

Pennsylvania DOT Demonstration Project
for
Implementation of Performance Engineered Mixtures (PEM) / AASHTO PP 84

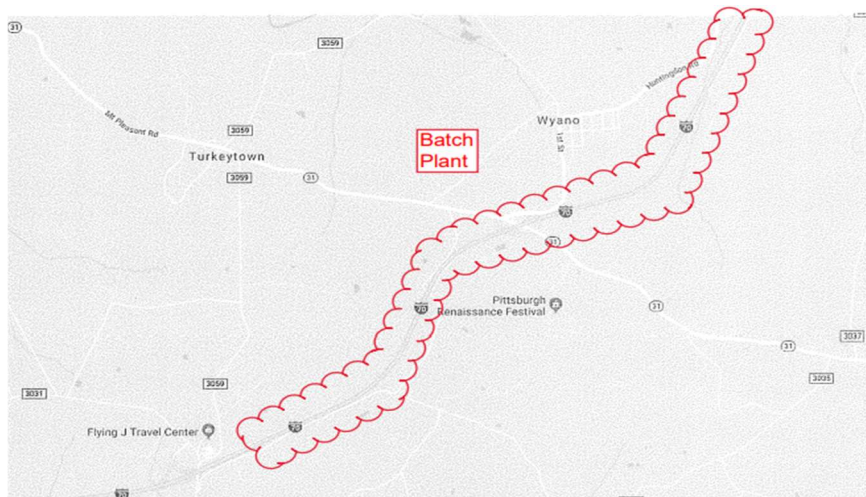
INTRODUCTION:

The Pennsylvania Department of Transportation applied for fund through the Performance Engineered Concrete Paving Mixtures pooled fund project (TPF-5(368)) to collect data and demonstrate the new tests. The application was approved by FHWA for a total of \$ 100,000. The application can be found in the Appendix.

Two projects were included in this demonstration project:

The first project location was on SR 376 in Moon Township, Allegheny County. The project limits are 2000 feet east of the Business 376 interchange to 1,100 feet east of the Airport terminal/PA turnpike Interchange. The project includes approximately 5 miles of full depth reconstruction of both east and westbound lanes of 11" thick concrete pavement and shoulders on 4" cement treated permeable base course on 6" of 2A subbase, on a cement stabilized subgrade.

The second project location was on SR 70 in South Huntington Township, Westmoreland County. The project limits are 4410 feet east of the I-70 Interchange #49 (Smithton) to 6125 feet east of the I-70 Interchange #51. The project includes approximately 3 miles of full depth reconstruction of both east and westbound lanes of 14" thick concrete pavement on 4" of cement treated permeable base on 6" of 2A subbase.



PEM implementation funds were used for the following:

Category A: Identify which tests you will be evaluating, your mix design/approval process, and how the use of the tests differs from your current process.

Currently, PennDOT requires trial batching, air, slump, unit weight, specific gravities, ASR mitigation (R80), fineness modulus, and compressive strength at 7 and 28 days for our mix designs. We have started doing CTE testing for our MEDPG design program. We specify a minimum and maximum cement content, and a maximum water cement ratio (for slip form paving it is 0.47).

Although there are several mix designs that are approved for this project, the contractor plans to submit several additional mixes that will incorporate the added tests required for this demonstration project.

For this project, we incorporate the following, in addition to what is currently require:

1. Rate of flexural strength development to 90 days
2. Rate of strength development to 90 days
3. ASTM C 157- Unrestrained Volume Change
4. Formation factor from resistivity testing
5. Super air meter
6. W/C ratio ≤ 0.45
7. Volume of paste

(These additional requirements will be obtained through SHADOW testing)

Category B: Identify which test(s) you will be evaluating, how your acceptance process will use the test(s) results, and how the use of the tests differs from your current process.

Currently, PennDOT requires slump, air content and temperature of the fresh concrete for QC control. Compressive strength testing of the hardened concrete is required for acceptance. W/C ratio is checked on every ticket also.

For this project, we incorporate the following, in addition to what is currently required:

1. Super Air Meter
2. Formation Factor from resistivity testing
3. Box Test

(These additional requirements will be obtained through SHADOW testing)

Category C: Identify what you will require in the QC Plan and how you will monitor compliance with the Plan. Note if you currently require QC Plans; if currently required, note how your process will differ on this project.

Currently PennDOT requires a yearly QC plan. The following are the minimum requirements: Describe the construction equipment, personnel, and methods necessary to construct and test concrete courses for all structural elements. Including testing frequencies and action points to initiate corrective measures. Action points and limits are established for slump, temperature, and air content.

For this project, we incorporate the following, in addition to what is currently required:

1. Unit weight (weekly)
2. Super air meter (1200 yd² or daily)
3. Water content (1200 yd² or daily)
4. Formation Factor from resistivity (1200 yd² or daily)
5. Box test (weekly)

These additional tests will be incorporated into the QC plan and the test results will be recorded.

Category D: Identify what control charts you will require the contractor/supplier to use and how the charts will be monitored during construction.

Currently PennDOT does not mandate any control charts for concrete paving. It is optional. Test results are recorded in a diary along with information about the concrete placement and weather conditions. Control charts are required at concrete plants and quarries for control of materials.

For this project, we will do control charts for the following tests:

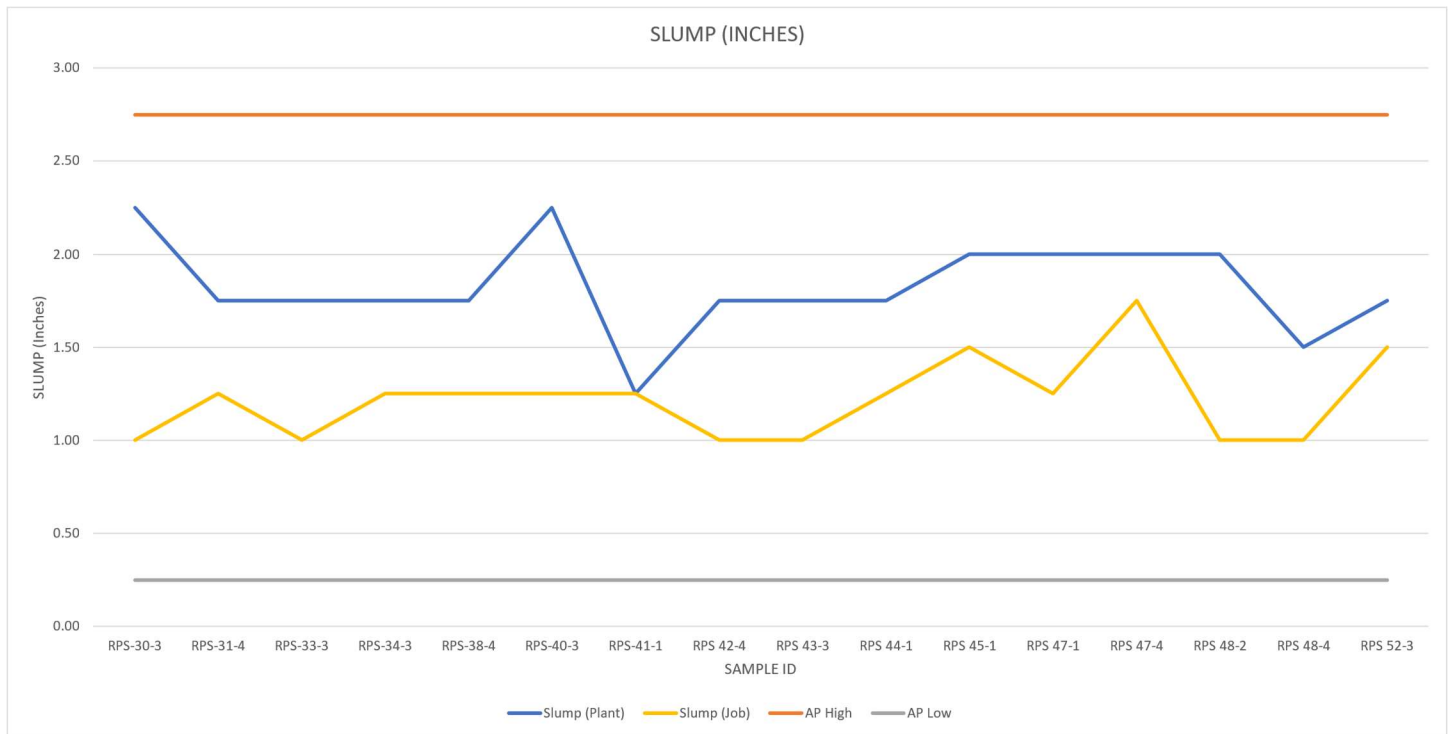
1. Super air meter
2. air content
3. Unit weight
4. Water content
5. Strength
6. Formation Factor from resistivity

(These additional requirements will be obtained through SHADOW testing)

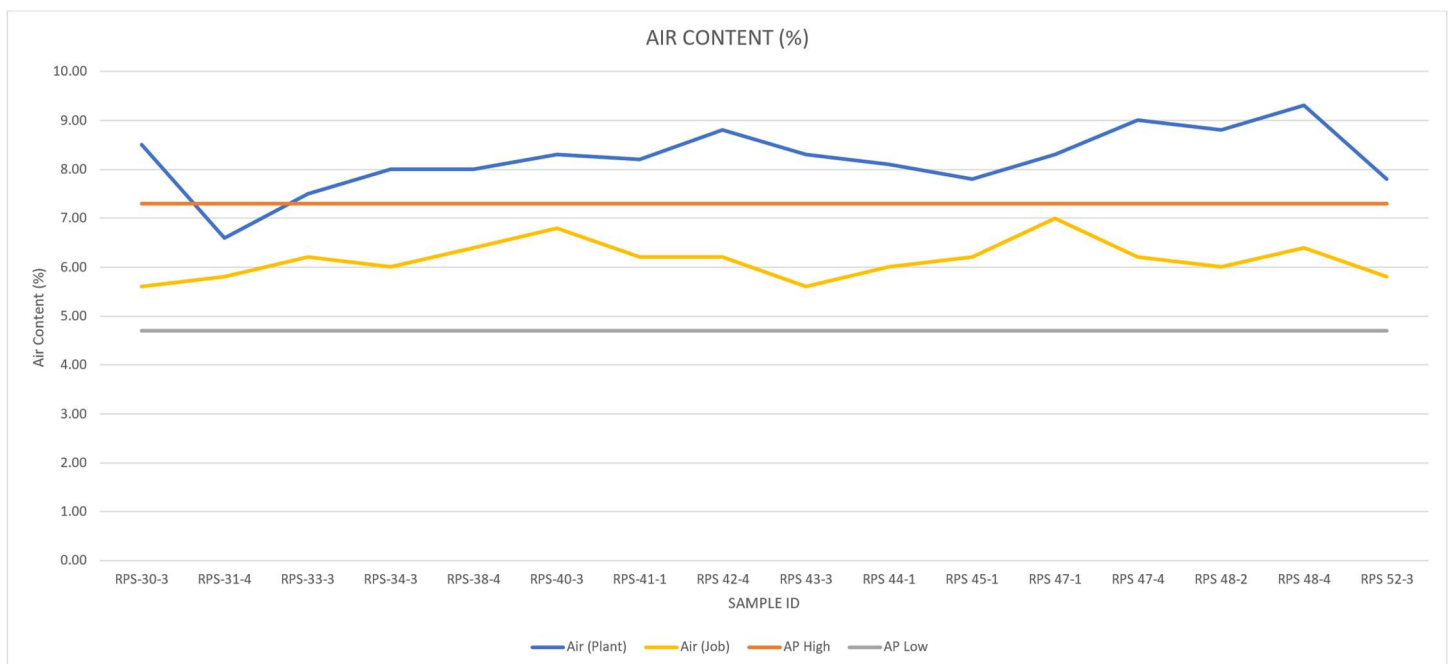
TEST RESULTS: All test data can be found in the appendix.

SR 376:

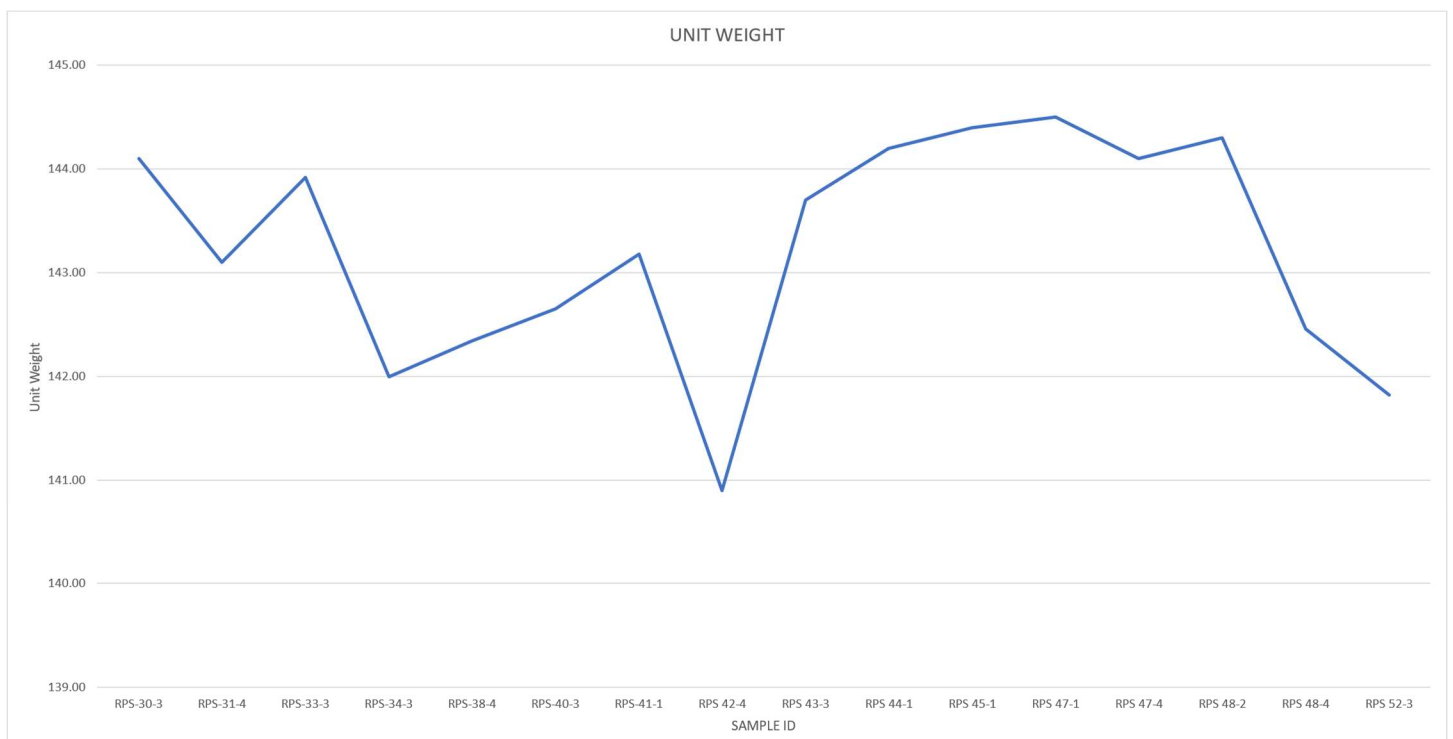
Slump



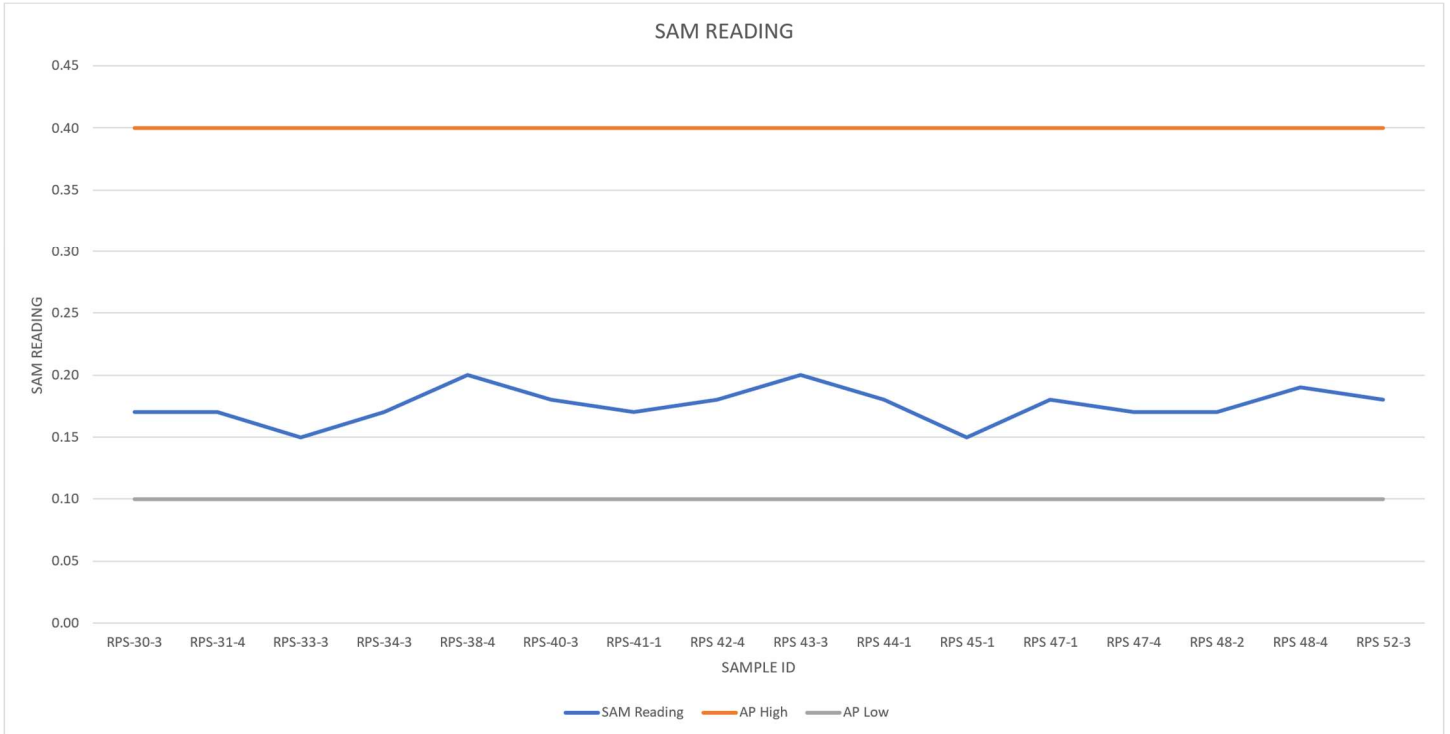
Air Content



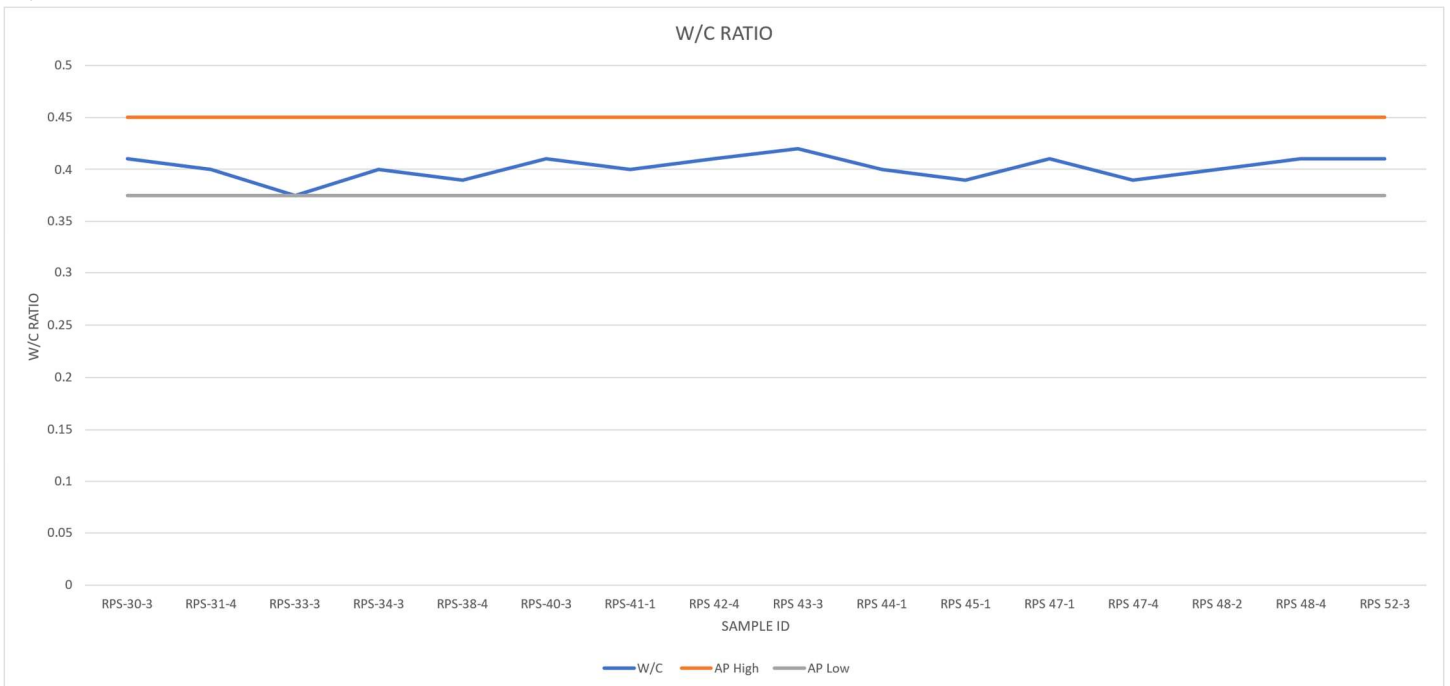
Unit Weight



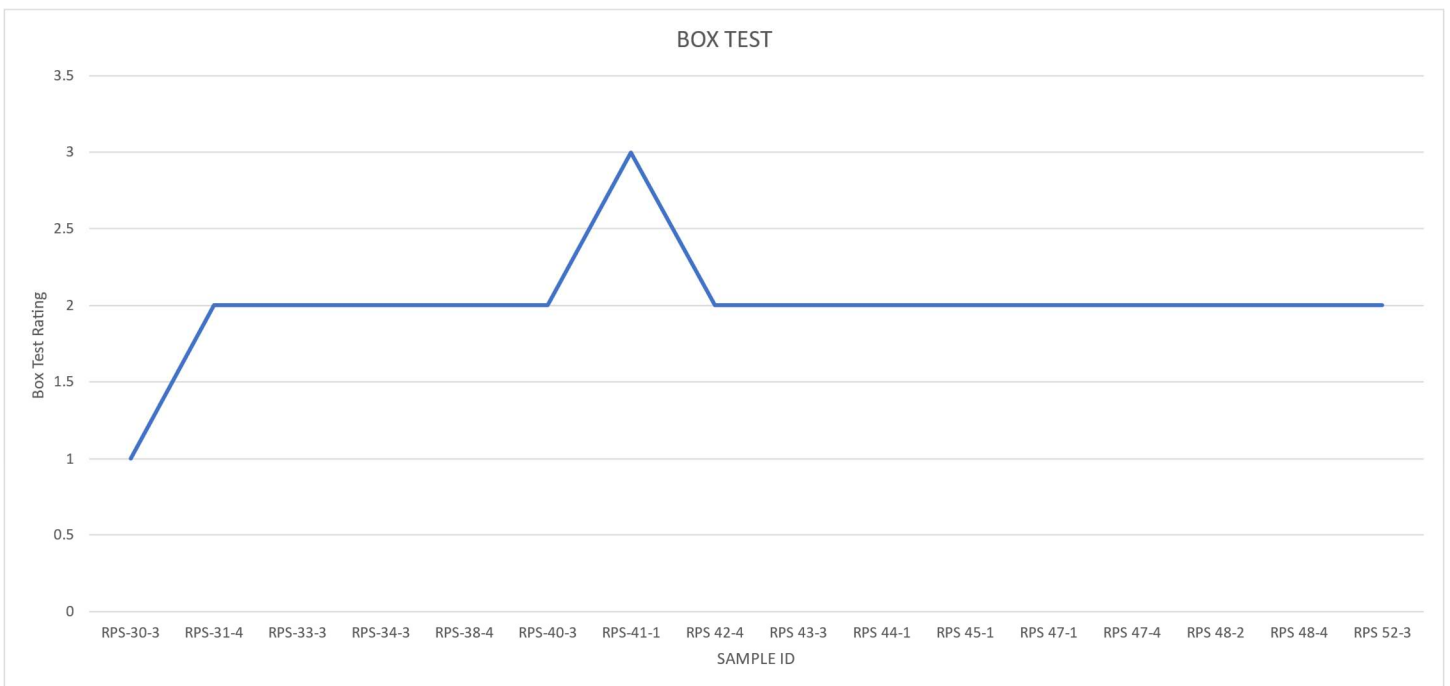
SAM



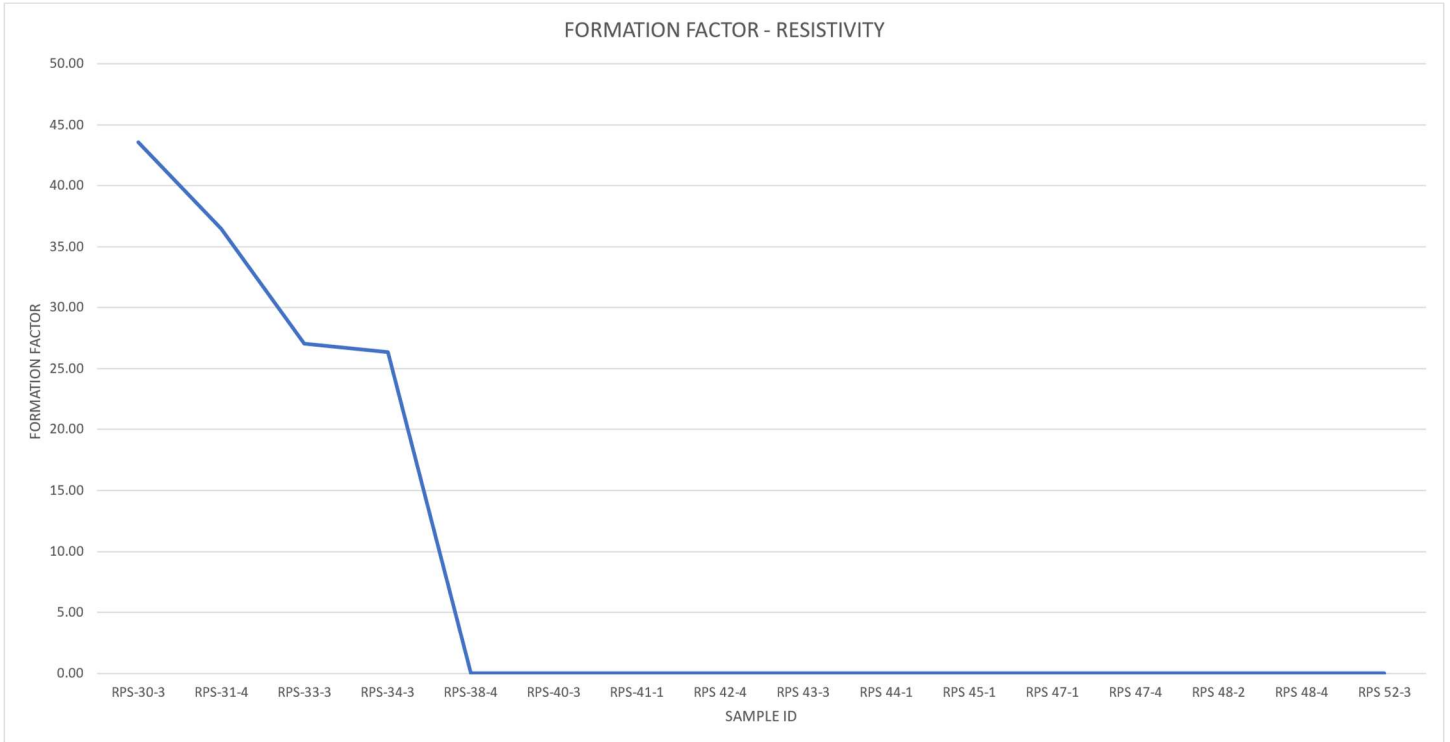
