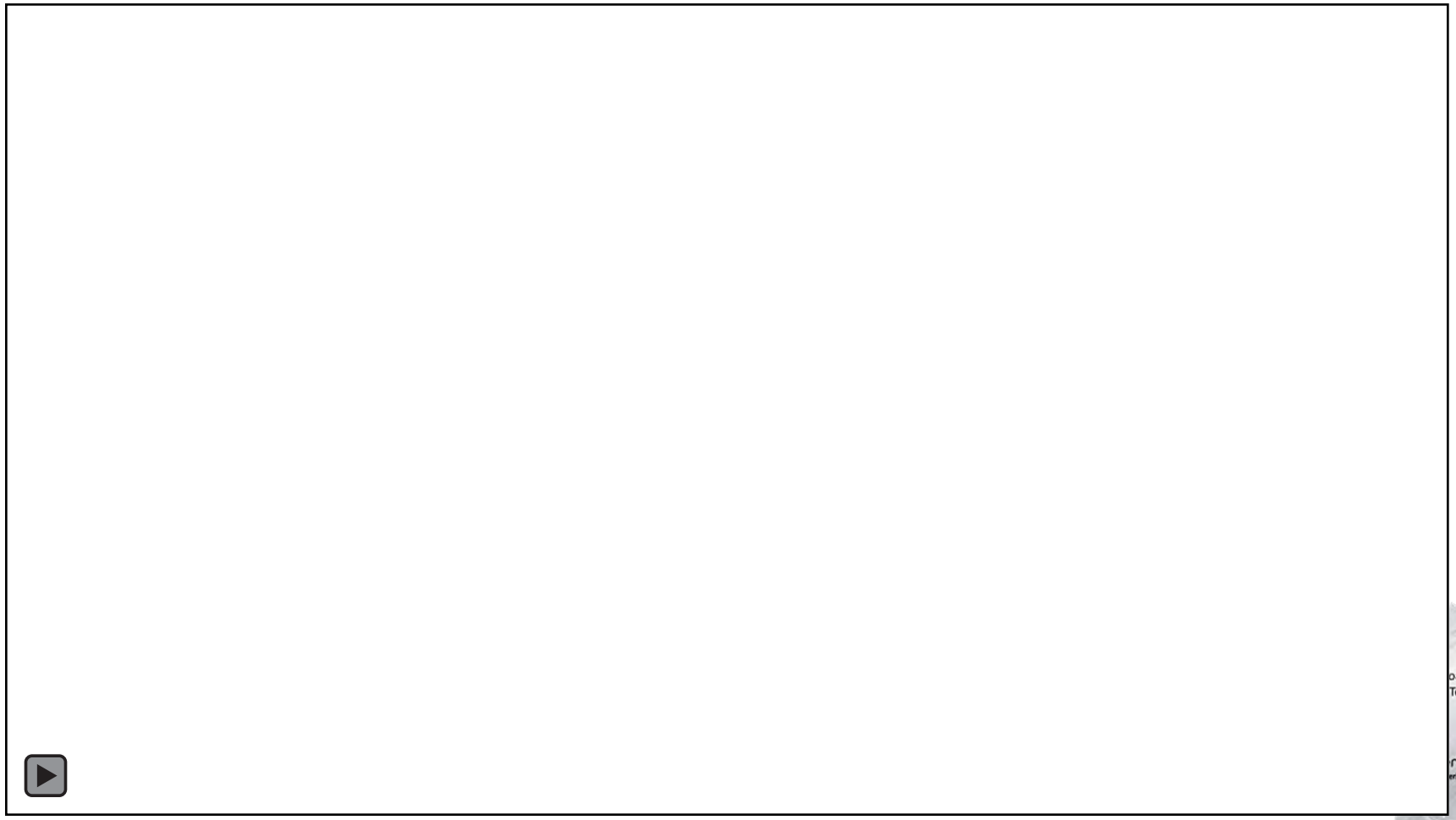
Low-Density Cellular Concrete (LDCC)



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Nico Sutmoller
Global Lightweight Fill Specialist

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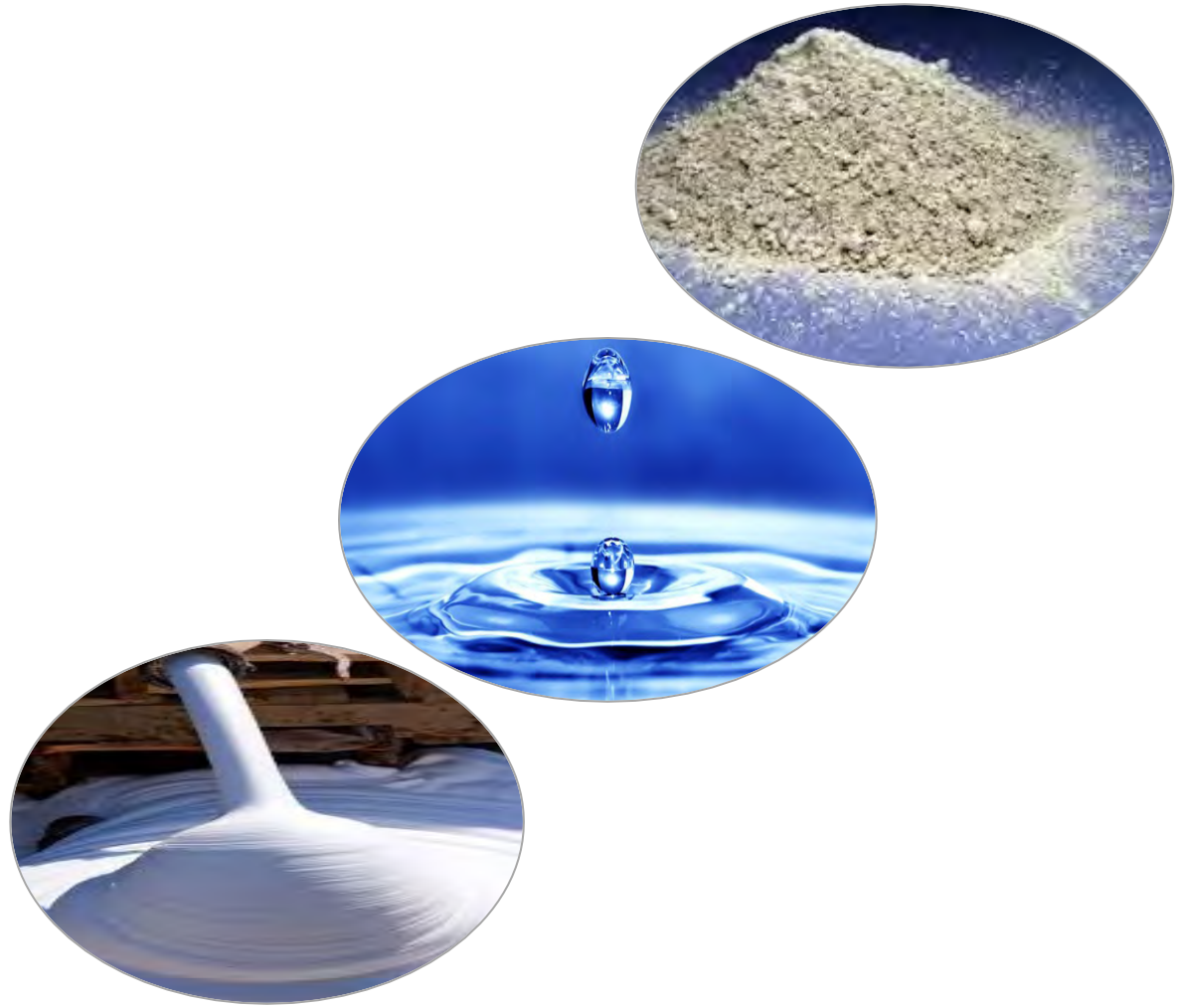
Low-Density Cellular Concrete (LDCC) is defined by ACI 523 as…

- Concrete made with hydraulic cement, water and preformed foam to produce a hardened material with an oven dry density of 50 pounds (22.7 kg) per cubic foot or less.

- Preformed foam is created by diluting a liquid foam concentrate with water in predetermined proportions and passing this mixture through a foam generator.



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LDCC replaces coarse aggregate with AIR

The air cells must be resilient in order to withstand the rigors of mixing and pumping in various applications







Foam has the stability to be calculated as a solid but the properties to be placed as a low density fluid material

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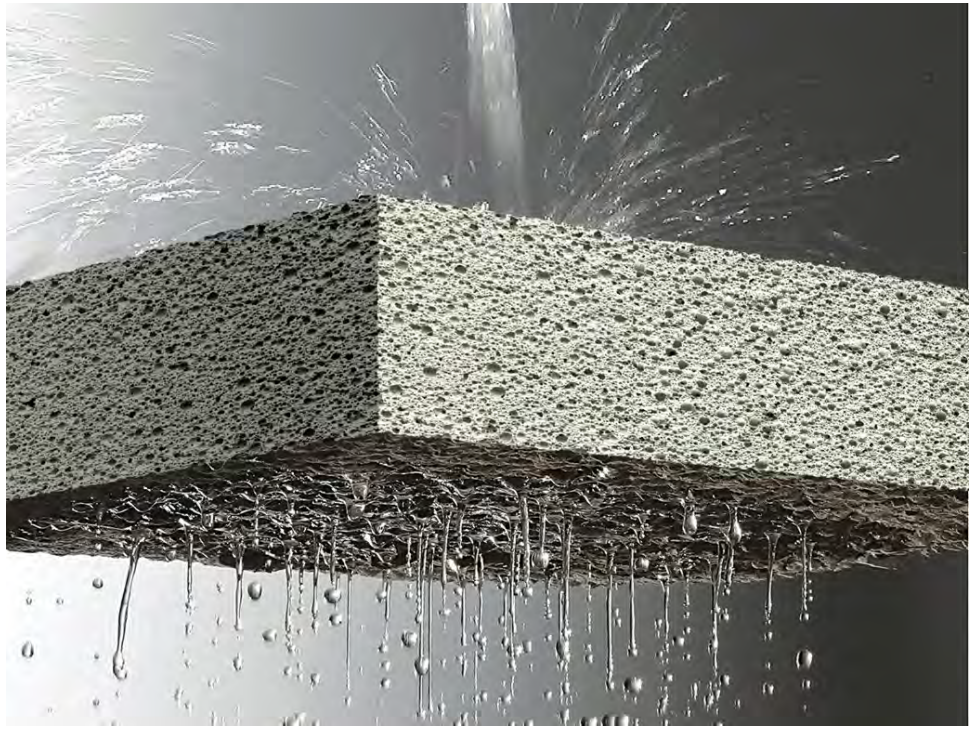
Permeable & Non-Permeable LDCC





