The Use of 100% Recycled Plastics for Infrastructure Projects in Conjunction With LDCC and the road to Carbon Neutrality

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Video courtesy of
CJGeO

Agenda

- Review of Low-Density Cellular Concrete
- Recent Trends & Opportunities
  - Utilization of Permeable LDCC
  - Specifications
  - High Water Ratio – reduction of cement utilization
  - Portland Limestone Cement
  - Use of 100% recyclable Plastics
  - Granular / Rock
- Applications on the horizon

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 lb/ft³ (800 kg/m³) 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.

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

Conforms to ACI industry standards

Types of Foam

Preformed

Produced by Foam Generator

ACI 523

Cellular Concrete

Agitated

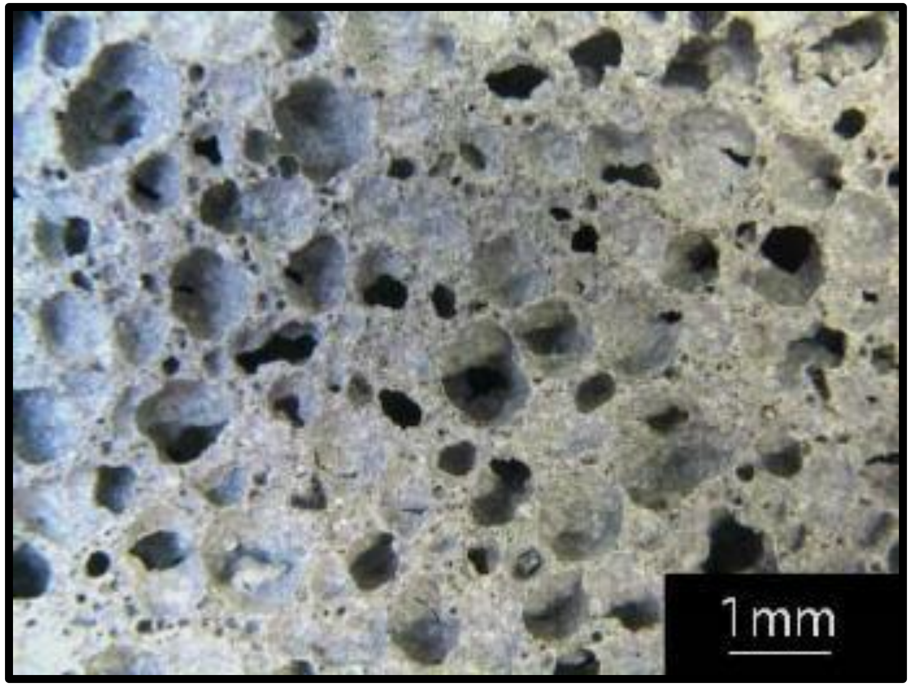
Produced by the mixing action of a concrete mixer

ACI 229

CLSM

Cellular concrete can be flowable fill (ACI 229) but flowable fill (CSLM) cannot be cellular concrete because of the density being higher than 50pcf.

LDCC pore structure when cured



Cementitious materials encapsulate the air bubbles, then dissipate, leaving a void structure as a replacement to traditional aggregate

Low-Density Cellular Concrete (LDCC) differs from conventional aggregate concrete in the methods of production, the density of the material and the extensive range of end uses.

- 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 Required
  - What you see is what you get

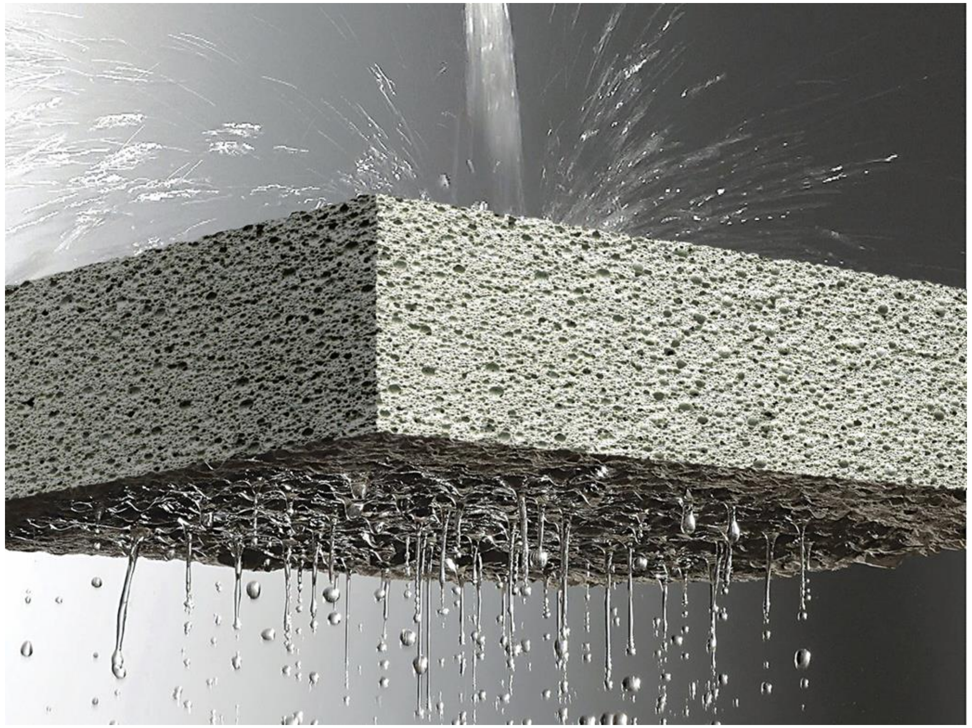
Ranges of Compressive Strength per ACI523

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

Keep in Mind......

