Reimagining Resilient Infrastructure: Low-Density Cellular Concrete and the Road to Carbon Neutrality

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Aerix Industries

Video courtesy of CJGeO

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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/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.

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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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Conforms to ACI industry standards

Types of Foam

Preformed Foam

Produced by Foam Generator

ACI 523

Low-Density Cellular Concrete
(max of 50 lb/ft³)

Agitated w/ Chemical Admixture

Produced by the mixing action
of a concrete mixer

ACI 229

Controlled Low Strength Material
(115 to 145 lb/ft³)

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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Some Benefits to Using LDCC

- Readily available
- Easy to deliver
- Self-leveling
- Self-consolidating
- Strong and durable
- Quick opening to traffic
- Does not settle
- Accelerates schedules
- Improves worker safety
- Can be excavated
- Reuseable

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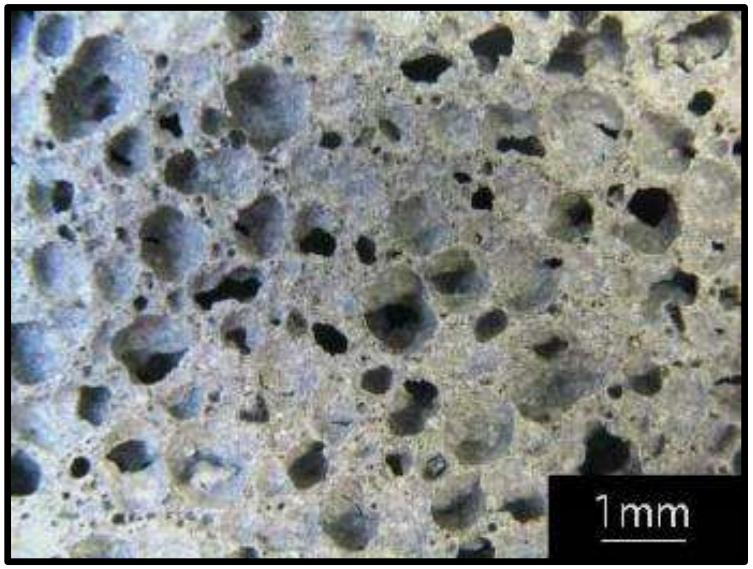
LDCC pore structure when cured



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.

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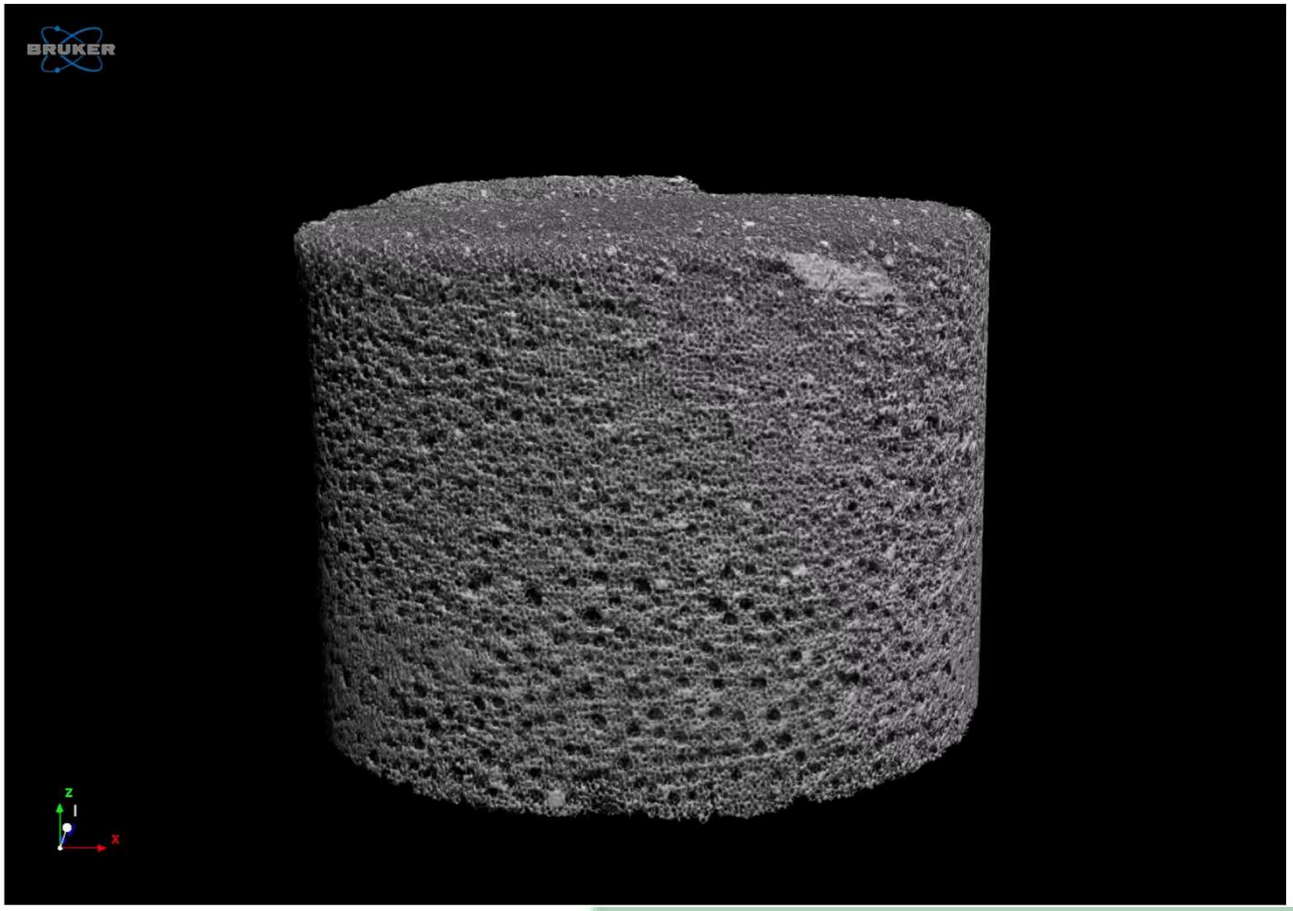
Micro CT-Scan of LDCC Sample