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Ranges of Compressive Strength per ACI523

Oven-dry density		Usual range of compressive strength at 28 days	
lb/ft^3	kg/m^3	psi	MPa
20 to 25	320 to 400	70 to 125	0.48 to 0.86
25 to 30	400 to 480	125 to 225	0.86 to 1.55
30 to 35	480 to 560	225 to 350	1.55 to 2.41
35 to 40	560 to 640	350 to 450	2.41 to 3.10
40 to 50	640 to 800	450 to 750	3.10 to 5.17

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Production of LDCC is more environmentally friendly than alternative methods

- 55% Less trucking
  - Truckloads / 1000 cubic yards (765 cubic meters)
    - Typical Fill - 100 trucks
    - Cellular Concrete – 45 trucks
    - Elimination in coarse aggregate haul
- 55% Less Fuel
- 55% Less Carbon Emissions
- Requires fewer pieces of equipment
  - Cleaner, less congested jobsites
- No compaction loss on purchased volumes
  - What you see is what you get



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Culvert or Annular Application



- 150 yd^3 (114 m^3)of 500psi (3.4 MPa) pumped 100ft (30.5m) under SR 1 for MaineDot





Photo Courtesy of SnapTite

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Utility/Tunnel Abandonment



*Information provided by
Mainmark, Australia

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Backfill on CMP Eagle Pass, TX







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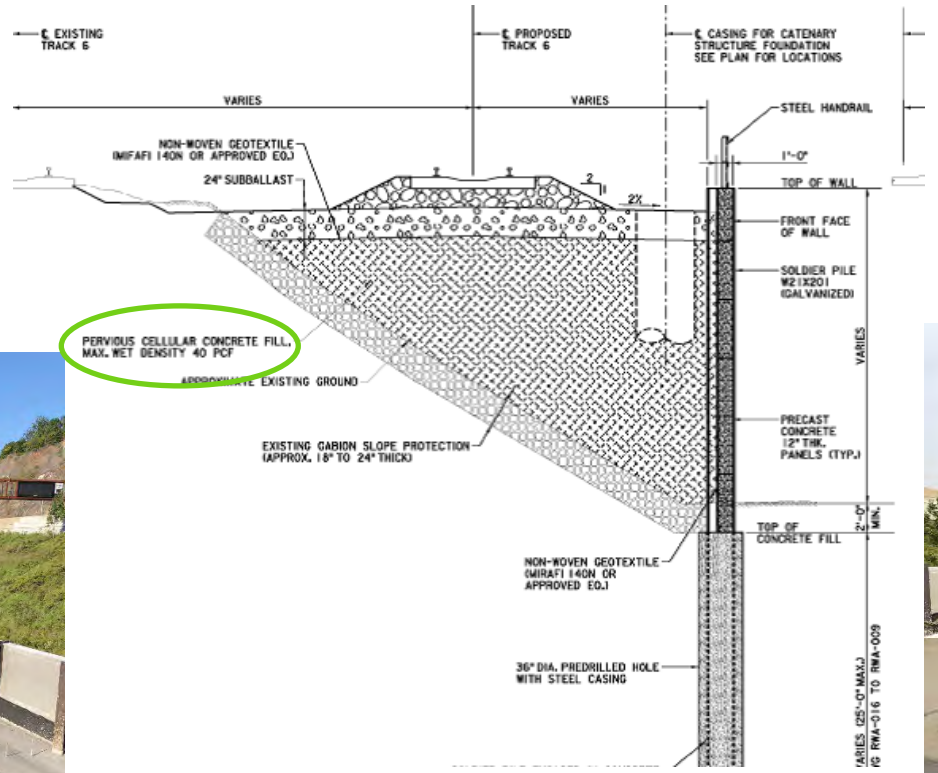
*Information provided by Custom-Crete, TX

Portal North Bridge, Secaucus, NJ









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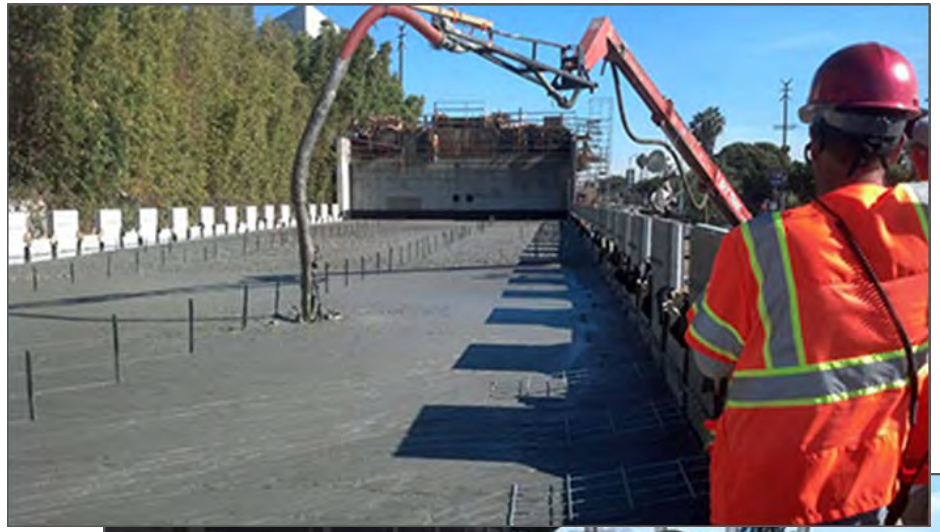
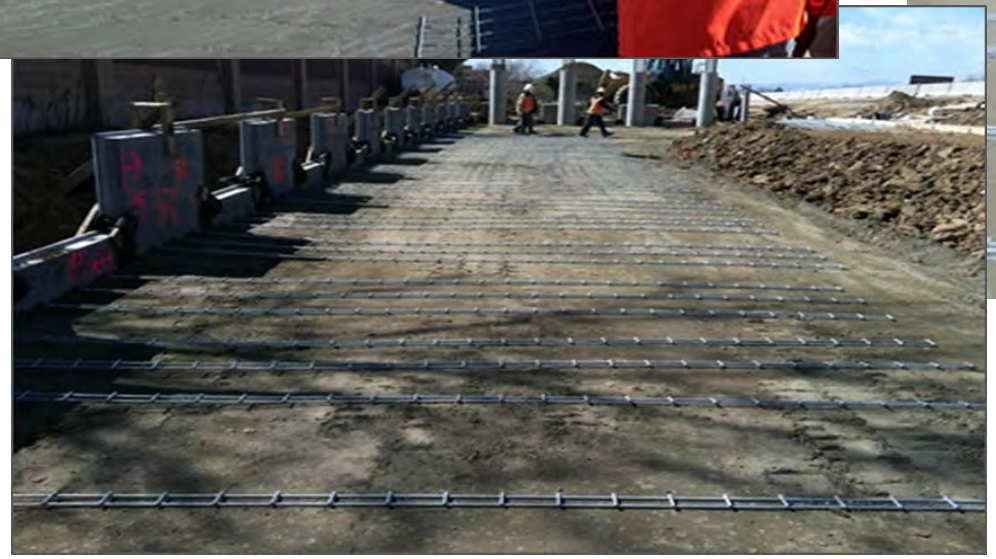
**Information provided by GeoCell/Midwest*

