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Construction Cycle 10 Support – Test Pavement Planning & Design

Test Plan

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ACRONYMS

2D – Dual Tandem Gear
3D –Dual Tridem Gear
AASHTO – American Association of State Highway and Transportation Officials
ASTM – American Society for Testing and Materials
AUPP – Area Under Pavement Profile
CBR – California Bearing Ratio
CC – Construction Cycle
CC8 – Construction Cycle 008
CC10 – Construction Cycle 010
CDF – Cumulative Damage Factor
CH – High Plasticity Clay
DAQ – Data Acquisition
DCP – Dynamic Cone Penetrometer
DGAC – Direction Générale De L'aviation Civile
D-PSPA – Dirt Portable Seismic Pavement Analyzer
FAA – Federal Aviation Administration
GPR – Ground Penetrating Radar
HMA – Hot Mix Asphalt
HWD – Heavy Weight Deflectometer
LWD – Light Weight Deflectometer
MIRA – Ultrasonic Tomography Device
NAPTF – National Airport Pavement Test Facility
NAPTV – National Airport Pavement Test Vehicle
NDT – Non-Destructive Testing
NI – National Instruments
NMAS – Nominal Maximum Aggregate Size
PCC – Portland Cement Concrete
PCI – Pavement Condition Index
PFG – Piezo-Floating Gate
PSPA – Portable Seismic Pavement Analyzer
PWL – Percent Within Limits
R&D – Research and Development
SPU – Signal Processing Unit
STA – Station
UDA – User-Defined Aircraft
VWC – Volumetric Water Content

1 INTRODUCTION

The NAPTF contains a fully-enclosed and instrumented airfield pavement test track that is 900 feet long by 64.5 feet wide. Indoor stationing and benchmarks have been established within the facility so that all testing and construction can be performed in an efficient and consistent manner. The test track is divided into independent test items on various subgrade classifications that are designed, constructed, and trafficked to failure. This plan discusses the objectives, proposed analyses, test items, instrumentation plan, and test plan for CC10 at NAPTF. CC10 consists of three rigid pavement test items, each with a unique cross-section, built over a medium-strength subgrade with a CBR = 7-8%. CC10 test items and transition areas will replace existing CC8 rigid pavement test items at NAPTF between STA 3+00 and 6+10. Each test item, comprised of fifteen concrete slabs, will be 90 feet long by 52.5 feet wide.

2 OBJECTIVES AND SCOPE

The FAA Airport Technology R&D Branch developed objectives for CC10. Data from the experiment will support the following objectives:

1. Obtain failure data at higher traffic levels, over 5 years, to better represent extended life conditions
2. Obtain data for realistic slab dimensions and joint spacings
3. Directly evaluate the effect of increased slab thickness on life
4. Investigate fatigue damage accumulation in the major phase of rigid pavement life before the appearance of significant cracks
5. Test structural performance of slabs with light fixture penetrations
6. Obtain data from instrumented light fixtures under load in rigid pavement
7. Collaborate with leading researchers and research centers

This test plan documents the design and proposed execution of the experiment. It discusses the analyses proposed to achieve the objectives, the test items and instrumentation necessary to obtain data for the analyses, and the test plan for the test items. The design report containing design data, calculations, and explanations for design decisions is included in Appendix A.

3 APPROACH

3.1 HIGHER TRAFFIC LEVELS

The approach to obtain failure data at higher traffic levels is to construct the pavement test item to approximate a typical pavement at a medium- to large-hub airport, then apply a large amount of traffic to the test item over a period of five years. A pavement thickness of approximately 15 inches should support between 150,000 and 200,000 passes of a 2D gear, satisfying the objective to obtain data at higher traffic levels.

3.2 REALISTIC SLAB DIMENSIONS AND JOINT SPACINGS

A slab thickness of 15 inches is realistic for a PCC pavement serving commercial aircraft. The maximum joint spacing for a slab this thick is 17.5 feet [1], which is reasonably close to typical runway joint spacing of 18.75 feet by 20 feet. Test items were designed with target slab dimensions of approximately 15 inches thick with approximately 17.5-foot joint spacing, which satisfies the objective to obtain data for test items with realistic slab dimensions and joint spacing. Specific data to be collected includes:

- Temperature gradient through the slab depth.
- Changes in relative humidity.
- Expansion and contraction of longitudinal joints. Correlate this to temperature, relative humidity, and joint transfer efficiency.
- Peak strain at the slab edge. Correlate this to temperature and relative humidity.
- Vertical stress in the base beneath the slab center and corner. Correlate this to temperature and relative humidity.
- Vertical deflections at the slab corner. Correlate this to temperature and relative humidity.

Vertical stress will be collected with pressure cells and vertical deflections will be collected with eddy current sensors. Locations of these sensor types will mirror each other to provide complementary data in warping and curling analysis.

3.3 EFFECT OF PAVEMENT THICKNESS ON PAVEMENT LIFE

Three test items of different thicknesses will be constructed to evaluate the effect of pavement thickness on pavement life. Each test item will be constructed using the same materials and construction techniques. The thickest item realistically approximates pavement at a medium- to large-hub airport. The other test items will be thinner and are expected to fail sooner. A statistical analysis comparing the results from each test item to the other test items will be performed to determine the effect of pavement thickness on pavement life. Specific comparisons between the test items will include:

- Number of passes to first crack.
- Number of passes to failure.
- Condition from visual inspection at various traffic passes.
- Peak strain at the slab edge due to trafficking.
- Vertical stress in the base beneath the slab center and corner due to trafficking.
- Vertical deflections at the slab corner due to trafficking.
- Peak strain at the slab edge with respect to temperature and relative humidity.
- Vertical stress in the base beneath the slab center and corner with respect to temperature and relative humidity.
- Vertical deflections at the slab corner with respect to temperature and relative humidity.

3.4 FATIGUE DAMAGE BEFORE CRACKING

The technique developed by Dr. Nizar Lajnef of Michigan State University for PFG sensors will be used to identify fatigue damage before cracking. These sensors have been successfully installed in previous FAA projects [2] and have been used to detect pre-cracking fatigue damage of flexible pavements in other projects [3]. They measure the amount of time the strain in the pavement is greater than a given threshold, labeled a "gate," as shown in Figure 1. When plotted against the number of loading cycles, changes in the slope of the strain-time line indicate various stages of damage in the material, as shown in Figure 2.