- Low-Density Cellular Concrete (LDCC)
  - Is designed to replace traditionally compacted backfill
  - It is not designed to be the driving or wearing surface
- Flowable & Self-Compacting
- Rapidly Placed
- Sustainable & Resilient
- 100% recyclable

Permeable & Non-Permeable LDCC



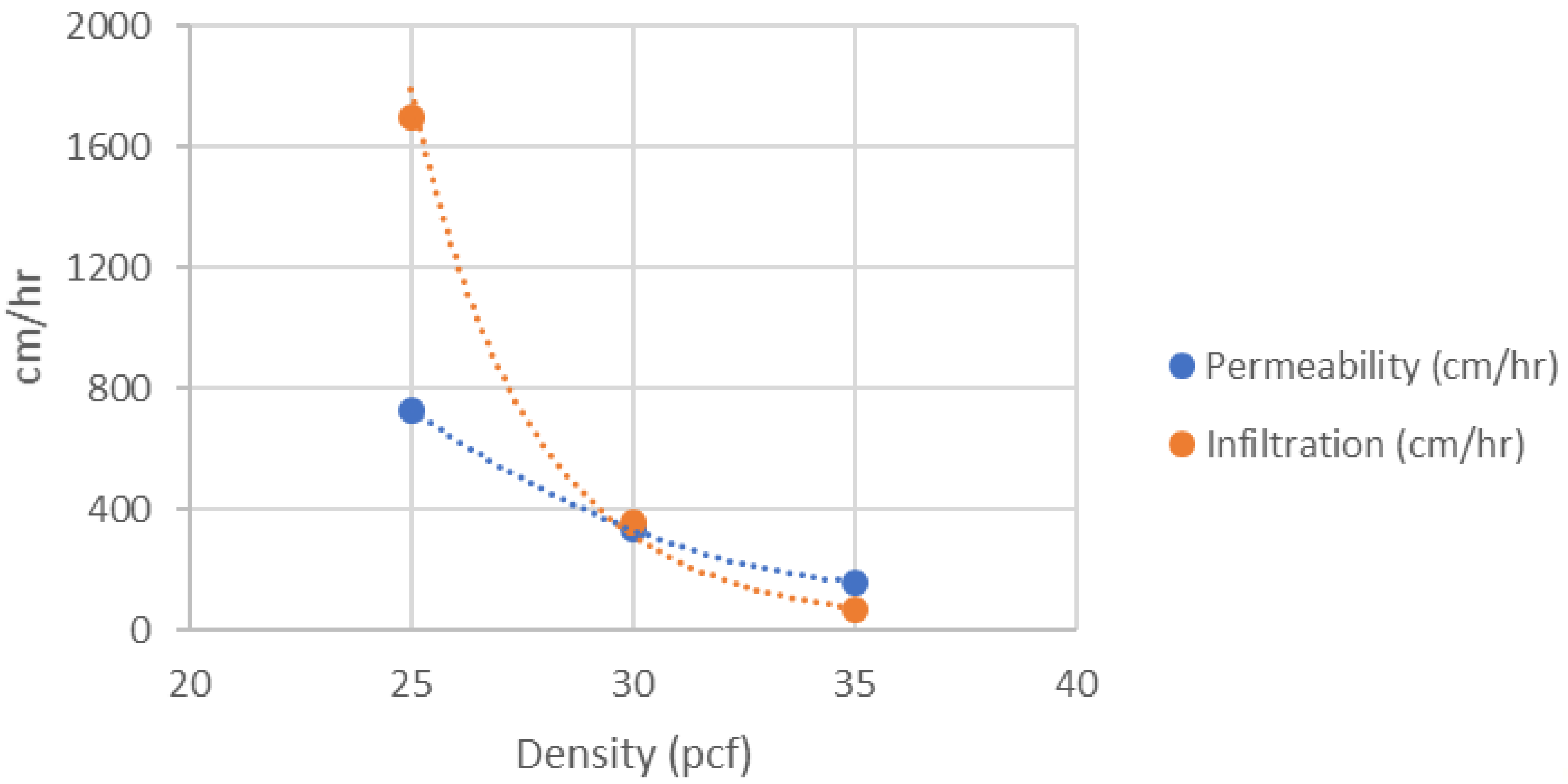
Coefficient of Permeability k (cm/sec) (log scale)

	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		

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

PLDCC Permeability / Infiltration



Permeability of PLDCC

Observation of Permeability
±12 hours after placement

*Information provided by
CellFill, Grove, OK

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Louis Armstrong Airport, New Orleans, LA

**Project by*
MixOnSite USA Inc., Buffalo Grove, IL

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Typical Applications

- Tunnel & Mine Abandonment
- Annular Fills for Tunnels, Water & Sewer Lines
- Void Fills
- Soft Soil Remediation
- Tremie Applications
- Retaining Structure Backfills
- Slope Stabilization
- Fill for Underground Utility, Conduit & Pipes
- Tanks & Pipeline Abandonment
- Fill Around Conduits and Pipes
- Green Roof Applications

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

Kaneohe Kailua Tunnel, Honolulu, HI

Information provided by Southland/Mole JV, Kaneohe, HI

Kaneohe Kailua Tunnel, Honolulu, HI

“Aerix Industries provided a quality bubble and the physical bubble was not compromised at all over the entire distance pumped”

Don Painter, Project Manager of Southland/Mole JV

- 28,000yd³ 50pcf
- 4” injection line
- Material pumped for 3 miles
- Water chilled from 70° to 50°
- Maintained 18” to 24” controlled lifts due to distance and heat

