Sustainability and the Road to Carbon Neutrality with Low-Density Cellular Concrete (LDCC)

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Aerix Industries



Video courtesy of
Cell-Crete

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Agenda

- What is LDCC/PLDCC
- Performance Based Specifications
- IL Cement can be a challenge
- 100% recycled plastics
  - What's the process
  - How can it be incorporated into LDCC
  - What are the benefits
- Summary of sustainability and the road to carbon neutrality
- Sampling of LDCC/PLDCC applications

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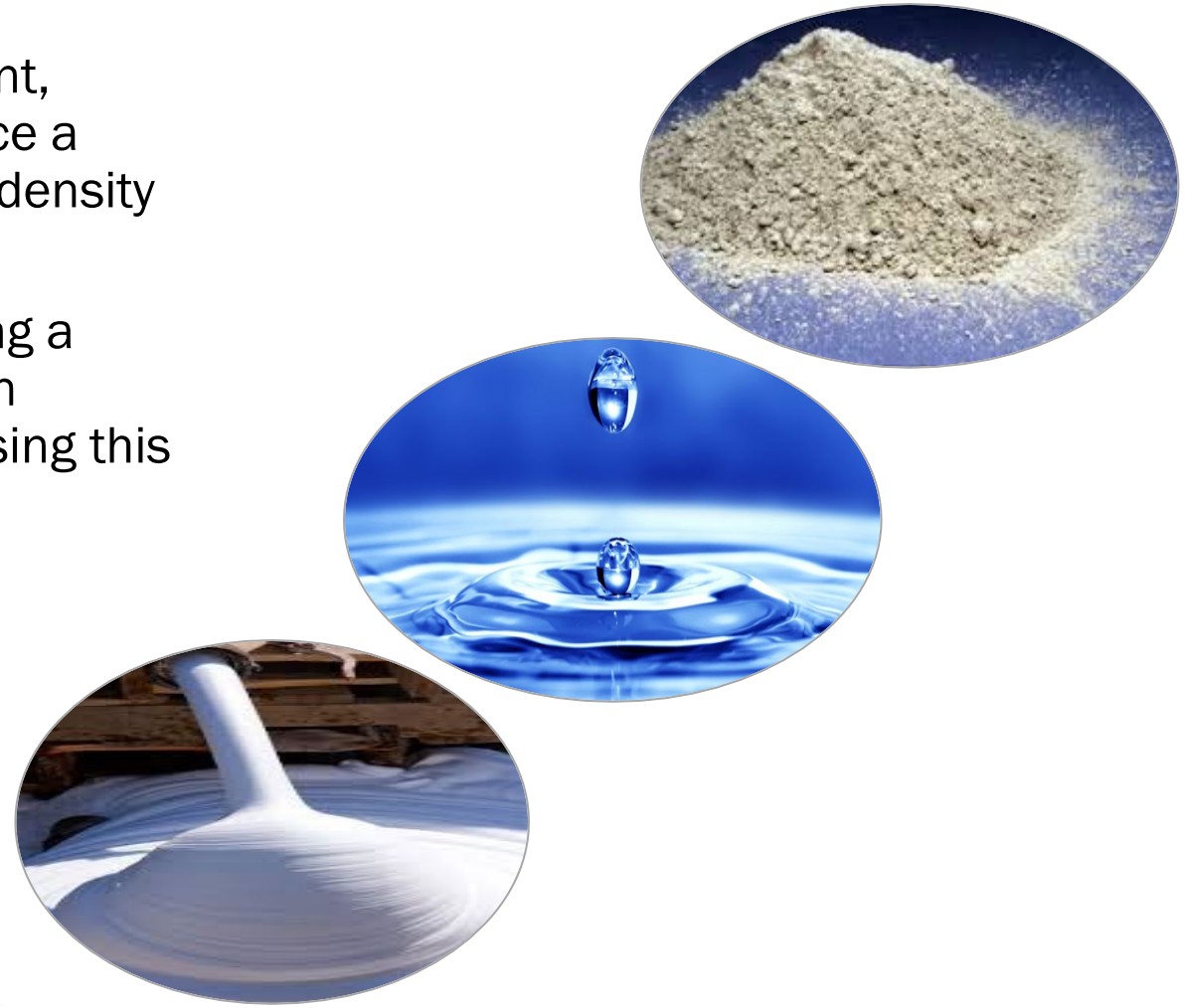
Low-Density Cellular Concrete (LDCC) is defined by ACI 523 as…

- Concrete made with hydraulic cement, water and preformed foam to produce a hardened material with an oven dry density of 50 lb/ft^3 (800 kg/m^3) 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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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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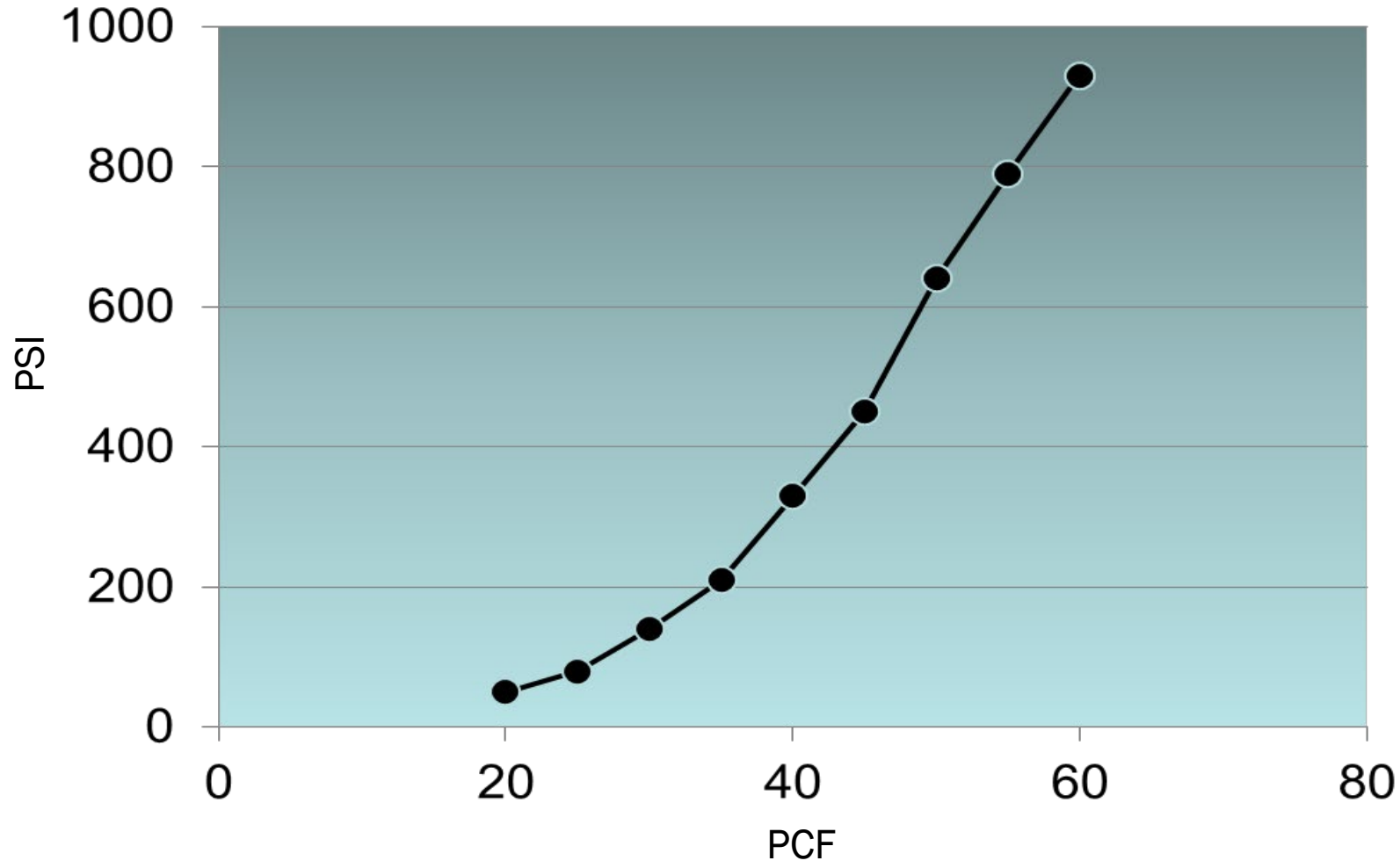
Typical Strength curve of cellular concrete



