
UA9DM	3-1/2"	PLAIN END	24"	670648067200
UA9DMB	3-1/2"	BELL END	24"	670648196603
UA9EM	3-1/2"	PLAIN END	30"	670648067354
UA9EMB	3-1/2"	BELL END	30"	670648055191
UA9FM	3-1/2"	PLAIN END	36"	670648067330
UA9FMB	3-1/2"	BELL END	36"	670648196757
UA9HM	3-1/2"	PLAIN END	48"	670648067347
UA9HMB	3-1/2"	BELL END	48"	670648196849
UA9CNB	4"	BELL END	18"	670648186970
UA9DN	4"	PLAIN END	24"	670648067361
UA9DNB	4"	BELL END	24"	670648196610
UA9EN	4"	PLAIN END	30"	670648067378
UA9ENB	4"	BELL END	30"	670648196689
UA9FN	4"	PLAIN END	36"	670648067385
UA9FNB	4"	BELL END	36"	670648196764
UA9HN	4"	PLAIN END	48"	670648067392
UA9HNB	4"	BELL END	48"	670648196856
UA9IN	4"	PLAIN END	60"	670648227666
UA9INB	4"	BELL END	60"	670648227673
UA9JN	4"	PLAIN END	72"	670648227789
UA9MN	4"	PLAIN END	108"	670648967319
UA9RN	4"	PLAIN END	144"	670648142761
UA9SNB	4"	BELL END	150"	670648967333
UA9VN	4"	PLAIN END	300"	670648142778
UA9EP	5"	PLAIN END	30"	670648067422
UA9EPB	5"	BELL END	30"	670648196696
UA9FP	5"	PLAIN END	36"	670648067439
UA9FPB	5"	BELL END	36"	670648196771
UA9HP	5"	PLAIN END	48"	670648067446
UA9HPB	5"	BELL END	48"	670648196863
UA9IP	5"	PLAIN END	60"	670648227680
UA9IPB	5"	BELL END	60"	670648227697
UA9JP	5"	PLAIN END	72"	670648142754
UA9TP	5"	PLAIN END	180"	670648193817
UA9VP	5"	PLAIN END	300"	670648142785
UA9FR	6"	PLAIN END	36"	670648067484
UA9FRB	6"	BELL END	36"	670648196788
UA9HR	6"	PLAIN END	48"	670648067491
UA9HRB	6"	BELL END	48"	670648196870
UA9IR	6"	PLAIN END	60"	670648227703
UA9IRB	6"	BELL END	60"	670648227710
UA9JRB	6"	BELL END	72"	670648145199
UA9LRB	6"	BELL END	96"	670648967302
UA9MR	6"	PLAIN END	108"	670648967326
UA9RRB	6"	BELL END	144"	670648356236
UA9SR	6"	PLAIN END	150"	670648126334
UA9TRB	6"	BELL END	180"	670648120134
UA9VR	6"	PLAIN END	300"	670648967340

Carton Quantity = 1

II. Engineers Report

TAXIWAY ALPHA WEST RECONSTRUCTION & TAXIWAY BRAVO RECONFIGURATION
(HOT SPOT 1)

Engineer's Report

Memphis International Airport
MSCAA Project No. 18-1413-01 & 18-1413-04

Prepared for:
Memphis Shelby County Airport Authority
2491 Winchester Rd., #113
Memphis, TN 38116

Prepared by:
Allen & Hoshall
1661 International Dr., Suite 100
Memphis, TN 38120
(901) 820-0820

May 8, 2026
(Bravo added October 11, 2024, updated May 8, 2026)

Table of Contents

Appendices

1.0 Introduction

This report has been prepared to supplement the preparation of construction plans and specifications for the reconstruction of Taxiway Alpha West and realignment of Taxiway Bravo located at Memphis International Airport in Shelby County, Tennessee. The owner and project sponsor is the Memphis Shelby County Airport Authority (MSCAA)

Taxiway Alpha is a full-length parallel taxiway located on the south side of Runway 9/27 and this taxiway provides east/west access across the airfield. Taxiway Alpha West provides airfield access to the Signature Ramp FBO. This project consists of the reconstruction of Taxiway Alpha West from east of Taxiway November to just east of the existing Taxiway Bravo Intersection. In conjunction with the Alpha project, Taxiway Bravo (Hot Spot) Reconfiguration was also combined with this project but will be bid separately.

2.0 Description of Work

The Taxiway Alpha West Reconstruction project will include:

- Reconstruction of Taxiway Alpha and the intersections with Taxiways B, C, N, S, and X pavements.
- New 30-foot paved shoulders for Taxiway Alpha, as well as crossing taxiways that are reconstructed due to new intersection geometry.
- Earthwork and grading of the existing ground surface in the Taxiway Safety Area to meet the requirements of Advisory Circular 150/5300-13B
- Replacement of existing airfield edge lights with new flush/inset LED lights
- Replacement of existing taxiway centerline lights with new LED Centerline lights and based on the MSCAA SMGCS system.
- Replacement of existing airfield signage with new LED signage
- Replacement of existing airfield electrical conduit and conductor with new conduit and conductor
- Replacement of herringbone underdrain & edge drain system in taxiway subgrade
- Replacement of stormwater conveyance piping and replacement of culverts underneath the reconstructed taxiway

The Taxiway Bravo Reconfiguration (Hot Spot 1) project will include:

- Realignment of existing Taxiway Bravo from a diagonal connection between Alpha and Sierra to a parallel/perpendicular alignment to eliminate confusion at the intersection of Taxiway Sierra, existing diagonal Bravo, and 18C which has been identified as (Hot Spot 1).
- New 30-foot paved shoulders for Taxiway Bravo and fillet transitions to existing Taxiway Sierra
- Earthwork and grading of the existing ground surface in the Taxiway Safety Area to meet the requirements of Advisory Circular 150/5300-13B
- Replacement of existing airfield edge lights with new flush/inset LED lights

- Replacement of existing taxiway centerline lights with new LED Centerline lights and based on the MSCAA SMGCS system.
- Replace existing LED airfield signage with new LED signage and sign panels where appropriate
- Replacement of existing airfield electrical conduit and conductor with new conduit and conductor
- Replacement of herringbone underdrain & edge drain system in taxiway subgrade

3.0 Existing Topographic Survey

A topographic survey of the Alpha West project area was performed by Geodesy and Allen & Hoshall and will be used for the design of the construction documents. The topographic survey is based on the Tennessee State Plane Coordinate System, NAD 1983. Additional control points were established for the topographic survey and this control point information will be included in the contract documents. The vertical elevation for the topographic survey is based on NAVD 1988.

The field work for the topographic survey included establishing the location of the above ground utility manholes, utility covers and the drainage systems. The field work did not include the investigation of the existing FAA and MSCAA electrical manholes, electrical conduit, underdrains, water utilities or sanitary sewers. MSCAA provided drawing files of the existing underground utility systems and this information will be included in the contract documents.

4.0 Surface Conditions of Existing Pavement

Allen & Hoshall made a site visit to document the existing pavement surface and site conditions on August 5, 2019. The pavement surface condition and various site pictures are included in Appendix A of this report. A&H will request a meeting with the FAA and MSCAA Airfield Electrical for a site visit to verify circuitry and to identify active circuits.

5.0 Subsurface Conditions - Geotechnical

The subsurface investigation for the Alpha West project was performed by KS Ware LLC. The subsurface investigation included 14 borings and 8 pavement cores located in the existing pavement surfaces of Taxiways A, B, C, & S.

The subsurface investigation for Taxiway Bravo Reconfiguration (Hot Spot 1) was performed by Athena (formerly KS Ware & Associates). The investigation for this project included 5 additional borings along the planned realignment of new Bravo.

The boring logs for each of the borings located in Taxiway A, B, C, & S are included in Appendix B of the report. A summary table of the pavement layer thickness and aggregate base material is also included in Appendix B.

6.0 Subsurface Conditions – Non-destructive Testing

The non-destructive testing (NDT) of the taxiway pavement was performed by RDM International, Inc. on April 29th and April 30th, 2019. NDTs were conducted in the center of the slabs and on transfer joints of the slabs with staggered spacing. For each lane, testing was conducted at 100 feet longitudinal spacing, i.e. every 4 slabs interval. A total of 122 center slab tests and 95 joint tests were conducted for Taxiway A. A total of 83 tests, including center and joint tests, were conducted for the crossing taxiways. NDT field data can be found in the attachments in Appendix E of this report.

The field data was analyzed and backcalculated to estimate the elastic moduli of the existing pavement section materials and the subgrade soils.

The report from RDM International "Taxiway A Rehabilitation Pavement Design" is included in Appendix E of the report.

7.0 Horizontal Geometry

Existing Taxiways

Existing Taxiway Alpha is nominally seventy-five feet wide PCC with 35-foot-wide AC paved shoulders on each side. Taxiway Alpha has a taxiway safety area of 214 feet. The existing section of Taxiway Alpha West consists of an average of 18.3" of PCC underlain by an average of 3.3" of AC on an average of 4.6" of Cemented Base. Taxiway Charlie, Sierra, and Bravo are composed of a similar paving section and are seventy-five feet wide except for the fillet widening at intersections to accommodate aircraft turning movements. Existing Taxiway Bravo also has widened shoulders (60 foot) to accommodate the engine overhang on occasional Group VI operations. Once Bravo is reconstructed in its new alignment, the shoulders will be thirty foot wide.

The existing Taxiway X that connects the Signature FBO Ramp to Taxiway Alpha is an existing bituminous pavement connector with an AC thickness of 22" and has no paved shoulders. The existing alignment of Taxiway X meets Taxiway Alpha at an acute angle. This existing taxiway alignment will be corrected in the new taxiway design with a 90-degree intersection angle at Taxiway Alpha centerline.

Taxiway Design Group

The current and future aircraft fleet mix projected to travel on Taxiway Alpha West includes the Boeing 737-700, 757-200 Cargo, B767-3 and the B777F. Based on FAA Advisory Circular 150/5300 13B, the B-757-200 aircraft is classified as Airplane Design Group (ADG) IV and B777F aircraft is classified as Airplane Design Group (ADG) V. The Airplane Design Group (ADG) is an FAA-defined grouping of aircraft types which has six group classifications based on the aircraft wingspans and tail heights. The design aircraft chosen for this project is the B777F.

The second classification of aircraft is the Taxiway Design Group (TDG). This classification is based on the aircraft's outer width of the Main Gear Width (MGW) and the distance from the aircraft Cockpit to Main Gear distance (CMG). The B777F aircraft are classified as Taxiway Design Group 5. The B757-200 aircraft is classified as Taxiway Design Group 4 and was chosen as the design aircraft for the connector taxiway to the Signature FBO Ramp.

Taxiway Design

The current FAA Advisory Circular 150/5300-13B provides guidance on taxiway design based on the aircraft's Main Gear Width (MGW) and the Cockpit to Main Gear Distance (CMG). Taxiways are to be designed based on the "cockpit over centerline" taxiing with pavement widths to allow for aircraft wander. The taxiways are to be designed based on the aircraft nose gear steering angle of no more than 50 degrees to prevent excessive nose wheel tire scrubbing. The Taxiway Edge Safety Margin (TESM) is the distance measured from the outside of the (main) landing gear to the full-strength taxiway edge.

The minimum taxiway width for a TDG (Taxiway Design Group) 4 is 50 feet with a Taxiway Edge Safety Margin of 10 feet. The minimum taxiway width for a Taxiway Design Group 5 is 75 feet with a Taxiway Edge Safety Margin of 15 feet. The new FBO Taxiway to Signature Ramp (Taxiway X) will be designed as a TDG 4 taxiway. Taxiways Alpha, Bravo, Charlie, and Sierra will be designed to TDG 5 taxiway standards.

The existing taxiway pavement widths and intersection fillets of Taxiway A, C, B, N, S, and X were analyzed using the computer program *Transoft AviPlan Airside Pro*. Aircraft movements were analyzed with the most demanding aircraft expected to utilize Taxiway Alpha which was determined to be a Boeing 777 Freighter. Intersection analysis along Taxiway Alpha with Taxiways Charlie and Taxiway Sierra were simulated with a 92' centerline radius due to new intersection construction. The aircraft movement analysis from Taxiway November to Taxiway Alpha (185' radius on the south, 150' north radius) was modeled with existing centerline radius because of the existing lights that won't be relocated for this project. The same condition applies at the Taxiway Alpha and Taxiway Bravo intersection (north side) where existing centerline geometry will remain in place, and we'll tie to existing centerline radius lighting. The taxiway aircraft movement analysis is included in Appendix C of the report.

8.0 Vertical Alignment and Taxiway Cross-Slopes

Taxiway Alpha pavement surface includes areas with a normal crown pavement section and areas with a super-elevated pavement section. The super-elevated pavement section includes the section of pavement from Taxiway Sierra to Taxiway Bravo. The pavement section cross-slope falls from the south taxiway edge to the north pavement edge.

The taxiway pavement is required to have a cross-slope (transverse grade) ranging from 1.0% to 1.5% per FAA AC 150/5300-13B. The topographic survey of the pavement surface was used to check the existing pavement cross-slopes and the existing pavement cross-slopes are shown in Appendix D. Multiple sections of the existing pavement exceed the 1.5% slope. There are areas of pavement with cross-slopes less than 1.0% and these areas occur in the transition areas from a normal crown pavement to a super-elevated pavement section.

The new pavement sections will be designed based on a 1.25% normal crown cross-slope. There are certain areas of Taxiway Alpha and corresponding intersecting taxiways that exceed the 1.25% cross-slope due to superelevation to make the required tie-ins. At no time will the cross-slope exceed 1.50%.

The existing Taxiway A centerline profile has a longitudinal gradient less than 1.5% and this is in accordance with FAA AC 150/5300-13B for Aircraft Categories C, D, and E. The taxiway profiles will include vertical curve lengths of minimum 100 feet for each 1.0 percent of change.

9.0 Pavement Design

Aircraft Movements

The estimation of current aircraft movements on Taxiway Alpha West is based on the assumption that Taxiway Alpha is primarily used by cargo aircraft. Taxiway Alpha is assumed to have 40% of total airport cargo traffic. The fleet mix and annual departures were extrapolated from Table 26 of Memphis International Airport Masterplan 2019 and are tabulated below:

FedEx	Departure	20 years Total		Annual
Cargo Aircraft	Weight, lbs.	Airport	TW A	TW A
A300-600	380,518	133,287	53,315	2,666
A310-2CF	315,041	8,723	3,489	174
ATR-72		34,028	13,611	681
B757-200 Cargo	256,000	757,105	302,842	15,142
B767-3	413,000	1,948,215	779,286	38,964
B777F	768,800	389,218	155,687	7,784
DC-10-10	458,000	97,066	38,826	1,941
MD-11	633,000	107,802	43,121	2,156

The existing and future aircraft departure estimates for Taxiway A are included in Appendix E.

Proposed Pavement Sections

Taxiway A

The recommended pavement section for Taxiway A is 19.0” P-501 PCC / 4” ATPB (Asphalt Treated Permeable Base, formerly P-402) / 8” P-304 CTB / founded on 12” of P-220 Cement Treated Subgrade. We propose that the 12” lift of P-220 be installed in 2 lifts *if* the Contractor’s means or methods does not thoroughly mix the 12” lift in one pass.

Taxiway C

The recommended pavement section for Taxiway C is 19.0” P-501 PCC / 4” ATPB (Asphalt Treated Permeable Base, formerly P-402) / 8” P-304 CTB / founded on 12” of P-220 Cement Treated Subgrade.

Taxiway S

The recommended pavement section for Taxiway S is 19.0” P-501 PCC / 4” ATPB (Asphalt Treated Permeable Base, formerly P-402) / 8” P-304 CTB / founded on 12” of P-220 Cement Treated Subgrade.

Taxiway B

The recommended pavement section for Taxiway B is 19.0” P-501 PCC / 4” ATPB (Asphalt Treated Permeable Base, formerly P-402) / 8” P-304 CTB / founded on 12” of P-220 Cement Treated Subgrade.

Taxiway X (Taxiway connector to Signature FBO Ramp)

The recommended pavement section for Taxiway X is 9” P-401 AC / 6” P-209 Aggregate Base Course / founded on 12” of P-220 Cement Treated Subgrade. We propose that the 12” lift of P-

220 be installed in 2 lifts *if* the Contractor's means or methods does not thoroughly mix the 12" lift in one pass.

Taxiway Shoulders

The project will include the construction of bituminous shoulders on Taxiways A, B, C, S, and N. The pavement design for the new shoulders will be in accordance with Chapter 6 of the FAA Advisory Circular 150/5320-6F.

The shoulder pavement section is required to be designed to support the maximum loads estimated from either the loading from a total of 15 fully loaded passes of the most demanding aircraft or the loads from the anticipated airport maintenance and/or ARFF vehicle traffic. The flexible shoulder pavements sections are designed to allow for safe operation of an airplane on an emergency basis on the paved shoulder areas without damaging the aircraft.

The recommended pavement section for the new shoulders is 4" P-403 / 12" P-219 Aggregate Base Course / founded on 12" of P-220.

The design of the taxiways and shoulder pavement sections is included in the RDM International, Inc "Taxiway A West Reconstruction Pavement Design" and is included in Appendix E.

PCC Joint Spacing

MEM has historically utilized 25'x25' PCC panels for decades on Runways, Taxiways, and Aprons with good outcomes in pavement longevity. The current FAA Pavement Design Advisory Circular, 150-5320-6G, Note 2 in Table 3-7 recommends a maximum joint spacing (panel size) of 20 feet with greater spacing allowed by technical analysis as long as the spacing does not exceed 5 times the radius of relative stiffness, in inches. In our case, based on the project specific pavement and subgrade parameters and material characteristics given in Appendix B, we have determined the Radius of Relative Stiffness for the PCC pavement as follows:

$$L = [E * h^3 / 12 * (1-u^2) * k]^{0.25}$$

$$L = 62.84''$$

Where E = Modulus of elasticity of concrete = 4,000,000 psi
h = panel thickness = 19"
u = Poisson's ratio for concrete = 0.15
$k = 150$ psi/in^3

For the T/W Alpha West project, 5 times the radius of relative stiffness is 315" or 26.18'. The use of a 25' joint spacing is, therefore, acceptable for this Project.

10.0 Project Sequence –

Taxiway Alpha Phasing

Taxiway Alpha will be reconstructed in 4 major phases with sub-phases of shorter durations when work is being done on adjacent taxiways and inside the Runway Safety Areas. The operational requirements for FedEx require that no more than one north/south route be closed at any given time.

Phase 1A will include the area from station 12+25.98 Taxiway A at concrete panel joint line in Taxiway November heading East toward station 14+00. This subphase of the overall Phase 1, Phase 1a, is intended to allow the contractor to complete this smaller section of work first and limit the amount of closure of Taxiway November. Work in this phase also impacts the ILS Critical Area for Runway 9. Construction of the new ILS Service Road will also occur during this phase as access to this area from Taxiway November is needed for this work.

Phase 1B includes the area from station 14+00 to 31+25 and will include the construction of the new 90-degree connector taxiway to the Signature FBO Ramp. Direct access to Taxiway Alpha from the Signature FBO Ramp will be cutoff in this phase of work. This subphase of Phase 1 allows traffic on Taxiway November as well as Charlie to proceed as normal.

Phase 2A & 2B will include the area of Taxiway Alpha from 31+25 to 41+00. This phase will close the intersection of Alpha and Charlie. Phase 2A includes the actual intersection of Taxiway Alpha and Taxiway Charlie and will close Taxiway Alpha from 31+25 to 35+75. North/South Aircraft movements can use Taxiways N, S & B during this phase. The Phase 2B portion of the work is from station 35+75 to 41+00 and is work inside the Runway Safety Area for 18C. Care will be taken during this phase to not disturb FAA equipment to the north and 18C Localizer on the south side of Taxiway Alpha near this phase of work. Work during this phase will require a runway closure for 18C or restrict to departures only.

Phase 3 will include the area of Taxiway Alpha from station 41+00 to 47+50 and close the intersection of Taxiway Sierra and Taxiway Alpha. During this time, North/South Aircraft movements will be allowed on N, C, and B.

Phase 4 will include the area of Taxiway Alpha from station 47+50 to the end of project at station 53+50.11. This phase will close the North/South route of Taxiway Bravo and reconstruct the south and southwest part of that intersection. Taxiways N, C, & S will be available for North/South routing of aircraft across Runway 9/27 & Taxiway Alpha.

Taxiway Bravo Phasing

Taxiway Bravo will be reconstructed in 3 major phases with sub-phases of shorter durations when work is being done on adjacent taxiways and inside the Runway Safety Areas.

Phase 1 work on Bravo will consist of the portions of new Bravo alignment outside of the Taxiway Safety Areas of Sierra and Alpha while those two taxiways remain open to aircraft traffic.

Phase 2 and 2A work consists of new centerline striping and centerline lighting as well as fillet construction along Taxiway Sierra to facilitate northbound/southbound turning movements onto and from the realigned Taxiway Bravo. Phase 2A work is a subphase of Phase 2 and will be performed during short term, daily Runway closures (at least 3 days/week + weekends) as allowed and coordinated with MEM Ops with all equipment removed daily.

Phase 3 work will consist of reconstruction of Taxiway Alpha from Station 47+75 to Station 53+50. Taxiway Alpha will be closed from just east of new Bravo and Alpha intersection alignment to Taxiway Yankee to the east. The portion of Bravo between Runway 9-27 and Alpha will also be closed during this phase.

The contract documents will address the requirements of temporary electrical conduit and conductor to be installed for each phase of the project to keep the taxiway edge lights and signage operational during construction.

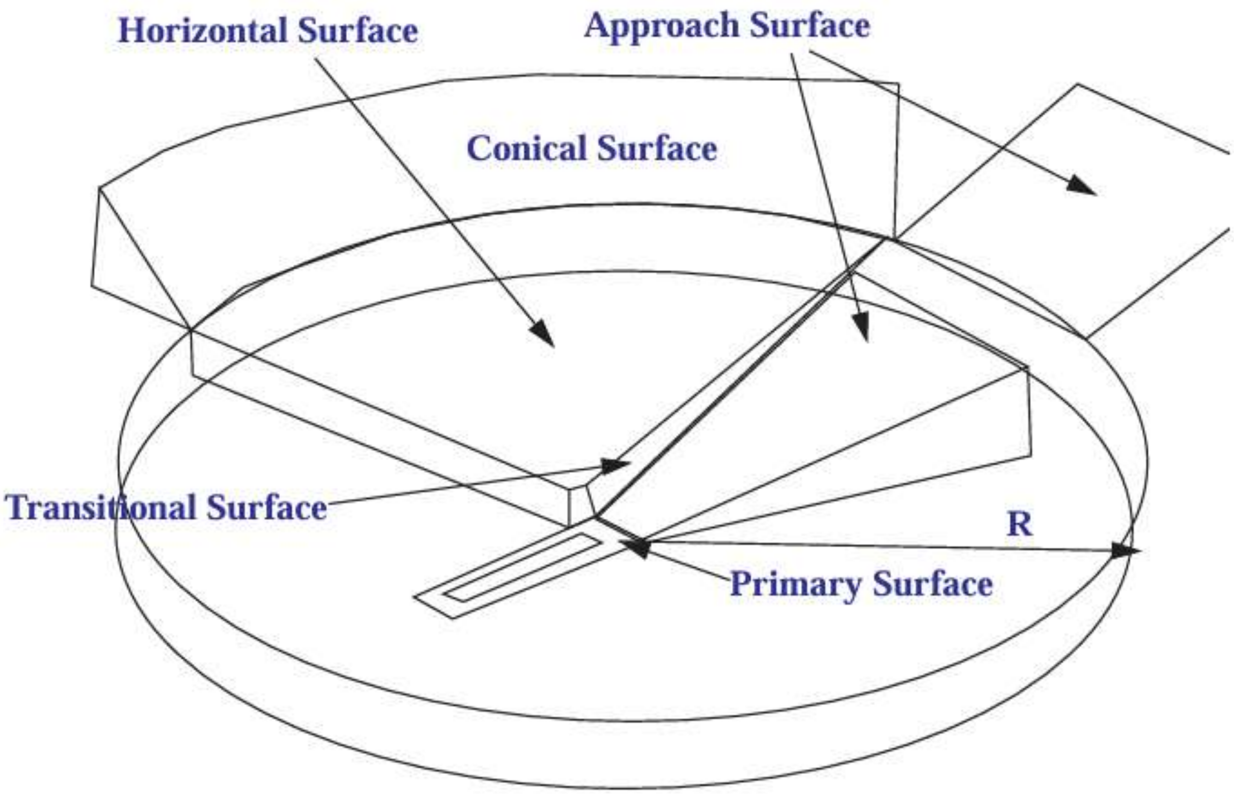
11.0 Taxiway Safety Area Grading

The new 30 foot shoulder areas will be graded at 1.25% cross-slope with a 1.5” drop at the outer pavement edge. All shoulders will be constructed with a cross-slope falling away from the taxiway pavement edge. The final ground surface for 10 feet from the shoulder outer edge will be graded at 5% cross-slope and the remaining Taxiway Safety Area ground surface will be graded 3% cross-slope for a minimum of 107 feet from taxiway Alpha centerline. The new ground surface from the Taxiway Safety Area limits outward will be graded at 5:1 maximum slopes to match existing ground. See the Proposed Taxiway A Typical Section and Taxiway B Typical Section.

Taxiway X-ray will be realigned to a 90-degree intersection with Taxiway Alpha and lead into the Signature Ramp (FBO) from the north. This taxiway will be designed as a Group IV taxiway. This new taxiway will be 50 feet in nominal width with asphalt shoulders. The Taxiway Safety Area for this connector will be 171 feet total.

12.0 Imaginary Surfaces Evaluation

Federal Regulation 49 CFR Part 77 establishes standards and notification requirements for objects affecting navigable airspace. These surfaces include but are not limited to, Primary Surface, Approach Surface, Transitional Surface, Horizontal Surface, and Conical Surface.



Previously, the elevation difference between the Signature FBO ramp and the existing taxiway Alpha exceeded the allowable 1.5% centerline grade for a 90-degree connection so it was instead connected at an acute angle. The design and reconstruction of Taxiway Alpha raised the proposed profile of the new taxiway Alpha by approximately 4 feet in the vicinity of the new tie-in to the Signature Ramp FBO Apron to facilitate a perpendicular intersection.

Primary Surface

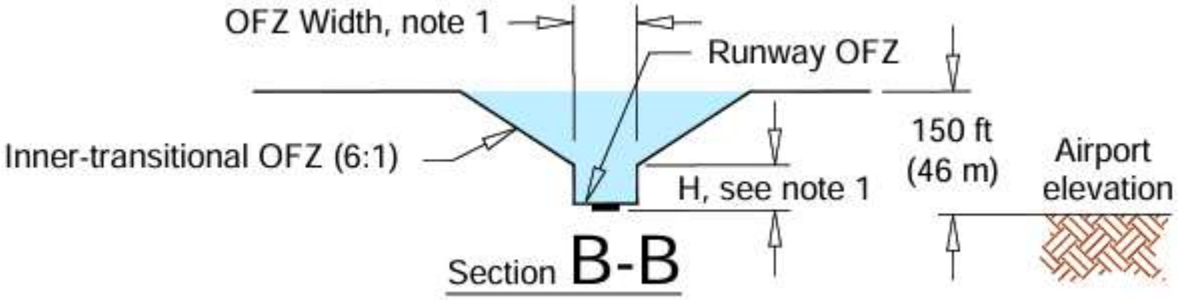
The FAR Part 77 Primary Surface for Runway 9-27 is a horizontal surface extending 1,000 feet wide (500’ each side of the runway centerline) and rectangular in shape and begins and ends 200’ past the threshold on each end. The elevation of any point on the Primary Surface is the same as the elevation of the nearest point on the runway centerline. At 500’ from the centerline, the Primary Surface then begins to rise at a rate of 7H:1V. The Primary Surface elevation varies along the centerline of Alpha relative to the profile of the runway.

PIA – Precision Instrument Approach surface begins 200 feet past the runway 9-27 threshold at the threshold elevation and rises at a rate of 50H:1V (2% grade) for a horizontal distance of 10,000 feet.

IT-OFZ Alpha lies within the Inner Transitional Object Free Zone of Runway 9-27. Taxiway Alpha is a parallel taxiway to Runway 9-27 with approximately 600’ of separation between them. The Runway Object Free zone (ROFZ) is centered about the runway centerline and is 400’ wide and follows the elevation of the runway centerline. No object may be within this clearing surface unless it is mounted in a frangible manner and fixed by function.

Diagram below shows a cross-section of the OFZ and IT-OFZ. Runway 9-27 supports approach visibilities of lower than ¾ mile (1.2 Km) but not lower than ½ mile (0.8 Km). To calculate the value of “H”, $H_{feet} = 61 - 0.094(S_{feet}) – 0.003(E_{feet})$, where S is equal to the most demanding wingspan of the RDC of the runway, E is equal to the runway threshold elevation above sea level. In our case, H = 61 – 0.094(211.5’ Boeing 747 wingspan) – 0.003(251.5). H_{feet} = 40.37’.

Since Taxiway Alpha is approximately 600’ south of Runway 9-27, a Boeing 747 plane taxiing along Alpha with a tail height of 63.5’ will still be approximately 43’ under the IT-OFZ of Runway 9-27 when taxiing along Alpha.

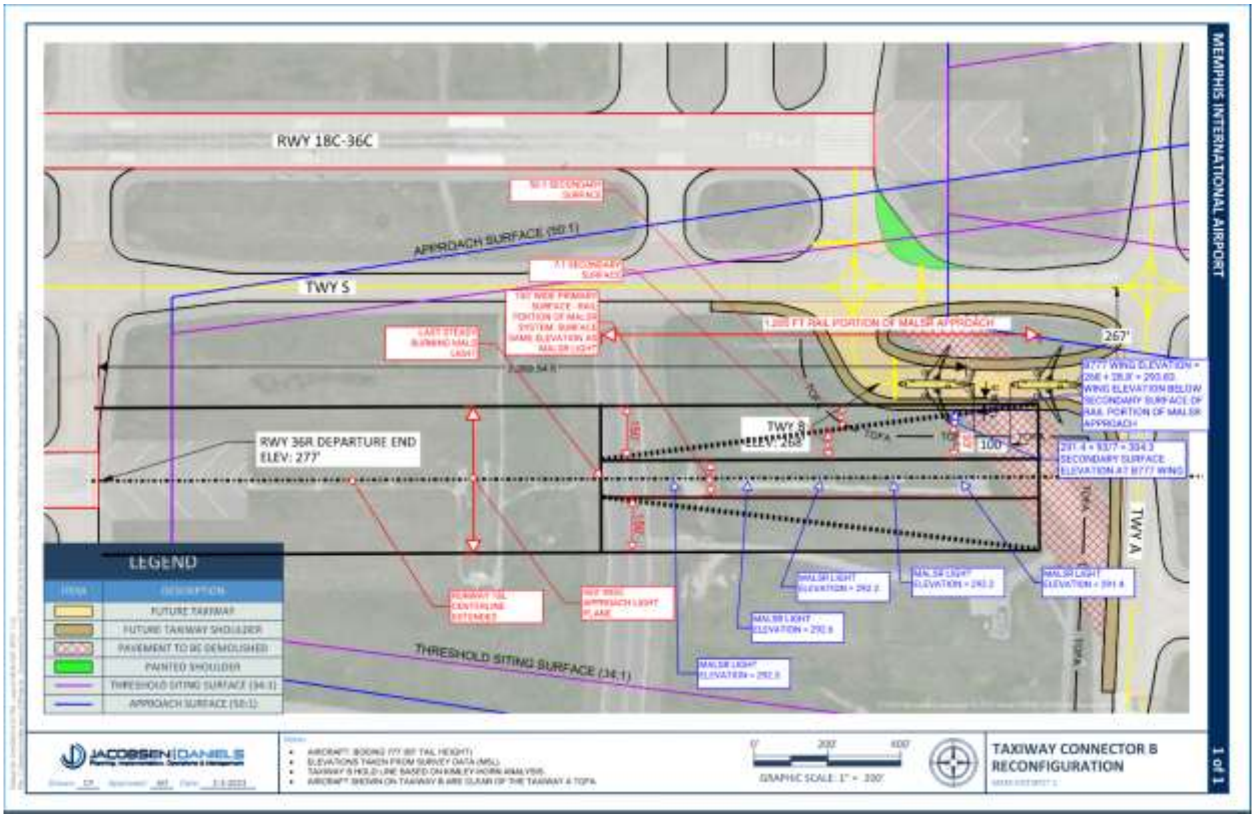


Visibility - Lower than 3/4 mile (1.2 Km) but not lower than 1/2 mile (0.8 Km)

Taxiway Bravo Realignment – Hot Spot 1

The realignment of Taxiway Bravo to eliminate the Hot Spot 1 presented an additional clearing surface to be evaluated. The MALSR for 18C extends north towards Alpha and existing diagonal Bravo. The realignment of Bravo required the analysis of the Approach Light Plane (ALP) of 18C to maintain and ensure visibility of all the lights in the MALSR to planes on approach if there were planes queued on realigned Bravo waiting for take-off. The typical installation of an ALS RAIL is that all sequence flashing lights be in a horizontal light plane with no obstruction penetrating the primary and secondary RAIL planes. The primary plane of the RAIL system begins at the last steady-burning light of the MALS portion and extends 200 feet beyond the last flashing light in the RAIL portion of the MALSR system. The primary plane has a total width of 100 feet, 50 feet each side of the extended runway centerline, and a surface that follows the plane of the MALSR RAIL System.

Beginning at the edge of the primary plane, a secondary plane having a slope of 7:1 extends outward from the edge of the primary plane for a distance of 150 feet. Both primary and secondary planes begin at the last steady-burning lights of the MALSR system and extend 200 feet beyond the last flashing light in the RAIL portion of the MALSR system. An additional secondary plane underlies the 7:1 plane, with a longitudinal slope of 50:1, beginning at the height of the last steady-burning light and extending outward (laterally) to 150 feet from the edge of the primary plane at zero gradient. The surface extends longitudinally to 200 feet beyond the last flashing light of the RAIL system. Objects must not penetrate either the primary or secondary plane. See diagram below for specifics of the 18C MALSR System and corresponding elevations of the horizontal ALP. In our case the B777 Wing elevation is below the transitional section.



13.0 Drainage Design

The existing storm water runoff flows to existing grassed open ditch areas on each side of Taxiway A. The stormwater is collected and routed generally northward toward Nonconnah Creek north of the Airport. The storm water is carried via RCP storm drain piping and RCBC (Reinforced Concrete Box Culverts) to a collection system which eventually routes through FedEx's Hub, under Democrat Road, and discharges into Nonconnah Creek. This project will replace all drainage piping that crosses under the reconstructed areas of Taxiway Alpha with Class V Reinforced Concrete Pipes.

The grading and drainage plans will be in accordance with the FAA AC 150/5320-5D "Airport Drainage Design". Rainfall intensity data for pipe sizing and runoff calculations will be obtained from the Memphis and Shelby County Stormwater Management Manual.

14.0 Underdrains

New 4-inch underdrains will be installed in a herringbone pattern underneath the drainage layers of Taxiway Alpha and Taxiway Bravo. The 4" underdrains will be connected to larger 6" underdrain collection pipes and ultimately 6" laterals that will tie into nearby drainage system or daylight into grassed areas outside of the Taxiway Safety Area. The existing 6" underdrain collection system currently installed along the edges will be demolished.

15.0 Erosion Control

The project includes the construction of 30’ paved shoulders on each side of the taxiways and earthwork operations on the existing ground surfaces to fill and grade the slopes to meet the Taxiway Safety Area grading requirements. The earthwork operations will extend to a minimum of 107’ on each side of the taxiway centerline (85.5’ for Taxiway X-ray) and new slopes at 5:1 will be graded to match existing ground elevations.

Based on a multiple-phased project, a recommendation is made for the newly graded areas to be sodded.

The use of best management practices is required by the erosion control plan and specifications for control of erosion during construction. Erosion control devices to be installed to help control erosion include wattles, silt fence, temporary slope drains, inlet protection, and headwall protection will be utilized. All erosion control plans and specifications are in accordance with Tennessee Erosion and Sediment Control Handbook and the FAA AC 150/5320-5D “Airport Drainage Design”.

16.0 Marking

The existing Taxiway centerlines consist of a 12” wide yellow reflective centerline with 6” wide non-reflective black borders. The centerlines of Taxiways N, X, C, S, and B are also along low-visibility SMGCS routes and will be 12” wide yellow reflective centerlines with 6” black borders and will be enhanced 150’ prior to the Runway 9-27 holding position marking.

Per FAA AC 150/5340-1M, the taxiway intermediate holding position marking is set back in accordance with the taxiway or taxilane centerline to fixed/movable object criteria (taxiway/taxilane object free area). These markings and corresponding geographic position markings (SMGCS) will be located 160’ from the centerline of Taxiway Alpha based on the requirement for objects to be outside the Taxiway Object Free Area for a Group V aircraft.

New taxiway edge markings will be provided along the taxiway and the optional 3’ wide taxiway shoulder markings will not be added at this time at the direction of MSCAA.

All taxiway centerline, holding position, edge lines, non-movement markings, and surface directional signage will be painted yellow with glass beads and non-reflective black borders.

The taxiway markings will be in accordance with the requirements of Advisory Circular 150/5340-1M “Standards for Airport Markings”.

17.0 Airfield Electrical

Taxiway Edge Lights

The existing taxiway edge lights and centerline lights along Taxiway A, C, S, and B, within project limits will be removed and new semi-flush LED edge lights and centerline lights will be installed. On the taxiway Bravo Reconfiguration project, the edge lights will be elevated. The existing demolition will include the lights, light cans, transformers and concrete base encasement. The existing underground conduit and conductor along the taxiways will be demolished and new conduit, conductor, and grounding system will be constructed.

The taxiway light and signage circuit conductors will tie-in to the existing circuits that will be intercepted in various handholes in close proximity to Airfield Electrical Vault #2 (See sheet E-LT-04).

Temporary electrical jumper conduit and conductor will be installed for each phase of the project to keep the edge light and signage circuits operational.

Airfield Signage

There is a current project that is replacing all the Airfield Signage with new LED signs and base foundations. Airfield Signage that is within our construction areas will be protected and covered on a phase-by-phase basis during construction. In instances where the sign is relocated, the contractor is removing/replacing the modular sign bases to the new locations. It is the preference of MSCAA to have the signage circuit separate from the edge light circuit.

Existing MSCAA and FAA Electrical Manholes

The existing MSCAA and FAA electrical and communication underground utilities have several existing manholes located near the existing taxiway pavement edges. The construction of new 30-foot-wide shoulders and grading operations to meet the Taxiway Safety Area cross-slope requirements will require multiple manhole adjustments to raise the structures to the new final grades.

18.0 Project Construction Cost

The estimated project construction cost is based on cost data from recent construction projects and has been compiled by Connico.

The estimated probable construction cost is included in Appendix F.

Appendix A

Field Photos

Alpha @ November looking East

Typical Edge light on shoulder

Edge Light (existing)

Typical concrete joint and sealant

Existing underdrain cleanout (typical)

Looking north up Taxiway November at tie-in joint

Typical Delpatch Elastomeric Concrete repair (typical)

Delpatch surrounding existing cleanout

Existing centerline light can approximately 1.5’ off centerline stripe

Existing taxiway edge striping and shoulder striping at Alpha/November intersection

ILS Holding Position Sign @ Taxiway Alpha and November

Duct end marker along Taxiway Alpha @ November intersection

Existing Taxiway Signage (Typical)

Existing Inlet Grate near Taxiway Alpha/November intersection

Taxiway Guidance Sign

Airfield Electric Handhole

Fillet Panels

Runway 9 Localizer Antenna and access drive

Localizer and MALSR

Localizer and MALSR

Localizer and MALSR

Taxiway Edge Light and L-853 Blue Taxiway Reflector in the distance

Inch and a half drop off at existing PCC pavement/asphalt shoulder interface

Typical underdrain cleanout

Typical PCC joint

Centerline light along Taxiway Alpha approx..2’ from stripe

PCC Cracking

Glide Slope Antenna for Runway 9

Cracking along Alpha that has been routed and sealed

Crack/Edge Repair along centerline

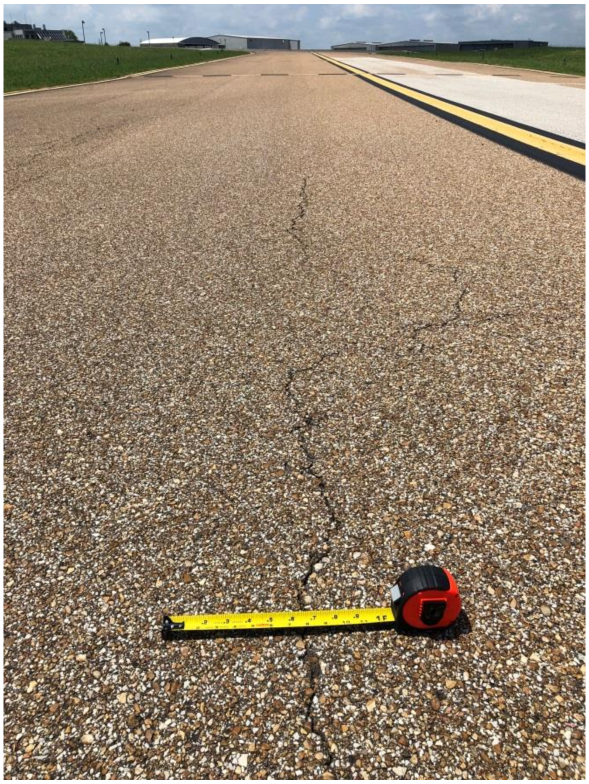
Grade differential at proposed tie-in with Taxiway X-Ray

Proposed taxiway tie-in at Signature Ramp for new Taxiway X-Ray

Signature Ramp GA Tie-down and Parking Area

Standing water (bird bath) at existing Taxiway X-Ray/Alpha intersection

Taxiway X-Ray looking Southwest towards Signature Ramp from Alpha



Longitudinal distress cracking in Taxiway X-Ray

Existing L-853 Blue Taxiway Edge Reflectors along Taxiway X-Ray

Taxiway X-Ray and Taxiway Alpha intersection looking towards Taxiway Charlie

Beginning of edge fillet for Taxiway Charlie

“Delpatch” Repairs along Taxiway Alpha near Taxiway Charlie

Taxiway Alpha intersection with Taxiway Charlie

Routed and Sealed longitudinal crack just south of centerline near Charlie

Delpatch corner break/spall repair

Geotechnical Boring # 6

Joint Spalling

Geotechnical Boring # 13

Along Taxiway Charlie looking north towards 9-27 Hold

Elevated Runway Guard light and LED Taxiway Edge Light

Taxiway Charlie repairs near 9-27 Hold

Taxiway Charlie @ 9-27 Hold looking north towards FedEx Hub

East fillet widening of Taxiway Charlie looking South towards Taxiway Alpha

Corner Repair along Taxiway Charlie

Extensive patching at Taxiway Charlie & Taxiway Alpha Intersection

Extensive patching at Taxiway Charlie & Taxiway Alpha Intersection

Extensive patching at Taxiway Charlie & Taxiway Alpha Intersection

Core Hole #7

Typical slab joint transition

In-pavement Runway Guard Lights @ 9-27 Hold

9-Way Can Plaza holding water

Elevated Runway Guard Light

Distressed Area at Taxiway Sierra Centerline north of Taxiway Alpha

Geotechnical Boring # 15

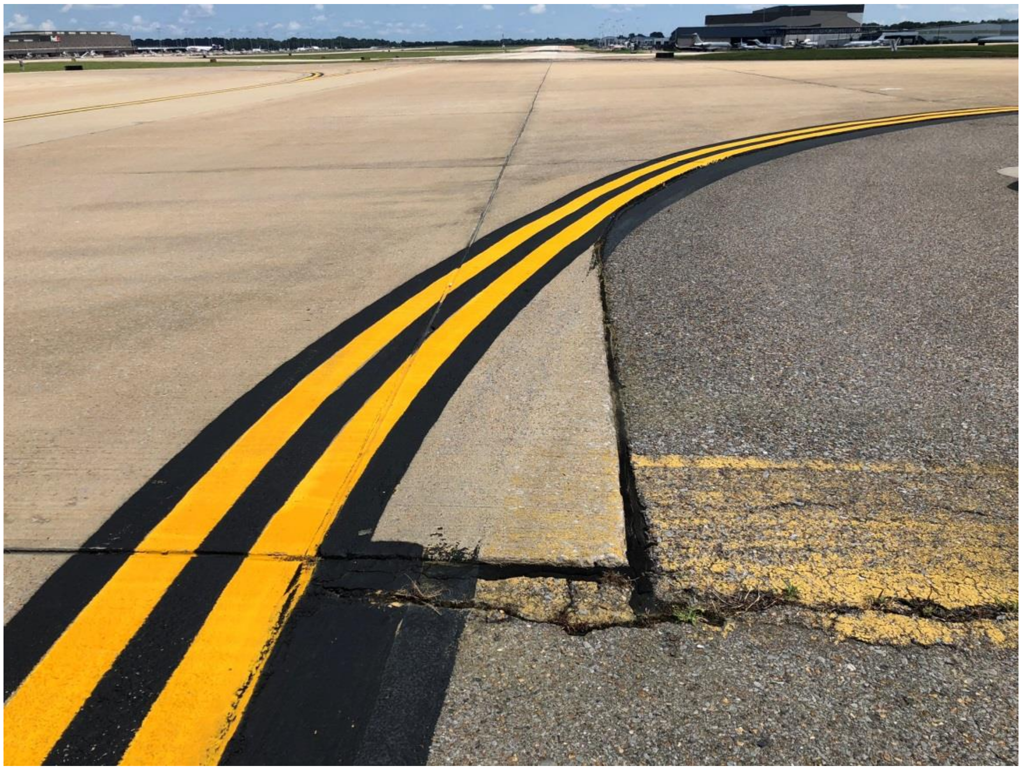
Crack Repair along Sierra looking South

Thickened-edge expansion joint along Taxiway Alpha

Repairs @ mid-intersection of Taxiway Sierra and Taxiway Alpha

PCC Panel Replacement on Taxiway Sierra looking South

Typical Taxiway Guidance Sign



Fillet widening along Taxiway Alpha for southern radius

4-Module sign

Delpatch repairs along Taxiway Bravo

Taxiway Bravo Delpatch Repairs with joint sealant

Geotechnical Boring #16

Existing shallow radius “pancake cans” installed at Bravo Intersection

Core Hole #11

Proposed tie-in joint at Taxiway Bravo Intersection (left half remains)

Proposed tie-in joint @ Bravo looking west. Right half remains

Taxiway Bravo @ Proposed tie-in joint (Right half remains)

Taxiway Alpha Centerline @ Bravo

Appendix B

Geotechnical Report

REPORT OF GEOTECHNICAL EXPLORATION

Taxiway Alpha West Reconstruction
Memphis International Airport
Memphis, Tennessee

Prepared For:
Allen & Hoshall
1661 International Drive, Suite 100
Memphis, Tennessee 38210

Prepared By:
K. S. Ware and Associates, L.L.C.
52 Lindsley Avenue, Suite 101
Nashville, Tennessee 37210

KSWA Project No. 100-19-0019

November 11, 2019

KSWA
K. S. Ware & Associates, L.L.C.
Geotechnical • CEI • Environmental
52 Lindsley Avenue, Suite 101
Nashville, Tennessee 37210
Phone: 615-255-9702

November 11, 2019

Mr. Harry Pratt, PE
Allen & Hoshall
1661 International Drive, Suite 100
Memphis, Tennessee 38210

Subject: **Report of Geotechnical Engineering Services**
Taxiway Alpha West Reconstruction
Memphis International Airport
Memphis, Tennessee
KSWA Project No. 100-19-0019

Dear Mr. Pratt:

K. S. Ware & Associates, LLC (KSWA) is pleased to submit this report which provides the results of our pavement exploration for the Taxiway Alpha West Reconstruction project at the Memphis International Airport in Memphis, Tennessee. Our services were provided in general accordance with our proposal for Geotechnical Engineering Services dated December 18, 2018.

The attached report summarizes the project information provided to us, describes the site and subsurface conditions encountered, and details our geotechnical recommendations for the project. The Appendices include figures, descriptions of our field-testing procedures, and our field and laboratory test results.

We appreciate the opportunity to be of service to you on this project. Please contact us if you have any questions regarding this report. We look forward to serving as your geotechnical consultant on the remainder of this project.

Respectfully submitted,

K. S. Ware and Associates, L.L.C.

Bradley D. Kouchoukos

NATHAN LONG
No. 111689

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Bradley D. Kouchoukos, E.I.
Staff Professional

Nathan Long, P.E., P.G.
Senior Geotechnical Engineer

Enclosures: Report of Geotechnical Exploration

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APPENDICES

1.0 INTRODUCTION

1.1 PROJECT INFORMATION

Our understanding of the project is based on information provided by Mr. Harry Pratt of Allen & Hoshall during multiple e-mail and telephone conversations throughout the project. The initial e-mail included a document titled "Exhibit A – Scope of Services", which provided general project information and general requirements for the geotechnical study.

The project consists of reconstructing approximately 4,125 linear feet of Taxiway Alpha West at the Memphis International Airport. The reconstruction will extend from Taxiway November at the west end of Taxiway Alpha to east of Taxiway Bravo. The project will also include tie-ins along Taxiways November, Charlie, Sierra, and Bravo and along the Signature Ramp. The reconstructed taxiway will consist of new concrete pavement with asphalt shoulders. We understand full depth replacement of the existing pavement including the cemented base material is planned. The new taxiways will be designed for ADG Group V, while the Signature Ramp will be designed as ADG Group IV. We have assumed final pavement surface elevations will be similar to existing pavement surface elevations.

1.2 PURPOSE AND SCOPE OF EXPLORATION

The purpose of the exploration was to evaluate the subsurface conditions along the project alignment and provide geotechnical design recommendations for the project. Our scope of services was detailed in our proposal for Geotechnical Engineering Services, dated December 18, 2018.

Our geotechnical exploration services did not include sampling and testing of the soil, rock, surface water, groundwater, or air for the presence of environmental contaminants. Therefore, special procedures were not recommended for handling or managing sediments encountered during future construction or for handling the soil and rock samples from the borings in the geotechnical testing lab.

2.0 SITE GEOLOGY

2.1 GEOLOGIC FORMATION

Memphis International Airport is located in the Coastal Plain physiographic province. This province extends along the southeast and east coasts of the United States from the southern tip of Texas to the southern tip of Florida along the Gulf of Mexico and then extends north to New Jersey along the coast of the Atlantic Ocean. The Coastal Plain province generally lies along the coastal states but extends north from Louisiana and Mississippi through the eastern portions of Arkansas, the west portions of Tennessee, and the southern tip of Illinois. In Tennessee, the area between the Tennessee River and Mississippi River is considered to be part of the Coastal Plain province; there are three subcategories within this area. Starting from the east, along the western banks of the Tennessee River, is an approximately 10-mile wide section of hilly land which consists of sedimentary rocks overlain by residual soils (derived in place from weathering of the bedrock), alluvial soils (soils deposited by streams) locally, and about 4 feet of loess (wind-blown silts and clays). To the west of the hilly land is an area called the Tennessee Bottoms or the bottom land which extends to steep bluffs along the shores of the Mississippi River in Memphis. This area consists of rolling hills and streams formed from marine sediments consisting mainly of clays, silts and sands covered by loess at the surface. The loess can be up to 100 feet thick in the bluffs overlooking the Mississippi River; however, the loess can also be absent where streams have eroded these soils and filled the stream valley with alluvium. The third section is called the Mississippi Alluvial Plain. This area is west of the Tennessee Bottoms and consist of lowland areas, flood plains, and swamp land typically less than 300 feet above sea level.

The Surficial Geologic Map of the Southeast Memphis Quadrangle, Shelby County, Tennessee indicates the airport is underlain by loess and artificial fill. The late Pleistocene-aged loess deposits include wind-blown sediments consisting of generally of clayey silt brown and light-brown in color. These soils are relatively strong and stable when the water content is near the soil's Plastic Limit but become soft and unstable if the water content moves above the Plastic Limit. Artificial fill in Memphis typically consists of brown silt to clayey silt, but can also include construction debris, organics, and other deleterious materials. The strength, compressibility, and stability of artificial fill subgrades depend on the fill material type, lift thicknesses, water content, and compaction effort applied during placement.

2.2 SOIL SURVEY

The soil survey of Shelby County, Tennessee, downloaded from the United States Department of Agriculture website[1] indicates the soil types across Taxiway Alpha consist of Graded land (Gr). This land type consists of developed areas that primarily consisted of Grenada, Loring, and Memphis soils prior to grading. Typical engineering classifications for these soils include clays (CL), clayey silts (ML), and non-plastic sands (SC) by the Unified Soil Classification System (USCS) classification and A-4, A-6 and A-7 by American Association of State Highway and Transportation Officials (AASHTO) classification.

1- http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.asp

3.0 EXPLORATION PROCEDURES AND FINDINGS

3.1 GENERAL

We performed our subsurface exploration and field testing between May 8, 2019 and May 15, 2019, excluding the weekend days. Our proposed exploration consisted of coring through the existing pavement and cemented base material at 29 locations (13 coreholes and 16 borings) and extending the borings to a depth of 10 feet below existing grade. Due to limited access to the Memphis Airport property, we were unable to complete five of the proposed coreholes (C-3, C-5, C-6, C-11, and C-12) and two of the borings (B-7 and B-15).

The boring and corehole locations were marked in the field by Allen & Hoshall's surveying subcontractor prior to us arriving on-site. We had to offset some of the exploration locations due to underground utilities identified in the vicinity of the planned exploration locations. The corehole and boring locations shown on the Exploration Plan in Appendix A should be considered approximate. Additional discussion regarding the field procedures used during this exploration are provided in Appendix B.