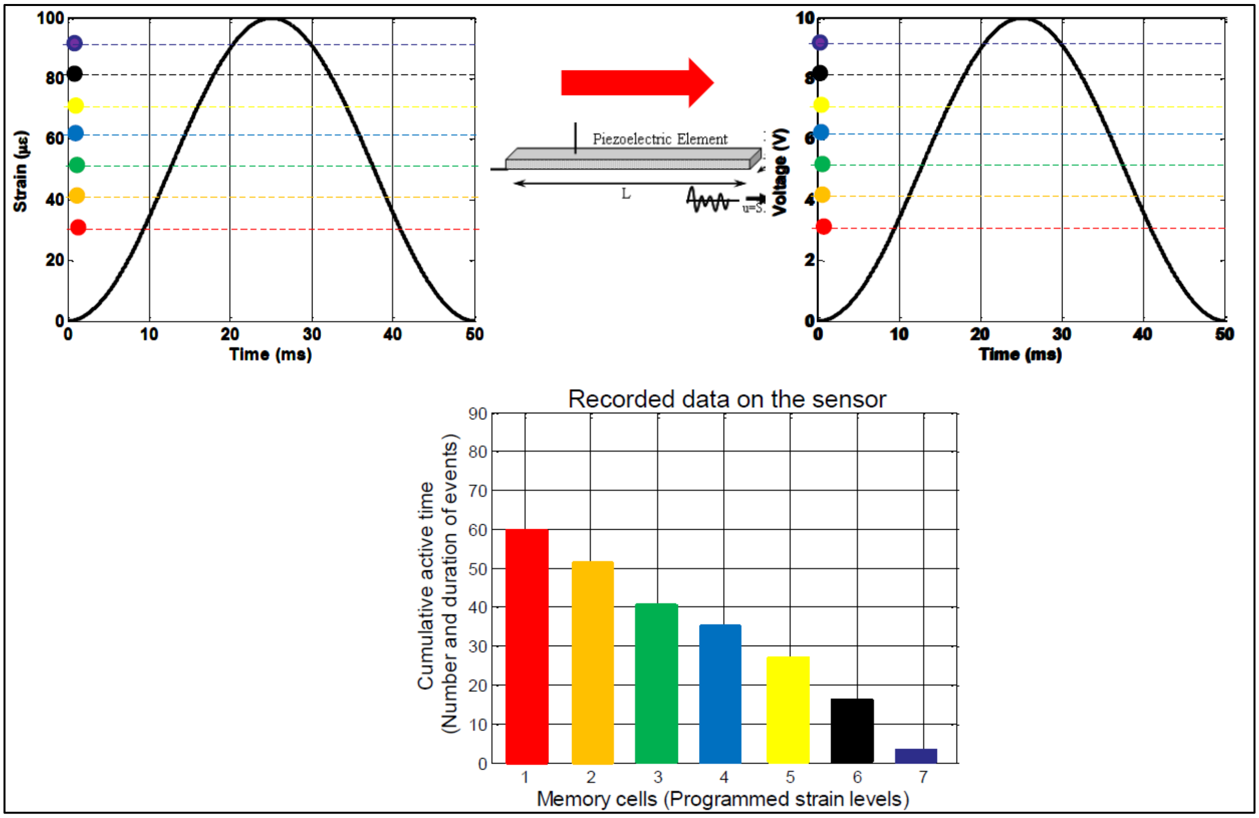


Figure 1. PFG sensor data [3]

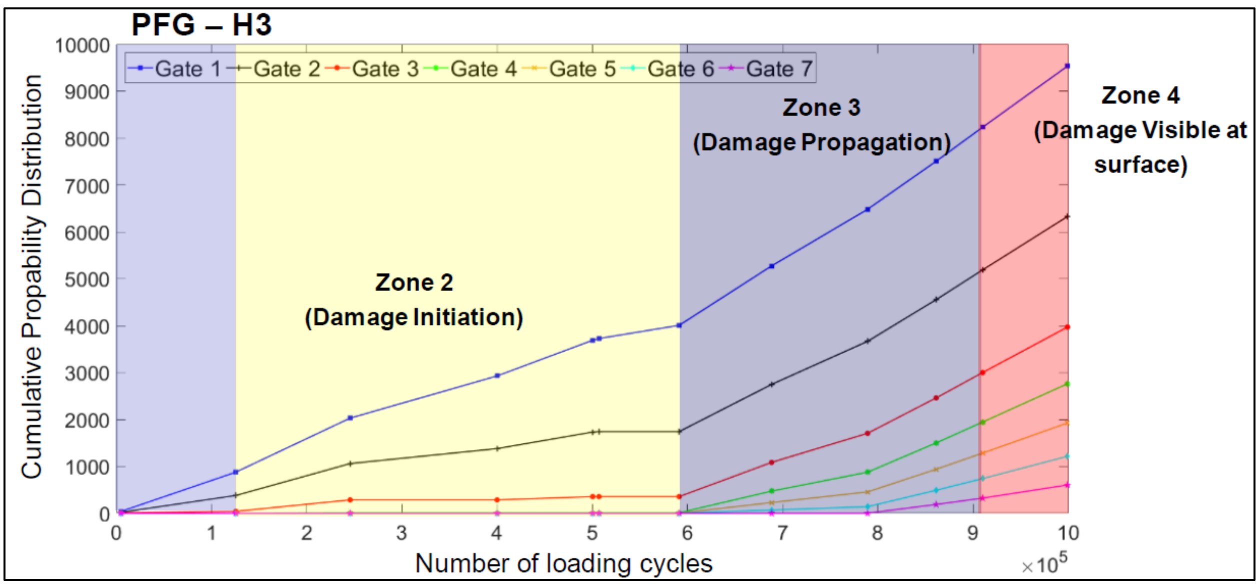


Figure 2. Interpretation of PFG sensor data [3]

The test items will contain PFG sensors to determine if the sensors and technique are effective in a rigid pavement. The results of the analysis will be compared to crack initiation data from the visual surveys. Additionally, HWD deflection basin indices (AUPP, AREA, F-1 Factor, F-2 Factor, etc.) will be compared to traffic cycles and PCI data to see if a correlation can be developed relating the parameters to damage in the pavement.

Some PFG sensors will be paired with embedded strain gauges. Strain gauge data will be converted to strain-time data then analyzed using the technique developed for PFGs. The results of the strain gauge analyses will be compared to the results of the PFG analyses.

3.5 COLLABORATE WITH LEADING RESEARCHERS

3.5.1 Piezo-Floating Gate Sensors

FAA will collaborate with Dr. Nizar Lajnef of Michigan State University to investigate fatigue damage before cracking. Dr. Lajnef will provide the PFG sensors required for the experiment and participate in the analysis.

