LOW-DENSITY CELLULAR CONCRETE (LDCC)

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.

LOW-DENSITY CELLULAR CONCRETE (LDCC) IS DEFINED BY ACI 523 AS...

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.

LDCC pore structure when cured

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

Lightweight Cellular Concrete differs from conventional aggregate concrete in the methods of production, the density of the material and the extensive range of end uses.

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 (CLSM) cannot be cellular concrete because of the density being higher than 50pcf.

KEEP IN MIND.....

- Lightweight 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
Permeable & Non-Permeable LDCC

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 job sites

Typical Guidelines cellular concrete mixes

<table>
<thead>
<tr>
<th>Cost Density</th>
<th>Typical Compressive Strength @ 28 days</th>
<th>Performed Concrete</th>
<th>Water</th>
<th>Foam Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>pcf</td>
<td>psi</td>
<td>lb/cu ft</td>
<td>g/l</td>
<td>m3/m³</td>
</tr>
<tr>
<td>25</td>
<td>520</td>
<td>50</td>
<td>0.36</td>
<td>105</td>
</tr>
<tr>
<td>25</td>
<td>490</td>
<td>80</td>
<td>0.05</td>
<td>403</td>
</tr>
<tr>
<td>25</td>
<td>441</td>
<td>210</td>
<td>0.45</td>
<td>312</td>
</tr>
<tr>
<td>26</td>
<td>401</td>
<td>210</td>
<td>0.45</td>
<td>304</td>
</tr>
<tr>
<td>26</td>
<td>401</td>
<td>330</td>
<td>0.23</td>
<td>412</td>
</tr>
<tr>
<td>46</td>
<td>731</td>
<td>450</td>
<td>5.13</td>
<td>407</td>
</tr>
<tr>
<td>46</td>
<td>681</td>
<td>440</td>
<td>4.81</td>
<td>879</td>
</tr>
<tr>
<td>46</td>
<td>681</td>
<td>440</td>
<td>4.45</td>
<td>970</td>
</tr>
<tr>
<td>46</td>
<td>681</td>
<td>440</td>
<td>4.45</td>
<td>970</td>
</tr>
</tbody>
</table>

ASTM test methods that apply to cellular concrete

- ASTM C 869
- ASTM C 796
- ASTM C 495

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

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

*Standard Test Method for Compressive Strength of Lightweight Insulating Concrete*
Quality Control is Always Measured in the Field

Compressibility testing on LDCC validates ability to resist bubble collapse from pressure

Compressibility device to evaluate stability of LDCC

Note: The clear cylinder limits the pressure that can be applied, as does the loading by turning a screw through a threaded top plate. However, the grout is tracked through the pump during calibration, so the test acts as confirmation of the cellular concrete performance that is observed during pumping.

The LDCC level was 12 inches at zero pressure.

*Information provided by Ardaman & Associates, Inc. Tampa, FL

The LDCC fully rebounded to the original fill height.

At 30 psi pressure, the LDCC was reduced in height to 9 inches.

*Note there was no visible collapse of the cellular concrete after the test.

*Information provided by Ardaman & Associates, Inc. Tampa, FL

Advancements

Foam technology has made huge advancements with a very stable bubble

• Typical Foams
  • 3 foot lift thickness
  • Pumping distance limited to 5,000 feet maximum
  • Only non-permeable
  • Viscosity was almost 1
  • Fly ash usage limited

• Advanced Foam Technology
  • Lift of 35’ has been achieved
  • Pumping distance increased to more than 16,000 feet
  • Permeability is also an option
  • Thicker material
  • Compatibility with fly ash / slag cement

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

Cellular concrete is an ideal solution for annular and tunnel backfill

• Highly flexible material able to completely fill annular space
• Lightweight and easily pumped long distances at low pressures
• Will not float pipe or damage liner for sliplining
• Strength and density can be customized to project requirements
• Shrinkage of less than 0.3%
• Quick and easy installation
• Environmentally Safe

*Cellular concrete has been pumped over 700 feet vertically and over 15,000 feet horizontally.
  Can accommodate any diameter pipe

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Culvert or Annular Application

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

Gravity Sewer Annular Fill
Kaneohe Kailua Tunnel, Honolulu, HI

- 28,000\text{yd}^3$ 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

Typical Applications

- Tunnel & Mine Abandonment
- Annular Fills for Tunnels, Water & Sewer Lines
- Road 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

Utility/Tunnel Abandonment
UST Abandonment project – largest volume LDCC project known.

Was used to receive, store and distribute diesel and jet fuels for military use in California, Arizona and Nevada.