3.2 SURFACE AND SUBSURFACE CONDITIONS

The existing Taxiway Alpha West consisted primarily of concrete pavement underlain by a thin layer of bituminous pavement and a cemented base material. The pavement surface generally slopes gradually downward away from the taxiway centerline towards the pavement edge.

Pavement Section

Each of the pavement cores, completed within Taxiway Alpha West, encountered an initial layer of concrete pavement ranging in thickness from approximately 16 to 21-½ inches. Below the surficial concrete, we encountered bituminous pavement ranging in thickness from about 2-½ to 5-½ inches. At the pavement cores completed within the Signature Ramp (C-2 and B-13), the concrete core consisted entirely of bituminous pavement with a thickness of approximately 22 and 22-½ inches, respectively. Below the bituminous pavement in the pavement cores completed within Taxiway Alpha West, we encountered a cemented base material ranging in thickness from 2 to 8-½ inches. We anticipate a cemented base material is present beneath the Signature Ramp as well; however, due to the limited number of borings completed within this area, it could not be confirmed that a cemented base material is present. We note that the cement treated base was not recovered during pavement coring, and we estimated the thickness based on the drilling observations. Table 1 on the following page includes the concrete pavement, bituminous pavement, and cemented base approximate thicknesses encountered at the 23 locations.

Table 1: Pavement Section Thicknesses

Corehole / Boring No.	Concrete Pavement Thickness (in.)	Bituminous Pavement Thickness (in.)	Cemented Base Thickness (in.)	Total Pavement Thickness (in.)
C-1	18.0	4.0	NA	NA
C-2	0.0	22.0	NA	NA
C-4	18.0	NA	NA	NA
C-7	18.0	2.5	NA	NA
C-8	21.5	NA	NA	NA
C-9	17.5	2.5	NA	NA
C-10	18.0	3.0	NA	NA
C-13	19.0	2.5	NA	NA
B-1	18.5	3.5	4.0	26.0
B-2	18.0	4.0	4.0	26.0
B-3	18.0	5.0	3.0	26.0
B-4	18.0	4.0	4.0	26.0
B-5	18.0	4.5	3.5	26.0
B-6	20.5	3.5	2.0	26.0
B-8	17.5	2.5	6.0	26.0
B-9	16.0	3.0	7.0	26.0
B-10	18.0	3.5	8.5	30.0
B-11	17.5	3.5	8.0	29.0
B-12	17.5	3.0	5.5	26.0
B-13	0.0	22.0	NA	22.5
B-14	18.0	3.0	3.0	24.0
B-16	19.0	3.0	2.0	24.0
AVG	**18.3****	**3.3***	**4.6**	**26.2**

*Bituminous pavement thickness within coreholes should be considered as minimal values. Due to limitations of coring equipment and thickness of overlying concrete pavement, the exact total bituminous pavement thickness could not be confirmed.

**Concrete pavement and bituminous pavement thickness averages neglect coring C-2 and boring B-13, which consisted entirely of bituminous pavement.

Existing Fill

Beneath the pavement section, Borings B-6 and B-16 encountered existing fill to respective depths of 5-½ and 6 feet. The fill at Boring B-6 consisted of very loose sandy silt (ML), and the fill at Boring B-16 consisted of stiff lean clay (CL).

Native Soils

Below the existing fill at Borings B-6 and B-16 and below the pavement section at the remaining borings, we encountered native soils to the boring termination depth of 10 feet. The native soils generally consisted of soft to stiff lean clays (CL) with a layer of very loose to medium dense silt (ML) generally present in the borings between approximate depths of 5-½ and 8 feet.

Groundwater

The majority of the borings were dry during our exploration. However, we encountered groundwater at an approximate depth of 8 feet during drilling operations at Borings B-1 and B-3. We backfilled the borings upon completion for safety precautions, so delayed groundwater measurements were not taken. Groundwater levels will differ depending on the time of year, climatic conditions, and construction activities. Perched groundwater conditions may develop within the overburden soils during seasonal wet periods of the year and after heavy precipitation events.

4.0 LABORATORY TESTING

KSWA performed laboratory testing on representative split-spoon, Shelby tube, and bulk soil samples in general accordance with ASTM procedures. The laboratory testing included:

- Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass (ASTM D2216)
- Standard Test Methods of Liquid Limit, Plastic Limit, and Plasticity Index (ASTM D4318)
- Standard Test Method for Determining the Amount of Material Finer than 75-µm (No. 200) Sieve in Soils by Washing (ASTM D1140)
- Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates (ASTM C136/C136M)
- Standard Test Method for Laboratory Compaction Characteristic of Soil Using Modified Effort (ASTM D1557)
- Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils (ASTM D1883)

The moisture content data and Atterberg limit are presented on the individual boring logs in Appendix B. Laboratory test reports for grain size analysis, Modified Proctor, and CBR tests are within the Appendix C.

Table 2: Summary of Soil Laboratory Test Results

Boring No.	Sample Type	Sample Depth (ft)	Modified Proctor		CBR	LL (%)	PI (%)	Percent Passing #200 Sieve (%)	Unconfined Compression (psf)	USCS Class.
			Max. Dry Density (lbs/ft^3)	**Optimum Moisture (%)**						
B-1	ST	6 to 8	-	-	-	NP	NP	98.0	1,440	ML
B-2/B-5	Bulk	0 to 10	116.5	13.9	9.5	36	14	89.1	-	CL
B-3	ST	6 to 8	-	-	-	NP	NP	98.1	1,920	ML
B-5	SS	3.5 to 5	-	-	-	42	24	91.0	-	CL
B-8/B-10	Bulk	0 to 10	118.2	12.6	7.0	33	10	97.0	-	CL
B-9	ST	3.5 to 5.5	-	-	-	NP	NP	81.4	-	ML
B-11	ST	6 to 8	-	-	-	NP	NP	99.0	1,420	ML
B-12	SS	3.5 to 5	-	-	-	37	13	92.3	-	CL
B-12	Bulk	0 to 10	120.9	12.2	6.0	33	11	71.3	-	CL
B-13	SS	3.5 to 5	-	-	-	35	13	93.3	-	CL

*Bulk samples consist of soil material beneath pavement section and cemented base material

**Unconfined compression strength test samples were determined to be silt (ML) based on grain size analysis and Atterberg Limit testing. It should be noted, unconfined compression strengths of silt (ML) may not be representative of the soils strength due to lack of cohesion.

5.0 GEOTECHNICAL CONSIDERATIONS

5.1 GENERAL

The conclusions and recommendations presented herein were developed based upon our engineering reconnaissance of the site, the field test results, a visual examination of the samples recovered, laboratory tests on selected samples, our understanding of the proposed construction, and our experience. The conclusions and recommendations presented in this report have been derived by relating the general principles of the discipline of geotechnical engineering to the proposed construction outlined in the Project Information section of this report. Because changes in surface, subsurface, and climatic conditions can occur, the use of this report must be restricted to this specific project.

Our understanding of the proposed design and construction is based on the documents provided to us at the time this report was prepared and information referenced in the Project Information section of this report. We recommend we be consulted to review the final design documents, plans, and specifications to check the conclusions and recommendations of this geotechnical report have been interpreted correctly. Any changes or modifications which are made in the field during the construction phase which alter site grading, structure locations, infrastructure, or other related site work should also be reviewed by our office.

If conditions which vary from the facts of this report are encountered in the field during construction, we recommend the Geotechnical Engineer of Record be contacted immediately to review the changed conditions in the field and make appropriate recommendations.

5.2 SUBGRADE SUITABILITY

Based on the project information provided and the available subsurface data, it is our opinion the site is suitable for the planned reconstruction. The subgrade materials below the existing pavement generally consists of firm to stiff lean clay with some soft zones. Soft to firm soils are frequently unstable under a proofrolling load. Additionally, the moisture content of the near-surface soil samples was frequently higher than the optimum moisture content of the bulk samples tested. Soils with a relatively high moisture content are also frequently unstable under a proofrolling load.

The stability of the near-surface soils will likely be impacted by exposure to moisture and/or construction traffic, once the pavement materials have been stripped to prepare the site for construction. The near-surface soils consist of either existing fill or native loess. Loess is typically extremely sensitive to changes in moisture content. Dry loess materials are generally stable and will exhibit favorable strength characteristics. Conversely, when these soils are moist, as a result of local precipitation or climatic conditions, the soils become weak and unstable, particularly under repeated loading from heavy construction equipment. Also, due to the silt content of these soils, they can degrade rapidly even when favorable moisture conditions are present. Therefore, regardless of the time of year construction takes place, some remedial repair of weak subgrades will likely be required.

If construction occurs during warm, dry weather months, it may be possible to repair shallow instability through scarifying, moisture conditioning, and recompacting the upper 8 to 12 inches of subgrade. However, this process will likely not be practical during cooler, wet weather months when moisture conditioning can be problematic. During wet weather, it may be necessary to undercut unstable soils and use a borrow source to haul in drier soils for backfilling. If widespread subgrade instability is present, stabilizing the subgrade with cement is an option that may be considered (cement stabilization is typically more cost-effective over larger areas). KSWA recommends that a budget be established for subgrade repairs consistent with the time of year construction takes place.

5.3 PAVEMENT DEMOLITION

We understand that the taxiway pavements will be completely demolished and removed, which will include the underlying asphalt and cement treated base. We expect the amount of materials removed will be significant. The existing concrete can potentially be used for other functions, such as P-219 recycled concrete aggregate base, if the demolition methods allow for such crushing and gradation. Detailed analysis of the demolished materials would be required prior to use and approval.

6.0 GEOTECHNICAL EVALUATION & RECOMMENDATIONS

As stated in the Project Information section of this report, we understand the airport plans to complete a full-depth reconstruction of the existing concrete pavement along Alpha West Taxiway and tie-ins at four intersecting taxiways and the Signature Ramp. If the information contained in Project Information section changes, we recommend KSWA be contacted to confirm our design and construction recommendations are appropriate, in consideration of the new available information.

6.1 GENERAL PAVEMENT RECOMMENDATIONS

Based on our observations and classifications made in the field and tests performed in the laboratory, KSWA is providing the following pavement design parameters and general pavement recommendations.

As discussed in the previous section, remediation of soft to firm subgrade soil prior to final grading and paving should be expected. The stabilization method, the lateral extent, and the depth will depend on actual conditions exposed during construction and on actual grading plans for the pavement areas. On-site recommendations should be made by the geotechnical engineer-of-record or his representative. Additionally, we recommend that the upper 12 inches of the subgrade materials be compacted to at least 100 percent of the maximum dry density as determined by the modified Proctor test in accordance with Federal Aviation Administration's (FAA) Standard Specifications for Construction of Airports, dated December 21, 2018, Section 152-2.10.

6.2 PAVEMENT DESIGN RECOMMENDATIONS

The design CBR and subgrade modulus values are highly dependent on the type of near surface material and the level of compaction. Based on the limited information obtained from our field exploration, our laboratory testing, and our experience with similar soil conditions, KSWA recommends using a CBR value of 7 and a subgrade modulus of 150 pounds per cubic inch (pci) for the existing subgrade compacted to 98 percent of the Modified Proctor (ASTM D1557) maximum dry density within the upper 12 inches of subgrade.

Pavements and base courses may be placed after the subgrade has been properly compacted, fine graded, and proofrolled as recommended in the Construction Considerations section of this report. All activities should be accomplished in accordance with FAA Standard Specifications for Construction of Airports. Actual pavement section thickness should be determined by the designer based on actual loads, traffic volume, and the owner's design life requirements.

Experience has shown most pavement failures are caused by localized soft spots in the subgrade or inadequate drainage. Proof rolling, under the observation of our geotechnical engineer, will greatly reduce the incidents of weak spots in the subgrade. However, the civil design must include proper drainage to reduce softening of the subgrade, frost damage, heaving, soil migration, and pumping failures. The pavement surface and subgrade should have a minimum slope of 2 percent. Water infiltrating the mineral aggregate base should be designed to drain into catch basins (through weep holes), out-slope areas, or drainage trenches.

The soils exposed at the pavement subgrade level may be moisture sensitive. Experience indicates there is typically an extensive time lag between the time grading is completed and pavement construction occurs (i.e. grading may occur during hot, dry weather and pavement construction may occur during wet, cool weather). Once grading has been performed, the subgrade may be disturbed throughout the construction process due to utility excavations, construction traffic, desiccation, or rainfall. As a result, the pavement subgrade may become unsuitable for pavement construction over time and corrective action may be required. The subgrade should be carefully evaluated at the time of pavement construction by proof rolling with a heavily-loaded tandem-axle dump truck. Particular attention should be given to high traffic areas that displayed distressed and to areas where backfilled trenches are located.

Design pavement section thicknesses are typically determined based on post-construction traffic loading conditions, which do not account for heavy construction traffic during the early stages of development. A partially constructed structural section subjected to heavy construction traffic can result in pavement deterioration and premature failure. Our experience indicates this pavement construction practice can result in pavements which will not perform as intended. Considering this information, several alternatives are available to mitigate the impact of heavy construction traffic on the pavement construction. These include using thicker sections to account for construction traffic, using some method of stabilization to improve the support characteristics of the pavement subsurface, or by routing heavy construction traffic around paved areas using a “haul road” constructed for that purpose.

Maintenance is essential to good long-term performance of rigid and flexible pavements. Any distressed areas should be repaired promptly to prevent the failure from spreading due to loading and water infiltration.

7.0 CONSTRUCTION CONSIDERATIONS

7.1 SITE PREPARATION

Site preparation should initially include removing the existing concrete pavement, underlying bituminous pavement, and underlying cemented base material. Additionally, any topsoil or soils containing organic content should be removed in their entirety from any new planned pavement areas. At the completion of these activities, the subgrade should be evaluated as follows:

- Recompacting the upper 12 inches of exposed subgrade materials to 95 percent of the maximum dry density (100 percent if within 12 inches of the final subgrade elevation).
- Perform proof rolling prior to any fill or base material placement in fill areas and/or following cuts to grade in cut areas.
- Proof rolling should be performed using a fully-loaded tandem-axle dump truck or other rubber-tired equipment judged suitable by the geotechnical engineer.
- Our geotechnical engineer or his representative should observe proof rolling activities.
- Remediate soft, organic, or yielding subgrade materials encountered during the proof rolling operations as recommended by our geotechnical engineer.

7.1.1 Stabilization of Weak Soils

If areas of instability remain after scarifying and recompacting the existing soil in place, other options may be considered for stabilizing weak subgrade areas. These options are briefly described below.

- Scarify and Recompact – It may be possible to stabilize near-surface soils that are unstable due to excessive moisture by scarifying the unstable soils, allowing them to dry, and recompacting them in accordance with structural fill criteria. This process can be successful during hot, dry periods and when the construction schedule is flexible. Drying the soils can be problematic during cold, wet weather or when the construction schedule is not flexible.

- Undercut and Replace – This method involves the excavation of the soft/unstable soils until stiff soils are exposed. The undercut is then backfilled with compacted soil.

- Undercut and Stabilize with Geotextiles and/or Geogrids and Granular Fill – After the undercut surface has been made smooth, geotextiles and/or geogrids can be placed across the surface, followed by placement of granular fill (size and gradation of granular fill to be compatible with the geotextile/geogrid selected). Once a stable surface has been achieved, additional structural fill may be placed, if required.

- Stabilize with Cement or Lime Admixtures – Cement or lime stabilization is performed by a specialty contractor who mobilizes to the site, mixes the soils with cement or lime, and replaces and compacts these soils to the planned subgrade elevation. This stabilization method dries and treats the soils to provide a stable subbase.

As previously noted, the near-surface soils consist of loess. The stability of these soils is a function of the soil's water content. Experience indicates soils with water contents near the soil's Plastic Limit (usually in the teens) are typically strong and stable. Soils with water contents several points above the Plastic Limit are often weak and unstable. Some remedial subgrade work should be expected based on the water contents near ground level at the time of this exploration.

Protection of the subgrade is a critical issue for maintaining the stability of subgrades formed in loess. Positive surface drainage should be maintained throughout construction. Areas which break down because of construction traffic or exposure to moisture should be repaired to prevent the failed area from spreading. Heavy equipment such as concrete trucks should be restricted to using construction roads specifically prepared for that purpose. Such roads can consist of 2 or more feet of crushed stone or crushed concrete. Soil-cement is also a viable alternative.

7.2 COMPACTED FILL RECOMMENDATIONS

Once the subgrade has been properly prepared, compacted fill may be placed in accordance with the recommendations provided below to attain final desired construction elevations. Fill operations should not begin until representative soil samples are collected and tested (allow 3 to 4 days for sampling and testing). The test results will be used to determine whether the proposed fill material meets the specified criteria and for quality control during grading. Fill placement and compaction should be observed by a geotechnical representative on a full-time basis. Our limited laboratory testing indicates most of the on-site soils meet the criteria recommended below. Materials from both on-site and off-site sources proposed for use as structural fill should meet the criteria provided below.

- Liquid Limit less than 50
- Plasticity Index less than 25
- Maximum dry density (ASTM D1557) of 95 pcf or greater
- Free of large rock fragments (greater than 3 inches in diameter) and organic materials (less than 5 percent by weight)
- Amount of rock fragments retained on a 3/4-inch sieve should be less than 30 percent by weight

Structural fill should be placed and compacted using the following criteria:

- Soil fill should be placed in lifts of uniform thickness. The loose lift thickness should not exceed the amount which can be properly compacted throughout its entire depth with the equipment available, usually no more than 8 inches for cohesive material. In confined areas such as utility trenches, lift thicknesses of 3 to 4 inches may be required to achieve the recommended degree of compaction.
- Fill should be properly keyed into stripped and scarified subgrades. The upper one foot of remaining materials in cut areas or in areas which do not receive more than one foot of new fill should be scarified and recompacted using the guidelines outlined in this report section.

- So a positive tie is created along the interface of engineered fill and sloping ground (steeper than 4H:1V), we recommend the host slope be benched as the fill is placed. For this project, benching is defined as grading a saw tooth or terrace configuration into the slope. In general, at a minimum, we recommend benches should be about three feet tall and a minimum of eight feet wide, although some modification to bench geometry is permissible based upon conditions observed at particular locations. Further, fill placement should begin at the bottom of the slope and the working fill surface should be maintained approximately horizontal.
- Fill should not be placed on frozen or saturated subgrades.
- Based on the FAA Standard Specifications for Construction of Airports, dated December 21, 2018, Section 152-2.10 Compaction requirements, the top 12 inches of the pavement subgrade must be compacted to not less than 100 percent of the maximum dry density as determined by the Modified Proctor (ASTM D1557) and to within 2 percent of optimum moisture content immediately prior to paving. Additionally, the subgrade in areas outside of the limits of the pavement areas should be compacted to a depth of 12 inches to a density not less than 95 percent of the maximum dry density as determined by a Standard Proctor (ASTM D698). Additionally, the compacted fill should be stable under the moving load of a loaded tandem-axle dump truck.
- Density tests should be performed at a frequency of no less than one test per 5,000 square feet for pavement areas for each fill layer placed, with a minimum of two tests per lift. For utility trenches, one density test should be performed every 50 linear feet for each one-foot thick fill layer placed, with a minimum of two tests per lift. Any areas not meeting the recommended compaction should be reworked and recompacted to achieve compliance. The recommended test frequencies are for preliminary planning and should be adjusted in the field to account for material variability, rate of placement, weather and other factors.
- The soils should be placed near (within two percent of) the optimum water content (ASTM D1557). Aeration (i.e., drying) is often necessary to bring fill materials to the required water content during wet and rainy periods. During dry periods, water may need to be added to achieve the proper water content for compaction. Clayey and silty soils may require aeration prior to compaction, even during dry periods. The water content testing performed during this exploration suggests some of the on-site soils are significantly above the optimum water contents.
- Soil slopes should be protected from erosion by seeding, sodding, or other means, and surface run-off should be diverted away from slopes. For erosion protection, grass or other vegetation should be established on permanent slopes as soon as practical.
- Compacted soil fill embankments should be constructed no steeper than a ratio of 3 horizontal to 1 vertical (i.e., 3H:1V). We also recommend permanent cut slopes be constructed no steeper than 3H:1V.
- Compacted fills should extend horizontally outside of planned pavement areas at least 10 feet before sloping.
- Cut and fill slopes should be regularly evaluated during the construction for indications of movement.
- Excavations should be constructed in accordance with applicable Occupational Safety and Health Administration (OSHA) regulations.

7.3 GENERAL EARTHWORK CONSIDERATIONS

During earthwork operations, positive surface drainage should be maintained to prevent water from ponding on the exposed ground surface. The exposed subgrade may be rolled with a rubber-tired or steel drummed roller to improve surface run-off if precipitation is expected. Our geotechnical engineer should be consulted if the subgrade soils become excessively wet or dry, or frozen.

7.4 GROUNDWATER CONTROL RECOMMENDATIONS

Groundwater was not generally encountered in the borings, except for Borings B-1 and B-3, which encountered groundwater at a depth of 8 feet below the existing ground surface. We anticipate in most cases, depending on seasonal conditions, any seepage encountered can be handled by conventional dewatering methods (i.e., pumping from small sumps located near the source or in collector areas). If larger quantities of groundwater are encountered, the Geotechnical Engineer should be contacted.

8.0 QUALIFICATIONS OF RECOMMENDATIONS

The recommendations provided herein were developed in part using the subsurface information obtained from the pavement corings and soil test borings advanced at the site. Soil test borings depict the soil conditions only at the specific location and time at which they were completed. The soil conditions at other locations on the site or at other times may differ from those occurring at the boring locations.

The scope of this geotechnical exploration did not include assessment or exploration for the presence or absence of hazardous or toxic materials in the soil, rock, groundwater, surface water, or air within or beyond the site. Any statements in this report or indicated on the test boring logs regarding odors, staining of soils, or other unusual conditions observed are strictly for the information of KSWA's client.

KSWA's professional services were performed, findings obtained, and recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. KSWA is not responsible for the conclusions, opinions, or recommendations made by others based upon the data included herein.

KSWA's services include retaining the soil samples obtained during this study for 30 days after report submittal. Further storage or transfer of the samples can be made at the Client's expense upon a written request.

APPENDIX A

EXPLORATION PLAN

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

N

NOT TO SCALE

JOB NO. 100-19-0019

CLIENT: Allen & Hoshall

PROJECT NAME:
Taxiway Alpha West
Reconstruction

DATE: 6/12/19

Exploration Plan

Memphis International Airport
Memphis, Tennessee

DRAWN BY: BK

REVIEWED BY: NL

LEGEND

KSWA
K. S. Ware & Associates, L.L.C.
Geotechnical • CEI • Environmental

Figure 1

APPENDIX B

FIELD TESTING PROCEDURES

FIELD CLASSIFICATION SYSTEM

SOIL CLASSIFICATION CHART

TEST BORING LOGS

CORE PHOTOGRAPHS

FIELD TESTING PROCEDURES

Drilling, sampling, and testing were conducted in general accordance with methods of the American Society for Testing and Materials (ASTM) or other widely-accepted geotechnical engineering standards. Descriptions of the procedures used during this exploration are provided below.

BORING AND COREHOLE LOCATIONS AND ELEVATIONS

The boring and corehole locations were selected and marked in the field by the Client's surveying subcontractor prior to beginning our exploration. We located the exploration locations on the Exploration Location Plan by estimating distances and angles relative to on-site features. Surveying of boring and corehole coordinates was beyond the scope of our exploration and was performed by others.

TEST BORINGS
ASTM D 1586

Test borings were advanced using auger drilling techniques. At regular intervals, soil samples were obtained with a standard 1.4-inch I.D., 2.0-inch O.D., split-barrel sampler. The sampler was initially seated 6 inches to penetrate any loose cuttings and then driven an additional foot with blows of a 140-pound hammer falling 30 inches. The number of hammer blows required to drive the sampler the final foot is the *standard penetration resistance*, or N-value. Standard penetration resistance, when properly evaluated, is an index to the soil's strength and density. The criteria used during this exploration are presented on the Field Classification System sheet in this appendix. Representative portions of the soil samples obtained were placed in sealed containers and transported to our laboratory, where our engineer selected samples for laboratory testing.

The standard penetration tests were performed using an automatic hammer. The automatic hammer has a higher efficiency than the traditional rope and cathead hammer, thus yielding comparatively lower N-values. This reduction in N-value was accounted for during our engineering analysis. However, the consistencies presented on the boring logs were based on the customary relationships with N-value.

BORING LOGS

The soil samples obtained during the drilling were visually classified using the USCS as a guide (reference Soil Classification Chart in Appendix B). The Test Boring Logs in Appendix B provide the soil descriptions and penetration resistances, and represent our interpretation of the conditions encountered at each boring location. The stratification lines indicated on the boring records represent the approximate boundaries between material types, but these transitions may be gradual. The boring logs were prepared based on the field logs and review of the laboratory classification test results. The USCS designations indicated on the boring logs are based on visual-manual evaluation of the samples unless otherwise defined by laboratory testing.

The boring logs indicate estimated interfaces between soil strata. The interfaces indicated represent the approximate interface location, but the actual transition between strata may be gradual. Water levels indicated on the boring logs represent the conditions only at the time each measurement was taken.

FIELD CLASSIFICATION SYSTEM

Sands and Gravels

No. of Blows	Relative Density
0-5	Very Loose
6-10	Loose
11-30	Medium dense
31-50	Dense
51+	Very Dense

Silts and Clays

No. of Blows	Relative Consistency
0-2	Very Soft
3-4	Soft
5-9	Firm
10-15	Stiff
16-30	Very Stiff
31+	Hard

Particle Size Identification

Boulders:	8-inch diameter or larger
Cobbles:	3- to 8-inch diameter
Gravel:	
Coarse:	1- to 3-inch
Medium:	0.50- to 1-inch
Fine:	0.25- to 0.50-inch
Sand:	
Coarse:	2.00-mm to 0.25-inch (diameter of pencil lead)
Medium:	0.074-mm to 2.00-mm (diameter of broom straw)
Fine:	0.042-mm to 0.074-mm (diameter of human hair)
Silt:	0.002-mm to 0.042-mm (Cannot see particles)
Clay:	<0.002-mm

Relative Proportions

Descriptive Term	Percent
Trace	1-10
Little	11-20
Some	21-35
And	36-50

Relative Quality of Rock Cores

Quality	RQD
Very Poor	0-25%
Poor	25-50%
Fair	50-75%
Good	75-90%
Excellent	90-100%

$$\text{RQD} = \frac{\text{Total length of core recovered in pieces 4 inches long or longer} \times 100\%}{\text{Total length of core run}}$$

Rock Hardness

Very Soft	Rock disintegrates or easily compresses to touch; can be hard to very hard soil
Soft	Rock is coherent but breaks easily to thumb pressure at sharp edges and crumbles with firm hand pressure
Moderately Hard	Small pieces can be broken off along sharp edges by considerable hard thumb pressure; can be broken by light hammer blows
Hard	Rock cannot be broken by thumb pressure, but can be broken by moderate hammer blows
Very Hard	Rock can be broken by heavy hammer blows

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)	●	GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
			○	GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	○	GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
			▨	GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)	⁘	SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
			⁘	SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	⁘	SM	SILTY SANDS, SAND - SILT MIXTURES
			▨	SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50	▥	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			▨	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			▤	OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50	▥	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
			▨	CH	INORGANIC CLAYS OF HIGH PLASTICITY
			〰	OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			⁂	PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

KSWA BORING LOG

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BORING NO. B-01

PROJECT NAME: MSCAA Taxiway Alpha West
LOCATION: Memphis, TN
PROJECT NO.: 100-19-0019

Sheet 1 of 1

Approx. Surface El. (feet, MSL):
Location: **See Exploration Plan**

Depth, feet	MATERIAL DESCRIPTION	Recovery (%)	RQD (%)	SPT Values	N-Value	Pocket Pen (tsf)	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
1.6	CONCRETE (18.5 inches)									
1.8	ASPHALT (3.5 inches)									
2.2	CEMENTED BASE (4 inches)	100		50/2"						
5.5	LEAN CLAY (CL), little sand (upper 6"), oxidation, reddish black nodules, gray-brown, firm, moist	83		2-2-3	5	2.0	26.2			
8.0	SILT (ML), brown, loose, moist	83					30.2	NP	NP	NP
10.0	▽ LEAN CLAY (CL), oxidation, black nodules, gray-brown, soft, v. moist to wet	100		2-2-2	4	3.0	30.2			
	BORING TERMINATED AT 10 FBGS									

Completion Depth (ft.): **10.0**
Date Started: **5/10/19**
Date Completed: **5/10/19**
Drilled By: **Geotechnology**
Logged By: **K. Andrus**

Remarks: **Groundwater encountered at an approximate depth of 8 feet during drilling operations. CME 55 Drill Rig. 6" Flight Auger. Backfilled with sand and patched with concrete.**

KSWA BORING LOG

K. S. Ware & Associates, L.L.C.
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BORING NO. B-02

PROJECT NAME: MSCAA Taxiway Alpha West
LOCATION: Memphis, TN
PROJECT NO.: 100-19-0019

Sheet 1 of 1

Approx. Surface El. (feet, MSL):
Location: **See Map**

Depth, feet	Graphic Log	MATERIAL DESCRIPTION	Samples	Recovery (%)	RQD (%)	SPT Values	N-Value	Pocket Pen (tsf)	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
1.5	░	CONCRETE (18 inches)										
1.8	■	ASPHALT (4 inches)										
2.2	▩	CEMENTED BASE (4 inches)	☒	100		50/2"			12.4			
5.5	▨	LEAN CLAY (CL), with silt, black nodules, gray-brown, stiff, moist	☒	78		2-4-6	10	3.0	23.5			
8.0	▥	SILT (ML), brown, v. loose, moist	☒	89		2-2-2	4	2.0	30.3			
10.0	▨	LEAN CLAY (CL), with silt, black nodules, oxidation, gray, firm, moist	☒	78		1-2-3	5	2.0	31.1	35	22	13
		BORING TERMINATED AT 10 FBGS										

Completion Depth (ft.): **10.0**
Date Started: **5/10/19**
Date Completed: **5/10/19**
Drilled By: **Geotechnology**
Logged By: **K. Andrus**

Remarks: **CME 55 Drill Rig. 6" Flight Auger. Bulk Sample taken. Backfilled with sand and patched with concrete. Dry upon completion.**

KSWA BORING LOG

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BORING NO. B-03

PROJECT NAME: **MSCAA Taxiway Alpha West**
LOCATION: **Memphis, TN**
PROJECT NO.: **100-19-0019**
Sheet 1 of 1

Approx. Surface El. (feet, MSL):
Location: **See Map**

Depth, feet	MATERIAL DESCRIPTION	Samples	Recovery (%)	RQD (%)	SPT Values	N-Value	Pocket Pen (tsf)	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
1.5	CONCRETE (18 inches)										
1.9	ASPHALT (5 inches)										
2.2	CEMENTED BASE (3 inches)	⊠	0		50/2"						
5.5	LEAN CLAY (CL), black nodules, oxidation, light brown with gray streaking, firm, moist	⊠	78		2-4-4	8	4.5	25.6			
8.0 ▽	SILT (ML), brown, loose, moist	■	88					28.9	NP	NP	NP
10.0	LEAN CLAY (CL), black nodules, oxidation, brown with light gray mottling, soft, wet	⊠	100		1-1-2	3	2.0	34.0			
	BORING TERMINATED AT 10 FBGS										

Depth scale: 4, 8, 12, 16, 20

Completion Depth (ft.): **10.0**
Date Started: **5/10/19**
Date Completed: **5/10/19**
Drilled By: **Geotechnology**
Logged By: **K. Andrus**

Remarks: **Groundwater encountered at an approximate depth of 8 feet during drilling operations. CME 55 Drill Rig. 6" Flight Auger. Backfilled with sand and patched with concrete.**

KSWA BORING LOG

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BORING NO. B-04

PROJECT NAME: **MSCAA Taxiway Alpha West**
LOCATION: **Memphis, TN**
PROJECT NO.: **100-19-0019**

Sheet 1 of 1

Approx. Surface El. (feet, MSL):
Location: **See Map**

Depth, feet	MATERIAL DESCRIPTION	Samples	Recovery (%)	RQD (%)	SPT Values	N-Value	Pocket Pen (tsf)	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
1.5	CONCRETE (18 inches)										
1.8	ASPHALT (4 inches)										
2.2	CEMENTED BASE (4 inches)	☒	100		50/1.5"			13.9			
5.5	LEAN CLAY (CL), black nodulus, brown with gray streaking, firm, moist	☒	67		2-2-4	6	2.5	26.0			
8.0	SILT (ML), brown, v. loose, moist	☒	94		1-1-2	3	1.5	30.3			
10.0	LEAN CLAY (CL), black nodules, brown with gray streaking, soft, moist	☒	100		1-2-2	4	1.5	31.5			
	BORING TERMINATED AT 10 FBGS										

Depth scale: 4, 8, 12, 16, 20

Completion Depth (ft.):	**10.0**
Date Started:	**5/10/19**
Date Completed:	**5/10/19**
Drilled By:	**Geotechnology**
Logged By:	**K. Andrus**

Remarks: **CME 55 Drill Rig. 6" Flight Auger. Backfilled with sand and patched with concrete. Dry upon completion.**

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BORING NO. B-05

PROJECT NAME: MSCAA Taxiway Alpha West
LOCATION: Memphis, TN
PROJECT NO.: 100-19-0019

Sheet 1 of 1

Approx. Surface El. (feet, MSL):
Location: See Map

Depth, feet	Graphic Log	MATERIAL DESCRIPTION	Samples	Recovery (%)	RQD (%)	SPT Values	N-Value	Pocket Pen (tsf)	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
1.5		CONCRETE (18 inches)										
1.9		ASPHALT (4.5 inches)										
2.2		CEMENTED BASE (3.5 inches)										
3.5		LEAN CLAY (CL), rock fragments, gray, stiff, moist	☒	67		25-6-5	11	4.5	22.5			
5.5		LEAN CLAY (CL), some silt, gray with brown mottling, firm, moist	☒	72		1-2-3	5	2.25	28.8	42	18	24
8.0		SILT (ML), brown, loose, moist	☒	100		2-3-4	7	2.75	24.2			
10.0		LEAN CLAY (CL), black nodules, oxidation, gray with brown mottling, firm, moist	☒	100		2-2-3	5	2.5	26.6			
		BORING TERMINATED AT 10 FBGS										

Completion Depth (ft.): **10.0**
Date Started: **5/8/19**
Date Completed: **5/8/19**
Drilled By: **Geotechnology**
Logged By: **V. Gallagher**

Remarks: **CME 55 Drill Rig. 6" Flight Auger. Backfilled with sand and patched with concrete. Dry upon completion.**

KSWA BORING LOG

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BORING NO. B-06

PROJECT NAME: **MSCAA Taxiway Alpha West**
LOCATION: **Memphis, TN**
PROJECT NO.: **100-19-0019**
Sheet 1 of 1

Approx. Surface El. (feet, MSL):
Location: **See Map**

Depth, feet	Graphic Log	MATERIAL DESCRIPTION	Samples	Recovery (%)	RQD (%)	SPT Values	N-Value	Pocket Pen (tsf)	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
		CONCRETE (20.5 inches) 1.7										
		ASPHALT (3.5 inches) 2.0	☒	100		50/2"						
		CEMENTED BASE (2 inches) 2.2										
		SANDY SILT (ML), roots, gray with red-brown mottling, v. moist (FILL)										
4			☒	72		WoH-WoH-1	1		23.4			
		5.5										
		SILT (ML), brown, loose, moist	☒	89		2-5-4	9	2.75	24.0			
8		8.0										
		LEAN CLAY (CL), some silt, gray with brown mottling, firm, moist	☒	100		1-3-3	6	1.75	32.6			
		10.0										
		BORING TERMINATED AT 10 FBGS										
12												
16												
20												

Completion Depth (ft.): **10.0**
Date Started: **5/8/19**
Date Completed: **5/8/19**
Drilled By: **Geotechnology**
Logged By: **V. Gallagher**

Remarks: **CME 55 Drill Rig. 6" Flight Auger. Backfilled with sand and patched with concrete. WoH=Weight of Hammer. Dry upon completion.**

KSWA BORING LOG

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BORING NO. B-08

PROJECT NAME: **MSCAA Taxiway Alpha West**
LOCATION: **Memphis, TN**
PROJECT NO.: **100-19-0019**

Sheet 1 of 1

Approx. Surface El. (feet, MSL):
Location: **See Map**

Depth, feet	Graphic Log	MATERIAL DESCRIPTION	Samples	Recovery (%)	RQD (%)	SPT Values	N-Value	Pocket Pen (tsf)	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
1.5	░	CONCRETE (17.5 inches)										
1.7	■	ASPHALT (2.5 inches)										
2.2	▦	CEMENTED BASE (6 inches)										
3.5	▨	LEAN CLAY (CL), dark gray, firm, dry to moist	☒	72		4-3-4	7	3.5	21.0			
5.5	▨	LEAN CLAY (CL), oxidation, light gray-brown, firm, moist	☒	89		3-3-4	7	2.0 - 2.5				
8.0	▥	SILT (ML), brown, loose, moist	☒	94		2-4-4	8	2.0	25.7			
10.0	▨	LEAN CLAY (CL), oxidation, light gray, firm, moist	☒	94		2-2-3	5	2.5	26.3	33	23	10
		BORING TERMINATED AT 10 FBGS										

Depth scale: 4, 8, 12, 16, 20

Completion Depth (ft.): **10.0**
Date Started: **5/15/19**
Date Completed: **5/15/19**
Drilled By: **Geotechnology**
Logged By: **K. Andrus**

Remarks: **CME 55 Drill Rig. 6" Flight Auger. Bulk Sample taken. Backfilled with sand and patched with concrete. Dry upon completion.**

KSWA BORING LOG

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BORING NO. B-09

PROJECT NAME: **MSCAA Taxiway Alpha West**
LOCATION: **Memphis, TN**
PROJECT NO.: **100-19-0019**

Sheet 1 of 1

Approx. Surface El. (feet, MSL):
Location: **See Map**

Depth, feet	Graphic Log	MATERIAL DESCRIPTION	Samples	Recovery (%)	RQD (%)	SPT Values	N-Value	Pocket Pen (tsf)	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
1.3		CONCRETE (16 inches)										
1.6		ASPHALT (3 inches)										
2.2		CEMENTED BASE (7 inches)										
3.5		LEAN CLAY (CL), black nodules, dark gray, firm, moist	☒	67		3-5-3	8	3.5	20.2			
8.0		SILT (ML), brown, loose, moist	☒	100		1-4-5	9	2.0 - 2.5				
			■	15								
10.0		LEAN CLAY (CL), rock fragments, black nodules, oxidation, brown, stiff, moist	☒	100		5-8-7	15	2.5 - 3.0	19.5			
		BORING TERMINATED AT 10 FBGS										

Completion Depth (ft.): **10.0**
Date Started: **5/15/19**
Date Completed: **5/15/19**
Drilled By: **Geotechnology**
Logged By: **K. Andrus**

Remarks: **CME 55 Drill Rig. 6" Flight Auger. Backfilled with sand and patched with concrete. Dry upon completion.**

KSWA BORING LOG

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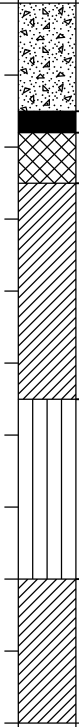
BORING NO. B-10

PROJECT NAME: **MSCAA Taxiway Alpha West**
LOCATION: **Memphis, TN**
PROJECT NO.: **100-19-0019**
Sheet 1 of 1

Approx. Surface El. (feet, MSL):
Location: **See Map**



Depth, feet	MATERIAL DESCRIPTION	Samples	Recovery (%)	RQD (%)	SPT Values	N-Value	Pocket Pen (tsf)	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
	CONCRETE (18 Inches)										
1.5	ASPHALT (3.5 inches)										
1.8	CEMENTED BASE (8.5 inches)										
2.5	LEAN CLAY (CL), brown with gray mottling, stiff, moist	☒	67		2-5-9	14	4.5				
		☒	89		2-5-6	11	2.5 - 3.0				
5.5	SILT (ML), brown, m. dense, moist	☒	94		3-6-12	18	4.0	22.0			
8.0	LEAN CLAY (CL), little silt, black nodules, brown, v. stiff, moist	☒	100		6-8-10	18	2.75	18.6			
10.0	BORING TERMINATED AT 10 FBGS										

Depth scale: 4, 8, 12, 16, 20

Completion Depth (ft.): **10.0**
Date Started: **5/14/19**
Date Completed: **5/14/19**
Drilled By: **Geotechnology**
Logged By: **K. Andrus**

Remarks: **CME 55 Drill Rig. 6" Flight Auger. Bulk Sample taken. Backfilled with sand and patched with concrete. Dry upon completion.**

KSWA BORING LOG

K. S. Ware & Associates, L.L.C.
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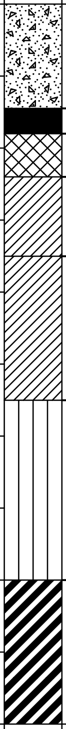
BORING NO. B-11

PROJECT NAME: MSCAA Taxiway Alpha West
LOCATION: Memphis, TN
PROJECT NO.: 100-19-0019

Sheet 1 of 1

Approx. Surface El. (feet, MSL):
Location: See Map



Depth, feet	Graphic Log	MATERIAL DESCRIPTION	Samples	Recovery (%)	RQD (%)	SPT Values	N-Value	Pocket Pen (tsf)	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
1.5		CONCRETE (17.5 Inches)										
1.8		ASPHALT (3.5 inches)										
2.4		CEMENTED BASE (8 inches)										
3.5		LEAN CLAY (CL), dark gray to brown, v. stiff, moist	☒	67		4-10-11	21	4.5	18.5			
5.5		LEAN CLAY (CL), rock fragments, black nodules, gray to grown, stiff, moist	☒	89		5-6-6	12	2.0 - 2.5				
8.0		SILT (ML), brown, loose, moist	■	88					26.2	NP	NP	NP
10.0		FAT CLAY (CH), oxidation, brown, soft, v. moist	☒	100		1-2-2	4	1.5	30.0			
		BORING TERMINATED AT 10 FBGS										

Depth scale: 4, 8, 12, 16, 20

Completion Depth (ft.): **10.0**
Date Started: **5/14/19**
Date Completed: **5/14/19**
Drilled By: **Geotechnology**
Logged By: **K. Andrus**

Remarks: **CME 55 Drill Rig. 6" Flight Auger. Backfilled with sand and patched with concrete. Dry upon completion.**

KSWA BORING LOG

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BORING NO. B-12

PROJECT NAME: **MSCAA Taxiway Alpha West**
LOCATION: **Memphis, TN**
PROJECT NO.: **100-19-0019** Sheet 1 of 1

Approx. Surface El. (feet, MSL):
Location: **See Map**

Depth, feet	Graphic Log	MATERIAL DESCRIPTION	Samples	Recovery (%)	RQD (%)	SPT Values	N-Value	Pocket Pen (tsf)	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
	⁘	CONCRETE (17.5 inches) 1.5										
	■	ASPHALT (3 inches) 1.7										
	▦	CEMENTED BASE (5.5 inches) 2.2										
	▒	CLAYEY SAND (SC), some gravel, orange-red, m. dense, moist 3.5	☒	87		15-13-11	24	3.0 - 3.5	9.4			
4	▨	LEAN CLAY (CL), black nodules, gray-brown, stiff, moist 5.5	☒	94		4-5-7	12	2.5 - 3.0				
	▥	SILT (ML), brown, m. dense, moist 8.0	☒	89		4-5-7	12	2.25	22.6			
8	▨	LEAN CLAY (CL), black nodules, gray-brown, stiff, moist 10.0	☒	83		3-4-7	11	3.0	21.1	33	22	11
		BORING TERMINATED AT 10 FBGS										
12												
16												
20												

Completion Depth (ft.):	**10.0**
Date Started:	**5/14/19**
Date Completed:	**5/14/19**
Drilled By:	**Geotechnology**
Logged By:	**K. Andrus**

Remarks: **CME 55 Drill Rig. 6" Flight Auger. Bulk Sample taken. Backfilled with sand and patched with concrete. Dry upon completion.**

KSWA BORING LOG

KSWA
K. S. Ware & Associates, L.L.C.
Geotechnical • CEI • Environmental

BORING NO. B-13

PROJECT NAME: **MSCAA Taxiway Alpha West**
LOCATION: **Memphis, TN**
PROJECT NO.: **100-19-0019**

Sheet 1 of 1

Approx. Surface El. (feet, MSL):
Location: **See Map**

Depth, feet	Graphic Log	MATERIAL DESCRIPTION	Samples	Recovery (%)	RQD (%)	SPT Values	N-Value	Pocket Pen (tsf)	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
	■	ASPHALT (22.5 inches)										
1.9	▨	LEAN CLAY (CL), black nodules, oxidation, light brown, stiff, moist	☒	87		3-5-6	11	4.5	22.7			
4	▨		■	29								
5.5	▥	SILT (ML), brown, v. loose, moist	☒	100		1-2-2	4	2.25	28.8			
8.0	▨	LEAN CLAY (CL), some silt, gray with brown mottling, soft, moist	☒	100		1-1-2	3	1.75	28.9			
10.0		BORING TERMINATED AT 10 FBGS										
12												
16												
20												

Completion Depth (ft.): **10.0**
Date Started: **5/8/19**
Date Completed: **5/8/19**
Drilled By: **Geotechnology**
Logged By: **V. Gallagher**

Remarks: **CME 55 Drill Rig. 6" Flight Auger. Backfilled with sand and patched with concrete.**

KSWA BORING LOG

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BORING NO. B-14

PROJECT NAME: **MSCAA Taxiway Alpha West**
LOCATION: **Memphis, TN**
PROJECT NO.: **100-19-0019**

Sheet 1 of 1

Approx. Surface El. (feet, MSL):
Location: **See Map**

Depth, feet	MATERIAL DESCRIPTION	Recovery (%)	RQD (%)	SPT Values	N-Value	Pocket Pen (tsf)	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
1.5	CONCRETE (18 inches)									
1.8	ASPHALT (3 inches)									
2.0	CEMENTED BASE (3 inches)									
3.5	LEAN CLAY (CL), rock fragments, dark gray, stiff, moist	78		5-6-6	12	3.5				
5.5	SANDY LEAN CLAY (CL), rock fragments, dark brown, soft, moist	67		4-2-2	4	2.5	11.5			
8.0	SILT (ML), brown, loose, moist	67		2-4-5	9	3.0	20.6			
10.0	LEAN CLAY (CL), black nodules, oxidation, gray, firm, moist	94		2-3-4	7	2.75	24.8			
	BORING TERMINATED AT 10 FBGS									

Completion Depth (ft.): **10.0**
Date Started: **5/15/19**
Date Completed: **5/15/19**
Drilled By: **Geotechnology**
Logged By: **K. Andrus**

Remarks: **CME 55 Drill Rig. 6" Flight Auger. Backfilled with sand and patched with concrete. Dry upon completion.**

KSWA BORING LOG

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BORING NO. B-16

PROJECT NAME: **MSCAA Taxiway Alpha West**
LOCATION: **Memphis, TN**
PROJECT NO.: **100-19-0019**

Sheet 1 of 1

Approx. Surface El. (feet, MSL):
Location: **See Map**

MATERIAL DESCRIPTION	Depth, feet	Samples	Recovery (%)	RQD (%)	SPT Values	N-Value	Pocket Pen (tsf)	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
CONCRETE (19 Inches)	1.6										
ASPHALT (3 inches)	1.8										
CEMENTED BASE (2 inches)	2.0										
LEAN CLAY (CL), gray, stiff, moist (FILL)	3.5	☒	67		3-7-6	13					
LEAN CLAY (CL), wood chips, black streaking, gray-brown, stiff, moist (FILL)	6.0	☒	67		6-6-7	13	4.5	18.6			
SILT (ML), brown, v. loose, moist	8.0	☒	56		3-1-2	3	1.5	21.2			
LEAN CLAY (CL), oxidation, gray-brown, firm, moist to dry	10.0	☒	67		2-3-4	7	2.5	22.4			
BORING TERMINATED AT 10 FBGS											

Completion Depth (ft.): **10.0**
Date Started: **5/14/19**
Date Completed: **5/14/19**
Drilled By: **Geotechnology**
Logged By: **K. Andrus**

Remarks: **CME 55 Drill Rig. 6" Flight Auger. Backfilled with sand and patched with concrete.**