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ASTM test methods for LDCC

ASTM C 869

"Standard Specification for Foaming Agents Used in Making Preformed Foam for Cellular Concrete"

ASTM C 796

"Standard Test Method for Foaming Agents for use in Producing Cellular Concrete using Preformed Foam"

ASTM C 495

"Standard Test Method for Compressive Strength of Lightweight Insulating Concrete"

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QA/QC is monitored in the field







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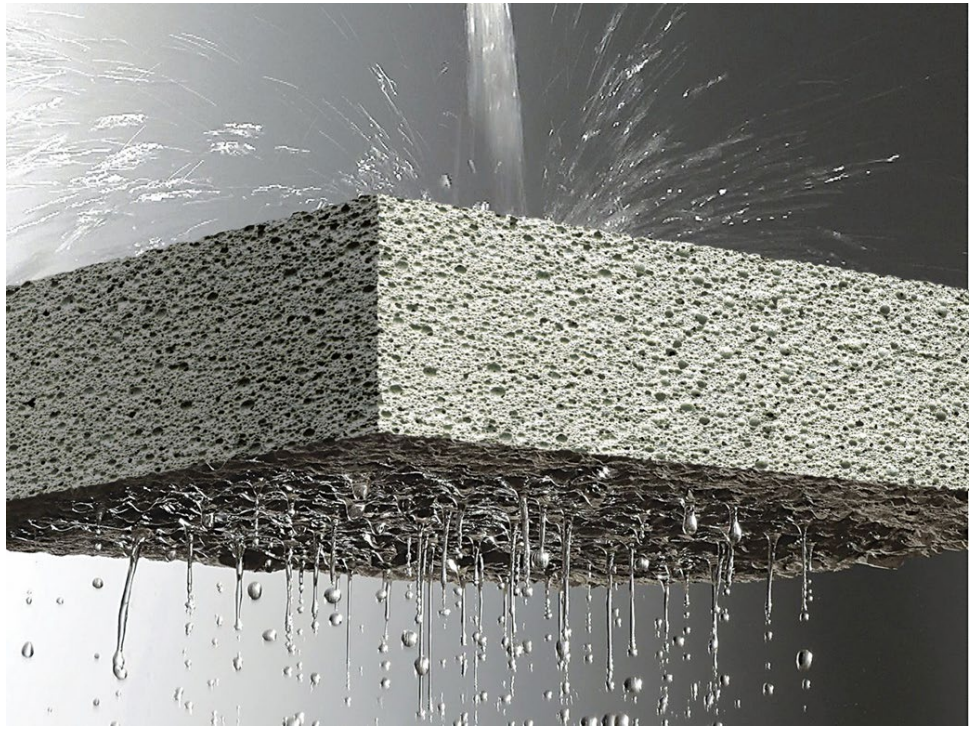
Permeable & Non-Permeable LDCC





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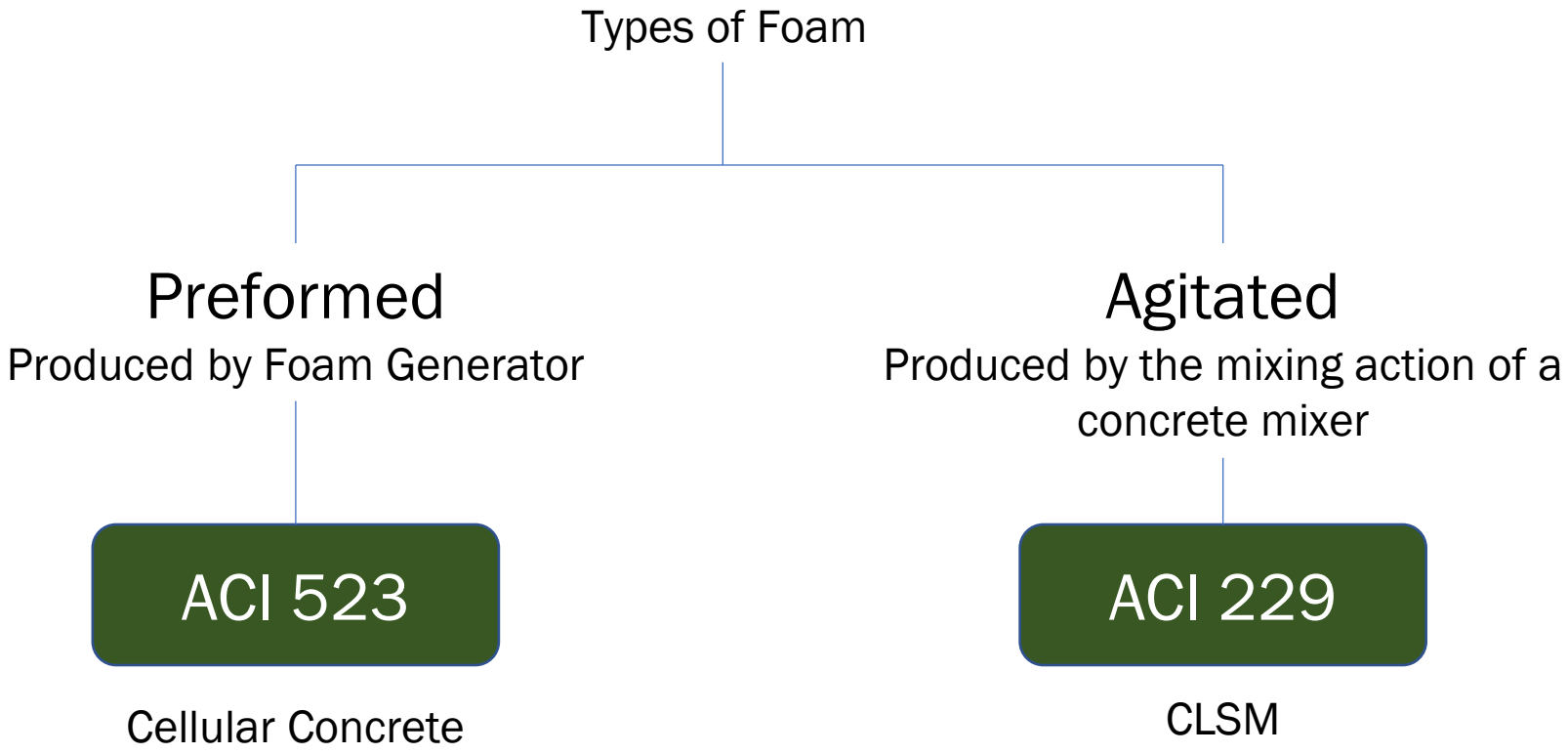
Conforms to ACI industry standards



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

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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

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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.

