



PROJECT CONTRIBUTORS

	Whitman, Reuquardt and Associates, LLP	-	Designer
	Schnabel Engineering, Inc.	-	Geotechnical Investigation
	Phillips Construction, LLC	-	Prime Contractor
	Procon, Inc.	-	Concrete Sub-contractor
	PER, Inc.	-	Sub-contractor for Conveyance of Concrete
	Chandler Concrete, Inc.	-	Concrete Supplier
	McDonough Bolyard Peck, Inc.	-	Construction Inspection
	Virginia Department of Transportation	-	Owner, Project Mgr.
	Virginia Transportation Research Council	-	Technical Support

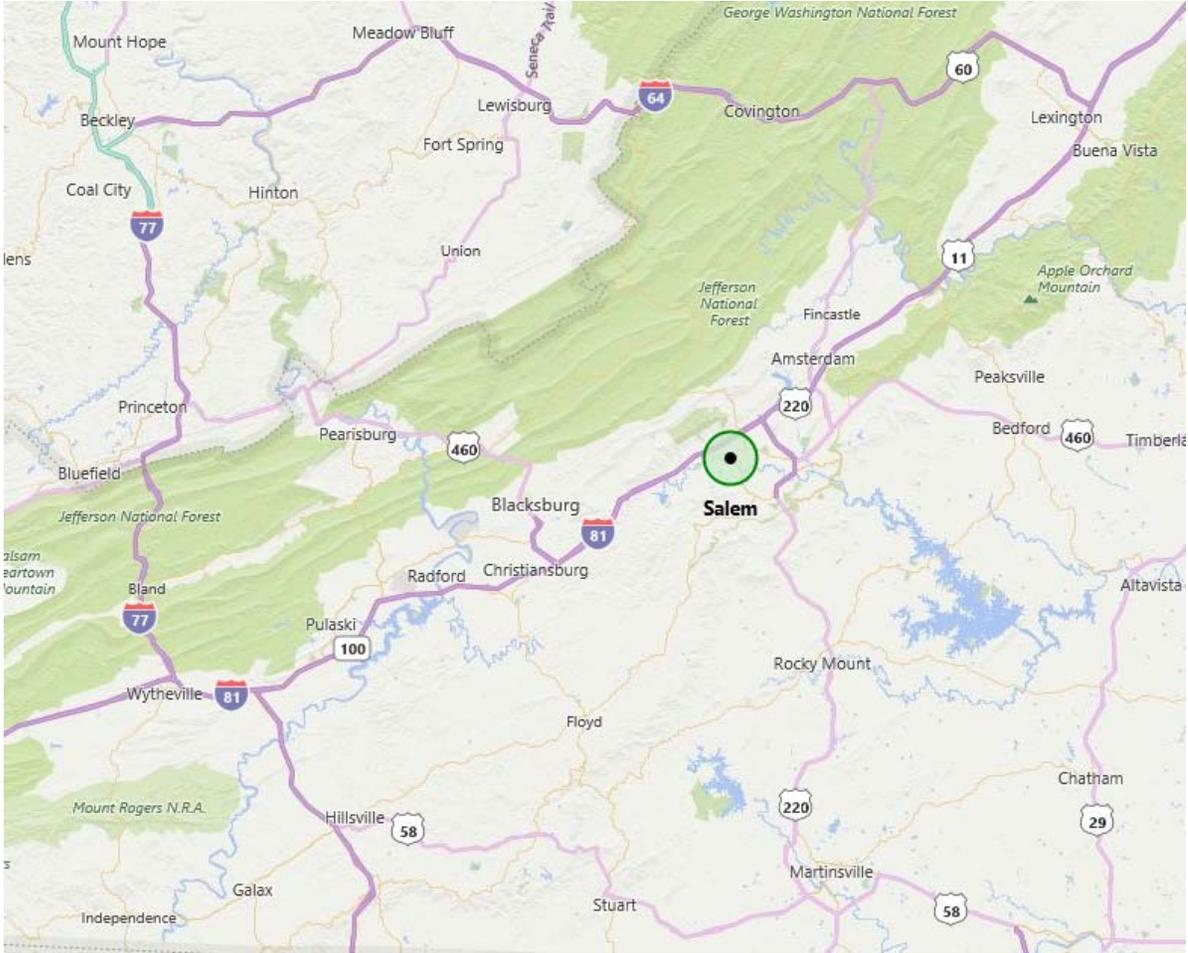
PERVIOUS CONCRETE Making the Impossible Possible