3.5.2 MIRA

FAA will collaborate with Dr. Lev Khazanovich of University of Pittsburgh to evaluate MIRA as a tool to identify pavement deterioration. Dr. Khazanovich aided in development of the MIRA portion of this test plan and will participate in comparing MIRA results to other pavement imaging tools. Specific comparisons include:

- Placement of dowels, movement of dowels, and joint degradation during trafficking as determined by MIT Scan 2-BT to the same information as determined by MIRA.
- Compare GPR to MIRA, specifically for changes occurring in the pavement during trafficking.

3.5.3 Dynamic Backcalculation

FAA will collaborate with DGAC to develop dynamic backcalculation techniques. DGAC aided in preparation of the HWD portion of this test plan. FAA will collect the entire time signal history of HWD tests on test items. They will provide the HWD data and supporting material characterization data to DGAC to aid DGAC with development of dynamic backcalculation models for rigid pavements.

3.6 STRUCTURAL PERFORMANCE OF SLABS CONTAINING LIGHT FIXTURES

Two slabs of one test item will have in-pavement light fixtures installed in them. The performance of the slabs containing fixtures will be compared to the performance of the other slabs in the test item. Specific measures of performance to be compared include the peak strain and the number of traffic passes until the slab cracks. Additionally, HWD testing will be conducted with the load plate directly on top of the light, two feet away from the light, and in similar locations on an adjacent slab. The results will be compared to determine if the light fixture affects the response of the pavement.

3.7 RESPONSE OF LIGHT FIXTURES IN RIGID PAVEMENT

The light fixtures installed in CC10 will contain instrumentation similar to that installed for previous research at NAPTF on light fixtures in flexible pavement [4]. Fixture responses and HWD data will be compared to data from the previous research.

4 CONSTRUCTION CYCLE 10 TEST ITEMS

4.1 PAVEMENT

Three test items will support the proposed CC10 experiment. The test items are instrumented P-501 PCC pavement constructed inside the NAPTF. The PCC thickness of the test items ranges from 13.5 inches to 15.5 inches as shown in Figure 3. All test items have a 5-inch P-403 asphalt stabilized base and a P-154 granular subbase. The test items use the same PCC and HMA mix designs. The PCC has a design flexural strength of 700 psi. The HMA is a ¾-inch NMAS PG76-22 material. The subgrade beneath the test items is a CH soil with CBR of 7% to 8%. Test items will be denoted with "MRS" which corresponds to the subgrade strength (M = medium strength), type of pavement (R = rigid), and whether it contains a stabilized base (S = stabilized). The spacing between longitudinal joints is 17.5 feet and the spacing between transverse joints is 18.0 feet in all test items, as shown in Figure 4. Appendix A documents the design of the test items.

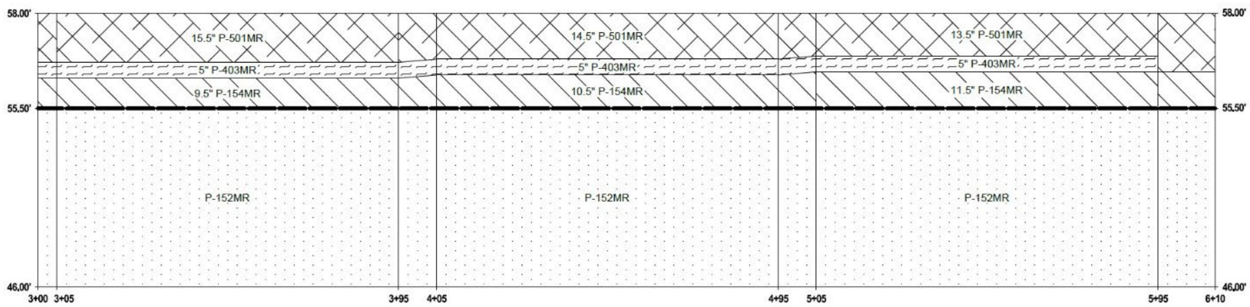


Figure 3. Proposed cross sections for CC10

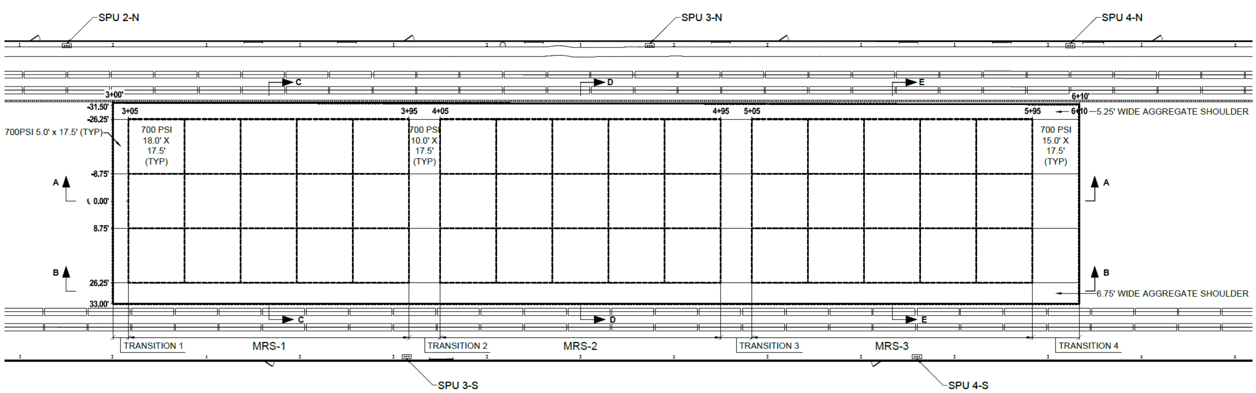
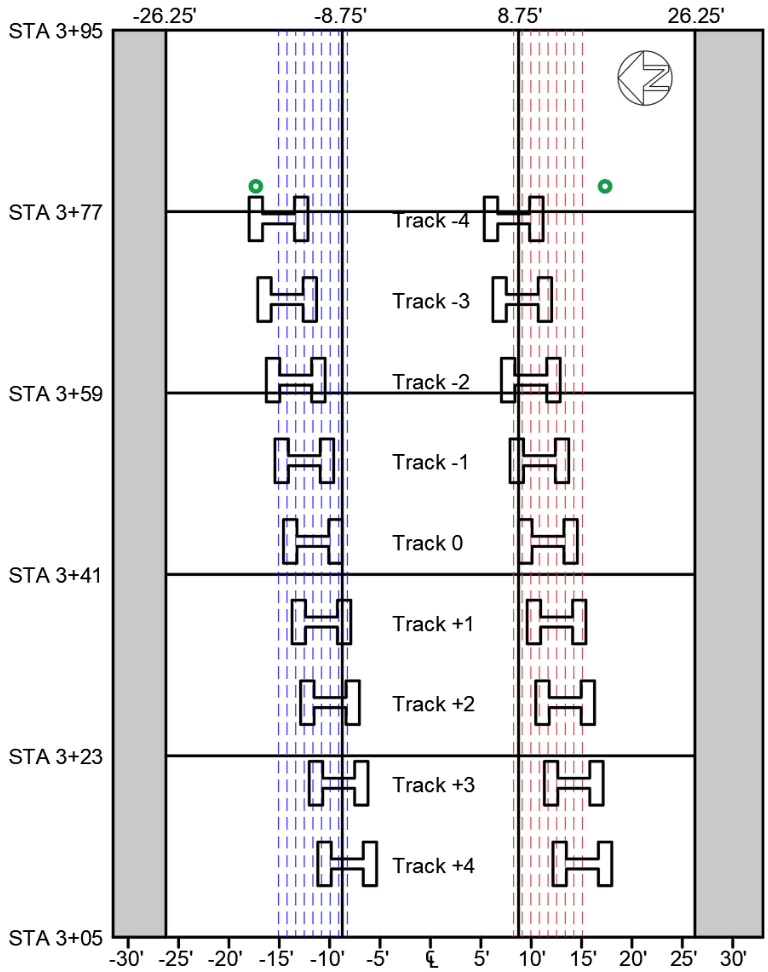