Segmental Wall Configuration







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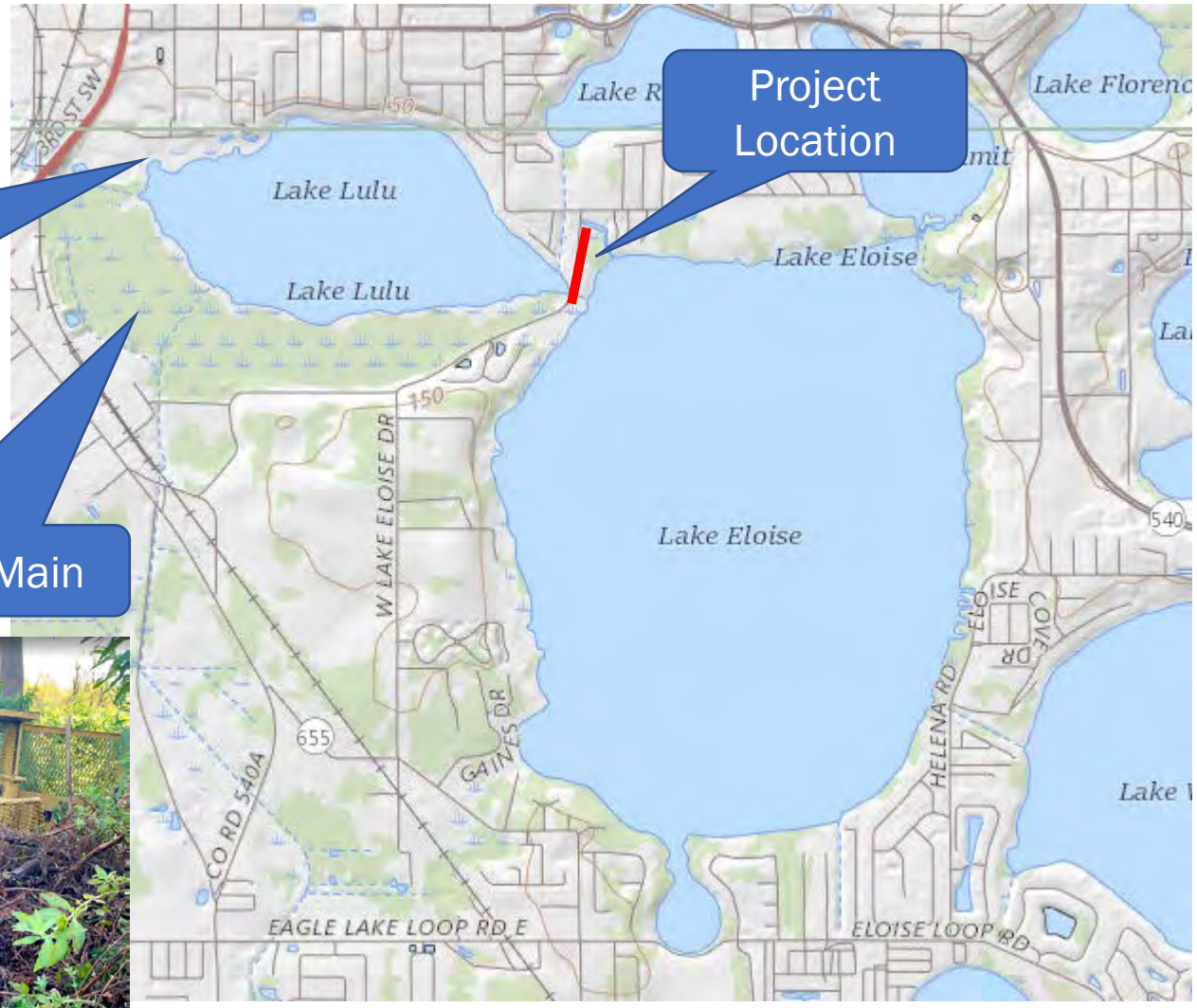
West Lake Eloise Drive

Chain'O Lakes Complex
- New Fieldhouse
- Surcharged Road
- Surcharge Ballfields

Reclaimed Water Main





- 470 feet of road between Lake Lulu and Lake Eloise
- Road settled over time
- Pavement is in poor condition
- Site floods regularly during wet season
- Road closed to traffic almost annually now

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Objectives for W. Lake Eloise Dr.
Winter Haven, Florida

- Resolve potential long-term settlements
- Improve long-term pavement condition
- Keep the road open during high-water events
- Prevent potential uplift of lightweight sub-base during high-water events
- Mitigate the high-water table on both sides of the road
- Increase road elevation 1.5 feet to avoid future flooding
- Reduce the construction timeline

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The Problem





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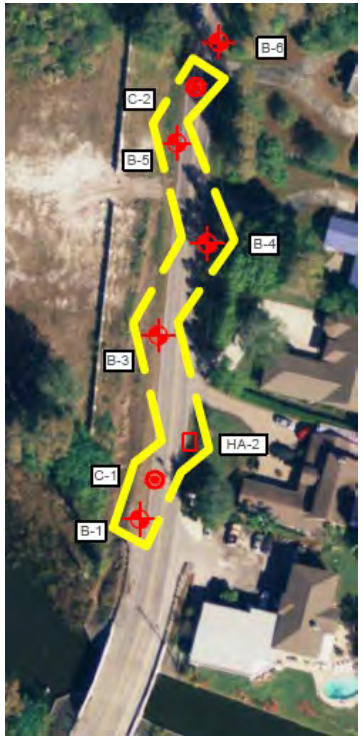
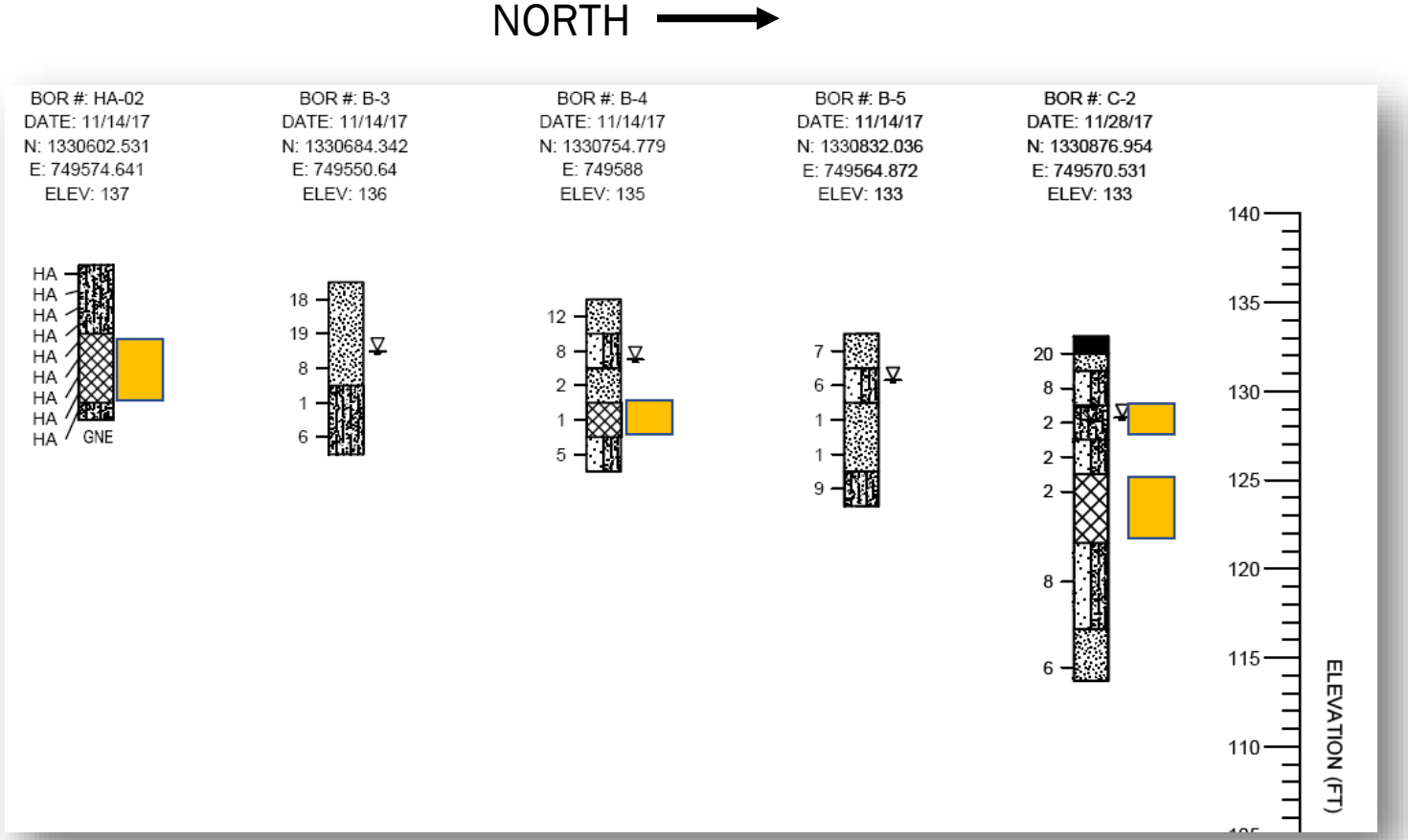
Soil Conditions





- Soil Survey includes Hontoon Muck and Samsula Muck
- Water Table at or above ground surface **except** during dry spells
- Borings showed sand placed over organic muck and peat (former surface soils)
- Asphalt was up to 1 foot thick in places