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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

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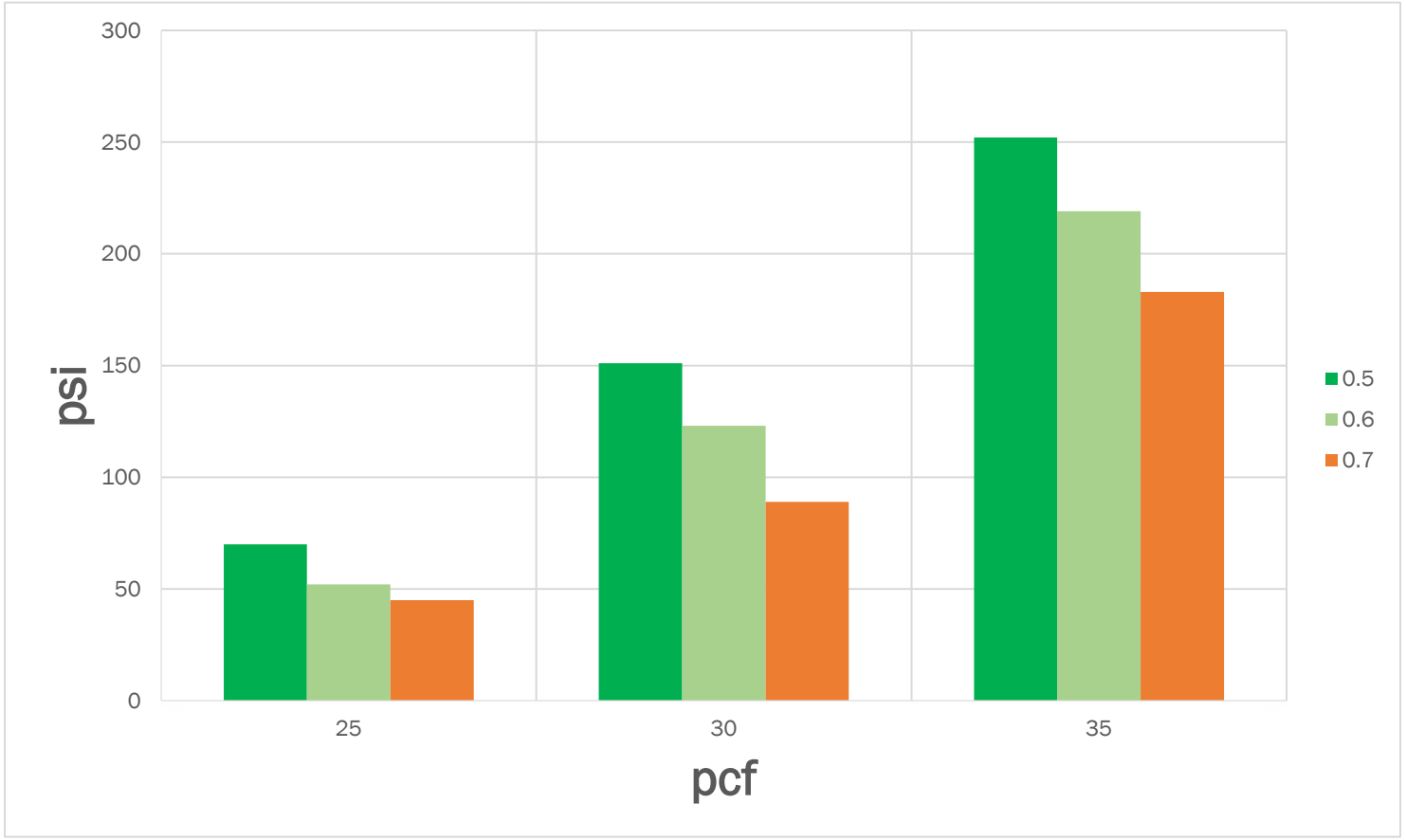
Effect of water/cement (W/C) ratio*

w/c ratio and its' effect on Compressive strengths



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*Information provided by
Aerix Industries Internal Studies

Resin 8





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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

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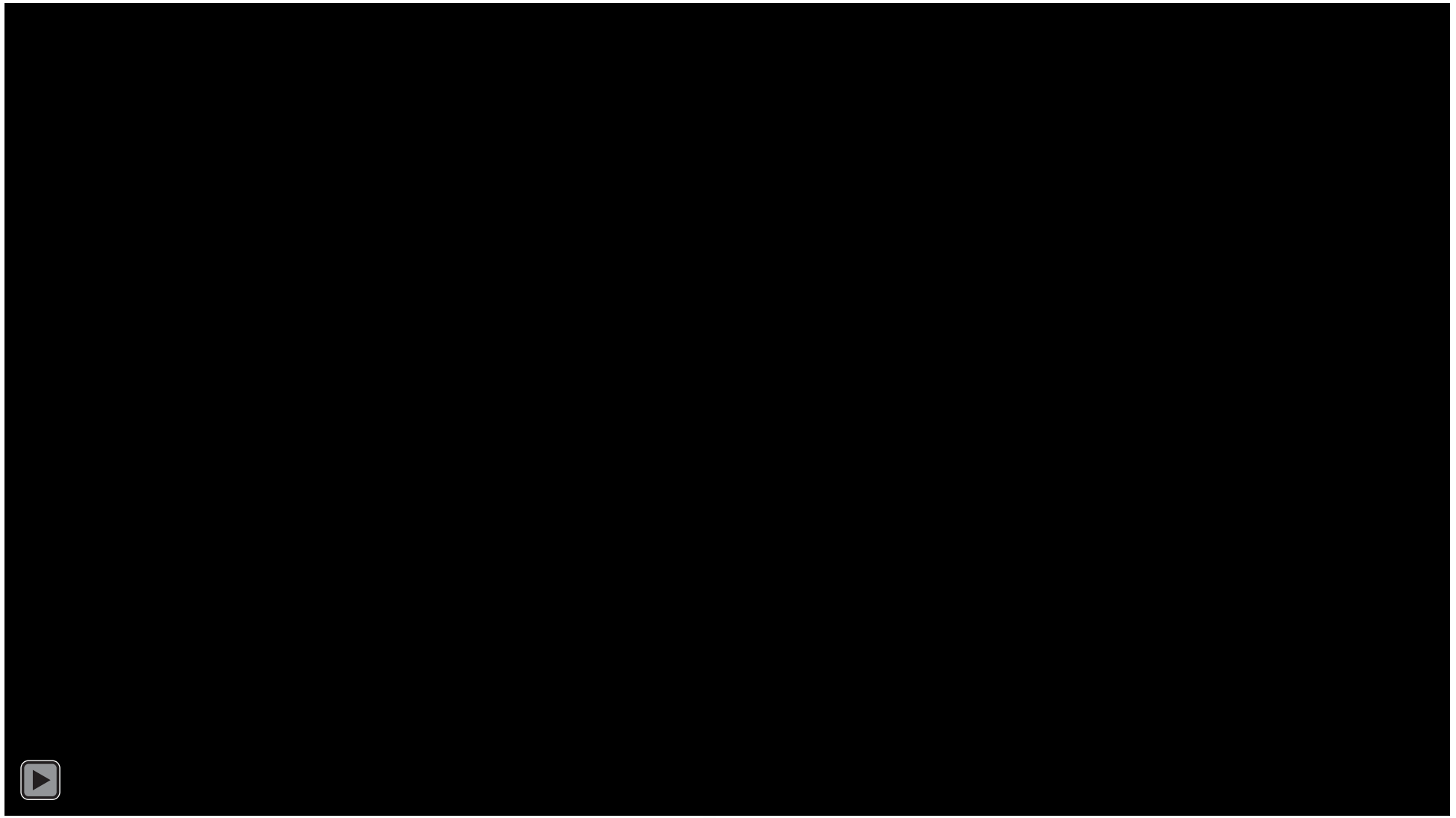
Process of Plastics Recycling