PAVEMENT CORE PHOTOGRAPHS
TAXIWAY ALPHA WEST RECONSTRUCTION
MEMPHIS INTERNATIONAL AIRPORT
PROJECT NO. 100-19-0019

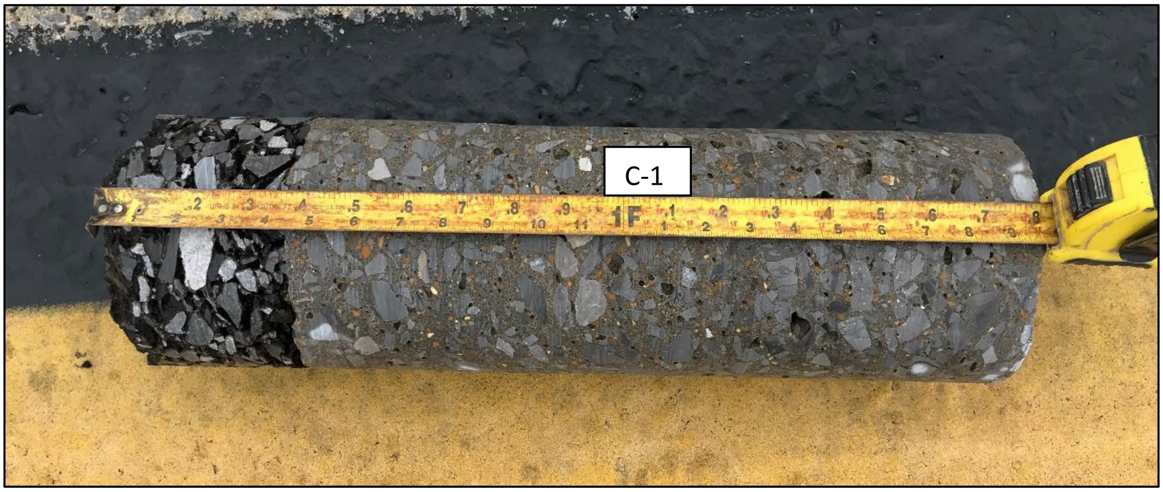

Photo 1: Concrete Core Location C-1

Photo 2: Concrete Core Location C-2

Photo 3: Concrete Core Location C-4

PAVEMENT CORE PHOTOGRAPHS
TAXIWAY ALPHA WEST RECONSTRUCTION
MEMPHIS INTERNATIONAL AIRPORT
PROJECT NO. 100-19-0019

Photo 4: Concrete Core Location C-7

Photo 5: Concrete Core Location C-8

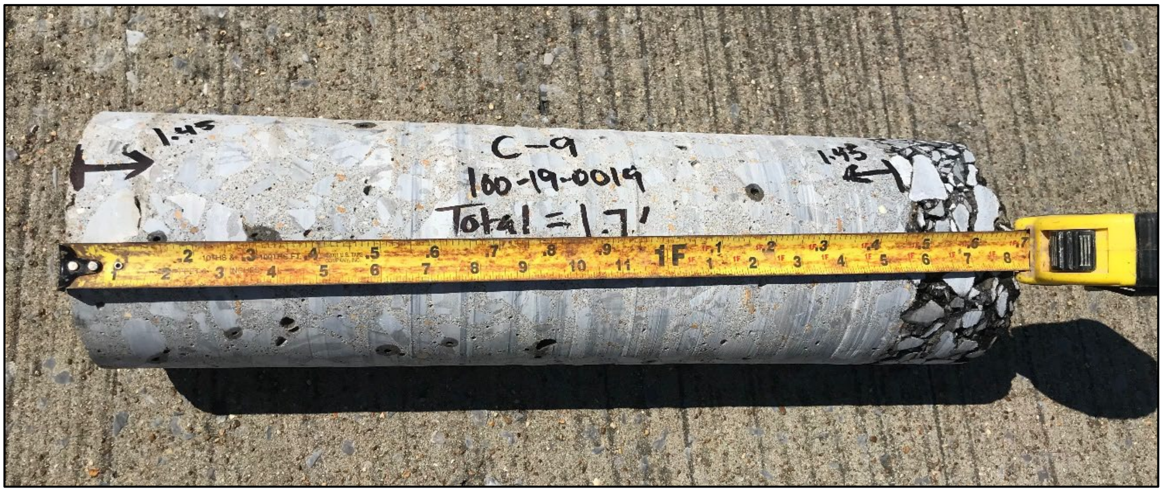

Photo 6: Concrete Core Location C-9

PAVEMENT CORE PHOTOGRAPHS
TAXIWAY ALPHA WEST RECONSTRUCTION
MEMPHIS INTERNATIONAL AIRPORT
PROJECT NO. 100-19-0019

Photo 7: Concrete Core Location C-10

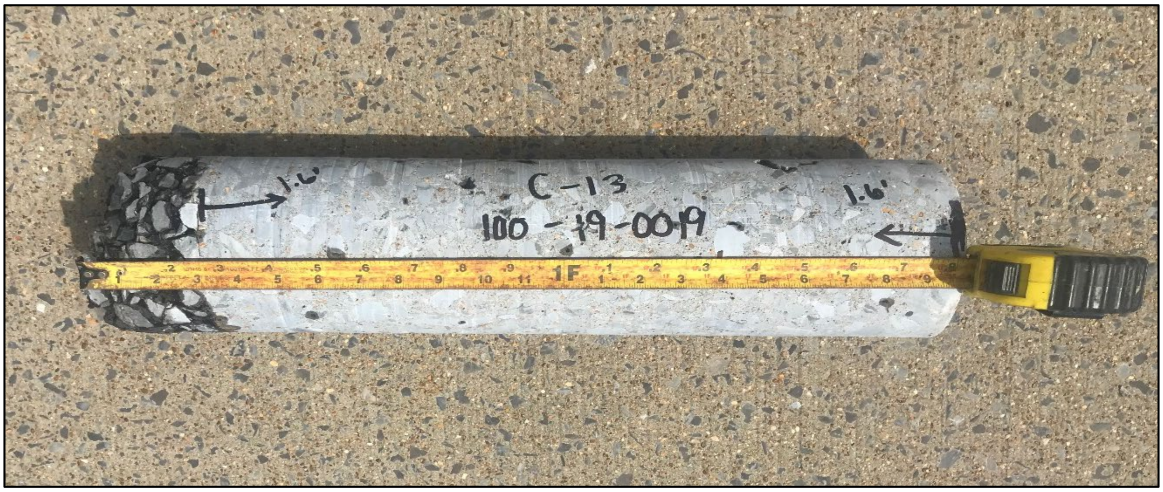

Photo 8: Concrete Core Location C-13

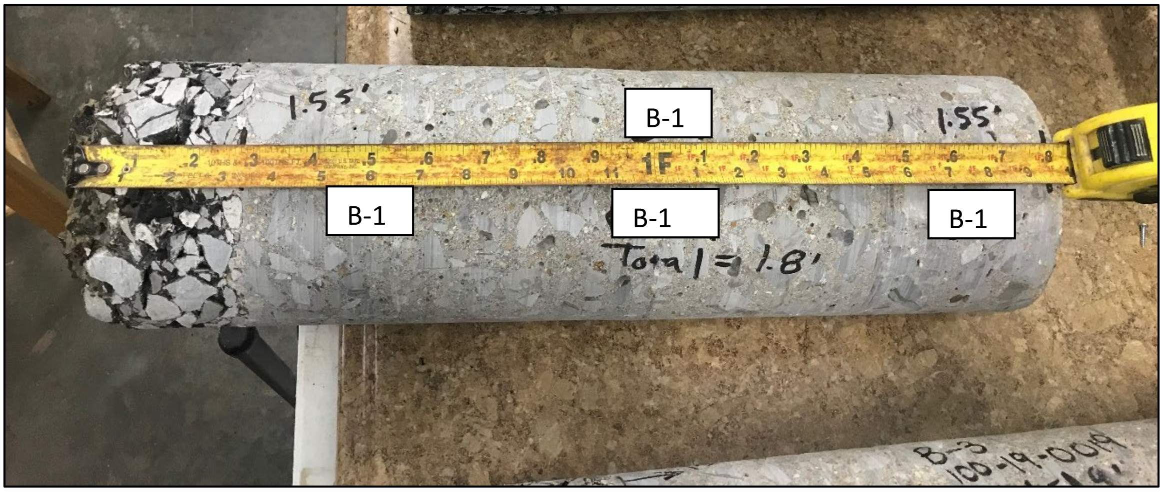

Photo 9: Concrete Core Location B-1

PAVEMENT CORE PHOTOGRAPHS
TAXIWAY ALPHA WEST RECONSTRUCTION
MEMPHIS INTERNATIONAL AIRPORT
PROJECT NO. 100-19-0019

Photo 10: Concrete Core Location B-2

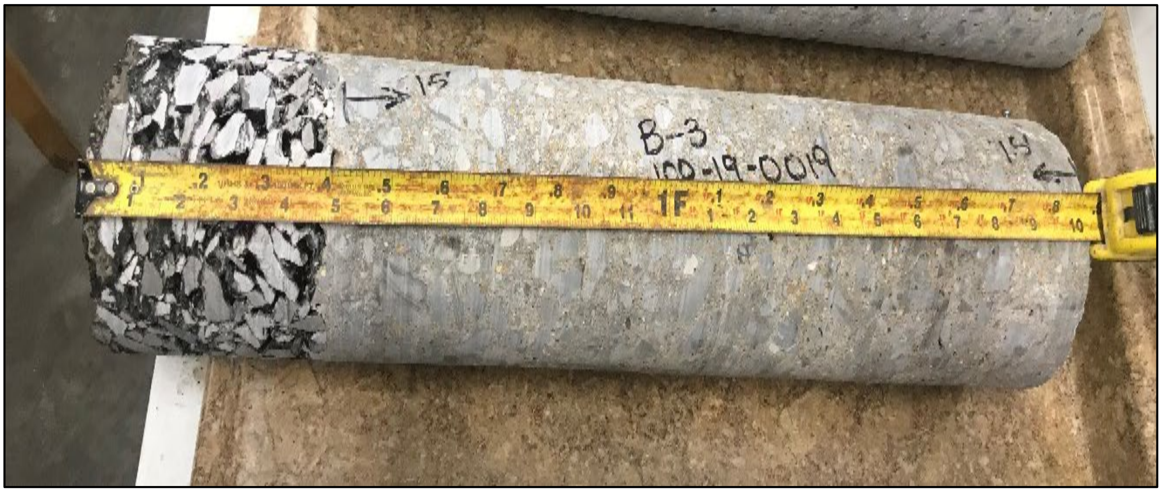

Photo 11: Concrete Core Location B-3

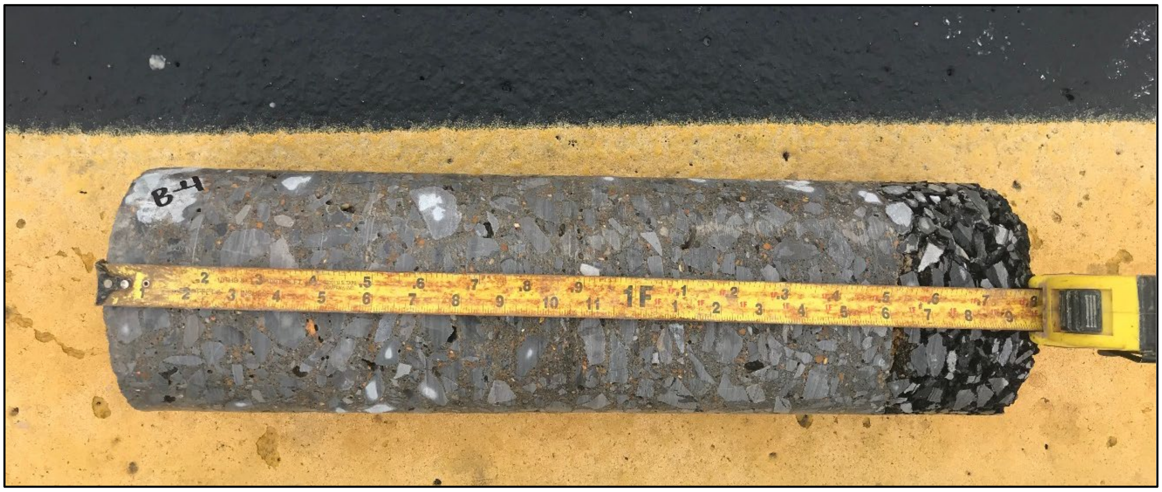

Photo 12: Concrete Core Location B-4

PAVEMENT CORE PHOTOGRAPHS
TAXIWAY ALPHA WEST RECONSTRUCTION
MEMPHIS INTERNATIONAL AIRPORT
PROJECT NO. 100-19-0019

Photo 13: Concrete Core Location B-5

Photo 14: Concrete Core Location B-6

Photo 15: Concrete Core Location B-8

PAVEMENT CORE PHOTOGRAPHS
TAXIWAY ALPHA WEST RECONSTRUCTION
MEMPHIS INTERNATIONAL AIRPORT
PROJECT NO. 100-19-0019

Photo 16: Concrete Core Location B-9

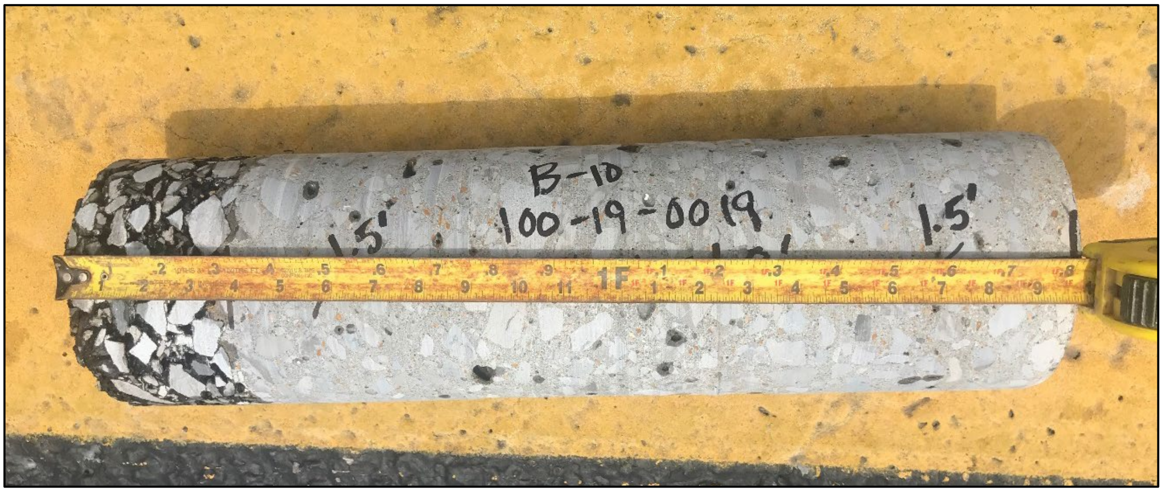

Photo 17: Concrete Core Location B-10

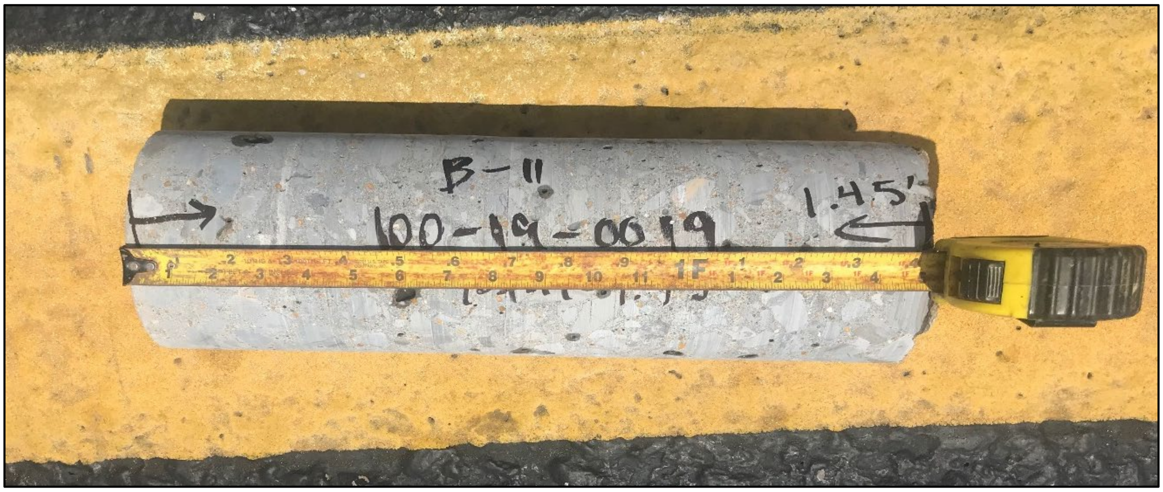

Photo 18: Concrete Core Location B-11

PAVEMENT CORE PHOTOGRAPHS
TAXIWAY ALPHA WEST RECONSTRUCTION
MEMPHIS INTERNATIONAL AIRPORT
PROJECT NO. 100-19-0019

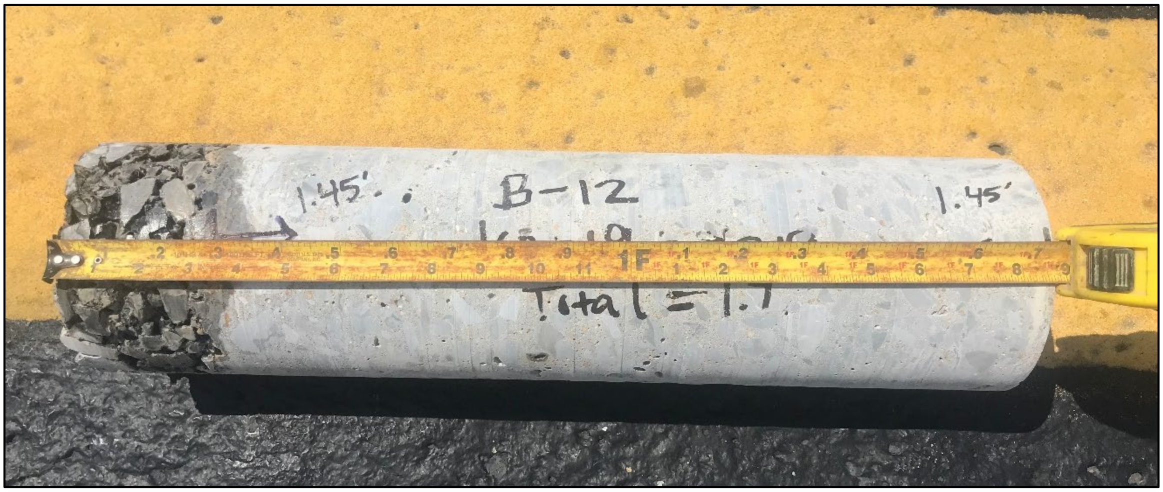

Photo 19: Concrete Core Location B-12

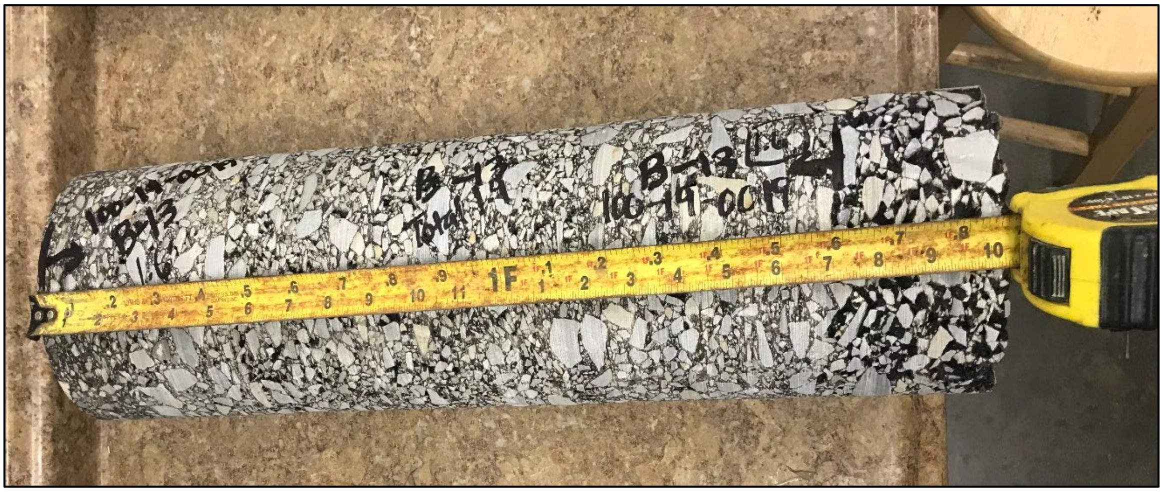

Photo 20: Concrete Core Location B-13

Photo 21: Concrete Core Location B-14

PAVEMENT CORE PHOTOGRAPHS
TAXIWAY ALPHA WEST RECONSTRUCTION
MEMPHIS INTERNATIONAL AIRPORT
PROJECT NO. 100-19-0019

Photo 22: Concrete Core Location B-15

Photo 23: Concrete Core Location B-16

APPENDIX C

Laboratory Test Results

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Nashville,Tennessee 37210
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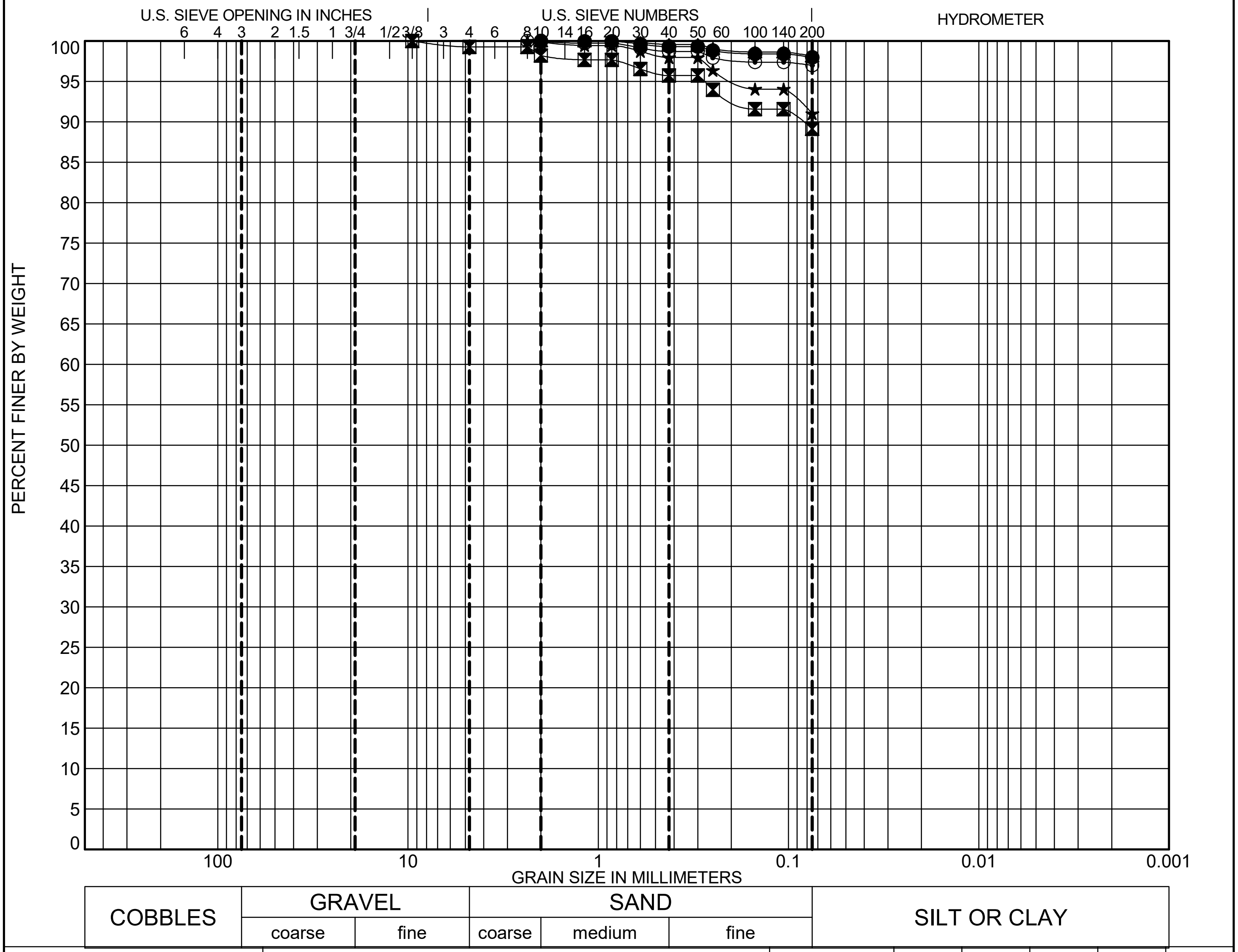
Fax: (615) 256-5873

GRAIN SIZE DISTRIBUTION
ASTM D6913 - COARSE GRAIN SIZE
ASTM D7928 - FINE GRAIN SIZE

CLIENT: Allen & Hoshall
PROJECT NAME: MSCAA Taxiway Alpha West
PROJECT NUMBER 100-19-0019
PROJECT LOCATION: Memphis, TN
SOIL DESCRIPTION: Bulk sample from auger cuttings from depths of 2 to 10 feet



	Specimen Identification		Classification	Spec. Grav.	LL	PL	PI	Cc	Cu
●	**B-01,**	**6'**	**SILT (ML)**		**NP**	**NP**	**NP**		
☒	**B-02,**	**10'**	**LEAN CLAY(CL)**		**36**	**22**	**14**		
▲	**B-03,**	**6'**	**SILT (ML)**		**NP**	**NP**	**NP**		
★	**B-05,**	**3.5'**	**LEAN CLAY(CL)**		**42**	**18**	**24**		
⊙	**B-08,**	**10'**	**LEAN CLAY(CL)**		**33**	**23**	**10**		

	Specimen Identification		D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Clay
●	**B-01,**	**6'**	**2**				**0.0**	**2.0**	**98.0**	
☒	**B-02,**	**10'**	**9.5**				**0.7**	**10.1**	**89.1**	
▲	**B-03,**	**6'**	**2**				**0.0**	**1.9**	**98.1**	
★	**B-05,**	**3.5'**	**2.36**				**0.0**	**9.0**	**91.0**	
⊙	**B-08,**	**10'**	**2.36**				**0.0**	**3.0**	**97.0**	

TESTED BY: Z. Shannon **TEST DATE**: 6/11/2019 **REVIEWED BY**: B. Kouchoukos **DATE**: 6/12/2019

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GRAIN SIZE DISTRIBUTION
ASTM D6913 - COARSE GRAIN SIZE
ASTM D7928 - FINE GRAIN SIZE

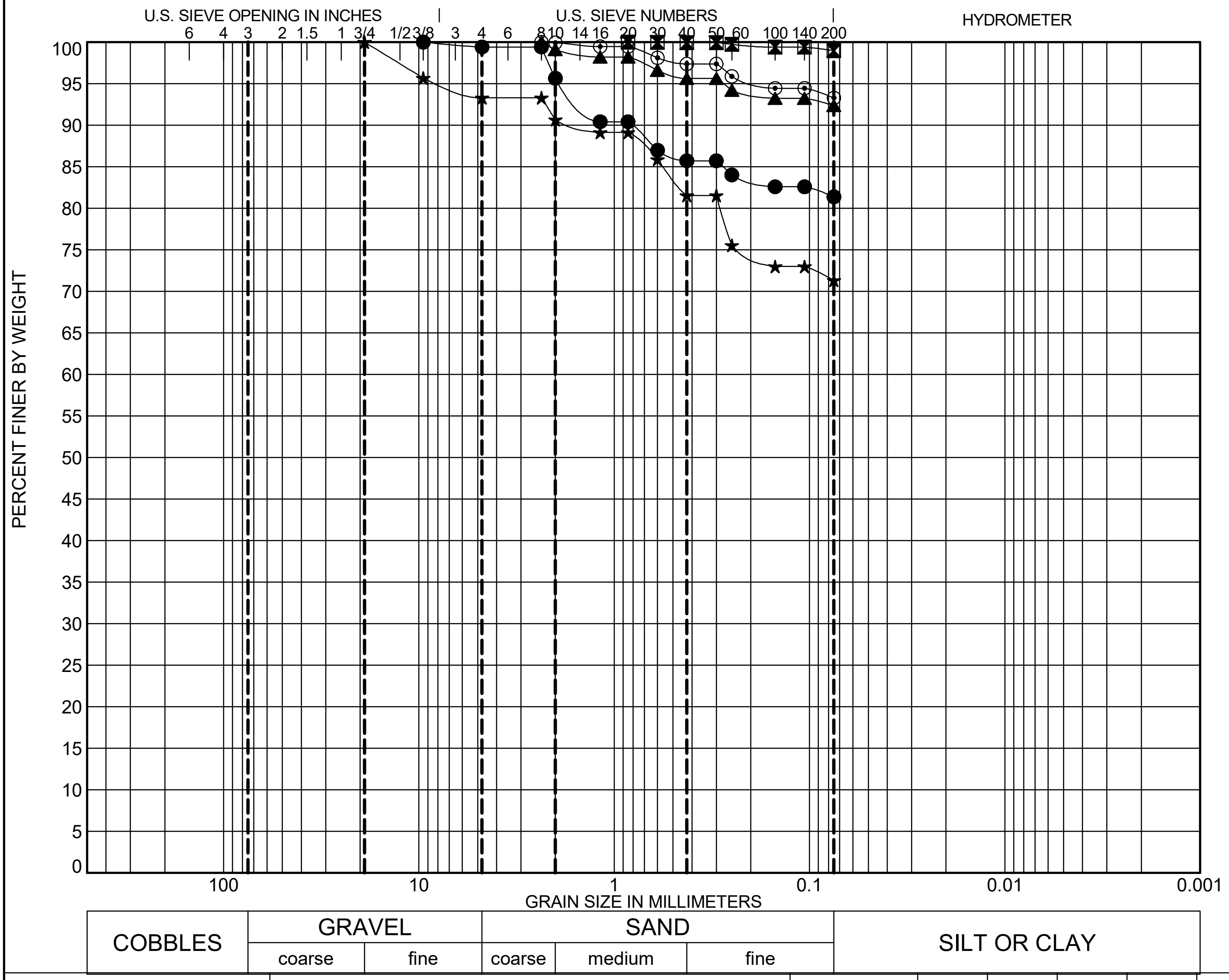
CLIENT: Allen & Hoshall

PROJECT NAME: MSCAA Taxiway Alpha West

PROJECT NUMBER 100-19-0019

PROJECT LOCATION: Memphis, TN

SOIL DESCRIPTION:



	Specimen Identification	Classification	Spec. Grav.	LL	PL	PI	Cc	Cu
●	**B-09, 3.5'**	**SILT (ML)**		**NP**	**NP**	**NP**		
⊠	**B-11, 6'**	**SILT (ML)**		**NP**	**NP**	**NP**		
▲	**B-12, 3.5'**	**LEAN CLAY(CL)**		**37**	**24**	**13**		
★	**B-12, 10'**	**LEAN CLAY with SAND(CL)**		**33**	**22**	**11**		
⊙	**B-13, 3.5'**	**LEAN CLAY(CL)**		**35**	**22**	**13**		

	Specimen Identification	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Clay
●	**B-09, 3.5'**	**9.5**				**0.6**	**18.0**	**81.4**	
⊠	**B-11, 6'**	**0.85**				**0.0**	**1.0**	**99.0**	
▲	**B-12, 3.5'**	**2.36**				**0.0**	**7.7**	**92.3**	
★	**B-12, 10'**	**19**				**6.7**	**22.0**	**71.3**	
⊙	**B-13, 3.5'**	**2.36**				**0.0**	**6.7**	**93.3**	

TESTED BY: Z. Shannon **TEST DATE**: 6/11/2019 **REVIEWED BY**: B. Kouchoukos **DATE**: 6/12/2019

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ATTERBERG LIMITS (ASTM D4318)

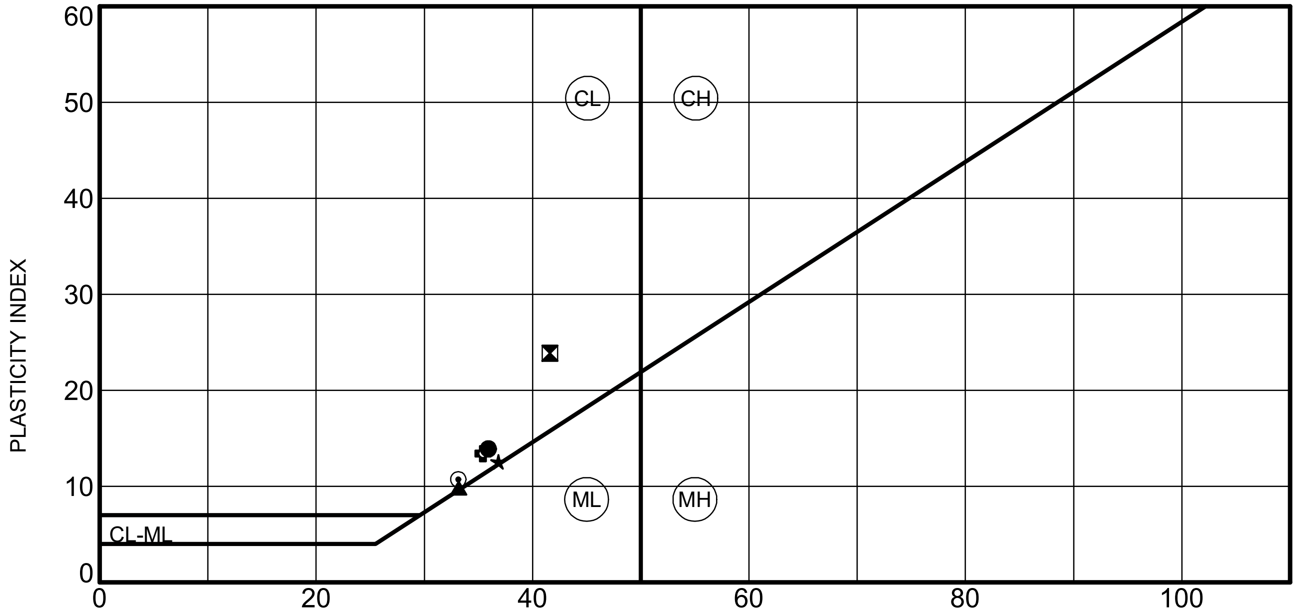
CLIENT: Allen & Hoshall

PROJECT NAME: MSCAA Taxiway Alpha West

PROJECT NUMBER 100-19-0019

PROJECT LOCATION: Memphis, TN

Equipment Used: Liquid Limit Device, Oven, Ohaus 3kg Scale, Metal Tares, Mortar and Pestle, Spatula, Plastic Grooving Tool



Specimen Identification		SAMPLE TYPE	LL	PL	PI	% Fines	Soil Description
●	**B-02, 10'**	**B**	**36**	**22**	**14**	**89**	**LEAN CLAY(CL)**
☒	**B-05, 3.5'**	**SS**	**42**	**18**	**24**	**91**	**LEAN CLAY(CL)**
▲	**B-08, 10'**	**B**	**33**	**23**	**10**	**97**	**LEAN CLAY(CL)**
★	**B-12, 3.5'**	**SS**	**37**	**24**	**13**	**92**	**LEAN CLAY(CL)**
⊙	**B-12, 10'**	**B**	**33**	**22**	**11**	**71**	**LEAN CLAY with SAND(CL)**
✤	**B-13, 3.5'**	**SS**	**35**	**22**	**13**	**93**	**LEAN CLAY(CL)**
	B-1, 6'	**ST**	**NP**	**NP**	**NP**	**98**	**SILT(ML)**
	B-3, 6'	**ST**	**NP**	**NP**	**NP**	**98**	**SILT(ML)**
	B-9, 3.5'	**ST**	**NP**	**NP**	**NP**	**81**	**SILT(ML)**
	B-11, 6'	**ST**	**NP**	**NP**	**NP**	**99**	**SILT(ML)**

Abbreviations:
NP = Non-plastic
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
SS = Split Spoon
ST = Shelby Tube
G = Grab Sample
B = Bulk Sample

TESTED BY: Z. Shannon

TEST DATE: 6/6/2019

REVIEWED BY: B. Kouchoukos

DATE: 6/11/2019

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Phone: (615) 255-9702
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MODIFIED PROCTOR (ASTM D1557)

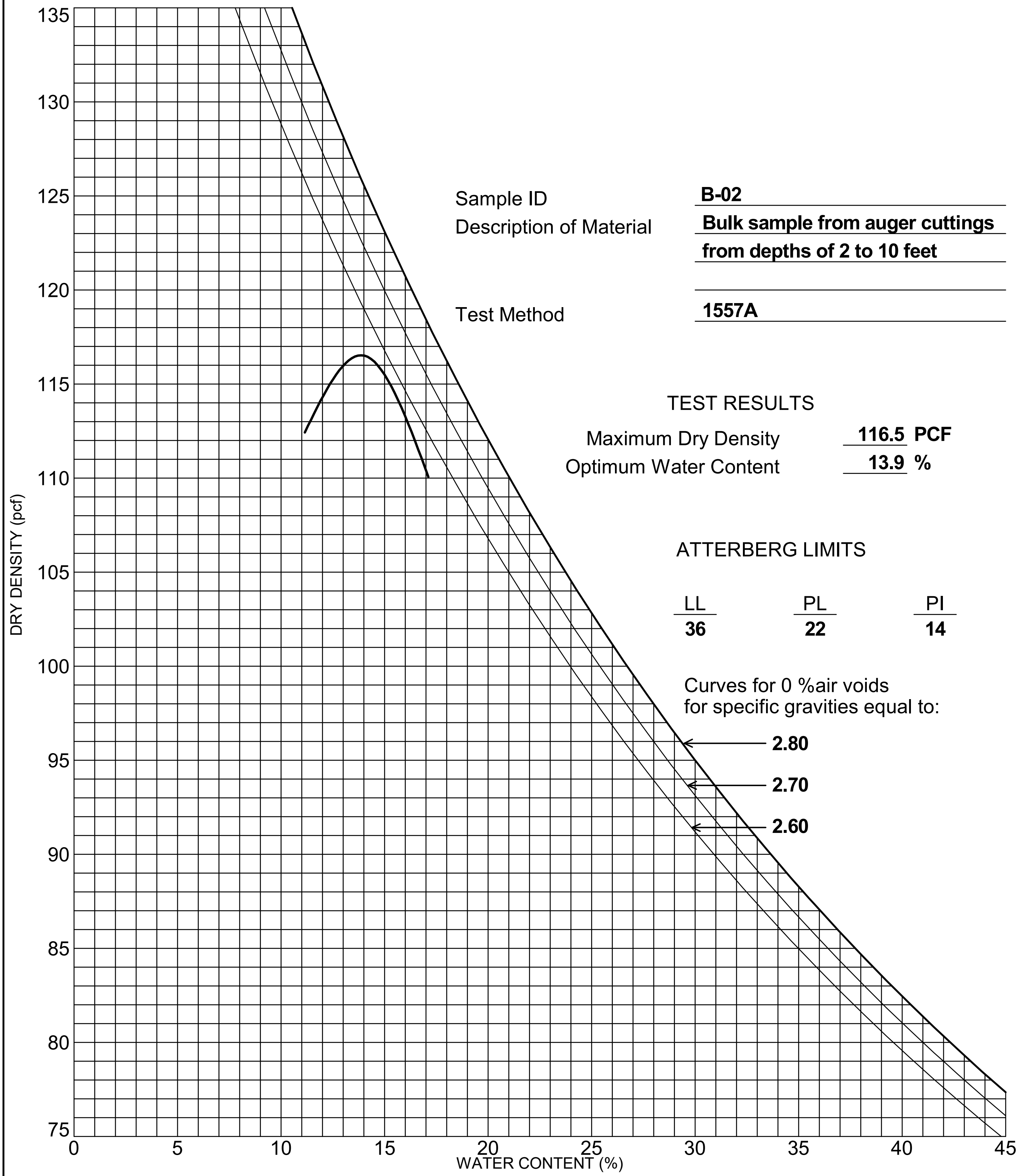
CLIENT: Allen & Hoshall

PROJECT NAME: MSCAA Taxiway Alpha West

PROJECT NUMBER 100-19-0019

PROJECT LOCATION: Memphis, TN

EQUIPMENT USED: Modified Hammer, 4 inch Mold, Ohaus 3 kilogram Scale, Oven, Ohaus 8 kilogram Scale



Sample ID **B-02**

Description of Material **Bulk sample from auger cuttings from depths of 2 to 10 feet**

Test Method **1557A**

TEST RESULTS

Maximum Dry Density	**116.5 PCF**
Optimum Water Content	**13.9 %**

ATTERBERG LIMITS

LL	PL	PI
36	**22**	**14**

TESTED BY: Z. Shannon
REVIEWED BY: B. Kouchoukos

TEST DATE: 5/23/2019
DATE: 6/12/2019

SAMPLE RECEIVED: 5/21/2019

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MODIFIED PROCTOR (ASTM D1557)

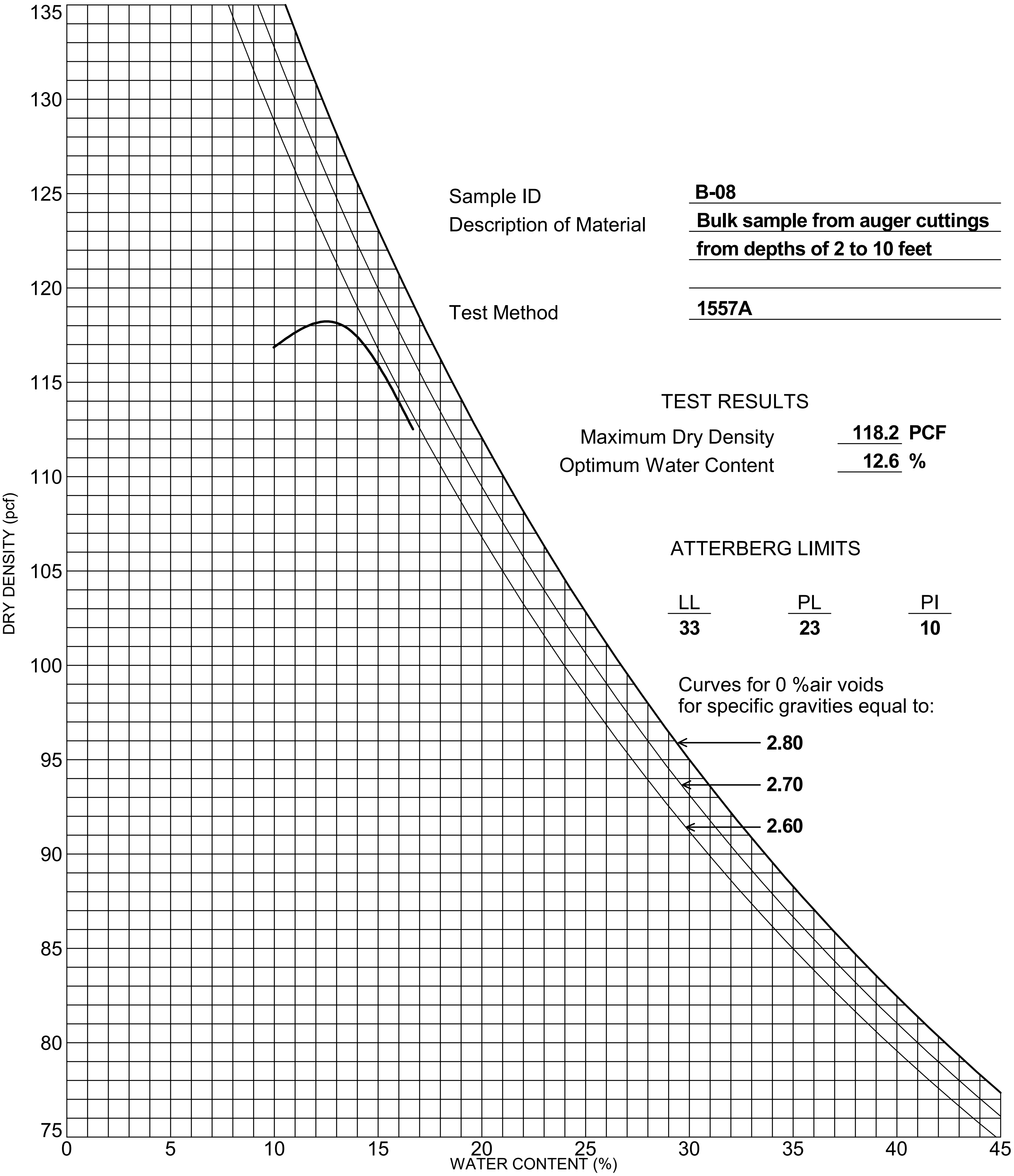
CLIENT: Allen & Hoshall

PROJECT NAME: MSCAA Taxiway Alpha West

PROJECT NUMBER 100-19-0019

PROJECT LOCATION: Memphis, TN

EQUIPMENT USED: Modified Hammer, 4 inch Mold, Ohaus 3 kilogram Scale, Oven, Ohaus 8 kilogram Scale



Sample ID **B-08**

Description of Material **Bulk sample from auger cuttings from depths of 2 to 10 feet**

Test Method **1557A**

TEST RESULTS

Maximum Dry Density **118.2 PCF**

Optimum Water Content **12.6 %**

ATTERBERG LIMITS

LL	PL	PI
33	**23**	**10**

TESTED BY: Z. Shannon
REVIEWED BY: B. Kouchoukos

TEST DATE: 6/5/2019
DATE: 6/12/2019

SAMPLE RECEIVED: 5/21/2019

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MODIFIED PROCTOR (ASTM D1557)

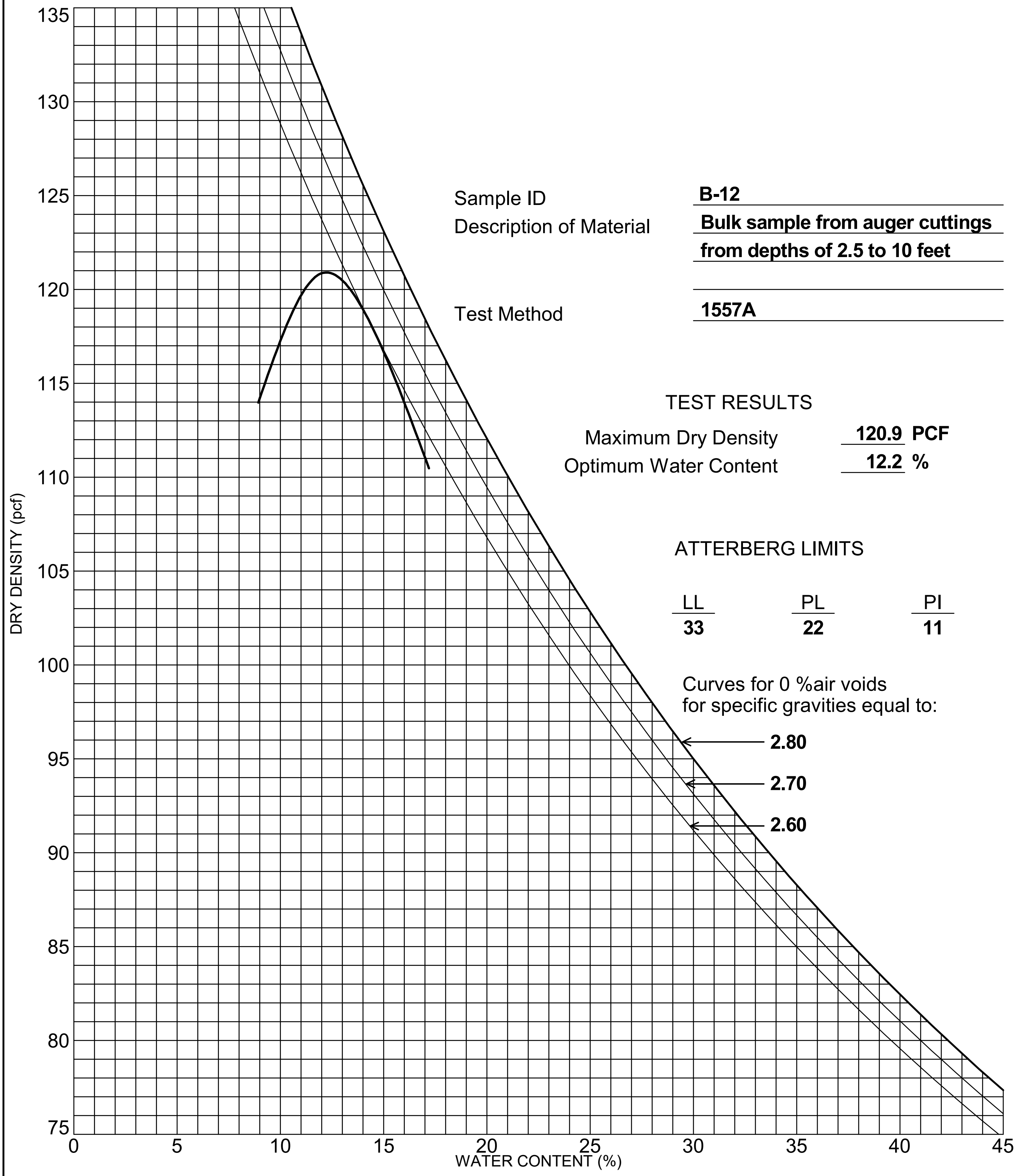
CLIENT: Allen & Hoshall

PROJECT NAME: MSCAA Taxiway Alpha West

PROJECT NUMBER 100-19-0019

PROJECT LOCATION: Memphis, TN

EQUIPMENT USED: Modified Hammer, 4 inch Mold, Ohaus 3 kilogram Scale, Oven, Ohaus 8 kilogram Scale



Sample ID **B-12**

Description of Material **Bulk sample from auger cuttings from depths of 2.5 to 10 feet**

Test Method **1557A**

TEST RESULTS

Maximum Dry Density **120.9 PCF**

Optimum Water Content **12.2 %**

ATTERBERG LIMITS

LL	PL	PI
33	**22**	**11**

TESTED BY: Z. Shannon
REVIEWED BY: B. Kouchoukos

TEST DATE: 6/5/2019
DATE: 6/12/2019

SAMPLE RECEIVED: 5/21/2019

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UNCONFINED COMPRESSIVE STRENGTH TEST
COHESIVE SOIL (ASTM D2166)

CLIENT: Allen & Hoshall

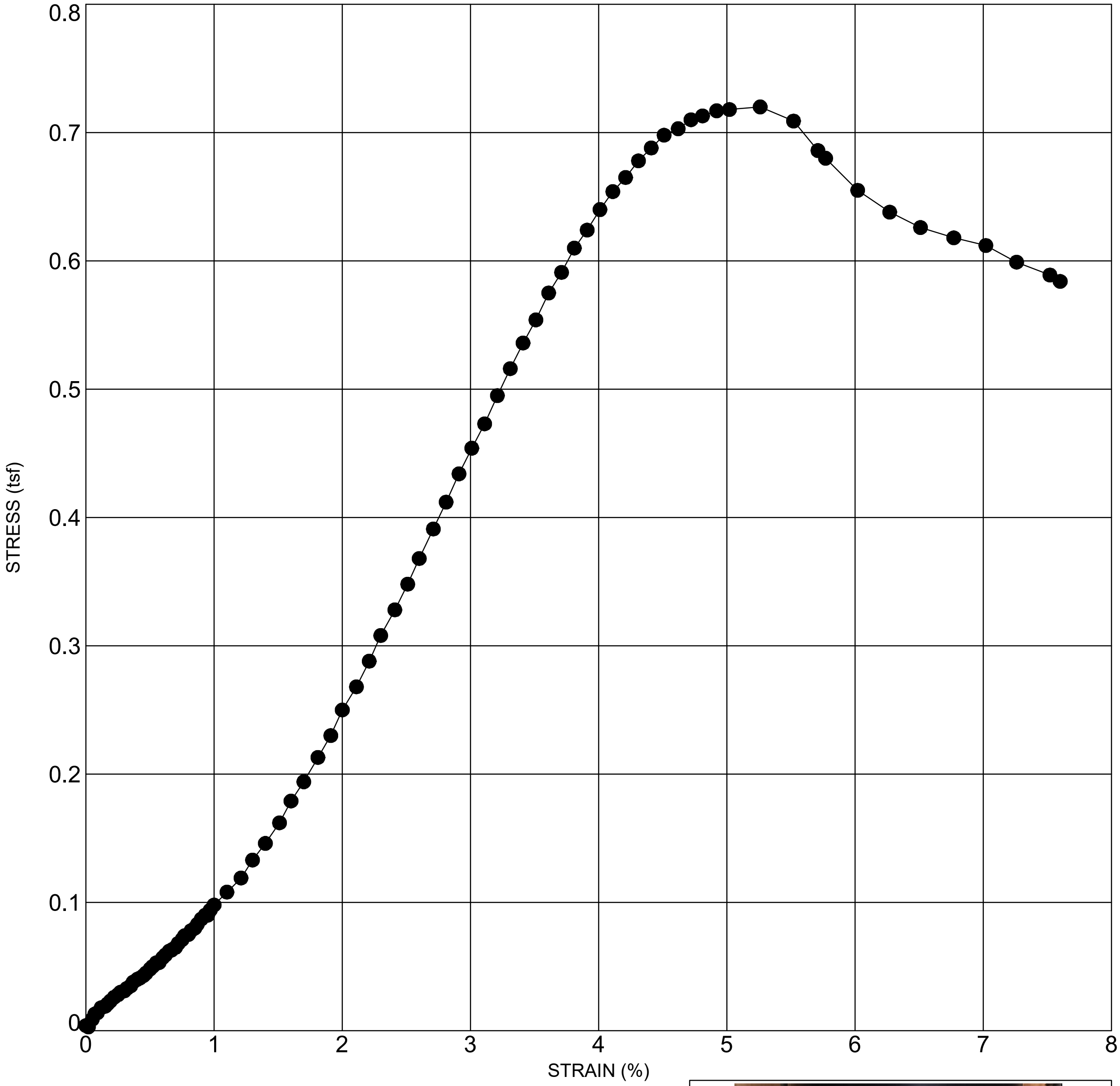
PROJECT NAME: MSCAA Taxiway Alpha West

PROJECT NUMBER 100-19-0019

PROJECT LOCATION: Memphis, TN

SOIL DESCRIPTION: SILT (ML), brown, loose

SAMPLE RECEIVED: 5/13/2019



SAMPLE: B-01

Diameter (in): 2.82

Height (in): 5.52

Ratio (h/d): 1.96

LL: NP

PL: NP

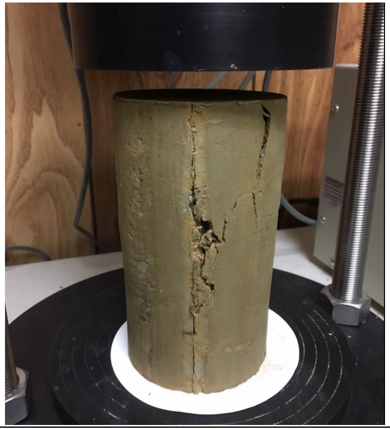
Strain at Failure (%): 5.26

Strength (tsf): 0.72

Dry Density (pcf): 93.40

Water Content (%): 30.15922

Rate of Strain to Failure (%/min): 1



-Dry Density and Moisture content data were obtained after compression testing

-Specimen was an intact ST sample

TESTED BY: Z. Shannon
REVIEWED BY: B. Kouchoukos

TEST DATE: 6/11/2019
APPROVED DATE: 6/14/2019

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Nashville,Tennessee 37210
Phone: (615) 255-9702
Fax: (615) 256-5873

UNCONFINED COMPRESSIVE STRENGTH TEST COHESIVE SOIL (ASTM D2166)

CLIENT: Allen & Hoshall

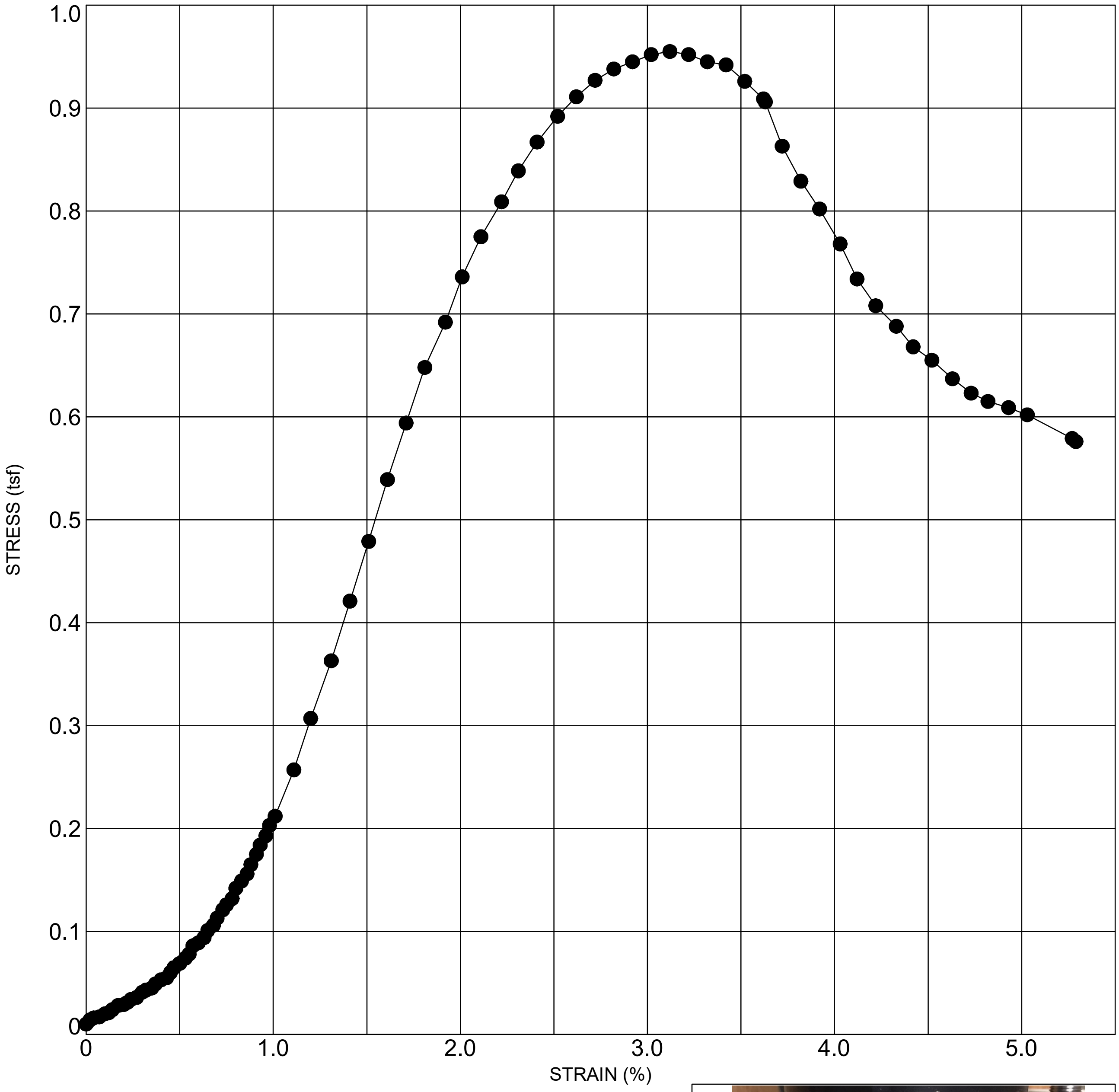
PROJECT NAME: MSCAA Taxiway Alpha West

PROJECT NUMBER 100-19-0019

PROJECT LOCATION: Memphis, TN

SOIL DESCRIPTION: SILT (ML), brown, loose

SAMPLE RECEIVED: 5/13/2019



SAMPLE: B-03

Diameter (in): 2.83

Height (in): 5.51

Ratio (h/d): 1.95

LL: NP

PL: NP

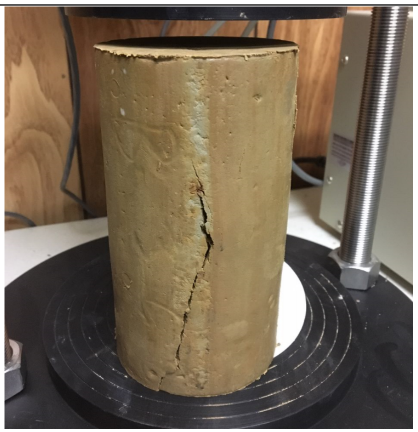
Strain at Failure (%): 3.12

Strength (tsf): 0.96

Dry Density (pcf): 96.00

Water Content (%): 28.90529

Rate of Strain to Failure (%/min): 1



-Dry Density and Moisture content data were obtained after compression testing

-Specimen was an intact ST sample

TESTED BY: Z. Shannon
REVIEWED BY: B. Kouchoukos

TEST DATE: 6/11/2019
APPROVED DATE: 6/14/2019

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Nashville,Tennessee 37210
Phone: (615) 255-9702
Fax: (615) 256-5873