**Information provided by Southland/Mole JV, Kaneohe, HI*

Flowability

Information provided by Mainmark, Australia

Performance-Based Specifications

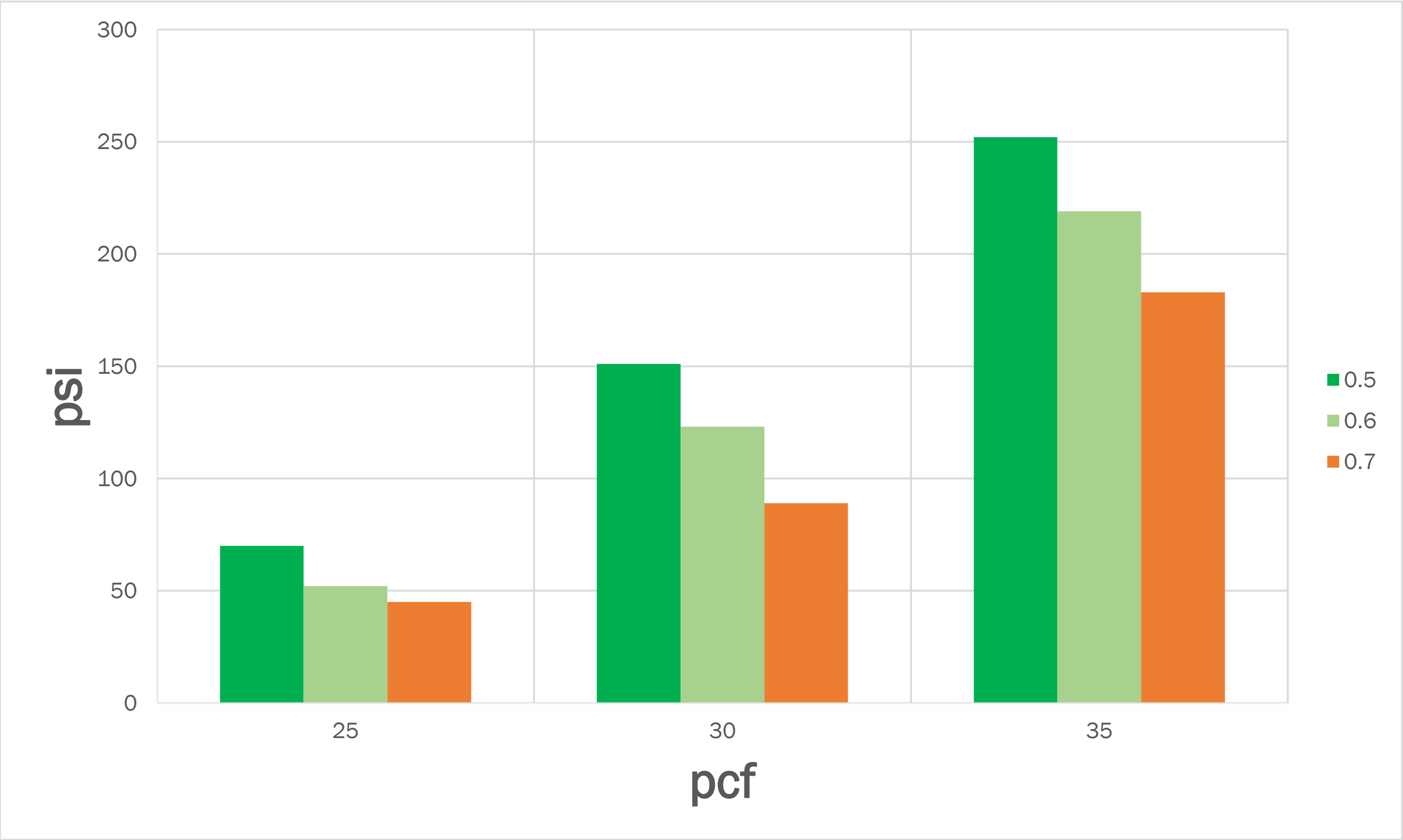
- Designers and engineers are encouraged to start making the shift from prescriptive specifications towards performance specifications.
- **Prescriptive specifications** are like a recipe with ingredients listed while performance specifications focus on the end results.
- **Performance specifications for LDCC/PLDCC**
    - Gives both the material producer and contractor the flexibility to innovate and leverage the latest technologies to improve structural performance, energy efficiency, resiliency, and carbon reduction.
    - Allows LDCC/PLDCC producers to design with the application in mind rather than use the same specifications regardless of the project.
        - For instance, LDCC in an annular space grouting application does not necessarily have to be of the same strength as the LDCC used in an embankment fill for a highway. A "one mix fits all" approach to LDCC is decidedly prescriptive and should be avoided.

Move towards IL Cement

- Extremely High Inclusion rates (5 – 15%)
  - Higher in Europe (up to 35%)
- Specific gravity not very consistent
- Much higher Blaine (Fineness) than Type I/II
- Higher Water demand
- Variations through out North America in compressive strengths

- Treat IL like a flyash (test it, test it, test it)
- Two sources - 28 days breaks were 100 psi lower than the other

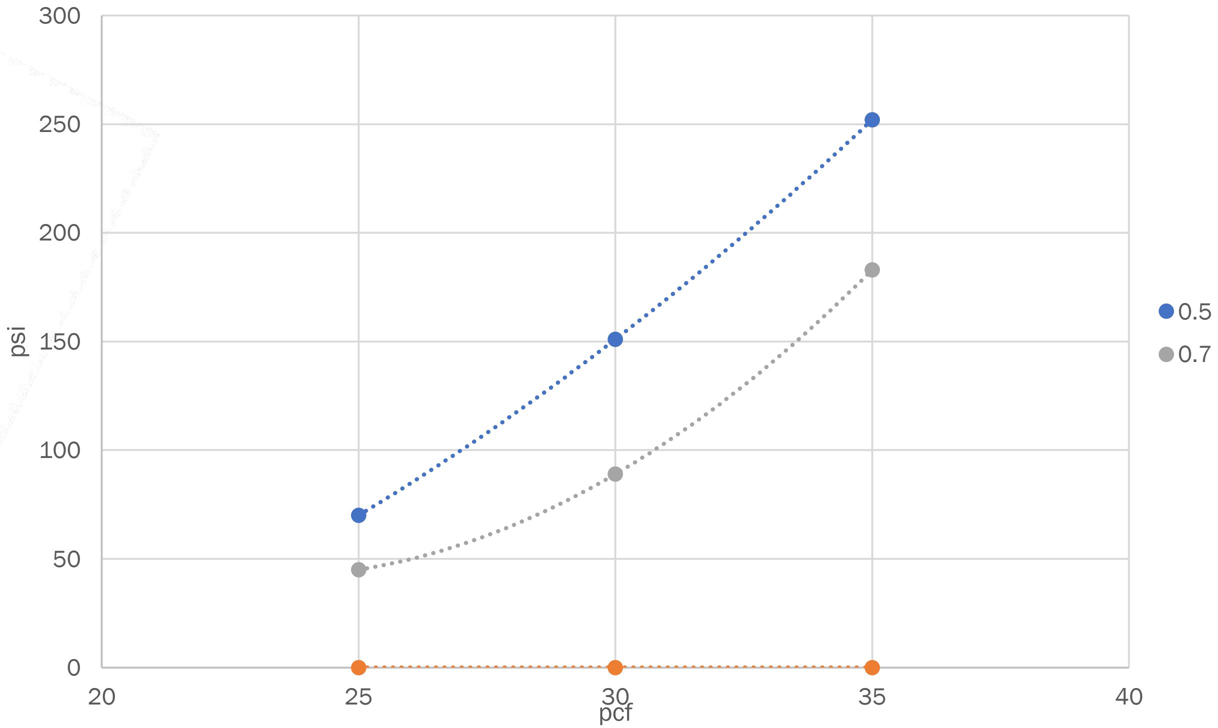
w/c ratio and its’ effect on Compressive strengths



*Information provided by
Aerix Industries Internal Studies

A step to Carbon Neutrality

High Water Cement (HWC) ratio verses comparison to lower c/w ratio



- Reduction up to ≈18% in cement utilization
- Specialty HWC bubble to handle high W/C ratio