Construction of the I-81 Exit 140
Park-n-Ride in Salem, VA

Travis Higgs, P.E.
VDOT Salem Materials



Exit 140 Park-n-Ride location



The Impossible

- Existing Exit 140 Park-n-Ride surrounded by two secondaries, a primary and the interstate
- Already over crowded
- <100 parking spaces
- No room for expansion



The Possible

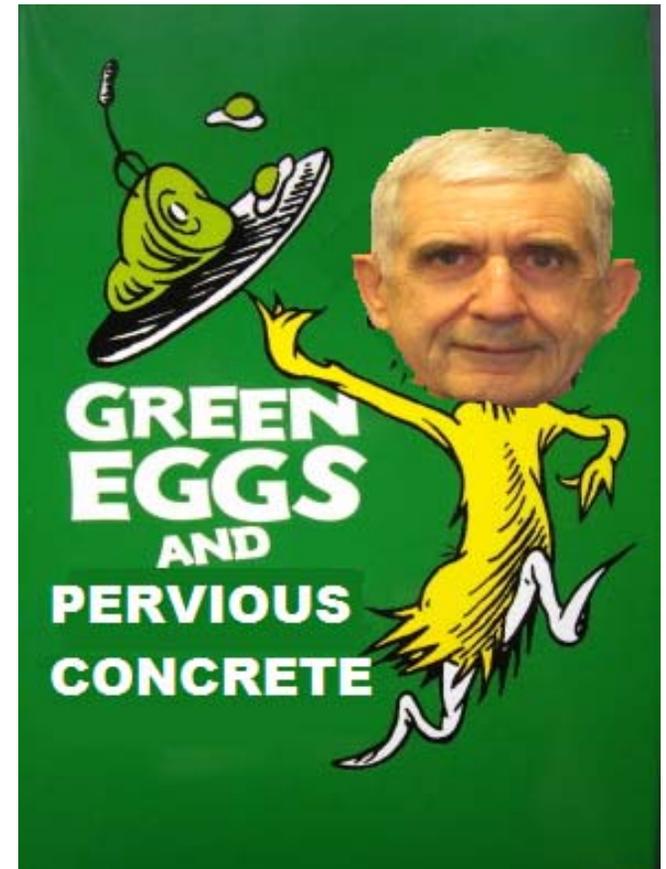
- **Exit 140 Park-n-Ride**
 - **Pervious Concrete**
 - Approx. 250 spaces
 - Approx. 2.5 acres
 - **Exit 118 Park-n-Ride**
 - **Conventional Asphalt**
 - Approx. 250 spaces
 - Approx. 4 acres



Why Pervious Concrete?

Green Eggs and Pervious Concrete

- **Dr. Celik: Do you like Pervious Concrete?**
 - I do not like it Celik I am!
- **Dr. Celik: Would you, could you try it on an interstate?**
 - I would not, could not try it on an interstate!
- **Dr. Celik: Would you could you try it on a secondary?**
 - I would not could not try it on an interstate or a secondary!
- **Dr. Celik: Would you could you try it on a shoulder?**
 - I would not could not try it on an interstate or a secondary or a shoulder!
- **Dr. Celik: Would you could you try it on a parking lot?**
 - Okay! I will try it on a parking lot!
 - Wow! I do like it in a parking lot!
 - I like it in a parking lot, I would like it on a
- **NOT SO FAST!**



Pervious Concrete Test Slab Acceptance Criteria

- **Fresh Density and Void Content (ASTM C 1688)**
 - Density: 125 pcf to 140 pcf
 - Voids: 15% to 25%
- **Infiltration Rate (ASTM C 1701)**
 - Greater than 100 inches per hour
- **Hardened Density and Void Content (ASTM C 1754)**
 - Density: +/- 5 pcf of Approved Mix Design
 - Voids: +/- 4% of Approved Mix Design
- **Core Length (ASTM C 174)**
 - -3/8 in. to + 1.5 in. of Design Thickness
- **Average Compressive Strength at 28 days (ASTM C 39)**
 - Greater than 2,000 psi

Fresh Pervious Concrete Test

- **ASTM C 1688 – Fresh Density and Voids Test was performed on every truck load**
- **This was the only fresh test performed on the pervious concrete for acceptance**
- **Fresh density was very sensitive to moisture content**



Fresh Pervious Concrete Test

- Inverted slump cone test was attempted, but found to not be as practical as the squeeze test



Infiltration Rate Test

- **ASTM C 1747**
- **Infiltration Rate was never a problem as the minimum 100 in./hr. established for the project was easily attained and may have actually been too high on occasion as some measured values exceeded 1,000 in./hr.**



Evaluation of Cores for Strength, Hardened Density and Voids

- Cores were taken to evaluate the strength, in-place density, void content and thickness of the pervious concrete.
- In-place density and voids were a challenge throughout the project. There was a slight variation between the density and voids measured using ASTM C 1754 Method A versus Method B. Method A (slow drying) was generally used for the project as the ASTM recognizes that Method B (fast drying) may produce lower density and higher void content.
- Strength (min. 2,000 psi) was generally achieved on average after 28-days of field curing. Cores checked for density and voids by use of Method A (slow drying) can be used for strength testing; however, we found 30% reduction in strength for oven dried cores vs. field cured.