UNCONFINED COMPRESSIVE STRENGTH TEST COHESIVE SOIL (ASTM D2166)

CLIENT: Allen & Hoshall

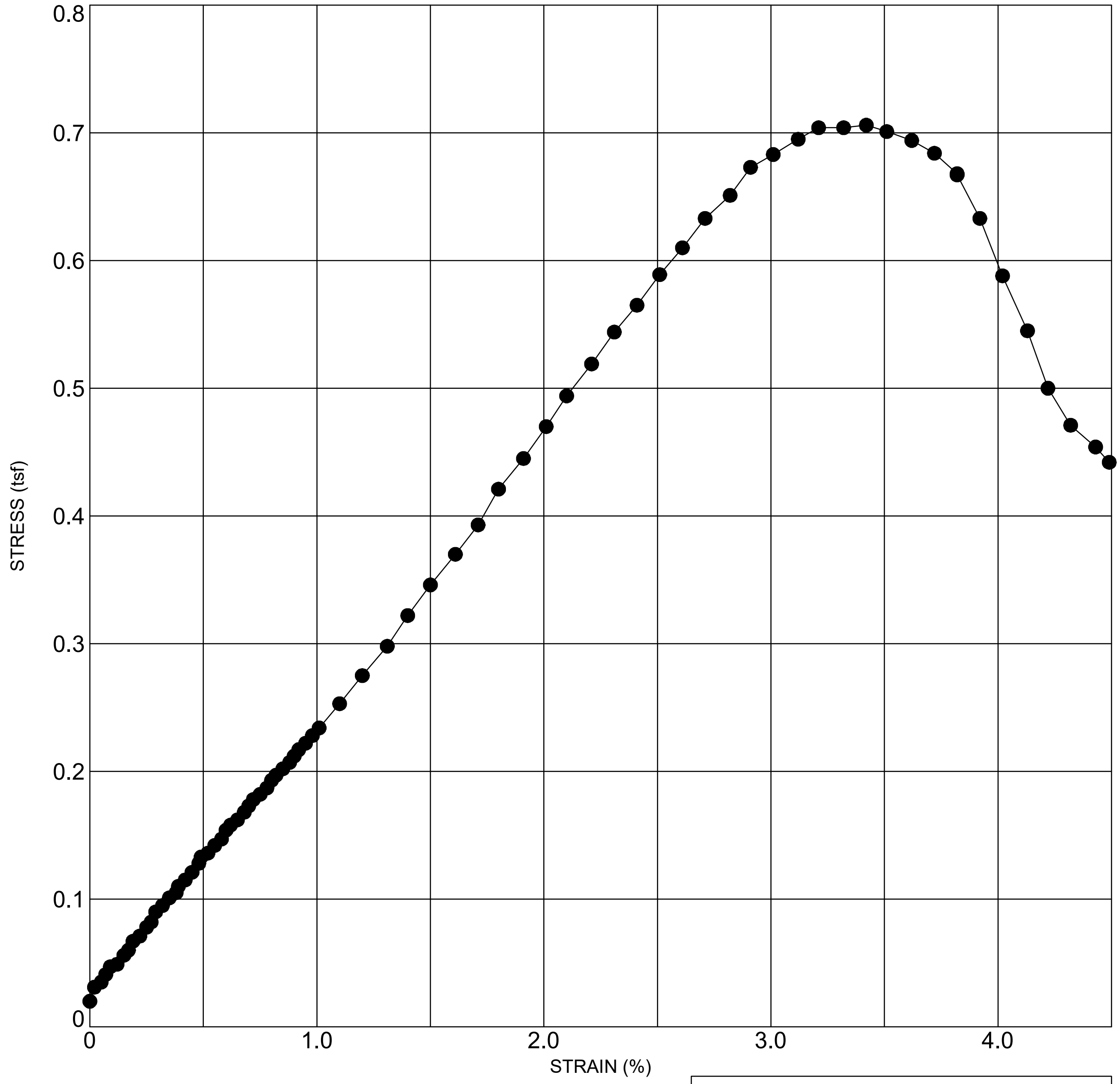
PROJECT NAME: MSCAA Taxiway Alpha West

PROJECT NUMBER 100-19-0019

PROJECT LOCATION: Memphis, TN

SOIL DESCRIPTION: SILT (ML), brown, loose

SAMPLE RECEIVED: 5/21/2019



SAMPLE: B-11

Diameter (in): 2.80

Strain at Failure (%): 3.42

Height (in): 5.54

Strength (tsf): 0.71

Ratio (h/d): 1.98

Dry Density (pcf): 95.60

LL: NP

Water Content (%): 26.23669

PL: NP

Rate of Strain to Failure (%/min): 1

-Dry Density and Moisture content data were obtained after compression testing

-Specimen was an intact ST sample

TESTED BY: Z. Shannon **TEST DATE**: 6/11/2019
REVIEWED BY: B. Kouchoukos **APPROVED DATE**: 6/14/2019

K. S. Ware & Associates, L.L.C.
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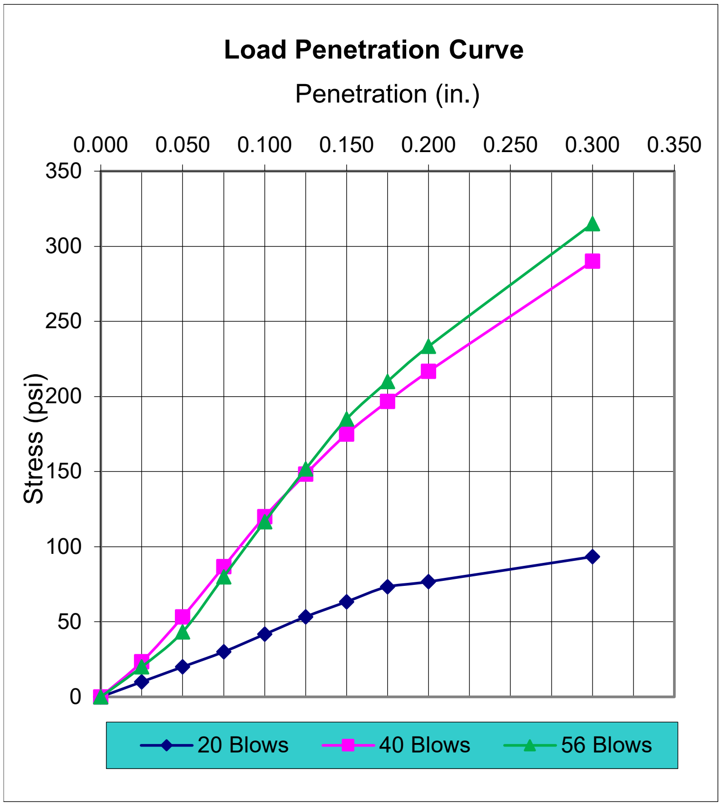
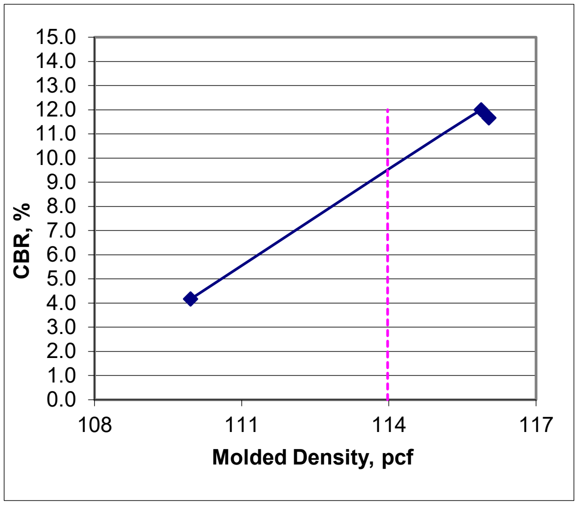
Report of California Bearing Ratio Test (ASTM D1883)

Project Name:	MSCAA	Proctor Type:	Modified
Project Number:	100-19-0019	Maximum Dry Density:	116.3
Sample ID:	B-2/B-5 Bulk	Optimum Moisture:	13.9
Date Received:	5/13/2019		
Sample Description:	LEAN CLAY (CL), brown, firm, moist		

Test	Pre-Test			Post-Test			CBR, %		Line	%
# Blows	DD	% Max	%m	DD	% Max	%m	0.1"	0.2"	Corr.	Swell
20	110.0	94.5	13.1	104.6	90.0	25.3	4.2	4.2	0	2.574
40	115.9	99.6	12.7	113.5	97.6	18.6	12.0	11.7	0	1.702
56	116.0	99.8	13.6	113.4	97.5	19.7	11.7	12.3	0	1.942





CBR* = 9.5

* for 98% max DD and
0.1 in. penetration

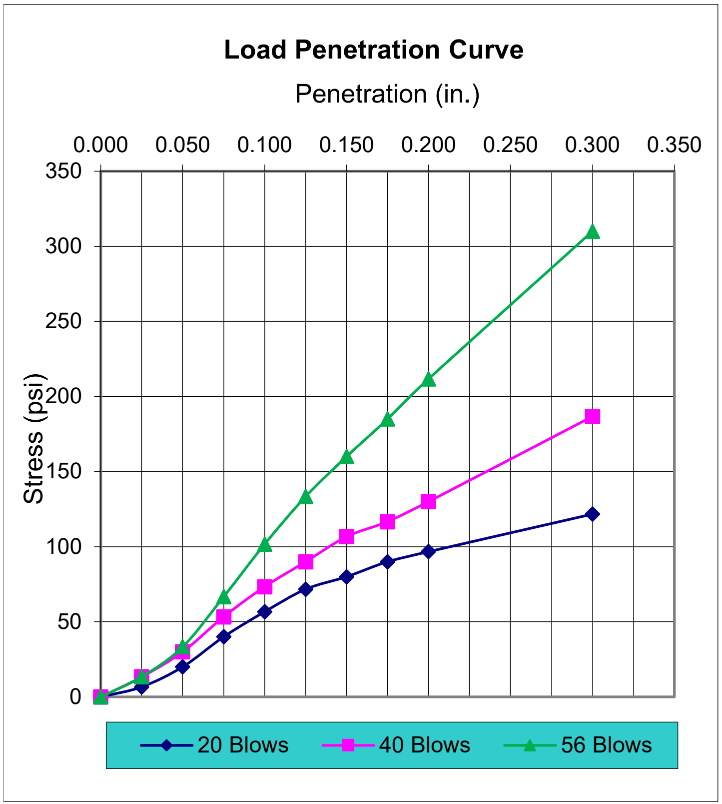
Submitted By:	Z. Shannon	Date:	6/11/2019
Reviewed By:	B. Kouchoukos	Date:	6/12/2019

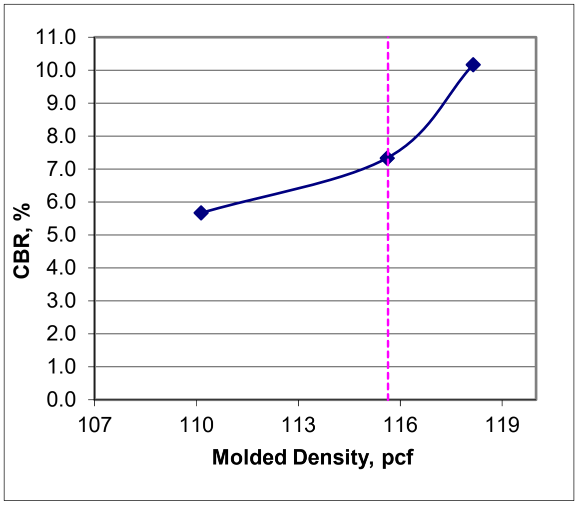
K. S. Ware & Associates, L.L.C.
Geotechnical • CEI • Environmental

Report of California Bearing Ratio Test (ASTM D1883)

Project Name:	MSCAA	Proctor Type:	Modified
Project Number:	100-19-0019	Maximum Dry Density:	118.0
Sample ID:	B-8/B10	Optimum Moisture:	12.6
Date Received:	5/21/2019		
Sample Description:	LEAN CLAY (CL), brown, firm, moist		

Test	Pre-Test			Post-Test			CBR, %		Line	%
# Blows	DD	% Max	%m	DD	% Max	%m	0.1"	0.2"	Corr.	Swell
20	110.1	93.3	13.6	107.6	91.2	21.8	5.7	5.3	0	1.942
40	115.6	98.0	13.0	112.7	95.5	20.0	7.3	7.1	0	2.225
56	118.1	100.1	13.0	114.7	97.2	19.3	10.2	10.7	0	1.876





CBR* = 7.0

* for 98% max DD and
0.1 in. penetration

Submitted By:	Z. Shannon	Date:	6/11/2019
Reviewed By:	B. Kouchoukos	Date:	6/12/2019

KSWA

K. S. Ware & Associates, L.L.C.

Geotechnical • CEI • Environmental

Report of California Bearing Ratio Test (ASTM D1883)

Project Name: MSCAA

Project Number: 100-19-0019

Sample ID: B-12 Bulk

Date Received: 5/21/2019

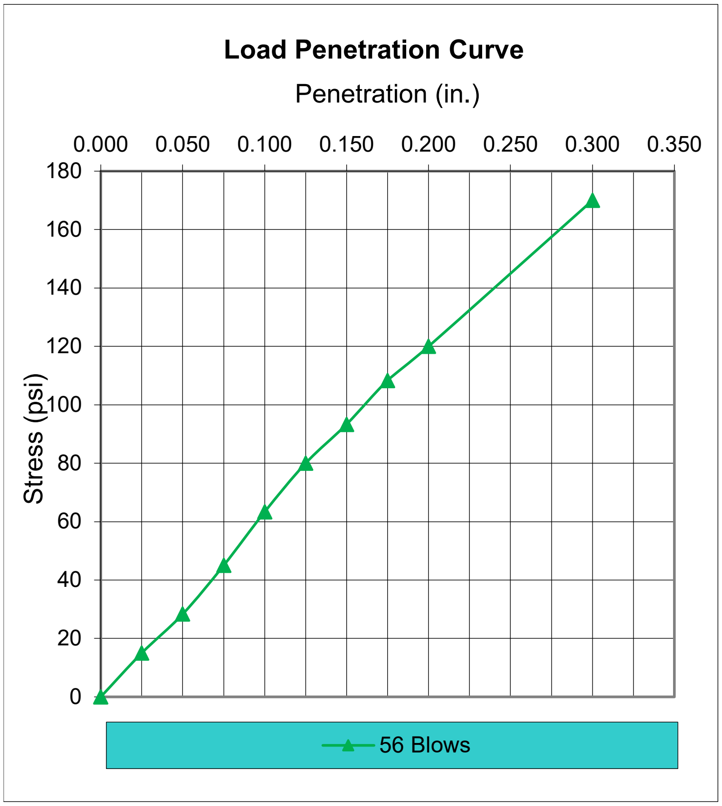
Sample Description: LEAN CLAY (CL), brown, firm, moist

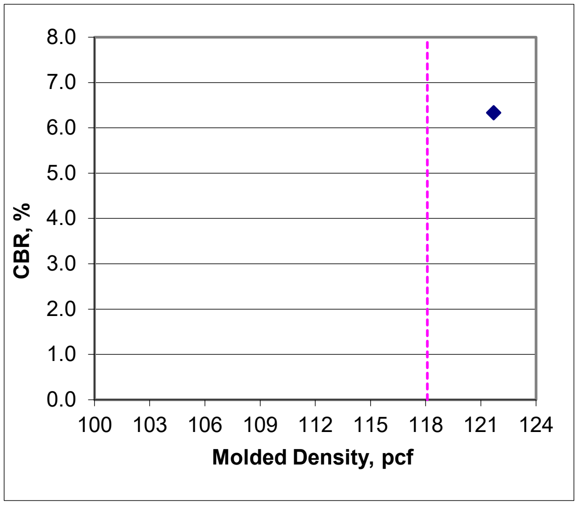
Proctor Type: Modified

Maximum Dry Density: 120.5

Optimum Moisture: 11.8

Test # Blows	Pre-Test			Post-Test			CBR, %		Line Corr.	% Swell
	DD	% Max	%m	DD	% Max	%m	0.1"	0.2"		
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
56	121.7	101.0	11.4	117.8	97.8	18.4	6.3	6.2	0	2.552





CBR* = 6.0

* for 98% max DD and
0.1 in. penetration

Submitted By: Z. Shannon Date: 6/11/2019

Reviewed By: B. Kouchoukos Date: 6/12/2019

ATHENA

[formerly KS Ware & Associates]

REPORT OF GEOTECHNICAL EXPLORATION

Taxiway Bravo Intersection Reconfiguration
Memphis International Airport
Memphis, Tennessee

Prepared For:
Allen & Hoshall
1661 International Drive, Suite 100
Memphis, Tennessee 38210

Prepared By:
Athena Engineering and Environmental, LLC
52 Lindsley Avenue, Suite 101
Nashville, Tennessee 37210

Athena Project No. 100-19-0019

March 29, 2023

ATHENA
[formerly KS Ware & Associates]

Nashville, TN | Bowling Green, KY | Chattanooga, TN | Pensacola, FL

March 29, 2023

Mr. Tim Gibson, PE
Allen & Hoshall
1661 International Drive, Suite 100
Memphis, Tennessee 38210

Subject: Report of Geotechnical Exploration
Taxiway Bravo Intersection Reconfiguration
Memphis International Airport
Memphis, Tennessee
Athena Project No. 100-19-0019

Dear Mr. Gibson:

Athena Engineering and Environmental, LLC (Formerly K. S. Ware & Associates, LLC) is pleased to submit this report which provides the results of our geotechnical exploration for the Taxiway Bravo Intersection Reconfiguration project at the Memphis International Airport in Memphis, Tennessee. Our services were provided in general accordance with our Proposal for Geotechnical Exploration dated April 14, 2022.

The attached report summarizes the project information provided to us, describes the site and subsurface conditions encountered, and details our geotechnical recommendations for the project. The Appendices include figures, descriptions of our field-testing procedures, and our field and laboratory test results.

We appreciate the opportunity to be of service to you on this project. Please contact us if you have any questions regarding this report. We look forward to serving as your geotechnical consultant on the remainder of this project.

Respectfully submitted,

Athena Engineering and Environmental, L.L.C.

NATHAN LONG
No. 111689

Bradley D. Kouchoukos

Bradley D. Kouchoukos, P.E., VMA
Geotechnical Project Engineer

Nathan Long, P.E., P.G.
VP of Geotechnical Services

Enclosures: Report of Geotechnical Exploration

Distribution: File (1)

engineering environmental

52 Lindsley Ave., Suite 101 | Nashville, TN 37210
615.255.9702 p | 615.256.5873 f | info@athenaee.com

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1.0 INTRODUCTION

1.1 PROJECT INFORMATION

Our understanding of the project is based on information provided by Mr. Tim Gibson of Allen & Hoshall via e-mail correspondence on April 5, 2022. The initial e-mail included a document titled “Bravo Proposed Borings”, which provided a proposed layout for Taxiway Bravo intersection reconfiguration and a proposed boring layout.

We understand the project consists of constructing a new taxiway near the intersections of Taxiways Alpha and Bravo and Taxiway Sierra and Bravo. The taxiway will be about 924 feet long and will generally run parallel to the east side of Taxiway Sierra. We assume the new taxiway section will be primarily concrete paved with asphalt shoulders. The existing taxiway in this section will be demolished and removed to make way for this replacement taxiway. We have assumed final pavement surface elevations will be similar to existing pavement surface elevations. Therefore, we anticipate maximum cut and fill of 3 feet each will be required to achieve final subgrade elevations.

We understand this intersection project will be incorporated into the Taxiway Alpha West Reconstruction project. Athena (formerly KSWA) completed a geotechnical exploration for the Taxiway Alpha West Reconstruction project in November 2019.

1.2 PURPOSE AND SCOPE OF EXPLORATION

The purpose of the exploration was to evaluate the subsurface conditions along the new taxiway alignment and provide geotechnical design recommendations for the project. Our scope of services was detailed in our Proposal for Geotechnical Exploration, dated April 14, 2022.

Our geotechnical exploration services did not include sampling and testing of the soil, rock, surface water, groundwater, or air for the presence of environmental contaminants. Therefore, special procedures were not recommended for handling or managing sediments encountered during future construction or for handling the soil and rock samples from the borings in the geotechnical testing lab.

2.0 SITE GEOLOGY

2.1 GEOLOGIC FORMATION

Memphis International Airport is located in the Coastal Plain physiographic province. This province extends along the southeast and east coasts of the United States from the southern tip of Texas to the southern tip of Florida along the Gulf of Mexico and then extends north to New Jersey along the coast of the Atlantic Ocean. The Coastal Plain province generally lies along the coastal states but extends north from Louisiana and Mississippi through the eastern portions of Arkansas, the west portions of Tennessee, and the southern tip of Illinois. In Tennessee, the area between the Tennessee River and Mississippi River is considered to be part of the Coastal Plain province; there are three subcategories within this area. Starting from the east, along the western banks of the Tennessee River, is an approximately 10-mile-wide section of hilly land which consists of sedimentary rocks overlain by residual soils (derived in place from weathering of the bedrock), alluvial soils (soils deposited by streams) locally, and about 4 feet of loess (wind-blown silts and clays). To the west of the hilly land is an area called the Tennessee Bottoms or the bottom land which extends to steep bluffs along the shores of the Mississippi River in Memphis. This area consists of rolling hills and streams formed from marine sediments consisting mainly of clays, silts and sands covered by loess at the surface. The loess can be up to 100 feet thick in the bluffs overlooking the Mississippi River; however, the loess can also be absent where streams have eroded these soils and filled the stream valley with alluvium. The third section is called the Mississippi Alluvial Plain. This area is west of the Tennessee Bottoms and consist of lowland areas, flood plains, and swamp land typically less than 300 feet above sea level.

The Surficial Geologic Map of the Southeast Memphis Quadrangle, Shelby County, Tennessee indicates the airport is underlain by loess and artificial fill. The loess deposits include wind-blown sediments consisting of generally of clayey silt brown and light-brown in color. These soils are relatively strong and stable when the water content is near the soil's Plastic Limit but become soft and unstable if the water content moves above the Plastic Limit. Artificial fill in Memphis typically consists of brown silt to clayey silt, but can also include construction debris, organics, and other deleterious materials. The strength, compressibility, and stability of artificial fill subgrades depend on the fill material type, lift thicknesses, water content, and compaction effort applied during placement.

2.2 SOIL SURVEY

The soil survey of Shelby County, Tennessee, downloaded from the United States Department of Agriculture website[1] indicates the soil types across the proposed Taxiway Bravo consist of Graded land (Gr). This soil type consists of developed areas that primarily consisted of Grenada, Loring, and Memphis soils prior to grading. Typical engineering classifications for these soils include clays (CL), clayey silts (ML), and non-plastic sands (SC) by the Unified Soil Classification System (USCS) classification and A-4, A-6 and A-7 by American Association of State Highway and Transportation Officials (AASHTO) classification.

1- http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.asp

3.0 EXPLORATION PROCEDURES AND FINDINGS

3.1 GENERAL

We performed our subsurface exploration and field testing on February 9, 2023. Our proposed exploration consisted of soil boring at three locations (Borings B-17, B-18, and B-21) within existing grass areas and pavement coring at two locations (Borings B-19 and B-20) within the existing taxiway along the proposed Taxiway Bravo alignment. We also completed dynamic cone penetrometer (DCP) testing at each borehole/corehole location. Due to a limited work window to access the Memphis Airport property, we were unable to complete soil sampling at Borings B-19 and B-20. Borings B-1 through B-16 were performed as part of our initial study for the Taxiway Alpha West Reconstruction project.

The exploration locations were marked in the field by Athena's representative with the client's surveyor prior to beginning fieldwork. The corehole and boring locations shown on the Exploration Location Plan in Appendix A should be considered approximate. Additional discussion regarding the field procedures used during this exploration are provided in Appendix B.

3.2 SURFACE AND SUBSURFACE CONDITIONS

The site primarily consists of grassed areas adjacent to existing Taxiways Bravo, Sierra, and Alpha. Taxiway Sierra is along the west end of the site, Taxiway Alpha is along the north end of the site, and Taxiway Bravo cuts across the site. The grassed areas are relatively flat and slope away from the pavements. The pavement surface generally slopes gradually downward away from the taxiway centerline towards the pavement edge. We estimate total relief across the site to be about 7 feet.

Surface Materials

Borings B-17, B-18, and B-21 initially encountered 12 to 14 inches of topsoil. Borings B-19 and B-20, completed within Taxiway Bravo, encountered an initial layer of asphalt pavement ranging in thickness from approximately 2½ to 3½ inches underlain by concrete pavement ranging in thickness from approximately 6½ to 12 inches. Based on our observations and test results from DCP testing, we do not believe this portion of Taxiway Bravo is underlain by a cemented base material. Table 1 below includes the asphalt and concrete pavement approximate thicknesses encountered at the two locations.

Table 1: Pavement Section Thicknesses

Boring No.	Asphalt Pavement Thickness (in.)	Concrete Pavement Thickness (in.)	Total Pavement Thickness (in.)
B-19	3.5	12.0	15.5
B-20	2.5	6.5	9.0
AVG	3.0	9.25	12.25

Native Soils

Below the existing surface materials, we encountered native soils to the boring termination depth of 10 feet. The native soils generally consisted of firm to stiff Silty Clay (CL-ML) with occasional soft and very stiff layers with Standard Penetration Test N-values ranging from 2 to 15 blows per foot. A layer of Silt (ML) was present between the approximate depths of 1 and 3½ feet in Boring B-18.

Groundwater

No measurable groundwater was encountered during or upon completion of drilling operations at the boring locations. We backfilled the borings upon completion for safety precautions, so delayed groundwater measurements were not taken. Groundwater levels will differ depending on the time of year, climatic conditions, and construction activities. Perched groundwater conditions may develop within the overburden soils during seasonal wet periods of the year and after heavy precipitation events.

Dynamic Cone Penetrometer (DCP) Test

We performed DCP testing (ASTM D6951) at each of the boring locations for the purpose of evaluating the strength of the subgrade materials currently present along the proposed Taxiway Bravo alignment. The DCP test results were plotted to determine the estimated CBR value of the subgrade material. The results of these tests are provided in Table 2 below. In the upper limits of DCP testing, unusually low soil values can often be attributed to disturbed soil due to auger operations. The DCP test data is included in Appendix B of this report.

Table 2 - DCP Estimated CBR Values

Boring No.	Starting Depth (in.)	Depth Range (in.)	Average Estimated CBR Value
B-17	0.0	0 - 34	>10
B-18	0.0	0 – 13	>10
		13 – 18	8
		18 – 34	>10
B-19	15.5*	0 – 16	9
		16 – 36	>10
B-20	9.0*	0 – 16	6
		16 – 35	>10
B-21	6.0	0 – 6	5
		6 – 11	8
		11 – 34	>10

*Borings B-19 and B-20 depth ranges begin at the bottom of the existing pavement section.

4.0 LABORATORY TESTING

Athena performed laboratory testing on representative split-spoon, Shelby tube, and bulk soil samples in general accordance with ASTM procedures. The laboratory testing included:

- Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass (ASTM D2216)
- Standard Test Methods of Liquid Limit, Plastic Limit, and Plasticity Index (ASTM D4318)
- Standard Test Method for Determining the Amount of Material Finer than 75-µm (No. 200) Sieve in Soils by Washing (ASTM D1140)
- Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates (ASTM C136/C136M)
- Standard Test Method for Laboratory Compaction Characteristic of Soil Using Modified Effort (ASTM D1557)
- Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils (ASTM D1883)

The moisture content data and Atterberg limit are presented on the individual boring logs in Appendix B. Laboratory test reports for grain size analysis, Modified Proctor, and CBR tests are within Appendix C and Table 3 below.

Table 3: Summary of Soil Laboratory Test Results

Boring No.	Sample Type	Sample Depth (ft)	Modified Proctor		CBR (%)	LL (%)	PI (%)	Percent Passing #200 Sieve (%)	Unconfined Compression (psf)	USCS Class.
			Max. Dry Density (lbs/ft^3)	Optimum Moisture (%)						
B-18	ST	1 – 3	---	---	---	NP	NP	99.9	1,460*	ML
B-21	ST	1 – 3	---	---	---	29	7	98.7	2,380	CL-ML
B-21	Bulk	1 – 5	116.7	13.0	4.5	28	7	97.5	---	CL-ML

*Unconfined compression strength test sample was determined to be silt (ML) based on grain size analysis and Atterberg Limit testing. It should be noted, unconfined compression strengths of silt (ML) may not be representative of the soils strength due to lack of cohesion.

5.0 GEOTECHNICAL CONSIDERATIONS

5.1 GENERAL

Based upon an engineering reconnaissance of the site, the boring and laboratory data, visual-manual examination of the samples, and Athena's understanding of the proposed construction and experience as geotechnical engineers, Athena reached the conclusions and developed the recommendations provided herein. The conclusions and recommendations in this report have been derived by relating the general principles of the discipline of geotechnical engineering to the proposed construction outlined by the Project Information section of this report. Because changes in surface, subsurface, and climatic conditions can occur, the use of this report should be restricted to this specific project. Any changes or modifications which are made in the field during the construction phase which alter site grading, infrastructure, or other related site work, should also be reviewed by Athena. If conditions which vary from the facts of this report are encountered during construction, the Geotechnical Engineer of Record should be contacted immediately to review the changed conditions in the field and make appropriate recommendations.

5.2 SUBGRADE SUITABILITY

Based on the project information provided and the available subsurface data, it is our opinion the site is suitable for the planned reconfiguration. The subgrade materials along the proposed Taxiway Bravo alignment generally consists of firm to stiff silty clay with some soft zones. Soft to firm soils are frequently unstable under a proofrolling load. Additionally, the moisture content of the near-surface soil samples in the upper five feet was significantly higher than the optimum moisture content of 13 percent of the bulk sample tested. Soils with a relatively high moisture content are also frequently unstable under a proofrolling load.

The stability of the near-surface soils will likely be impacted by exposure to moisture and/or construction traffic, once the topsoil has been stripped to prepare the site for construction. The near-surface soils consist of native loess. Loess is typically extremely sensitive to changes in moisture content. Dry loess materials are generally stable and will exhibit favorable strength characteristics. Conversely, when these soils are moist, as a result of local precipitation or climatic conditions, the soils become weak and unstable, particularly under repeated loading from heavy construction equipment. Also, due to the silt content of these soils, they can degrade rapidly even when favorable moisture conditions are present. Therefore, regardless of the time of year construction takes place, some remedial repair of weak subgrades will likely be required.

If construction occurs during warm, dry weather months, it may be possible to repair shallow instability through scarifying, moisture conditioning, and recompacting the upper 8 to 12 inches of subgrade. However, this process will likely not be practical during cooler, wet weather months when moisture conditioning can be problematic. During wet weather, it may be necessary to undercut unstable soils and use a borrow source to haul in drier soils for backfilling. If widespread subgrade instability is present, stabilizing the subgrade with cement is an option that may be considered (cement stabilization is typically more cost-effective over larger areas). Athena recommends a budget be established for subgrade repairs consistent with the time of year construction takes place.

5.3 PAVEMENT DEMOLITION

We understand Taxiway Bravo between Taxiway Sierra and Taxiway Alpha will be completely demolished and removed, which will include the asphalt and underlying concrete pavements. The existing concrete can potentially be used for other functions, such as P-219 recycled concrete aggregate base, if the demolition methods allow for such crushing and gradation. Detailed analysis of the demolished materials would be required prior to use and approval.

6.0 GEOTECHNICAL EVALUATION & RECOMMENDATIONS

The pavement recommendations contained in this report section were developed in consideration of the project information detailed in Section 1.1 of this report. If this information is not correct or has been updated, we should be contacted to review the corrected or updated information and confirm the recommendations presented herein are appropriate.

6.1 GENERAL PAVEMENT RECOMMENDATIONS

Based on our observations and classifications made in the field and from tests performed in the laboratory, Athena is providing the following pavement design parameters and general pavement recommendations.

As discussed in the previous section, remediation of soft to firm subgrade soil prior to final grading and paving should be expected. The stabilization method, the lateral extent, and the depth will depend on actual conditions exposed during construction and on actual grading plans for the pavement areas. On-site recommendations should be made by the geotechnical engineer-of-record or his representative. Additionally, we recommend the upper 12 inches of the subgrade materials be compacted to at least 100 percent of the maximum dry density as determined by the modified Proctor test in accordance with Federal Aviation Administration’s (FAA) Standard Specifications for Construction of Airports, dated December 21, 2018, Section 152-2.10.

6.2 PAVEMENT DESIGN RECOMMENDATIONS

The design CBR and subgrade modulus values are highly dependent on the type of near surface material and the level of compaction. Based on the soil conditions encountered during our field explorations (2019 and 2023), the field DCP test results, our laboratory testing results, and our experience with similar soil conditions, Athena recommends using a CBR value of 6 percent and a subgrade modulus of 150 pounds per cubic inch (pci) for the existing subgrade compacted to 100 percent of the Modified Proctor (ASTM D1557) maximum dry density within the upper 12 inches of subgrade.

Base courses and pavements may be placed after the subgrade has been properly compacted, fine graded, and proofrolled, as recommended in the Construction Considerations section of this report. All activities should be accomplished in accordance with FAA Standard Specifications for Construction of Airports. Actual pavement section thickness should be determined by the designer based on actual loads, traffic volume, and the owner’s design life requirements.

Experience has shown most pavement failures are caused by localized soft spots in the subgrade or inadequate drainage. Proof rolling, under the observation of our geotechnical engineer, will greatly reduce the incidents of weak spots in the subgrade. However, the civil design must include proper drainage to reduce softening of the subgrade, frost damage, heaving, soil migration, and pumping failures. The pavement surface and subgrade should have a minimum slope of 2 percent. Water infiltrating the mineral aggregate base should be designed to drain into catch basins (through weep holes), out-slope areas, or drainage trenches.

The soils exposed at the pavement subgrade level may be moisture sensitive. Experience indicates there is typically an extensive time lag between the time grading is completed and pavement construction occurs (i.e. grading may occur during hot, dry weather and pavement construction may occur during wet, cool weather). Once grading has been performed, the subgrade may be disturbed throughout the construction process due to utility excavations, construction traffic, desiccation, or rainfall. As a result, the pavement subgrade may become unsuitable for pavement construction over time and corrective action may be required. The subgrade should be carefully evaluated at the time of pavement construction by proof rolling with a heavily-loaded tandem-axle dump truck. Particular attention should be given to high traffic areas that display distress and to areas where backfilled trenches are located.

Design pavement section thicknesses are typically determined based on post-construction traffic loading conditions, which do not account for heavy construction traffic during the early stages of development. A partially constructed structural section subjected to heavy construction traffic can result in pavement deterioration and premature failure. Our experience indicates this pavement construction practice can result in pavements which will not perform as intended. Considering this information, several alternatives are available to mitigate the impact of heavy construction traffic on the pavement construction. These include using thicker sections to account for construction traffic, using some method of stabilization to improve the support characteristics of the pavement subsurface, or by routing heavy construction traffic around paved areas using a “haul road” constructed for that purpose.

Maintenance is essential to long-term performance of rigid and flexible pavements. Any distressed areas should be repaired promptly to prevent the failure from spreading due to loading and water infiltration.

7.0 CONSTRUCTION CONSIDERATIONS

7.1 SITE PREPARATION

Site preparation should initially include removing the existing asphalt pavement and underlying concrete pavement associated with existing Taxiway Bravo and topsoil along the remainder of the proposed Taxiway Bravo alignment. Existing near-surface underground electrical lines may also be present along the shoulders of existing Taxiway Bravo and should be terminated and removed during pavement demolition. At the completion of these activities, the subgrade should be evaluated as follows:

- Recompacting the upper 12 inches of exposed subgrade materials to 95 percent of the maximum dry density (100 percent if within 12 inches of the final subgrade elevation).
- Perform proof rolling prior to any fill or base material placement in fill areas and/or following cuts to grade in cut areas.
- Proof rolling should be performed using a fully-loaded tandem-axle dump truck or other rubber-tired equipment judged suitable by the geotechnical engineer.
- Our geotechnical engineer or his representative should observe proof rolling activities.
- Remediate soft, organic, or yielding subgrade materials encountered during the proof rolling operations as recommended by our geotechnical engineer.

7.1.1 Stabilization of Weak Soils

The following options may be considered for stabilizing weak subgrade areas:

- Scarify and Recompact – It may be possible to stabilize near-surface soils that are unstable due to excessive moisture by scarifying the unstable soils, allowing them to dry, and recompacting them in accordance with structural fill criteria. This process can be successful during hot, dry periods and when the construction schedule is flexible. Drying the soils can be problematic during cold, wet weather or when the construction schedule is not flexible.
- Undercut and Replace – This method involves the excavation of the soft/unstable soils until stiff soils are exposed. The undercut is then backfilled with compacted soil.
- Undercut and Stabilize with Geotextiles and/or Geogrids and Granular Fill – After the undercut surface has been made smooth, geotextiles and/or geogrids can be placed across the surface, followed by placement of granular fill (size and gradation of granular fill to be compatible with the geotextile/geogrid selected). Once a stable surface has been achieved, additional structural fill may be placed, if required.
- Stabilize with Cement or Lime Admixtures – Cement or lime stabilization is performed by a specialty contractor who mobilizes to the site, mixes the soils with cement or lime, and replaces and compacts these soils to the planned subgrade elevation. This stabilization method dries and treats the soils to provide a stable subbase.

As previously noted, the near-surface soils consist of loess. The stability of these soils is a function of the soil's water content. Experience indicates soils with water contents near the soil's Plastic Limit (usually in the teens and low 20s) are typically strong and stable. Soils with water contents several points above the Plastic Limit are often weak and unstable. Remedial subgrade work should be expected based on the water contents of the near surface soils at the time of this exploration.

Protection of the subgrade is a critical issue for maintaining the stability of subgrades formed in loess. Positive surface drainage should be maintained throughout construction. Areas which break down because of construction traffic or exposure to moisture should be repaired to prevent the failed area from spreading. Heavy equipment such as concrete trucks should be restricted to using construction roads specifically prepared for that purpose. Such roads can consist of 2 or more feet of crushed stone or crushed concrete. Soil-cement is also a viable alternative.

7.2 COMPACTED FILL RECOMMENDATIONS

Once the subgrade has been properly prepared, compacted fill may be placed in accordance with the recommendations provided below to attain final desired construction elevations. Fill operations should not begin until representative soil samples are collected and tested (allow 3 to 4 days for sampling and testing). The test results will be used to determine whether the proposed fill material meets the specified criteria and for quality control during grading. Fill placement and compaction should be observed by a geotechnical representative on a full-time basis. Our limited laboratory testing indicates most of the on-site soils meet the criteria recommended below; however, significant drying will likely be required to achieve proper compaction. Materials from both on-site and off-site sources proposed for use as structural fill should meet the criteria provided below.

- Liquid Limit less than 50
- Plasticity Index less than 25
- Maximum dry density (ASTM D1557) of 95 pcf or greater
- Free of large rock fragments (greater than 3 inches in diameter) and organic materials (less than 5 percent by weight)
- Amount of rock fragments retained on a 3/4-inch sieve should be less than 30 percent by weight

Structural fill should be placed and compacted using the following criteria:

- Soil fill should be placed in lifts of uniform thickness. The loose lift thickness should not exceed the amount which can be properly compacted throughout its entire depth with the equipment available, usually no more than 8 inches for cohesive material. In confined areas such as utility trenches, lift thicknesses of 3 to 4 inches may be required to achieve the recommended degree of compaction.

- Fill should be properly keyed into stripped and scarified subgrades. The upper one foot of remaining materials in cut areas or in areas which do not receive more than one foot of new fill should be scarified and recompacted using the guidelines outlined in this report section.
- So a positive tie is created along the interface of engineered fill and sloping ground (steeper than 4H:1V), we recommend the host slope be benched as the fill is placed. For this project, benching is defined as grading a saw tooth or terrace configuration into the slope. In general, at a minimum, we recommend benches should be about three feet tall and a minimum of eight feet wide, although some modification to bench geometry is permissible based upon conditions observed at particular locations. Further, fill placement should begin at the bottom of the slope and the working fill surface should be maintained approximately horizontal.
- Fill should not be placed on frozen or saturated subgrades.
- Based on the FAA Standard Specifications for Construction of Airports, dated December 21, 2018, Section 152-2.10 Compaction requirements, the top 12 inches of the pavement subgrade must be compacted to not less than 100 percent of the maximum dry density as determined by the Modified Proctor (ASTM D1557) and to within 2 percent of optimum moisture content immediately prior to paving. Additionally, the subgrade in areas outside of the limits of the pavement areas should be compacted to a depth of 12 inches to a density not less than 95 percent of the maximum dry density as determined by a Standard Proctor (ASTM D698). Additionally, the compacted fill should be stable under the moving load of a heavily-loaded tandem-axle dump truck.
- Density tests should be performed at a frequency of no less than one test per 5,000 square feet for pavement areas for each fill layer placed, with a minimum of two tests per lift. For utility trenches, one density test should be performed every 50 linear feet for each one-foot-thick fill layer placed, with a minimum of two tests per lift. Any areas not meeting the recommended compaction should be reworked and recompacted to achieve compliance. The recommended test frequencies are for preliminary planning and should be adjusted in the field to account for material variability, rate of placement, weather, and other factors.
- The soils should be placed near (within two percent of) the optimum water content (ASTM D1557). Aeration (i.e., drying) is often necessary to bring fill materials to the required water content during wet and rainy periods. During dry periods, water may need to be added to achieve the proper water content for compaction. Clayey and silty soils may require aeration prior to compaction, even during dry periods. The water content testing performed during this exploration suggests the on-site soils are significantly above the optimum water contents.
- Soil slopes should be protected from erosion by seeding, sodding, or other means, and surface run-off should be diverted away from slopes. For erosion protection, grass or other vegetation should be established on permanent slopes as soon as practical.

- Compacted soil fill embankments should be constructed no steeper than a ratio of 3 horizontal to 1 vertical (i.e., 3H:1V). We also recommend permanent cut slopes be constructed no steeper than 3H:1V.
- Compacted fills should extend horizontally outside of planned pavement areas at least 10 feet before sloping.
- Cut and fill slopes should be regularly evaluated during the construction for indications of movement.
- Excavations should be constructed in accordance with applicable Occupational Safety and Health Administration (OSHA) regulations.

7.3 GENERAL EARTHWORK CONSIDERATIONS

During earthwork operations, positive surface drainage should be maintained to prevent water from ponding on the exposed ground surface. The exposed subgrade may be rolled with a rubber-tired or steel drummed roller to improve surface run-off if precipitation is expected. Our geotechnical engineer should be consulted if the subgrade soils become excessively wet or dry, or frozen.

7.4 GROUNDWATER CONTROL RECOMMENDATIONS

No measurable groundwater was encountered during or upon completion in the borings. Groundwater levels may fluctuate with season changes. If water-bearing strata are exposed at subgrade, the magnitude and duration of seepage will vary. We anticipate that in most cases, depending on seasonal conditions, any seepage encountered can be handled by conventional dewatering methods (i.e., pumping from small sumps located near the source or in collector areas). If larger quantities of groundwater are encountered, the Geotechnical Engineer should be contacted.

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8.0 QUALIFICATIONS OF RECOMMENDATIONS

The recommendations provided herein were developed in part using the subsurface information obtained from the pavement coreholes and soil test borings advanced at the site. Soil test borings depict the soil conditions only at the specific location and time at which they were completed. The soil conditions at other locations on the site or at other times may differ from those occurring at the boring locations.

The conclusions and recommendations contained in this report were based on the available subsurface information, the project information provided, and the assumptions previously stated. Revisions in the plans for the proposed construction from those anticipated in this report should be brought to the attention of an Athena geotechnical engineer or his representative to determine whether any changes in the pavement recommendations are necessary. If deviations from the noted pavement conditions are encountered during construction, they should also be brought to the attention of the geotechnical engineer.

The scope of our geotechnical services did not include assessment or investigation for the presence or absence of hazardous or toxic materials in the soil, groundwater, or surface water within or beyond the site studied. Any statements in this report or indicated on the test boring logs regarding odors, staining of soils or other unusual conditions observed are strictly for the information of our client.

Our professional services were performed, our findings obtained, and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. Athena is not responsible for the conclusions, opinions, or recommendations made by others based upon the data included herein.

Our services include retaining the soil samples obtained during this study for 60 days after report submittal. Further storage or transfer of the samples can be made at the Client’s expense upon a written request.

APPENDIX A

SITE VICINITY PLAN

EXPLORATION LOCATION PLAN

N

NOT TO SCALE

JOB NO. 100-19-0019
CLIENT: Allen & Hoshall
CLIENT ADDRESS:
1661 International Drive, Suite 100
Memphis, TN 38120
DATE: 3/14/2023

Site Vicnity Plan

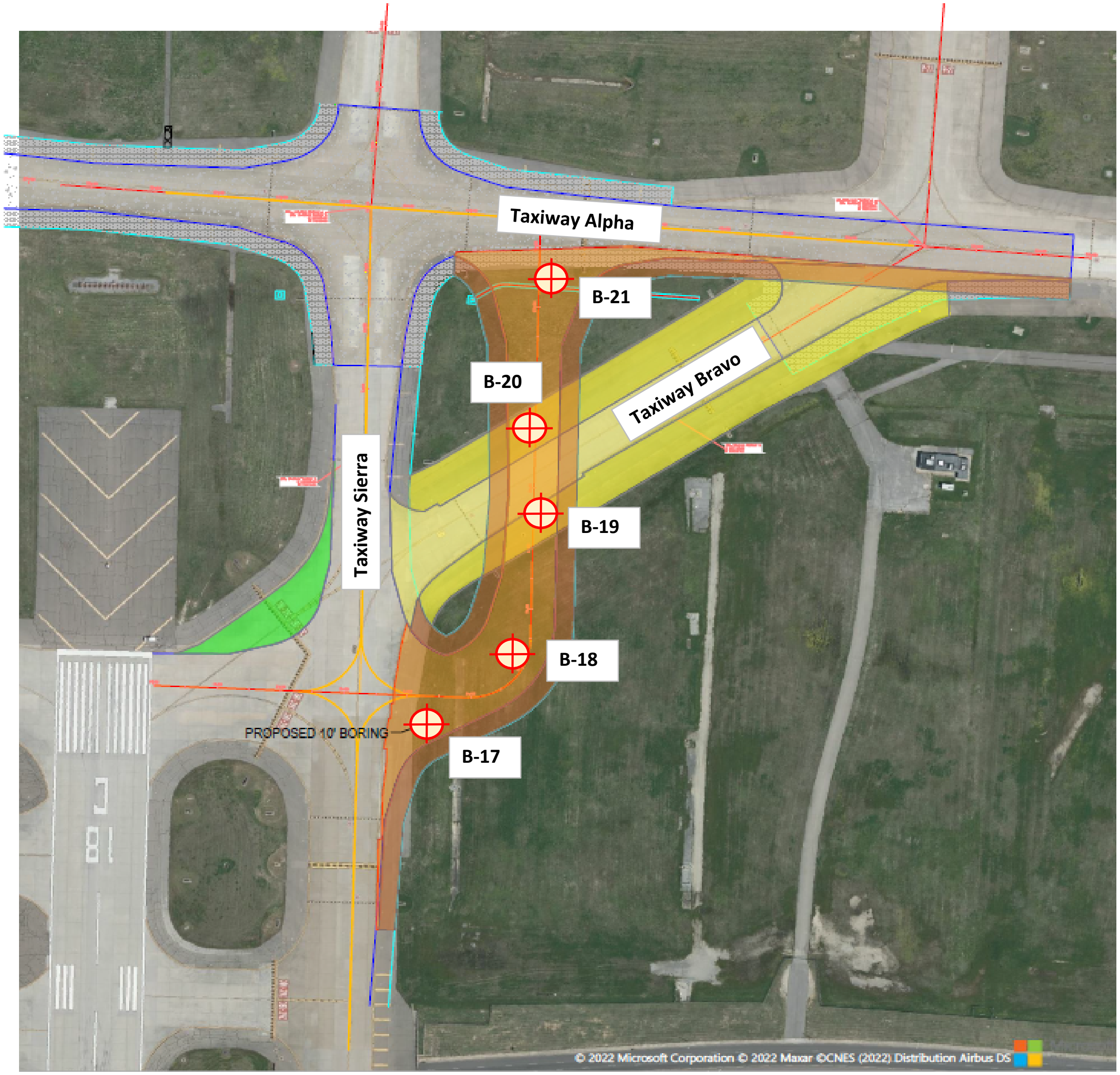
Taxiway Bravo Intersection Reconfiguration
Memphis International Airport
Memphis, Tennessee

DRAWN BY: BK
REVIEWED BY: NL

LEGEND

ATHENA
[formerly KS Ware & Associates]

Figure 1



LEGEND

🟨 PAVEMENT DEMOLITION

🟧 NEW CONSTRUCTION

🟩 PAINTED "SHOULDER"

Note: Base drawing "Bravo Proposed Borings" provided by client

N

NOT TO SCALE

JOB NO. 100-19-0019
CLIENT: Allen & Hoshall
CLIENT ADDRESS:
1661 International Drive, Suite 100
Memphis, TN 38120
DATE: 3/14/2023

Exploration Location Plan

Taxiway Bravo Intersection Reconfiguration
Memphis International Airport
Memphis, Tennessee

DRAWN BY: BK
REVIEWED BY: NL

LEGEND

⌖ Soil Test Boring Location

ATHENA
[formerly KS Ware & Associates]

Figure 2

APPENDIX B

FIELD TESTING PROCEDURES

FIELD CLASSIFICATION SYSTEM

SOIL CLASSIFICATION CHART

TEST BORING LOGS

PAVEMENT CORE PHOTOGRAPHS

DCP RESULTS

FIELD TESTING PROCEDURES

Drilling, sampling, and testing were conducted in general accordance with methods of the American Society for Testing and Materials (ASTM) or other widely-accepted geotechnical engineering standards. Descriptions of the procedures used during this exploration are provided below.

BORING AND COREHOLE LOCATIONS AND ELEVATIONS

The boring and corehole locations were selected by the Client and marked in the field by Athena's representative with the Client's surveyor prior to beginning our exploration. We located the exploration locations on the Exploration Location Plan by estimating distances and angles relative to on-site features. Surveying of boring and corehole coordinates was beyond the scope of our exploration.

TEST BORINGS

ASTM D 1586

Test borings were advanced using auger drilling techniques. At regular intervals, soil samples were obtained with a standard 1.4-inch I.D., 2.0-inch O.D., split-barrel sampler. The sampler was initially seated 6 inches to penetrate any loose cuttings and then driven an additional foot with blows of a 140-pound hammer falling 30 inches. The number of hammer blows required to drive the sampler the final foot is the *standard penetration resistance*, or N-value. Standard penetration resistance, when properly evaluated, is an index to the soil's strength and density. The criteria used during this exploration are presented on the Field Classification System sheet in this appendix. Representative portions of the soil samples obtained were placed in sealed containers and transported to our laboratory, where our engineer selected samples for laboratory testing.

The standard penetration tests were performed using an automatic hammer. The automatic hammer has a higher efficiency than the traditional rope and cathead hammer, thus yielding comparatively lower N-values. This reduction in N-value was accounted for during our engineering analysis. However, the consistencies presented on the boring logs were based on the customary relationships with N-value.