Resin 8

Only 9.5% of plastic waste is being recycled
The remaining 90.5% is incinerated or ends up in landfills or the ocean
More than 150 million tons of CO_2e of greenhouse gases emitted per year are due to plastic incineration

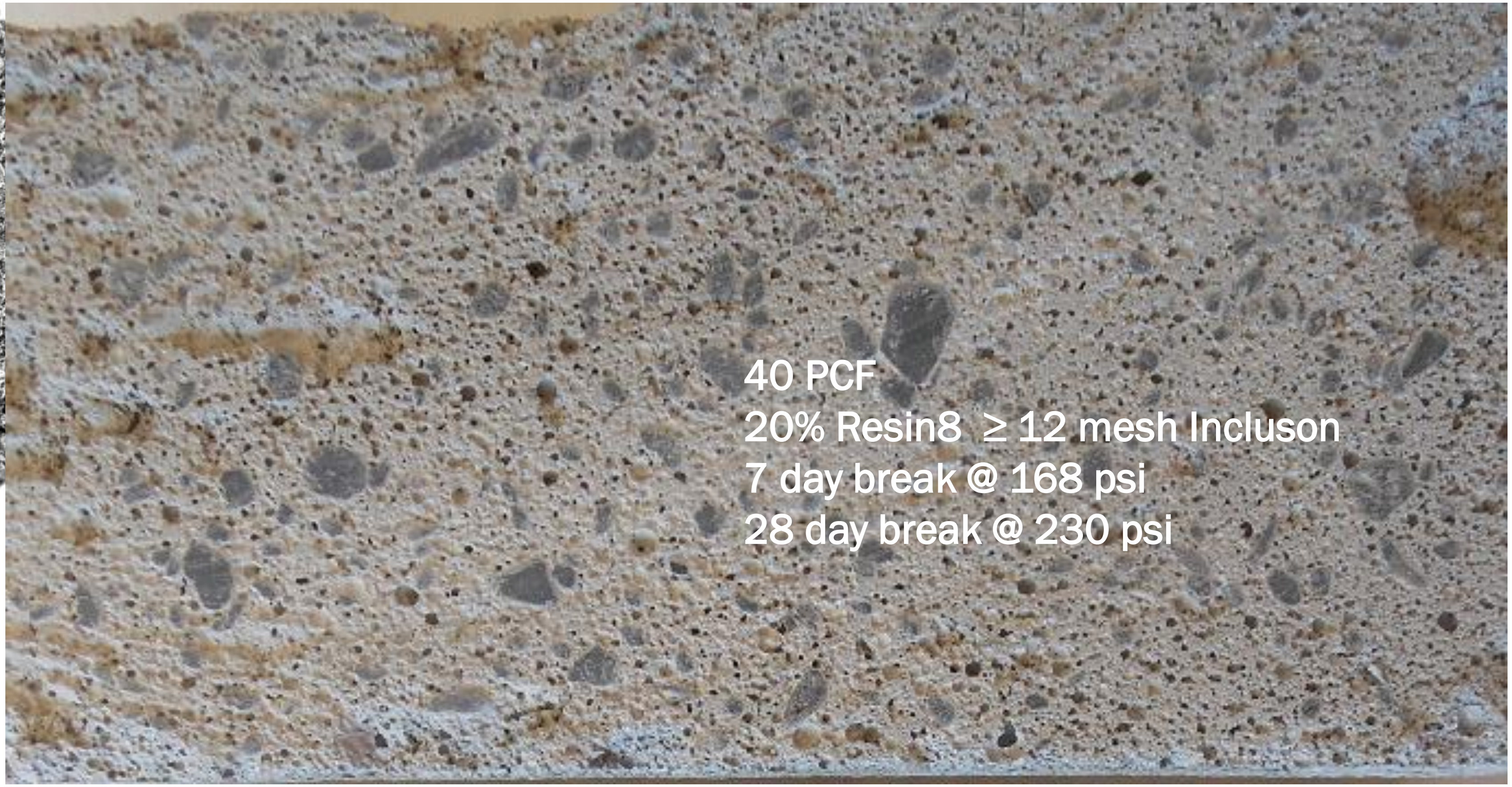
RESIN8

RESINS 1-7 = Resin8™

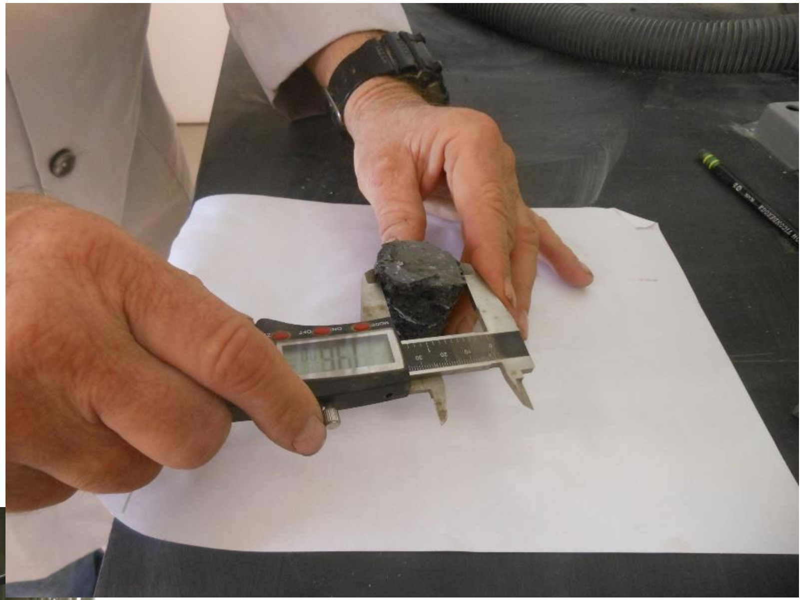
#1 PET	#2 HDPE	#3 PVC	#4 LDPE	#5 PP Polypropylene	#6 PS Polystyrene	#7 Other
Soft drink and water bottles, microwave food trays, mouthwash	Laundry detergent bottles, milk, water, juice jugs	Bottles for shampoo, cleaning, cooking oil, clamshell food containers, plastic wrap	Squeezable bottles, bread bags, frozen food bags, plastic bags	Medicine bottles, yoghurt containers, bottle caps, margarine tubs	Food trays, cups, egg containers, carry out containers	3 and 5 gallon reusable water jugs, CD cases, sunglasses