Figure 4. CC10 plan view

4.2 LIGHT FIXTURES

CC10 contains two in-pavement light fixtures. The fixtures are in the thickest pavement test item, MRS-1, as shown in Figure 5. The fixtures are Astronics 850A touchdown zone and intersection lights mounted in L-868B one-piece bases.



Light Can Center Position		
Name	STA	Offset
	ft	ft
North	3+79.5	-17.329
South	3+79.5	17.329

Track	Carriage Centerline Position	
	North Carriage	South Carriage
#	*ft*	*ft*
-4	-15.079	8.255
-3	-14.226	9.108
-2	-13.373	9.961
-1	-12.520	10.814
0	-11.667	11.667
+1	-10.814	12.520
+2	-9.961	13.373
+3	-9.108	14.226
+4	-8.255	15.079

LEGEND
- North Carriage
- South Carriage
- Light Fixture

Figure 5. In-pavement light fixture locations

4.3 INSTRUMENTATION

CC10 has two sets of instrumentation: pavement instrumentation and light fixture instrumentation. Appendix A documents the design of instrumentation.

4.3.1 Pavement Instrumentation

Each test item contains seven types of gauges to monitor the responses required for the CC10 analysis: moisture sensors, pressure cells, thermocouples, embedded strain gauges, relative humidity measuring systems, eddy current sensors, and PFG sensors. Table 1 summarizes the sensor types. Figure 6 is a plan view of the sensors in a typical test item.

Table 1. Sensors in the test pavements

Sensor Type	Measured Response	Purpose	Quantity
Moisture Sensor	Measure volumetric water content (VWC) and temperature. 0-100% VWC	Determine the moisture and temperature variation at various depths throughout the project life cycle	3
Pressure Cell	Vertical pressure, psi	Capture wheel load pressure at the bottom of the concrete	30
Thermocouple	Concrete temperature, ºF	Capture the environmental changes in the concrete at varying depths	24 (6 trees with 4 thermocouples per tree)
Embedded Strain Gauge	Horizontal strain or deformation, με	Capture material strain at the bottom of the concrete layer due to trafficking	228[1]
Piezo-Floating Gate Sensor		Identify fatigue damage accumulation throughout pavement life	78
Relative Humidity Measuring System	Relative humidity, %	Monitor internal relative humidity within concrete	6
Eddy Current Sensor	Peak deflection, mils	Monitor corner displacement and deflections due to trafficking, curling, and warping	33

[1] Quantity does not include instrumentation required for light cans

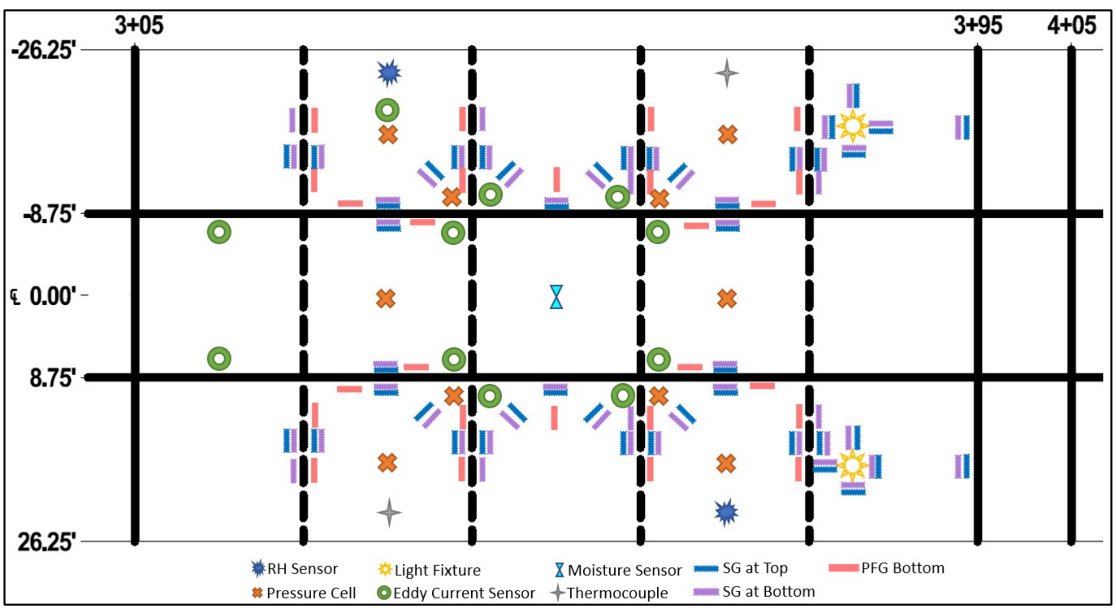


Figure 6. Instrumentation plan view of one test item (typical)