W/C



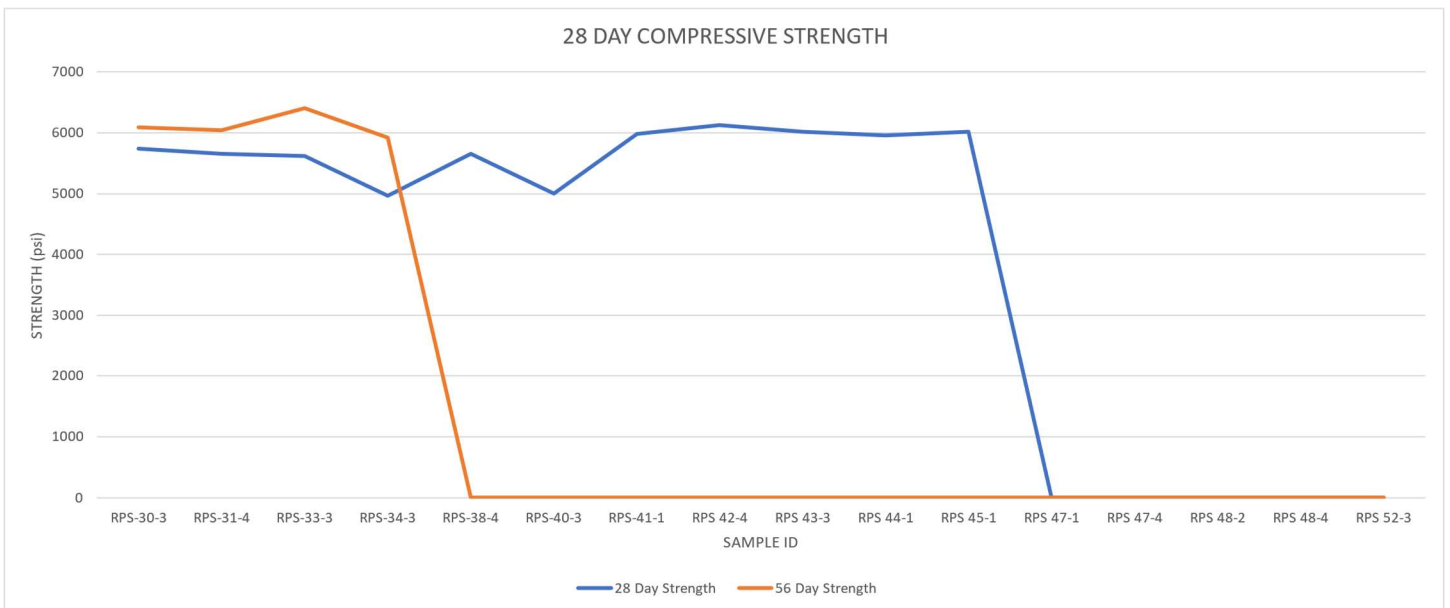
Box Test



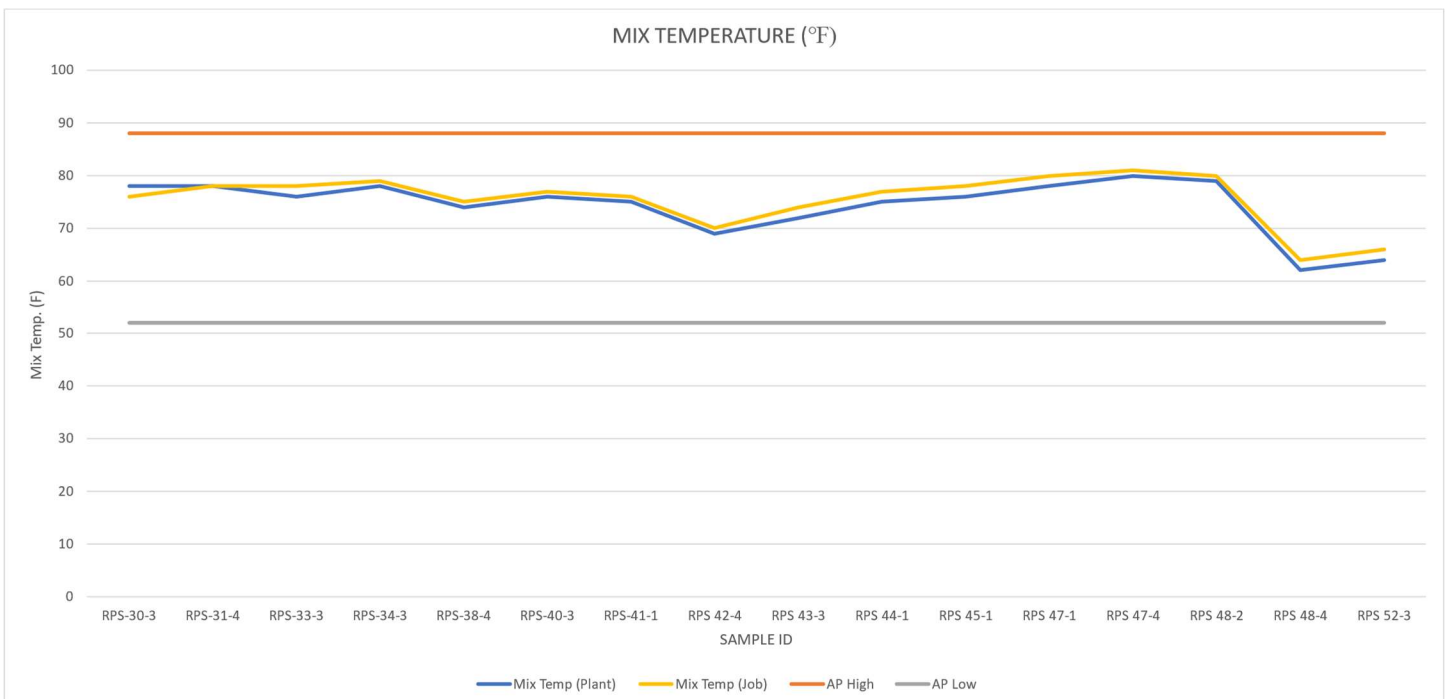
Resistivity



Strength

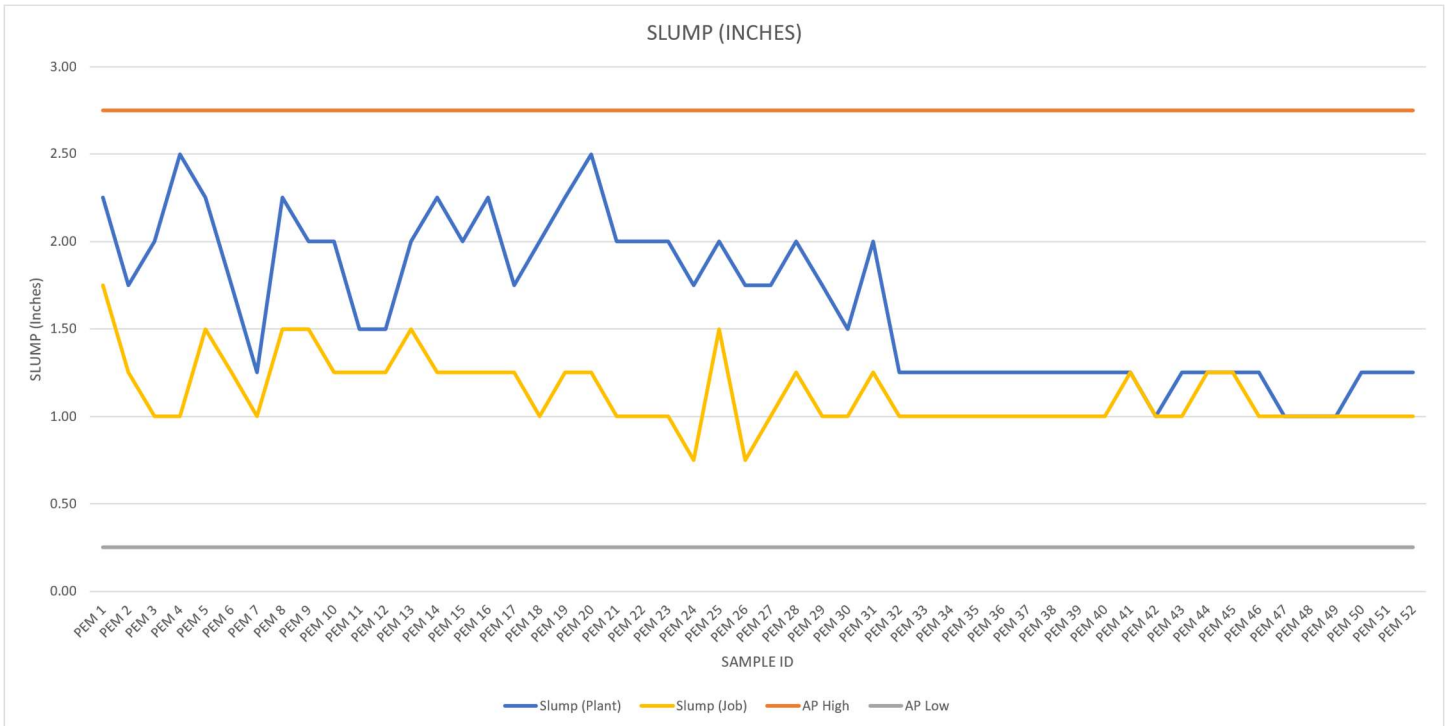


Mix Temperature

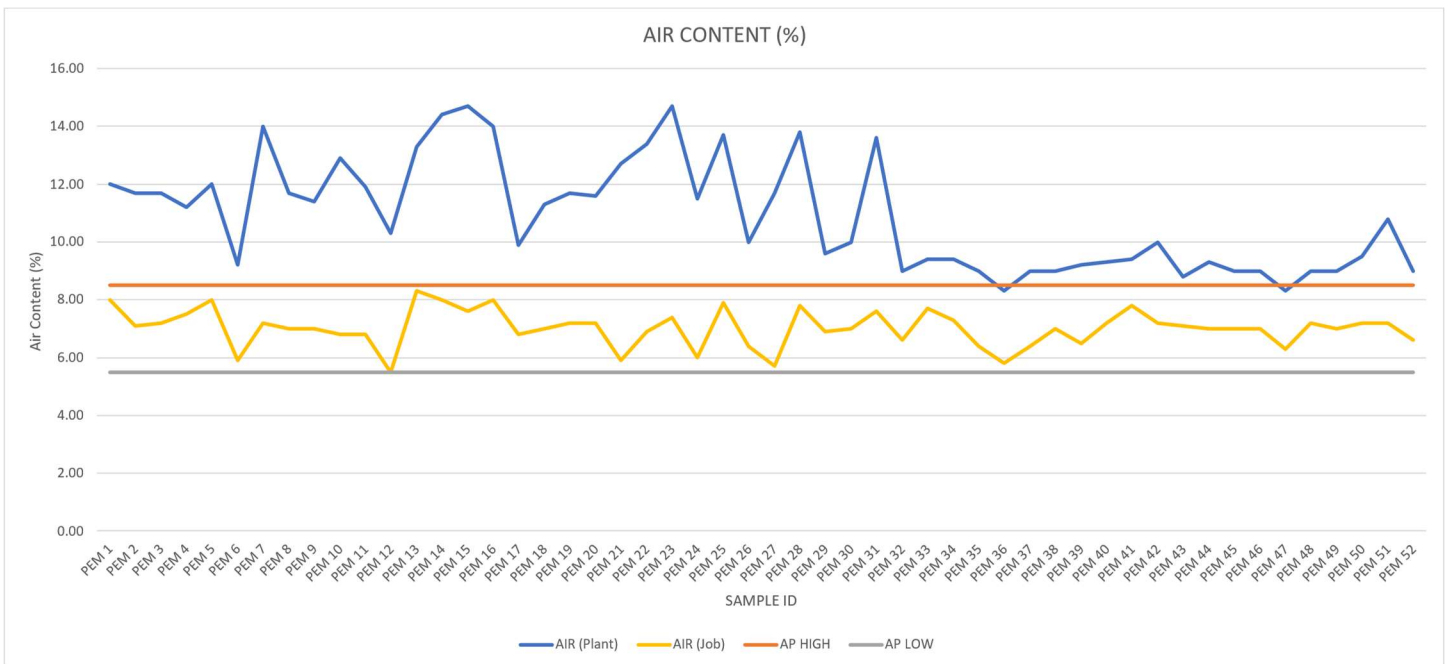


SR 70:

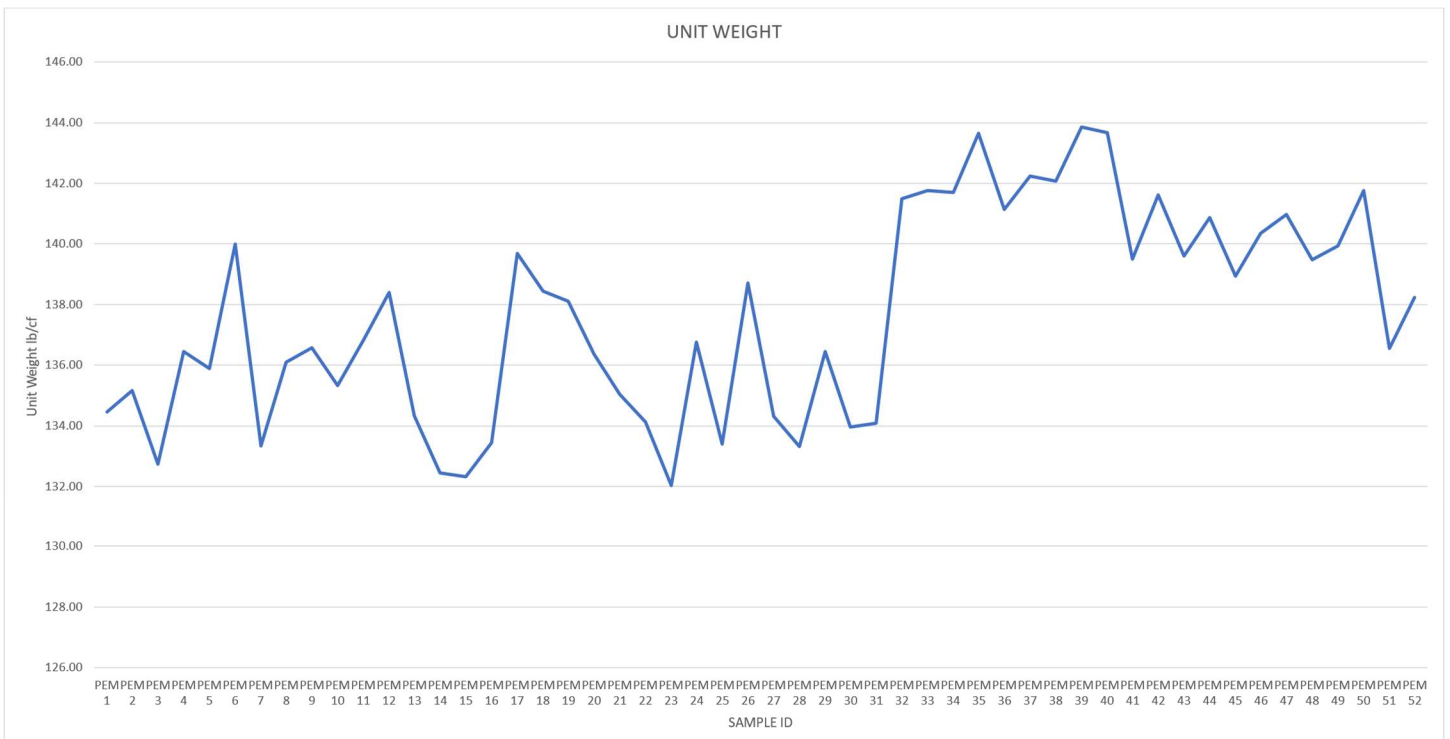
Slump



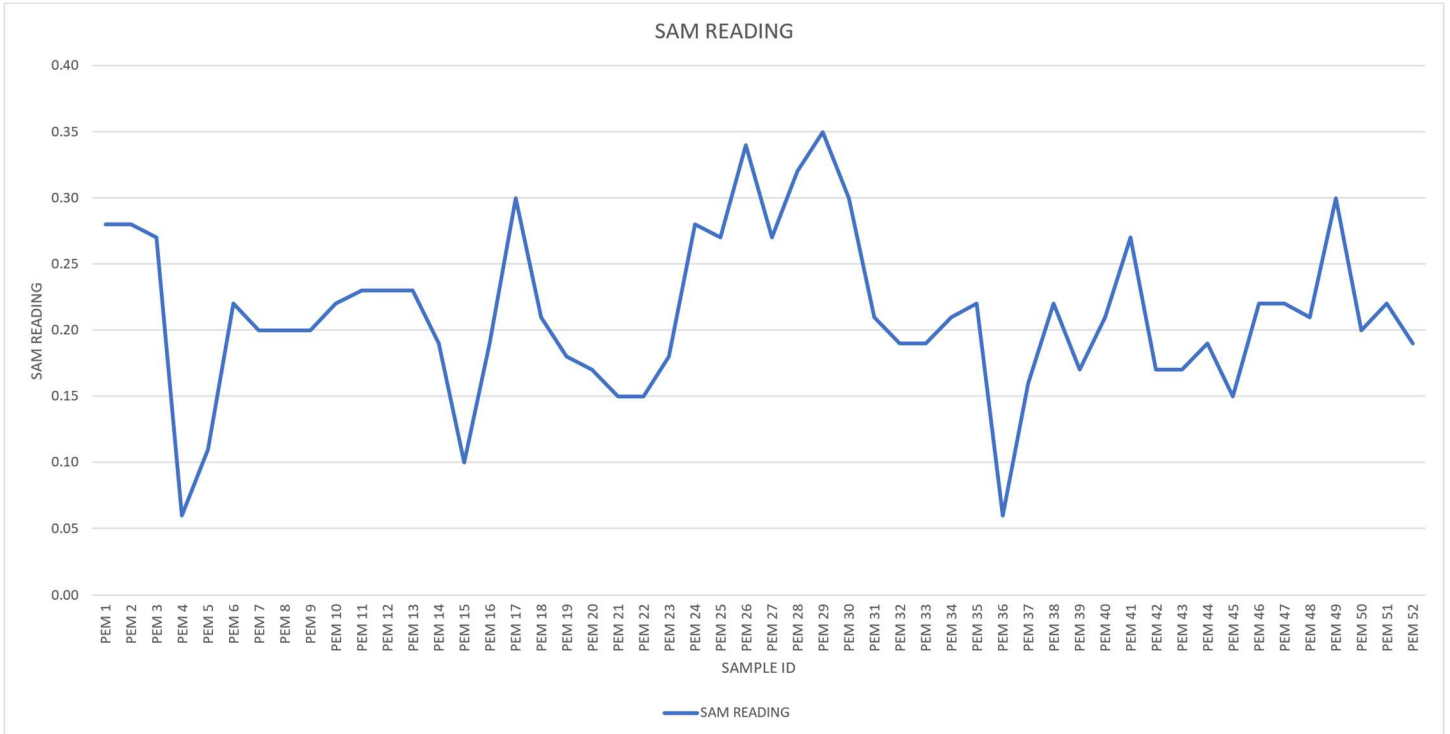
Air Content



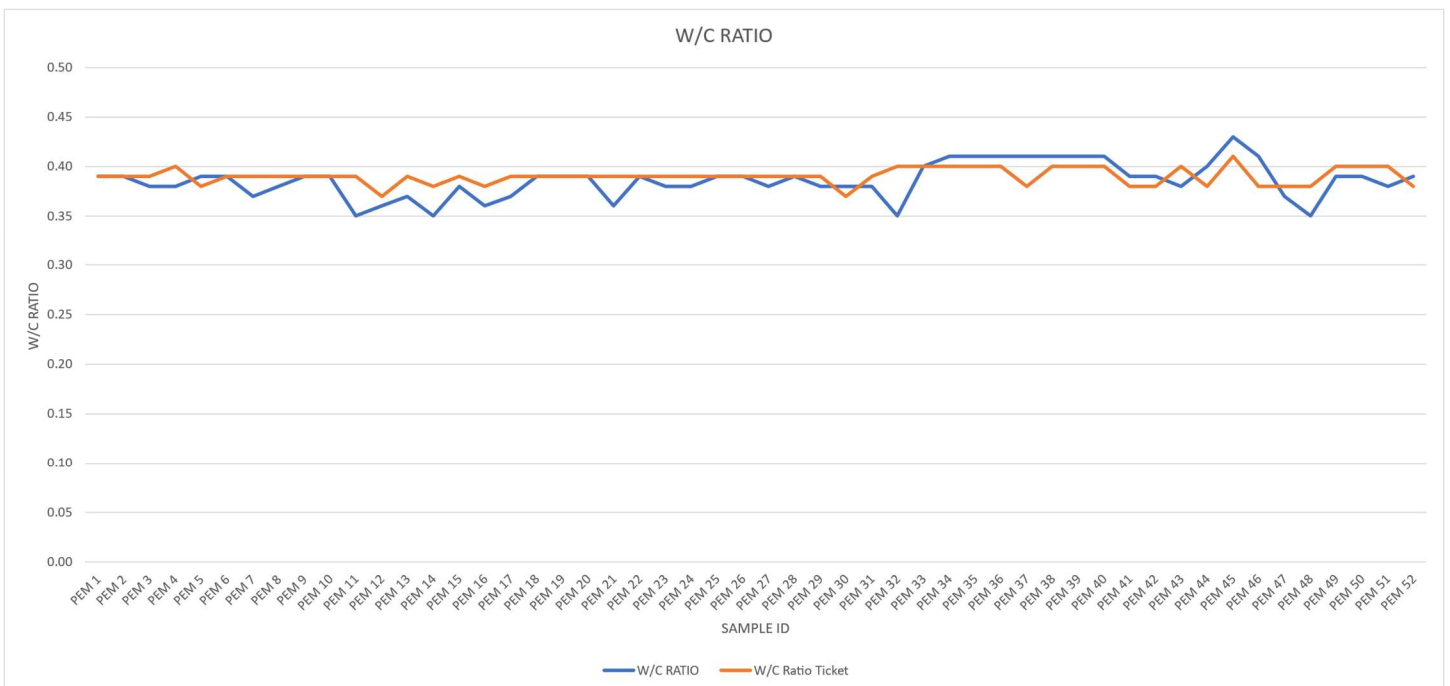
Unit Weight



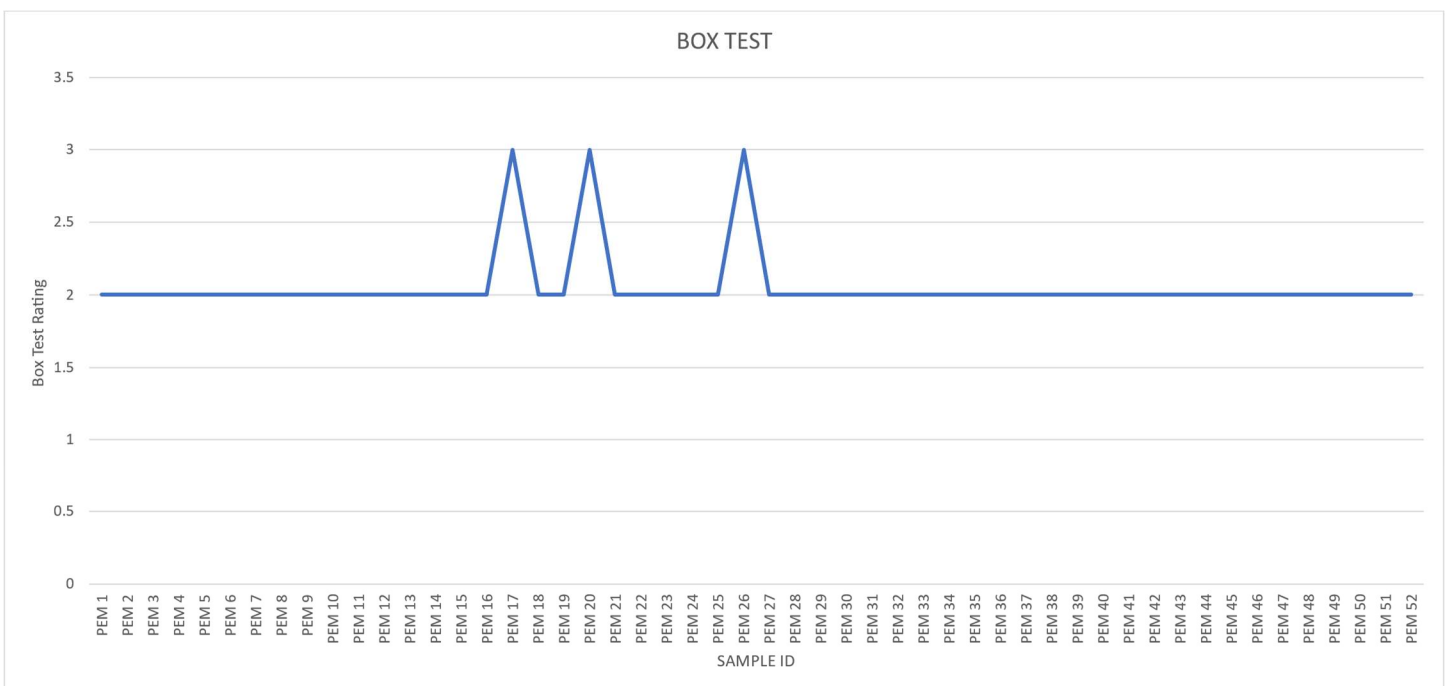
SAM



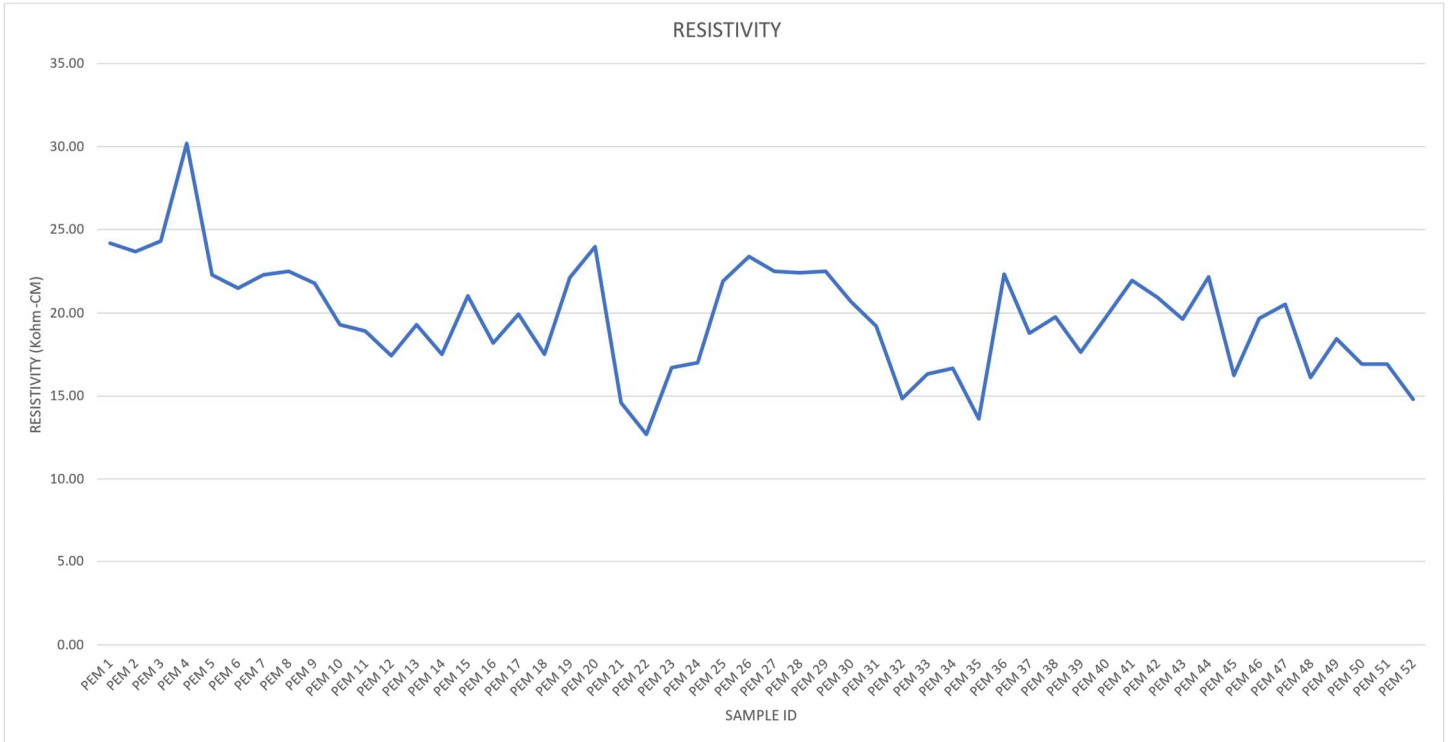
W/C Ratio



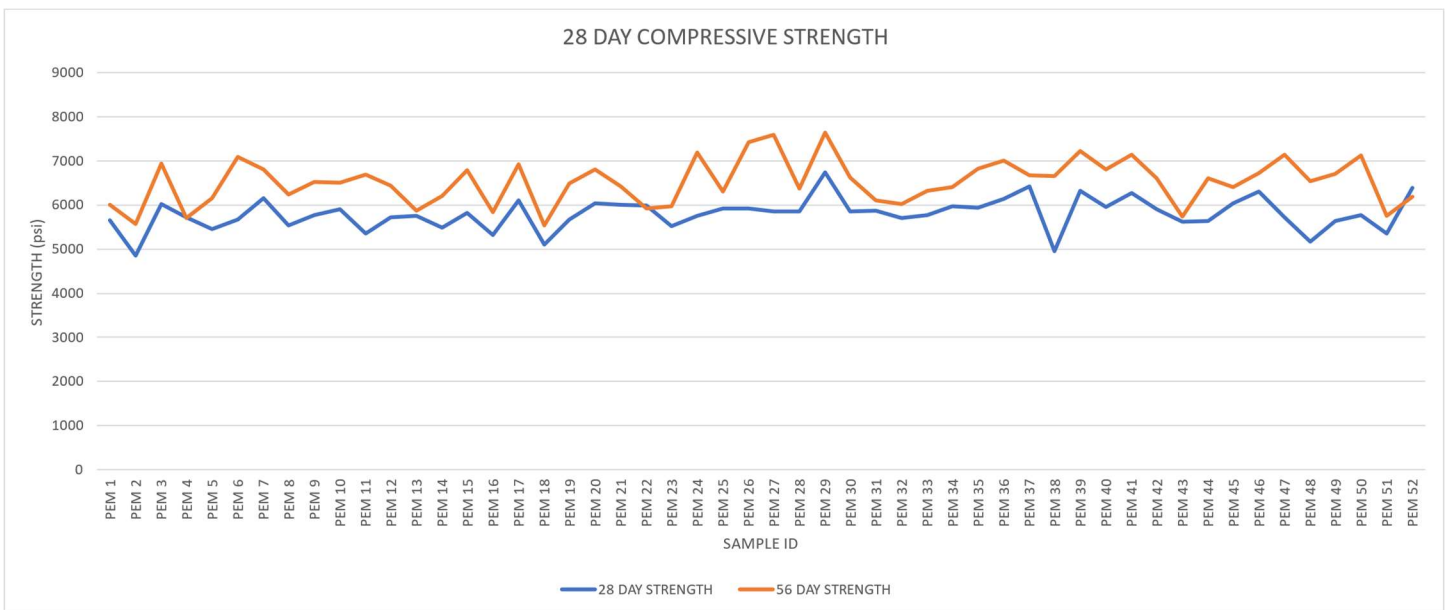
Box Test



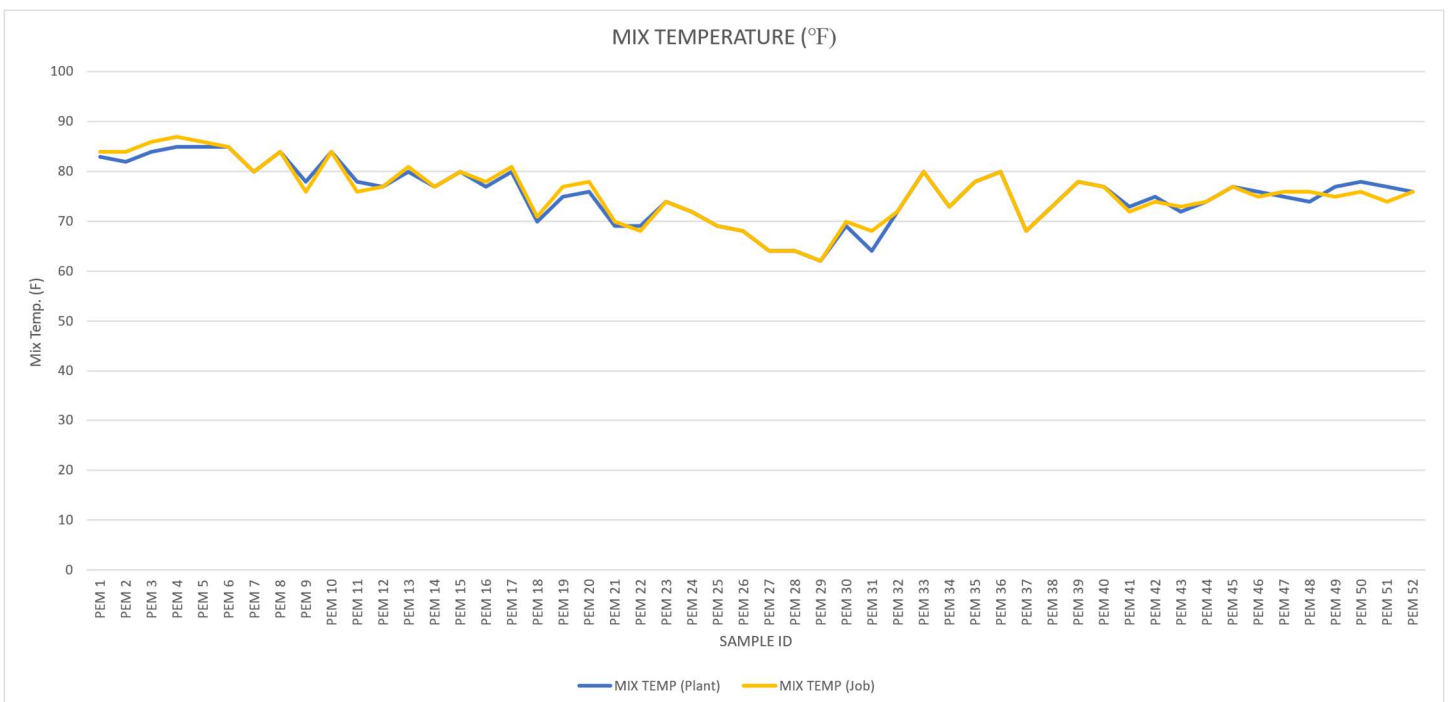
Resistivity



Compressive Strength



Mix Temperature



PEM Tests – Agency perspective:

Our current mix design criteria are as follows:

Slip Form Paving-

Cement Factor- 517 – 611 lbs./cu. yd.

W/C Ratio 0.37 to 0.42

Optimized Gradation

Permeability – AASHTO T 277 or AASHTO T 358

Shrinkage – ASTM C157

Aggregates – ASTM C1293 (Concrete mitigated as per AASHTO R 80)

The Box test will be incorporated in the design portion for paving mixes.

Resistivity during production is being discussed.

The SAM Air Meter is still being looked at. There are concerns about the durability of the meter.

APPENDIX :

Test data for SR 376:

Slump

| DATE | SAMPLE ID | SLUMP (Plant) | SLUMP (Job) | AP HIGH | AP LOW |
|------------|-----------|---------------|-------------|---------|--------|
| 8/15/2018 | RPS-30-3 | 2.25 | 1 | 2.75 | 0.25 |
| 8/20/2018 | RPS-31-4 | 1.75 | 1.25 | 2.75 | 0.25 |
| 8/23/2018 | RPS-33-3 | 1.75 | 1 | 2.75 | 0.25 |
| 8/27/2018 | RPS-34-3 | 1.75 | 1.25 | 2.75 | 0.25 |
| 9/11/2018 | RPS-38-4 | 1.75 | 1.25 | 2.75 | 0.25 |
| 9/13/2018 | RPS-40-3 | 2.25 | 1.25 | 2.75 | 0.25 |
| 9/15/2018 | RPS-41-1 | 1.25 | 1.25 | 2.75 | 0.25 |
| 9/24/2018 | RPS 42-4 | 1.75 | 1 | 2.75 | 0.25 |
| 9/29/2018 | RPS 43-3 | 1.75 | 1 | 2.75 | 0.25 |
| 10/1/2018 | RPS 44-1 | 1.75 | 1.25 | 2.75 | 0.25 |
| 10/3/2018 | RPS 45-1 | 2.00 | 1.5 | 2.75 | 0.25 |
| 10/8/2018 | RPS 47-1 | 2.00 | 1.25 | 2.75 | 0.25 |
| 10/10/2018 | RPS 47-4 | 2.00 | 1.75 | 2.75 | 0.25 |
| 10/11/2018 | RPS 48-2 | 2.00 | 1 | 2.75 | 0.25 |
| 10/13/2018 | RPS 48-4 | 1.50 | 1 | 2.75 | 0.25 |
| 10/30/2018 | RPS 52-3 | 1.75 | 1.5 | 2.75 | 0.25 |

Air Content

| DATE | SAMPLE ID | AIR (Plant SAM) | AIR (Job) | AP HIGH | AP LOW |
|------------|-----------|-----------------|-----------|---------|--------|
| 8/15/2018 | RPS-30-3 | 8.50 | 5.6 | 7.3 | 4.7 |
| 8/20/2018 | RPS-31-4 | 6.60 | 5.8 | 7.3 | 4.7 |
| 8/23/2018 | RPS-33-3 | 7.50 | 6.2 | 7.3 | 4.7 |
| 8/27/2018 | RPS-34-3 | 8.00 | 6 | 7.3 | 4.7 |
| 9/11/2018 | RPS-38-4 | 8.00 | 6.4 | 7.3 | 4.7 |
| 9/13/2018 | RPS-40-3 | 8.30 | 6.8 | 7.3 | 4.7 |
| 9/15/2018 | RPS-41-1 | 8.20 | 6.2 | 7.3 | 4.7 |
| 9/24/2018 | RPS 42-4 | 8.80 | 6.2 | 7.3 | 4.7 |
| 9/29/2018 | RPS 43-3 | 8.30 | 5.6 | 7.3 | 4.7 |
| 10/1/2018 | RPS 44-1 | 8.10 | 6 | 7.3 | 4.7 |
| 10/3/2018 | RPS 45-1 | 7.80 | 6.2 | 7.3 | 4.7 |
| 10/8/2018 | RPS 47-1 | 8.30 | 7 | 7.3 | 4.7 |
| 10/10/2018 | RPS 47-4 | 9.00 | 6.2 | 7.3 | 4.7 |
| 10/11/2018 | RPS 48-2 | 8.80 | 6 | 7.3 | 4.7 |
| 10/13/2018 | RPS 48-4 | 9.30 | 6.4 | 7.3 | 4.7 |
| 10/30/2018 | RPS 52-3 | 7.80 | 5.8 | 7.3 | 4.7 |