BORING LOGS

The soil samples obtained during the drilling were visually classified using the USCS as a guide (reference Soil Classification Chart in Appendix B). The Test Boring Logs in Appendix B provide the soil descriptions and penetration resistances, and represent our interpretation of the conditions encountered at each boring location. The stratification lines indicated on the boring records represent the approximate boundaries between material types, but these transitions may be gradual. The boring logs were prepared based on the field logs and review of the laboratory classification test results. The USCS designations indicated on the boring logs are based on visual-manual evaluation of the samples unless otherwise defined by laboratory testing.

The boring logs indicate estimated interfaces between soil strata. The interfaces indicated represent the approximate interface location, but the actual transition between strata may be gradual. Water levels indicated on the boring logs represent the conditions only at the time each measurement was taken.

FIELD CLASSIFICATION SYSTEM

Sands and Gravels

No. of Blows	Relative Density
0-5	Very Loose
6-10	Loose
11-30	Medium dense
31-50	Dense
51+	Very Dense

Silts and Clays

No. of Blows	Relative Consistency
0-2	Very Soft
3-4	Soft
5-9	Firm
10-15	Stiff
16-30	Very Stiff
31+	Hard

Particle Size Identification

Boulders:	8-inch diameter or larger
Cobbles:	3- to 8-inch diameter
Gravel:	
Coarse:	1- to 3-inch
Medium:	0.50- to 1-inch
Fine:	0.25- to 0.50-inch
Sand:	
Coarse:	2.00-mm to 0.25-inch (diameter of pencil lead)
Medium:	0.074-mm to 2.00-mm (diameter of broom straw)
Fine:	0.042-mm to 0.074-mm (diameter of human hair)
Silt:	0.002-mm to 0.042-mm (Cannot see particles)
Clay:	<0.002-mm

Relative Proportions

Descriptive Term	Percent
Trace	1-10
Little	11-20
Some	21-35
And	36-50

Relative Quality of Rock Cores

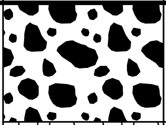
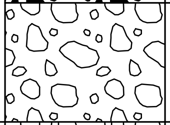
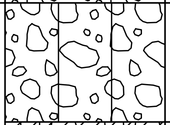
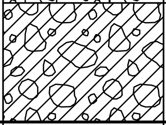
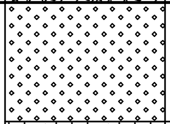
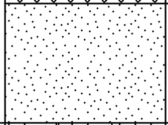
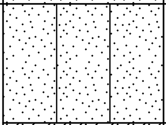
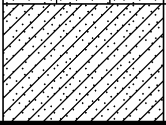
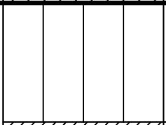
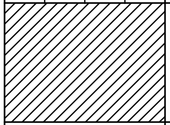
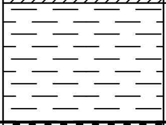
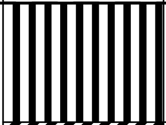
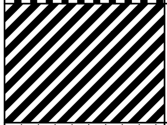
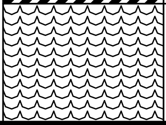
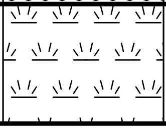
Quality	RQD
Very Poor	0-25%
Poor	25-50%
Fair	50-75%
Good	75-90%
Excellent	90-100%

$$RQD = \frac{\text{Total length of core recovered in pieces 4 inches long or longer x}}{\text{Total length of core run}} 100\%$$

Rock Hardness

Very Soft	Rock disintegrates or easily compresses to touch; can be hard to very hard soil
Soft	Rock is coherent but breaks easily to thumb pressure at sharp edges and crumbles with firm hand pressure
Moderately Hard	Small pieces can be broken off along sharp edges by considerable hard thumb pressure; can be broken by light hammer blows
Hard	Rock cannot be broken by thumb pressure, but can be broken by moderate hammer blows
Very Hard	Rock can be broken by heavy hammer blows

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		(LITTLE OR NO FINES)		GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
		(APPRECIABLE AMOUNT OF FINES)		GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	SAND AND SANDY SOILS	CLEAN SANDS		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		(LITTLE OR NO FINES)		SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	SANDS WITH FINES		SM	SILTY SANDS, SAND - SILT MIXTURES
		(APPRECIABLE AMOUNT OF FINES)		SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

ATHENA BORING LOG

ATHENA
[formerly KS Ware & Associates]

BORING NO. B-17

PROJECT NAME: **Taxiway Bravo Intersection Reconfiguration**
LOCATION: **Memphis International Airport**
PROJECT NO.: **100-19-0019**
Sheet 1 of 1

Approx. Surface El. (feet, MSL):
Location: **See Location Plan**

Depth, feet	Graphic Log	MATERIAL DESCRIPTION	Samples	Recovery (%)	RQD (%)	SPT Values	N-Value	Pocket Pen (tsf)	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
		TOPSOIL (12 Inches)										
1.0		SILTY CLAY (CL-ML), brown, firm to stiff, moist	☒	67		4-7-3	10	3.5	18.1			
4			☒	94		1-2-3	5	2.25	23.8			
5.5		SILTY CLAY (CL-ML), light brown, trace black nodules, firm to stiff, moist	☒	100		3-3-4	7	2.75	24.0			
8												
8.5		SILTY CLAY (CL-ML), light brown with orange mottling, stiff, moist	☒	100		3-5-9	14	2.5	23.4			
10.0		BORING TERMINATED AT 10.0 FBGS										
12												

Completion Depth (ft.): **10.0**
Date Started: **2/9/23**
Date Completed: **2/9/23**
Drilled By: **Geotechnology**
Logged By: **J. Benoit**

Remarks: **No measurable groundwater observed during or upon completion of drilling operations. Backfilled with auger cuttings. Geoprobe track-mounted drill rig with auto-hammer. 3-1/4" I.D. HSA, AWJ Split-Spoon sampling**

ATHENA BORING LOG

ATHENA
[formerly KS Ware & Associates]

BORING NO. B-18

PROJECT NAME: Taxiway Bravo Intersection Reconfiguration
LOCATION: Memphis International Airport
PROJECT NO.: 100-19-0019

Sheet 1 of 1

Approx. Surface El. (feet, MSL):
Location: See Location Plan

Depth, feet	Graphic Log	MATERIAL DESCRIPTION	Samples	Recovery (%)	RQD (%)	SPT Values	N-Value	Pocket Pen (tsf)	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
		TOPSOIL (12 Inches)										
1.0		SILT (ML), brown, firm, moist	■	100					29.0	NP	NP	NP
3.5	▨	SILTY CLAY (CL-ML), brown with light brown mottling, soft to firm, v. moist	☒	100		1-1-1	2	1.5	26.9			
4												
6.0	▨	SILTY CLAY (CL-ML), brown, firm to stiff, moist	☒	100		1-3-2	5	1.25	25.7			
8	▨		☒	100		1-2-4	6	1.5	24.9			
10.0		BORING TERMINATED AT 10.0 FBGS										
12												

Completion Depth (ft.): **10.0**
Date Started: **2/9/23**
Date Completed: **2/9/23**
Drilled By: **Geotechnology**
Logged By: **J. Benoit**

Remarks: **No measurable groundwater observed during or upon completion of drilling operations. Backfilled with auger cuttings. Geoprobe track-mounted drill rig with auto-hammer. 3-1/4" I.D. HSA, AWJ Split-Spoon sampling**

ATHENA BORING LOG

BORING NO. B-21

PROJECT NAME: Taxiway Bravo Intersection Reconfiguration
LOCATION: Memphis International Airport
PROJECT NO.: 100-19-0019

Sheet 1 of 1

Approx. Surface El. (feet, MSL):
Location: **See Location Plan**

Depth, feet	Graphic Log	MATERIAL DESCRIPTION	Samples	Recovery (%)	RQD (%)	SPT Values	N-Value	Pocket Pen (tsf)	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index
		TOPSOIL (14 Inches)										
1.2		SILTY CLAY (CL-ML), light brown, stiff, moist	■	100					25.3	29	22	7
3.5		SILTY CLAY (CL-ML), trace gravel, light brown, trace black nodules, firm to stiff, moist	☒	89		1-3-4	7	2.25	21.5			
4												
6.0		SILTY CLAY (CL-ML), light brown with brown mottling and black nodules, stiff to v. stiff, moist	☒	100		3-6-9	15	4.0	21.4			
8			☒	100		3-7-8	15	4.0	20.3			
10.0		BORING TERMINATED AT 10.0 FBGS										
12												

Completion Depth (ft.): **10.0**
Date Started: **2/9/23**
Date Completed: **2/9/23**
Drilled By: **Geotechnology**
Logged By: **J. Benoit**

Remarks: **No measurable groundwater observed during or upon completion of drilling operations. Backfilled with auger cuttings. Geoprobe track-mounted drill rig with auto-hammer. 3-1/4" I.D. HSA, AWJ Split-Spoon sampling**

PAVEMENT CORE PHOTOGRAPHS
TAXIWAY BRAVO INTERSECTION RECONFIGURATION
MEMPHIS INTERNATIONAL AIRPORT
PROJECT NO. 100-19-0019

Photo 1: Concrete Core Location B-19

*Due to equipment issues, Athena's subcontractor had to switch to a small diameter core barrel when concrete was encountered as can be observed in Photo 1.

Photo 2: Concrete Core Location B-20

DCP TEST DATA

B-17

Project: *Taxiway Bravo Intersection*
Date: 2/9/2023
Location: Memphis International Airport
Soil Type(s): SILTY CLAY (CL-ML)

Hammer
● 10.1 lbs.
○ 17.6 lbs.
○ Both hammers used

Soil Type
○ CH
○ CL
● All other soils

No. of Blows	Accumulative Penetration (mm)	Type of Hammer
0	20	2
5	85	2
13	140	2
17	200	2
17	260	2
14	325	2
7	380	2
6	445	2
7	500	2
7	560	2
9	625	2
9	685	2
9	740	2
10	800	2
10	855	2
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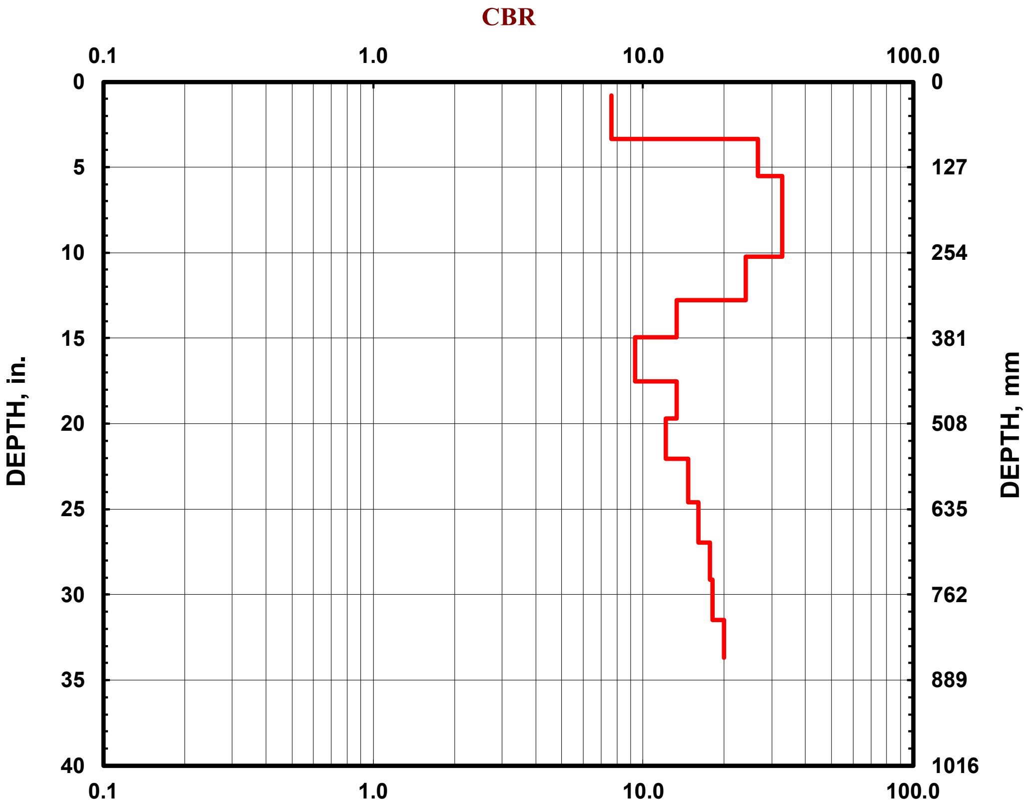

DCP TEST DATA

B-18

Project: *Taxiway Bravo Intersection*
Location: Memphis International Airport

Date: 2/9/2023
Soil Type(s): SILT (ML)

Hammer
● 10.1 lbs.
○ 17.6 lbs.
○ Both hammers used

Soil Type
○ CH
○ CL
● All other soils

No. of Blows	Accumulative Penetration (mm)	Type of Hammer
0	40	2
16	100	2
28	160	2
33	240	2
9	320	2
5	380	2
5	450	2
6	505	2
7	565	2
6	620	2
7	680	2
7	720	2
9	805	2
7	860	2
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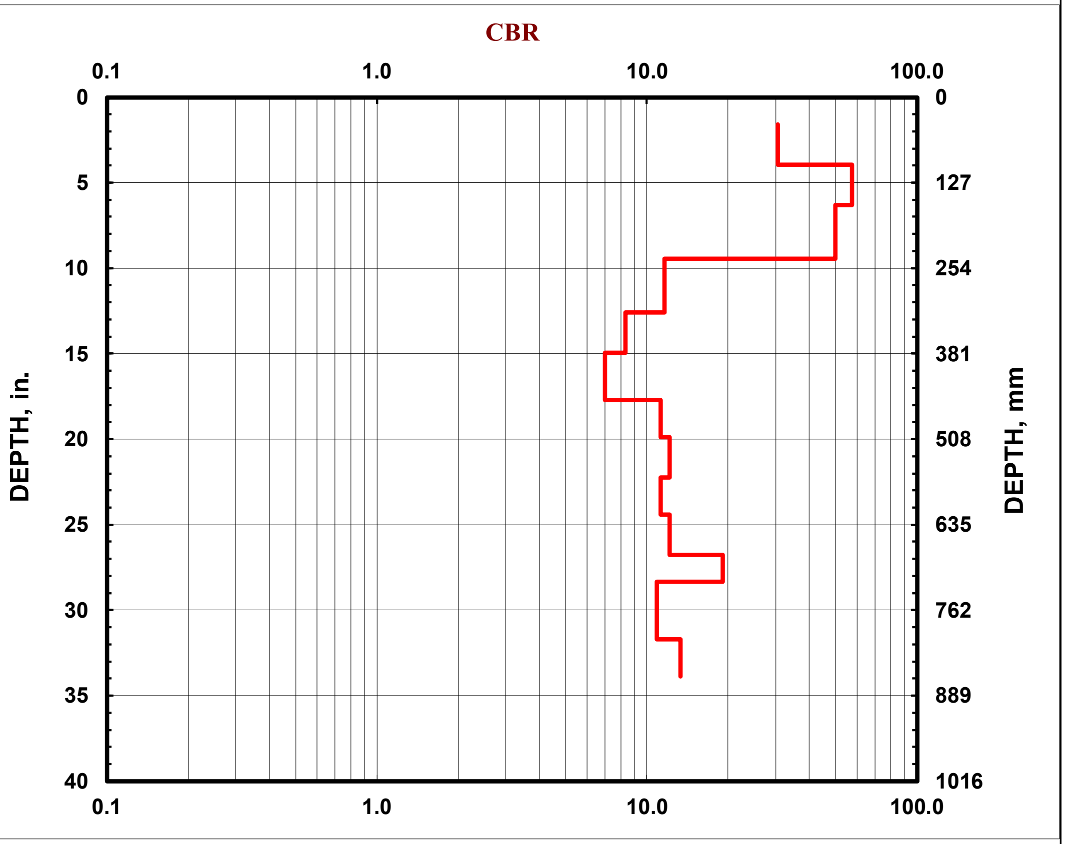

DCP TEST DATA

B-19

Project: *Taxiway Bravo Intersection* **Date:** 2/9/2023

Location: Memphis International Airport **Soil Type(s):** SILTY CLAY (CL-ML)

Hammer
● 10.1 lbs.
○ 17.6 lbs.
○ Both hammers used

Soil Type
○ CH
○ CL
● All other soils

No. of Blows	Accumulative Penetration (mm)	Type of Hammer
0	80	2
5	140	2
5	210	2
6	275	2
6	340	2
7	410	2
7	470	2
7	535	2
7	600	2
7	660	2
7	735	2
8	790	2
8	855	2
8	910	2
		2
		2
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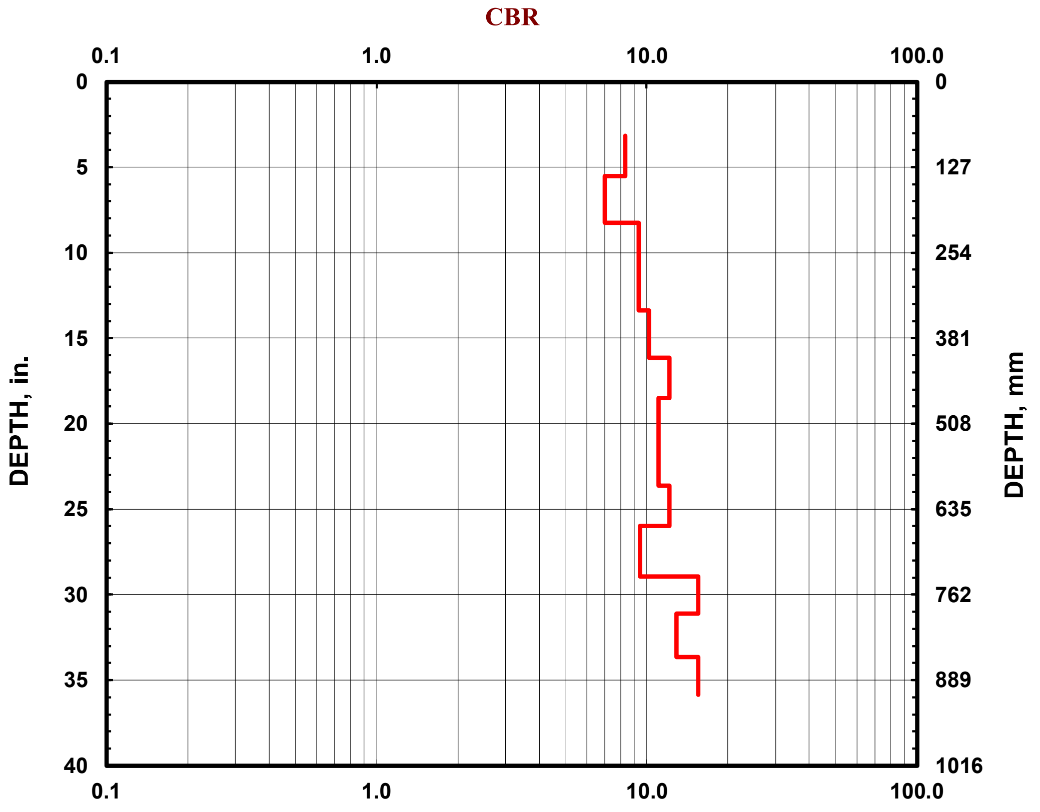

DCP TEST DATA

B-20

Project: *Taxiway Bravo Intersection*

Location: Memphis International Airport

Date: 2/9/2023

Soil Type(s): SILTY CLAY (CL-ML)

Hammer
● 10.1 lbs.
○ 17.6 lbs.
○ Both hammers used

Soil Type
○ CH
○ CL
● All other soils

No. of Blows	Accumulative Penetration (mm)	Type of Hammer
0	20	2
3	80	2
3	140	2
3	200	2
4	270	2
4	330	2
6	395	2
6	450	2
7	515	2
7	570	2
8	630	2
9	695	2
8	750	2
10	820	2
10	890	2
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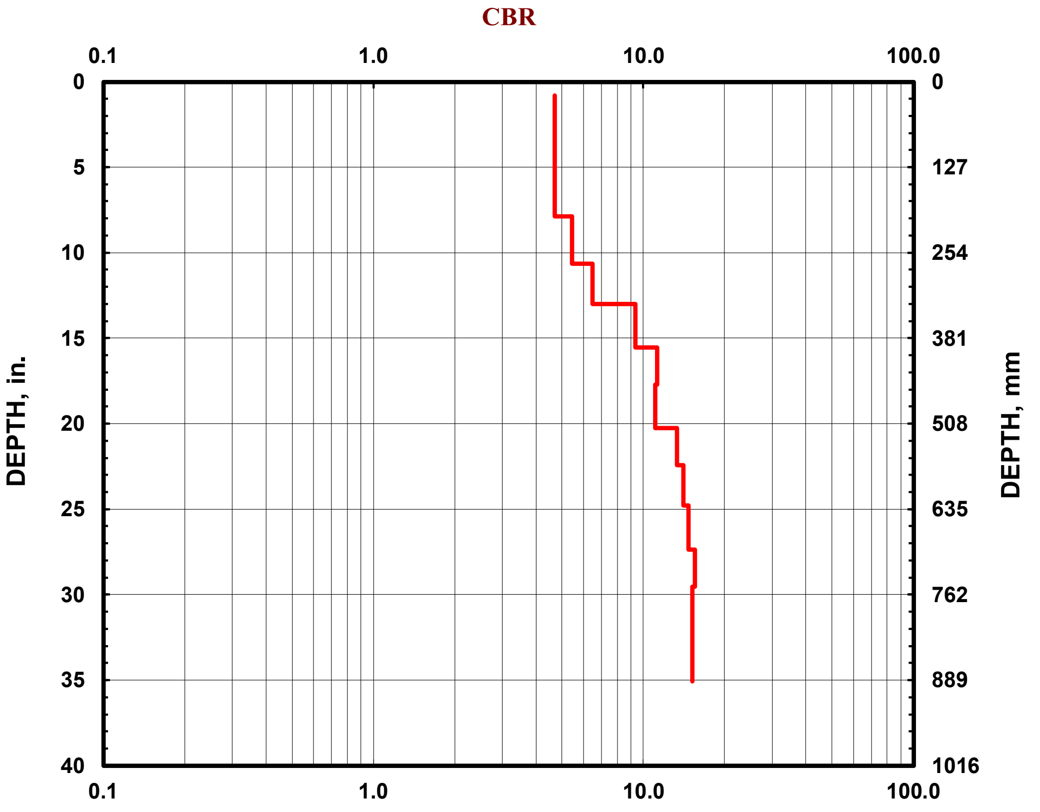

DCP TEST DATA

B-21

Project: *Taxiway Bravo Intersection*
Location: Memphis International Airport
Date: 2/9/2023
Soil Type(s): SILTY CLAY (CL-ML)

Hammer
● 10.1 lbs.
○ 17.6 lbs.
○ Both hammers used

Soil Type
○ CH
○ CL
● All other soils

No. of Blows	Accumulative Penetration (mm)	Type of Hammer
0	25	2
3	90	2
4	155	2
5	220	2
5	285	2
5	340	2
7	400	2
8	470	2
8	535	2
8	595	2
8	655	2
8	710	2
9	770	2
11	830	2
10	880	2
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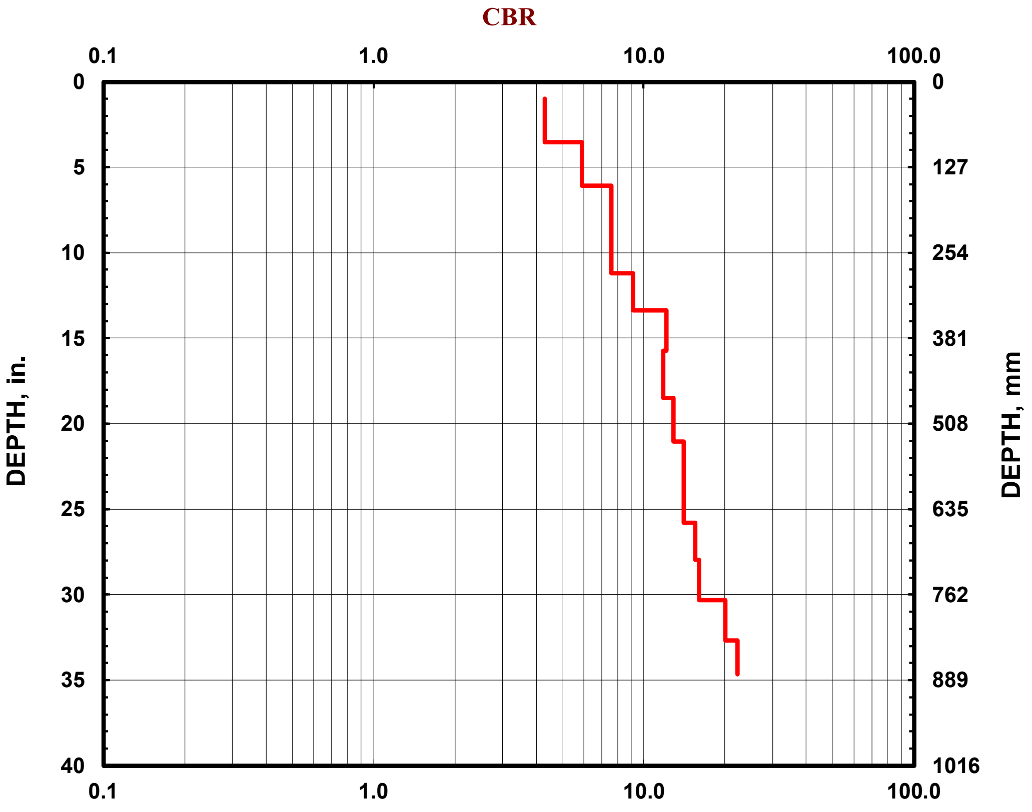


APPENDIX C

Laboratory Test Results

ATHENA
[formerly KS Ware & Associates]

350 Cal Batsel Road
Bowling Green, KY 42101
Phone: (615) 255-9702

ATTERBERG LIMITS (ASTM D4318)

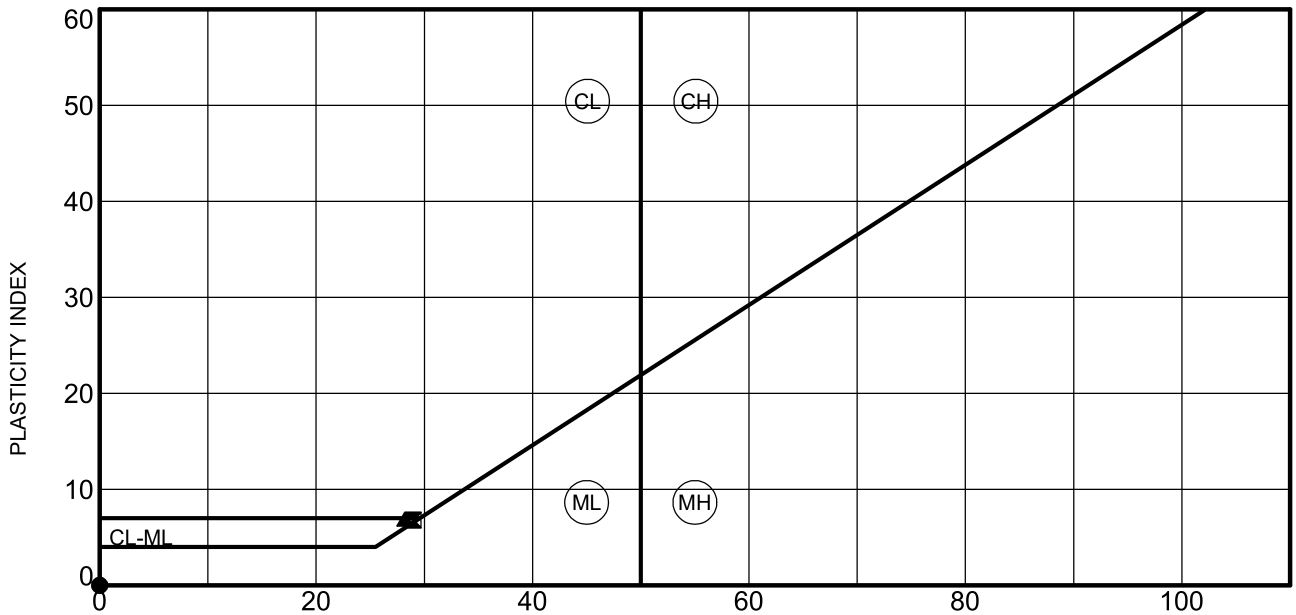
CLIENT: Allen & Hoshall

PROJECT NAME: Taxiway Bravo Intersection Reconfiguration

PROJECT NUMBER 100-19-0019

PROJECT LOCATION: Memphis International Airport

Equipment Used: Liquid Limit Device, Oven, Ohaus 3kg Scale, Metal Tares, Mortar and Pestle, Spatula, Plastic Grooving Tool



	Specimen Identification	SAMPLE TYPE	LL	PL	PI	% Fines	Soil Description
●	**B-18, 1'**	**ST**	**0**	**0**	**NP**	**100**	**SILT(ML)**
☒	**B-21, 1'**	**ST**	**29**	**22**	**7**	**99**	**SILTY CLAY(CL-ML)**
▲	**Bulk, 1'**	**B**	**28**	**21**	**7**	**98**	**SILTY CLAY(CL-ML)**

Abbreviations:
NP = Non-plastic
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
SS = Split Spoon
ST = Shelby Tube
G = Grab Sample
B = Bulk Sample

TESTED BY: S. Krikorian

TEST DATE: 3/2/2023

REVIEWED BY: B. Kouchoukos

DATE: 3/14/2023

ATHENA
[formerly KS Ware & Associates]

350 Cal Batsel Road
Bowling Green, KY 42101
Phone: (615) 255-9702

GRAIN SIZE DISTRIBUTION
ASTM D6913 - COARSE GRAIN SIZE
ASTM D7928 - FINE GRAIN SIZE

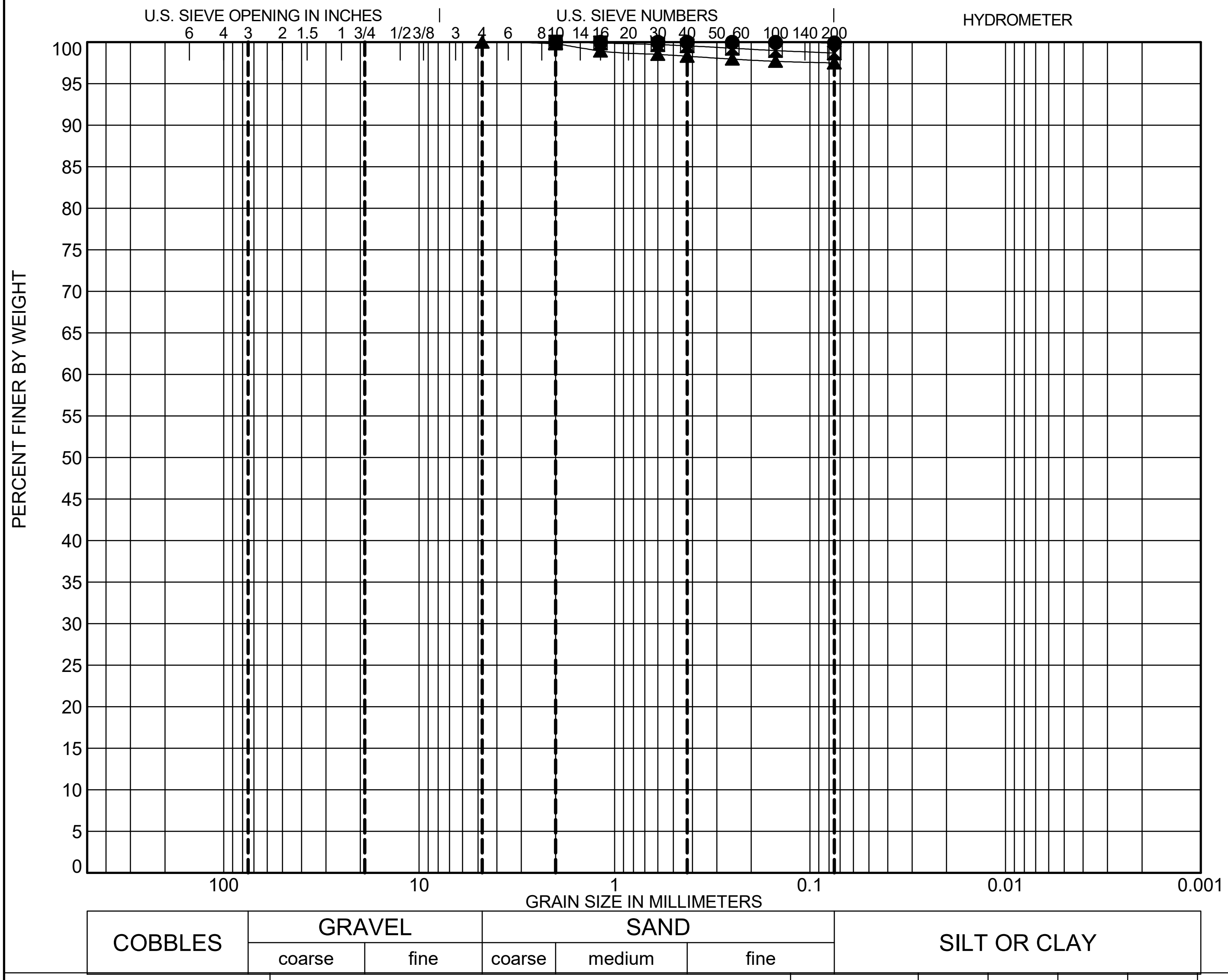
CLIENT: Allen & Hoshall

PROJECT NAME: Taxiway Bravo Intersection Reconfiguration

PROJECT NUMBER 100-19-0019

PROJECT LOCATION: Memphis International Airport

SOIL DESCRIPTION: Varies



Specimen Identification			Classification	Spec. Grav.	LL	PL	PI	Cc	Cu
●	**B-18,**	**1'**	SILT(ML)		**NP**	**NP**	**NP**		
☒	**B-21,**	**1'**	SILTY CLAY(CL-ML)		**29**	**22**	**7**		
▲	**Bulk,**	**1'**	SILTY CLAY(CL-ML)		**28**	**21**	**7**		

Specimen Identification			D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silts	%Clays
●	**B-18,**	**1'**	**2**				**0.0**	**0.1**	**99.9**	
☒	**B-21,**	**1'**	**2**				**0.0**	**1.3**	**98.7**	
▲	**Bulk,**	**1'**	**4.75**				**0.0**	**2.5**	**97.5**	

TESTED BY: S. Krikorian **TEST DATE**: 2/27/2023 **REVIEWED BY**: B. Kouchoukos **DATE**: 3/14/2023

ATHENA
[formerly KS Ware & Associates]

350 Cal Batsel Road
Bowling Green, KY 42101
Phone: (615) 255-9702

UNCONFINED COMPRESSIVE STRENGTH TEST COHESIVE SOIL (ASTM D2166)

CLIENT: Allen & Hoshall

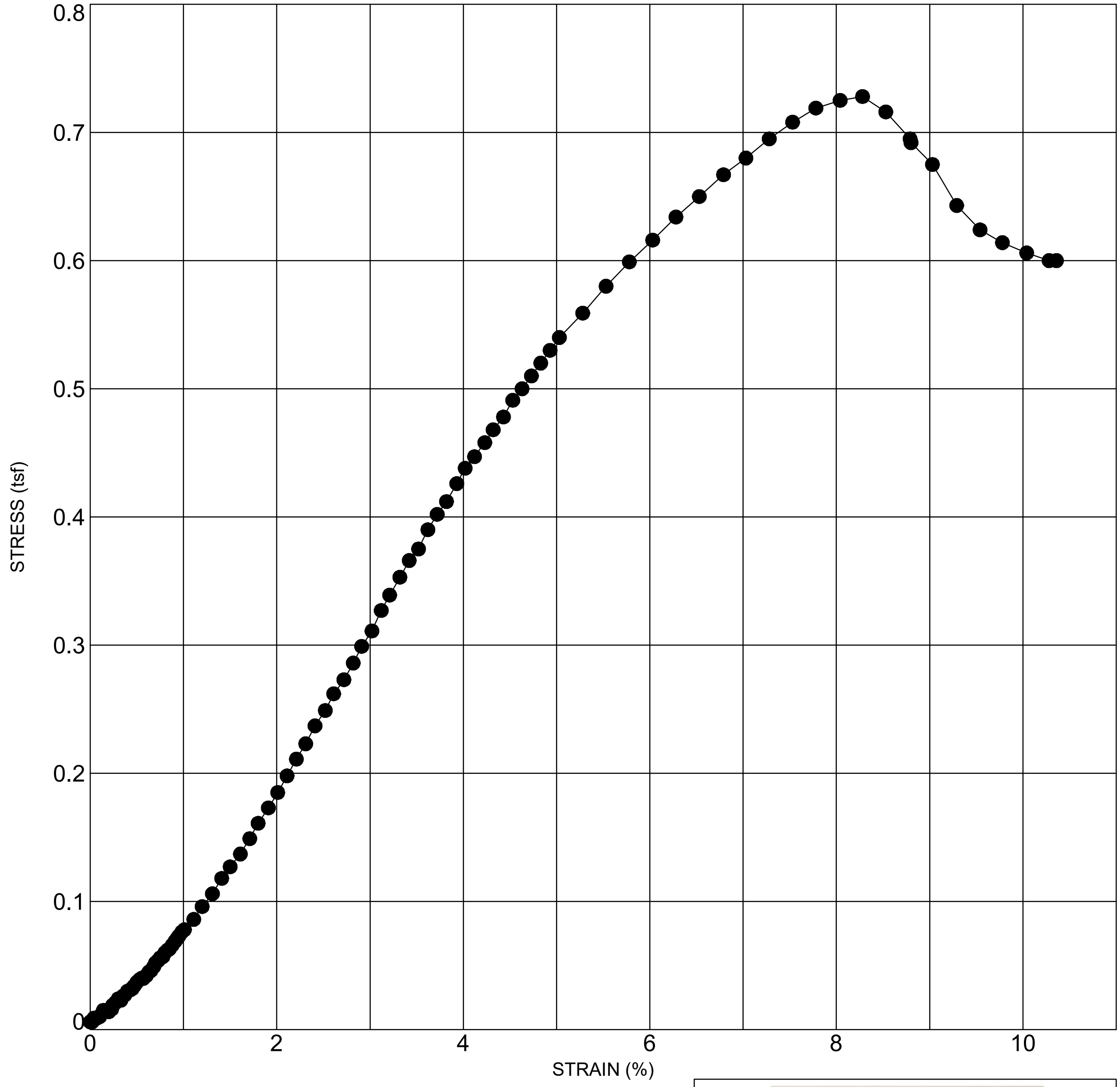
PROJECT NAME: Taxiway Bravo Intersection Reconfiguration

PROJECT NUMBER 100-19-0019

PROJECT LOCATION: Memphis International Airport

SOIL DESCRIPTION: SILT (ML)

SAMPLE RECEIVED: 2/9/2023



SAMPLE: B-18 1'

Diameter (in): 2.80

Strain at Failure (%): 8.28

Height (in): 5.76

Strength (tsf): 0.73

Ratio (h/d): 2.06

Dry Density (pcf): 95.30

LL: NP

Water Content (%): 28.98

PL: NP

Rate of Strain to Failure (%/min): 1

-Specimen was taken from Shelby Tube sample

-

TESTED BY: S. Krikorian
REVIEWED BY: B. Kouchoukos

TEST DATE: 2/24/2023
APPROVED DATE: 3/14/2023

ATHENA
[formerly KS Ware & Associates]

350 Cal Batsel Road
Bowling Green, KY 42101
Phone: (615) 255-9702

UNCONFINED COMPRESSIVE STRENGTH TEST COHESIVE SOIL (ASTM D2166)

CLIENT: Allen & Hoshall

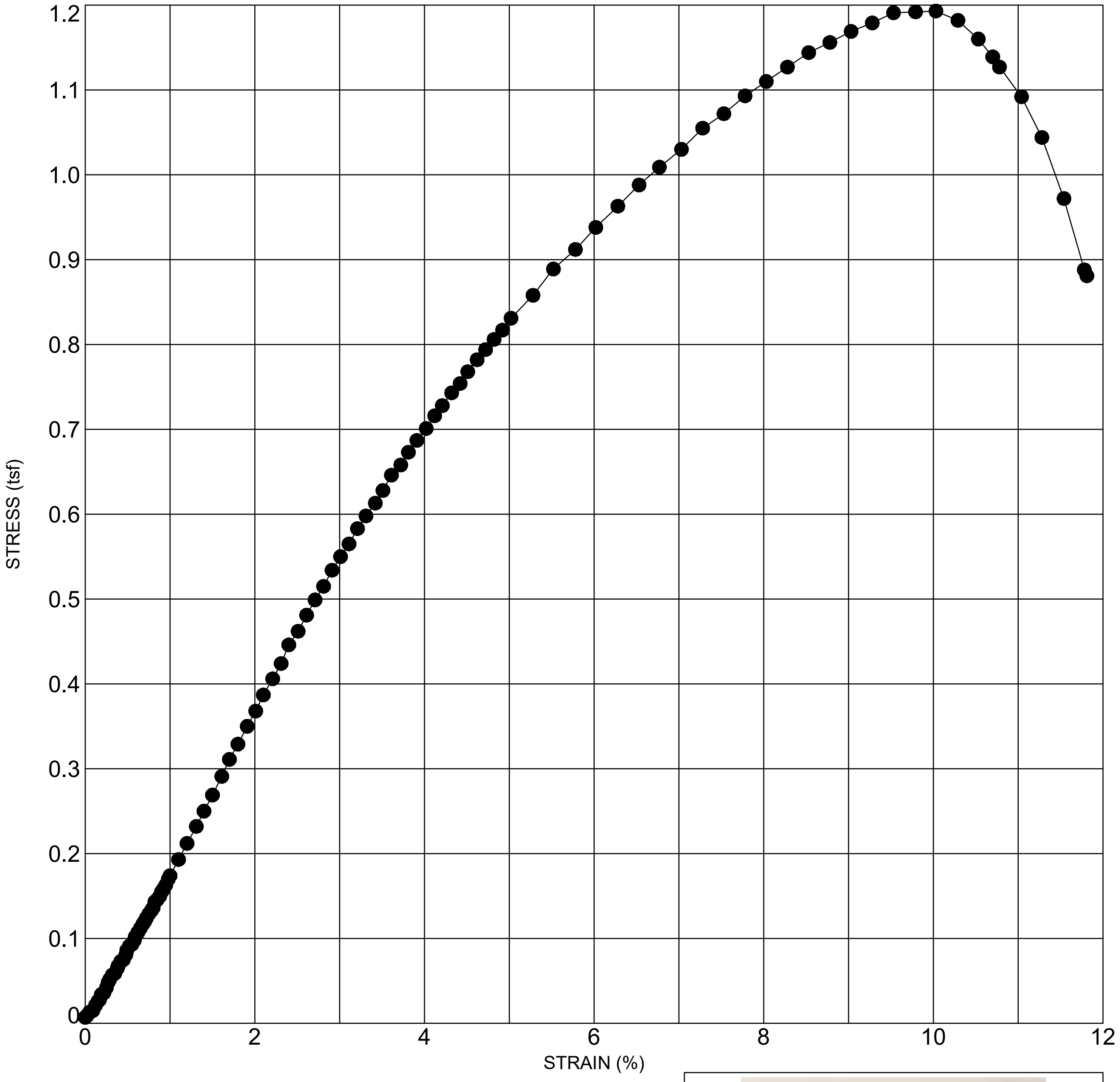
PROJECT NAME: Taxiway Bravo Intersection Reconfiguration

PROJECT NUMBER: 100-19-0019

PROJECT LOCATION: Memphis International Airport

SOIL DESCRIPTION: SILTY CLAY (CL-ML)

SAMPLE RECEIVED: 2/9/2023



SAMPLE: B-21 1'

Diameter (in): 2.85

Strain at Failure (%): 10.03

Height (in): 5.73

Strength (tsf): 1.19

Ratio (h/d): 2.01

Dry Density (pcf): 99.60

LL: 29

Water Content (%): 25.30

PL: 22

Rate of Strain to Failure (%/min): 1

-Specimen was taken from Shelby Tube sample

-

TESTED BY: S. Krikorian

TEST DATE: 2/24/2023

REVIEWED BY: B. Kouchoukos

APPROVED DATE: 3/14/2023

ATHENA
[formerly KS Ware & Associates]

350 Cal Batsel Road
Bowling Green, KY 42101
Phone: (615) 255-9702

MODIFIED PROCTOR (ASTM D1557)

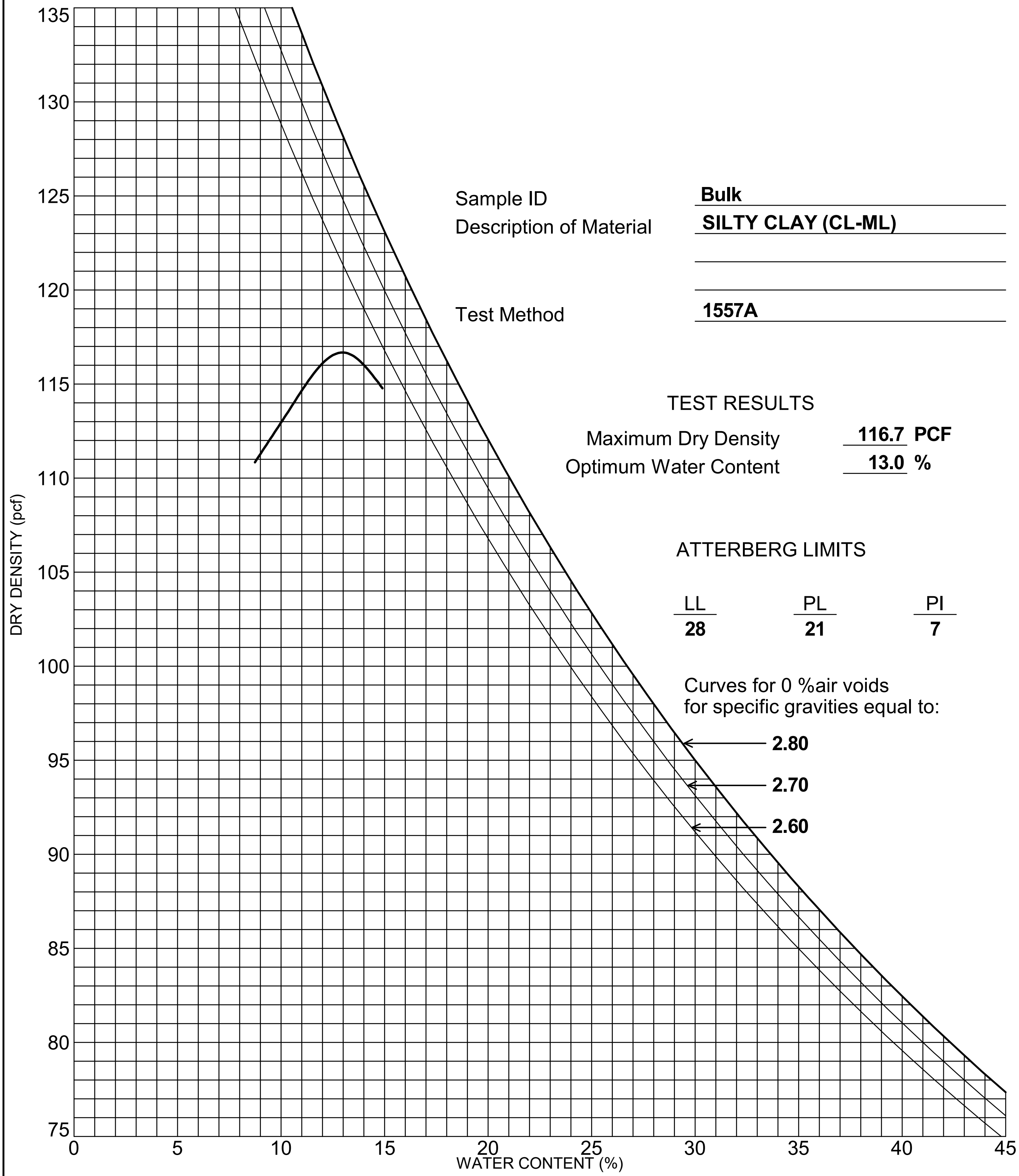
CLIENT: Allen & Hoshall

PROJECT NAME: Taxiway Bravo Intersection Reconfiguration

PROJECT NUMBER 100-19-0019

PROJECT LOCATION: Memphis International Airport

EQUIPMENT USED: Modified Hammer, 4 inch Mold, Ohaus 3 kilogram Scale, Oven, Ohaus 8 kilogram Scale



Sample ID **Bulk**

Description of Material **SILTY CLAY (CL-ML)**

Test Method **1557A**

TEST RESULTS

Maximum Dry Density **116.7** **PCF**

Optimum Water Content **13.0** **%**

ATTERBERG LIMITS

LL	PL	PI
28	**21**	**7**

TESTED BY: S. Krikorian
REVIEWED BY: K. Andrus

TEST DATE: 2/28/2023
DATE: 3/13/2023

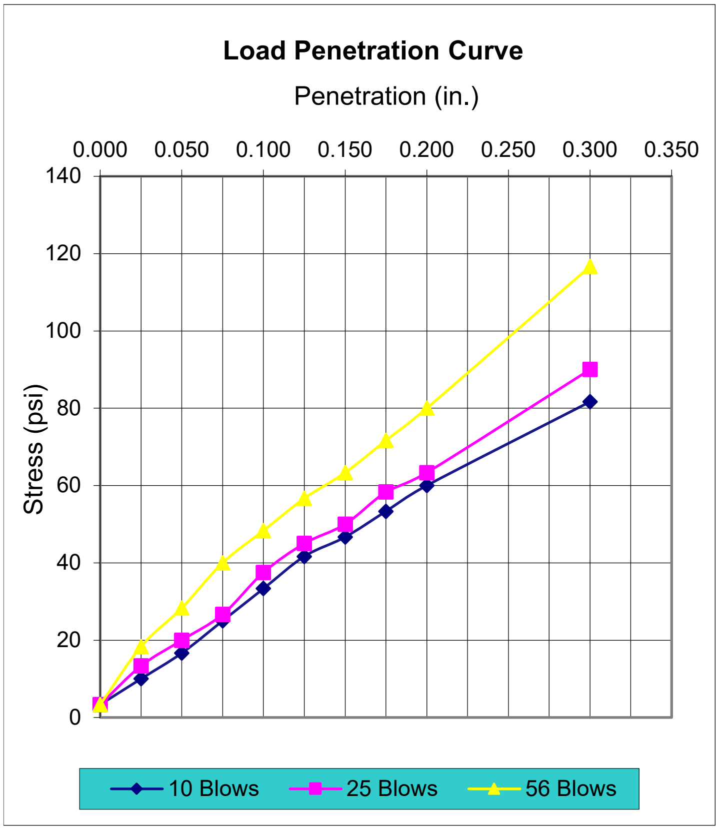
SAMPLE RECEIVED: 2/20/2023

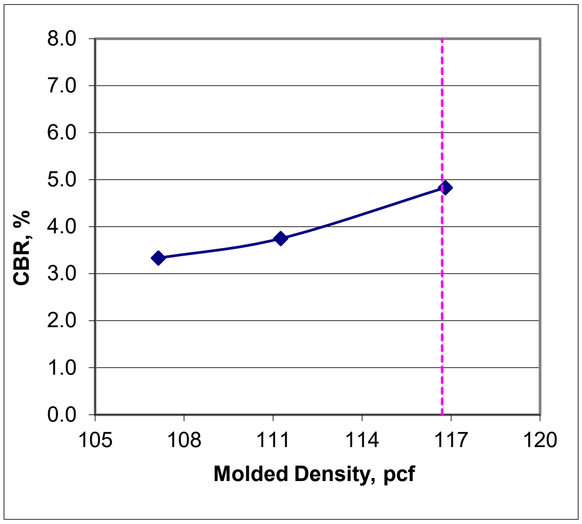
ATHENA
[formerly KS Ware & Associates]

Report of California Bearing Ratio Test (ASTM D1883)

Project Name:	Taxiway Bravo Intersection	Proctor Type:	Modified
Project Number:	100-19-0019	Maximum Dry Density:	116.7
Sample ID:	B-21 Bulk	Optimum Moisture:	13.0
Date Received:	2/15/2023		
Sample Description:	Brown Silty Clay		

Test	Pre-Test			Post-Test			CBR, %		Line	%
# Blows	DD	% Max	%m	DD	% Max	%m	0.1"	0.2"	Corr.	Swell
20	107.1	91.8	12.5	103.0	88.2	25.1	3.3	4.0	0	2.2251
30	111.3	95.3	12.6	105.2	90.2	25.0	3.8	4.2	0	1.9634
65	116.8	100.1	13.2	110.7	94.8	24.3	4.8	5.3	0	2.0506





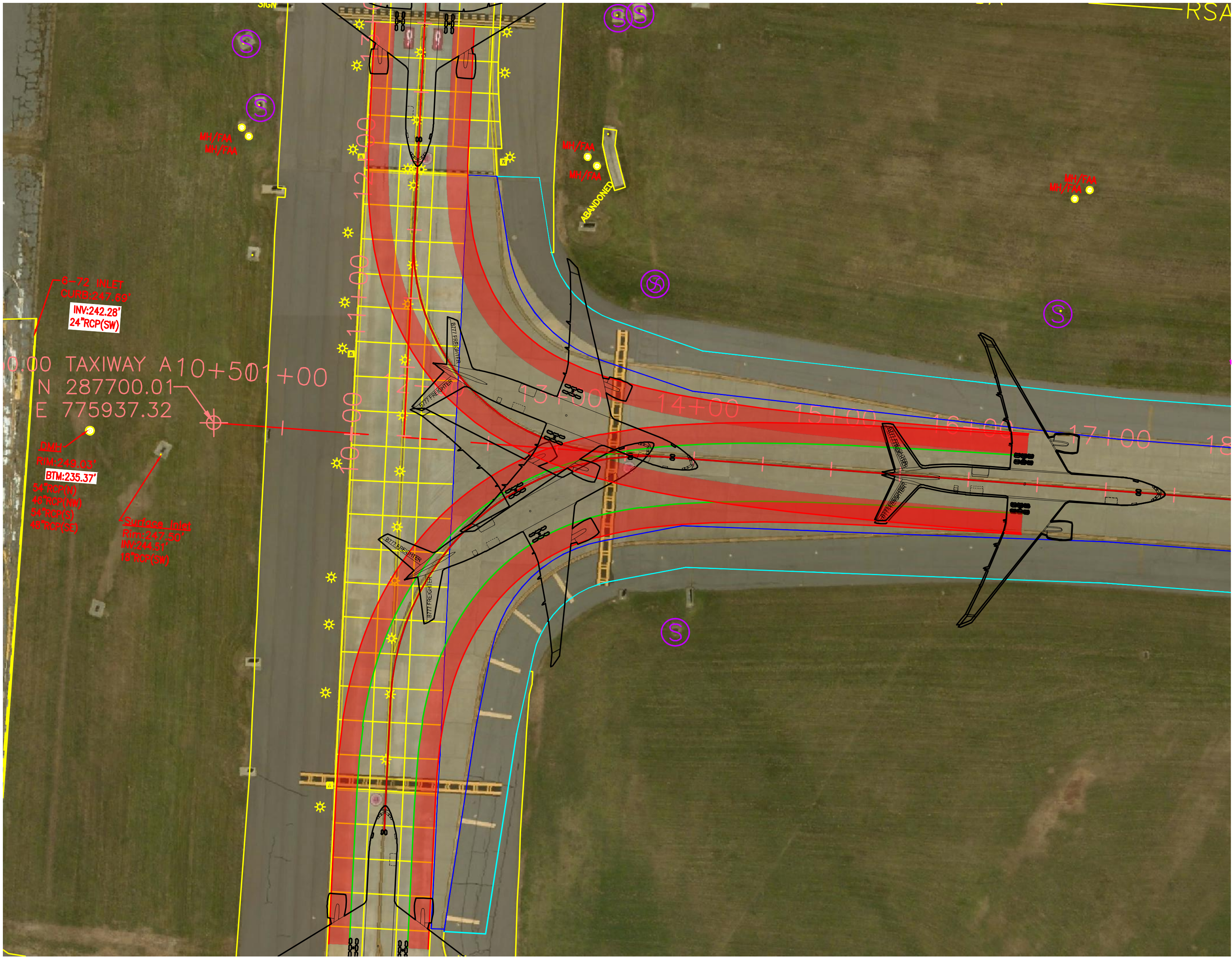
CBR* = 4.5

* for 100% max DD and
0.1 in. penetration

Submitted By:	S. Krikorian	Date:	3/21/2023
Reviewed By:	B. Kouchoukos	Date:	3/23/2023

Appendix C

Horizontal Geometry
Aircraft Movements – Taxiway Edge Safety Margin



Allen&Hoshall
engineers-architects-surveyors

NORTH

GRAPHIC SCALE

100 0 50 100 200

(IN FEET)
1 inch = 100 ft.