Micro CT-Scan provided by
University of Nebraska - Lincoln

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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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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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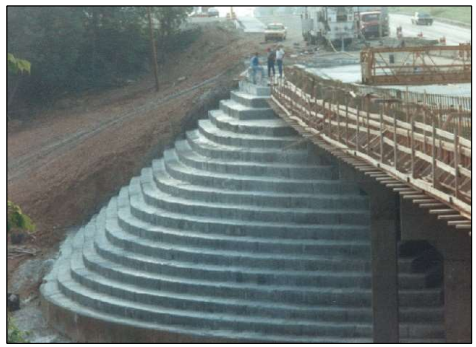
Important to Remember



- 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% reusable

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Permeable & Non-Permeable LDCC

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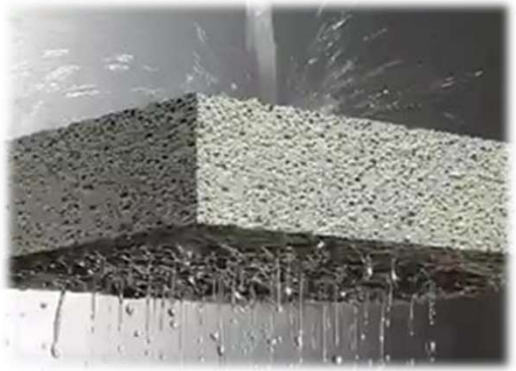
Coefficient of Permeability k (cm/sec) (log scale)

	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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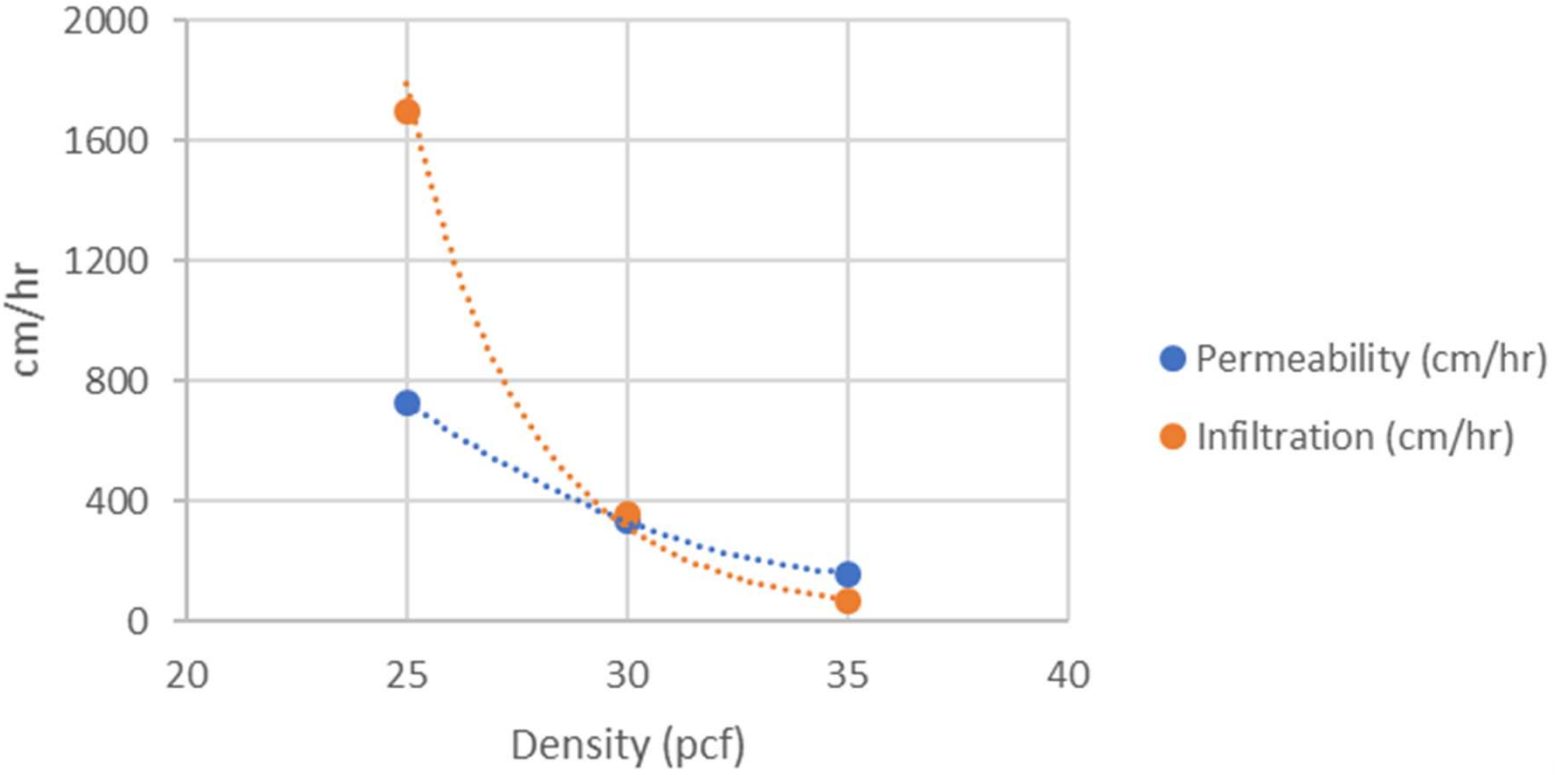
PLDCC Permeability / Infiltration