Unit weight

| DATE | SAMPLE ID | UNIT WEIGHT |
|------------|-----------|-------------|
| 8/15/2018 | RPS-30-3 | 144.10 |
| 8/20/2018 | RPS-31-4 | 143.10 |
| 8/23/2018 | RPS-33-3 | 143.92 |
| 8/27/2018 | RPS-34-3 | 142.00 |
| 9/11/2018 | RPS-38-4 | 142.34 |
| 9/13/2018 | RPS-40-3 | 142.65 |
| 9/15/2018 | RPS-41-1 | 143.18 |
| 9/24/2018 | RPS 42-4 | 140.90 |
| 9/29/2018 | RPS 43-3 | 143.70 |
| 10/1/2018 | RPS 44-1 | 144.20 |
| 10/3/2018 | RPS 45-1 | 144.40 |
| 10/8/2018 | RPS 47-1 | 144.50 |
| 10/10/2018 | RPS 47-4 | 144.10 |
| 10/11/2018 | RPS 48-2 | 144.30 |
| 10/13/2018 | RPS 48-4 | 142.46 |
| 10/30/2018 | RPS 52-3 | 141.82 |

SAM

| DATE | SAMPLE ID | SAM READING | AP HIGH | AP LOW |
|------------|-----------|-------------|---------|--------|
| 8/15/2018 | RPS-30-3 | 0.17 | 0.4 | 0.1 |
| 8/20/2018 | RPS-31-4 | 0.17 | 0.4 | 0.1 |
| 8/23/2018 | RPS-33-3 | 0.15 | 0.4 | 0.1 |
| 8/27/2018 | RPS-34-3 | 0.17 | 0.4 | 0.1 |
| 9/11/2018 | RPS-38-4 | 0.20 | 0.4 | 0.1 |
| 9/13/2018 | RPS-40-3 | 0.18 | 0.4 | 0.1 |
| 9/15/2018 | RPS-41-1 | 0.17 | 0.4 | 0.1 |
| 9/24/2018 | RPS 42-4 | 0.18 | 0.4 | 0.1 |
| 9/29/2018 | RPS 43-3 | 0.20 | 0.4 | 0.1 |
| 10/1/2018 | RPS 44-1 | 0.18 | 0.4 | 0.1 |
| 10/3/2018 | RPS 45-1 | 0.15 | 0.4 | 0.1 |
| 10/8/2018 | RPS 47-1 | 0.18 | 0.4 | 0.1 |
| 10/10/2018 | RPS 47-4 | 0.17 | 0.4 | 0.1 |
| 10/11/2018 | RPS 48-2 | 0.17 | 0.4 | 0.1 |
| 10/13/2018 | RPS 48-4 | 0.19 | 0.4 | 0.1 |
| 10/30/2018 | RPS 52-3 | 0.18 | 0.4 | 0.1 |

W/C ratio

| DATE | SAMPLE ID | W/C | AP HIGH | AP LOW |
|------------|-----------|-------|---------|--------|
| 8/15/2018 | RPS-30-3 | 0.41 | 0.45 | 0.375 |
| 8/20/2018 | RPS-31-4 | 0.4 | 0.45 | 0.375 |
| 8/23/2018 | RPS-33-3 | 0.375 | 0.45 | 0.375 |
| 8/27/2018 | RPS-34-3 | 0.4 | 0.45 | 0.375 |
| 9/11/2018 | RPS-38-4 | 0.39 | 0.45 | 0.375 |
| 9/13/2018 | RPS-40-3 | 0.41 | 0.45 | 0.375 |
| 9/15/2018 | RPS-41-1 | 0.4 | 0.45 | 0.375 |
| 9/24/2018 | RPS 42-4 | 0.41 | 0.45 | 0.375 |
| 9/29/2018 | RPS 43-3 | 0.42 | 0.45 | 0.375 |
| 10/1/2018 | RPS 44-1 | 0.4 | 0.45 | 0.375 |
| 10/3/2018 | RPS 45-1 | 0.39 | 0.45 | 0.375 |
| 10/8/2018 | RPS 47-1 | 0.41 | 0.45 | 0.375 |
| 10/10/2018 | RPS 47-4 | 0.39 | 0.45 | 0.375 |
| 10/11/2018 | RPS 48-2 | 0.4 | 0.45 | 0.375 |
| 10/13/2018 | RPS 48-4 | 0.41 | 0.45 | 0.375 |
| 10/30/2018 | RPS 52-3 | 0.41 | 0.45 | 0.375 |

Box test

| DATE | SAMPLE ID | BOX TEST RATING |
|------------|-----------|-----------------|
| 8/15/2018 | RPS-30-3 | 1 |
| 8/20/2018 | RPS-31-4 | 2 |
| 8/23/2018 | RPS-33-3 | 2 |
| 8/27/2018 | RPS-34-3 | 2 |
| 9/11/2018 | RPS-38-4 | 2 |
| 9/13/2018 | RPS-40-3 | 2 |
| 9/15/2018 | RPS-41-1 | 3 |
| 9/24/2018 | RPS 42-4 | 2 |
| 9/29/2018 | RPS 43-3 | 2 |
| 10/1/2018 | RPS 44-1 | 2 |
| 10/3/2018 | RPS 45-1 | 2 |
| 10/8/2018 | RPS 47-1 | 2 |
| 10/10/2018 | RPS 47-4 | 2 |
| 10/11/2018 | RPS 48-2 | 2 |
| 10/13/2018 | RPS 48-4 | 2 |
| 10/30/2018 | RPS 52-3 | 2 |