LDCC + Resin 8


RESIN8

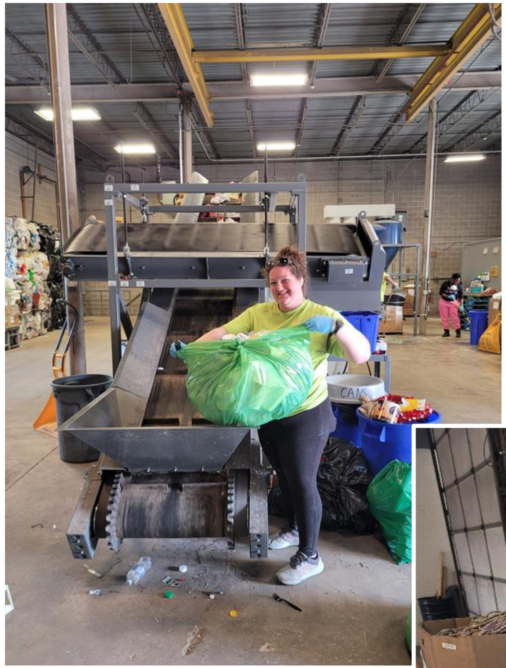

40 PCF
20% Resin8 ≥ 12 mesh Incluson
7 day break @ 168 psi
28 day break @ 230 psi

Initial Resin8 Rock raw material compressive testing

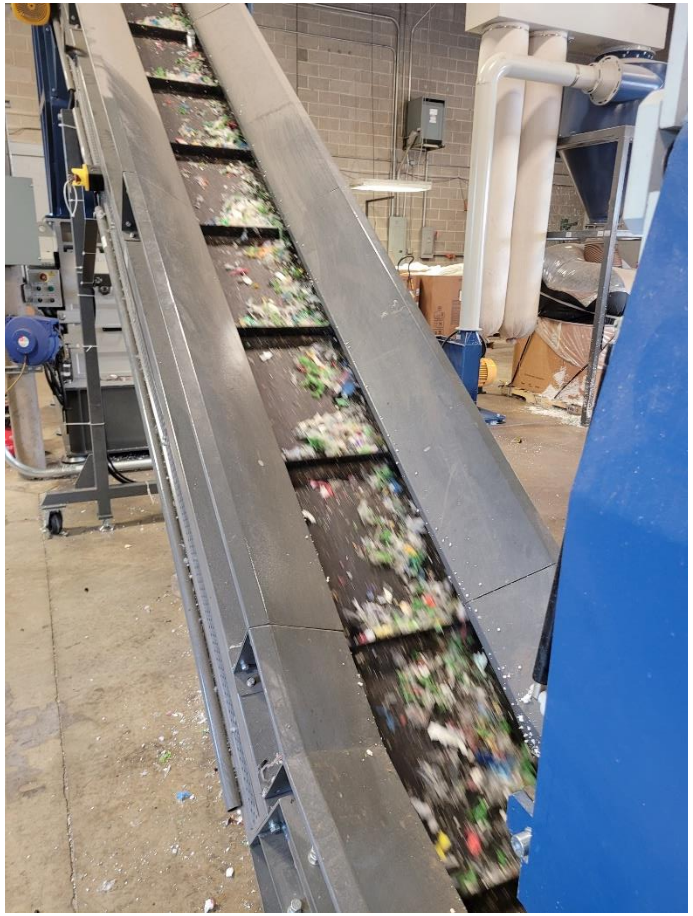


Material fractured at 1150 psi

Resin8 Raw materials



The Process



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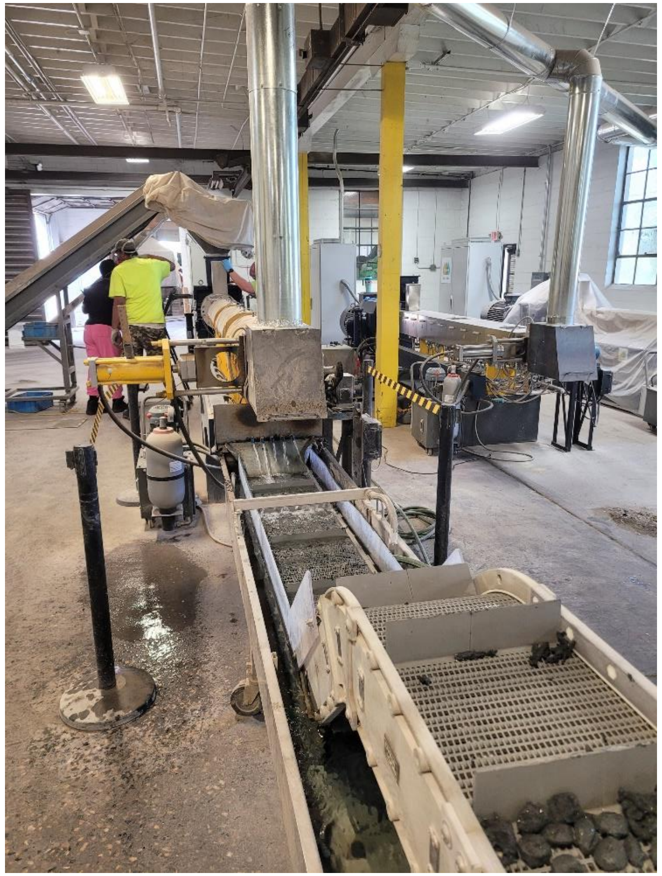
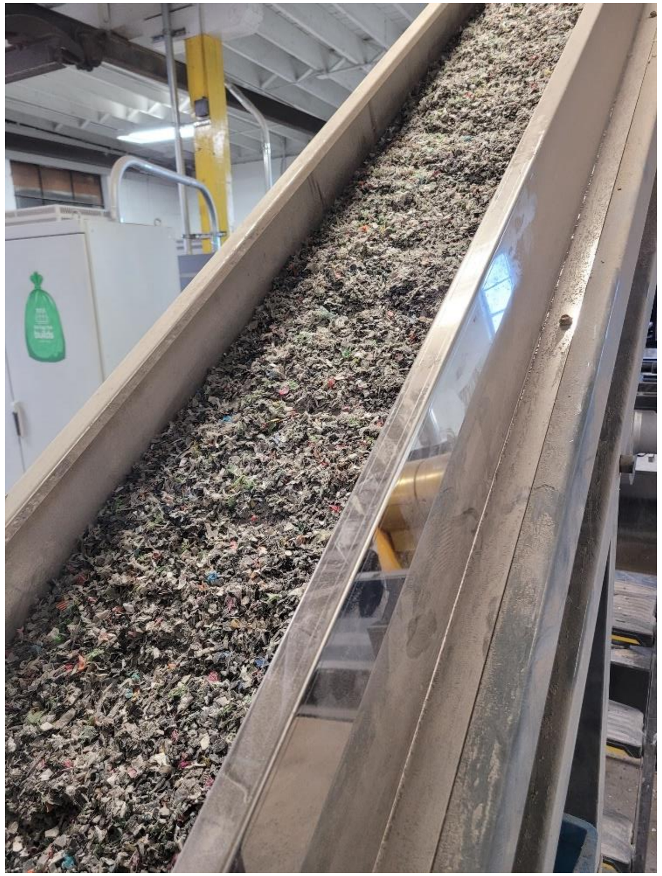
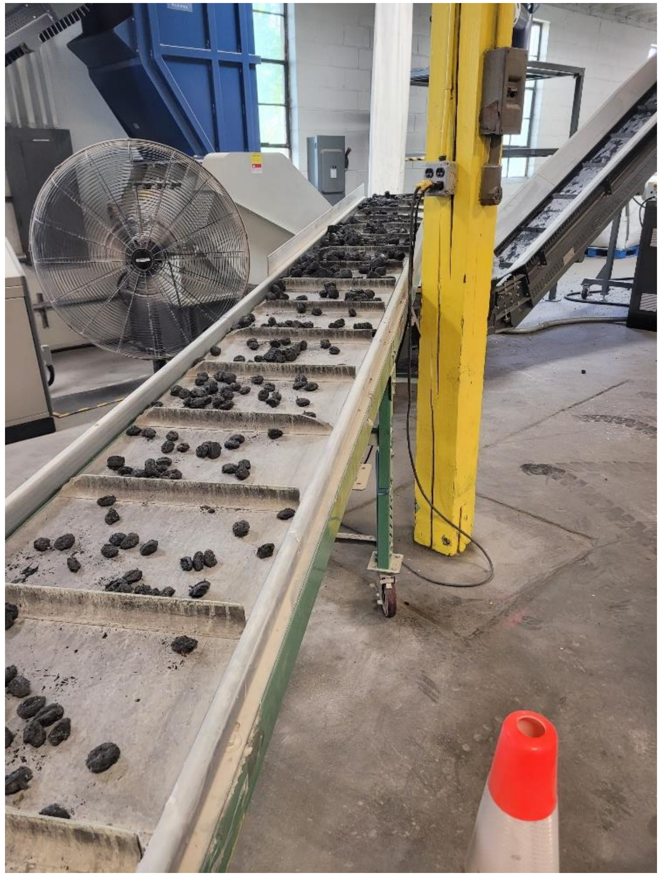






Gerhart Cole Phase 1 Testing

Resin8 in 0.5 f^3 mold before confined compressive strength test

Resin8 in 0.5 f^3 mold after confined compressive strength test

Resin8 in testing mold setup on load frame during Consolidation test

Resin8 in membrane before CID test

Resin8 in membrane after CID test

Initial Summary of Resin8 Rock

GERHART COLE