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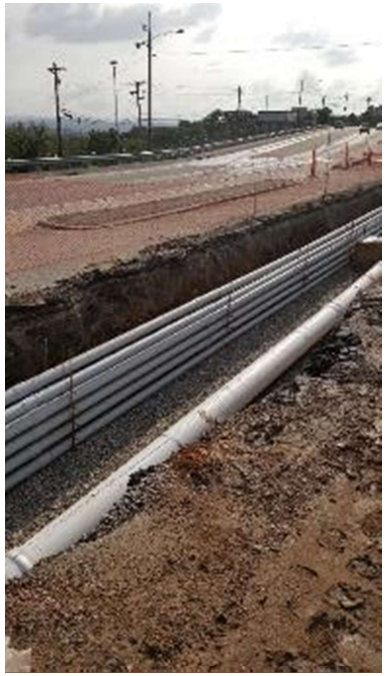
Permeability of PLDCC



Observation of Permeability
±12 hours after placement

*Information provided by
CellFill, Grove, OK*

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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

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Louis Armstrong Airport, New Orleans, LA

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

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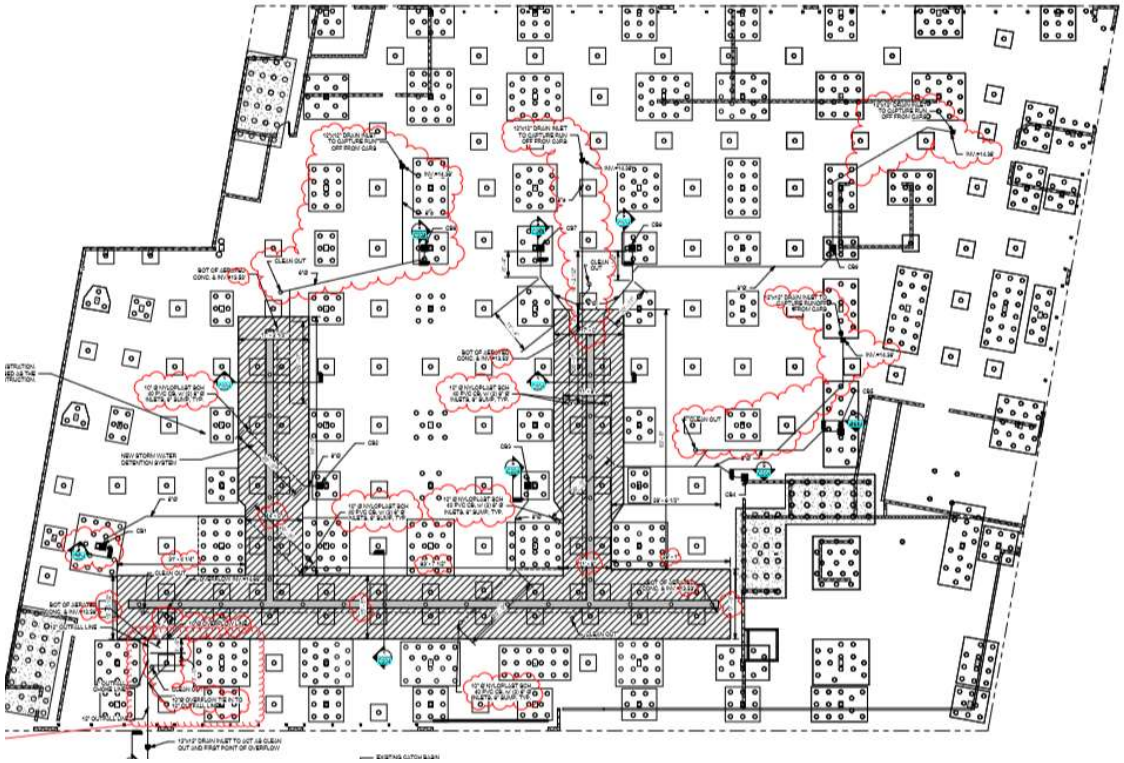
2424 Tulane Stormwater Detention System
New Orleans, LA