Resistivity

| DATE | SAMPLE ID | RESISTIVITY |
|------------|-----------|-------------|
| 8/15/2018 | RPS-30-3 | 43.59 |
| 8/20/2018 | RPS-31-4 | 36.45 |
| 8/23/2018 | RPS-33-3 | 27.05 |
| 8/27/2018 | RPS-34-3 | 26.35 |
| 9/11/2018 | RPS-38-4 | 0.00 |
| 9/13/2018 | RPS-40-3 | 0.00 |
| 9/15/2018 | RPS-41-1 | 0.00 |
| 9/24/2018 | RPS 42-4 | 0.00 |
| 9/29/2018 | RPS 43-3 | 0.00 |
| 10/1/2018 | RPS 44-1 | 0.00 |
| 10/3/2018 | RPS 45-1 | 0.00 |
| 10/8/2018 | RPS 47-1 | 0.00 |
| 10/10/2018 | RPS 47-4 | 0.00 |
| 10/11/2018 | RPS 48-2 | 0.00 |
| 10/13/2018 | RPS 48-4 | 0.00 |
| 10/30/2018 | RPS 52-3 | 0.00 |

Strength

| DATE | SAMPLE ID | 28 DAY STRENGTH | 56 DAY STRENGTH |
|------------|-----------|-----------------|-----------------|
| 8/15/2018 | RPS-30-3 | 5735 | 6095 |
| 8/20/2018 | RPS-31-4 | 5650 | 6040 |
| 8/23/2018 | RPS-33-3 | 5620 | 6400 |
| 8/27/2018 | RPS-34-3 | 4965 | 5925 |
| 9/11/2018 | RPS-38-4 | 5655 | 0 |
| 9/13/2018 | RPS-40-3 | 4995 | 0 |
| 9/15/2018 | RPS-41-1 | 5980 | 0 |
| 9/24/2018 | RPS 42-4 | 6130 | 0 |
| 9/29/2018 | RPS 43-3 | 6020 | 0 |
| 10/1/2018 | RPS 44-1 | 5955 | 0 |
| 10/3/2018 | RPS 45-1 | 6020 | 0 |
| 10/8/2018 | RPS 47-1 | 0 | 0 |
| 10/10/2018 | RPS 47-4 | 0 | 0 |
| 10/11/2018 | RPS 48-2 | 0 | 0 |
| 10/13/2018 | RPS 48-4 | 0 | 0 |
| 10/30/2018 | RPS 52-3 | 0 | 0 |

Mix Temperature

| DATE | SAMPLE ID | MIX TEMP (Plant) | MIX TEMP (Job) | AP HIGH | AP LOW |
|------------|-----------|------------------|----------------|---------|--------|
| 8/15/2018 | RPS-30-3 | 78 | 76 | 88 | 52 |
| 8/20/2018 | RPS-31-4 | 78 | 78 | 88 | 52 |
| 8/23/2018 | RPS-33-3 | 76 | 78 | 88 | 52 |
| 8/27/2018 | RPS-34-3 | 78 | 79 | 88 | 52 |
| 9/11/2018 | RPS-38-4 | 74 | 75 | 88 | 52 |
| 9/13/2018 | RPS-40-3 | 76 | 77 | 88 | 52 |
| 9/15/2018 | RPS-41-1 | 75 | 76 | 88 | 52 |
| 9/24/2018 | RPS 42-4 | 69 | 70 | 88 | 52 |
| 9/29/2018 | RPS 43-3 | 72 | 74 | 88 | 52 |
| 10/1/2018 | RPS 44-1 | 75 | 77 | 88 | 52 |
| 10/3/2018 | RPS 45-1 | 76 | 78 | 88 | 52 |
| 10/8/2018 | RPS 47-1 | 78 | 80 | 88 | 52 |
| 10/10/2018 | RPS 47-4 | 80 | 81 | 88 | 52 |
| 10/11/2018 | RPS 48-2 | 79 | 80 | 88 | 52 |
| 10/13/2018 | RPS 48-4 | 62 | 64 | 88 | 52 |
| 10/30/2018 | RPS 52-3 | 64 | 66 | 88 | 52 |

Test data for SR 70:

Slump:

| DATE | SAMPLE ID | SLUMP (Plant) | SLUMP (Job) | AP HIGH | AP LOW |
|------------|-----------|---------------|-------------|---------|--------|
| 6/21/2019 | PEM 1 | 2.25 | 1.75 | 2.75 | 0.25 |
| 6/25/2019 | PEM 2 | 1.75 | 1.25 | 2.75 | 0.25 |
| 6/26/2019 | PEM 3 | 2.00 | 1.00 | 2.75 | 0.25 |
| 7/10/2019 | PEM 4 | 2.50 | 1.00 | 2.75 | 0.25 |
| 7/12/2019 | PEM 5 | 2.25 | 1.50 | 2.75 | 0.25 |
| 7/16/2019 | PEM 6 | 1.75 | 1.25 | 2.75 | 0.25 |
| 7/27/2019 | PEM 7 | 1.25 | 1.00 | 2.75 | 0.25 |
| 7/29/2019 | PEM 8 | 2.25 | 1.50 | 2.75 | 0.25 |
| 8/5/2019 | PEM 9 | 2.00 | 1.50 | 2.75 | 0.25 |
| 8/6/2019 | PEM 10 | 2.00 | 1.25 | 2.75 | 0.25 |
| 8/10/2019 | PEM 11 | 1.50 | 1.25 | 2.75 | 0.25 |
| 8/16/2019 | PEM 12 | 1.50 | 1.25 | 2.75 | 0.25 |
| 8/20/2019 | PEM 13 | 2.00 | 1.50 | 2.75 | 0.25 |
| 8/24/2019 | PEM 14 | 2.25 | 1.25 | 2.75 | 0.25 |
| 8/28/2019 | PEM 15 | 2.00 | 1.25 | 2.75 | 0.25 |
| 9/3/2019 | PEM 16 | 2.25 | 1.25 | 2.75 | 0.25 |
| 9/4/2019 | PEM 17 | 1.75 | 1.25 | 2.75 | 0.25 |
| 9/9/2019 | PEM 18 | 2.00 | 1.00 | 2.75 | 0.25 |
| 9/10/2019 | PEM 19 | 2.25 | 1.25 | 2.75 | 0.25 |
| 9/12/2019 | PEM 20 | 2.50 | 1.25 | 2.75 | 0.25 |
| 10/30/2019 | PEM 21 | 2.00 | 1.00 | 2.75 | 0.25 |
| 11/1/2019 | PEM 22 | 2.00 | 1.00 | 2.75 | 0.25 |
| 11/4/2019 | PEM 23 | 2.00 | 1.00 | 2.75 | 0.25 |
| 11/6/2019 | PEM 24 | 1.75 | 0.75 | 2.75 | 0.25 |
| 11/14/2019 | PEM 25 | 2.00 | 1.50 | 2.75 | 0.25 |
| 11/15/2019 | PEM 26 | 1.75 | 0.75 | 2.75 | 0.25 |
| 11/18/2019 | PEM 27 | 1.75 | 1.00 | 2.75 | 0.25 |
| 11/19/2019 | PEM 28 | 2.00 | 1.25 | 2.75 | 0.25 |
| 11/20/2019 | PEM 29 | 1.75 | 1.00 | 2.75 | 0.25 |
| 11/25/2019 | PEM 30 | 1.50 | 1.00 | 2.75 | 0.25 |
| 11/26/2019 | PEM 31 | 2.00 | 1.25 | 2.75 | 0.25 |
| 8/6/2020 | PEM 32 | 1.25 | 1.00 | 2.75 | 0.25 |
| 8/11/2020 | PEM 33 | 1.25 | 1.00 | 2.75 | 0.25 |
| 8/12/2020 | PEM 34 | 1.25 | 1.00 | 2.75 | 0.25 |
| 8/14/2020 | PEM 35 | 1.25 | 1.00 | 2.75 | 0.25 |
| 8/18/2020 | PEM 36 | 1.25 | 1.00 | 2.75 | 0.25 |
| 8/20/2020 | PEM 37 | 1.25 | 1.00 | 2.75 | 0.25 |
| 8/21/2020 | PEM 38 | 1.25 | 1.00 | 2.75 | 0.25 |
| 8/24/2020 | PEM 39 | 1.25 | 1.00 | 2.75 | 0.25 |
| 8/26/2020 | PEM 40 | 1.25 | 1.00 | 2.75 | 0.25 |
| 9/4/2020 | PEM 41 | 1.25 | 1.25 | 2.75 | 0.25 |
| 9/23/2020 | PEM 42 | 1.00 | 1.00 | 2.75 | 0.25 |
| 9/25/2020 | PEM 43 | 1.25 | 1.00 | 2.75 | 0.25 |
| 9/28/2020 | PEM 44 | 1.25 | 1.25 | 2.75 | 0.25 |
| 9/30/2020 | PEM 45 | 1.25 | 1.25 | 2.75 | 0.25 |
| 10/2/2020 | PEM 46 | 1.25 | 1.00 | 2.75 | 0.25 |
| 10/6/2020 | PEM 47 | 1.00 | 1.00 | 2.75 | 0.25 |
| 10/8/2020 | PEM 48 | 1.00 | 1.00 | 2.75 | 0.25 |
| 10/13/2020 | PEM 49 | 1.00 | 1.00 | 2.75 | 0.25 |
| 10/21/2020 | PEM 50 | 1.25 | 1.00 | 2.75 | 0.25 |
| 10/23/2020 | PEM 51 | 1.25 | 1.00 | 2.75 | 0.25 |
| 10/26/2020 | PEM 52 | 1.25 | 1.00 | 2.75 | 0.25 |

Air Content:

| DATE | SAMPLE ID | AIR (Plant SAM) | AIR (Job) | AP HIGH | AP LOW |
|------------|-----------|-----------------|-----------|---------|--------|
| 6/21/2019 | PEM 1 | 12.00 | 8.00 | 8.5 | 5.5 |
| 6/25/2019 | PEM 2 | 11.70 | 7.10 | 8.5 | 5.5 |
| 6/26/2019 | PEM 3 | 11.70 | 7.20 | 8.5 | 5.5 |
| 7/10/2019 | PEM 4 | 11.20 | 7.50 | 8.5 | 5.5 |
| 7/12/2019 | PEM 5 | 12.00 | 8.00 | 8.5 | 5.5 |
| 7/16/2019 | PEM 6 | 9.20 | 5.90 | 8.5 | 5.5 |
| 7/27/2019 | PEM 7 | 14.00 | 7.20 | 8.5 | 5.5 |
| 7/29/2019 | PEM 8 | 11.70 | 7.00 | 8.5 | 5.5 |
| 8/5/2019 | PEM 9 | 11.40 | 7.00 | 8.5 | 5.5 |
| 8/6/2019 | PEM 10 | 12.90 | 6.80 | 8.5 | 5.5 |
| 8/10/2019 | PEM 11 | 11.90 | 6.80 | 8.5 | 5.5 |
| 8/16/2019 | PEM 12 | 10.30 | 5.50 | 8.5 | 5.5 |
| 8/20/2019 | PEM 13 | 13.30 | 8.30 | 8.5 | 5.5 |
| 8/24/2019 | PEM 14 | 14.40 | 8.00 | 8.5 | 5.5 |
| 8/28/2019 | PEM 15 | 14.70 | 7.60 | 8.5 | 5.5 |
| 9/3/2019 | PEM 16 | 14.00 | 8.00 | 8.5 | 5.5 |
| 9/4/2019 | PEM 17 | 9.90 | 6.80 | 8.5 | 5.5 |
| 9/9/2019 | PEM 18 | 11.30 | 7.00 | 8.5 | 5.5 |
| 9/10/2019 | PEM 19 | 11.70 | 7.20 | 8.5 | 5.5 |
| 9/12/2019 | PEM 20 | 11.60 | 7.20 | 8.5 | 5.5 |
| 10/30/2019 | PEM 21 | 12.70 | 5.90 | 8.5 | 5.5 |
| 11/1/2019 | PEM 22 | 13.40 | 6.90 | 8.5 | 5.5 |
| 11/4/2019 | PEM 23 | 14.70 | 7.40 | 8.5 | 5.5 |
| 11/6/2019 | PEM 24 | 11.50 | 6.00 | 8.5 | 5.5 |
| 11/14/2019 | PEM 25 | 13.70 | 7.90 | 8.5 | 5.5 |
| 11/15/2019 | PEM 26 | 10.00 | 6.40 | 8.5 | 5.5 |
| 11/18/2019 | PEM 27 | 11.70 | 5.70 | 8.5 | 5.5 |
| 11/19/2019 | PEM 28 | 13.80 | 7.80 | 8.5 | 5.5 |
| 11/20/2019 | PEM 29 | 9.60 | 6.90 | 8.5 | 5.5 |
| 11/25/2019 | PEM 30 | 10.00 | 7.00 | 8.5 | 5.5 |
| 11/26/2019 | PEM 31 | 13.60 | 7.60 | 8.5 | 5.5 |
| 8/6/2020 | PEM 32 | 9.00 | 6.60 | 8.5 | 5.5 |
| 8/11/2020 | PEM 33 | 9.40 | 7.70 | 8.5 | 5.5 |
| 8/12/2020 | PEM 34 | 9.40 | 7.30 | 8.5 | 5.5 |
| 8/14/2020 | PEM 35 | 9.00 | 6.40 | 8.5 | 5.5 |
| 8/18/2020 | PEM 36 | 8.30 | 5.80 | 8.5 | 5.5 |
| 8/20/2020 | PEM 37 | 9.00 | 6.40 | 8.5 | 5.5 |
| 8/21/2020 | PEM 38 | 9.00 | 7.00 | 8.5 | 5.5 |
| 8/24/2020 | PEM 39 | 9.20 | 6.50 | 8.5 | 5.5 |
| 8/26/2020 | PEM 40 | 9.30 | 7.20 | 8.5 | 5.5 |
| 9/4/2020 | PEM 41 | 9.40 | 7.80 | 8.5 | 5.5 |
| 9/23/2020 | PEM 42 | 10.00 | 7.20 | 8.5 | 5.5 |
| 9/25/2020 | PEM 43 | 8.80 | 7.10 | 8.5 | 5.5 |
| 9/28/2020 | PEM 44 | 9.30 | 7.00 | 8.5 | 5.5 |
| 9/30/2020 | PEM 45 | 9.00 | 7.00 | 8.5 | 5.5 |
| 10/2/2020 | PEM 46 | 9.00 | 7.00 | 8.5 | 5.5 |
| 10/6/2020 | PEM 47 | 8.30 | 6.30 | 8.5 | 5.5 |
| 10/8/2020 | PEM 48 | 9.00 | 7.20 | 8.5 | 5.5 |
| 10/13/2020 | PEM 49 | 9.00 | 7.00 | 8.5 | 5.5 |
| 10/21/2020 | PEM 50 | 9.50 | 7.20 | 8.5 | 5.5 |
| 10/23/2020 | PEM 51 | 10.80 | 7.20 | 8.5 | 5.5 |
| 10/26/2020 | PEM 52 | 9.00 | 6.60 | 8.5 | 5.5 |