Table 1 - Resin8 Rock Laboratory Test Summary - Phase 1

Laboratory Testing Program of Resin8 Rock

Project No. 23-1669

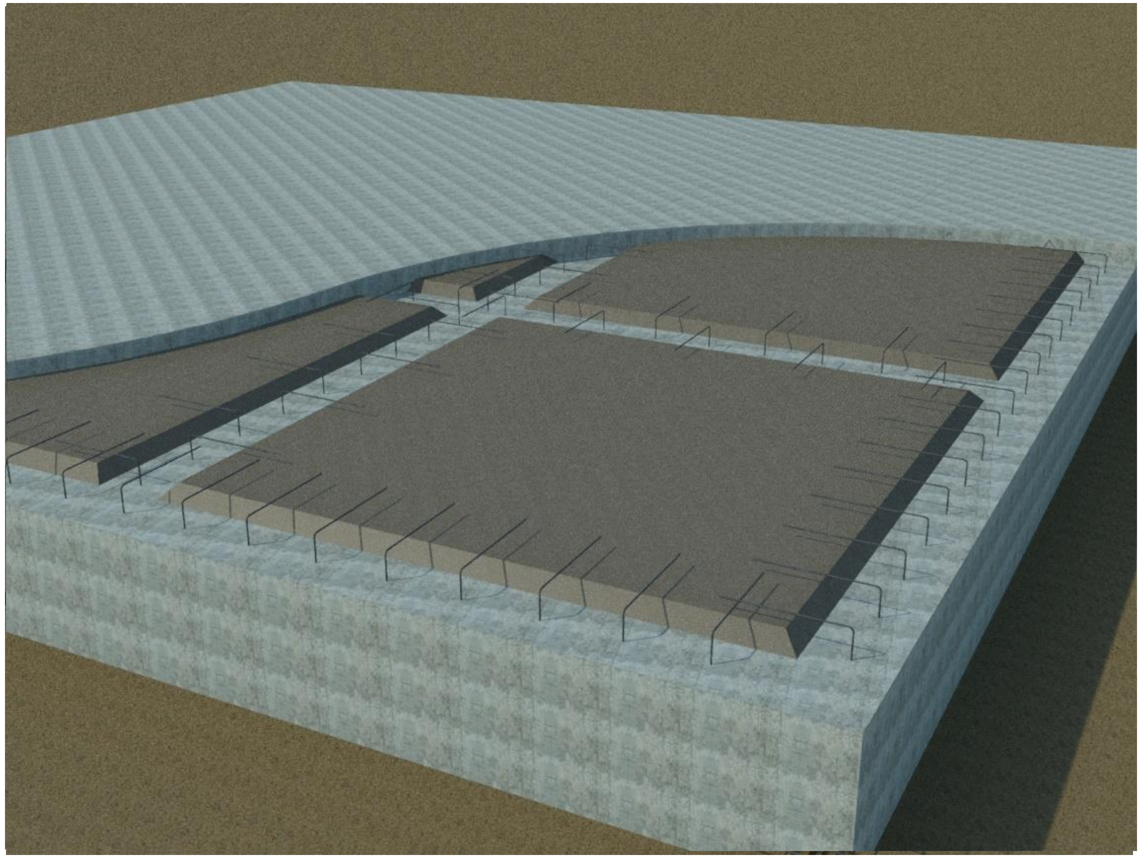
Sample	Average Loose Bulk Density (pcf)		Average Confined Compressive Strenth (psi)		Strain Rate of 1D Consolidation Creep									Angle of Repose (Deg)	Triaxial CID Testing			Comments
	0.5 cf	3.0 cf	10%	20%	165-200 psf	330-400 psf	660-800 psf	1250 psf	800 psf	1250 psf	2500 psf	1250 psf	800 psf		Friction angle, phi (deg)	Cohesion intercept, c (psi)	Stress range (psi)	
Resin8	20.61	-	14.39	39.39	0.0022	0.0024	0.0031	0.0053	-	-	-	-	-	36.0				
														38.5	34.6	3.6	2.1 - 8.3	
	-	20.51	17.05	49.94	-	0.0027	0.0035	0.0047	-	-	-	-	-	35.8				
														36.0				
	-	20.52	17.10	47.13	0.0018	0.0026	0.0029	0.0038	0.0001[a]	0.0006[b]	0.0043	0.0002[a]	0.0001[a]	36.1	40.0	2.0	2.1 - 8.3	
														38.1				