1661 International Drive
Memphis, TN 38120

72198
Job Number

5/10/21
Date

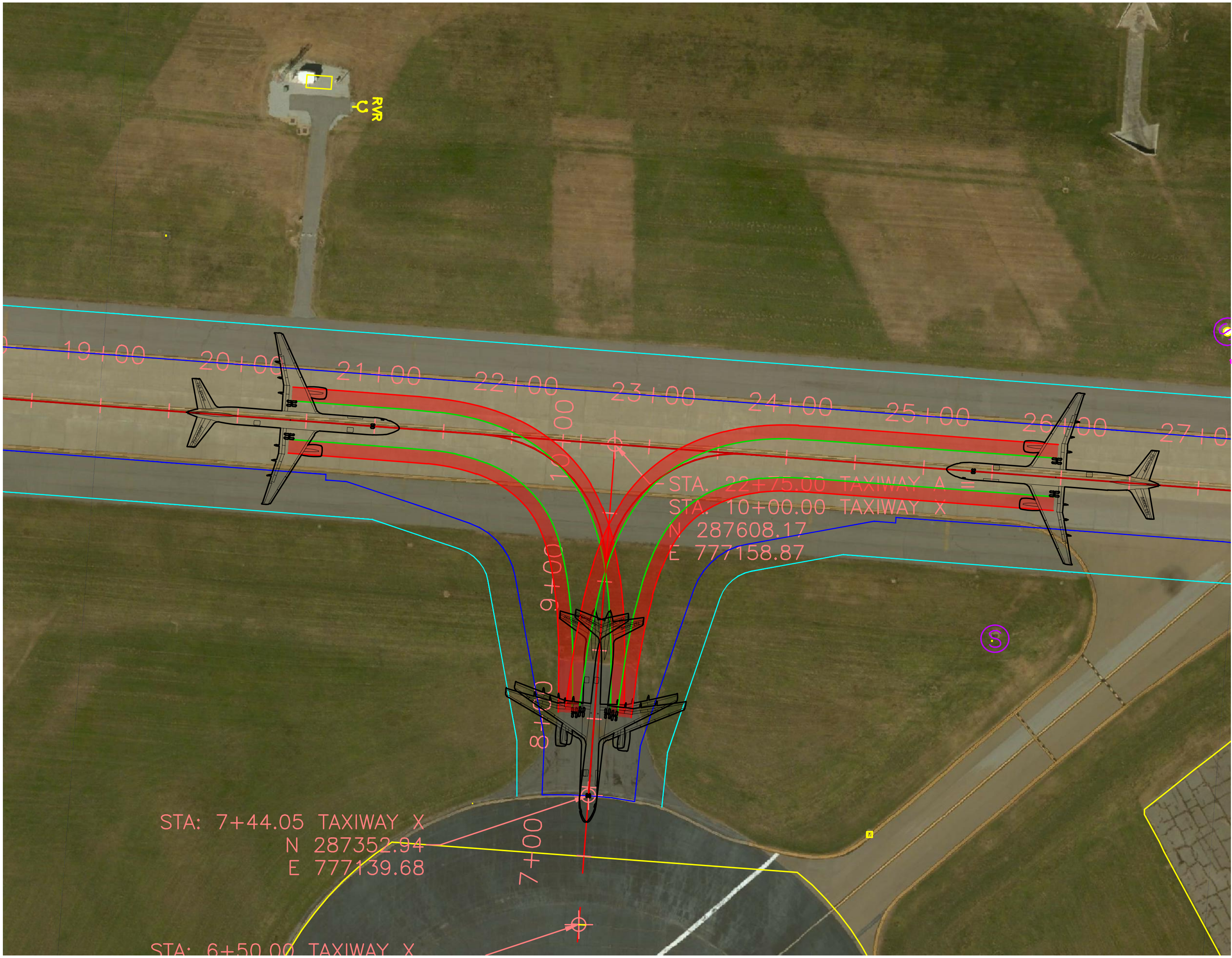
B777F Turning Movements with TESM

MEMPHIS SHELBY COUNTY AIRPORT AUTHORITY

TAXIWAY ALPHA WEST RECONSTRUCTION 18-1413

1" = 100'

1 OF 5
Sheet Number



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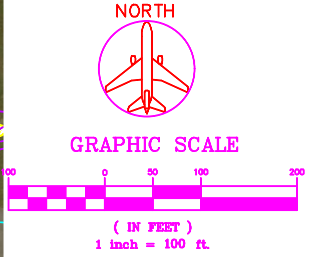

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Memphis, TN 38120

72198
Job Number

5/10/21
Date

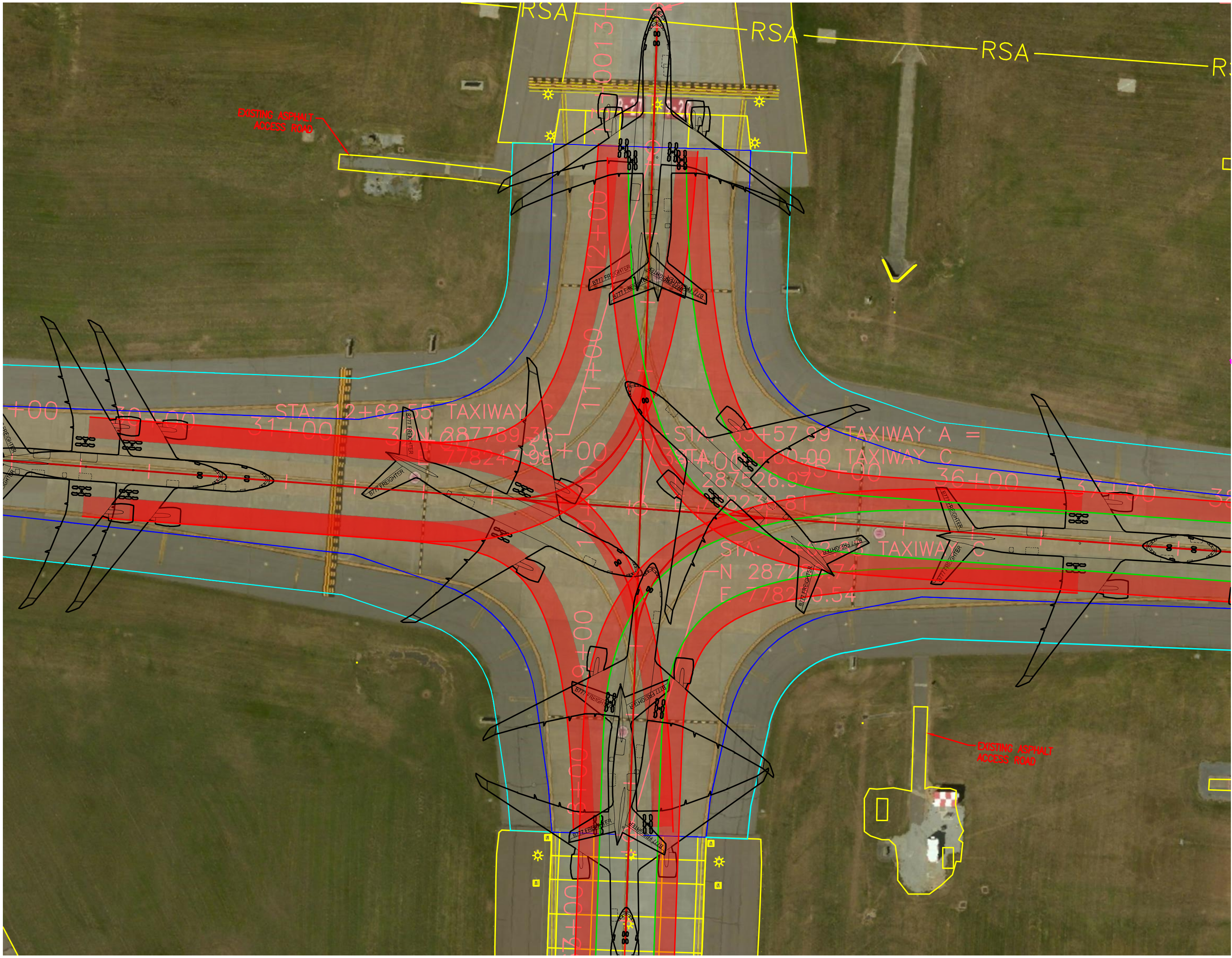
2 OF 5
Sheet Number

B757 Turning Movements with TESM

MEMPHIS SHELBY COUNTY AIRPORT AUTHORITY

TAXIWAY ALPHA WEST RECONSTRUCTION 18-1413

1" = 100'



Allen&Hoshall
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NORTH

GRAPHIC SCALE

100 0 50 100 200

(IN FEET)
1 inch = 100 ft.

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Memphis, TN 38120

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Job Number

5/10/21
Date

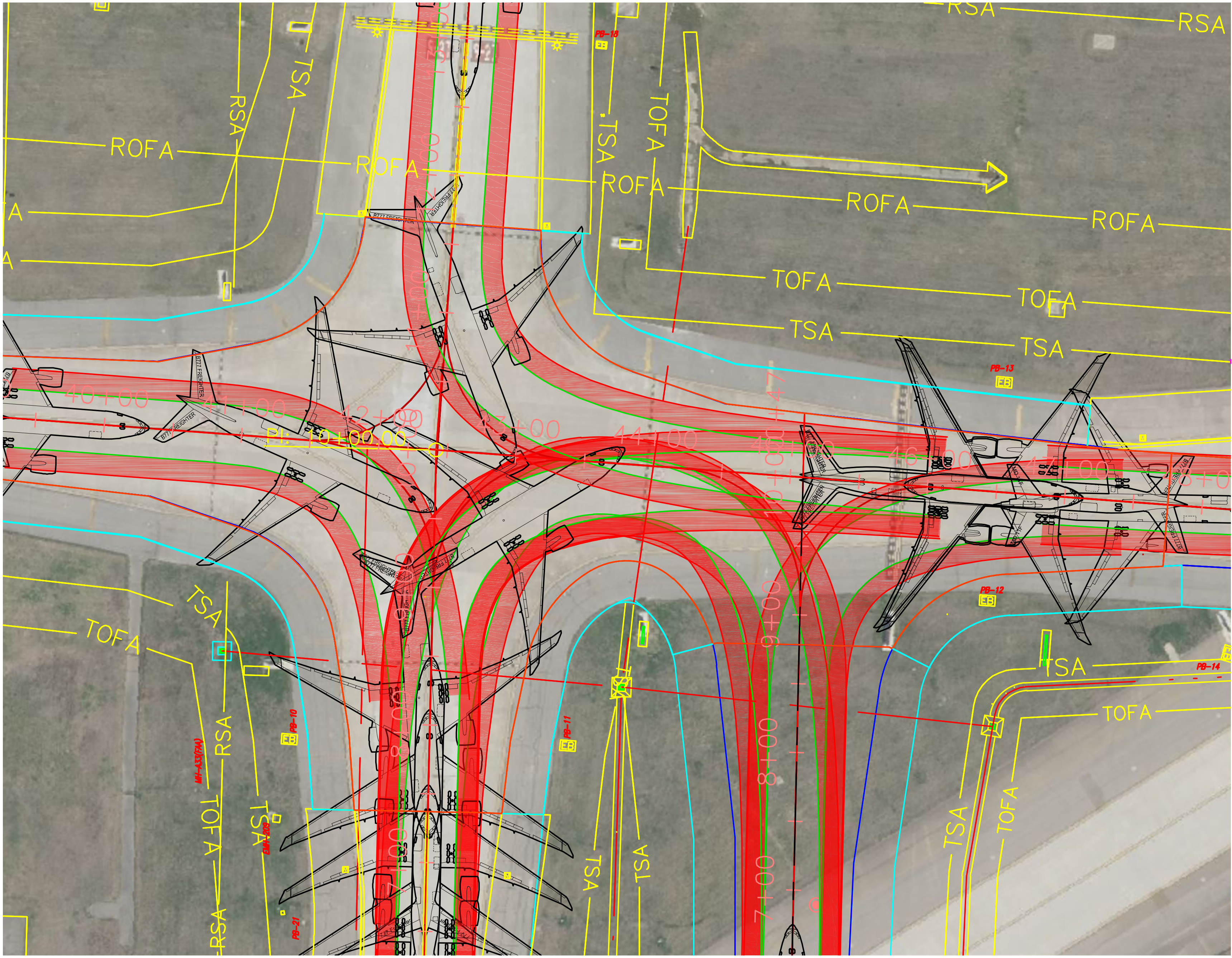
B777F Turning Movements with TESM

MEMPHIS SHELBY COUNTY AIRPORT AUTHORITY

TAXIWAY ALPHA WEST RECONSTRUCTION 18-1413

1" = 100'

3 OF 5
Sheet Number



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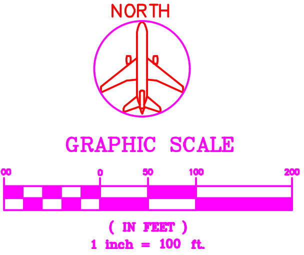

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72198
Job Number

5/10/21
Date

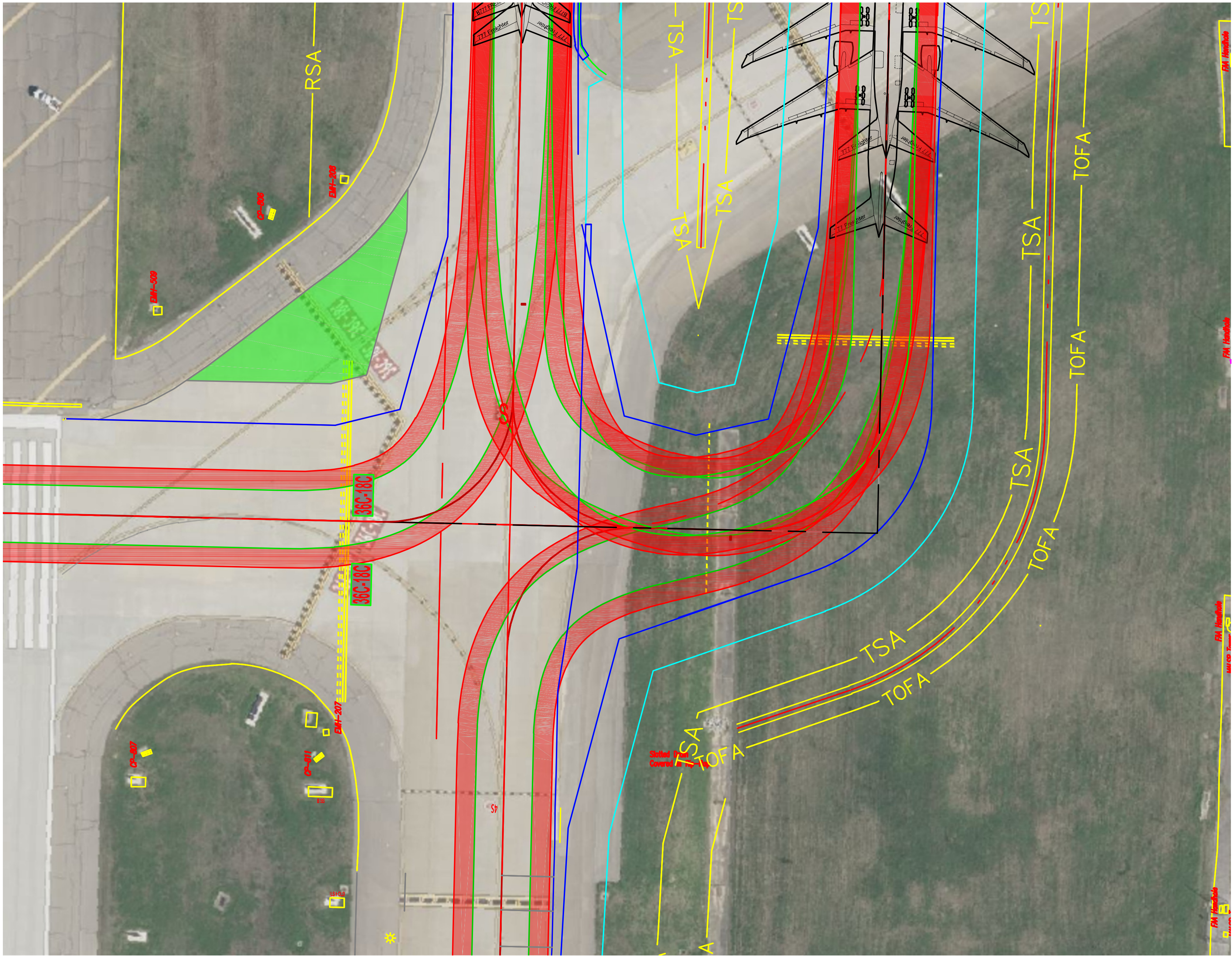
4 OF 5
Sheet Number

B777F Turning Movements with TESM — Alpha/Bravo/Sierra Intersection

MEMPHIS SHELBY COUNTY AIRPORT AUTHORITY

TAXIWAY ALPHA WEST RECONSTRUCTION 18–1413

1" = 100'



Allen&Hoshall
engineers-architects-surveyors

NORTH

GRAPHIC SCALE

100 0 50 100 200

(IN FEET)
1 inch = 100 ft.

1661 International Drive
Memphis, TN 38120

72198
Job Number

5/10/21
Date

5 OF 5
Sheet Number

B777F Turning Movements with TESM– Bravo/Sierra/S8 Intersection

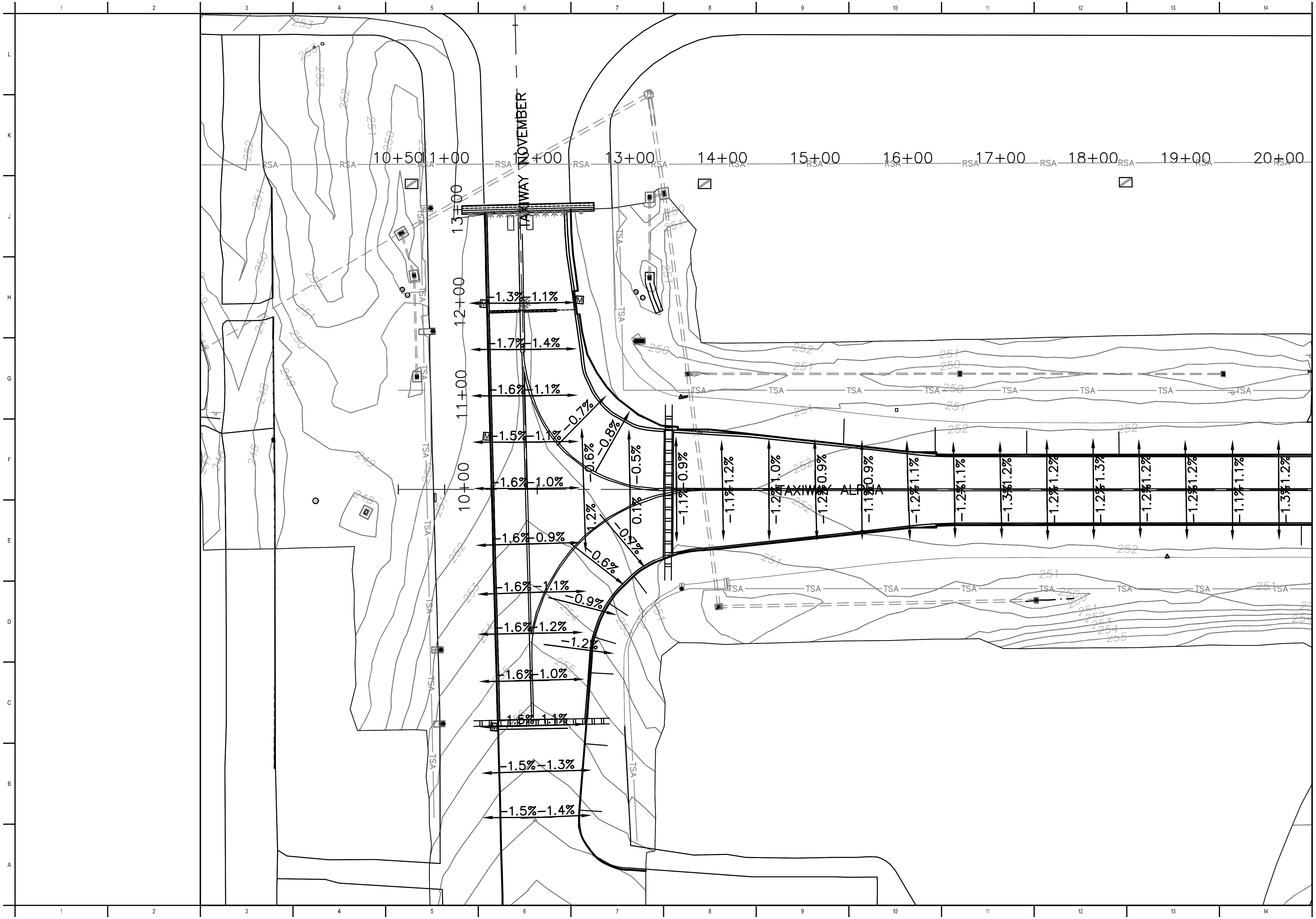
MEMPHIS SHELBY COUNTY AIRPORT AUTHORITY

TAXIWAY ALPHA WEST RECONSTRUCTION 18–1413

1" = 100'

Appendix D

Vertical Surface
Existing Taxiway Cross-Slopes



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SCALE: 1"=100'

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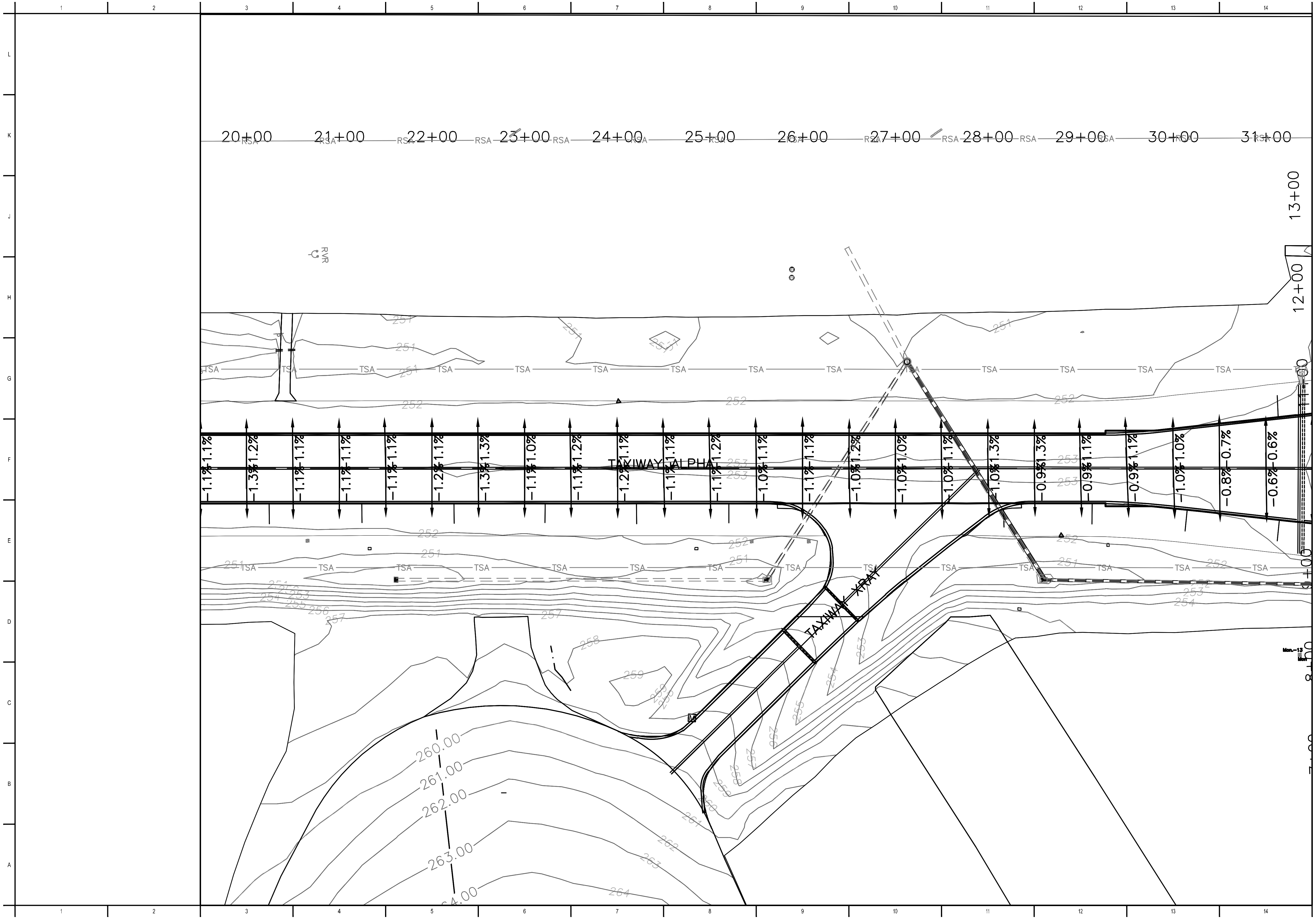
No.	Revision	Date

SLOPE ANALYSIS
TAXIWAY ALPHA WEST RECONSTRUCTION

EXISTING TAXIWAY ALPHA CROSS SLOPES

JOB NO: 72198
DATE: 7/31/2020
DRAWN:
CHECKED:
CAD FILE:

EXHIBIT 1



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EXISTING TAXIWAY ALPHA CROSS SLOPES

JOB NO: 72198
DATE: 7/31/2020
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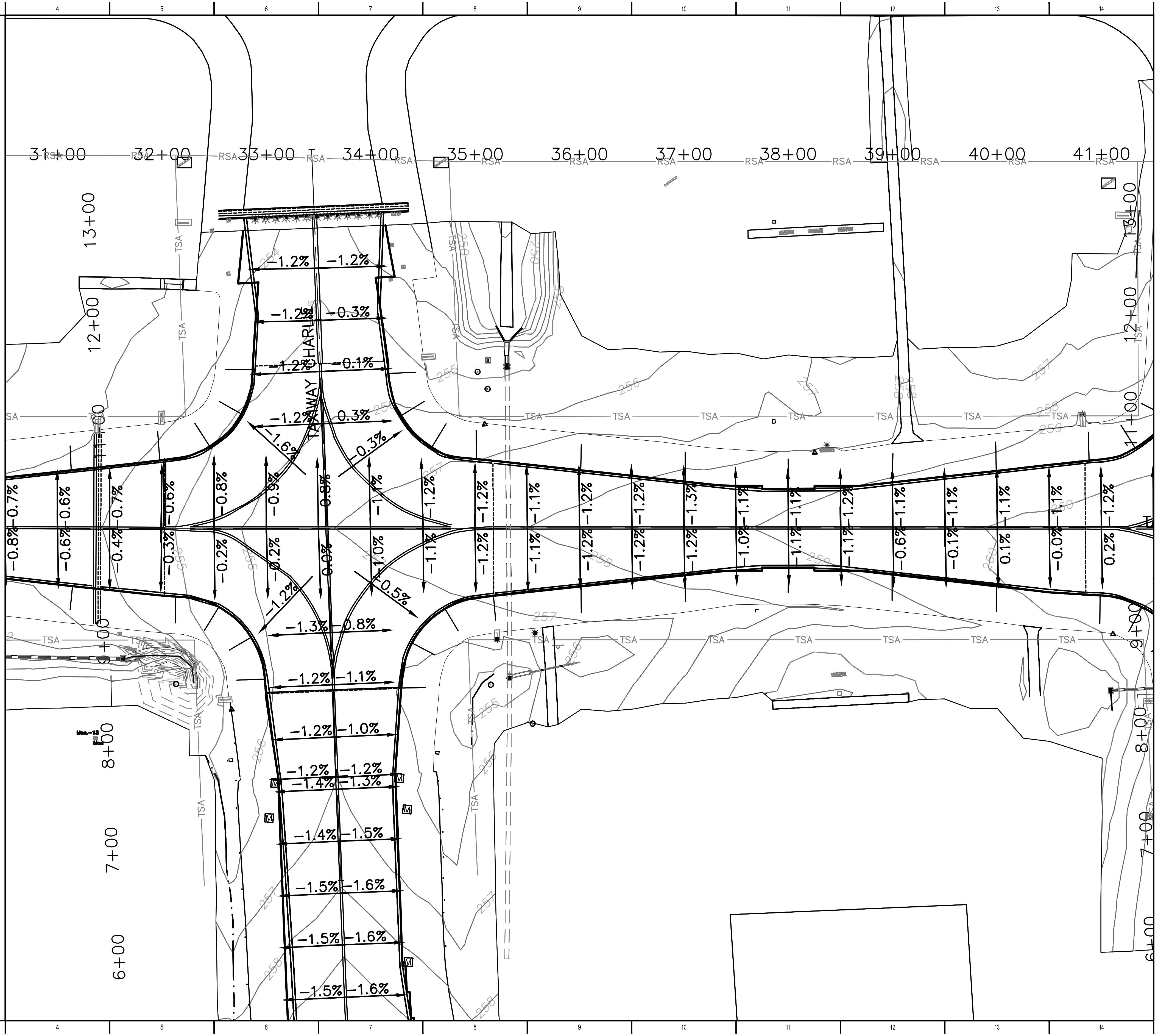
CHECKED:
CAD FILE:

EXHIBIT 2



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EXISTING TAXIWAY ALPHA CROSS SLOPES

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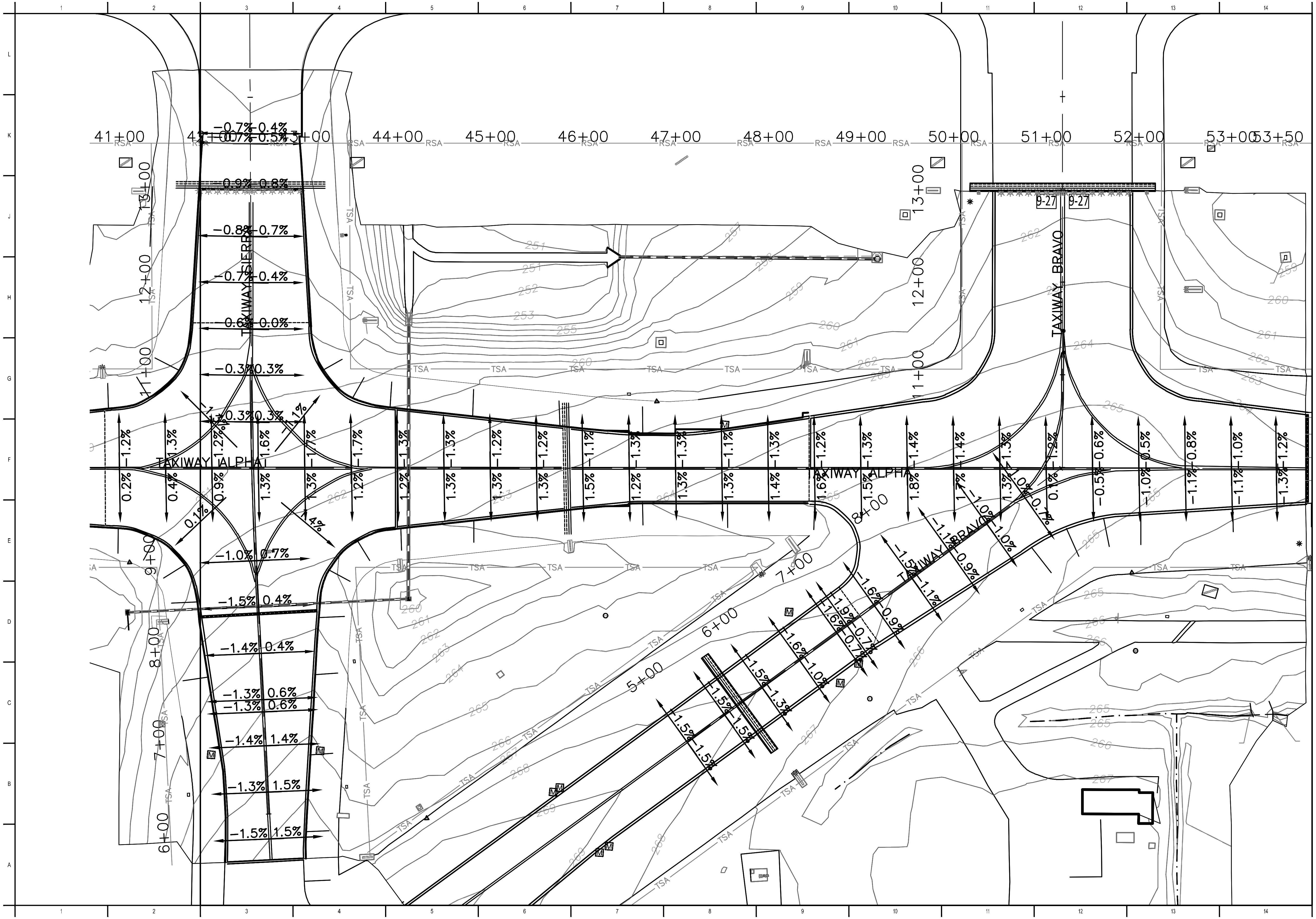
EXHIBIT 3



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SCALE: 1"=100'

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TAXIWAY ALPHA WEST RECONSTRUCTION

EXISTING TAXIWAY A CROSS SLOPES

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CAD FILE:

EXHIBIT 4

Appendix E

NDT Report & Pavement Design

TAXIWAY A WEST RECONSTRUCTION PAVEMENT DESIGN

at

TAKE OFF WITH US.
Memphis
INTERNATIONAL AIRPORT

Memphis, TN

REPORT

June 15, 2020

Prepared for:

Allen&Hoshall
engineers-architects-surveyors

Memphis, TN

Prepared by:

RDM
Engineering Technology Research

RDM International, Inc.
14310 Sullyfield Circle, Suite 600
Chantilly, VA 20151
Telephone 703-709-2540 • Fax 703-709-2535
www.rdmintlinc.com

TABLE OF CONTENTS

Appendix

EXECUTIVE SUMMARY

RDM International, Inc. (RDM) was retained by Allen & Hoshall, Inc. (A&H) to perform pavement evaluation and design services for the reconstruction of Taxiway A West at Memphis International Airport (MEM), Memphis, Tennessee. Taxiway A West is approximately 4.200 feet between Taxiway N and Taxiway B. Taxiway C and Taxiway S intersect Taxiway A along its length. Portions of these crossing taxiways are included in this project. An unnamed taxiway between Taxiway N and Taxiway C leading to the Signature Ramp was also included in this project. The primary objective of this report is to provide A&H with a structural evaluation and reconstruction design for the pavement areas within the project limits.

In April 2019, RDM conducted a visual survey to record medium or high severity level pavement distresses in the taxiway and shoulder pavements. Except for the connector taxiway to the Signature Ramp, all taxiways are Portland cement concrete (PCC) surfaced. Based on the results, the existing pavements were identified with a minimal amount of structural or functional related medium and high severity distresses. It was reported that certain locations of Taxiway A and associated connector taxiways had subgrade ‘pumping’ related concerns. RDM’s survey identified minor faulting in isolated locations and pumping was not witnessed. The condition of the shoulder pavements recorded a wide spread of medium to high severity distresses. The distribution of the witnessed distresses can be found on the maps in Appendix A.

Non-Destructive Tests (NDT) were performed on the pavements in the project limits during the distress survey. Taxiway A pavements are basically composed of 3 each, 25 feet wide PCC slabs across the taxiway width. NDT was performed on the 3 lanes with each lane consisting of one column of slabs. A total of 122 center slab tests and 95 joint tests were conducted for Taxiway A. NDT field data can be found in Appendix B. The Impulse Stiffness Modulus (ISM) in kips/in. was evaluated and indicated variation in the overall pavement strength over the length of Taxiway A. The ISM results were mapped and can be reviewed in Appendix C.

NDT data was analyzed to evaluate the elastic moduli of the pavement materials and subgrade soils. The pavement structures used for the NDT data analysis were based on 22 pavement cores conducted in the project limits. It was indicated that subgrade *k*-values varied from 130 psi/in. to 177 psi/in. Taxiway A pavements near the intersection with Taxiway B were identified as weaker than other areas.

The load transfer efficiency was evaluated using the NDT data conducted at the slab joints. The load transfer efficiency, especially in the center lane, is poor and may be completely lost based on the data. This appears to be the primary cause of faulting and reported pumping within the designated areas. The load carrying capacity will be significantly impacted.

The geotechnical investigation results were provided by K.S. Ware & Associates, L.L.C. (KSWA) based on 14 borings and 8 cores. The PCC thickness is generally consistent ranging from 16 to 21.5 inches with majority around 18 inches. The base was shown to be thin asphalt concrete (AC) on top of cement stabilized material. The AC base thickness varies from 2.5 to 5 inches and the cemented base material varies from 2 inches to 8.5 inches. The combined thicknesses of the AC and soil cement vary from 5 to 12 inches. The existing PCC pavement may be normalized as 18 inches of PCC on 8 inches of stabilized base. The AC pavement of the taxiway to the Signature Ramp is nominally 22 inches of AC.

Subgrade soils were indicated to be lean clay or lean clay fill classified as CL according to the Unified Soil Classification System (USCS). The N-values in blow counts per foot from the Standard Penetration Test (SPT) for the upper portion of the subgrade generally vary from 5 to 14 blows/ft., indicating relatively weak subgrade strength.

KSWA conducted 3 laboratory CBR tests on CL soil samples and the CBR values are 6.0%, 7.0%, and 9.5%, respectively. KSWA recommended that design subgrade CBR and *k*-value are 7% and 150 psi/in. when compacted to 98% modified proctor. The test and recommended subgrade strengths appear to be consistent with the back-calculated results with *k*-values ranging from 130 psi/in. to 177 psi/in.

A&H provided future aircraft fleet mix for the pavement design. The taxiways in the project limits are the primary routes for the heavy cargo aircraft traffic. It is expected to have 7,784 annual departures from the B777F. The connector taxiway to the Signature Ramp is required for 1,200 annual departures of the B757 aircraft.

Structural conditions of the existing pavements were analyzed based on remaining structural life. The Federal Aviation Administration (FAA) design procedures in Advisory Circular 150/5320-6F, "*Airport Pavement Design and Evaluation*", were followed using the FAARFIELD (v. 1.42) computer software. The existing PCC pavements are not structurally adequate for the future cargo traffic due primarily to the poor load transfer efficiency even though condition survey identified a current surface with minimal medium and high severity level distresses. Therefore, reconstruction is justified.

The PCC pavement was designed to be consistent with the previously designed and constructed Taxiway A East. The required PCC thicknesses were computed for the base system consisting of 4-inch asphalt treated permeable base (ATPB) on 8-inch cement treated base (CTB). A 12-inch cement treated subgrade layer was considered as the subgrade improvement measure. The designs were performed with variations of design inputs, including the variation of ATPB elastic modulus, cement treated soils, and the strength of the native subgrade soils. Standard construction materials in the Advisory Circular, AC150/5370-10H, "Standard Specifications for Construction of Airports," were considered for the design. The ATPB is not a standard FAA material and the specification should be developed to establish a modification to standard for the project. The following section is recommended.

19.0" P-501/4" ATPB/8" P-304/12" P-301 or P-156

For the connector taxiway to the Signature Ramp, the AC pavement has been designed for 1,200 annual departures of the B757 aircraft. The following section is recommended.

9" P-401/6" P-219/12" P-156

The shoulder pavement was designed for 15 passes of the B777F aircraft over the 20-year design period. The following sections is recommended.

4" P-403/12" P-219/12" P-156, or

5" P-403/10" P-219/12" P-156

The PCC slab joint spacing is requested to be 25 feet based on past performance history. Prior projects at MEM with thick PCC design thicknesses have been approved for the larger slab sizes. This is not consistent with the recommended maximum joint spacing by the FAA and a modification to standard (MOS) should be prepared and approved by the FAA. All joints should be doweled to provide adequate load transfer. Reinforcements should be provided for irregular slabs and slabs out of maximum aspect ratio of 1.25.

At the transition between the PCC and AC pavements and the PCC pavement and the shoulders, the details can be different from the provided design sections. The variation depends on the arrangement of the underdrains and the construction efficiency. RDM will provide further review when the plans are developed.

SECTION 1.0

INTRODUCTION

SECTION 1.0 INTRODUCTION

RDM International, Inc. (RDM) was retained by Allen & Hoshall, Inc. (A&H) to perform pavement evaluation and design services for the reconstruction of Taxiway A West pavements at Memphis International Airport (MEM), Memphis, Tennessee. The primary objective of this report is to provide A&H reconstruction designs based on the functional and structural evaluations of the existing pavement structures and future heavy cargo traffic.

Taxiway A West portion is approximately 4,200 feet between Taxiway N and Taxiway B. Taxiway C and Taxiway S cross Taxiway A within the proposed limits. Portions of these crossing taxiways are included in this project. An unnamed taxiway between Taxiway N and Taxiway C leading to the Signature Ramp was also included in this project.

The technical approach to the rehabilitation study consists of the following basic elements:

- **Distress Survey** – to inspect, locate, and quantify the medium to high severity pavement distresses shown on the pavement surface.

- **Nondestructive Testing** – to obtain data on the strength of the existing pavement layers and subgrade.

- **Review of Geotechnical Data** – to review the geotechnical investigation results for the existing pavement areas regarding pavement materials, layer thickness, and subgrade strengths.

- **Traffic Analysis** – to establish pavement design traffic for the pavement areas in the project limits based on data provided by A&H.

- **Pavement Evaluation and Design** – to evaluate the structural condition of the existing pavements and provide new pavement design section.

All analytical procedures utilized for this study conform to the Federal Aviation Administration (FAA) criteria for airfield pavement design. The observations, comments, and recommendations contained in this report have been prepared for the exclusive use of A&H for this project in accordance with generally accepted engineering practice. No other warranty is expressed or implied.

Performance of any engineering investigation is subject to many qualifications inherent to the practice of that profession and to the accuracy of data obtained. Although a reasonable effort was made to interpret data and correctly depict existing conditions, variations could exist between tested locations, and the historical documents provided by others that could contain discrepancies.

SECTION 2.0

DISTRESS SURVEY

SECTION 2.0 DISTRESS SURVEY

From April 29 to 30, 2019, RDM personnel conducted a visual survey of the distresses on the pavements within the project limit. This involved recording all the distresses in medium to high severities over the entire paved areas, including the shoulders. The specific objectives are:

- To identify the medium or high severity distress types on the pavement surface.
- To locate and map the distresses on the pavement surface.
- To quantify the recorded distresses for the establishment of rehabilitation measures in conjunction with structural evaluation results.

2.1 PROCEDURES

Using procedures detailed in FAA Advisory Circular 150/5380-7B, "*Airport Pavement Management Program (PMP)"* and Advisory Circular 150/5320-17A, "*Airfield Pavement Surface Evaluation and Rating Manuals."* a project level, detailed condition survey for the medium and high severities distresses was performed by RDM personnel.

The survey consisted of a project level visual inspection of the pavement surfaces for signs of pavement distresses resulting from the influence of aircraft traffic, the environment, pavement materials or construction deficiencies. The visual inspection survey included recording all medium and high severities distresses on the pavements included in the project scope. Hand-held GPS data collectors were utilized to record the location, quantity, and severity of each distress. Detailed maps showing the locations of all recorded distresses are included in Appendix A.

2.2 SURVEY RESULTS

Taxiway A and the crossing taxiways are Portland cement concrete (PCC) surfaced. The taxiway leading to the Signature Ramp is asphalt concrete (AC) overlaid PCC pavement. All the shoulders are AC surfaced. The slab counts with the identified medium or high severity distresses are shown in Table 2-1. As shown, three (3) slabs were recorded with load related medium severity cracking.

As shown on the distress maps, the cracked slabs are not on Taxiway A but on the crossing taxiways. The distresses appear to be concentrated within the three intersections with Taxiways B, C, and S. It is reported that pumping has also been an issue for this portion of Taxiway A. Pumping was not witnessed during RDM's survey, however, medium severity faulting was witnessed in the Taxiway S intersection north of Taxiway A. Faulting and pumping distresses are generally related with loss of support within the unbound pavement layers or subgrade. When the subbase is granular material, pumping is easier to be noticed. Repetitive pumping/faulting will cause the loss of the joint load transfer and lead to cracking and spalling of the slabs. Although pumping/faulting are not widely present visually, they may still exist and affect the load carrying capacity of the PCC slabs due to loss of joint load transfer.

The AC surfaced shoulders and the taxiway to the Signature Ramp were indicated to have widespread cracking. The severity and the density of the cracks indicate that a global maintenance should be provided.

TABLE 2-1 DISTRES SURVEY RESULTS

Distress	Severity	Slab Count
Corner Spall	High	5
Corner Spall	Medium	9
Joint Spall	Medium	12
Small Patch	High	1
Small Patch	Medium	6
Crack	Medium	3
Fault	Medium	2

2.3 REPAIR AND REHABILITATION

Based on the survey results, the PCC pavements are in good condition. The observed distresses can be addresses with typical repair methods such as partial depth patching and crack sealing. Major rehabilitation may not be necessary if the aircraft traffic will not change in terms of operating weights and frequencies.

The AC surfaced pavements, shoulders and the taxiway to the Signature Ramp were shown to have a high density of distresses. The AC surface materials can be milled and replaced to effectively rehabilitation the areas.

The structural condition of the existing pavement will be evaluated for load carrying capability using the forecasted traffic. Given potential grade constraints or expansion of the proposed project footprint, reconstruction is usually needed for the existing PCC pavement structure in need of strengthening.

SECTION 3.0

NONDESTRUCTIVE TESTING

SECTION 3.0 NONDESTRUCTIVE TESTING

On April 29, 2019, RDM performed nondestructive tests (NDT) in the pavement areas within the project limits. The primary purpose of the NDT is to measure the structural properties of the pavement systems. The load response data resulting from the dynamic force simulates the effect of moving aircraft loads. These data can be used as reliable input for structural analysis utilizing elastic theory for pavement design and evaluation. Additional advantages of NDT include:

- Minimal interference with airport operations.
- Measurement of in-situ structural response.
- Rapid data acquisition, and
- Low unit testing and data processing costs.

Normally, about 50 NDTs can be performed for an approximate cost equivalent to one (1) California Bearing Ratio (CBR) test. The NDT equipment used for the testing program is designed to generate a dynamic load on the pavement surface and measure the resultant vertical response of the pavement system, including subgrade, base courses, and surface layers. The equipment's microcomputer allows rapid data processing in the field. Therefore, NDT results can be directly referenced to field conditions, improving the reliability and speed of data acquisition. A primary value of NDT is the ability to economically evaluate much broader areas of pavement in a short time to better define variability in pavement strength.

NDT equipment, test procedures, and data reduction methods conformed to the requirements of FAA Advisory Circular 150/5370-11B, "*Use of Nondestructive Testing Device in the Evaluation of Airport Pavement*".

3.1 NDT PROCEDURES

To provide a meaningful database for evaluation, the following NDT sequences were utilized:

- Deflection Basin
- Impulse Stiffness Modulus (ISM)
- Load Transfer Efficiency

All tests were conducted under an impulse, (i.e., Falling Weight Deflectometer (FWD)) type forcing function, at a nominal amplitude of approximately 40,000 lbs.

3.1.1 DEFLECTION BASIN

This test method involves measuring deflections at the center of the machine loading plate and at fixed distances from the center. After the pavement thickness and composition are established, back-calculation procedures can be used to reduce the NDT data for structural evaluation purposes.

The PCC taxiway pavements are basically composed of 3 slabs across the taxiway width. The slab is 25 feet wide and 25 feet long. NDT was performed on 3 lanes with each lane consisting of one column of slabs. For the crossing taxiways, NDTs were primarily conducted on the center two slabs across the centerline.

NDTs were conducted in the center of the slabs and on transverse joints of the slabs with staggered spacing. For each lane, testing was conducted at 100 feet longitudinal spacing, i.e. every 4 slabs interval. A total of 122 center slab tests and 95 joint tests were conducted for Taxiway A. A total of 83 tests, including center and joint tests, were conducted for the crossing taxiways. NDT field data can be found in Appendix B.

The U.S. Army Corps of Engineers' (Report FAA RD-80-9) and subsequent FAA research found the back-calculated subgrade strength parameters from NDT to be a reliable estimate of in-situ subgrade strength. Sensitivity analyses also found the back-calculate subgrade strengths to be relatively insensitive to minor variations in base course and surface course moduli or thicknesses. Therefore, the subgrade strength from NDT is believed to be a reasonably accurate representation of in-situ subgrade strength.

For the PCC pavements, the closed-form back-calculation procedures can be used to process the NDT data. The closed-form procedures use the AREA method to compute the modulus of subgrade reaction (*k*-value) and elastic moduli (E) of Portland cement concrete (PCC) and base layers. This method is based on the unique relationship that exists between the normalized area under the deflection basin (i.e., AREA) and the radius of relative stiffness (ℓ) of the concrete slab. Once ℓ is computed from AREA, computation of k and E is a straightforward process.

For flexible pavements, layered elastic back-calculation procedures can be used to process the deflection basin data to compute the elastic moduli (*E*) of pavement layers and subgrade that provide best fit between the measured and computed deflection basins. The computer program developed by the FAA, BAKFAA, can be used for the back-calculation.

3.1.2 IMPULSE STIFFNESS MODULUS (ISM)

The ISM test procedure is defined as dynamic force divided by the pavement deflection measured at the loading plate. As such, it is a measure of overall support conditions from all influencing pavement and subgrade layers. For this study, the ISM data were used to find variation of overall pavement strength in the tested areas.

3.1.3 LOAD TRANSFER EFFICIENCY

As described in FAA Report DOT/FAA PM-83/22, *"Investigation of the FAA Overlay Design Procedures for Rigid Pavements"*, load transfer at Portland cement concrete (PCC) slab joints was also evaluated using the deflection ratio, defined as:

$$Deflection\ Ratio = \frac{Deflection - unloaded - side}{Deflection - loaded - side}$$

The deflection ratio is used in the elastic structural analysis computation to compute a load reduction factor that is used in determining allowable aircraft loading and rehabilitation requirements for existing pavements. From FAA Report DOT/FAA PM-83/22, it can be implied that a deflection ratio greater than 0.72 indicates adequate load transfer consistent with the FAA's design assumption of 25% load transfer between concrete slabs.