Test Slab

- **Forms on No. 57 Stone**
- **14 ft x 19 ft w/ joint to test joint rolling, resulting in 12.5 ft x 19 ft slab for shrinkage crack evaluation**
- **Tried three variations of cross-rolling**
 - No Weight
 - One Plate Weight – 35 lbs
 - Two Plate 'Weights – 70 lbs



Test Slab

- Concrete Placement
- Motorized Screed
- Cross-Rollers



Test Slab

- “Pizza Cutter” for Joints
- 0.5-inch strips were placed on forms for initial screed pass and then removed for weighted rolling
- Variations in weight of cross-roller did not make an impact on density



Test Slab Results

- **Fresh Density and Void Content (ASTM C 1688)**
 - Density: 128.4 pcf : 125 pcf to 140 pcf **PASS**
 - Voids: 19.6% : 15% to 25% **PASS**
- **Infiltration Rate (ASTM C 1701)**
 - Average = 343 in/hr. : Greater than 100 inches per hour **PASS**
- **Hardened Density and Void Content (ASTM C 1754)**
 - Density: 121.4 pcf : +/- 5 pcf of Approved Mix Design (122.8 – 132.8 pcf) **FAIL**
 - Voids: 25.6% : +/- 4% of Approved Mix Design (16 – 24%) **FAIL**
- **Core Length (ASTM C 174)**
 - Average Length = 6.07 in. : -3/8 in. to + 1.5 in. of Design Thickness **PASS**
- **Average Compressive Strength at 28 days (ASTM C 39)**
 - 7-day Average = 1,067 psi : Greater than 2,000 psi **FAIL**
 - 28-day Average = 2,590 psi : Greater than 2,000 psi **PASS**

Preparations for Production Slabs

- **Forms are set and No. 57 Aggregate has been graded.**



First Production Slabs / Test Slab No. 2

- Due to lack of density on Test Slab, cross-rollers were replaced with “heavy roller”
- On the test slab 0.5-inch strips were used for initial motorized screed pass; however, due to difficulty with getting the concrete to compact down and fear of slab to slab roughness, contractor switched to 0.375-inch strips.



First Production Slabs / Test Slab No. 2

- **Telebelt conveyor was used to distribute concrete from the trucks to the forms.**
- **Despite concerns of pervious concrete being exposed to air too long, the telebelt conveyor proved to be a valuable tool to distribute concrete quickly and without segregation**



First Production Slabs / Test Slab No. 2

- Procon had a lot of workers ready to go and kept a very tight operation with concrete being covered with plastic in 10 – 15 minutes after discharge



Test Slab No. 2 Results

- **Fresh Density and Void Content (ASTM C 1688)**
 - Density: 130.3 pcf : 125 pcf to 140 pcf **PASS**
 - Voids: 18.5% : 15% to 25% **PASS**
- **Infiltration Rate (ASTM C 1701)**
 - Average = 620 in/hr. : Greater than 100 inches per hour **PASS**
- **Hardened Density and Void Content (ASTM C 1754)**
 - Density: 122.6 pcf : +/- 5 pcf of Approved Mix Design (122.8 – 132.8 pcf) **FAIL**
 - Voids: 23.0% : +/- 4% of Approved Mix Design (16 – 24%) **PASS**
- **Core Length (ASTM C 174)**
 - Average Length = 5.1 in. : -3/8 in. to + 1.5 in. of Design Thickness **PASS**
- **Average Compressive Strength at 28 days (ASTM C 39)**
 - 28-day Average = 2,001 psi : Greater than 2,000 psi **PASS**

Next Production Slabs / Test Slab No. 3

- In an attempt to achieve more in-place density, the contractor switched to 0.5-inch strips on top of the forms and followed the mechanical screed with the heavy roller and weighted cross-rolling.
- The mix-design was slightly altered to allow more sand and 0.5% less voids (new target 19.5%)
- These steps were taken as the success of the pervious concrete is dependent upon the ability to effectively balance permeability, strength and stability.