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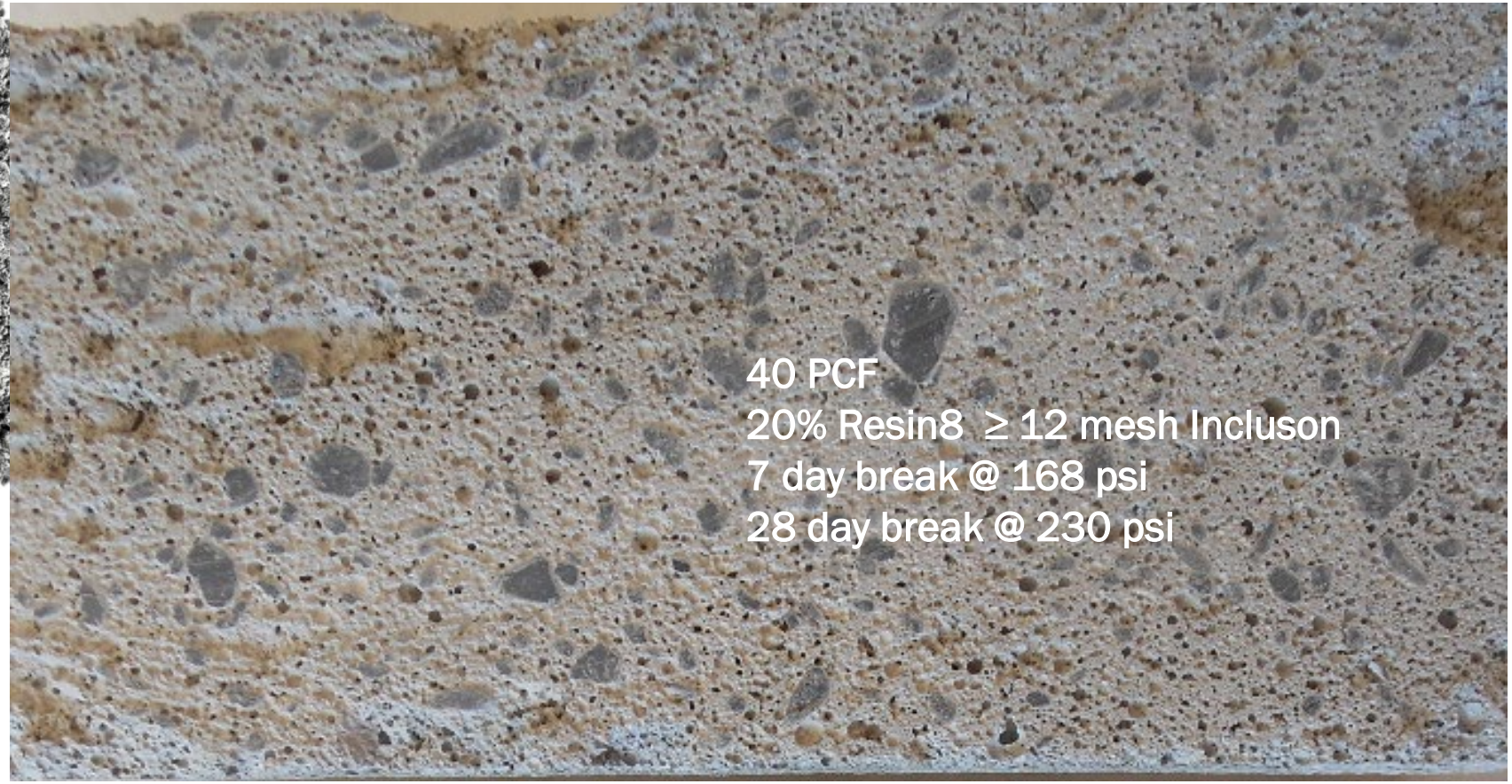
LDCC + Resin 8





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LDCC on the Road to Carbon Neutrality



- 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



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Typical Applications

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

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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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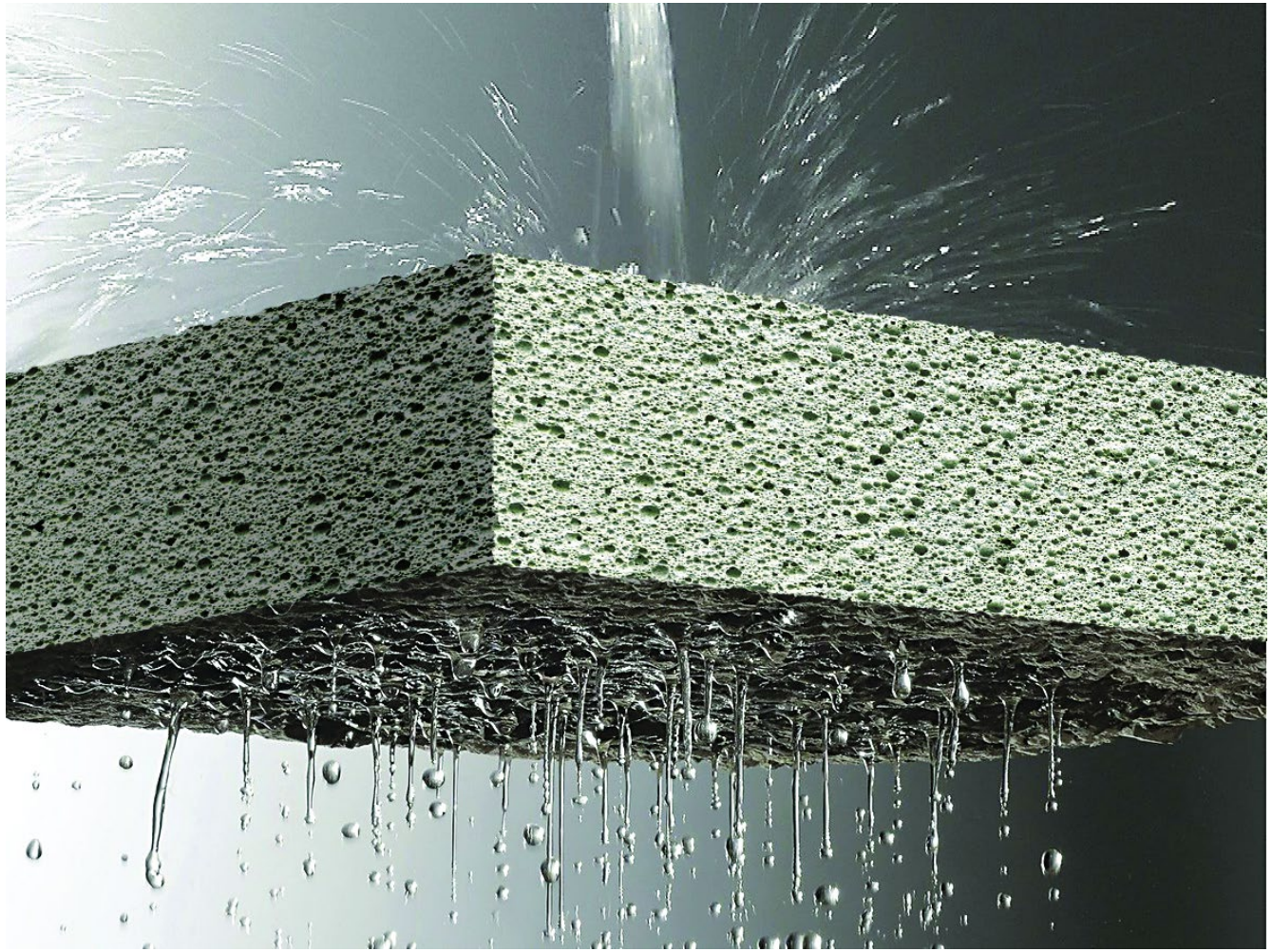
Permeable Low-Density Cellular Concrete (PLDCC)



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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		