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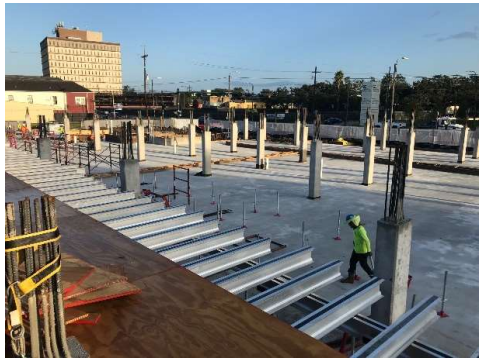
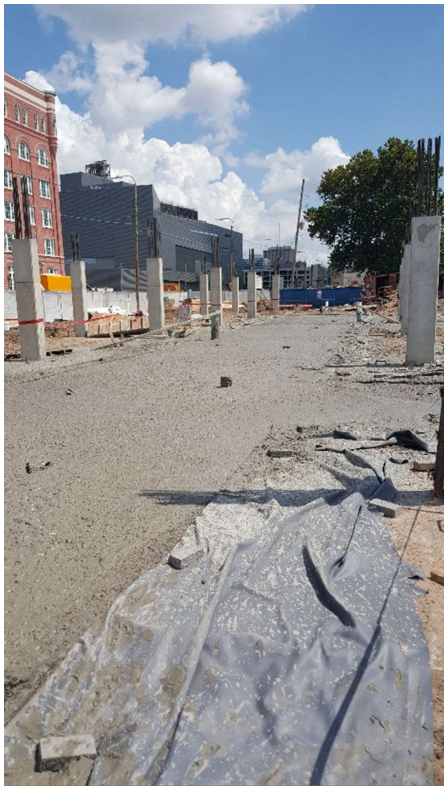
2424 Tulane Stormwater Detention System
New Orleans, LA





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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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Kaneohe Kailua Tunnel, Honolulu, HI

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

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Kaneohe Kailua Tunnel, Honolulu, HI

- 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

“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

Information provided by Southland/Mole JV, Kaneohe, HI

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Flowability

*Information provided by
Mainmark, Australia

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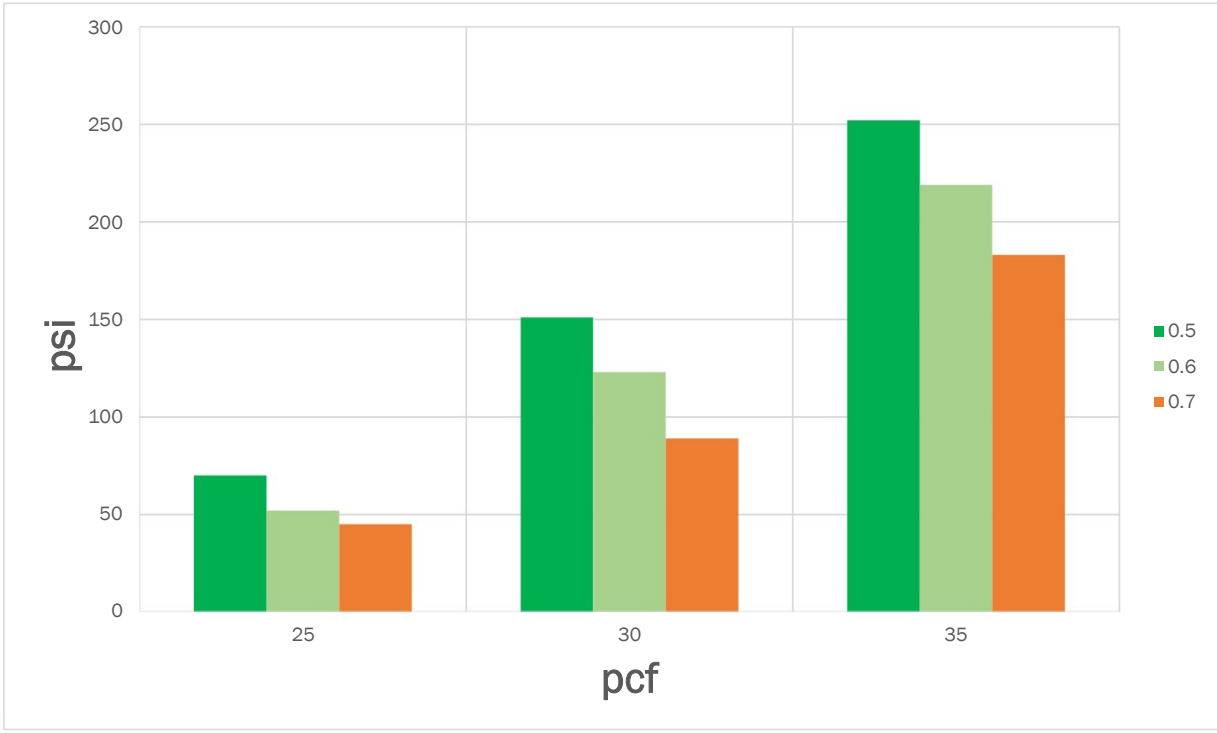
Effect of water/cement (W/C) ratio*