Next Production Slabs / Test Slab No. 3

- Contractor performed a small test section using only a pan float for compaction and finishing of the pervious concrete to see if it could achieve the necessary targets.
- The ability to use a pan float would have allowed the contractor to not have to form up 12-foot widths/lanes when they poured thus allowing them to place the pervious concrete more like a floor slab than concrete pavement which would in turn mean more production.
- Pan float compacted areas showed less density and less permeability than rolled locations.



Test Slab No. 3 Results

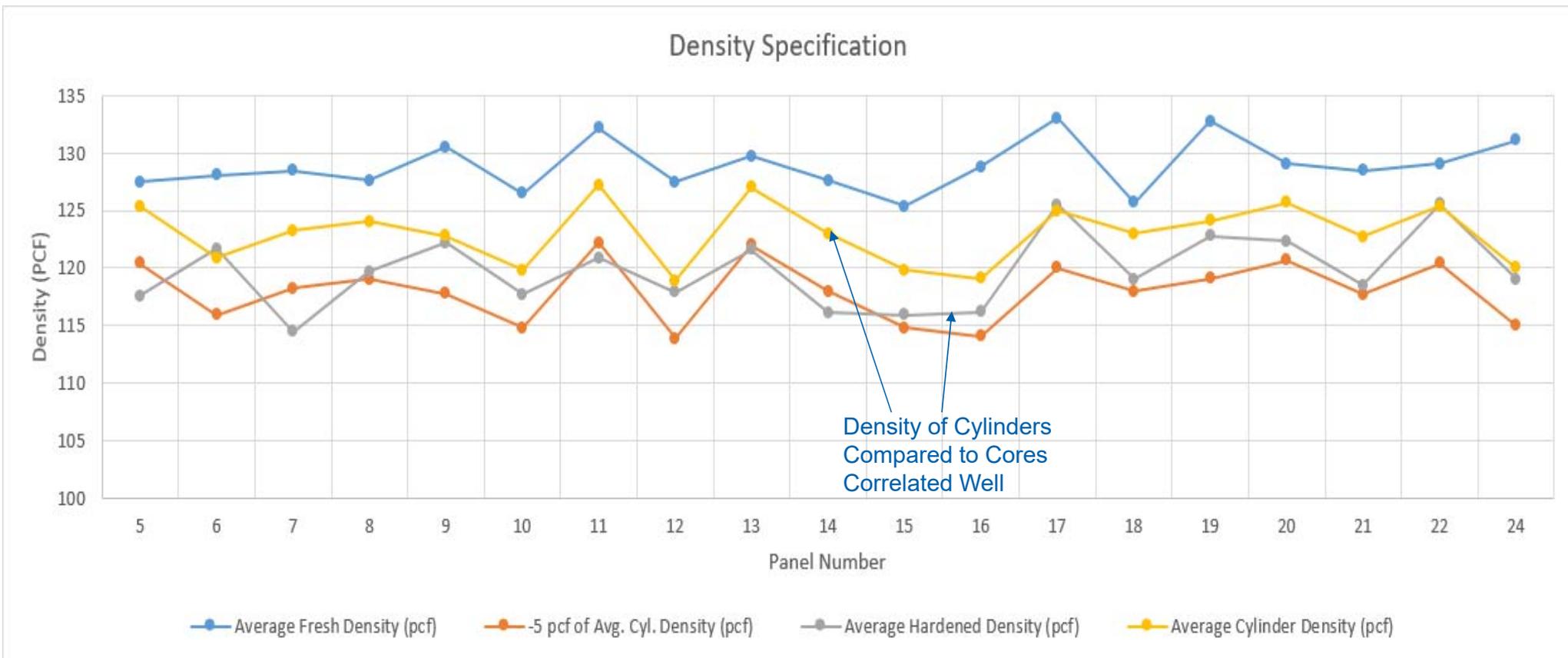
- **Fresh Density and Void Content (ASTM C 1688)**
 - Density: 130.3 pcf : 125 pcf to 140 pcf **PASS**
 - Voids: 18.5% : 15% to 25% **PASS**
- **Infiltration Rate (ASTM C 1701)**
 - Average = 540 in/hr. : Greater than 100 inches per hour **PASS**
- **Hardened Density and Void Content (ASTM C 1754)**
 - Density: 119.6 pcf : +/- 5 pcf of Approved Mix Design (122.8 – 132.8 pcf) **FAIL**
 - Voids: 26.6% : +/- 4% of Approved Mix Design (16 – 24%) **FAIL**
- **Core Length (ASTM C 174)**
 - Average Length = 5.1 in. : -3/8 in. to + 1.5 in. of Design Thickness **PASS**
- **Average Compressive Strength at 28 days (ASTM C 39)**
 - 7-day Average = 1,413 psi : Greater than 2,000 psi **FAIL**
 - 28-day Average = 1,875 psi : Greater than 2,000 psi **FAIL**