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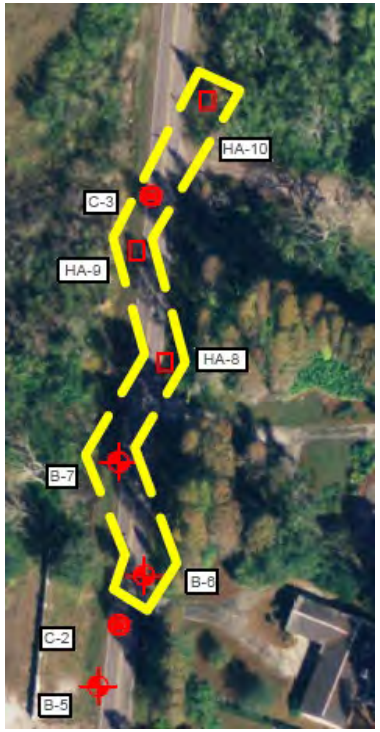
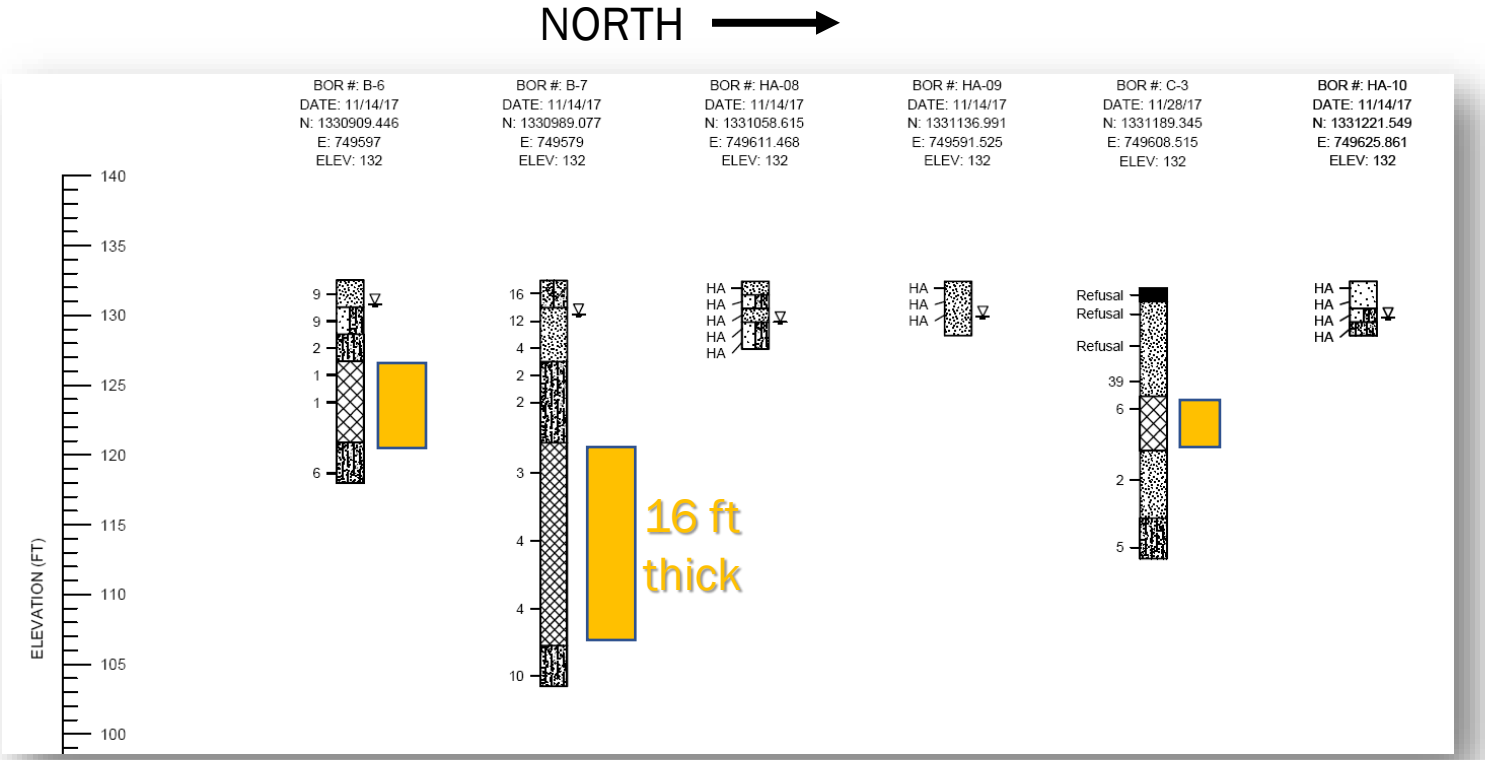
Soil Conditions





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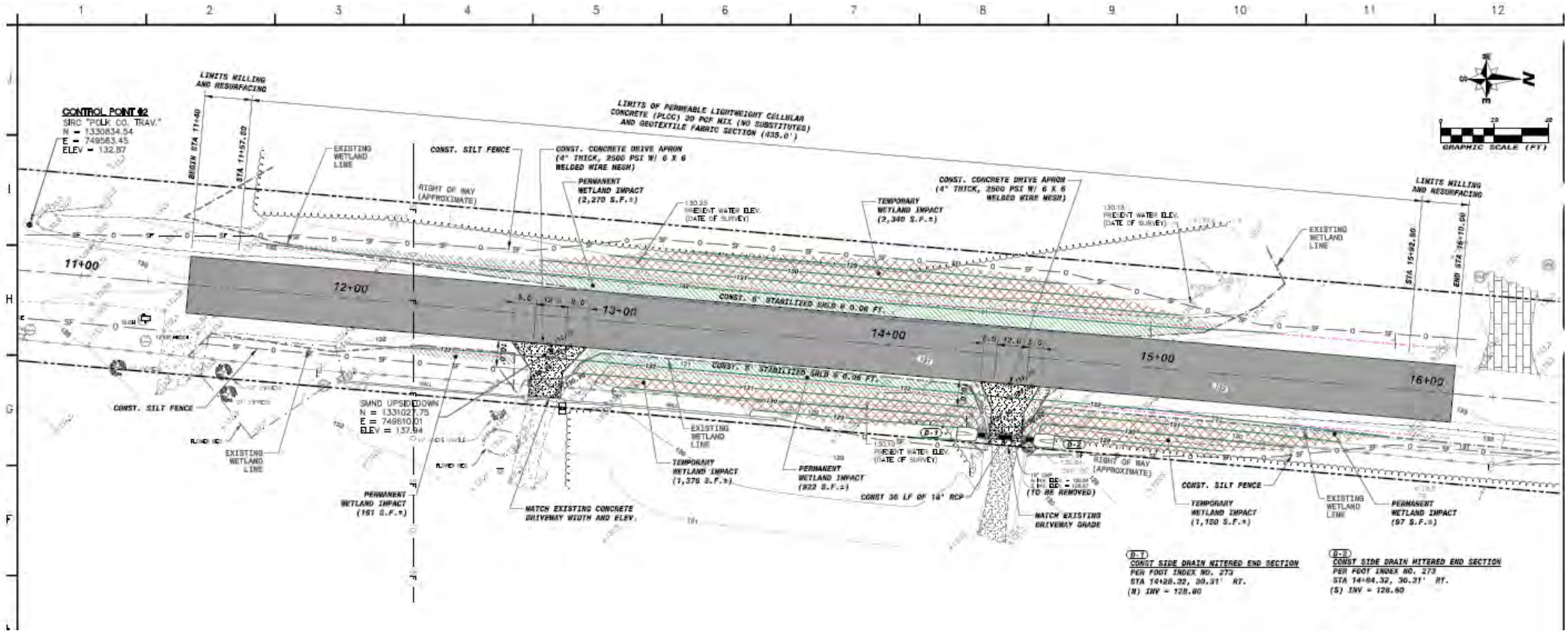
The Plan – Lightweight Backfill



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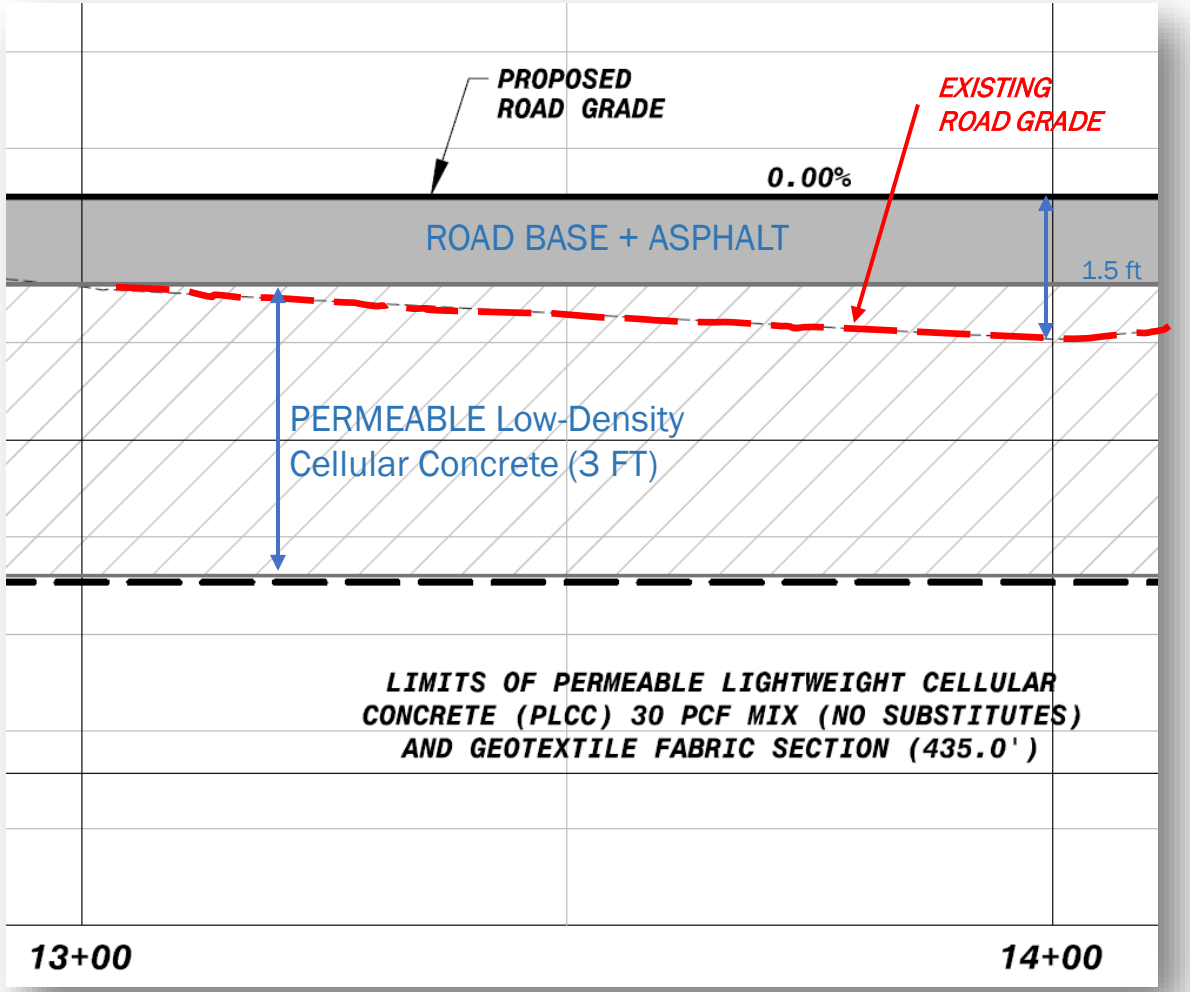
*Information provided by
Wood Environment & Infrastructure