w/c ratio and its' effect on Compressive strengths



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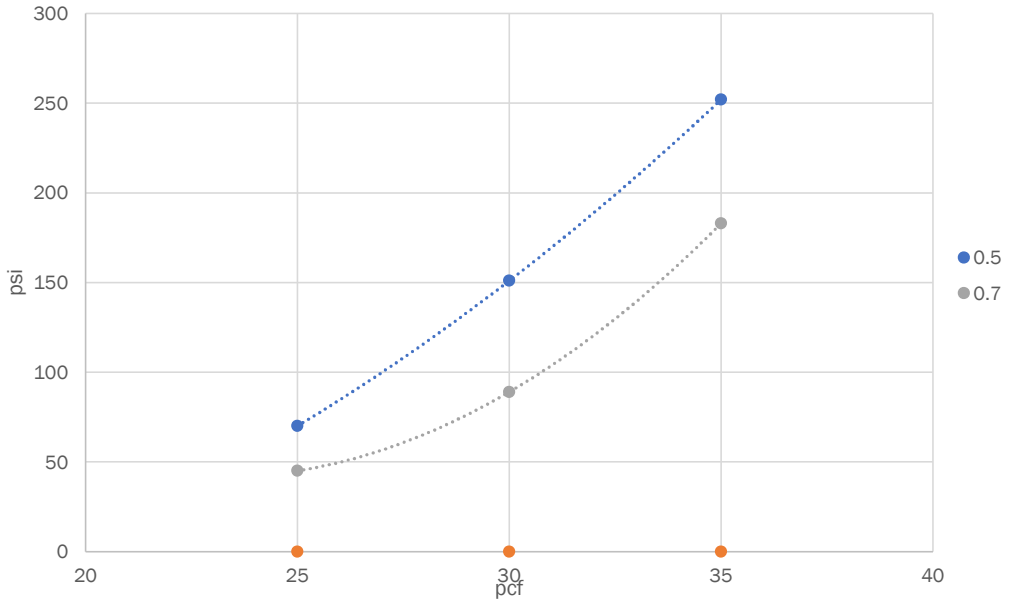
*Information provided by
Aerix Industries Internal Studies

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

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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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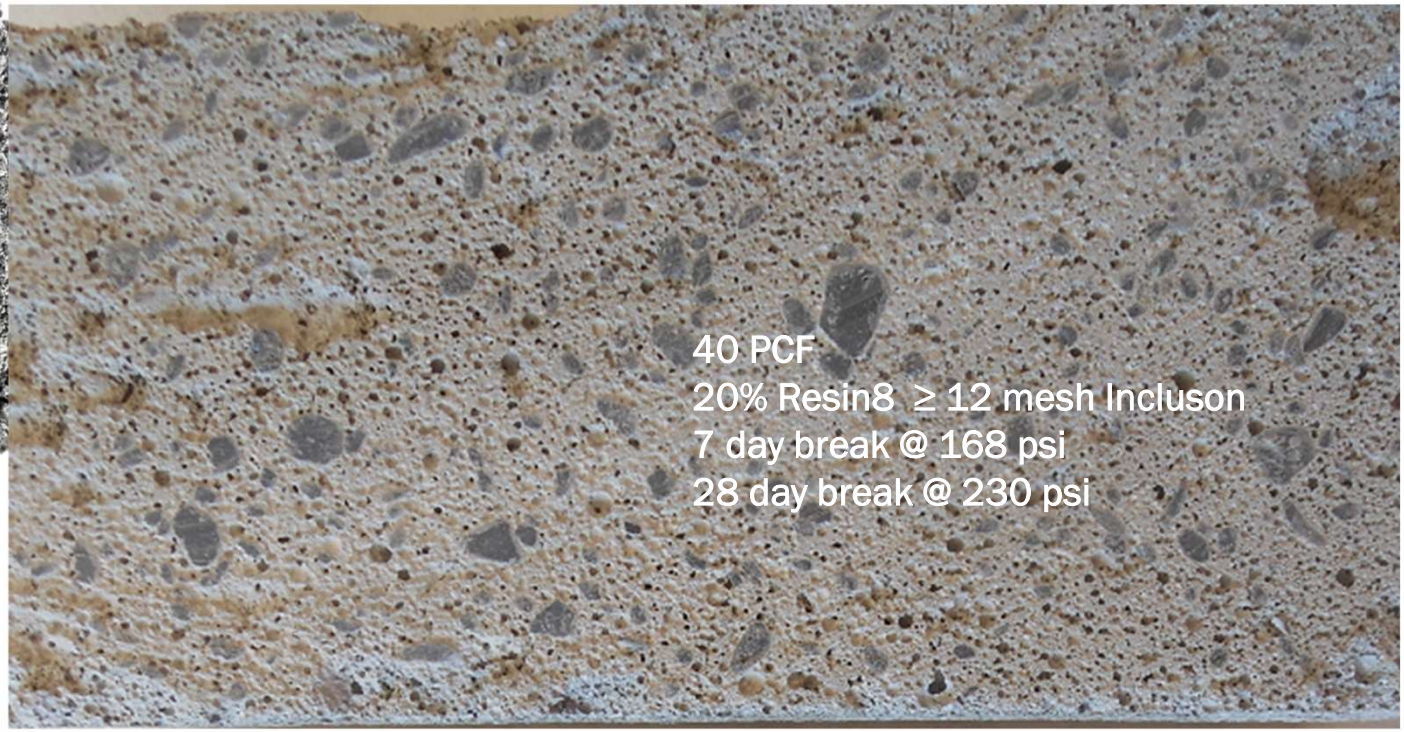
LDCC + Resin 8