4.3.2 Light Fixture Assembly Instrumentation

The light fixture assembly instrumentation is based on that of previous projects. Prior installations in asphalt pavements had pavement strain gauges only at the bottom of the asphalt layer. CC10 will have pavement strain gauges at the top and bottom of the PCC layer to capture top-down and bottom-up cracking. Instrumentation for each light fixture will consist of:

1) Four strain gauges on the underside of the light fixture.
2) Four horizontal and four vertical strain gauges mounted on the inner wall near mid-depth of the light base.
3) Six strain gauges in the bolted connection between the fixture and base.
4) Four pavement strain gauges in the pavement near the top of the light fixture.
5) Four pavement strain gauges in the pavement near the bottom of the light fixture.
6) Two pavement strain gauges (1 top, 1 bottom) located at the same distance from the transverse joint to compare strain gauges in the penetration versus the pavement itself

As part of the light fixture instrumentation installation and verification, a minimum of eight instrumented studs per light fixture assembly (six required and two spares) will be calibrated to provide results in units of pounds-force. Each bolt will be individually numbered and calibration of studs will be completed using a tension and compression testing machine to impart an axial load.

4.3.3 Data Acquisition Systems

SPU-3S Enclosure 1 (existing), SPU-3S Enclosure 2 (proposed), SPU-4S, and SPU-3N support the CC10 experiment. These units contain a mixture of National Instruments DAQs, VXI DAQs, and Campbell Scientific data loggers. SPU-3S Enclosure 1 supports MRS-1, SPU-3S Enclosure 2 supports MRS-2, and SPU-4S supports MRS-3. SPU-3N supports the light fixture instrumentation.

5 TEST PLAN

5.1 CC8 POST-TRAFFIC TESTING

As part of CC10 construction, the CC8 post-traffic testing plan will be executed. This includes extensive sampling of CC8 materials for laboratory testing, inspection of each CC8 layer, non-destructive testing (NDT), and test pits. A phased demolition will be carried out in a sequence to support the CC8 post-traffic testing. The CC8 post-traffic testing plan is provided in Appendix C.

5.2 TRAFFICKING

The NAPTV is essential to full-scale testing in NAPTF. The NAPTV is a rail-based test vehicle capable of simulating an aircraft weighing up to 1.3 million pounds to conduct full-scale pavement testing. The NAPTV is comprised of two carriages that can accommodate up to five load modules each with adjustable dual and tandem spacing (currently set to a dual tire spacing of 54 inches and a tandem tire spacing of 57 inches). Each load module can support two wheels (52-inch radials, 16 inches wide) which allows configurations of up to 20 wheels to represent modern aircraft gear configurations. The NAPTV can apply loads of up to 75,000 lbs/wheel and simulates aircraft wander by varying the lateral position of the carriages. This allows the NAPTV to simulate a normal distribution of aircraft traffic during traffic testing.

The wander pattern consists of 66 passes arranged in nine tracks, as shown in Table 2. Track 0 was located such that the inside tire of the NAPTV lined up with the longitudinal joints. The carriages will remain a fixed distance apart as they shift transversely to represent a full aircraft. Each complete passage of the NAPTV to the east counts as one pass, and the complete return to the west counts as a second pass. The complete wander pattern is detailed in Appendix B. For CC10, the vehicle speed is 2.5 mph.

Table 2. CC10 traffic wander wheel tracks

Track No.	Carriage Centerline Location, ft.	
	North	South
Track -4	-15.079	8.255
Track -3	-14.226	9.108
Track -2	-13.373	9.961
Track -1	-12.520	10.814
Track 0	-11.667	11.667
Track +1	-10.814	12.520
Track +2	-9.961	13.373
Track +3	-9.108	14.226
Track +4	-8.255	15.079

The three test items are expected to fail at different times, as summarized in Table 3. The table also lists the expected time to failure. The expected time to failure calculations assume that approximately 50% of a given calendar year is dedicated to CC10 trafficking and account for NAPTV maintenance and other downtime. All three test items will be trafficked at the beginning of the experiment. Trafficking will cease on items as they fail.

Table 3. CC10 expected passes to failure.

Test Item	Gear	Wheel Load (pounds)	Expected Passes	Expected Time to Failure (Calendar Months)
MRS-1	2D	55,000	174,656	65
MRS-2	2D	55,000	27,196	10
MRS-3	2D	55,000	4,548	2

5.3 DATA ACQUISITION

NI and VXI chassis will record strain gauge (pavement and light fixture), PFG sensor, pressure cell, and eddy current sensor data at 20Hz during trafficking and 1Hz at all other times. The NAPTV will trigger data recording during trafficking. Campbell CR1000 data loggers will collect moisture, temperature, and relative humidity readings at 1Hz. Data acquisition will commence during PCC paving and continue continuously until cessation of trafficking.

5.4 LABORATORY CHARACTERIZATION PLAN

Each layer will undergo an extensive testing scheme to evaluate key characteristics of the stockpiled and in-place materials. Each material will be sampled according to the appropriate ASTM standard indicated in Table 4.

CC10 is expected to require a small amount of new P-152MR fill material. A subgrade study was conducted on P-152MR during CC8 to determine if there were any changes in the material over time. Researchers in that study found that as exposure to the elements increased, the level of oxidation also increased which is believed to cause the variation of stiffness/strength properties throughout CCs [5]. As a result, the subgrade material will be tested to verify the properties previously characterized during CC8 and CC9.

Table 4. Sampling standards for each material

Material	Standard(s)	Comments
P-152MR	ASTM D75 (Stockpiled); ASTM D1587 (In-Place)	In-place samples to be backfilled in-kind.
P-154MR	ASTM D75	Loose samples to be collected after placement, but before compaction on the final lift. In-place samples to be collected outside wander pattern and backfilled in-kind.
P-403MR	ASTM D979	Loose samples to be collected from the back of the truck or paver for the final lift.
P-501MR	ASTM C172; ASTM C31	NAPTF NextGen Pavement Materials Laboratory to be used as curing facility.

Locations for sampling are determined by the Engineer and collected by the FAA NextGen Pavements Materials Laboratory. All tests, including quantity and purpose, are provided in Table 5 below. It is anticipated that the FAA NextGen Pavements Material Laboratory will perform all tests in this table except for P-501MR MIRA testing. The NDT engineer is responsible for MIRA coordination/testing.