Profile Detail



- Typical inundation 3 – 4 inches, 1 – 2X/year
- Remove Asphalt and Limerock base
- Dig down 2 – 3 feet, remove sandy soil
- Replace with 3 feet of PLDCC
- New base and asphalt
- Increase road elevation 1.5 feet to avoid future flooding

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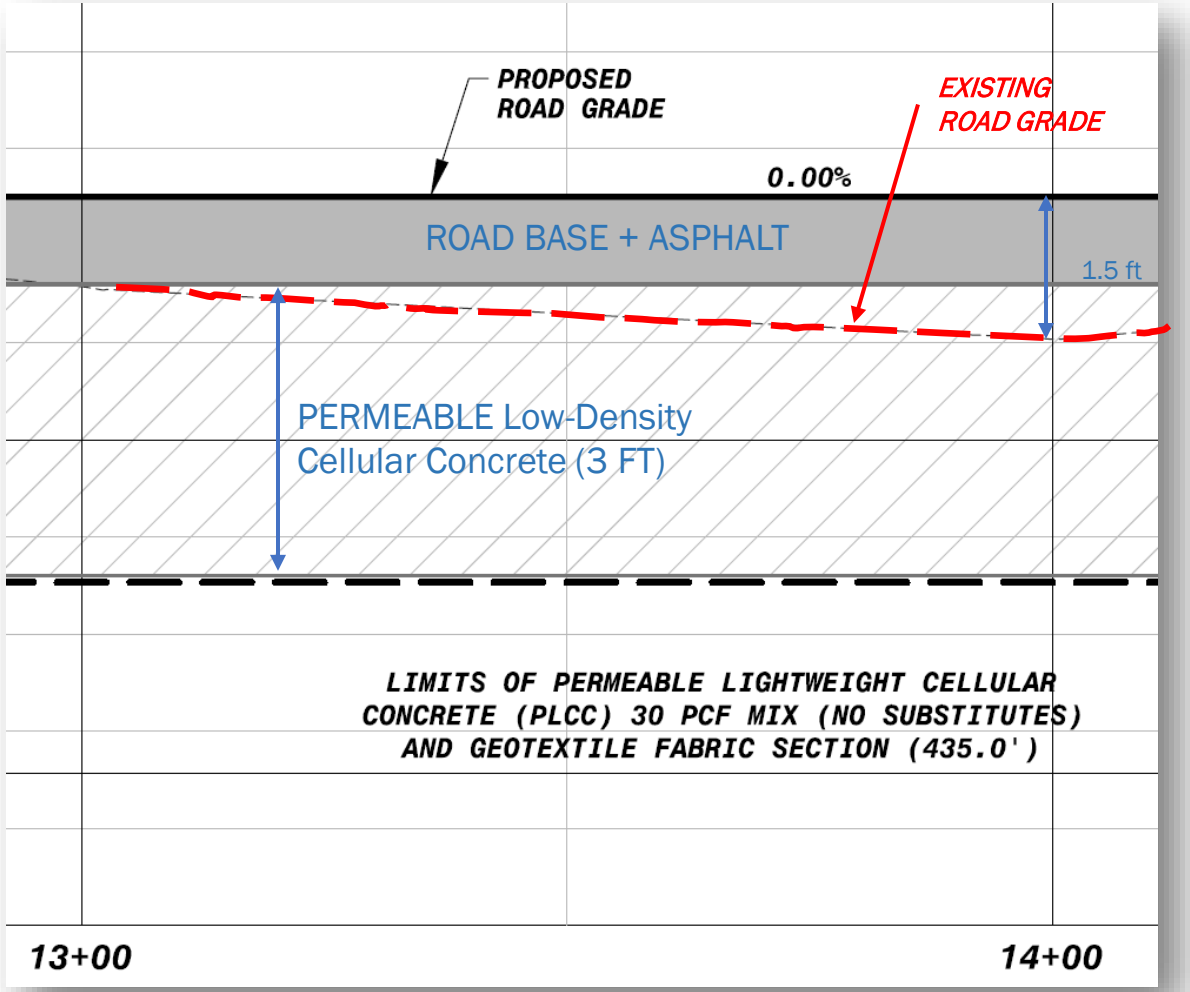
Design Considerations



- Increasing the road elevation would have started new round of settlement of buried organics
- Remove embankment soil = unload up to 300 PSF
- Replace with PLDCC = 3 ft x 30 PCF = + 90 PSF
- Add Limerock and Asphalt = 1 ft x 120 PCF = +120 PSF
- Net stress = -300+90+120 = -90 PSF (unload for total stress condition)

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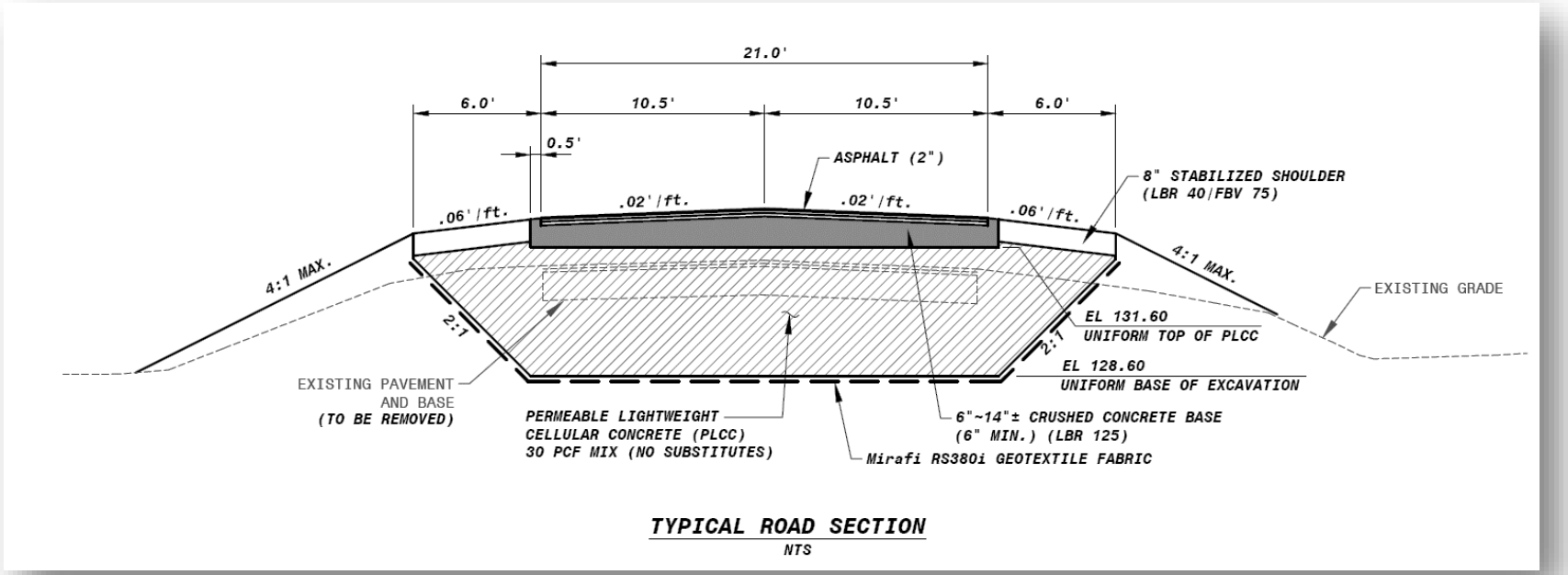
Uplift Considerations



- High-water table changes (reduces) stresses
- High-water table can cause uplift on the cellular concrete
- Added uplift anchor plates in the abundance of caution for an extreme high-water table conditions during the construction phase (PLDCC submerged)

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The long timeline

- Geotech Design – 2017
- Civil Design - 2018
- Permitting – 2018 / 2019
- Letting and Construction – March 2019 …. Then April… then May….
- Continual delays due to the site being too wet in order to dewater the site

- Finally an installation date in May 2020

- Lets’ take a tour of the of the construction and placement of the PLDCC

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Extremely High Watertable





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Dewatering







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Excavation & Dewatering





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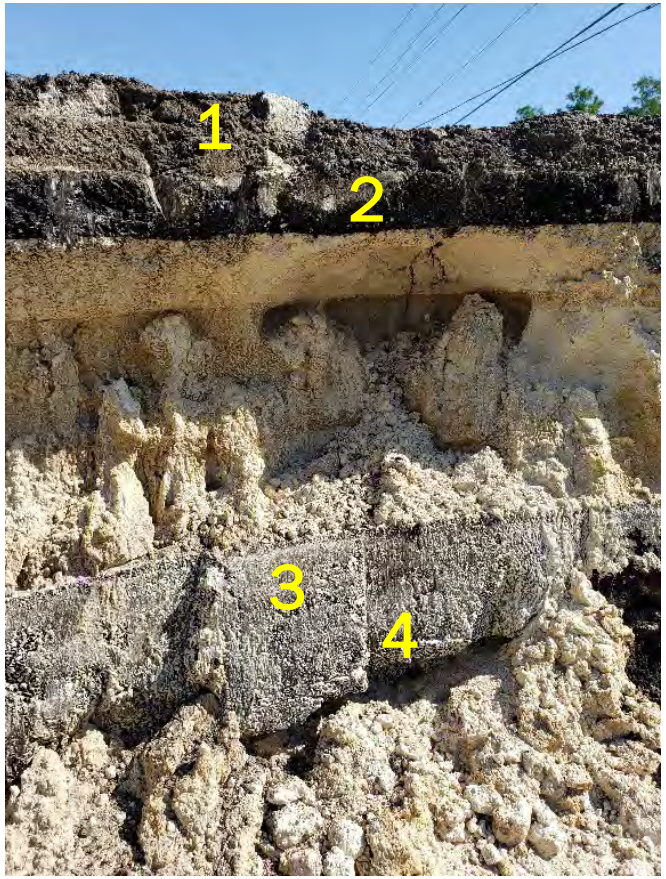
Five layers of Asphalt