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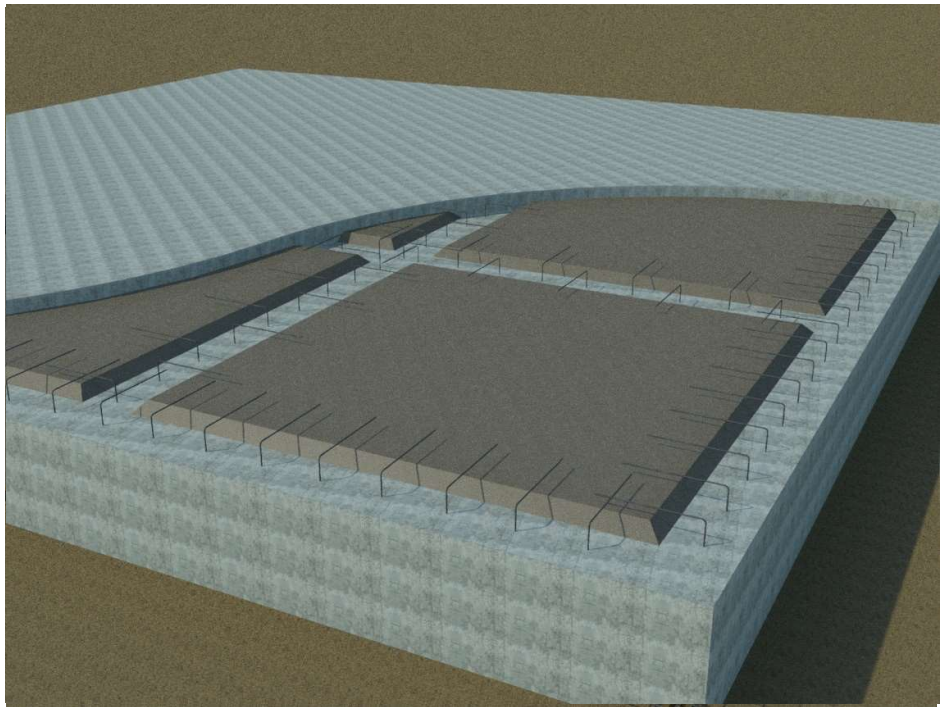
Using LDCC with Driven Piles Increasing the Elevation Needs



- 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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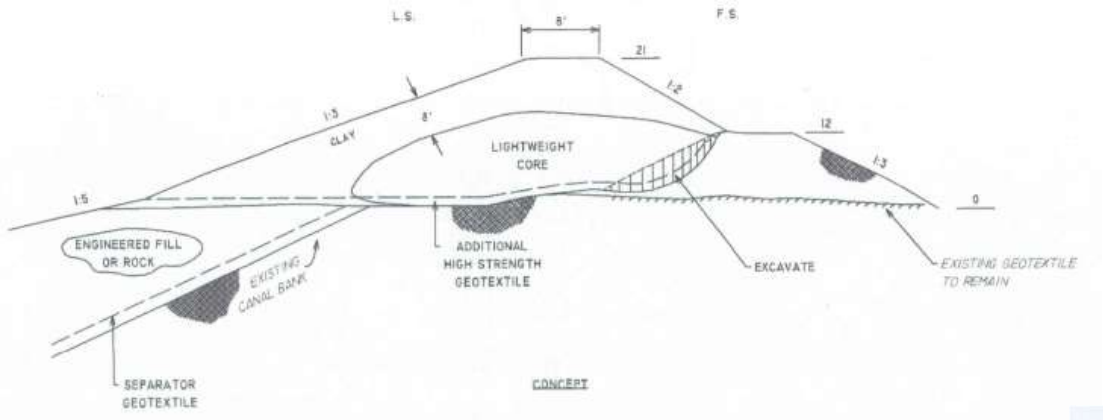
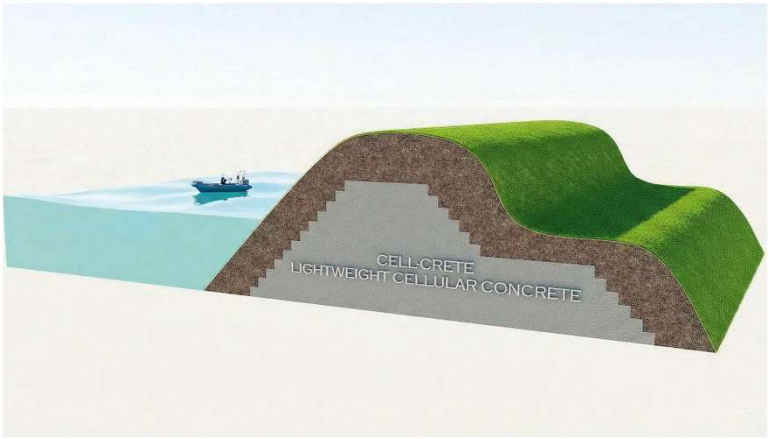
Lightweight Core in Levee Application