Table 5. Laboratory test plan for each material

Test	Standard	# of Tests	Purpose
P-152MR			
Atterberg Limits	ASTM D4318	3	Characterize soil
Specific Gravity	ASTM D854	3	Characterize soil
Modified Proctor	ASTM D1557	2	Develop moisture content and density relationship
Laboratory CBR[1]	ASTM D1883	10	Develop moisture content and CBR relationship
Drive Cylinder	ASTM D2937, ASTM D2216	TBD[2]	Moisture content, density
Resilient Modulus and Quick Shear[3]	AASHTO T307	9	Material stiffness, cohesion, angle of friction
Permanent Deformation[4]	N/A	9	Permanent plastic strain
P-154MR			
Sieve Analysis (pre-compaction)	ASTM C136/C117	3	Particle size distribution before compaction
Sieve Analysis (post-compaction)	ASTM C136/C117	3	Particle size distribution after compaction
Atterberg Limits	ASTM D4318	3	Characterize subbase
Specific Gravity	ASTM D854	3	Characterize subbase
Modified Proctor	ASTM D1557	3	Develop moisture content and density relationship
Resilient Modulus and Quick Shear	AASHTO T307	3	Material stiffness, cohesion, angle of friction
Permanent Deformation[4]	N/A	9	Permanent plastic strain

Table 5. Laboratory test plan for each material (continued)

Test	Standard	# of Tests	Purpose
P-403MR			
Air Voids	ASTM D2041/ D2726/D3203	TBD[5]	Acceptance testing
Asphalt Content by Ignition	ASTM D6307	TBD[6]	Acceptance testing
Sieve Analysis	ASTM C136/C117	TBD[6]	Acceptance testing
Dynamic Modulus	AASHTO T342	5	Stiffness
Flow Number	AASHTO TP79	5	Permanent deformation
Asphalt Pavement Analyzer (100psi and 254psi)	AASHTO T340	12	Rutting
High Temperature Indirect Tension	ASTM D6931	3	Rutting
Stress Sweep Rutting	N/A	6	Rutting
P-501MR			
Temperature	ASTM C1064	1 per truck[7]	Acceptance
Slump	ASTM C143	1 per truck[7]	Acceptance
Air Content	ASTM C231	1 per truck[7]	Acceptance
Unit Weight	ASTM C138	1 per truck[7]	Characterize concrete mix
Compressive Strength/Maturity Monitoring	ASTM C39/1074	1 per truck	1-day compressive strength
		1 per truck	3-day compressive strength
		1 per truck	7-day compressive strength
		1 per truck	14-day compressive strength
		1 per truck	28-day compressive strength
Flexural Strength	ASTM C78	1 per truck	1-day flexural strength
		1 per truck	3-day flexural strength
		1 per truck	7-day flexural strength
		1 per truck	14-day flexural strength
		1 per truck	28-day flexural strength[7]
		1 per truck	Pre-traffic flexural strength
Resonant Frequencies	ASTM C215	TBD[8]	Dynamic modulus of elasticity, dynamic modulus of rigidity, dynamic Poisson's ratio
Coefficient of Thermal Expansion	AASHTO T336	3[9]	Pre-traffic coefficient of thermal expansion
MIRA	N/A	TBD[10]	Detect hidden defects
P-610MR			
Temperature	ASTM C1064	1 per truck[7]	Acceptance
Slump	ASTM C143	1 per truck[7]	Acceptance
Air Content	ASTM C231	1 per truck[7]	Acceptance
Unit Weight	ASTM C138	1 per truck[7]	Characterize concrete mix
Compressive Strength	ASTM C39	1 per truck[7]	Acceptance (28-day)
Light Fixture Stud Strain Gauges			
Calibration	Custom procedure used for project BAA ARAS0004	each gauge	Calibrate instrumented studs to provide results in units of pounds-force of clamping force.

[1] Unsoaked laboratory CBR penetration tests conducted on each point of the modified proctor test by turning the mold upside down. CBR penetrations should be conducted on at least 5 samples prepared at moisture contents between 20% and 30%.

[2] Number of tests is dependent on how many accepted lifts for the Contractor to reach design grade. One drive cylinder to be taken next to each accepted CBR location.

[3] Three tests (25%, 50%, and 75% of failure stress determined by quick shear) to be performed for each test item
[4] Stress states (e.g. 50%, 70%, and 90%) will be determined once resilient modulus testing and quick shear testing is completed. Three samples to be tested for each stress state.
[5] Number of samples dependent on how many days of placement. Anticipation is one day of placement which would be a total of 12 samples (4x's each of lab compacted, field compacted mat, and field compacted joint).
[6] Number of samples dependent on how many days of placement. Anticipation is one day of placement which would be a total of four samples.
[7] Trucks to be randomly selected prior to placement to be considered for acceptance testing.
[8] Test on each compressive strength and flexural strength sample prior to breaking them.
[9] Recommend obtaining these samples from those already cast for compressive strength testing. Required geometry can be fabricated by cutting and coring a 6-inch diameter cylinder.
[10] Test on each flexural strength sample prior to breaking them. Additionally, for each pre-traffic flexural beam, test at 1-day, 3-day, 7-day, 28-day, and pre-traffic to monitor any changes that may occur in the beam throughout curing.

5.5 FIELD CHARACTERIZATION PLAN

5.5.1 Field Characterization During Construction

Unless otherwise noted, NDT will be conducted on the final, surface accepted lift to characterize the entire structure and support the objectives in Section 2. These tests are performed to provide a baseline for all layers that can ultimately be correlated to the NDT that is performed during trafficking operations. All tests, including quantity and purpose, are provided in Table 6 below. The NDT Engineer is responsible for the coordination of these tests with the FAA and other on-site contractors as necessary.