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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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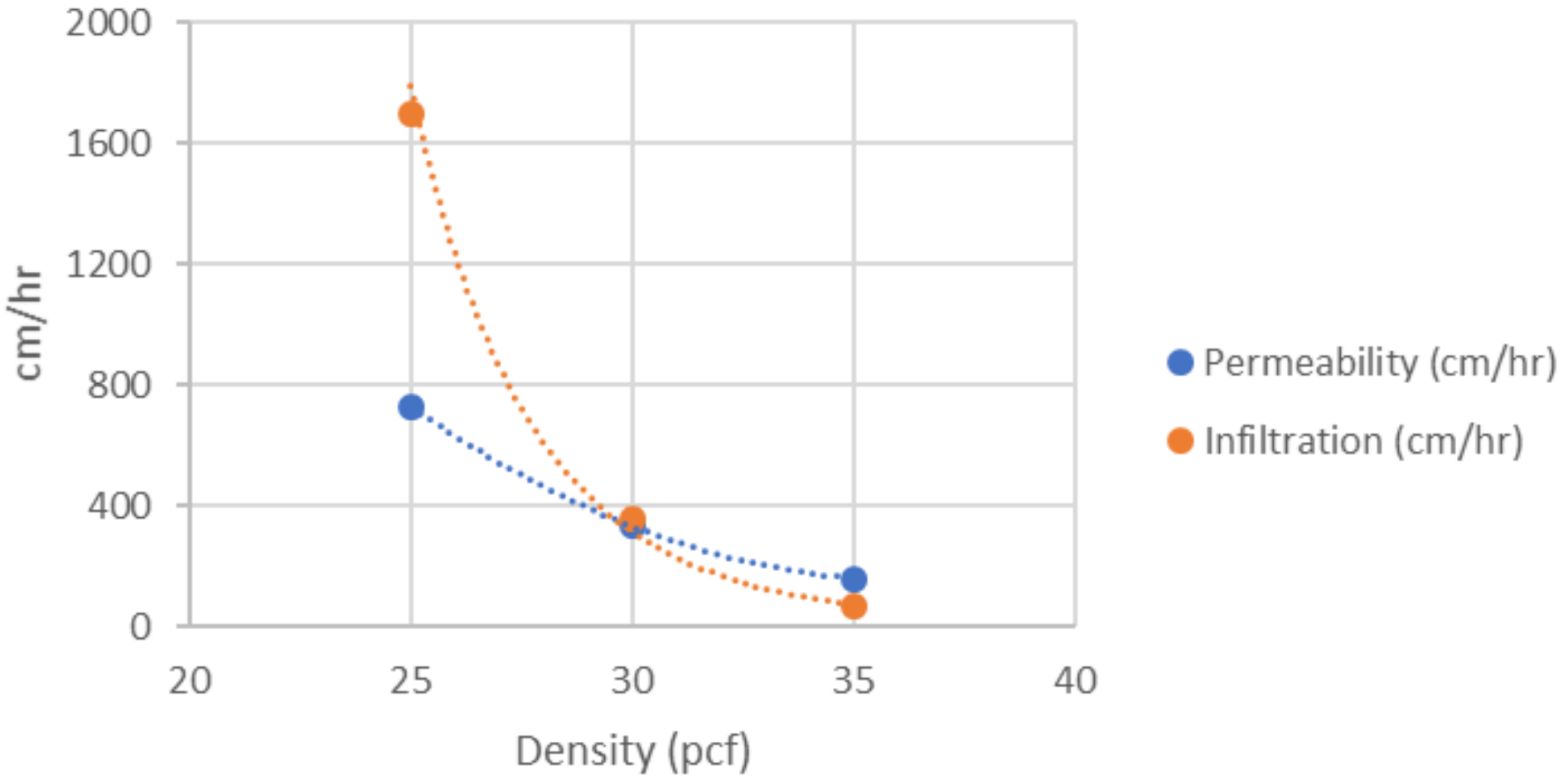
PLDCC Permeability / Infiltration



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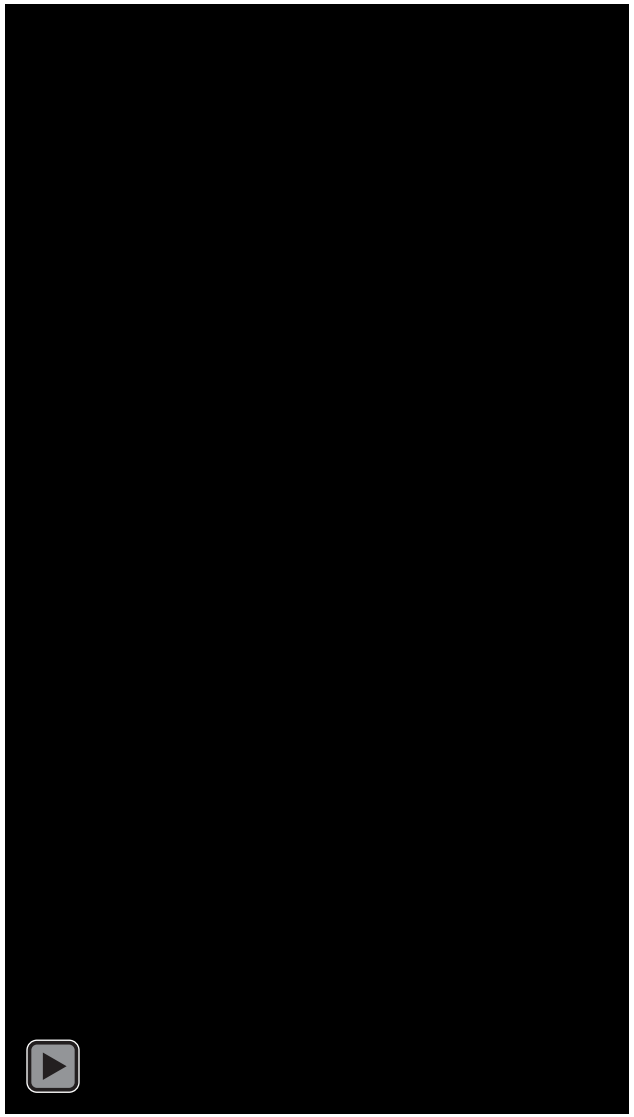
Permeability of PLDCC





Observation of Permeability
±12 hours after placement



*Information provided by
CellFill, Grove, OK

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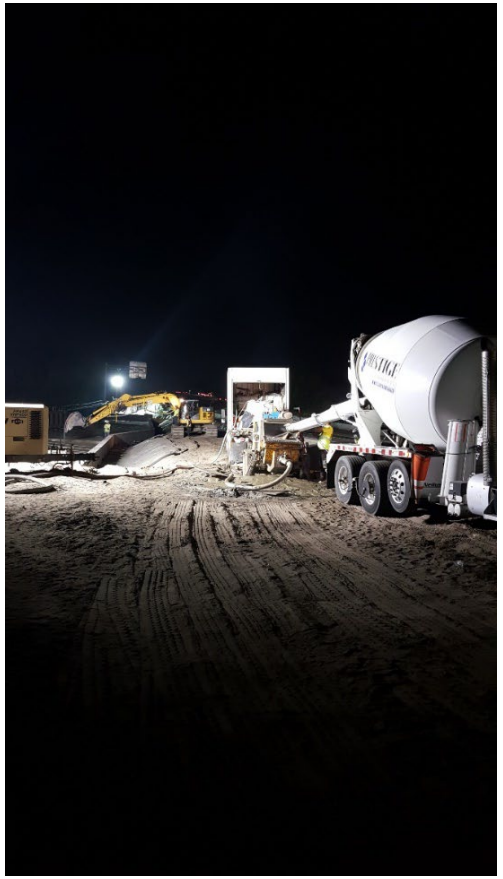
SR 50, Ocoee, FL







Information provided by CDM Smith & MixOnSite

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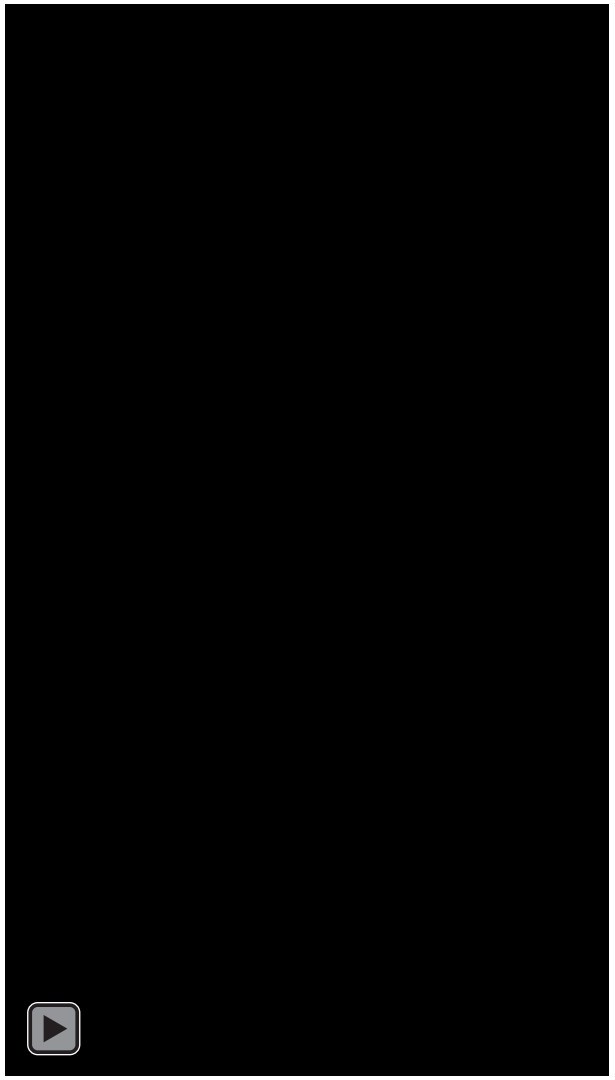
Permeable Low-Density Cellular being placed at Lake Eloise