Test Slab No. 3 Results

- **Although the acceptance criteria were not all met for the test slab, we finally had a mix design and placement plan that achieved the optimum balance of durability and permeability.**
- **Although not a specification test, as a check for durability, we performed ASTM C 1747.**
 - **Test on cylinders produced 34% mass loss.**
 - **Tests were run on cores**
 - **Cores with low density had > 40% mass loss**
 - **Cores with higher density had < 40% mass loss**



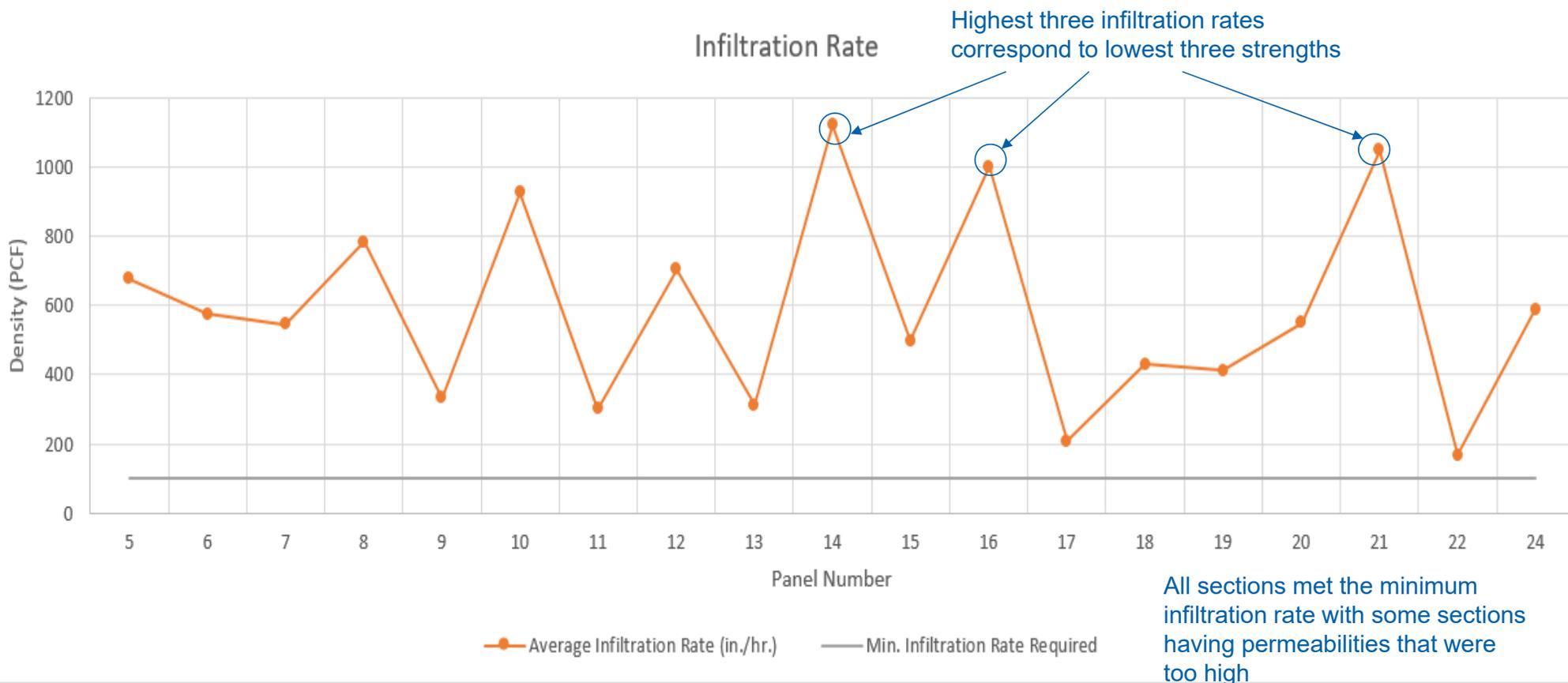
Overall Results - Density



Overall Results - Strength



Overall Results – Infiltration Rate



The Goal

Strength, Durability and Permeability



QUESTIONS?