Table 6. Field characterization test plan (construction)

Test	Standard	Purpose	Locations
P-152MR			
In-Place CBR	ASTM 4429/ NAPTF SOP	Acceptance	Determined randomly by Engineer for each lift
Straightedge/ Smoothness	NAPTF SOP	Acceptance	Longitudinal – offsets -25ft, -10ft, 10ft, and 25ft (full length); Transverse – every 15ft (full width); as determined by Engineer
Grade	NAPTF SOP	Acceptance	5ft by 5ft grid using rod and level or equivalent
Leica Scan	NAPTF SOP	Surface elevations	Full length and width
Vane Shear	ASTM D2573/ NAPTF SOP	Shear strength	Transverse offsets ±25ft, ±15ft, and ±5ft at STA 3+05, 3+20, 3+35, 3+50, 3+65, 3+80, 3+95, 4+05, 4+20, 4+35, 4+50, 4+65, 4+80, 4+95, 5+05, 5+20, 5+35, 5+50, 5+65, 5+80, 5+95; each accepted CBR location
LWD	ASTM E2583	Elastic modulus	Transverse offsets ±25ft, ±15ft, and ±5ft at STA 3+05, 3+20, 3+35, 3+50, 3+65, 3+80, 3+95, 4+05, 4+20, 4+35, 4+50, 4+65, 4+80, 4+95, 5+05, 5+20, 5+35, 5+50, 5+65, 5+80, 5+95; each accepted CBR location
D-PSPA	NAPTF SOP	Seismic modulus, stiffness	Transverse offsets ±25ft, ±15ft, and ±5ft at STA 3+05, 3+20, 3+35, 3+50, 3+65, 3+80, 3+95, 4+05, 4+20, 4+35, 4+50, 4+65, 4+80, 4+95, 5+05, 5+20, 5+35, 5+50, 5+65, 5+80, 5+95
GeoGauge	ASTM D6758/ NAPTF SOP	Stiffness and apparent modulus	Transverse offsets ±25ft, ±15ft, and ±5ft at STA 3+05, 3+20, 3+35, 3+50, 3+65, 3+80, 3+95, 4+05, 4+20, 4+35, 4+50, 4+65, 4+80, 4+95, 5+05, 5+20, 5+35, 5+50, 5+65, 5+80, 5+95
DCP	ASTM D6951	Soil strength and uniformity	Transverse offsets -15ft, 0ft, and 15ft at STA 3+50, 4+50, 5+50

Table 6. Field characterization test plan (construction) (continued)

Test	Standard	Purpose	Locations
P-152MR			
HWD	ASTM D4694/ NAPTF SOP	Elastic modulus, normalized deflections	Transverse offsets -15ft, 0ft, and 15ft at STA 3+35, 4+35, 5+35
Plate Load	ASTM D1195/ NAPTF SOP	k value	Transverse offsets -15ft, 0ft, and 15ft at STA 3+50, 4+50, 5+50
P-154MR			
In-Place Density	ASTM D6938	Acceptance	Determined randomly by Engineer for each lift
Straightedge/ Smoothness	NAPTF SOP	Acceptance	Longitudinal – offsets -25ft, -10ft, 10ft, and 25ft (full length); Transverse – every 15ft (full width); as determined by Engineer
Grade	NAPTF SOP	Acceptance	5ft by 5ft grid using rod and level or equivalent
Leica Scan	NAPTF SOP	Surface elevations	Full length and width
LWD	ASTM E2583	Elastic modulus	Transverse offsets ±25ft, ±15ft, and ±5ft at STA 3+05, 3+20, 3+35, 3+50, 3+65, 3+80, 3+95, 4+05, 4+20, 4+35, 4+50, 4+65, 4+80, 4+95, 5+05, 5+20, 5+35, 5+50, 5+65, 5+80, 5+95
D-PSPA	NAPTF SOP	Seismic modulus, stiffness	Transverse offsets ±25ft, ±15ft, and ±5ft at STA 3+05, 3+20, 3+35, 3+50, 3+65, 3+80, 3+95, 4+05, 4+20, 4+35, 4+50, 4+65, 4+80, 4+95, 5+05, 5+20, 5+35, 5+50, 5+65, 5+80, 5+95
GeoGauge	ASTM D6758/ NAPTF SOP	Stiffness and apparent modulus	Transverse offsets ±25ft, ±15ft, and ±5ft at STA 3+05, 3+20, 3+35, 3+50, 3+65, 3+80, 3+95, 4+05, 4+20, 4+35, 4+50, 4+65, 4+80, 4+95, 5+05, 5+20, 5+35, 5+50, 5+65, 5+80, 5+95
DCP	ASTM D6951	Soil strength and uniformity	Transverse offsets -15ft, 0ft, and 15ft at STA 3+50, 4+50, 5+50
HWD	ASTM D4694/ NAPTF SOP	Elastic modulus, normalized deflections	Transverse offsets -15ft, 0ft, and 15ft at STA 3+65, 4+65, 5+65
Plate Load	ASTM D1195/ NAPTF SOP	k value	Transverse offsets -15ft, 0ft, and 15ft at STA 3+50, 4+50, 5+50
P-403MR			
Straightedge/ Smoothness	NAPTF SOP	Acceptance	Longitudinal – center of each paving lane (if <20ft) or third points Transverse – every 15ft (full width); as determined by Engineer
Grade	NAPTF SOP	Acceptance	5ft by 5ft grid using rod and level or equivalent
Leica Scan	NAPTF SOP	Surface elevations	Full length and width
PSPA	NAPTF SOP	Seismic modulus, stiffness	Transverse offsets -17.5ft, 0ft, and 17.5ft at STA 3+14, 3+32, 3+50, 3+68, 3+86, 4+14, 4+32, 4+50, 4+68, 4+86, 5+14, 5+32, 5+50, 5+68, 5+86
HWD	ASTM D4694/ NAPTF SOP	Elastic modulus, normalized deflections	Transverse offsets -17.5ft, 0ft, and 17.5ft at STA 3+14, 3+32, 3+50, 3+68, 3+86, 4+14, 4+32, 4+50, 4+68, 4+86, 5+14, 5+32, 5+50, 5+68, 5+86
Plate Load	ASTM D1195/ NAPTF SOP	k value	Transverse offsets -17.5ft, 0ft, and 17.5ft at STA 3+50, 4+50, 5+50

Table 6. Field characterization test plan (construction) (concluded)

P-501MR			
Test	**Standard**	**Purpose**	**Locations**
Straightedge/ Smoothness	NAPTF SOP	Acceptance	Longitudinal – center of each paving lane (if <20ft) or third points Transverse – every 15ft (full width); as determined by Engineer
Grade	NAPTF SOP	Acceptance	5ft by 5ft grid using rod and level or equivalent
Leica Scan	NAPTF SOP	Surface elevations	Full length and width
PSPA	NAPTF SOP	Seismic modulus, stiffness	Transverse offsets -17.5ft, 0ft, and 17.5ft at STA 3+14, 3+32, 3+50, 3+68, 3+86, 4+14, 4+32, 4+50, 4+68, 4+86, 5+14, 5+32, 5+50, 5+68, 5+86
HWD[1]	ASTM D4694/ NAPTF SOP	Elastic modulus, normalized deflections	Transverse offsets -17.5ft, 0ft, and 17.5ft at STA 3+14, 3+32, 3+50, 3+68, 3+86, 4+14, 4+32, 4+50, 4+68, 4+86, 5+14, 5+32, 5+50, 5+68, 5+86

[1] 12-kip, 24-kip, and 36-kip drops

5.5.2 Pre-Trafficking Field Characterization Plan

An extensive NDT plan will be carried out to monitor the changes in the pavement throughout trafficking and support the objectives in Section 2. The NDT shown in Table 7 shall be performed immediately prior to trafficking a test item to provide a baseline. Standard testing locations vary between each type of NDT. Testing may be conducted at discrete locations (HWD, PSPA, ELATextur, MIT Scan 2-BT, MIT Scan T2, and MIRA), along transverse/longitudinal lines (GPR and SurPro), or across the full pavement area (Leica 3D scanner, NDT van 2D/3D imaging, and manual pavement survey).