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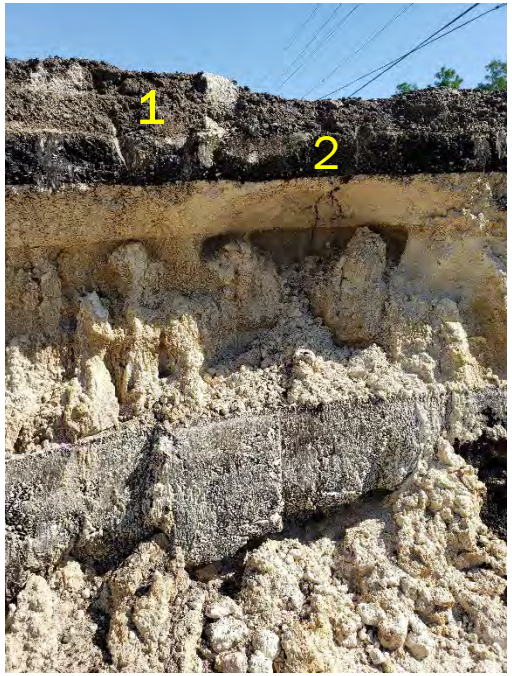
Five layers of Asphalt









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Site Confirmation of conditions





*Information provided by
CellFill, Grove, OK

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3 D Scan Image of project



3D Scanner
Trible XS10

Collects 26,600
data points/second

*Information provided by
CellFill, Grove, OK

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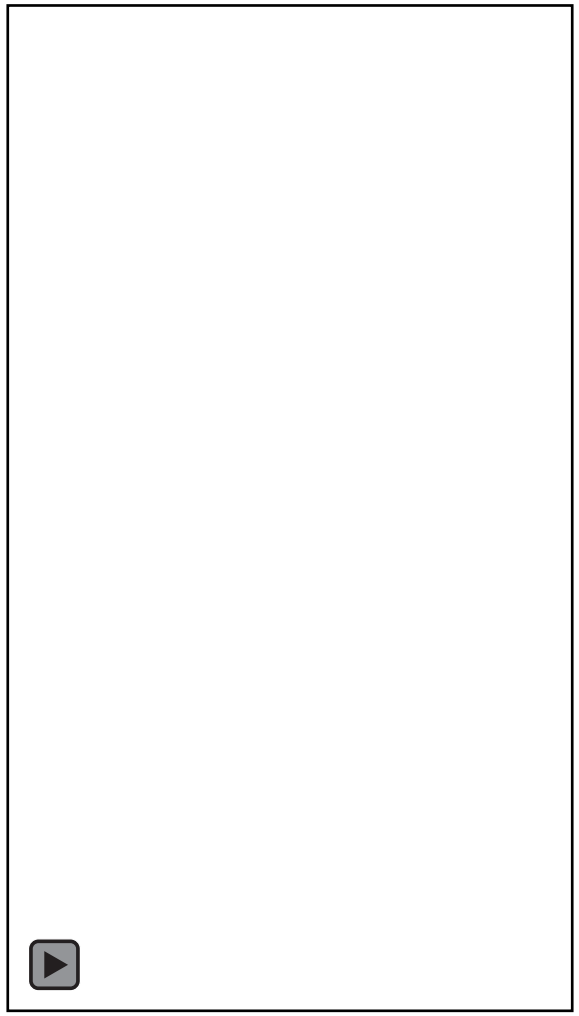
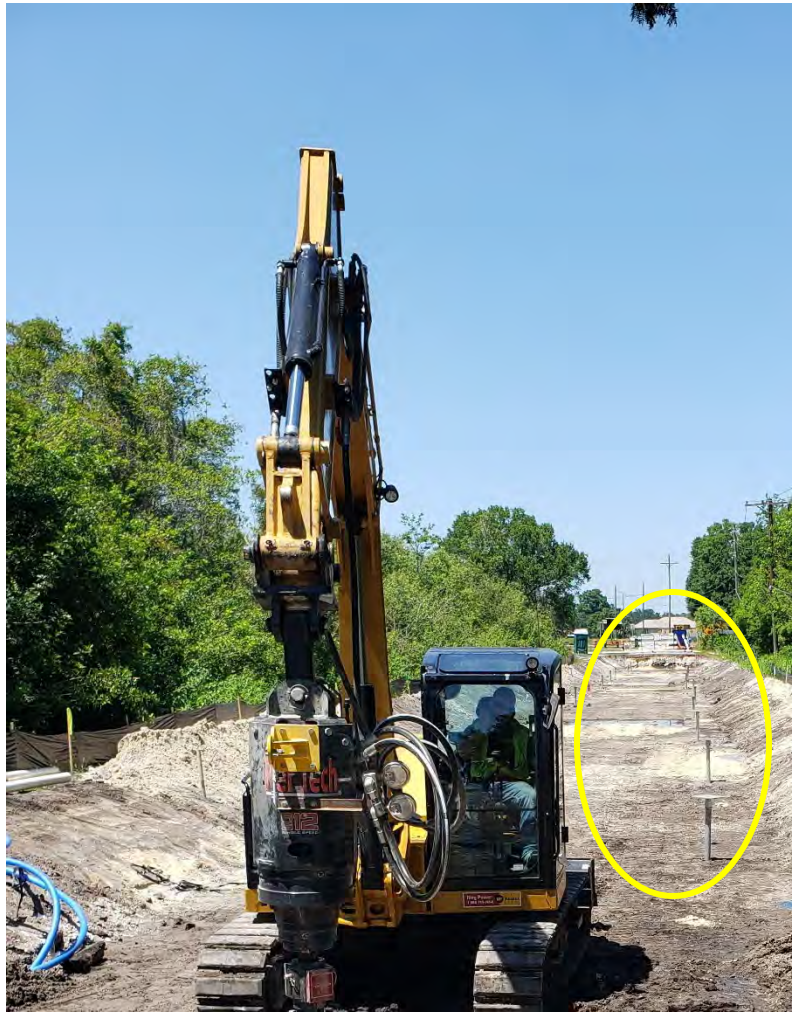
Placement of Helical Anchors



Helical Anchors

Used during the construction phase to prevent any potential uplift in case of a high-water event during the placement of the PLDCC and the actual road base and final asphalt layer





*Information provided by CellFill, Grove, OK

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Let the Permeable Low-Density Cellular Concrete (PLDCC) Placement Begin





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*Information provided by
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Permeable vs. Non-Permeable



- Bubble Chemistry is different
  - In non-permeable we need to maintain the bubble structure
  - With Permeable we need to coalesce the bubble structure

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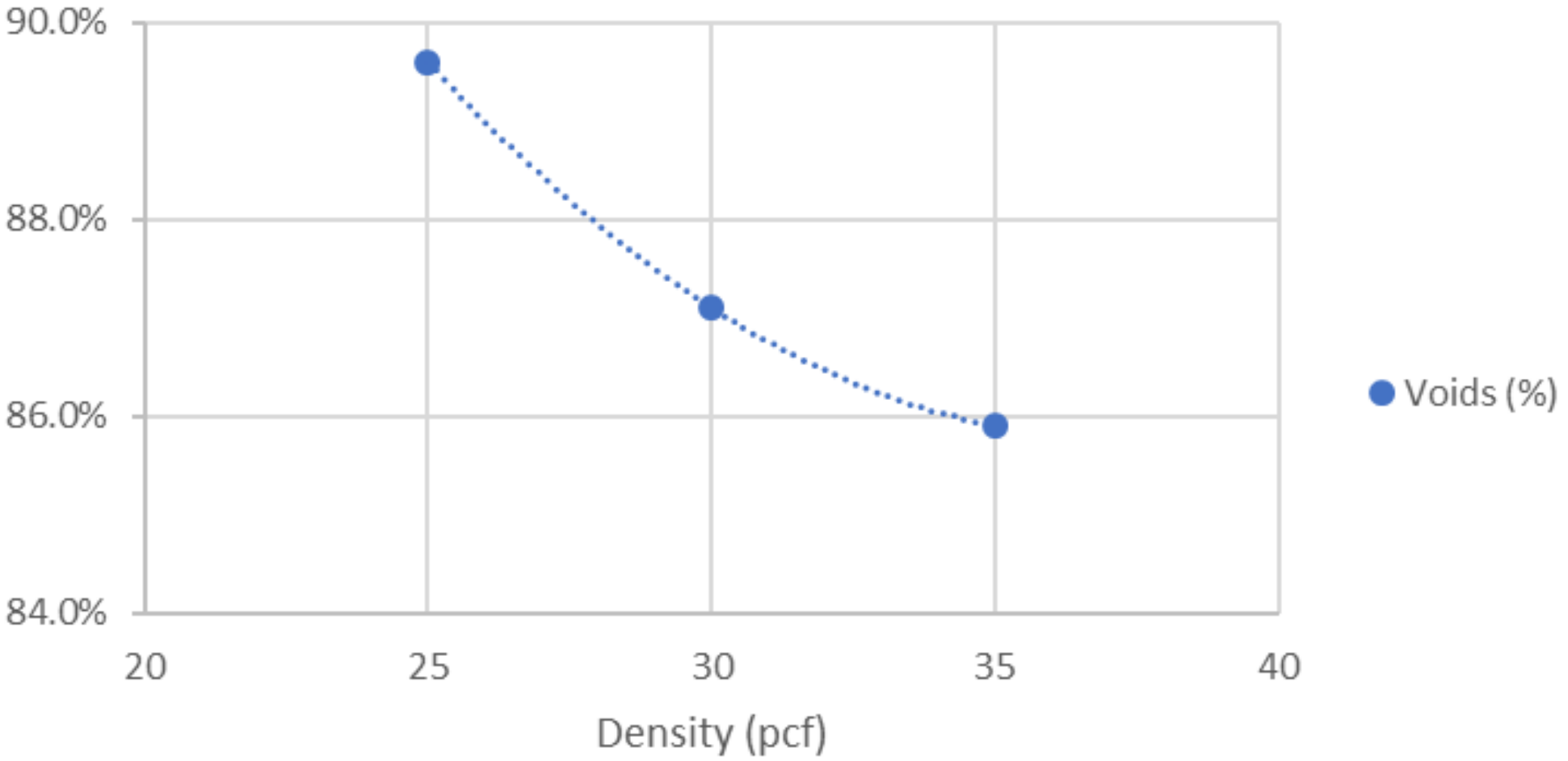
Void Factors of PLDCC