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Lake Eloise
Maintaining an Equilibrium of the water-table



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Louis Armstrong Airport, New Orleans, LA





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MixOnSite USA Inc., Buffalo Grove, IL

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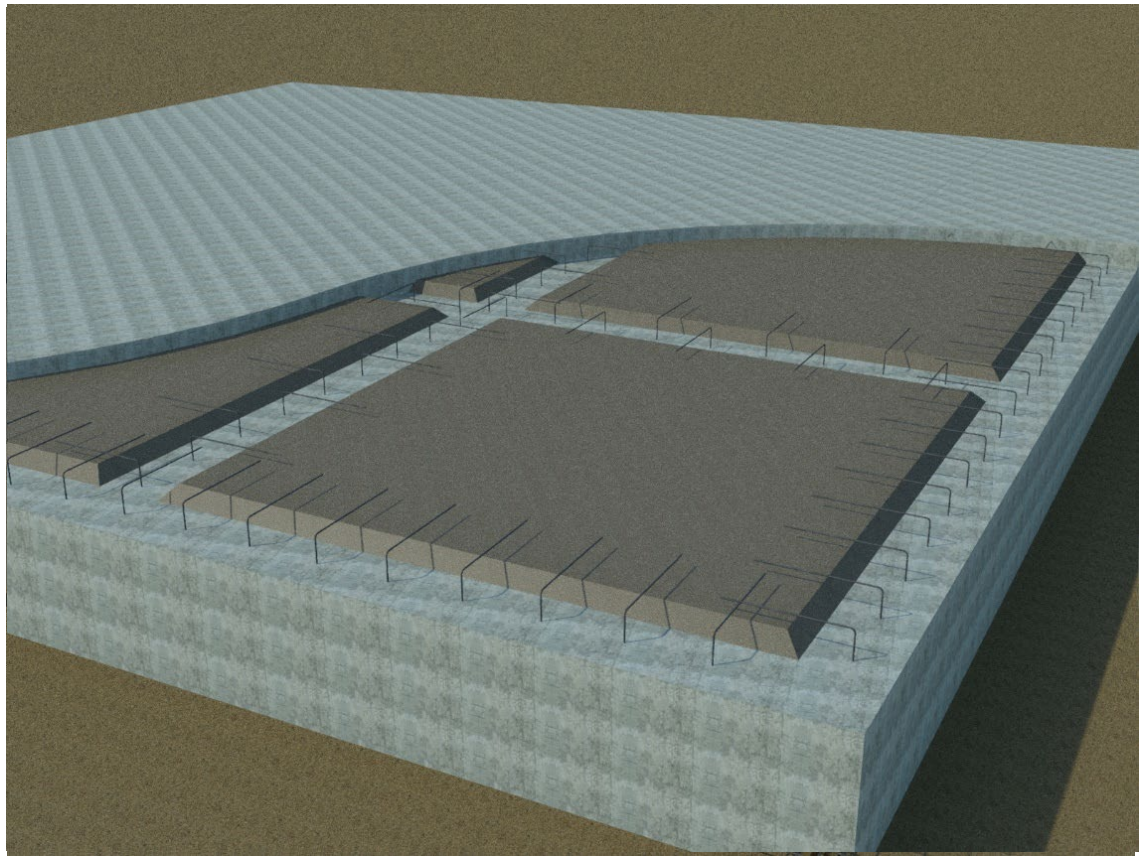
Using LDCC with Driven Piles Increasing the Elevation Needs



- 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.



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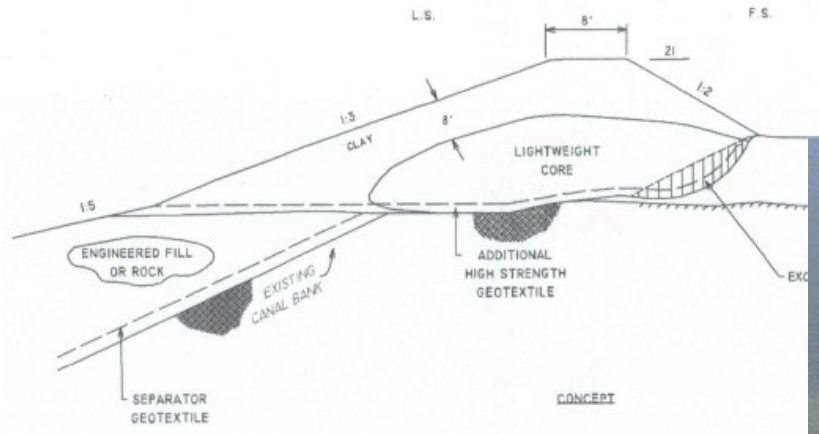
Lightweight Core in Levee Application





Picture courtesy of
Cell-Crete

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







Phots courtesy of
Cell-Crete

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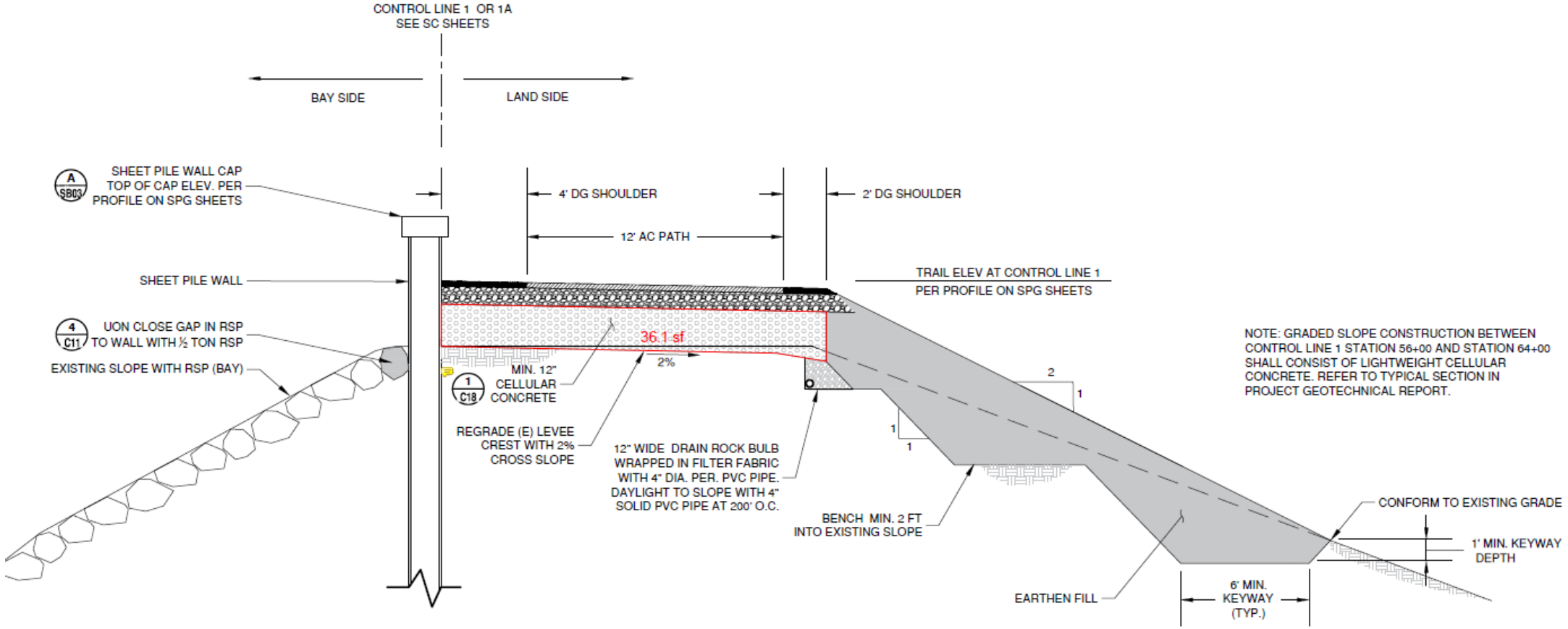
Foster City Levee Improvements, CA