Notes

a. Measured 1D Consolidation Creep upon unloading.

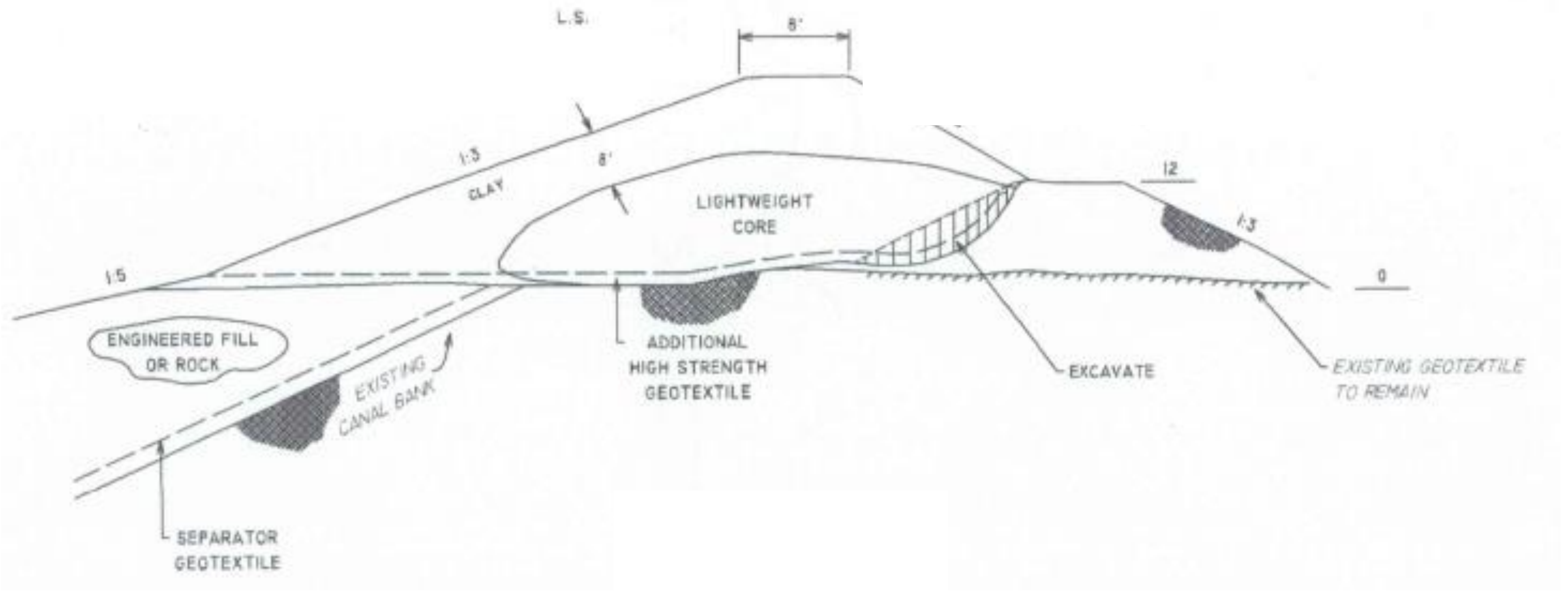
b. Measured 1D Consolidation Creep upon reloading.

Using LDCC with Driven Piles Increasing the Elevation Needs



- Drive piles as per the grade beam plans
- Cap off the piles to the desired height
- Place a Low-Density Cellular Concrete slab over the piles to the desired elevation
- Excavate out over the driven piles to create the forms for the grade beams
- Place the appropriate rebar for the grade beams
- Pour the grade beams
- Voila – With the final pour in place the elevation is achieved! Reducing the down drag on the driven piles.

Lightweight Core in Levee Application



Foster City Levee Improvements, CA
(just South of San Francisco)