** University of Missouri - Kansas City, J.T. Kevern

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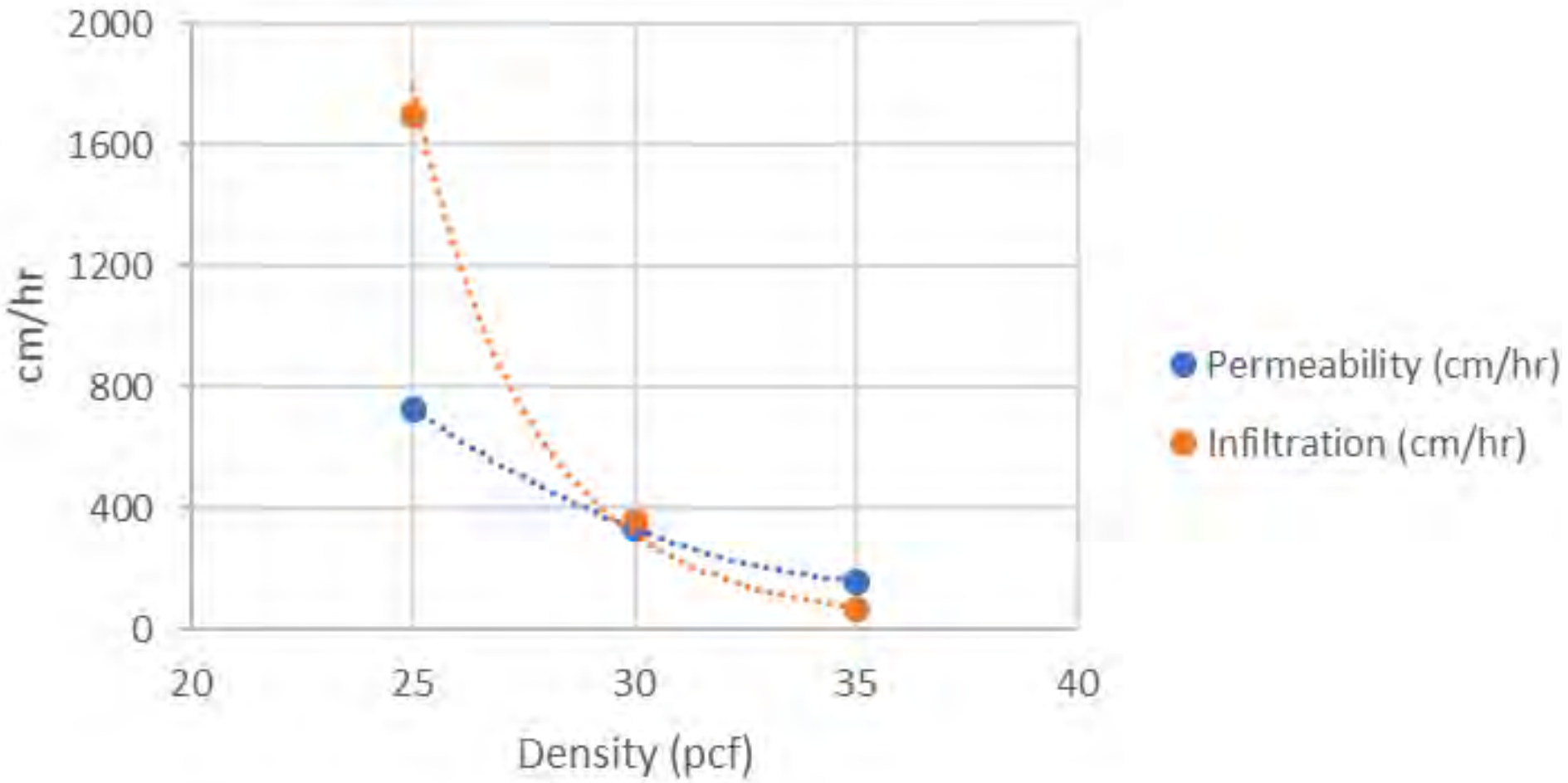
PLDCC Permeability / Infiltration



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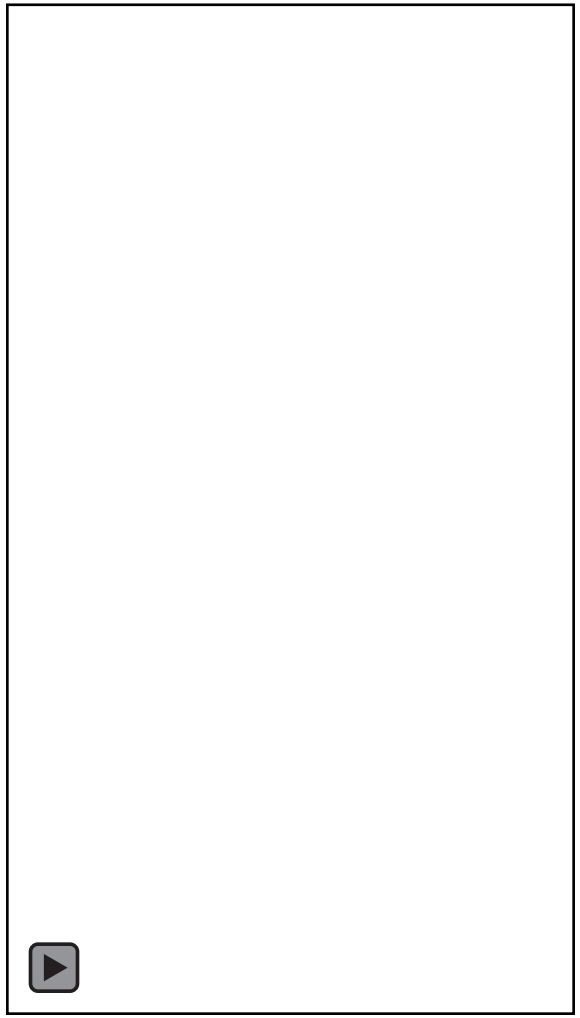
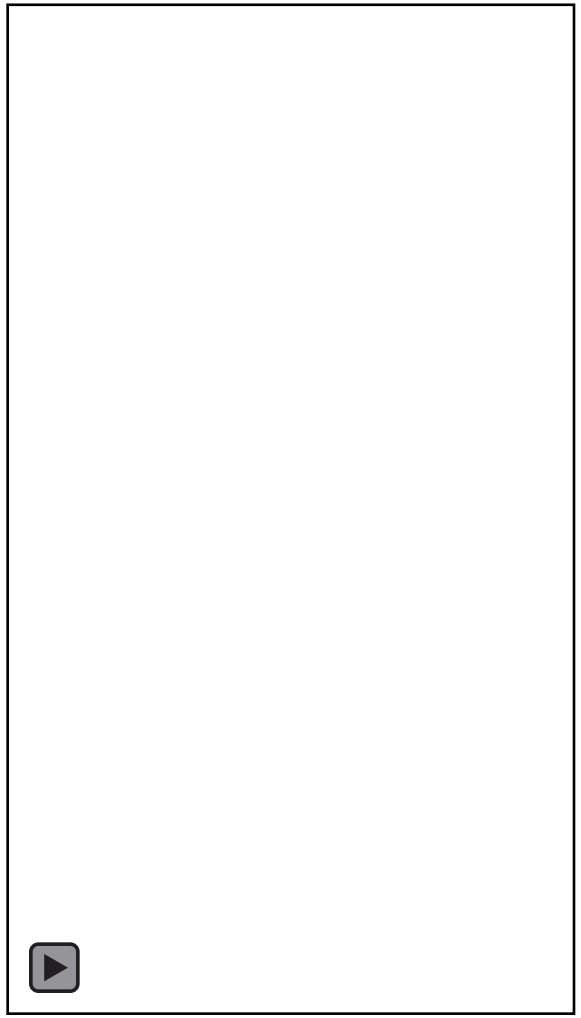
Non-Permeable vs. Permeable





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Day One continues smoothly







CellFill out of Oklahoma placing 30pcf PLDCC at a rate of 160 yd3 per hour

*Information provided by CellFill, Grove, OK

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Bulkhead Removed at Start of Day 2 of PLDCC Placement





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**Information provided by CellFill, Grove, OK*

QA/QC Permeability Test Results

	10^{2}	10^{1}	1.0	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}	10^{-9}
Drainage	Good						Poor			Practically Impermeable		
Backfill types	Clean gravel		Clean sands, clean sand and gravel mixture, **PLDCC**			Very fine, sand, organic and inorganic silts, mixtures of sand silt and clay, glacial till, stratified clay, **LDCC**				"Impermeable" soils, e.g., homogenous clays below zone of weathering		