Table 7. CC10 NDT testing plan (pre-trafficking)

Device	Purpose	Locations
HWD[1]	Elastic modulus, normalized deflections	Center of each slab; eddy current sensor locations; pressure cell locations; on top of light fixtures; longitudinal and transverse joint transfer (four slabs per test item – two north, two south)
PSPA	Seismic modulus, stiffness	Center of each slab; eddy current sensor locations; pressure cell locations
GPR	Layer thickness	Ground coupled – two transverse lines at center of each slab per test item, MIRA locations in MRS-3 Air coupled (van) – longitudinal lines at Track 0, Track ±3, MIT Scan T2 Target locations, and centerline of pavement
Leica 3D Scanner	3D point cloud, rut depth, transverse and longitudinal pavement profiles	Full width
NDT Van 2D/3D Imaging	2D/3D pavement surface images	Full width
Manual Pavement Survey	Crack mapping, pavement condition index	Full width
ELATextur	Mean profile depth, estimated texture depth	Three measurements in the wheel path, three measurements outside the wheel path per test item
SurPro	Transverse and longitudinal pavement profiles, Leica QC	Transverse lines at STA 3+50, 4+50, and 5+50 Longitudinal lines at offsets -9.75ft and 9.75ft
MIT Scan 2-BT	Determine dowel placement	All dowel locations
MIT Scan T2	Thickness verification	One target to be placed at Track ±3 for each test item at the bottom of the P-403MR and P-501MR layers (three targets required total for project)
MIRA[2]	Detect defects in pavement	6in and 18in from joint locations – every 3 inches. Four slabs per test item (two north, two south)

[1] 12-kip, 24-kip, and 36-kip drops
[2] Machine should be oriented parallel to the joint

5.5.3 Field Characterization During Trafficking

Once trafficking commences, the frequency of testing will vary depending on the device and the anticipated life of the test section. Each device and testing frequency are provided below in Table 8. Trafficking is only expected to occur 2-3 days a week to allow sufficient time for characterization testing and to provide NAPTV access for other projects.

Table 8. CC10 NDT testing plan (during trafficking)

Device	Locations	Frequency			
		Percent of Life	MRS-1	MRS-2	MRS-3
HWD[1]	Center of each slab; eddy current sensor locations; pressure cell locations; on top of light fixtures; longitudinal and transverse joint transfer (four slabs per test item – two north, two south)	~2%	Monthly	Weekly	Daily
PSPA	Center of each slab; eddy current sensor locations; pressure cell locations	~2%	Monthly	Weekly	Daily
GPR	Ground coupled – two transverse lines at center of each slab per test item, MIRA locations in MRS-3 Air coupled (van) – longitudinal lines at Track 0, Track ±3, and centerline of pavement	~20%	Yearly	Monthly	Bi-weekly
Leica 3D Scanner	Full width	~2%	Monthly	Weekly	Daily
NDT Van 2D/3D Imaging	Full width	~5%	Bi-monthly	Bi-weekly	Weekly
Manual Pavement Survey	Full width	~1%	Weekly	Daily	Daily
ELATextur	Three measurements in the wheel path, three measurements outside the wheel path per test item	~100%	Post-Traffic	Post-Traffic	Post-Traffic
SurPro	Transverse lines at STA 3+50, 4+50, and 5+50 Longitudinal lines at offsets -9.75ft and 9.75ft	~5%	Bi-monthly	Bi-weekly	Weekly
MIT Scan 2-BT	All dowel locations	~20%	Yearly	Monthly	Bi-weekly
MIT Scan T2	One target to be placed at Track ±3 for each test item at the bottom of the P-403MR and P-501MR layers (three targets required total for project).	~20%	Yearly	Monthly	Bi-weekly
MIRA[2]	6in and 18in from joint locations – every 3 inches. Four slabs per test item (two north, two south).	~5%	Bi-monthly	Bi-weekly	Weekly

[1] 12kip, 24kip, and 36kip drops
[2] Machine oriented parallel to the joint

5.5.4 Post-Traffic Testing

The post traffic test plan will be developed at the end of the experiment to reflect field conditions and observations during the experiment. It is expected to be substantially similar to the laboratory characterization plan and pre-traffic testing plan.

6 REFERENCES

[1] Federal Aviation Administration, "Advisory Circular No: 150/5320-6G - Airport Pavement Design and Evaluation," U.S. Department of Transportation, Washington D.C., 2021.

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[3] N. Lajnef, *Smart Pavement Monitoring,* Michigan State University, 2021.

[4] Applied Research Associates, Inc., "In-Pavement Lighting Installation, Instrumentation, and Testing Data Analysis Report," Federal Aviation Administration, Egg Harbor Township, 2020.

[5] C. Cary and H. Yin, "Development of CBR-Based Construction Criteria for CC8 Subgrade Compaction At the National Airport Pavement Test Facility," 2017.

[6] Federal Aviation Administration, "Advisory Circular No: 150/5370-10H - Standard Specification for Construction of Airports," U.S. Department of Transportation, Washington D.c., 2018.

[7] C. Tomlinson, R. Aponte, J. Gawrysiak, B. Mahaffay and M. Flynn, "Construction Cycle 8 (CC8) Construction Report," Federal Aviation Administration, Egg Harbor Township, 2018.

[8] Applied Research Associates, "Delivery Order 050 Construction Cycle 9 Report," Federal Aviation Administration, Egg Harbor Township, 2020.

APPENDIX A – CONSTRUCTION CYCLE 10 DESIGN REPORT

APPENDIX B – PROPOSED CC10 WANDER PATTERN

APPENDIX C – CC8 POST-TRAFFIC TESTING PLAN