TYPICAL SECTION G TCX 03

SCALE: 1/4" = 1'-0"

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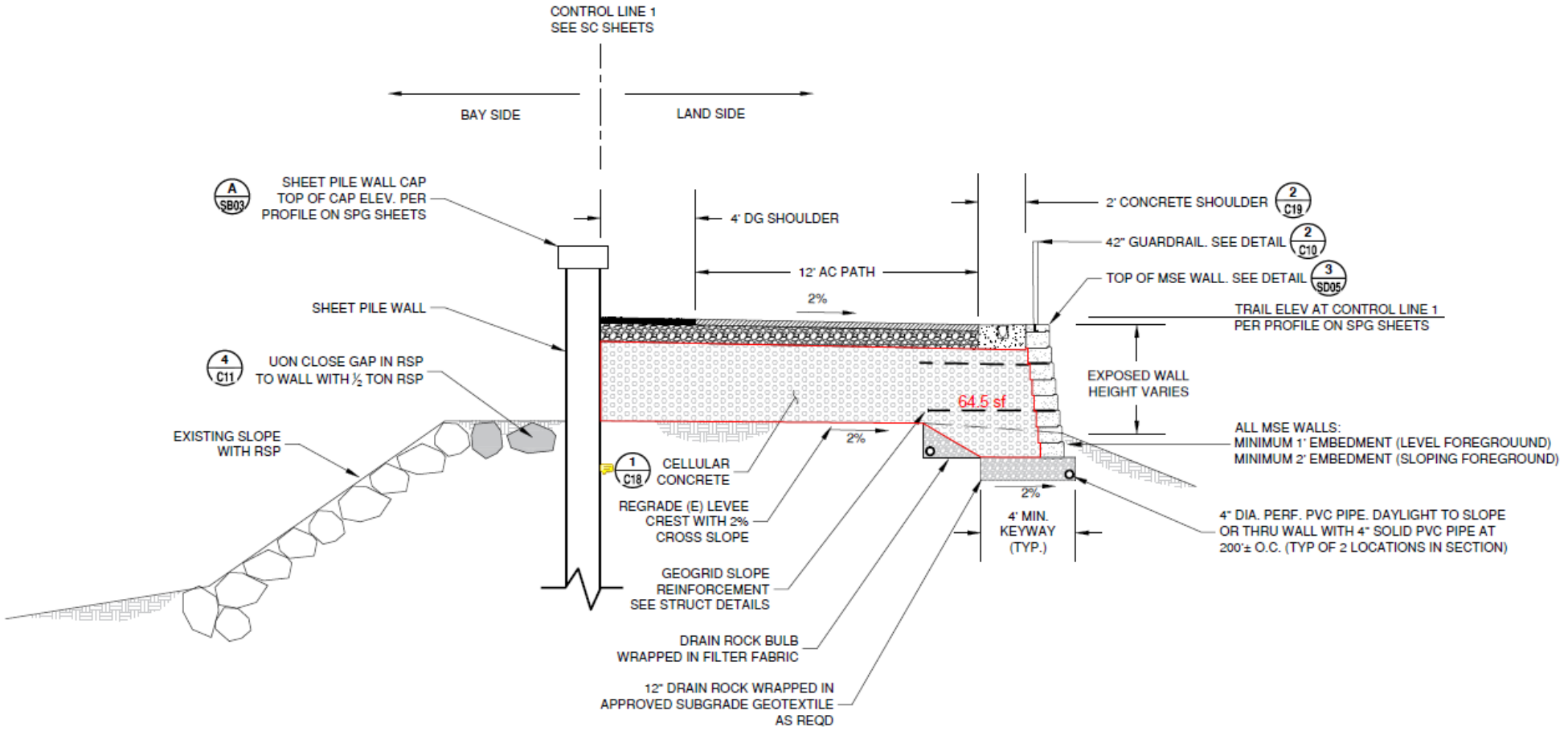
Foster City Levee Improvements, CA



TYPICAL SECTION H
SCALE: 1/4" = 1'-0" TCX 03

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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



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Portal North Bridge, Secaucus, NJ



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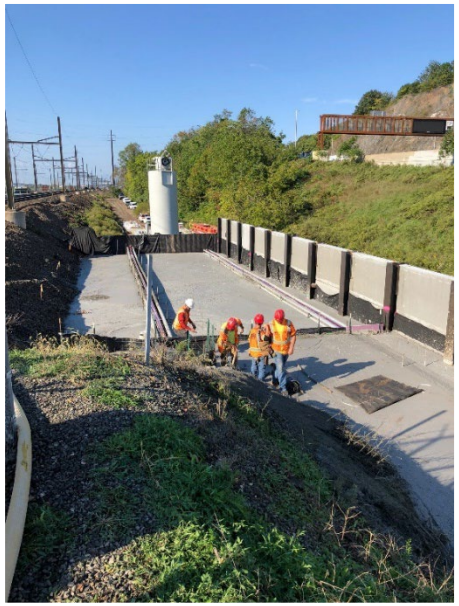
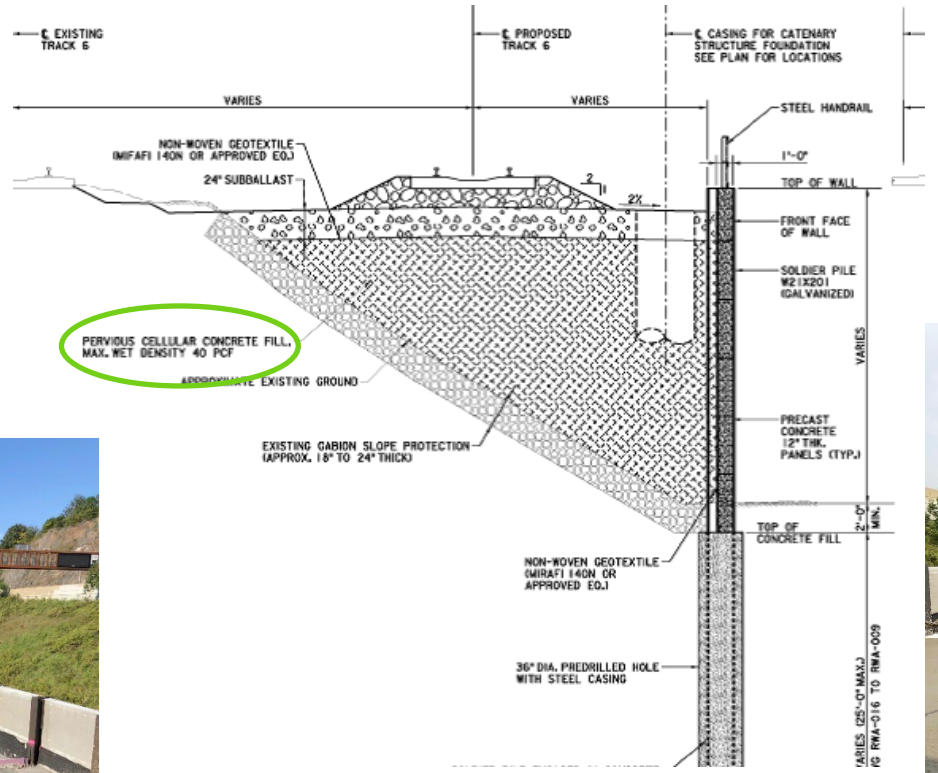
Portal North Bridge, Secaucus, NJ









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Segmental Wall Configuration







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Segmental Wall Configuration