W. Lake Eloise Dr.
Perm@ .17 cm/sec = $1.7*10^{-1}$

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Maintaining an Equilibrium of the water-table



*Information provided by
CellFill, Grove, OK

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Day 2 of PLDCC Placement









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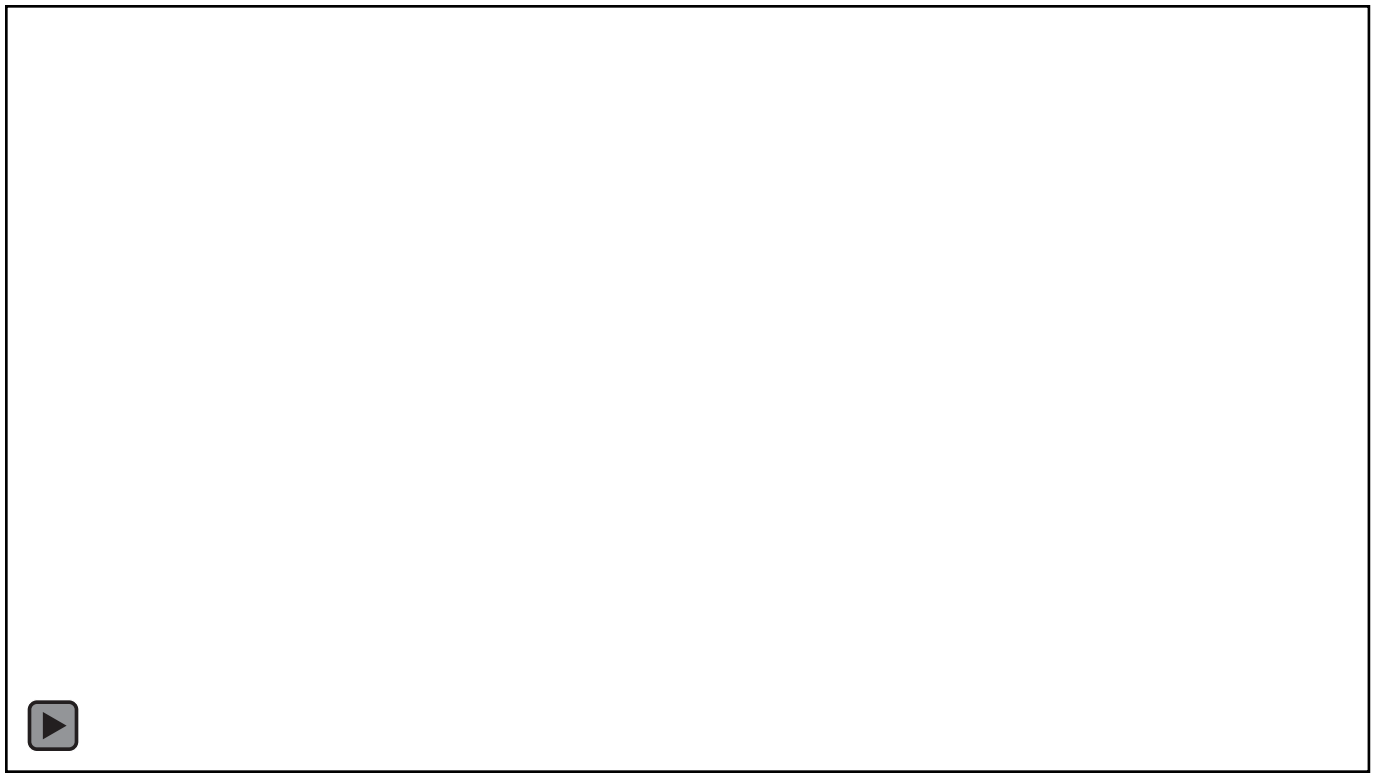
PLDCC overview



- Just over 1,400yd³ of 30pcf PLDCC was placed in 9 hours over two days.
- Deviation of the PLDCC density placed was +/- 1pcf
- Unconfined Compressive Strength exceed expectations at over 200psi
- Permeability of the field samples tested Permeability at .17 cm/sec = $1.7*10^{-1}$
- Final cost of the PLDCC was comparable to the price of a flowable fill
- Speeded up the construction schedule by at least 14 days

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**Information provided by Madrid Engineering Group, Bartow, FL*

Placing the Road sub-base with Crushed Concrete







<48 hrs after PLDCC Placement

- Removal of dewatering system
- Geotextile Placement
- Placement of 6” to 14” crushed concrete subbase before asphalt

Geotexile fabric placed between the PLDCC and stabilized shoulder layers with 2’ overlap on both sides of the road

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Laying down a layer of crushed concrete after the weekend







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Asphalt Down











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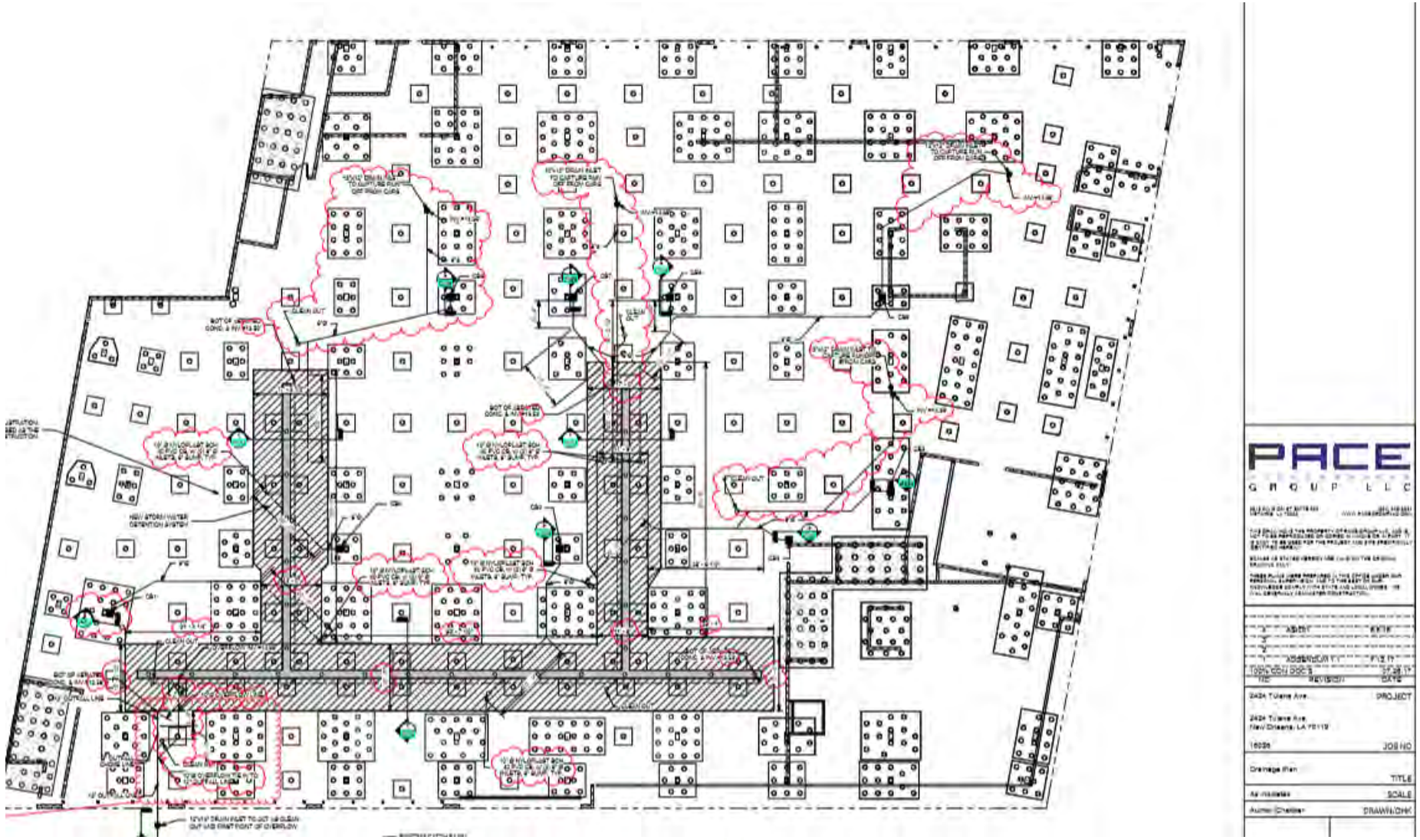
2424 Tulane Stormwater Detention System
New Orleans, LA



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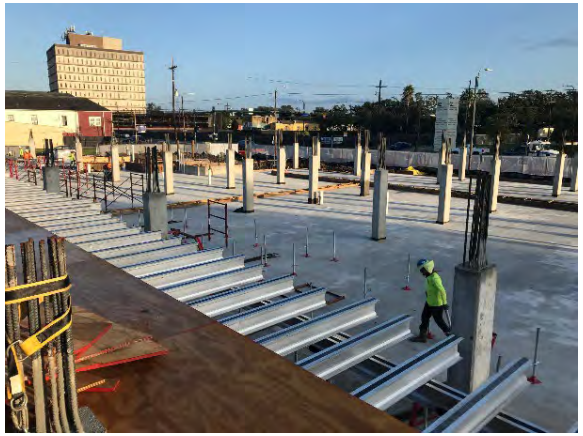
2424 Tulane Stormwater Detention System
New Orleans, LA







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What conclusions can we draw about PLDCC?

- Permeable!
- Densities range between 25-35 pcf
- Rapidly Installed
- Easily Placed
- Not a lot of formwork required
- Economical
- Versatile & Durable
- Permanent and Stable
- Environmentally Friendly



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