Unit Weight:

| DATE | SAMPLE ID | UNIT WEIGHT |
|------------|-----------|-------------|
| 6/21/2019 | PEM 1 | 134.46 |
| 6/25/2019 | PEM 2 | 135.16 |
| 6/26/2019 | PEM 3 | 132.73 |
| 7/10/2019 | PEM 4 | 136.45 |
| 7/12/2019 | PEM 5 | 135.90 |
| 7/16/2019 | PEM 6 | 140.00 |
| 7/27/2019 | PEM 7 | 133.33 |
| 7/29/2019 | PEM 8 | 136.10 |
| 8/5/2019 | PEM 9 | 136.58 |
| 8/6/2019 | PEM 10 | 135.34 |
| 8/10/2019 | PEM 11 | 136.83 |
| 8/16/2019 | PEM 12 | 138.39 |
| 8/20/2019 | PEM 13 | 134.34 |
| 8/24/2019 | PEM 14 | 132.45 |
| 8/28/2019 | PEM 15 | 132.33 |
| 9/3/2019 | PEM 16 | 133.45 |
| 9/4/2019 | PEM 17 | 139.68 |
| 9/9/2019 | PEM 18 | 138.44 |
| 9/10/2019 | PEM 19 | 138.12 |
| 9/12/2019 | PEM 20 | 136.36 |
| 10/30/2019 | PEM 21 | 135.04 |
| 11/1/2019 | PEM 22 | 134.12 |
| 11/4/2019 | PEM 23 | 132.04 |
| 11/6/2019 | PEM 24 | 136.76 |
| 11/14/2019 | PEM 25 | 133.40 |
| 11/15/2019 | PEM 26 | 138.72 |
| 11/18/2019 | PEM 27 | 134.32 |
| 11/19/2019 | PEM 28 | 133.32 |
| 11/20/2019 | PEM 29 | 136.44 |
| 11/25/2019 | PEM 30 | 133.96 |
| 11/26/2019 | PEM 31 | 134.08 |
| 8/6/2020 | PEM 32 | 141.49 |
| 8/11/2020 | PEM 33 | 141.77 |
| 8/12/2020 | PEM 34 | 141.69 |
| 8/14/2020 | PEM 35 | 143.65 |
| 8/18/2020 | PEM 36 | 141.14 |
| 8/20/2020 | PEM 37 | 142.23 |
| 8/21/2020 | PEM 38 | 142.07 |
| 8/24/2020 | PEM 39 | 143.85 |
| 8/26/2020 | PEM 40 | 143.67 |
| 9/4/2020 | PEM 41 | 139.50 |
| 9/23/2020 | PEM 42 | 141.62 |
| 9/25/2020 | PEM 43 | 139.60 |
| 9/28/2020 | PEM 44 | 140.87 |
| 9/30/2020 | PEM 45 | 138.94 |
| 10/2/2020 | PEM 46 | 140.35 |
| 10/6/2020 | PEM 47 | 140.98 |
| 10/8/2020 | PEM 48 | 139.48 |
| 10/13/2020 | PEM 49 | 139.94 |
| 10/21/2020 | PEM 50 | 141.76 |
| 10/23/2020 | PEM 51 | 136.56 |
| 10/26/2020 | PEM 52 | 138.24 |

SAM:

| DATE | SAMPLE ID | SAM READING |
|------------|-----------|-------------|
| 6/21/2019 | PEM 1 | 0.28 |
| 6/25/2019 | PEM 2 | 0.28 |
| 6/26/2019 | PEM 3 | 0.27 |
| 7/10/2019 | PEM 4 | 0.06 |
| 7/12/2019 | PEM 5 | 0.11 |
| 7/16/2019 | PEM 6 | 0.22 |
| 7/27/2019 | PEM 7 | 0.20 |
| 7/29/2019 | PEM 8 | 0.20 |
| 8/5/2019 | PEM 9 | 0.20 |
| 8/6/2019 | PEM 10 | 0.22 |
| 8/10/2019 | PEM 11 | 0.23 |
| 8/16/2019 | PEM 12 | 0.23 |
| 8/20/2019 | PEM 13 | 0.23 |
| 8/24/2019 | PEM 14 | 0.19 |
| 8/28/2019 | PEM 15 | 0.10 |
| 9/3/2019 | PEM 16 | 0.19 |
| 9/4/2019 | PEM 17 | 0.30 |
| 9/9/2019 | PEM 18 | 0.21 |
| 9/10/2019 | PEM 19 | 0.18 |
| 9/12/2019 | PEM 20 | 0.17 |
| 10/30/2019 | PEM 21 | 0.15 |
| 11/1/2019 | PEM 22 | 0.15 |
| 11/4/2019 | PEM 23 | 0.18 |
| 11/6/2019 | PEM 24 | 0.28 |
| 11/14/2019 | PEM 25 | 0.27 |
| 11/15/2019 | PEM 26 | 0.34 |
| 11/18/2019 | PEM 27 | 0.27 |
| 11/19/2019 | PEM 28 | 0.32 |
| 11/20/2019 | PEM 29 | 0.35 |
| 11/25/2019 | PEM 30 | 0.30 |
| 11/26/2019 | PEM 31 | 0.21 |
| 8/6/2020 | PEM 32 | 0.19 |
| 8/11/2020 | PEM 33 | 0.19 |
| 8/12/2020 | PEM 34 | 0.21 |
| 8/14/2020 | PEM 35 | 0.22 |
| 8/18/2020 | PEM 36 | 0.06 |
| 8/20/2020 | PEM 37 | 0.16 |
| 8/21/2020 | PEM 38 | 0.22 |
| 8/24/2020 | PEM 39 | 0.17 |
| 8/26/2020 | PEM 40 | 0.21 |
| 9/4/2020 | PEM 41 | 0.27 |
| 9/23/2020 | PEM 42 | 0.17 |
| 9/25/2020 | PEM 43 | 0.17 |
| 9/28/2020 | PEM 44 | 0.19 |
| 9/30/2020 | PEM 45 | 0.15 |
| 10/2/2020 | PEM 46 | 0.22 |
| 10/6/2020 | PEM 47 | 0.22 |
| 10/8/2020 | PEM 48 | 0.21 |
| 10/13/2020 | PEM 49 | 0.30 |
| 10/21/2020 | PEM 50 | 0.20 |
| 10/23/2020 | PEM 51 | 0.22 |
| 10/26/2020 | PEM 52 | 0.19 |

W/C ratio:

| DATE | SAMPLE ID | W/C Ticket | W/C Microwave |
|------------|-----------|------------|---------------|
| 6/21/2019 | PEM 1 | 0.39 | 0.39 |
| 6/25/2019 | PEM 2 | 0.39 | 0.39 |
| 6/26/2019 | PEM 3 | 0.39 | 0.38 |
| 7/10/2019 | PEM 4 | 0.40 | 0.38 |
| 7/12/2019 | PEM 5 | 0.38 | 0.39 |
| 7/16/2019 | PEM 6 | 0.39 | 0.39 |
| 7/27/2019 | PEM 7 | 0.39 | 0.37 |
| 7/29/2019 | PEM 8 | 0.39 | 0.38 |
| 8/5/2019 | PEM 9 | 0.39 | 0.39 |
| 8/6/2019 | PEM 10 | 0.39 | 0.39 |
| 8/10/2019 | PEM 11 | 0.39 | 0.35 |
| 8/16/2019 | PEM 12 | 0.37 | 0.36 |
| 8/20/2019 | PEM 13 | 0.39 | 0.37 |
| 8/24/2019 | PEM 14 | 0.38 | 0.35 |
| 8/28/2019 | PEM 15 | 0.39 | 0.38 |
| 9/3/2019 | PEM 16 | 0.38 | 0.36 |
| 9/4/2019 | PEM 17 | 0.39 | 0.37 |
| 9/9/2019 | PEM 18 | 0.39 | 0.39 |
| 9/10/2019 | PEM 19 | 0.39 | 0.39 |
| 9/12/2019 | PEM 20 | 0.39 | 0.39 |
| 10/30/2019 | PEM 21 | 0.39 | 0.36 |
| 11/1/2019 | PEM 22 | 0.39 | 0.39 |
| 11/4/2019 | PEM 23 | 0.39 | 0.38 |
| 11/6/2019 | PEM 24 | 0.39 | 0.38 |
| 11/14/2019 | PEM 25 | 0.39 | 0.39 |
| 11/15/2019 | PEM 26 | 0.39 | 0.39 |
| 11/18/2019 | PEM 27 | 0.39 | 0.38 |
| 11/19/2019 | PEM 28 | 0.39 | 0.39 |
| 11/20/2019 | PEM 29 | 0.39 | 0.38 |
| 11/25/2019 | PEM 30 | 0.37 | 0.38 |
| 11/26/2019 | PEM 31 | 0.39 | 0.38 |
| 8/6/2020 | PEM 32 | 0.40 | 0.35 |
| 8/11/2020 | PEM 33 | 0.40 | 0.40 |
| 8/12/2020 | PEM 34 | 0.40 | 0.41 |
| 8/14/2020 | PEM 35 | 0.40 | 0.41 |
| 8/18/2020 | PEM 36 | 0.40 | 0.41 |
| 8/20/2020 | PEM 37 | 0.38 | 0.41 |
| 8/21/2020 | PEM 38 | 0.40 | 0.41 |
| 8/24/2020 | PEM 39 | 0.40 | 0.41 |
| 8/26/2020 | PEM 40 | 0.40 | 0.41 |
| 9/4/2020 | PEM 41 | 0.38 | 0.39 |
| 9/23/2020 | PEM 42 | 0.38 | 0.39 |
| 9/25/2020 | PEM 43 | 0.40 | 0.38 |
| 9/28/2020 | PEM 44 | 0.38 | 0.40 |
| 9/30/2020 | PEM 45 | 0.41 | 0.43 |
| 10/2/2020 | PEM 46 | 0.38 | 0.41 |
| 10/6/2020 | PEM 47 | 0.38 | 0.37 |
| 10/8/2020 | PEM 48 | 0.38 | 0.35 |
| 10/13/2020 | PEM 49 | 0.40 | 0.39 |
| 10/21/2020 | PEM 50 | 0.40 | 0.39 |
| 10/23/2020 | PEM 51 | 0.40 | 0.38 |
| 10/26/2020 | PEM 52 | 0.38 | 0.39 |

Box Test:

| DATE | SAMPLE ID | BOX TEST RATING |
|------------|-----------|-----------------|
| 6/21/2019 | PEM 1 | 2 |
| 6/25/2019 | PEM 2 | 2 |
| 6/26/2019 | PEM 3 | 2 |
| 7/10/2019 | PEM 4 | 2 |
| 7/12/2019 | PEM 5 | 2 |
| 7/16/2019 | PEM 6 | 2 |
| 7/27/2019 | PEM 7 | 2 |
| 7/29/2019 | PEM 8 | 2 |
| 8/5/2019 | PEM 9 | 2 |
| 8/6/2019 | PEM 10 | 2 |
| 8/10/2019 | PEM 11 | 2 |
| 8/16/2019 | PEM 12 | 2 |
| 8/20/2019 | PEM 13 | 2 |
| 8/24/2019 | PEM 14 | 2 |
| 8/28/2019 | PEM 15 | 2 |
| 9/3/2019 | PEM 16 | 2 |
| 9/4/2019 | PEM 17 | 3 |
| 9/9/2019 | PEM 18 | 2 |
| 9/10/2019 | PEM 19 | 2 |
| 9/12/2019 | PEM 20 | 3 |
| 10/30/2019 | PEM 21 | 2 |
| 11/1/2019 | PEM 22 | 2 |
| 11/4/2019 | PEM 23 | 2 |
| 11/6/2019 | PEM 24 | 2 |
| 11/14/2019 | PEM 25 | 2 |
| 11/15/2019 | PEM 26 | 3 |
| 11/18/2019 | PEM 27 | 2 |
| 11/19/2019 | PEM 28 | 2 |
| 11/20/2019 | PEM 29 | 2 |
| 11/25/2019 | PEM 30 | 2 |
| 11/26/2019 | PEM 31 | 2 |
| 8/6/2020 | PEM 32 | 2 |
| 8/11/2020 | PEM 33 | 2 |
| 8/12/2020 | PEM 34 | 2 |
| 8/14/2020 | PEM 35 | 2 |
| 8/18/2020 | PEM 36 | 2 |
| 8/20/2020 | PEM 37 | 2 |
| 8/21/2020 | PEM 38 | 2 |
| 8/24/2020 | PEM 39 | 2 |
| 8/26/2020 | PEM 40 | 2 |
| 9/4/2020 | PEM 41 | 2 |
| 9/23/2020 | PEM 42 | 2 |
| 9/25/2020 | PEM 43 | 2 |
| 9/28/2020 | PEM 44 | 2 |
| 9/30/2020 | PEM 45 | 2 |
| 10/2/2020 | PEM 46 | 2 |
| 10/6/2020 | PEM 47 | 2 |
| 10/8/2020 | PEM 48 | 2 |
| 10/13/2020 | PEM 49 | 2 |
| 10/21/2020 | PEM 50 | 2 |
| 10/23/2020 | PEM 51 | 2 |
| 10/26/2020 | PEM 52 | 2 |