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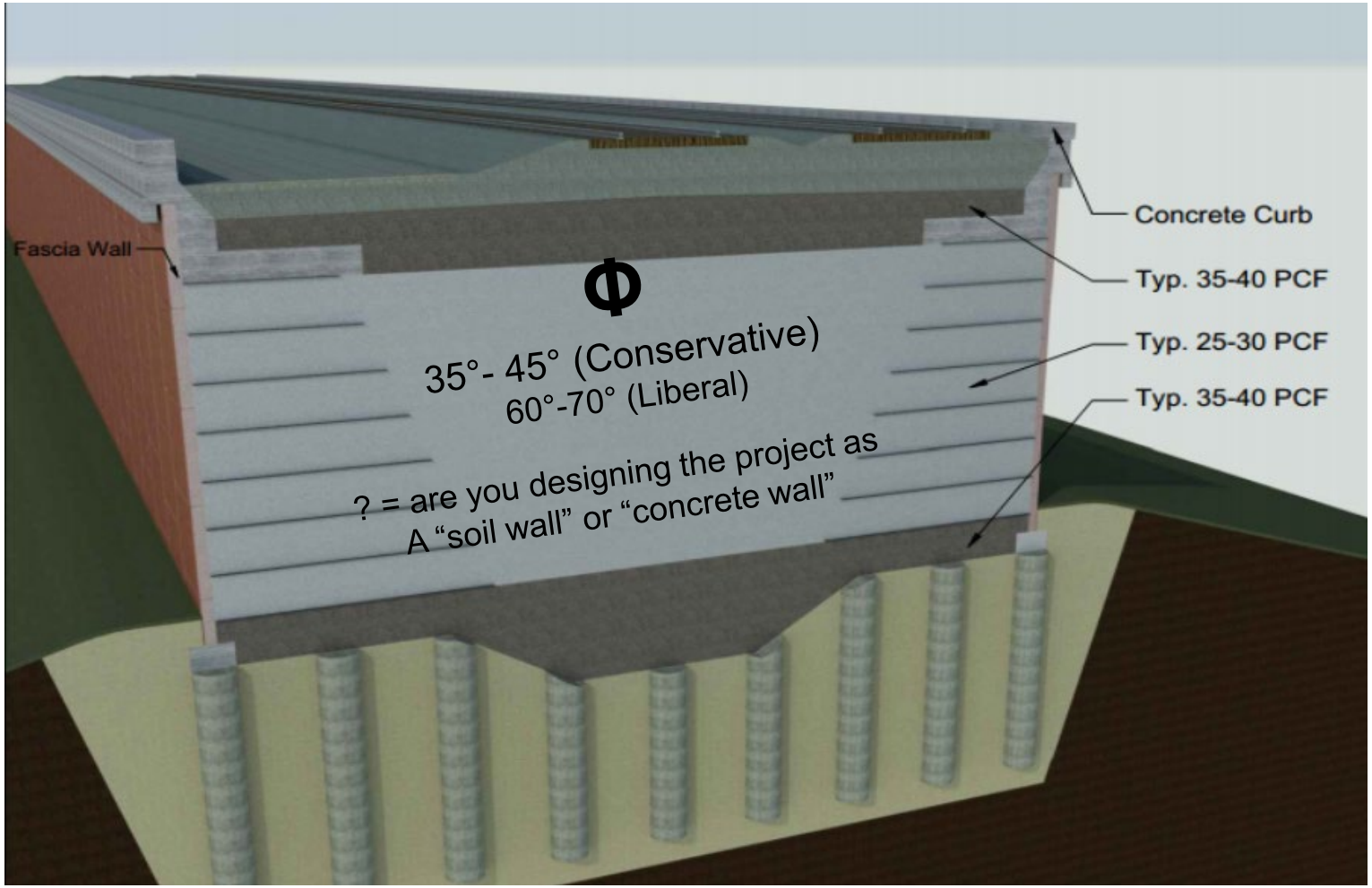
Strapping & Internal Angle of Friction



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SR 542, Bellingham, WA



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Duct Bank and Utility Trench Backfill



- Flows into every nook and cranny
- No vibration or compaction required
- No need to compact in the haunch of the utility
- Easily excavatable for maintenance



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Fully Excavatable & Versatile



Photo Courtesy of Throop Cellular



Photo Courtesy of A-Deck

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Removability Modulus**, RM

$$RM = \frac{W^{1.5} \times 104 \times C^{0.5}}{10^6}$$

Removability Modulus, RM, is calculated as follows:
Where :

W = unit weight (pcf)

C= 28-day compressive strength (psi)

Removability Modulus (RM) of 1.5 or less would indicate that the material is removeable

RM by Density/Strength

pcf	psi	RM
20	50	0.07
25	80	0.12
30	140	0.20
35	210	0.31
40	330	0.48
45	450	0.67
50	640	0.93
55	790	1.19
60	930	1.47
90	400	1.78
95	750	2.64
100	1000	3.29

RM Max = 1.5

*** As utilized by the CDOT, modified in 2017*

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Aerix Industries and the road to Carbon Neutrality



Aerix Industry is leading the Industry by example:

- Since the early ‘90s; moved all geotechnical applications toward all synthetic foaming agents
- Reduction of up to 18% cement by using a HWC foaming agent
- Increased utilization of portland-limestone cement (PLC)
- Incorporating 100% recycled plastics into the slurry mixes
- Increasing supplementary cementitious materials like slag, fly ash, silica fume, and other additives
- Encouraging higher water/cement ratios
- Performance-engineered mixtures
- No compaction requirements verses other lightweight fill alternatives and traditional materials
- LDCC is 100% recyclable, limiting the use of raw materials and production emissions on future projects
- On site blending where feasible to reduce jobsite traffic

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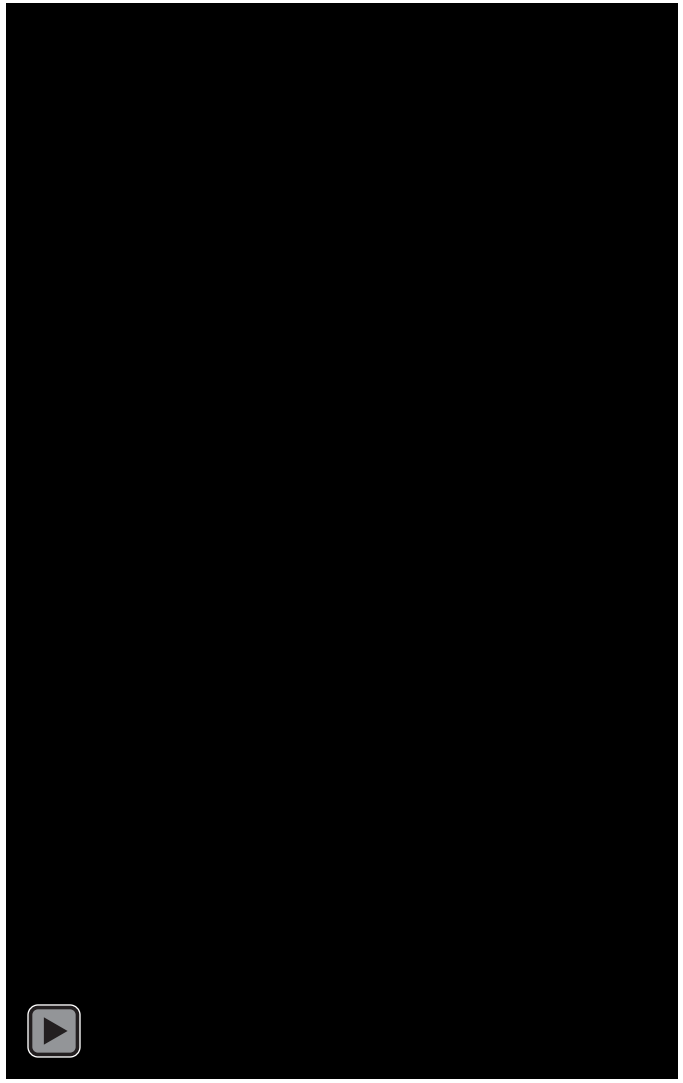
What conclusions can we draw about LDCC/PLDCC?

- Broad Range of Densities
- Economical
- Versatile
- Easily Placed
- Rapid Installation
- Durable
- Permanent and Stable
- Environmentally Friendly







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