3.2 EQUIPMENT REQUIREMENTS

RDM's Heavy Falling Weight Deflectometer (HWD) was used for the testing program. The machine meets the requirements of FAA Advisory Circular 150/5370-11B and can perform deflection basin and ISM test sequences. The HWD has a dynamic force range of from 6,000 lbs. to 50,000 lbs. and utilizes seven (7) sensors to record pavement response (deflection). For this study, the tests were conducted at nominal force amplitude of approximately 40,000 lbs.

3.3 DATA ANALYSIS

The primary purpose of the NDT program was to develop inputs on the strength of pavement and subgrade layers for structural analysis. For the layered elastic design procedures used for the pavement analysis, the primary characteristic is the elastic modulus (*E*), or *k*-value value for rigid pavement structure, of the subgrade.

3.3.1 OVERALL PAVEMENT STRENGTHS

The deflections at the loading plate from NDT are attributed to the deformation from pavement structures, including all pavement layers and subgrade, from the applied loads. Therefore, the measured deflections at the loading plate can be qualitatively related to the overall pavement strength. The higher the ISM value, the stronger the overall pavement strength. Based on the definition of the ISM, it can be used to qualitatively evaluate the overall pavement strength from all layers and subgrade.

The ISM values were computed at each test location. The variation of the ISM values along Taxiway A can be seen on the ISM plot in the attachments. The computed ISM values were also mapped over the aerial image for Taxiway A. The ISM values were treated as elevation points in Autodesk's Civil 3D program and a 2D surface was created. The 2D surface depicts the distributions of the ISM values in a color-coded format and can be seen in the exhibit in Appendix B.

As shown on the ISM plot, the ISM values generally are consistent between the three lanes. The ISM values generally vary around 9,000 kips/in. for the first 3,500 feet (from Taxiway N to the west of Taxiway B). At the intersection area with Taxiway B, the ISM values decreased compared to the preceding section.

The ISM values were separated into 5 ranges and mapped accordingly. As shown on the exhibit, the majority of Taxiway A has ISM values greater than 9,194 kips/in. The lowest range of values is from 4,014 kips/in to 7,898 kips/in. and is predominantly located in the Taxiway B intersection area.

The ISM values for the PCC pavements are generally related to the PCC slab thickness and subgrade support condition. Based on the boring data, the thickness of the PCC is nominally 18 to 19 inches consistently over this section of Taxiway A. Given the PCC thickness and surface condition is relatively consistent throughout the length of the project, the low ISM ranges may be attributed to the subgrade support condition.

Extremely low ISM values were excluded from the ISM plot and the map for Taxiway A. At these locations, high deflections at the loading plate were measured resulting in the low ISM values. The deflections at the sensors away from the loading plate dropped rapidly. This implies that voids may be present below the surface and may be the result of the subgrade fines pumping through the joints during seasonal changes or wet / inclement weather. Similar measurements were also obtained in the connector taxiways.

3.3.2 LOAD TRANSFER EFFICIENCY

The load transfer efficiency was evaluated using the deflection data from the slab joint tests. The deflection ratio between unloaded side and loaded side across the joint was computed. When the deflection ratio is greater than 0.72, the load transfer can be considered efficient to meet the design assumption according to the research.

The deflection ratio from the three test lanes of Taxiway A was computed and plotted against the NDT station. As can be seen in Appendix B, the load transfer efficiency in the center lane changes from efficient (>0.72) to potentially loss of load transfer (<0.40) condition. Given the deflection ratio was computed to be less than 0.30 along the center slabs within Taxiway A, a complete loss of the load transfer between slabs is possible. Similar results were also obtained in Taxiway B, C, and S intersection.

The 3-slab width layout means that the center slab lane experiences the majority of the aircraft load repetitions. The reported pumping issue generally results in a loss of support at the joints. The low deflection ratio was recorded in the project limits, indicating inadequate or loss of load transfer. Load carrying capacity may be reduced in these areas.

3.3.3 BACK-CALCULATION RESULTS

The NDT data were analyzed using the closed-form back-calculation procedures. Subgrade *k*-values were evaluated from the back-calculation as well as the elastic moduli of the PCC and the base. A nominal pavement structure, 18” PCC/8” combined AC and soil cement base, was used for the back-calculation. Some of the connector taxiway sections (Taxiway B and Taxiway C) were identified with abnormal deflection basins which is consistent with the faulting/pumping. Given the limited test data collected, these areas were not evaluated for back-calculation. The evaluation results for Taxiway A and connector taxiways are shown in Table 3-1.

The average elastic moduli of the PCC range from 5,472,000 psi to 6,953,000 psi that are typical for the PCC materials constructed using the FAA’s P-501 specification. The equivalent elastic moduli of the combined AC and soil cement base is generally close to one million psi which is also typical for cement stabilized material constructed using the FAA’s P-304 specification.

Subgrade *k*-values were directly obtained from the closed-form back-calculation procedures. The design *k*-values were computed by subtracting one standard deviation (Std. Dev.) from the average in accordance with the FAA’s design procedures. The design *k*-values vary from 130 psi/in. to 177 psi/in.

The taxiway to the Signature Ramp is nominally 22 inches AC on what is assumed to be soil cement subgrade, based on geotechnical investigation. The effective subgrade elastic modulus was estimated based on limited NDT data in this taxiway. Subgrade design *k*-value was estimated to be approximately 170 psi/in.

Based on the coefficient of variation (C.O.V.), subgrade support condition has higher variation in the center slabs of Taxiway A. This seems to be consistent with the evaluation of the joint load transfer efficiency where presence of voids has been implied.

The design subgrade strength will be further evaluated with the geotechnical investigation results to be discussed in Section 4.0.

TABLE 3-1 BACK-CALCULATION SUMMARY

NDT Station		Elastic Modulus, psi		Subgrade *k* -value, psi/in.			
From	**To**	**PCC**	**Base**	**Average**	**Std. Dev.**	**C.O.V.**	**Desgin**
TW A, 0+00 at TW N							
Left Lane							
0+00	31+77	6,309,000	946,400	176	27	15%	149
32+13	41+15	5,085,000	762,700	175	19	11%	156
Center Lane							
0+00	35+65	5,472,000	820,800	220	51	23%	169
35+82	40+64	5,674,000	851,100	143	13	9%	130
Right Lane							
0+00	37+39	6,079,000	911,800	169	32	19%	137
TW B, North of TW A							
		6,953,000	1,043,000	189	45	24%	144
TW C, South of TW A							
		5,891,000	883,600	226	49	22%	177
TW S, North of TW A							
		5,559,000	833,900	225	59	26%	166
TW S, South of TW A							
		6,098,000	914,700	198	49	25%	149

SECTION 4.0

GEOTECHNICAL INVESTIGATION

SECTION 4.0 GEOTECHNICAL INVESTIGATION

A geotechnical investigation was performed by K.S. Ware & Associates, L.L.C. (KSWA). A total of 14 borings and 8 cores were conducted in the project limits to obtain information on pavement structures and subgrade soils. KSWA's report was provided for reference.

Table 4-1 shows the pavement materials and layer thicknesses from the cores and borings. The cores and borings were listed approximately in the order from Taxiway N to Taxiway B along Taxiway A. Core C-2 and boring B-13 are on the taxiway to the Signature Ramp. Boring B-14 is in Taxiway C south of Taxiway A. Boring B-16 is in Taxiway B south of Taxiway A.

As shown, the PCC thickness is generally consistent ranging from 16 to 21.5 inches with majority around 18 inches. The AC base thickness varies from 2.5 to 5 inches. Cemented base material was identified in the borings with a wide range of thicknesses from 2 inches to 8.5 inches. This layer may have been used as a means of subgrade improvement like soil cement. The combined thicknesses of the AC and soil cement vary from 5 to 12 inches. At the core locations, the soil cement was not extracted. The existing PCC pavement may be normalized as 18 inches of PCC on 8 inches of stabilized base. The AC pavement of the taxiway to the Signature Ramp is nominally 22 inches of AC. KSWA indicated that soil cement may also be present in this taxiway.

Subgrade soils were indicated to be lean clay or lean clay fill classified as CL according to the Unified Soil Classification System (USCS). The N-values in blow counts per foot from the Standard Penetration Test (SPT) for the upper portion of the subgrade generally vary from 5 to 14 blows/ft., indicating relatively weak subgrade strength.

KSWA conducted 3 laboratory CBR tests on CL soil samples and the CBR values are 6.0%, 7.0%, and 9.5%, respectively. KSWA recommended that design subgrade CBR and *k*-value are 7% and 150 psi/in. when compacted to 98% modified proctor. The test and recommended subgrade strengths appear to be consistent with the back-calculated results with *k*-values ranging from 130 psi/in. to 177 psi/in.

KSWA indicated that the CL soils at the site are sensitive to the moisture contents. Stabilization may be necessary to expedite the construction.

TABLE 4-1 BORING RESULTS SUMMARY

Core/Boring	Thickness, in.		
No.	**PCC**	**AC**	**Soil Cement**
C-1	18.0	4.0	n/a
B-1	18.5	3.5	4.0
B-2	18.0	4.0	4.0
B-3	18.0	5.0	3.0
B-4	18.0	4.0	4.0
B-5	18.0	4.5	3.5
B-6	20.5	3.5	2.0
C-4	18.0	n/a	n/a
B-8	17.5	2.5	6.0
C-9	17.5	2.5	n/a
B-9	16.0	3.0	7.0
C-8	21.5	n/a	n/a
C-10	18.0	3.0	n/a
B-10	18.0	3.5	8.5
B-11	17.5	3.5	8.0
C-13	19.0	2.5	n/a
B-12	17.5	3.0	5.5
C-2	n/a	22.0	n/a
B-13	n/a	22.0	
B-14	18.0	3.0	3.0
C-7	18.0	2.5	n/a
B-16	19.0	3.0	2.0

SECTION 5.0

DESIGN TRAFFIC

SECTION 5.0 DESIGN TRAFFIC

According to A&H, Taxiway A is primarily used by the cargo aircraft. Taxiway A was assumed to have 40% of total airport cargo traffic. The fleet mix and the annual departures were provided in Table 5-1 for Taxiway A pavement design.

As shown, Taxiway A is expected to have 7,784 annual departures from the B777F. At the indicated departure weights, the B777F can have controlling impact on the pavement thickness requirements.

According to A&H, the existing connector taxiway to the Signature Apron will be demolished and a new taxiway will be constructed on a realigned location. It is requested that the new pavement in the connector be designed for 1,200 annual departures of the B757 aircraft.

TABLE 5-1 TAXIWAY A WEST DESIGN TRAFFIC

FedEx	Departure	20 years Total		Annual
Cargo Aircraft	**Weight, lbs.**	**Airport**	**TW A**	**TW A**
A300-600	380,518	133,287	53,315	2,666
A310-2CF	315,041	8,723	3,489	174
ATR-72	50,706	34,028	13,611	681
B757-200 Cargo	256,000	757,105	302,842	15,142
B767-3	413,000	1,948,215	779,286	38,964
B777F	768,800	389,218	155,687	7,784
DC-10-10	458,000	97,066	38,826	1,941
MD-11	633,000	107,802	43,121	2,156

SECTION 6.0

STRUCTURAL ANALYSIS METHODS

SECTION 6.0 STRUCTURAL ANALYSIS METHODS

The FAA's Advisory Circular, AC 150/5320-6F, "*Airport Pavement Design and Evaluation,*" was followed for this project. The associated computer program, FAARFIELD (v. 1.42), was used for the computations.

6.1 MECHANISTIC DESIGN CONCEPT

The FAA design methods employ fundamental mechanistic theory to compute load induced pavement responses based on the engineering properties of the pavement materials and subgrade, i.e., elastic modulus and Poisson ratio. FAA's FAARFIELD program uses layered elastic theory for flexible pavement response calculations and 3-dimensional (3-D) methods to compute rigid pavement response.

For flexible pavement, two (2) failure modes, rutting and surface fatigue cracking, are considered to be critical to performance. Rutting is related to the vertical compressive strain at the top of the subgrade, while fatigue cracking is related to the tensile strain at the bottom of the asphalt concrete layer. For the rigid pavement system, the failure criterion is the PCC fatigue cracking related to the tensile stress at the bottom of the PCC slab, and computed at the edge of the slab. Mechanistic stress and strain criteria are contained in FAA Research Reports RD-74-199, "*Development of a Structural Design Procedure for Flexible Airport Pavements*", and RD-77-81, "*Development of a Structural Design Procedure for Rigid Airport Pavements*".

Modifications to the failure criteria and computational models have been made in recent years as results from the research programs conducted at the FAA's National Airport Pavement Test Facility (NAPTF) became available. These modifications have been incorporated in the recently updated Advisory Circular and the FAARFIELD program.

FAARFIELD utilizes a cumulative damage model, whereby the structural damage is computed for each aircraft and summed until the terminal condition is reached when the cumulative damage factor (CDF) is equal to 1.0. This concept essentially eliminates the need for the critical design aircraft as required in prior conventional design procedure.

6.2 EVALUATION INPUTS

For proper execution of FAA’s design procedures, the following user inputs are required:

- Subgrade support in terms of elastic modulus (*E*) or CBR/*k*-value.
- Construction materials and properties.
- Traffic and design life.

Based on the discussions in Section 3.0 and Section 4.0, subgrade design *k*-values from NDT back-calculation and geotechnical investigations are consistent. Sensitivity analysis will be performed based on the range of the *k*-values. The structural evaluation is based on a 20-year design life based on the FAA’s design procedures.

SECTION 7.0

EVALUATION AND REHABILITATION

SECTION 7.0 EVALUATION AND REHABILITATION

Based on the condition survey results in Section 2.0, minimal structural related distresses were recorded during the visual inspection. When the existing pavement can provide more than 10 years of structural life, strengthening is not necessary unless future traffic requires.

However, the observed faulting and reported pumping issues will affect future pavement performance. The NDT analysis also indicated a loss of joint load transfer in the trafficked PCC center lane of Taxiway A. The load carrying capacity would be reduced based on the observations and the test data. Major rehabilitation such as reconstruction is the primary way to address concerns relating to pavement strength and the subgrade support.

7.1 REMAINING STRUCTURAL LIFE

The existing pavement structure of Taxiway A is nominally 18 inches of PCC on 8 inches of combined stabilized materials consisting of AC and soil cement. The structural life was estimated for the future traffic using FAARFIELD. Assuming subgrade *k*-value of 150 psi/in. based on NDT and geotechnical investigation, the remaining structural life is less than 15 years for concrete flexural strength of 750 psi, if the current pavement provides adequate load transfer between joints. For slabs with loss of load transfer, the structural life will be less than 3 years for future heavy cargo traffic. Therefore, rehabilitation is necessary for Taxiway A.

7.2 PAVEMENT RECONSTRUCTION MATERIALS

The west section rehabilitation of Taxiway A should be consistent with the previously designed and constructed east section of PCC pavement. Therefore, the PCC pavement structure was evaluated for future traffic. For the connector taxiway to the Signature Ramp and taxiway shoulders, the AC pavement structure was evaluated. Standard construction materials conforming to the FAA's specifications prescribed in the Advisory Circular, AC150/5370-10H, "Standard Specifications for Construction of Airports," were considered for the following design materials.

P-501 – Cement Concrete Pavement

P-401 – Asphalt Mix Pavement

P-403 – Asphalt Mix Pavement Surface

P-304 - Cement Treated Aggregate Base Course (CTB)

P-220 (Previously P-301) – Cement Treated Soil Base Course

P-219 – Recycled Concrete Aggregate Base Course

P-156 – Cement Treated Subgrade

The P-401 should be used for AC pavement in the taxiway to the Signature Ramp. The P-403 can be used for the shoulders.

The east section of Taxiway A utilized a 4-inch asphalt treated permeable base (ATPB) underneath the PCC surface for drainage on top of an 8-inch P-304. It is noted that the ATPB is not a standard FAA material and would require that the airport secure a modification to standard for the proposed specification.

The elastic modulus of the ATPB may vary. Two values were considered for sensitivity analysis, i.e., 100,000 psi and 150,000 psi.

The P-220 (previously P-301) is a stabilized base while the P-156 is a subgrade treatment material. The elastic modulus of the P-220 is 250,000 psi. However, the elastic modulus of the P-156 is generally less stiff than the P-220. A conservative elastic modulus of 30,000 psi was assumed for the P-156 as a user defined layer in FAARFIELD.

The design flexural strength of the PCC is assumed to be 685 psi. Assuming 5% gain in strength, the mix design can be developed for 650 psi at 28 days.

7.3 PCC PAVEMENT THICKNESS DESIGN RESULTS

Using the base system consisting of 4” ATPB/8” P-304/12” P-220 or P-156, the required PCC thicknesses were computed using FAARFIELD. Based on the NDT and geotechnical investigation, the strength values of the native subgrade soils were considered to be 130 psi/in. and 150 psi/in. An effective subgrade model was also considered using an effective *k*-value of 200 psi/in. on top of the 12-inch soil cement or cement treatment subgrade. Table 6-1 presents the computed and rounded PCC thicknesses for the different design inputs. The rounded thicknesses are the results to the nearest half of an inch of the computed thicknesses according to the FAA’s design procedures.

As shown, the required PCC thicknesses vary from 18.0 inches to 19.5 inches. The use of the P-220 resulted in 18.5 inches of PCC for the weakest subgrade strength. Based on NDT, the 130 psi/in. subgrade is localized. Most of the existing pavement areas were shown to have a *k*-value greater than 150 psi/in. The geotechnical investigation also recommended 150 psi/in. subgrade strength. Therefore, the results from subgrade *k*-value of 150 psi/in. and effective subgrade model were reasonable. A conservative section consistent with the east section of Taxiway A is recommended as:

19.0” P-501/4” ATPB/8-inch P-304/12” P-301 or P-156

TABLE 6-1 PCC THICKNESS RESULTS

Subgrade	Native Subgrade		Effective Subgrade
Treatment	**130 psi/in.**	**150 psi/in.**	**200 psi/in.**
	Elastic Modulus of 4" ATPB =150,000 psi		
12" P-220 Soild Cement	18.40"=>18.5"	17.90"=>18.0"	18.53"=>19.0"
12" P-156 Cement Treatment	19.41"=>19.5"	18.99"=>19.0"	
	Elastic Modulus of 4" ATPB =100,000 psi		
12" P-156 Cement Treatment	19.48"=>19.5"	19.06"=>19.0"	18.60"=>18.5"

Note: All sections consist of 4” ATPB/8” P-304/12” P-301 or P-156 as the base system for the PCC. The elastic modulus of the P-156 is assumed to be 30,000 psi. The elastic moduli of all other materials are default values in the FAARFIELD.

7.4 AC TAXIWAY PAVEMENT AND SHOULDERS

The AC taxiway was designed for 1,200 annual departures of the B757 aircraft for the connector taxiway to the Signature Ramp. The P-156 cement treatment is considered as subgrade improvement. The effective subgrade CBR on top of the 12-inch P-156 is considered to be 12% and is consistent with the effective subgrade *k*-value of 200 psi/in., resulting in a relatively conservative thickness.

The minimum AC surface and base thickness is 4 inches and 5 inches based on the FAA’s design procedures. The required P-219 thicknesses were computed. The following section may be used:

9” P-401/6” P-219/12” P-156

Based on the FAA’s design procedures, the shoulder pavements should provide adequate support for 15 passes of the most demanding aircraft in the fleet mix over the 20-year design period. The FAARFIELD analysis indicated that the B777 is the most demanding aircraft. For the effective subgrade strength model, the following sections are provided:

4” P-403/12” P-219/12” P-156, or

5” P-403/10” P-219/12” P-156

7.5 CONSTRUCTIBILITY

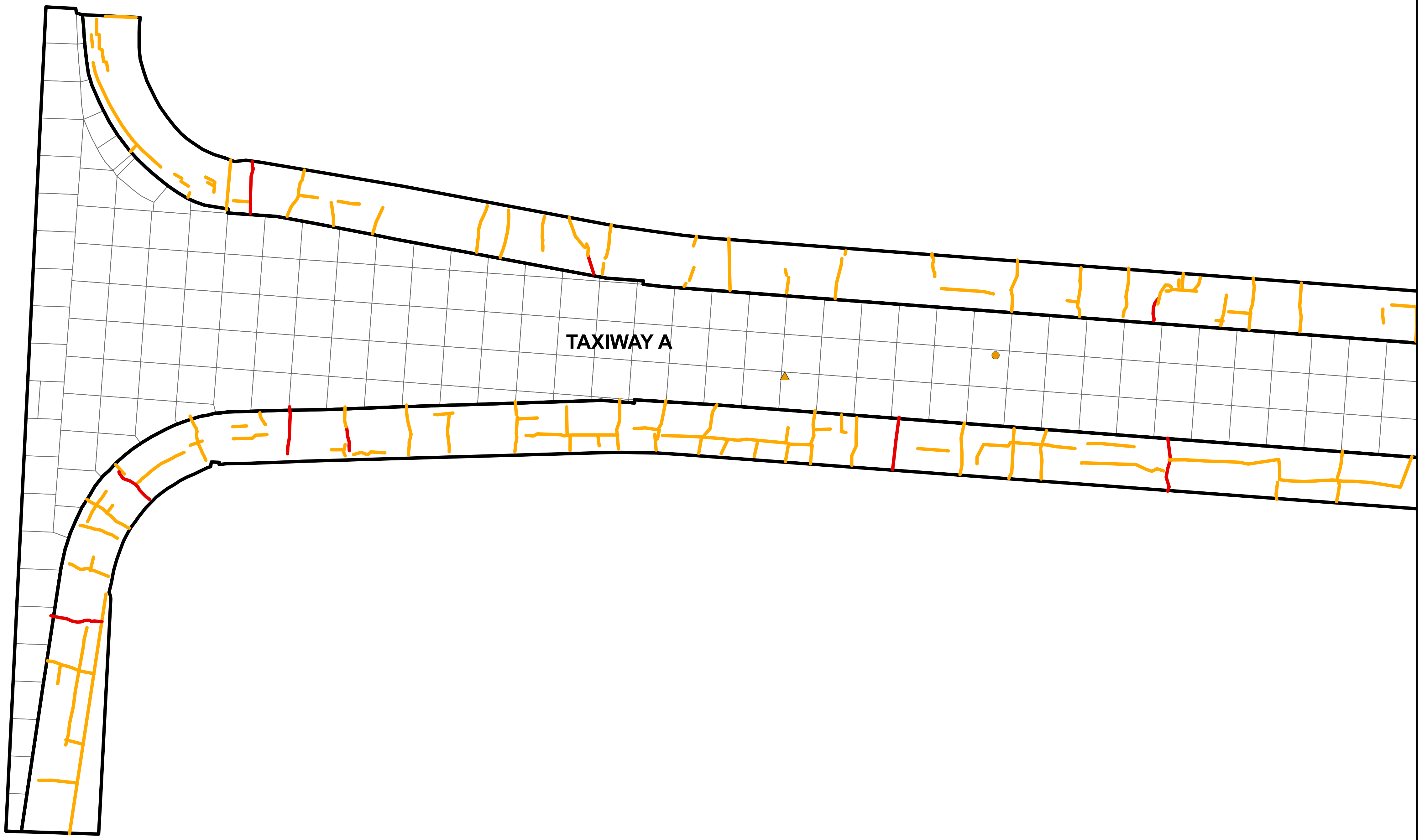
For PCC thicknesses greater than 16 inches, the current FAA's design procedures recommend a maximum joint spacing of 20 feet for PCC slabs supported on a stabilized base. The aspect ratio of the slab should not exceed 1.25. The slab size limitation is provided to minimize the warping and curling stresses that may be incurred by the changes in temperature and moisture within the depth of the slabs.

At MEM, the maximum joint spacing of 25 feet has been used for relatively thick PCC slabs for many years. The survey data provided for a prior project indicated that the 25 feet size slabs performed satisfactorily due to the substantial slab thickness, doweled joints, and high-quality concrete materials provided. If a Modification of Standard (MOS) to use the 25 feet slab size can be approved, the 25-foot joint spacing for the 19-inch thick slabs for this project may be considered. All joints should be doweled to provide adequate load transfer. Reinforcements should be provided for irregular slabs and slabs out of maximum aspect ratio.

At the transition between the PCC and AC pavements and the PCC pavement and the shoulders, the details can be different from the provided design sections. The variation depends on the arrangement of the underdrains and construction efficiencies required for paving set up. RDM will provide further review when the plans are developed.

APPENDIX A

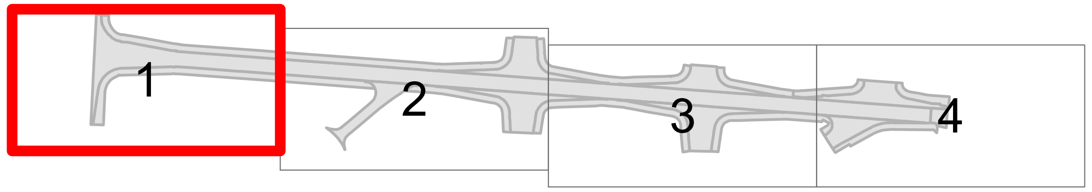
DISTRESS MAPS



Asphalt shoulders exhibit medium weathering

Legend

▭ Sections ▭ Slabs ▲ Corner Spall, H ▲ Corner Spall, M ● Joint Spall, M ■ Small Patch, H ■ Small Patch, M — Crack, M — Crack, H — Fault, H



0 80 160 Feet

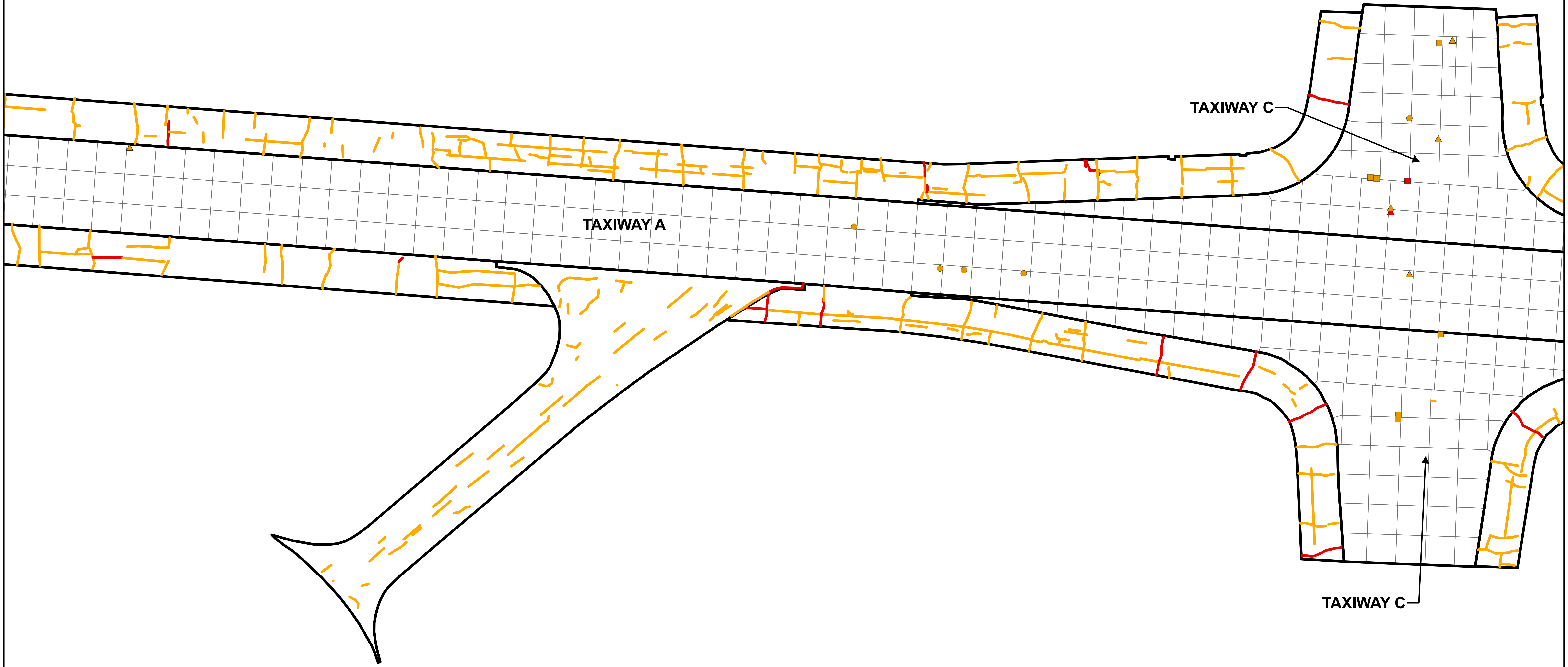
N S W E

Memphis International Airport
TAXIWAY A

DISTRESS MAP (2019)

Engineering Technology Research
RDM INTERNATIONAL INC.
14310 SULLYFIELD CIRCLE, SUITE 600
CHANTILLY, VA 20151

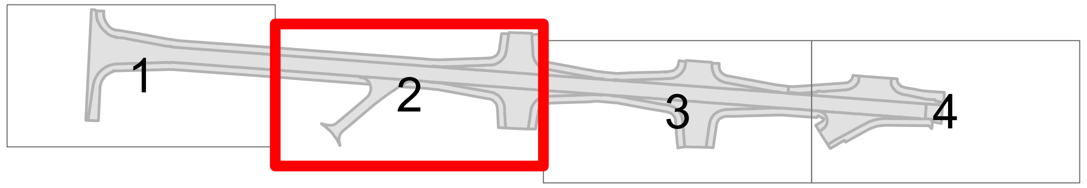
DESIGNED:	RDM-
CHECKED:	
DRAWN:	SHEET NAME
ACCEPTED:	
SUBMITTED:	PAGE
APPROVED:	

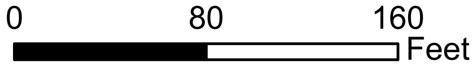


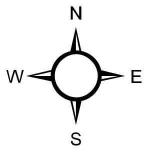
Asphalt shoulders exhibit medium weathering

Legend

▭ Sections ▭ Slabs ▲ Corner Spall, H ▲ Corner Spall, M ● Joint Spall, M ■ Small Patch, H ■ Small Patch, M — Crack, M — Crack, H — Fault, H







Memphis International Airport
TAXIWAY A

DISTRESS MAP (2019)

Engineering Technology Research
RDM INTERNATIONAL INC.
14310 SULLYFIELD CIRCLE, SUITE 600
CHANTILLY, VA 20151

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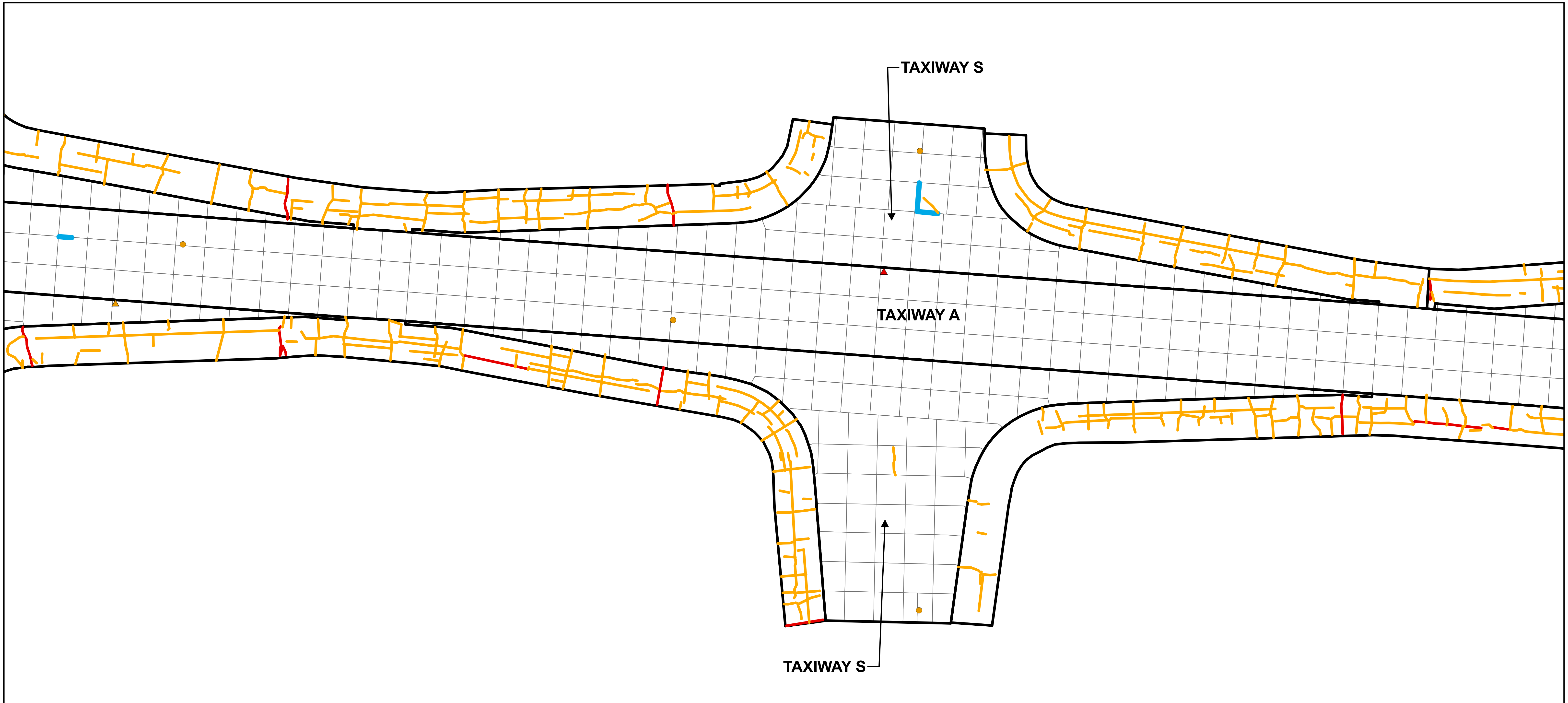
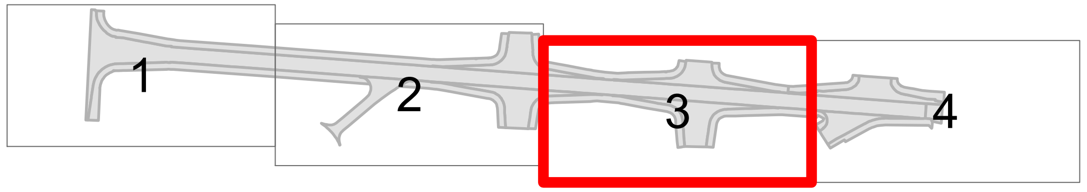
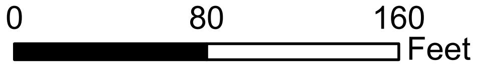


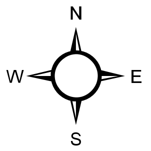
Asphalt shoulders exhibit medium weathering

Legend

▭ Sections ▭ Slabs ▲ Corner Spall, H ▲ Corner Spall, M ● Joint Spall, M ■ Small Patch, H ■ Small Patch, M — Crack, M — Crack, H — Fault, H







Memphis International Airport
TAXIWAY A

DISTRESS MAP (2019)

Engineering Technology Research
RDM INTERNATIONAL INC.
14310 SULLYFIELD CIRCLE, SUITE 600
CHANTILLY, VA 20151

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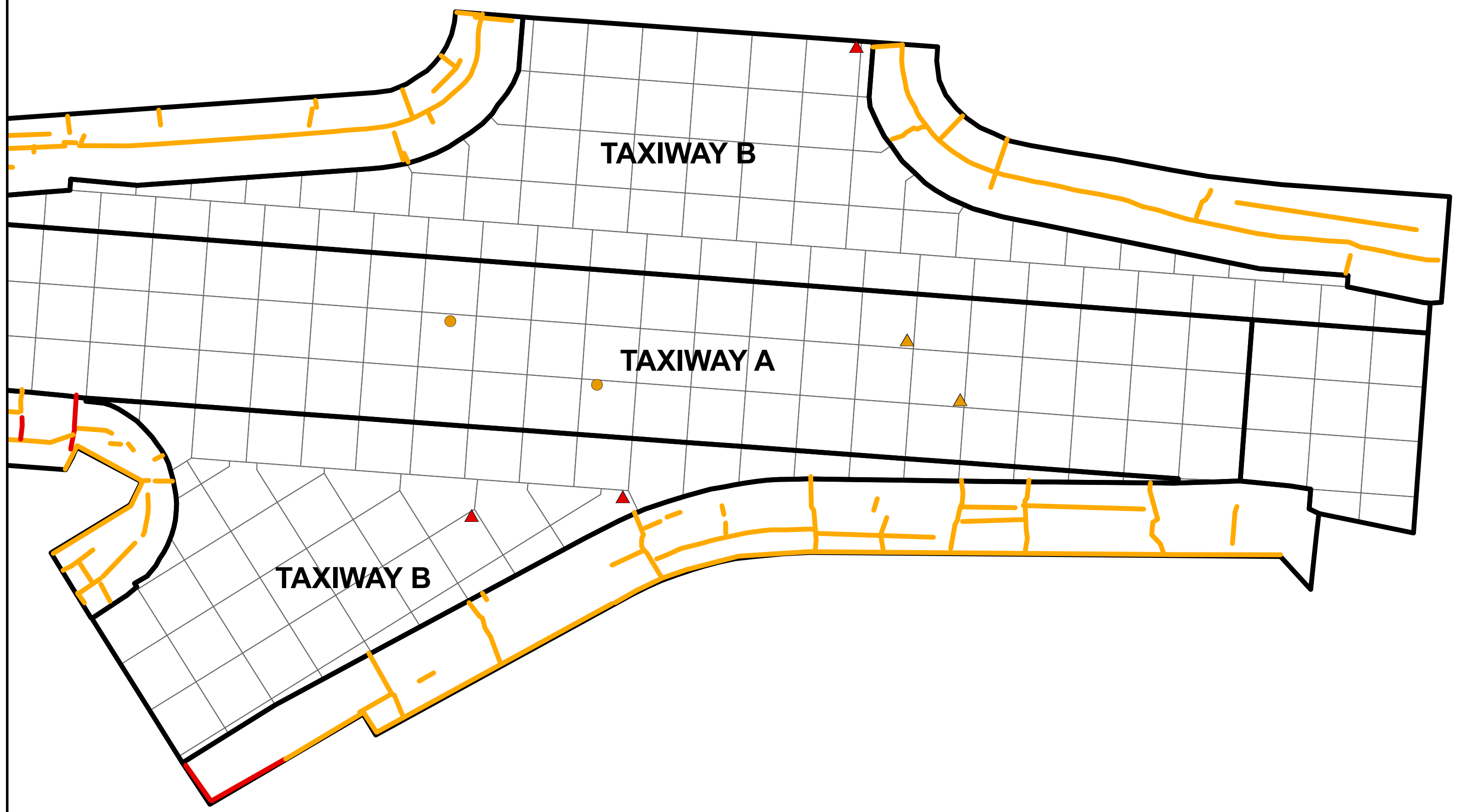
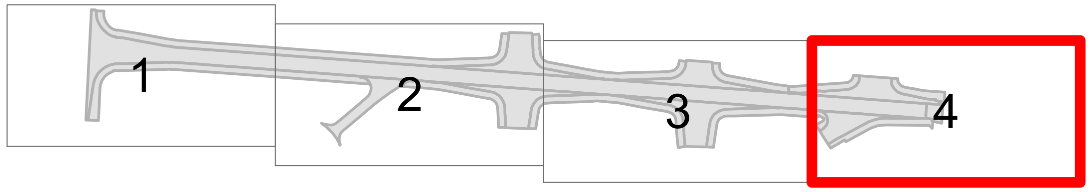


Asphalt shoulders exhibit medium weathering

Legend

☐ Sections ☐ Slabs ▲ Corner Spall, H ▲ Corner Spall, M ● Joint Spall, M ■ Small Patch, H ■ Small Patch, M — Crack, M — Crack, H — Fault, H



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Memphis International Airport
TAXIWAY A

DISTRESS MAP (2019)

Engineering Technology Research
RDM INTERNATIONAL INC.
14310 SULLYFIELD CIRCLE, SUITE 600
CHANTILLY, VA 20151

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APPROVED:

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APPENDIX B

NDT FIELD DATA

Memphis International Airport

Taxiway A West

NDT Field Data

NDT	Lane	NDT Station		Force				Displacement Sensors (mils)				Pvmnt	ISM
No.	No.	Distance	Offset	(kip)	d1 (0)	d2 (8")	d3 (12")	d4 (24")	d5 (36")	d6 (48")	d7 (60")	Temp (F)	(kip/in)
0+00 at edge of Taxiway N													
1	1	11	25' L	40	3.32	3.26	3.12	2.96	2.90	2.61	2.47	67.60	12,033
3	1	113	25' L	40	4.07	4.05	3.94	3.89	3.62	3.15	2.98	72.00	9,818
5	1	216	25' L	40	3.50	3.46	3.31	3.29	2.95	2.61	2.53	71.90	11,418
7	1	315	25' L	40	3.04	3.01	2.91	2.98	2.61	2.26	2.17	70.80	13,159
8	1	415	25' L	40	3.13	3.12	2.95	2.93	2.59	2.35	2.21	72.20	12,785
10	1	515	25' L	40	3.32	3.29	3.07	3.26	2.82	2.45	2.31	72.10	12,033
12	1	615	25' L	40	3.75	3.62	3.63	3.32	3.05	2.78	2.59	71.20	10,669
14	1	714	25' L	40	3.61	3.61	3.64	3.74	3.17	2.75	2.66	71.70	11,091
16	1	817	25' L	40	3.42	3.37	3.24	3.24	2.93	2.60	2.51	73.00	11,711
18	1	914	25' L	40	3.90	3.94	3.89	3.94	3.34	2.96	3.13	71.10	10,244
20	1	1015	25' L	40	4.24	4.16	4.07	3.98	3.38	3.04	2.88	73.60	9,431
22	1	1114	25' L	40	4.94	4.88	4.79	5.24	4.42	4.07	3.89	74.30	8,092
24	1	1213	25' L	40	3.80	3.79	3.70	3.44	3.19	2.82	2.70	74.00	10,538
26	1	1314	25' L	40	3.77	3.69	3.51	3.65	3.09	2.79	2.69	71.20	10,605
28	1	1412	25' L	40	3.92	3.92	3.77	3.63	3.48	3.14	2.92	74.70	10,198
30	1	1514	25' L	40	3.82	3.82	3.64	3.83	3.40	3.00	2.87	73.40	10,461
32	1	1616	25' L	40	4.08	4.04	3.91	3.74	3.58	3.22	3.04	73.50	9,811
33	1	1714	25' L	40	4.11	4.05	3.99	3.84	3.60	3.13	2.96	72.50	9,726
35	1	1815	25' L	40	3.26	3.21	3.06	3.05	2.71	2.38	2.13	74.40	12,275
39	1	2015	25' L	40	4.02	3.97	3.90	3.79	3.46	3.09	2.94	73.60	9,943
40	1	2113	25' L	40	3.71	3.72	3.55	3.52	3.21	2.84	2.73	73.30	10,787
42	1	2212	25' L	40	4.16	4.13	3.88	3.96	3.42	3.11	2.93	75.00	9,623
44	1	2312	25' L	40	4.53	4.51	4.43	4.11	3.76	3.37	3.13	75.00	8,837
45	1	2413	25' L	40	4.15	4.12	3.98	3.77	3.40	3.14	2.95	75.60	9,650
47	1	2513	25' L	40	4.33	4.32	4.14	3.96	3.66	3.23	3.03	74.80	9,240
48	1	2614	25' L	40	4.25	4.22	3.81	4.22	3.25	2.83	2.56	73.90	9,418
50	1	2715	25' L	40	3.51	3.48	3.40	3.36	2.81	2.47	3.74	75.80	11,402
52	1	2816	25' L	40	4.07	4.04	3.87	3.63	3.29	2.93	2.64	77.30	9,822
54	1	2912	25' L	40	3.39	3.30	3.04	3.02	2.58	2.23	2.05	72.50	11,814
56	1	3017	25' L	40	3.68	3.59	3.39	3.28	2.73	2.44	2.27	72.40	10,868
58	1	3117	25' L	40	3.63	3.61	3.30	3.20	2.79	2.44	2.22	74.80	11,033
60	1	3213	25' L	40	4.01	3.97	3.74	3.58	3.22	2.86	2.65	73.10	9,980
62	1	3315	25' L	40	4.53	4.50	4.22	4.16	3.69	3.29	2.99	74.90	8,833
64	1	3415	25' L	40	4.01	3.96	3.87	3.88	3.29	2.88	2.69	72.70	9,967
66	1	3512	25' L	40	4.03	4.01	3.76	4.10	3.13	2.83	2.58	72.60	9,917
68	1	3612	25' L	40	4.41	4.40	4.08	4.32	3.66	3.18	3.01	76.30	9,074
70	1	3713	25' L	40	5.06	4.67	4.52	4.70	3.84	3.60	3.39	74.30	7,898
71	1	3811	25' L	40	4.20	4.21	3.93	4.11	3.56	3.24	2.98	77.50	9,521
72	1	3915	25' L	40	4.98	4.62	4.51	4.41	4.14	3.71	3.41	75.50	8,040
74	1	4012	25' L	40	5.51	5.16	4.95	4.91	4.56	3.96	3.68	76.00	7,262
76	1	4115	25' L	40	5.60	5.40	5.07	4.89	4.47	4.01	3.69	74.20	7,149
84	2	160	Center	40	4.43	4.40	4.04	4.06	3.50	4.33	1.43	71.20	9,039
88	2	362	Center	40	3.50	3.25	3.12	2.91	2.76	2.44	2.37	76.00	11,439
90	2	466	Center	40	3.05	3.05	2.95	2.82	2.69	2.34	2.20	75.90	13,097
92	2	564	Center	40	3.69	3.64	3.38	3.18	2.94	2.68	2.47	79.20	10,849
94	2	663	Center	40	3.65	3.56	3.29	3.49	2.84	2.41	2.32	79.00	10,971
96	2	762	Center	40	4.40	3.30	3.15	3.14	2.74	2.47	2.33	78.00	9,101
98	2	863	Center	40	3.55	3.72	3.35	3.38	2.97	2.76	2.46	74.80	11,269
100	2	964	Center	40	3.27	3.59	3.43	3.28	3.01	2.66	2.59	79.60	12,249
102	2	1066	Center	40	4.38	4.21	4.12	3.77	3.57	3.21	3.04	78.00	9,141
105	2	1179	Center	40	6.12	4.49	4.32	3.92	3.51	3.16	2.84	77.80	6,539
106	2	1267	Center	40	3.69	3.46	3.26	3.12	2.84	2.61	2.43	79.30	10,840
107	2	1364	Center	40	4.19	3.87	3.54	3.63	3.23	2.81	2.63	78.30	9,539
109	2	1466	Center	40	4.38	3.79	3.51	3.44	3.10	2.87	2.65	78.10	9,130
110	2	1565	Center	40	4.60	3.70	3.63	3.65	3.15	2.87	2.65	77.00	8,695
112	2	1664	Center	40	3.97	3.76	3.71	3.49	3.22	2.94	2.72	76.40	10,067
114	2	1765	Center	40	3.80	3.80	3.52	3.34	3.17	2.82	2.64	77.80	10,521
115	2	1864	Center	40	4.03	3.93	3.70	3.81	3.19	3.00	2.56	77.40	9,920
116	2	1880	Center	40	4.70	4.22	4.06	3.77	3.45	2.96	2.75	76.40	8,505
117	2	1964	Center	40	3.92	4.01	3.73	3.76	3.51	3.06	2.82	81.60	10,209
119	2	2065	Center	40	4.08	3.92	3.57	3.57	3.27	2.98	2.82	81.70	9,799
120	2	2166	Center	40	3.84	3.96	3.77	3.74	3.36	3.11	2.94	76.50	10,424
122	2	2264	Center	40	4.42	4.36	4.13	4.21	3.40	3.37	3.18	78.30	9,046
123	2	2361	Center	40	4.35	4.34	4.09	3.98	3.81	3.37	3.14	76.70	9,201

Memphis International Airport

Taxiway A West

NDT Field Data

NDT	Lane	NDT Station		Force	Displacement Sensors (mils)							Pvmnt	ISM
No.	No.	Distance	Offset	(kip)	d1 (0)	d2 (8")	d3 (12")	d4 (24")	d5 (36")	d6 (48")	d7 (60")	Temp (F)	(kip/in)
0+00 at edge of Taxiway N													
125	2	2466	Center	40	4.78	4.25	4.09	3.94	3.66	3.38	3.13	78.20	8,375
127	2	2562	Center	40	4.71	4.11	3.94	3.70	3.52	3.04	2.76	78.00	8,489
129	2	2663	Center	40	4.05	3.44	3.33	3.28	2.78	2.53	2.35	79.70	9,865
131	2	2762	Center	40	3.45	3.42	3.19	3.09	2.78	2.41	2.20	80.30	11,588
133	2	2867	Center	40	3.19	3.62	3.55	3.31	3.00	2.64	2.40	76.00	12,544
135	2	2964	Center	40	4.41	3.31	3.13	2.94	2.60	2.33	2.14	81.30	9,070
136	2	3063	Center	40	4.03	3.53	3.32	3.31	2.82	2.44	2.23	80.00	9,916
138	2	3166	Center	40	3.85	3.91	3.79	3.78	3.20	2.85	2.80	75.60	10,395
140	2	3265	Center	40	4.56	4.50	4.45	4.16	3.91	3.40	3.11	79.00	8,767
142	2	3368	Center	40	5.28	5.22	4.99	4.76	4.27	3.81	3.48	79.90	7,582
144	2	3465	Center	40	3.85	3.83	3.73	3.55	3.10	2.68	2.51	80.10	10,398
146	2	3565	Center	40	4.34	4.27	3.72	3.65	3.29	2.92	2.54	79.00	9,221
147	2	3582	Center	40	5.85	4.72	4.54	4.02	3.59	3.18	2.88	79.00	6,837
148	2	3668	Center	40	6.65	4.67	4.46	4.29	3.97	3.61	3.32	78.80	6,016
149	2	3771	Center	40	6.34	6.16	6.06	5.64	5.04	4.54	4.13	75.20	6,312
150	2	3965	Center	40	4.53	4.46	4.20	4.22	3.82	3.33	3.15	78.20	8,838
152	2	4064	Center	40	5.01	4.95	4.70	4.60	4.25	3.83	3.50	78.80	7,986
158	3	40	25' R	40	3.87	3.88	3.73	3.92	3.39	3.12	2.79	74.40	10,345
160	3	137	25' R	40	4.46	4.44	4.36	4.30	3.80	3.40	3.23	79.60	8,960
161	3	236	25' R	40	4.35	3.76	3.64	3.62	3.21	2.94	2.72	81.40	9,194
163	3	337	25' R	40	4.28	4.13	4.07	4.02	3.41	3.09	2.90	81.60	9,354
164	3	440	25' R	40	4.94	3.55	3.45	3.27	3.07	2.82	2.62	83.20	8,096
165	3	537	25' R	40	3.78	3.87	3.61	3.91	3.25	2.87	2.65	78.10	10,589
169	3	738	25' R	40	3.85	3.50	3.26	3.15	2.88	2.53	2.36	85.10	10,400
171	3	838	25' R	40	4.40	4.32	4.13	4.08	3.71	3.29	3.05	85.10	9,094
172	3	937	25' R	40	4.78	4.80	4.65	4.49	4.08	3.66	3.41	81.00	8,370
174	3	1038	25' R	40	4.24	4.23	4.15	3.98	3.66	3.36	3.19	84.50	9,423
176	3	1138	25' R	40	4.05	4.06	3.84	3.79	3.38	3.02	2.92	80.30	9,868
178	3	1235	25' R	40	4.07	4.03	3.91	4.24	3.52	3.03	2.61	84.70	9,840
180	3	1338	25' R	40	3.62	3.49	3.35	3.67	3.14	2.73	2.48	80.10	11,049
181	3	1437	25' R	40	3.84	3.66	3.48	3.43	3.07	2.80	2.68	84.00	10,430
183	3	1539	25' R	40	3.98	3.85	3.69	3.63	3.32	3.01	2.85	81.90	10,050
185	3	1636	25' R	40	4.02	3.83	3.82	3.71	3.35	2.98	2.68	83.50	9,940
187	3	1738	25' R	40	4.48	4.21	4.07	3.92	3.65	3.32	1.29	85.20	8,930
188	3	1840	25' R	40	4.28	4.27	4.18	4.31	3.86	3.34	2.97	84.50	9,347
190	3	1937	25' R	40	4.62	4.53	4.16	4.45	3.66	3.34	3.10	84.30	8,665
191	3	1956	25' R	40	5.66	5.41	5.16	4.92	4.18	3.73	3.40	83.80	7,070
192	3	2039	25' R	40	4.26	4.24	4.06	4.41	3.51	3.14	2.91	85.20	9,396
194	3	2139	25' R	40	3.28	3.44	3.37	3.30	2.90	2.62	2.44	82.90	12,212
195	3	2240	25' R	40	4.30	4.26	4.04	4.12	3.71	3.36	3.17	83.40	9,310
197	3	2337	25' R	40	4.39	4.35	4.21	4.17	3.69	3.36	3.17	83.40	9,106
199	3	2439	25' R	40	5.12	4.90	4.75	4.56	4.15	3.71	3.43	78.40	7,813
200	3	2541	25' R	40	5.68	4.94	4.80	4.84	4.25	3.75	3.62	83.10	7,041
202	3	2640	25' R	40	5.62	5.55	5.34	5.21	4.40	3.95	3.57	83.90	7,112
204	3	2737	25' R	40	3.70	3.68	3.51	3.44	3.04	2.66	2.48	79.20	10,812
206	3	2839	25' R	40	3.66	3.45	3.21	3.05	2.70	2.34	2.11	84.40	10,923
208	3	2936	25' R	40	3.70	3.57	3.52	3.48	2.91	2.57	2.35	79.70	10,803
209	3	3039	25' R	40	4.25	4.81	4.67	4.66	4.04	3.61	3.12	84.10	9,414
211	3	3138	25' R	40	4.65	4.57	4.43	4.57	3.99	3.72	3.44	80.00	8,603
213	3	3238	25' R	40	4.30	4.29	4.05	3.88	3.55	3.11	2.83	85.10	9,306
215	3	3337	25' R	40	4.79	4.71	4.65	4.59	4.00	3.55	3.26	84.50	8,353
217	3	3438	25' R	40	4.84	4.60	4.47	4.45	3.87	3.42	3.12	80.50	8,268
219	3	3537	25' R	40	4.52	4.45	4.18	4.09	3.67	3.31	3.04	84.50	8,841
220	3	3641	25' R	40	4.78	4.74	4.52	4.43	4.00	3.57	3.30	80.10	8,371
222	3	3739	25' R	40	6.72	6.49	6.33	6.09	5.53	4.96	4.57	80.80	5,951
223	3	3837	25' R	40	5.86	4.55	4.38	4.51	3.92	3.54	3.36	81.00	6,828
224	3	3946	25' R	40	9.97	5.95	5.73	5.53	4.85	4.29	3.71	84.30	4,014
226	3	4037	25' R	40	6.71	6.66	6.55	6.36	5.80	5.27	4.80	84.30	5,964