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

Phots courtesy of
Cell-Crete

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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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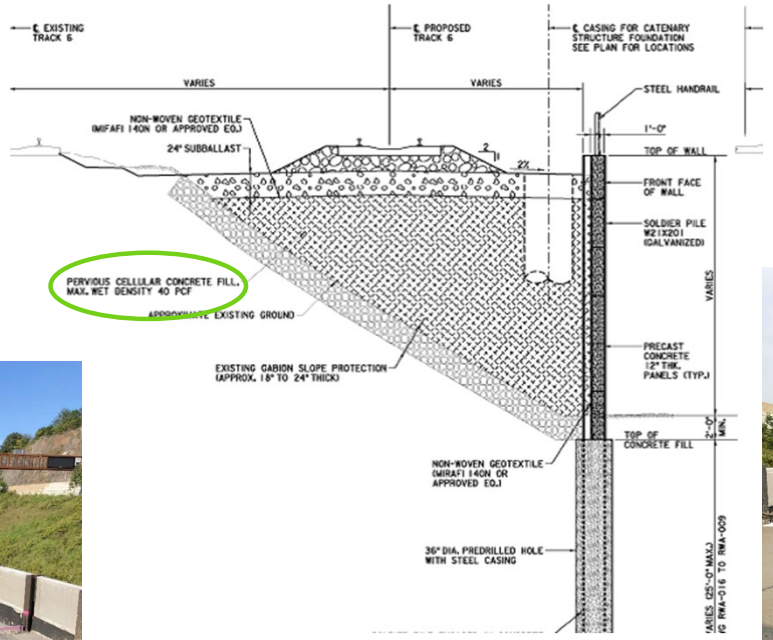
Portal North Bridge, Secaucus, NJ



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Segmental Wall Configuration

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Segmental Wall Configuration

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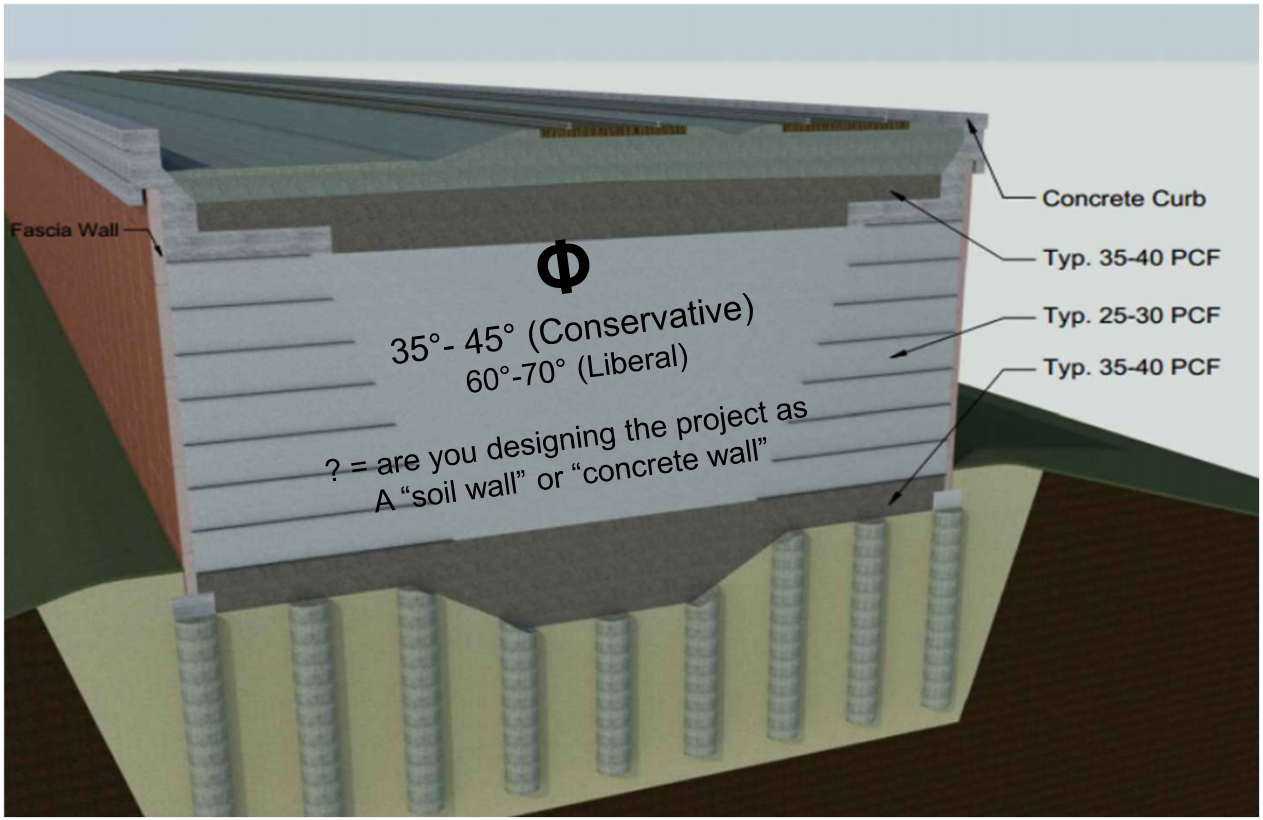
Strapping & Internal Angle of Friction