Phots courtesy of
Cell-Crete

LDCC/PLDCC is ideal retaining wall backfill

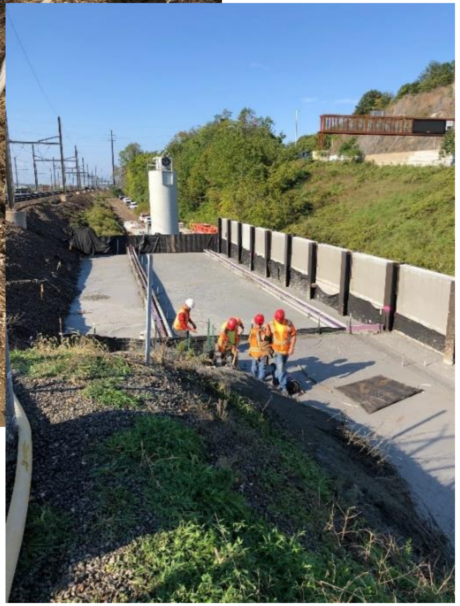
LDCC/PLDCC Advantages

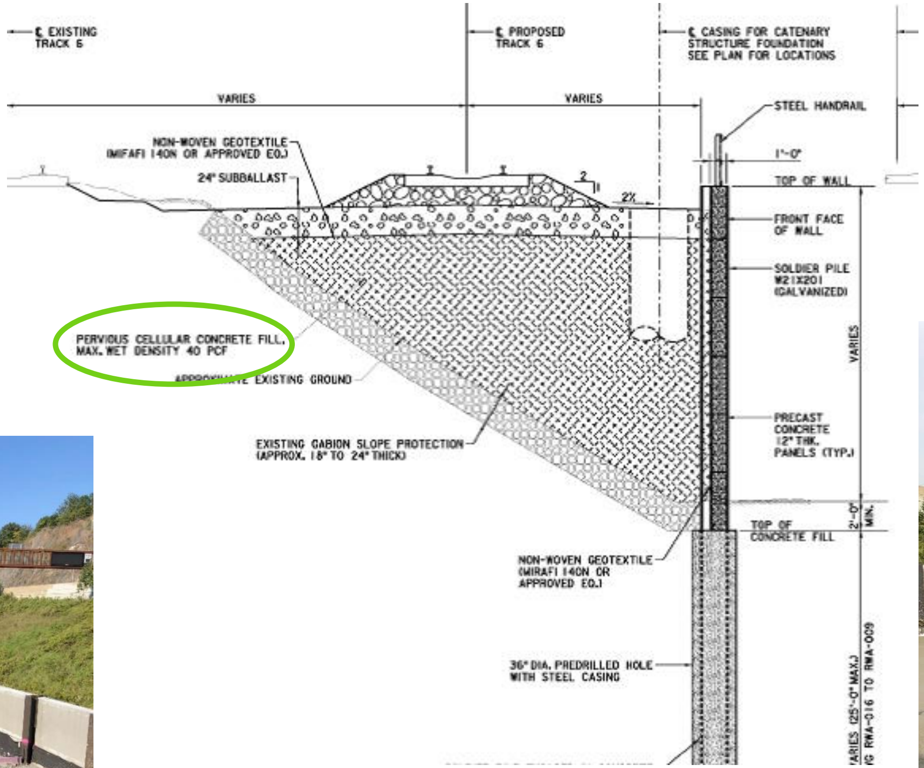
- Reduce Lateral Load
- Ease of Placement
- Increased lift heights
- Reduces schedule impact
- Allows for design flexibility
- Engineered Permeability

Portal North Bridge, Secaucus, NJ

*Information provided by GeoCell/Midwest

Portal North Bridge, Secaucus, NJ



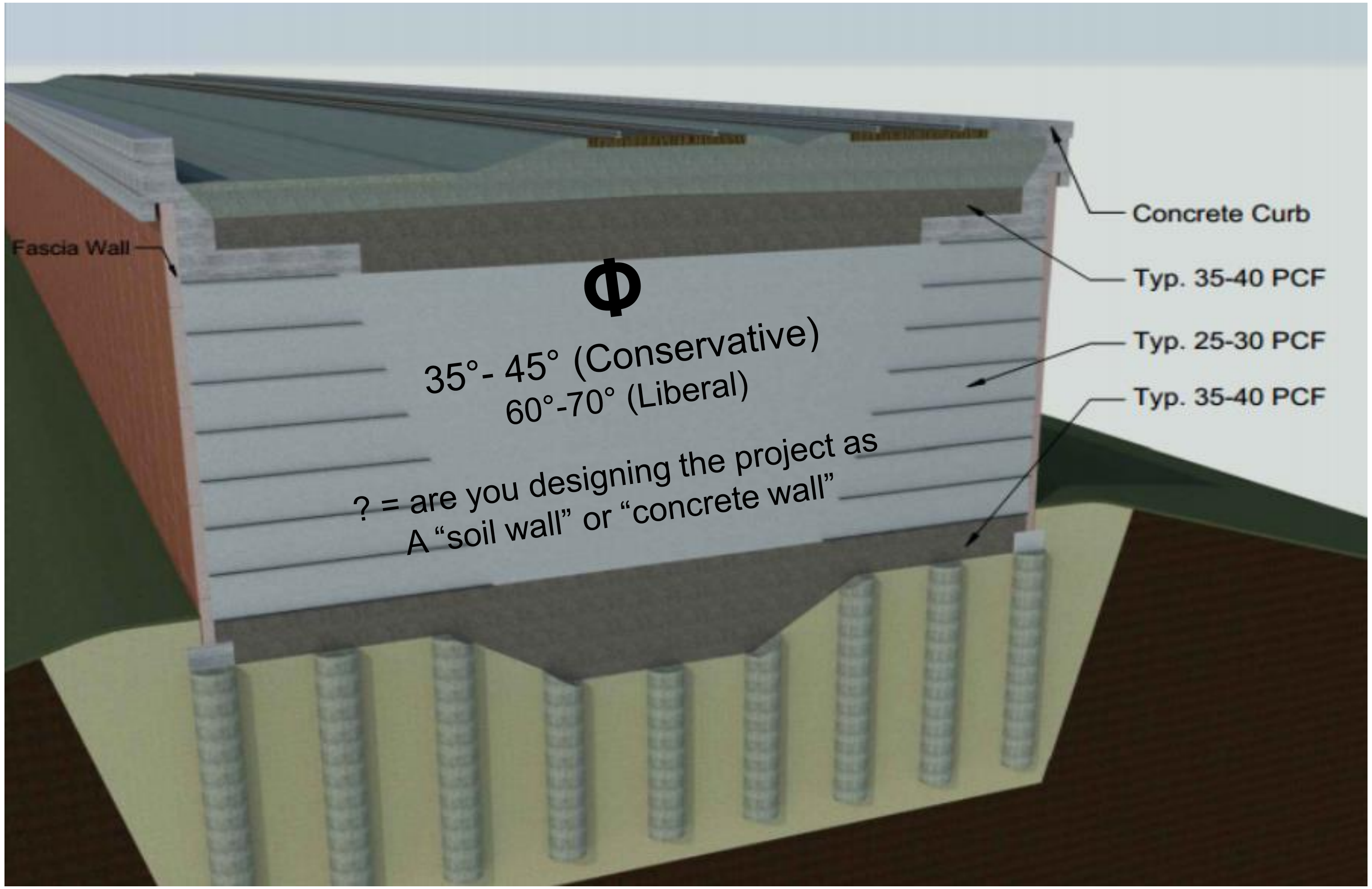


**Information provided by GeoCell/Midwest*

Segmental Wall Configuration

Segmental Wall Configuration

Strapping & Internal Angle of Friction



SR 542, Bellingham, WA

- Vertical Facia walls >50’
- Shotcrete over the facia walls

Contact Information

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