Memphis International Airport

Taxiway A West

NDT Field Data

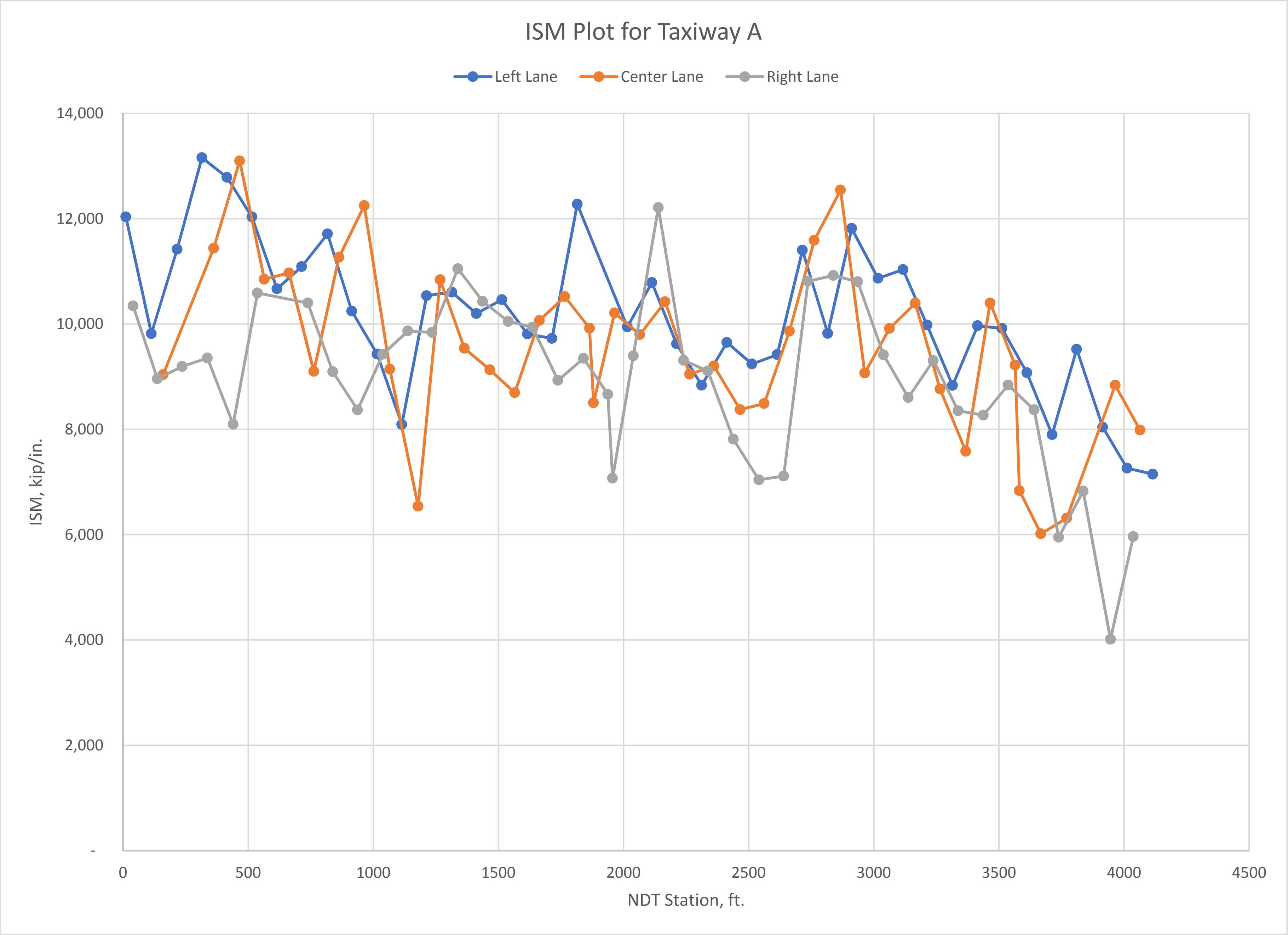
NDT	Lane	NDT Station		Force			Displacement Sensors (mils)					Pvmnt	ISM
No.	No.	Distance	Offset	(kip)	d1 (0)	d2 (8")	d3 (12")	d4 (24")	d5 (36")	d6 (48")	d7 (60")	Temp (F)	(kip/in)
0+00 at edge of Taxiway N													
Joint Tests													**d3/d1**
2	1	26	25' L	40	4.48	4.31	4.13	3.48	3.12	2.72	2.51	67.50	0.92
4	1	126	25' L	40	5.44	5.34	5.27	4.95	4.35	3.75	3.50	70.40	0.97
6	1	229	25' L	40	5.07	4.99	4.10	4.06	3.35	2.89	2.67	70.80	0.81
9	1	433	25' L	40	3.83	3.70	3.56	3.32	3.01	2.57	2.44	72.20	0.93
11	1	527	25' L	40	3.77	3.77	3.56	3.43	3.14	2.67	1.72	71.60	0.95
13	1	628	25' L	40	4.66	3.91	3.72	3.87	3.28	2.79	2.60	70.60	0.80
15	1	727	25' L	40	4.27	4.08	3.90	3.67	3.31	2.92	2.73	72.80	0.91
19	1	927	25' L	40	5.40	4.64	4.39	4.08	3.57	3.20	2.90	73.90	0.81
21	1	1027	25' L	40	5.32	4.81	4.46	4.16	3.65	3.25	2.93	73.90	0.84
23	1	1127	25' L	40	7.08	5.84	5.62	5.12	4.65	4.05	3.74	73.40	0.79
25	1	1225	25' L	40	5.04	4.34	4.23	3.95	3.35	3.04	2.84	72.70	0.84
27	1	1326	25' L	40	5.26	5.31	5.05	4.49	3.97	3.52	3.11	72.00	0.96
29	1	1427	25' L	40	5.36	5.37	5.17	4.86	4.21	3.63	3.37	74.20	0.97
31	1	1527	25' L	40	4.94	4.90	4.71	4.63	3.92	3.47	3.10	73.70	0.95
34	1	1726	25' L	40	4.90	4.86	4.75	4.48	4.02	3.72	3.41	73.80	0.97
36	1	1827	25' L	40	4.72	4.62	4.27	4.27	3.48	2.95	2.75	71.20	0.90
37	1	1912	25' L	40	3.99	3.97	3.74	3.58	3.27	2.98	2.75	75.60	0.94
38	1	1926	25' L	40	4.81	4.74	4.35	4.14	3.56	3.10	2.85	72.00	0.91
41	1	2125	25' L	40	4.65	4.54	4.14	3.94	3.55	3.10	3.06	75.40	0.89
43	1	2224	25' L	40	5.12	5.08	4.64	4.27	3.82	3.46	3.15	72.10	0.91
46	1	2425	25' L	40	5.61	5.61	5.30	5.20	4.25	3.70	3.80	75.10	0.95
49	1	2625	25' L	40	4.55	4.50	4.38	3.89	3.48	3.07	2.75	75.50	0.96
51	1	2726	25' L	40	3.70	3.70	3.49	3.25	2.96	2.56	2.32	75.70	0.94
53	1	2826	25' L	40	4.66	4.47	4.27	3.79	3.22	2.77	2.40	72.90	0.92
55	1	2926	25' L	40	5.33	5.29	4.64	3.99	3.44	2.77	2.40	74.70	0.87
57	1	3028	25' L	40	6.80	3.52	3.44	2.87	2.55	2.19	1.97	74.00	0.51
59	1	3128	25' L	40	7.11	3.81	3.66	3.27	2.78	2.42	2.13	76.60	0.51
61	1	3229	25' L	40	5.25	4.16	3.67	3.43	2.99	2.62	2.36	75.10	0.70
63	1	3330	25' L	40	6.11	5.73	5.37	5.19	4.20	3.50	3.44	75.20	0.88
65	1	3431	25' L	40	5.91	5.57	5.29	5.05	3.96	3.33	2.91	75.70	0.90
67	1	3525	25' L	40	6.00	5.71	5.48	5.16	4.30	3.58	2.70	75.50	0.91
69	1	3626	25' L	40	5.52	4.78	4.71	4.24	3.80	3.40	3.05	76.40	0.85
73	1	3928	25' L	40	6.69	6.58	6.31	5.67	5.01	4.31	3.91	76.00	0.94
75	1	4028	25' L	40	8.26	5.39	5.07	4.60	4.16	3.66	3.30	75.20	0.61
76	1	4114	25' L	40	5.47	5.42	4.96	4.80	4.31	3.90	3.79	74.70	0.91
77	1	4129	25' L	40	10.75	4.60	4.42	4.08	3.56	3.06	2.80	74.20	0.41
83	2	76	Center	40	6.12	6.82	5.71	5.24	4.75	4.05	3.89	70.40	0.93
85	2	177	Center	40	38.33	4.65	4.49	4.00	3.67	3.15	2.85	71.40	0.12

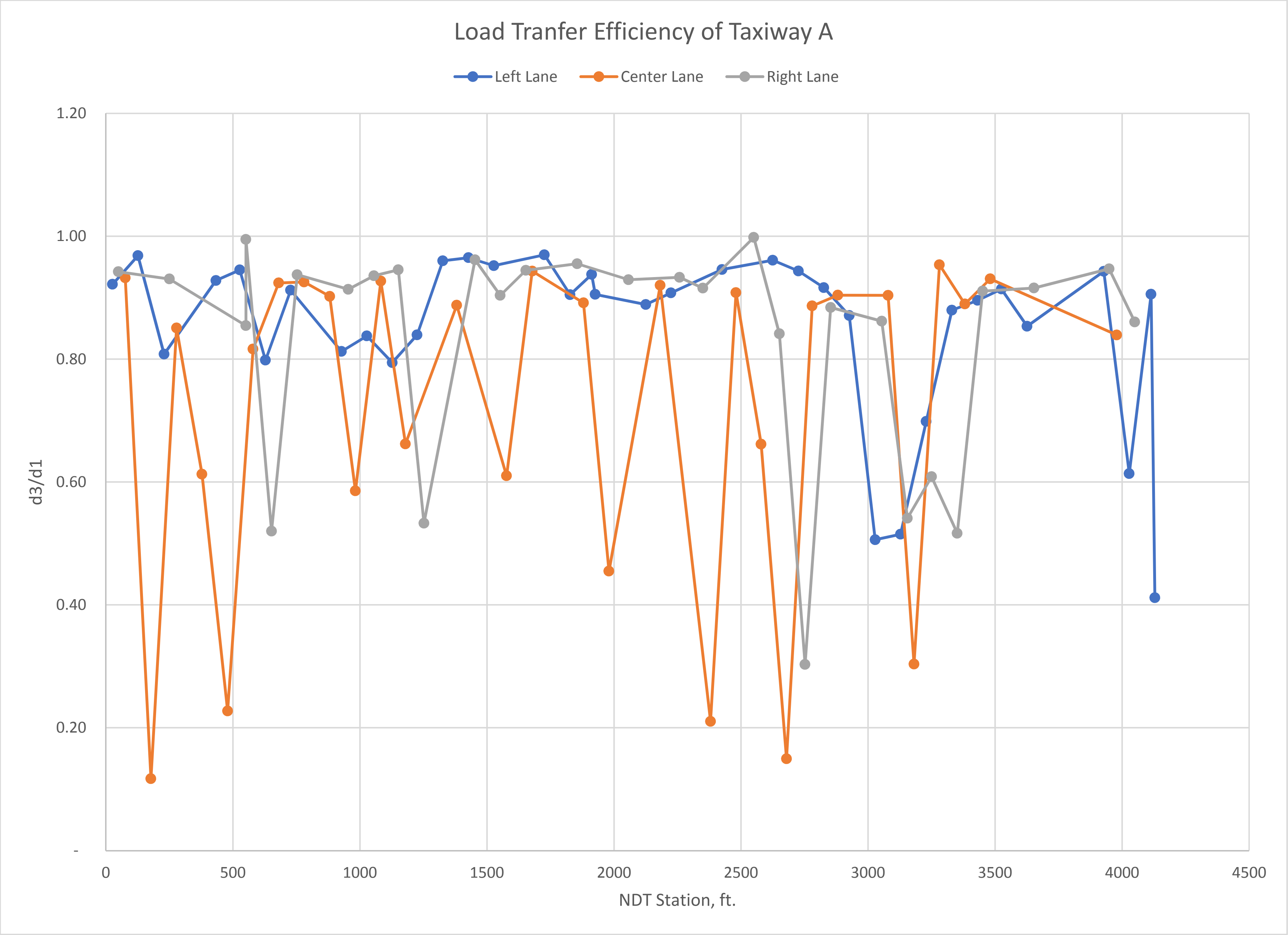
Memphis International Airport

Taxiway A West

NDT Field Data

NDT	Lane	NDT Station		Force			Displacement Sensors (mils)					Pvmnt	ISM
No.	No.	Distance	Offset	(kip)	d1 (0)	d2 (8")	d3 (12")	d4 (24")	d5 (36")	d6 (48")	d7 (60")	Temp (F)	(kip/in)
0+00 at edge of Taxiway N													
87	2	278	Center	40	4.80	4.27	4.09	3.83	3.32	2.96	2.71	75.30	0.85
89	2	378	Center	40	5.38	3.50	3.30	3.24	2.92	2.54	2.41	75.90	0.61
91	2	479	Center	40	15.21	3.68	3.46	3.26	2.91	2.62	2.41	74.00	0.23
93	2	579	Center	40	4.86	4.24	3.97	3.92	3.47	2.95	2.73	78.60	0.82
95	2	680	Center	40	4.20	4.04	3.88	3.86	3.02	2.68	2.45	77.00	0.92
97	2	780	Center	40	4.13	4.21	3.82	3.77	3.14	2.79	2.77	75.40	0.93
99	2	881	Center	40	4.59	4.29	4.14	3.79	3.53	3.10	2.85	77.60	0.90
101	2	982	Center	40	6.93	4.17	4.06	3.74	3.41	2.96	2.75	79.40	0.59
103	2	1082	Center	40	4.94	4.86	4.58	4.36	3.84	3.43	3.15	77.40	0.93
105	2	1179	Center	40	6.35	4.47	4.20	3.89	3.47	3.13	2.81	75.40	0.66
108	2	1381	Center	40	4.86	4.52	4.31	4.11	3.59	3.18	2.94	78.10	0.89
111	2	1577	Center	40	6.79	4.47	4.14	3.85	3.49	3.11	3.03	78.40	0.61
113	2	1678	Center	40	4.73	4.65	4.47	4.42	3.67	3.23	2.95	75.70	0.94
116	2	1880	Center	40	4.53	4.28	4.04	4.20	3.38	3.03	2.80	76.40	0.89
118	2	1980	Center	40	7.77	3.81	3.53	3.48	3.10	2.82	2.82	81.50	0.45
121	2	2182	Center	40	5.20	5.01	4.79	4.37	3.86	3.42	3.17	77.10	0.92
124	2	2380	Center	40	22.31	4.97	4.69	4.40	3.94	3.58	3.32	80.00	0.21
126	2	2480	Center	40	6.07	5.84	5.52	4.97	4.45	3.83	3.46	80.30	0.91
128	2	2579	Center	40	6.34	4.37	4.19	3.83	3.40	3.05	2.73	75.80	0.66
130	2	2679	Center	40	24.46	3.84	3.65	3.41	3.06	2.58	2.39	77.10	0.15
132	2	2780	Center	40	3.60	3.37	3.19	2.98	2.53	2.28	2.03	78.90	0.89
134	2	2881	Center	40	5.22	4.97	4.71	4.35	3.57	3.06	2.62	78.00	0.90
137	2	3079	Center	40	4.16	4.08	3.76	3.45	2.99	2.49	2.28	79.80	0.90
139	2	3181	Center	40	13.40	4.15	4.07	3.72	3.27	2.88	2.58	79.00	0.30
141	2	3281	Center	40	5.51	5.42	5.25	4.50	4.06	3.45	3.12	78.70	0.95
143	2	3381	Center	40	5.49	5.23	4.89	4.45	3.86	3.35	3.04	78.20	0.89
145	2	3481	Center	40	4.64	4.47	4.31	4.00	3.40	3.02	2.63	79.50	0.93
151	2	3979	Center	40	5.94	5.17	4.99	4.49	4.00	3.59	3.25	77.80	0.84
159	3	49	25' R	40	5.57	5.45	5.25	4.70	4.22	3.74	3.38	73.70	0.94
162	3	250	25' R	40	5.05	4.97	4.70	4.25	3.69	3.25	2.88	80.60	0.93
166	3	551	25' R	40	4.36	4.19	3.73	3.33	3.26	2.92	2.68	78.20	0.85
166	3	551	25' R	40	3.88	3.88	3.86	3.68	3.13	2.83	2.60	78.20	0.99
168	3	652	25' R	40	7.83	4.28	4.07	3.93	3.44	3.04	2.81	83.00	0.52
170	3	753	25' R	40	3.79	3.75	3.56	3.52	2.92	2.64	2.42	79.50	0.94
173	3	954	25' R	40	6.21	5.89	5.67	5.23	4.75	4.32	3.93	85.70	0.91
175	3	1055	25' R	40	5.72	5.71	5.35	4.97	4.37	3.84	3.48	83.60	0.94
177	3	1151	25' R	40	4.57	4.55	4.32	4.00	3.53	3.19	2.91	83.20	0.95
179	3	1252	25' R	40	8.22	4.69	4.38	4.07	3.55	3.13	2.86	84.40	0.53
182	3	1453	25' R	40	4.36	4.21	4.20	3.88	3.45	3.06	2.86	83.70	0.96
184	3	1552	25' R	40	4.67	4.49	4.22	3.91	3.47	3.05	2.83	82.60	0.90
186	3	1653	25' R	40	4.40	4.38	4.16	3.95	3.52	3.18	2.90	83.30	0.94
189	3	1855	25' R	40	5.55	5.55	5.30	4.93	4.16	3.81	3.47	83.20	0.96
193	3	2057	25' R	40	5.06	5.02	4.70	4.22	3.66	3.19	2.87	84.20	0.93
196	3	2258	25' R	40	5.86	5.78	5.47	4.98	4.42	3.91	3.49	83.50	0.93
198	3	2350	25' R	40	5.63	5.41	5.15	4.68	4.20	3.78	3.42	82.40	0.92
201	3	2550	25' R	40	5.25	5.24	5.24	4.97	4.07	3.59	3.25	83.20	1.00
203	3	2651	25' R	40	6.18	5.40	5.20	4.65	3.97	3.46	3.10	80.30	0.84
205	3	2752	25' R	40	15.10	4.86	4.57	4.21	3.61	3.04	2.71	84.20	0.30
207	3	2853	25' R	40	4.45	4.17	3.94	3.72	3.05	2.57	2.25	83.00	0.88
210	3	3054	25' R	40	5.73	5.32	4.94	5.06	3.87	3.26	2.91	80.10	0.86
212	3	3155	25' R	40	8.45	4.73	4.57	4.49	3.79	3.22	2.86	83.40	0.54
214	3	3250	25' R	40	7.04	4.33	4.28	4.11	3.20	2.74	2.47	83.20	0.61
216	3	3351	25' R	40	7.39	3.95	3.82	3.48	3.11	2.77	2.48	80.70	0.52
218	3	3451	25' R	40	5.08	4.94	4.62	4.58	3.79	3.17	2.91	83.80	0.91
221	3	3653	25' R	40	6.05	5.90	5.54	5.02	4.34	3.80	3.38	80.80	0.92
225	3	3949	25' R	40	5.57	5.45	5.28	4.79	4.30	3.88	3.55	84.70	0.95
227	3	4050	25' R	40	6.11	5.37	5.26	4.83	4.32	3.85	3.49	78.80	0.86


ISM Plot for Taxiway A
Left Lane
Center Lane
Right Lane
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
ISM, kip/in.
0
500
1000
1500
2000
2500
3000
3500
4000
4500
NDT Station, ft.


Load Tranfer Efficiency of Taxiway A
Left Lane
Center Lane
Right Lane
1.20
1.00
0.80
0.60
0.40
0.20
-
d3/d1
0
500
1000
1500
2000
2500
3000
3500
4000
4500
NDT Station, ft.

Memphis International Airport

Portion of Other Taxiways Within Project Limits

NDT Field Data

NDT	Lane	Force	Displacement Sensors (mils)							Pvmnt	ISM
No.	No.	(kip)	d1 (0)	d2 (8")	d3 (12")	d4 (24")	d5 (36")	d6 (48")	d7 (60")	Temp (F)	(kip/in)
Taxiway N, interface slabs with Taxiway A											
1	1	40	6.70	4.95	4.74	4.54	4.19	3.74	3.36	80.50	5,967
2	1	40	3.50	3.75	3.61	3.56	3.19	2.95	2.75	82.50	11,439
4	1	40	3.67	3.56	3.38	3.28	2.97	2.74	2.57	81.70	10,886
5	1	40	5.82	3.60	3.45	3.40	3.12	2.81	2.61	83.90	6,868
7	1	40	6.02	4.80	4.67	4.50	4.16	3.81	3.55	85.10	6,643
8	1	40	2.81	2.81	2.35	2.28	2.10	1.83	1.82	84.90	14,243
Joint Tests											**d3/d1**
3	1	40	4.93	4.65	4.48	4.09	3.69	3.36	3.08	82.10	0.91
9	1	40	2.71	2.62	2.60	2.46	2.10	1.86	1.74	86.40	0.96
Connecting Taxiway to GA Apron, AC Surfaced Pavement											
1	1	40	11.11	6.23	5.38	4.84	4.34	3.91	3.54	81.40	3,602
2	1	40	6.95	6.37	5.95	5.45	4.87	4.32	3.88	84.20	5,755
3	1	40	6.50	5.97	5.61	5.27	4.76	4.27	3.90	85.80	6,151
4	1	40	12.54	9.77	8.94	8.14	7.07	6.15	5.29	84.50	3,190
10	2	40	9.00	7.09	6.40	6.16	5.34	4.69	4.18	85.50	4,445
9	2	40	8.33	8.02	7.22	6.77	5.86	5.19	4.55	85.30	4,799
8	2	40	11.91	7.64	7.11	6.90	5.85	5.13	4.60	85.60	3,359
7	2	40	10.34	10.23	9.55	8.71	7.56	6.50	5.58	85.90	3,868
5	1	40	9.59	6.41	5.65	5.21	4.67	4.04	3.63	86.20	4,173
TW C, South of TW A, new slabs											
1	1	40	3.49	4.79	4.56	4.46	4.11	3.71	3.43	78.30	11,458
3	1	40	4.50	4.30	4.27	4.07	3.59	3.18	2.94	83.50	8,895
4	1	40	5.22	5.13	4.99	5.32	4.59	4.09	3.77	82.90	7,664
6	1	40	3.62	3.33	3.20	3.08	2.92	2.71	2.61	81.50	11,057
7	1	40	4.10	3.80	3.61	3.84	3.15	2.80	2.67	82.70	9,752
9	1	40	4.57	3.99	3.78	3.76	3.36	3.01	2.82	83.40	8,745
14	2	40	4.70	4.62	4.38	4.31	3.89	3.46	3.23	79.10	8,503
15	2	40	3.18	3.04	3.00	2.84	2.64	2.45	2.29	83.10	12,583
16	2	40	16.34	3.15	3.04	2.92	2.82	2.42	2.26	79.00	2,448
18	2	40	5.20	4.65	4.52	4.40	3.97	3.55	3.23	84.10	7,699
TW C, North of TW A. old slabs											
10	1	40	4.11	4.08	3.91	3.86	3.62	3.21	2.82	85.30	9,734
12	1	40	5.51	5.41	5.19	5.11	4.66	4.29	3.99	84.20	7,256
20	2	40	25.67	3.85	3.59	3.49	3.19	2.89	2.68	83.90	1,558
21	2	40	3.60	3.68	3.61	3.41	3.16	2.89	2.72	81.70	11,111
22	2	40	6.07	4.28	4.22	4.01	3.62	3.32	3.04	84.90	6,589
24	2	40	5.03	3.70	3.44	3.66	2.86	2.52	2.23	81.80	7,959
Joint Tests											**d3/d1**
2	1	40	4.55	4.50	4.27	3.93	3.59	3.27	3.01	81.40	0.94
5	1	40	4.62	4.52	4.14	3.80	3.35	2.95	2.68	81.30	0.90
8	1	40	4.77	4.75	4.55	4.29	3.71	3.30	2.99	83.70	0.95
11	1	40	19.78	4.32	4.07	3.81	3.45	3.11	2.85	84.60	0.21
13	1	40	9.36	5.78	5.33	4.74	4.19	3.70	3.23	83.10	0.57
17	2	40	4.35	4.23	4.09	3.66	3.27	2.94	2.64	81.50	0.94
19	2	40	8.26	4.59	4.41	4.07	3.63	3.23	2.93	84.40	0.53
23	2	40	7.39	4.92	4.63	4.26	3.83	3.45	3.12	83.30	0.63

Memphis International Airport

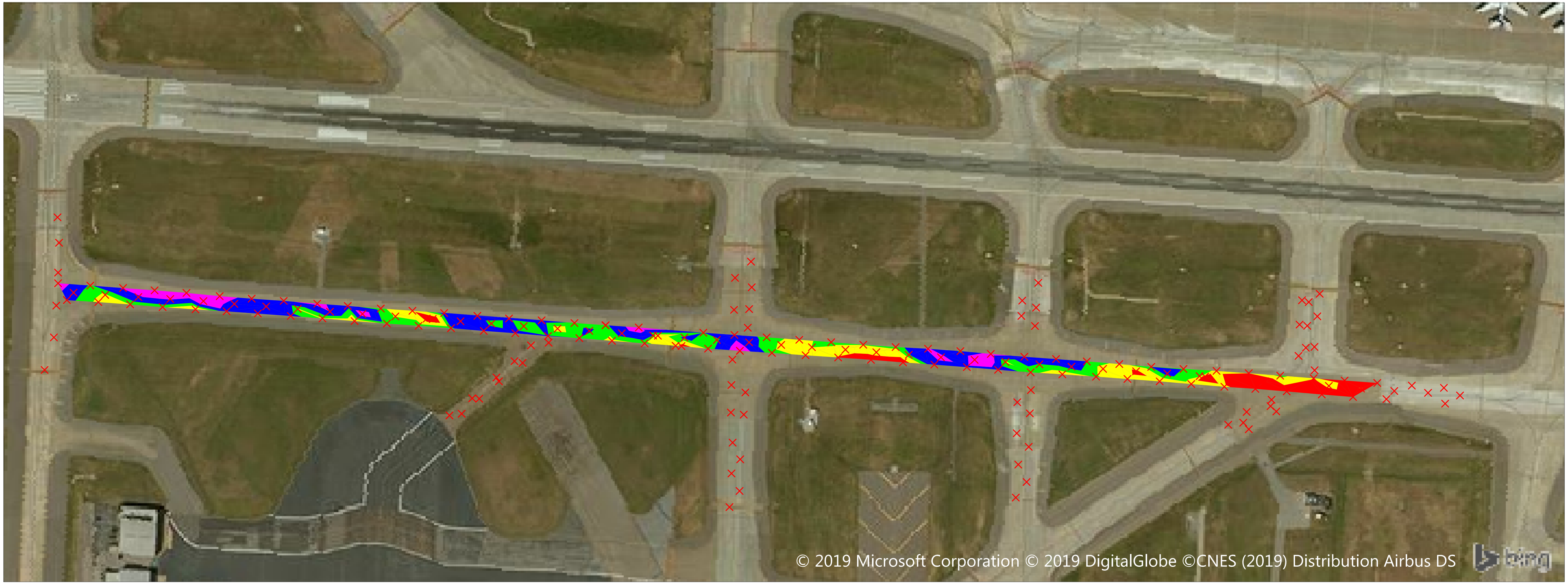
Portion of Other Taxiways Within Project Limits

NDT Field Data

NDT	Lane	Force	Displacement Sensors (mils)							Pvmnt	ISM
No.	**No.**	**(kip)**	**d1 (0)**	**d2 (8")**	**d3 (12")**	**d4 (24")**	**d5 (36")**	**d6 (48")**	**d7 (60")**	**Temp (F)**	**(kip/in)**
TW S, South of TW A											
1	1	40	11.31	3.23	3.13	2.99	2.74	2.49	2.29	80.00	3,536
2	1	40	3.88	3.69	3.49	3.36	3.11	2.76	2.52	81.10	10,320
3	1	40	5.44	3.61	3.61	3.58	3.13	2.77	2.34	80.30	7,353
5	1	40	3.96	3.29	2.94	2.69	2.44	2.09	1.95	80.80	10,101
9	2	40	4.42	4.37	4.26	4.04	3.80	3.40	3.10	81.10	9,055
10	2	40	38.34	3.75	3.60	3.25	2.92	2.53	2.24	81.10	1,043
12	2	40	5.04	4.98	4.94	4.68	3.97	3.49	3.10	80.40	7,935
13	2	40	2.92	2.91	2.77	2.63	2.45	2.24	2.09	79.00	13,700
TW S, North of TW A											
6	1	40	4.89	4.89	4.68	4.37	3.84	3.21	1.73	80.10	8,175
7	1	40	3.14	3.08	2.96	2.81	2.58	2.22	2.05	82.10	12,735
15	2	40	4.43	3.15	2.86	2.83	2.33	2.06	1.88	80.30	9,037
16	2	40	4.90	4.80	4.57	4.38	3.98	3.40	3.06	76.50	8,158
18	2	40	3.50	3.35	3.03	2.91	2.59	2.24	2.03	79.90	11,443
Joint Tests											**d3/d1**
4	1	40	5.05	4.63	4.42	3.92	3.33	2.86	2.43	79.10	0.88
8	1	40	4.20	3.57	3.44	3.03	2.64	2.31	2.03	80.20	0.82
11	2	40	8.86	2.72	2.64	2.42	2.17	1.92	1.71	80.30	0.30
14	2	40	7.83	4.49	4.34	3.86	3.30	2.89	2.59	82.30	0.55
17	2	40	3.90	3.74	3.37	3.06	2.57	2.16	1.96	80.70	0.86
TW B, South of TW A, old slabs											
1	1	40	5.59	5.52	5.37	5.27	4.76	4.33	3.98	83.40	7,151
2	1	40	7.38	7.35	7.33	7.18	6.75	6.36	5.95	79.20	5,417
4	1	40	4.22	4.25	3.97	3.99	3.57	3.22	2.37	83.10	9,476
17	2	40	6.59	6.45	6.27	6.29	5.61	5.09	4.61	84.30	6,066
15	2	40	5.77	5.80	5.61	5.45	5.03	4.58	4.18	86.40	6,932
18	3	40	5.24	5.29	5.19	5.04	4.60	4.13	3.79	79.40	7,629
20	3	40	6.42	6.40	6.38	6.27	5.96	5.58	5.22	85.90	6,227
TW B, North of TW A, new slabs											
5	1	40	4.47	4.41	4.22	4.18	3.75	3.37	3.12	81.60	8,952
7	1	40	3.49	3.48	3.36	3.28	3.05	2.84	2.65	81.40	11,461
9	1	40	4.78	4.44	4.19	4.41	3.86	3.53	3.24	86.50	8,373
14	2	40	3.46	2.98	2.82	2.92	2.49	2.29	2.16	86.90	11,545
13	2	40	3.47	3.43	3.28	3.21	2.89	2.60	2.37	86.90	11,528
11	2	40	4.57	4.50	4.37	4.28	3.83	3.45	3.15	87.00	8,761
10	2	40	4.38	4.22	4.10	4.06	3.51	2.99	2.65	87.30	9,136
21	3	40	3.51	3.46	3.21	3.15	2.75	2.46	2.27	83.00	11,383
22	3	40	3.75	3.69	3.61	3.52	3.23	2.98	2.75	82.30	10,661
24	3	40	3.14	3.13	3.10	3.11	2.86	2.63	2.47	83.90	12,740
Joint Tests											**d3/d1**
3	1	40	5.43	5.43	5.21	4.70	4.16	3.70	3.29	82.10	0.96
6	1	40	3.30	2.92	2.86	2.77	2.43	2.19	2.07	83.70	0.87
8	1	40	10.30	2.89	2.89	2.64	2.45	2.27	2.11	81.40	0.28
12	2	40	4.26	3.54	3.32	3.13	2.83	2.56	2.37	85.90	0.78
16	2	40	6.28	5.75	5.48	5.06	4.61	4.10	3.70	84.80	0.87
19	3	40	5.00	4.84	4.65	4.35	3.74	3.42	3.08	83.30	0.93
23	3	40	4.86	3.84	3.58	3.41	3.09	2.77	2.54	83.60	0.74

APPENDIX C

OVERALL PAVEMENT STRENGTH EXHIBIT



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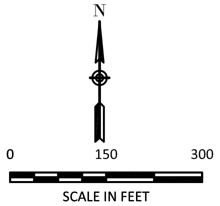
Taxiway A ISM Ranges

🟥 4,014kips/in.<ISM<7,898kips/in.
🟨 7,898kips/in.<ISM<9,194kips/in.
🟩 9,194kips/in.<ISM<9,967kips/in.
🟦 9,967kips/in.<ISM<11,269kips/in.
🟪 11,269kips/in.<ISM<13,159kips/in.

× NDT Location

Taxiway A Overall Pavement Strength



APPENDIX D

DESIGN OUTPUTS

FAARFIELD v 1.42 - Airport Pavement Design

Section PCC-1 in Job 1918-MEM.
Working directory is C:\Users\bxie\OneDrive\Documents\FAARFIELD\

The structure is New Rigid.
Design Life = 20 years.
A design for this section was completed on 05/22/20 at 15:36:28.

Pavement Structure Information by Layer, Top First

No.	Type	Thickness in	Modulus psi	Poisson's Ratio	Strength R,psi
1	PCC Surface	18.40	4,000,000	0.15	685
2	Variable St (flex)	4.00	150,000	0.35	0
3	P-304 CTB	8.00	500,000	0.20	0
4	P-301 SCB	12.00	250,000	0.20	0
5	Subgrade	0.00	10,438	0.40	0

Total thickness to the top of the subgrade = 42.40 in

Airplane Information

No.	Name	Gross Wt. lbs	Annual Departures	% Annual Growth
1	A300-600 LB	380,518	2,666	0.00
2	A310-200	315,041	174	0.00
3	B757-200	256,000	15,142	0.00
4	B767-300 ER Freighter	413,000	38,964	0.00
5	B777 Freighter (Preliminary)	768,800	7,784	0.00
6	DC10-10	458,000	1,941	0.00
7	MD11ER	633,000	2,156	0.00
8	MD11ER Belly	633,000	2,156	0.00

Additional Airplane Information

No.	Name	CDF Contribution	CDF Max for Airplane	P/C Ratio
1	A300-600 LB	0.00	0.00	3.44
2	A310-200	0.00	0.00	3.69
3	B757-200	0.00	0.00	3.90
4	B767-300 ER Freighter	0.00	0.00	3.62
5	B777 Freighter (Preliminary)	1.00	1.00	3.89
6	DC10-10	0.00	0.00	3.81
7	MD11ER	0.00	0.00	3.68
8	MD11ER Belly	0.00	0.00	3.01

FAARFIELD v 1.42 - Airport Pavement Design

Section PCC-1 in Job 1918-MEM.
Working directory is C:\Users\bxie\OneDrive\Documents\FAARFIELD\

The structure is New Rigid.
Design Life = 20 years.
A design for this section was completed on 05/22/20 at 15:38:44.

Pavement Structure Information by Layer, Top First

No.	Type	Thickness in	Modulus psi	Poisson's Ratio	Strength R,psi
1	PCC Surface	17.90	4,000,000	0.15	685
2	Variable St (flex)	4.00	150,000	0.35	0
3	P-304 CTB	8.00	500,000	0.20	0
4	P-301 SCB	12.00	250,000	0.20	0
5	Subgrade	0.00	12,544	0.40	0

Total thickness to the top of the subgrade = 41.90 in

Airplane Information

No.	Name	Gross Wt. lbs	Annual Departures	% Annual Growth
1	A300-600 LB	380,518	2,666	0.00
2	A310-200	315,041	174	0.00
3	B757-200	256,000	15,142	0.00
4	B767-300 ER Freighter	413,000	38,964	0.00
5	B777 Freighter (Preliminary)	768,800	7,784	0.00
6	DC10-10	458,000	1,941	0.00
7	MD11ER	633,000	2,156	0.00
8	MD11ER Belly	633,000	2,156	0.00

Additional Airplane Information

No.	Name	CDF Contribution	CDF Max for Airplane	P/C Ratio
1	A300-600 LB	0.00	0.00	3.44
2	A310-200	0.00	0.00	3.69
3	B757-200	0.00	0.00	3.90
4	B767-300 ER Freighter	0.00	0.00	3.62
5	B777 Freighter (Preliminary)	1.00	1.00	3.89
6	DC10-10	0.00	0.00	3.81
7	MD11ER	0.00	0.00	3.68
8	MD11ER Belly	0.00	0.00	3.01

FAARFIELD v 1.42 - Airport Pavement Design

Section PCC-1 in Job 1918-MEM.
Working directory is C:\Users\bxie\OneDrive\Documents\FAARFIELD\

The structure is New Rigid.
Design Life = 20 years.
A design for this section was completed on 05/22/20 at 12:21:18.

Pavement Structure Information by Layer, Top First

No.	Type	Thickness in	Modulus psi	Poisson's Ratio	Strength R,psi
1	PCC Surface	19.41	4,000,000	0.15	685
2	Variable St (flex)	4.00	150,000	0.35	0
3	P-304 CTB	8.00	500,000	0.20	0
4	User Defined	12.00	30,000	0.35	0
5	Subgrade	0.00	10,438	0.40	0

Total thickness to the top of the subgrade = 43.41 in

Airplane Information

No.	Name	Gross Wt. lbs	Annual Departures	% Annual Growth
1	A300-600 LB	380,518	2,666	0.00
2	A310-200	315,041	174	0.00
3	B757-200	256,000	15,142	0.00
4	B767-300 ER Freighter	413,000	38,964	0.00
5	B777 Freighter (Preliminary)	768,800	7,784	0.00
6	DC10-10	458,000	1,941	0.00
7	MD11ER	633,000	2,156	0.00
8	MD11ER Belly	633,000	2,156	0.00

Additional Airplane Information

No.	Name	CDF Contribution	CDF Max for Airplane	P/C Ratio
1	A300-600 LB	0.00	0.00	3.44
2	A310-200	0.00	0.00	3.69
3	B757-200	0.00	0.00	3.90
4	B767-300 ER Freighter	0.00	0.00	3.62
5	B777 Freighter (Preliminary)	1.00	1.00	3.89
6	DC10-10	0.00	0.00	3.81
7	MD11ER	0.00	0.00	3.68
8	MD11ER Belly	0.00	0.00	3.01

FAARFIELD v 1.42 - Airport Pavement Design

Section PCC-1 in Job 1918-MEM.
Working directory is C:\Users\bxie\OneDrive\Documents\FAARFIELD\

The structure is New Rigid.
Design Life = 20 years.
A design for this section was completed on 05/22/20 at 13:29:53.

Pavement Structure Information by Layer, Top First

No.	Type	Thickness in	Modulus psi	Poisson's Ratio	Strength R,psi
1	PCC Surface	18.99	4,000,000	0.15	685
2	Variable St (flex)	4.00	150,000	0.35	0
3	P-304 CTB	8.00	500,000	0.20	0
4	User Defined	12.00	30,000	0.35	0
5	Subgrade	0.00	12,544	0.40	0

Total thickness to the top of the subgrade = 42.99 in

Airplane Information

No.	Name	Gross Wt. lbs	Annual Departures	% Annual Growth
1	A300-600 LB	380,518	2,666	0.00
2	A310-200	315,041	174	0.00
3	B757-200	256,000	15,142	0.00
4	B767-300 ER Freighter	413,000	38,964	0.00
5	B777 Freighter (Preliminary)	768,800	7,784	0.00
6	DC10-10	458,000	1,941	0.00
7	MD11ER	633,000	2,156	0.00
8	MD11ER Belly	633,000	2,156	0.00

Additional Airplane Information

No.	Name	CDF Contribution	CDF Max for Airplane	P/C Ratio
1	A300-600 LB	0.00	0.00	3.44
2	A310-200	0.00	0.00	3.69
3	B757-200	0.00	0.00	3.90
4	B767-300 ER Freighter	0.00	0.00	3.62
5	B777 Freighter (Preliminary)	0.99	0.99	3.89
6	DC10-10	0.00	0.00	3.81
7	MD11ER	0.00	0.00	3.68
8	MD11ER Belly	0.00	0.00	3.01

FAARFIELD v 1.42 - Airport Pavement Design

Section PCC-1 in Job 1918-MEM.
Working directory is C:\Users\bxie\OneDrive\Documents\FAARFIELD\

The structure is New Rigid.
Design Life = 20 years.
A design for this section was completed on 05/22/20 at 13:42:23.

Pavement Structure Information by Layer, Top First

No.	Type	Thickness in	Modulus psi	Poisson's Ratio	Strength R,psi
1	PCC Surface	18.53	4,000,000	0.15	685
2	Variable St (flex)	4.00	150,000	0.35	0
3	P-304 CTB	8.00	500,000	0.20	0
4	Subgrade	0.00	18,148	0.40	0

Total thickness to the top of the subgrade = 30.53 in

Airplane Information

No.	Name	Gross Wt. lbs	Annual Departures	% Annual Growth
1	A300-600 LB	380,518	2,666	0.00
2	A310-200	315,041	174	0.00
3	B757-200	256,000	15,142	0.00
4	B767-300 ER Freighter	413,000	38,964	0.00
5	B777 Freighter (Preliminary)	768,800	7,784	0.00
6	DC10-10	458,000	1,941	0.00
7	MD11ER	633,000	2,156	0.00
8	MD11ER Belly	633,000	2,156	0.00

Additional Airplane Information

No.	Name	CDF Contribution	CDF Max for Airplane	P/C Ratio
1	A300-600 LB	0.00	0.00	3.44
2	A310-200	0.00	0.00	3.69
3	B757-200	0.00	0.00	3.90
4	B767-300 ER Freighter	0.00	0.00	3.62
5	B777 Freighter (Preliminary)	1.00	1.00	3.89
6	DC10-10	0.00	0.00	3.81
7	MD11ER	0.00	0.00	3.68
8	MD11ER Belly	0.00	0.00	3.01

FAARFIELD v 1.42 - Airport Pavement Design

Section PCC-1 in Job 1918-MEM.
Working directory is C:\Users\bxie\OneDrive\Documents\FAARFIELD\

The structure is New Rigid.
Design Life = 20 years.
A design for this section was completed on 05/22/20 at 13:35:51.

Pavement Structure Information by Layer, Top First

No.	Type	Thickness in	Modulus psi	Poisson's Ratio	Strength R,psi
1	PCC Surface	19.06	4,000,000	0.15	685
2	User Defined	4.00	100,000	0.35	0
3	P-304 CTB	8.00	500,000	0.20	0
4	User Defined	12.00	30,000	0.35	0
5	Subgrade	0.00	12,544	0.40	0

Total thickness to the top of the subgrade = 43.06 in

Airplane Information

No.	Name	Gross Wt. lbs	Annual Departures	% Annual Growth
1	A300-600 LB	380,518	2,666	0.00
2	A310-200	315,041	174	0.00
3	B757-200	256,000	15,142	0.00
4	B767-300 ER Freighter	413,000	38,964	0.00
5	B777 Freighter (Preliminary)	768,800	7,784	0.00
6	DC10-10	458,000	1,941	0.00
7	MD11ER	633,000	2,156	0.00
8	MD11ER Belly	633,000	2,156	0.00

Additional Airplane Information

No.	Name	CDF Contribution	CDF Max for Airplane	P/C Ratio
1	A300-600 LB	0.00	0.00	3.44
2	A310-200	0.00	0.00	3.69
3	B757-200	0.00	0.00	3.90
4	B767-300 ER Freighter	0.00	0.00	3.62
5	B777 Freighter (Preliminary)	1.00	1.00	3.89
6	DC10-10	0.00	0.00	3.81
7	MD11ER	0.00	0.00	3.68
8	MD11ER Belly	0.00	0.00	3.01

FAARFIELD v 1.42 - Airport Pavement Design

Section PCC-1 in Job 1918-MEM.
Working directory is C:\Users\bxie\OneDrive\Documents\FAARFIELD\

The structure is New Rigid.
Design Life = 20 years.
A design for this section was completed on 05/22/20 at 13:45:21.

Pavement Structure Information by Layer, Top First

No.	Type	Thickness in	Modulus psi	Poisson's Ratio	Strength R,psi
1	PCC Surface	18.60	4,000,000	0.15	685
2	User Defined	4.00	100,000	0.35	0
3	P-304 CTB	8.00	500,000	0.20	0
4	Subgrade	0.00	18,148	0.40	0

Total thickness to the top of the subgrade = 30.60 in

Airplane Information

No.	Name	Gross Wt. lbs	Annual Departures	% Annual Growth
1	A300-600 LB	380,518	2,666	0.00
2	A310-200	315,041	174	0.00
3	B757-200	256,000	15,142	0.00
4	B767-300 ER Freighter	413,000	38,964	0.00
5	B777 Freighter (Preliminary)	768,800	7,784	0.00
6	DC10-10	458,000	1,941	0.00
7	MD11ER	633,000	2,156	0.00
8	MD11ER Belly	633,000	2,156	0.00

Additional Airplane Information

No.	Name	CDF Contribution	CDF Max for Airplane	P/C Ratio
1	A300-600 LB	0.00	0.00	3.44
2	A310-200	0.00	0.00	3.69
3	B757-200	0.00	0.00	3.90
4	B767-300 ER Freighter	0.00	0.00	3.62
5	B777 Freighter (Preliminary)	1.00	1.00	3.89
6	DC10-10	0.00	0.00	3.81
7	MD11ER	0.00	0.00	3.68
8	MD11ER Belly	0.00	0.00	3.01

FAARFIELD v 1.42 - Airport Pavement Design

Section PCC-1 in Job 1918-MEM.
Working directory is C:\Users\bxie\OneDrive\Documents\FAARFIELD\

The structure is New Rigid.
Design Life = 20 years.
A design for this section was completed on 06/08/20 at 13:19:26.

Pavement Structure Information by Layer, Top First

No.	Type	Thickness in	Modulus psi	Poisson's Ratio	Strength R,psi
1	PCC Surface	19.48	4,000,000	0.15	685
2	User Defined	4.00	100,000	0.35	0
3	P-304 CTB	8.00	500,000	0.20	0
4	User Defined	12.00	30,000	0.35	0
5	Subgrade	0.00	10,438	0.40	0

Total thickness to the top of the subgrade = 43.48 in

Airplane Information

No.	Name	Gross Wt. lbs	Annual Departures	% Annual Growth
1	A300-600 LB	380,518	2,666	0.00
2	A310-200	315,041	174	0.00
3	B757-200	256,000	15,142	0.00
4	B767-300 ER Freighter	413,000	38,964	0.00
5	B777 Freighter (Preliminary)	768,800	7,784	0.00
6	DC10-10	458,000	1,941	0.00
7	MD11ER	633,000	2,156	0.00
8	MD11ER Belly	633,000	2,156	0.00

Additional Airplane Information

No.	Name	CDF Contribution	CDF Max for Airplane	P/C Ratio
1	A300-600 LB	0.00	0.00	3.44
2	A310-200	0.00	0.00	3.69
3	B757-200	0.00	0.00	3.90
4	B767-300 ER Freighter	0.00	0.00	3.62
5	B777 Freighter (Preliminary)	1.00	1.00	3.89
6	DC10-10	0.00	0.00	3.81
7	MD11ER	0.00	0.00	3.68
8	MD11ER Belly	0.00	0.00	3.01

FAARFIELD v 1.42 - Airport Pavement Design

Section Signature in Job 1918-MEM.
Working directory is C:\Users\bxie\OneDrive\Documents\FAARFIELD\

The aircraft list contains only one aircraft. Please see the introduction to the Help File for a discussion on using FAArfield to make single aircraft comparisons.
The structure is New Flexible. Asphalt CDF = 0.0809.
Design Life = 20 years.
A design for this section was completed on 06/08/20 at 16:59:21.

Pavement Structure Information by Layer, Top First

No.	Type	Thickness in	Modulus psi	Poisson's Ratio	Strength R,psi
1	P-401/ P-403 HMA Surface	4.00	200,000	0.35	0
2	P-401/ P-403 St (flex)	5.00	400,000	0.35	0
3	P-219 Recycled Conc. Agg.	5.95	46,006	0.35	0
4	Subgrade	0.00	18,000	0.35	0

Total thickness to the top of the subgrade = 14.95 in

Airplane Information

No.	Name	Gross Wt. lbs	Annual Departures	% Annual Growth
1	B757-300	273,500	1,200	0.00

Additional Airplane Information

Subgrade CDF

No.	Name	CDF Contribution	CDF Max for Airplane	P/C Ratio
1	B757-300	1.00	1.00	1.73

HMA CDF

No.	Name	CDF Contribution	CDF Max for Airplane	P/C Ratio
1	B757-300	0.00	0.00	1.46

P-401/P-403 St (flex) CDF

No.	Name	CDF Contribution	CDF Max for Airplane	P/C Ratio
1	B757-300	0.08	0.08	1.11

FAARFIELD v 1.42 - Airport Pavement Design

Section Shoulder in Job 1918-MEM.
Working directory is C:\Users\bxie\OneDrive\Documents\FAARFIELD\

The section does not have a design life of 20 years. This constitutes a deviation from standards and requires FAA approval.
The aircraft list contains only one aircraft. Please see the introduction to the Help File for a discussion on using FAArfield to make single aircraft comparisons.
The structure is New Flexible. Asphalt CDF = 0.0001.
Design Life = 1 years.
A design for this section was completed on 06/08/20 at 16:54:47.

Pavement Structure Information by Layer, Top First

No.	Type	Thickness in	Modulus psi	Poisson's Ratio	Strength R,psi
1	P-401/ P-403 HMA Surface	4.00	200,000	0.35	0
2	P-219 Recycled Conc. Agg.	11.19	55,940	0.35	0
3	Subgrade	0.00	18,000	0.35	0

Total thickness to the top of the subgrade = 15.19 in

Airplane Information

No.	Name	Gross Wt. lbs	Annual Departures	% Annual Growth
1	B777 Freighter (Preliminary)	768,800	15	0.00

Additional Airplane Information

Subgrade CDF

No.	Name	CDF Contribution	CDF Max for Airplane	P/C Ratio
1	B777 Freighter (Preliminary)	1.00	1.00	1.93

HMA CDF

No.	Name	CDF Contribution	CDF Max for Airplane	P/C Ratio
1	B777 Freighter (Preliminary)	0.00	0.00	1.02

FAARFIELD v 1.42 - Airport Pavement Design

Section Shoulder in Job 1918-MEM.
Working directory is C:\Users\bxie\OneDrive\Documents\FAARFIELD\

The section does not have a design life of 20 years. This constitutes a deviation from standards and requires FAA approval.
The aircraft list contains only one aircraft. Please see the introduction to the Help File for a discussion on using FAArfield to make single aircraft comparisons.
The structure is New Flexible. Asphalt CDF = 0.0004.
Design Life = 1 years.
A design for this section was completed on 06/08/20 at 16:53:28.

Pavement Structure Information by Layer, Top First

No.	Type	Thickness in	Modulus psi	Poisson's Ratio	Strength R,psi
1	P-401/ P-403 HMA Surface	5.00	200,000	0.35	0
2	P-219 Recycled Conc. Agg.	9.81	53,866	0.35	0
3	Subgrade	0.00	18,000	0.35	0

Total thickness to the top of the subgrade = 14.81 in

Airplane Information

No.	Name	Gross Wt. lbs	Annual Departures	% Annual Growth
1	B777 Freighter (Preliminary)	768,800	15	0.00

Additional Airplane Information

Subgrade CDF

No.	Name	CDF Contribution	CDF Max for Airplane	P/C Ratio
1	B777 Freighter (Preliminary)	1.00	1.00	1.96

HMA CDF

No.	Name	CDF Contribution	CDF Max for Airplane	P/C Ratio
1	B777 Freighter (Preliminary)	0.00	0.00	0.97

III. Pending Litigation

TW Bravo Hot Spot 1 - Construction – REBID – RFB No. 18-1413-04

Entities that have pending claims or litigation that perform work within the scope of this project:

As of June 1, 2026

1. Eutaw/ R.C. Joint Venture
2. DACO Construction Company