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SR 542, Bellingham, WA

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Sustainability of LDCC

- Can accelerate construction schedules leading to fewer/less severe community interruptions
- Industrial by-products such as fly ash and slag cement can be used in mixture design
- Need for fewer trucks reduces CO_2 emissions and traffic congestion, pavement wear, noise, and the use of scarce natural resources
- Self-consolidating and self-leveling aspects eliminate need of compaction equipment that reduces the carbon footprints on any project
- Resistant to animal infestation, rot, mold, mildew, and water degradation

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Sustainability of LDCC (continued)

- Less trench excavation means less energy used to open the trench, handle the spoil pile, and to backfill the trench
- Resistant to chemical abrasion/deterioration
- Installations can proceed quicker which means reduced traffic delays, detours, truck traffic, business interruptions, and community impacts
- For LDCC, foaming agents are safe and support sustainable development through LEED
- Ability to incorporate 100% recycled plastics

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Your new go-to resource for everything related to Lightweight Cellular Concrete (LCC).

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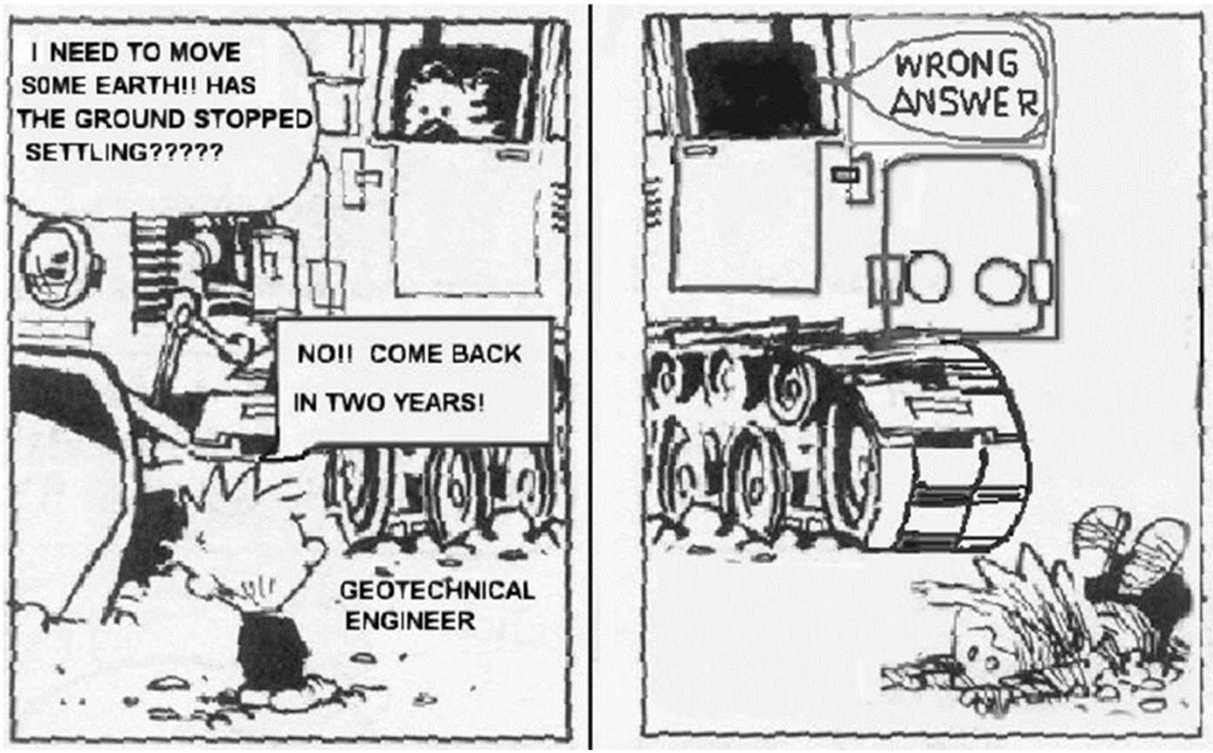
Thank You



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