Resistivity:

| DATE | SAMPLE ID | RESISTIVITY (Kohm-cm) |
|------------|-----------|-----------------------|
| 6/21/2019 | PEM 1 | 24.20 |
| 6/25/2019 | PEM 2 | 23.70 |
| 6/26/2019 | PEM 3 | 24.30 |
| 7/10/2019 | PEM 4 | 30.20 |
| 7/12/2019 | PEM 5 | 22.30 |
| 7/16/2019 | PEM 6 | 21.50 |
| 7/27/2019 | PEM 7 | 22.30 |
| 7/29/2019 | PEM 8 | 22.50 |
| 8/5/2019 | PEM 9 | 21.80 |
| 8/6/2019 | PEM 10 | 19.30 |
| 8/10/2019 | PEM 11 | 18.90 |
| 8/16/2019 | PEM 12 | 17.40 |
| 8/20/2019 | PEM 13 | 19.30 |
| 8/24/2019 | PEM 14 | 17.50 |
| 8/28/2019 | PEM 15 | 21.00 |
| 9/3/2019 | PEM 16 | 18.20 |
| 9/4/2019 | PEM 17 | 19.90 |
| 9/9/2019 | PEM 18 | 17.50 |
| 9/10/2019 | PEM 19 | 22.10 |
| 9/12/2019 | PEM 20 | 24.00 |
| 10/30/2019 | PEM 21 | 14.60 |
| 11/1/2019 | PEM 22 | 12.70 |
| 11/4/2019 | PEM 23 | 16.70 |
| 11/6/2019 | PEM 24 | 17.00 |
| 11/14/2019 | PEM 25 | 21.90 |
| 11/15/2019 | PEM 26 | 23.40 |
| 11/18/2019 | PEM 27 | 22.50 |
| 11/19/2019 | PEM 28 | 22.40 |
| 11/20/2019 | PEM 29 | 22.50 |
| 11/25/2019 | PEM 30 | 20.70 |
| 11/26/2019 | PEM 31 | 19.20 |
| 8/6/2020 | PEM 32 | 14.85 |
| 8/11/2020 | PEM 33 | 16.34 |
| 8/12/2020 | PEM 34 | 16.67 |
| 8/14/2020 | PEM 35 | 13.61 |
| 8/18/2020 | PEM 36 | 22.31 |
| 8/20/2020 | PEM 37 | 18.78 |
| 8/21/2020 | PEM 38 | 19.76 |
| 8/24/2020 | PEM 39 | 17.62 |
| 8/26/2020 | PEM 40 | 19.75 |
| 9/4/2020 | PEM 41 | 21.95 |
| 9/23/2020 | PEM 42 | 20.93 |
| 9/25/2020 | PEM 43 | 19.64 |
| 9/28/2020 | PEM 44 | 22.17 |
| 9/30/2020 | PEM 45 | 16.25 |
| 10/2/2020 | PEM 46 | 19.65 |
| 10/6/2020 | PEM 47 | 20.49 |
| 10/8/2020 | PEM 48 | 16.12 |
| 10/13/2020 | PEM 49 | 18.45 |
| 10/21/2020 | PEM 50 | 16.93 |
| 10/23/2020 | PEM 51 | 16.93 |
| 10/26/2020 | PEM 52 | 14.81 |

Strength:

| DATE | SAMPLE ID | 28 DAY STRENGTH | 56 DAY STRENGTH |
|------------|-----------|-----------------|-----------------|
| 6/21/2019 | PEM 1 | 5650 | 6000 |
| 6/25/2019 | PEM 2 | 4860 | 5580 |
| 6/26/2019 | PEM 3 | 6020 | 6950 |
| 7/10/2019 | PEM 4 | 5730 | 5705 |
| 7/12/2019 | PEM 5 | 5460 | 6150 |
| 7/16/2019 | PEM 6 | 5680 | 7098 |
| 7/27/2019 | PEM 7 | 6150 | 6810 |
| 7/29/2019 | PEM 8 | 5540 | 6240 |
| 8/5/2019 | PEM 9 | 5780 | 6530 |
| 8/6/2019 | PEM 10 | 5900 | 6505 |
| 8/10/2019 | PEM 11 | 5350 | 6689 |
| 8/16/2019 | PEM 12 | 5730 | 6440 |
| 8/20/2019 | PEM 13 | 5750 | 5875 |
| 8/24/2019 | PEM 14 | 5490 | 6210 |
| 8/28/2019 | PEM 15 | 5820 | 6785 |
| 9/3/2019 | PEM 16 | 5320 | 5840 |
| 9/4/2019 | PEM 17 | 6100 | 6930 |
| 9/9/2019 | PEM 18 | 5110 | 5540 |
| 9/10/2019 | PEM 19 | 5670 | 6495 |
| 9/12/2019 | PEM 20 | 6040 | 6810 |
| 10/30/2019 | PEM 21 | 6000 | 6426 |
| 11/1/2019 | PEM 22 | 5990 | 5920 |
| 11/4/2019 | PEM 23 | 5515 | 5975 |
| 11/6/2019 | PEM 24 | 5760 | 7199 |
| 11/14/2019 | PEM 25 | 5920 | 6301 |
| 11/15/2019 | PEM 26 | 5920 | 7435 |
| 11/18/2019 | PEM 27 | 5860 | 7600 |
| 11/19/2019 | PEM 28 | 5865 | 6380 |
| 11/20/2019 | PEM 29 | 6750 | 7639 |
| 11/25/2019 | PEM 30 | 5860 | 6628 |
| 11/26/2019 | PEM 31 | 5870 | 6102 |
| 8/6/2020 | PEM 32 | 5710 | 6032 |
| 8/11/2020 | PEM 33 | 5775 | 6331 |
| 8/12/2020 | PEM 34 | 5975 | 6401 |
| 8/14/2020 | PEM 35 | 5945 | 6820 |
| 8/18/2020 | PEM 36 | 6140 | 7010 |
| 8/20/2020 | PEM 37 | 6420 | 6671 |
| 8/21/2020 | PEM 38 | 4950 | 6652 |
| 8/24/2020 | PEM 39 | 6320 | 7231 |
| 8/26/2020 | PEM 40 | 5960 | 6813 |
| 9/4/2020 | PEM 41 | 6280 | 7148 |
| 9/23/2020 | PEM 42 | 5900 | 6608 |
| 9/25/2020 | PEM 43 | 5625 | 5746 |
| 9/28/2020 | PEM 44 | 5645 | 6612 |
| 9/30/2020 | PEM 45 | 6040 | 6407 |
| 10/2/2020 | PEM 46 | 6305 | 6734 |
| 10/6/2020 | PEM 47 | 5725 | 7147 |
| 10/8/2020 | PEM 48 | 5170 | 6534 |
| 10/13/2020 | PEM 49 | 5640 | 6712 |
| 10/21/2020 | PEM 50 | 5775 | 7122 |
| 10/23/2020 | PEM 51 | 5355 | 5762 |
| 10/26/2020 | PEM 52 | 6400 | 6185 |

Mix Temperature:

| DATE | SAMPLE ID | MIX TEMP (Plant) | MIX TEMP (Job) |
|------------|-----------|------------------|----------------|
| 6/21/2019 | PEM 1 | 83 | 84 |
| 6/25/2019 | PEM 2 | 82 | 84 |
| 6/26/2019 | PEM 3 | 84 | 86 |
| 7/10/2019 | PEM 4 | 85 | 87 |
| 7/12/2019 | PEM 5 | 85 | 86 |
| 7/16/2019 | PEM 6 | 85 | 85 |
| 7/27/2019 | PEM 7 | 80 | 80 |
| 7/29/2019 | PEM 8 | 84 | 84 |
| 8/5/2019 | PEM 9 | 78 | 76 |
| 8/6/2019 | PEM 10 | 84 | 84 |
| 8/10/2019 | PEM 11 | 78 | 76 |
| 8/16/2019 | PEM 12 | 77 | 77 |
| 8/20/2019 | PEM 13 | 80 | 81 |
| 8/24/2019 | PEM 14 | 77 | 77 |
| 8/28/2019 | PEM 15 | 80 | 80 |
| 9/3/2019 | PEM 16 | 77 | 78 |
| 9/4/2019 | PEM 17 | 80 | 81 |
| 9/9/2019 | PEM 18 | 70 | 71 |
| 9/10/2019 | PEM 19 | 75 | 77 |
| 9/12/2019 | PEM 20 | 76 | 78 |
| 10/30/2019 | PEM 21 | 69 | 70 |
| 11/1/2019 | PEM 22 | 69 | 68 |
| 11/4/2019 | PEM 23 | 74 | 74 |
| 11/6/2019 | PEM 24 | 72 | 72 |
| 11/14/2019 | PEM 25 | 69 | 69 |
| 11/15/2019 | PEM 26 | 68 | 68 |
| 11/18/2019 | PEM 27 | 64 | 64 |
| 11/19/2019 | PEM 28 | 64 | 64 |
| 11/20/2019 | PEM 29 | 62 | 62 |
| 11/25/2019 | PEM 30 | 69 | 70 |
| 11/26/2019 | PEM 31 | 64 | 68 |
| 8/6/2020 | PEM 32 | 72 | 72 |
| 8/11/2020 | PEM 33 | 80 | 80 |
| 8/12/2020 | PEM 34 | 73 | 73 |
| 8/14/2020 | PEM 35 | 78 | 78 |
| 8/18/2020 | PEM 36 | 80 | 80 |
| 8/20/2020 | PEM 37 | 68 | 68 |
| 8/21/2020 | PEM 38 | 73 | 73 |
| 8/24/2020 | PEM 39 | 78 | 78 |
| 8/26/2020 | PEM 40 | 77 | 77 |
| 9/4/2020 | PEM 41 | 73 | 72 |
| 9/23/2020 | PEM 42 | 75 | 74 |
| 9/25/2020 | PEM 43 | 72 | 73 |
| 9/28/2020 | PEM 44 | 74 | 74 |
| 9/30/2020 | PEM 45 | 77 | 77 |
| 10/2/2020 | PEM 46 | 76 | 75 |
| 10/6/2020 | PEM 47 | 75 | 76 |
| 10/8/2020 | PEM 48 | 74 | 76 |
| 10/13/2020 | PEM 49 | 77 | 75 |
| 10/21/2020 | PEM 50 | 78 | 76 |
| 10/23/2020 | PEM 51 | 77 | 74 |
| 10/26/2020 | PEM 52 | 76 | 76 |

Application:

Demonstration Project for
Implementation of Performance Engineered Mixtures/AASHTO PP 84
Project Application Form

Date: February 15, 2018

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| <p>1. State Agency: Pennsylvania Department of Transportation</p> <p>State Agency Contact(s): <u>Patricia Baer, Unit Manager, 717-787-2489, patrbaer@pa.gov</u></p> <p>FHWA Division Office Contact(s): <u>Jennifer Albert, Pavement and Materials Engineer, FHWA- Pennsylvania Division, 717-221-3410, Jennifer.albert@dot.gov</u></p> |
| <p>2. Project Location/Description: The SR 376 project is in Moon Township, Allegheny County. The project limits are 2000' east of the Business 376 Interchange to 1,100 east of the Airport Terminal/PA Turnpike Interchange. The project includes approximately 5 miles of full-depth reconstruction of both east and westbound lanes of 11" thick concrete pavement and shoulders on 4" Cement Treated Permeable Base Course, on 6" of 2A subbase, on a cement stabilized subgrade. Concrete paving operations on the eastbound lanes will begin in June 2018 and continue until October of 2018.</p> |
| <p>3. Requested Funding:</p> <p>Indicate which category(ies) of funding you are seeking support for:</p> <p>YES Category A: \$40,000 for incorporating two or more AASHTO PP 84-17 tests in the mix design/approval process. Shadow testing is acceptable.</p> <p>YES Category B: \$20,000 for incorporating one or more AASHTO PP 84-17 test in the acceptance process. Shadow testing is acceptable.</p> <p>YES Category C: \$20,000 for requiring a comprehensive QC Plan from the contractor that will be approved and monitored by the state.</p> <p>YES Category D: \$20,000 for requiring the use of control charts, as called for in AASHTO PP 84-17.</p> |
| <p>4. Description of What will be accomplished in each category:</p> <p>For each Category, from above, you are seeking funding support for, please discuss the requested information.</p> <p><u>Category A:</u> Identify which tests you will be evaluating, your mix design/approval process, and how the use of the tests differs from your current process.</p> <p>Currently, PennDOT requires trial batching, air, slump, unit weight, specific gravities, ASR mitigation (R80), fineness modulus, and compressive strength at 7 and 28 days for our mix designs. We have started doing CTE testing for our MEDPG design program. We specify a minimum and maximum cement content, and a maximum water cement ratio (for slip form paving it is 0.47).</p> <p>Although there are several mix designs that are approved for this project, the contractor (Golden Triangle) plans to submit several additional mixes that will incorporate the added tests required for this demonstration project.</p> <p>For this project, we incorporate the following, in addition to what is currently require:</p> <ul style="list-style-type: none">8. Rate of flexural strength development to 90 days9. Rate of strength development to 90 days |

10. ASTM C 157- Unrestrained Volume Change
11. Formation factor from resistivity testing
12. Super air meter
13. W/C ratio ≤ 0.45
14. Volume of paste

(These additional requirements will be obtained through SHADOW testing)

Category B: Identify which test(s) you will be evaluating, how your acceptance process will use the test(s) results, and how the use of the tests differs from your current process.

Currently, PennDOT requires slump, air content and temperature of the fresh concrete for QC control. Compressive strength testing of the hardened concrete is required for acceptance. W/C ratio is checked on every ticket also.

For this project, we incorporate the following, in addition to what is currently required:

4. Super Air Meter
5. Formation Factor from resistivity testing
6. Box Test

(These additional requirements will be obtained through SHADOW testing)

Through these incentive funds, it would be desired to purchase one SAM along with a cape (\$3500) or one Resipod probe (\$4980). The cost of equipment purchased shall not be over \$5000. This equipment will become the Contractor's after the project is finished.

Category C: Identify what you will require in the QC Plan and how you will monitor compliance with the Plan. Note if you currently require QC Plans; if currently required, note how your process will differ on this project.

Currently PennDOT requires a yearly QC plan. The following are the minimum requirements: Describe the construction equipment, personnel, and methods necessary to construct and test concrete courses for all structural elements. Including testing frequencies and action points to initiate corrective measures. Action points and limits are established for slump, temperature, and air content.

For this project, we incorporate the following, in addition to what is currently required:

6. Unit weight (weekly)
7. Super air meter (1200 yd² or daily)
8. Water content (1200 yd² or daily)
9. Formation Factor from resistivity (1200 yd² or daily)
10. Box test (weekly)

These additional tests will be incorporated into the QC plan and the test results will be recorded.

Category D: Identify what control charts you will require the contractor/supplier to use and how the charts will be monitored during construction.

Currently PennDOT does not mandate any control charts for concrete paving. It is optional. Test results are recorded in a diary along with information about the concrete placement and weather conditions. Control charts are required at concrete plants and quarries for control of materials.

For this project, we will do control charts for the following tests:

7. Super air meter
8. air content
9. Unit weight
10. Water content
11. Strength
12. Formation Factor from resistivity

(These additional requirements will be obtained through SHADOW testing)

5. Other Information:

For the water content test, AASHTO T 318 will be followed but the department would like to investigate the possibility of purchasing and using the new W/C device, that is being developed by Oklahoma State, for this project.

Submit to:

Michael F. Praul, P.E.

Senior Concrete Engineer

Office of Preconstruction, Construction, and Pavements (HICP-40)

michael.praul@dot.gov