**Permeable Low-Density Cellular Concrete (PLDCC)**

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

<table>
<thead>
<tr>
<th>k (cm/sec)</th>
<th>Large</th>
<th>Medium</th>
<th>Small</th>
</tr>
</thead>
<tbody>
<tr>
<td>10^-1</td>
<td>Clean gravel</td>
<td>Clean sands, clean sand and gravel mixture, PLDCC</td>
<td>Coarse sand, gravel, sand and gravel, sands, silts, organic and inorganic silts, mixtures of sand and clay, clay, sand, clay, LDCC</td>
</tr>
<tr>
<td>10^-2</td>
<td>Poor practicable</td>
<td>Clean sands, clean sand and gravel mixture, PLDCC</td>
<td>Coarse sand, gravel, sand and gravel, sands, silts, organic and inorganic silts, mixtures of sand and clay, clay, sand, clay, LDCC</td>
</tr>
<tr>
<td>10^-3</td>
<td>Very fine, sand, organic and inorganic silts, mixtures of sand and clay, clay, sand, clay, LDCC</td>
<td>Coarse sand, gravel, sand and gravel, sands, silts, organic and inorganic silts, mixtures of sand and clay, clay, sand, clay, LDCC</td>
<td></td>
</tr>
<tr>
<td>10^-4</td>
<td>&quot;Impermeable&quot; soils, e.g., homogenous clays below zone of weathering</td>
<td>Coarse sand, gravel, sand and gravel, sands, silts, organic and inorganic silts, mixtures of sand and clay, clay, sand, clay, LDCC</td>
<td></td>
</tr>
</tbody>
</table>

**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 (cm/hr)
- Infiltration (cm/hr)

**Permeability of Cellular Concrete**

Observation of Permeability: 25 hours after placement.
Void Factors of PLDCC

- Rapid installation without disturbing traffic pattern
- Minimize bearing pressure

Typical Applications
- Tunnel & Mine Abandonment
- AnnularFilled Water & Sewer Lines
- Void Fills
- Soil Remedia
- Tremie Applications
- Retaining Structure Backfills
- Slope Stabilization
- Fill for Underground Utility, Conduit & Pipes
- Tanks & Pipeline Abandonment
- Fill Around Conduits and Pipes
- Green Roof Applications
Use cellular concrete for subgrade modification when existing soils are undesirable.

LDCC/PLDCC Advantages
- Reduce Vertical Dead Loads
- Increase Bearing Capacity
- Increase Strength/Stability with Minimal Weight
- Reduce Settlement Potential
- Improve Seismic Stability
- Insulating

SR 50, Ocoee, FL

Permeable cellular concrete used on bridge approach to allow flood waters to drain. Standing water from flooding of Red River in Fargo, ND had deteriorated the bridge approach.

Using permeable cellular concrete on the bridge approach allowed the flood waters to drain alleviating pooling and potential deterioration.

I-29/I-80, Council Bluffs, IA

I-29/I-80, Council Bluffs, IA

I-29/I-80, Council Bluffs, IA

LODD/PLDCC

133,800 yd³ 32pcf LDCC
4,500 yd³ /day

Louis Armstrong Airport

New Orleans, LA

SR 50, Ocoee, FL

Louis Armstrong Airport

New Orleans, LA

River scouring embankment on I-29 threatened safety of motorists.

*Information provided by CDM Smith & MixOnSite

*Information provided by Cellular Concrete Inc., Zimmerman, MN

*Information provided by MixOnSite, Buffalo Grove, IL

*Project by MixOnSite USA Inc., Buffalo Grove, IL
What about sedimentation...clogging?

Using Cellular Concrete 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 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.

With the final pour in place, the elevation is achieved! Reducing the down drag on the driven piles.

Lightweight Core in Levee Application

Tunnel & Mine Abandonment
Annular Fills for Tunnels, Water & Sewer Lines
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Green Roof Applications
The fluidity of LDCC makes it favorable for tremie applications.

- 65+pcf density
- Material Mixed 35' underwater

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**LDCC/PLDCC Advantages**
- Reduce Lateral Load
- Ease of Placement
- Increased lift heights
- Reduces schedule impact
- Allows for design flexibility
- Engineered permeability
Grade Separation for UP RR Mainline

Backfill to Sheet Pill Wall with PLDCC

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- Green Roof Applications

Caltrans, Route 128, Napa County

Trench Backfill Opportunities
- Allows for narrower trench and less disturbance to the native material.
- Widths may be reduced to within 6 in of utility
- Enough space to properly place the cellular in the pipe haunch areas
- Eliminates backfill compaction.
- Fills all voids
Duct Bank and Utility Trench Backfill
- Flows into every nook and cranny
- No vibration or compaction required
- Easily excavatable for maintenance

GeoThermal Model – Utility Protection
- Identifies buried utilities with a dye
- Clear indicator for future operators
- Different colors can be used
  - Red – fiber optics or high voltage lines
  - Blue – water lines
  - Yellow – sewer lines

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Fully Excavatable & Versatile
**Typical Applications**

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**Green Roof Applications**

**Green Roof Environmental and Economic Benefits**

- Reduces storm water runoff and filters pollutants; neutralizes acidity of soil
- Slow down energy for help
- Acts as groundwater-potential barrier (up to 40 decibels in some cases)
- Expands the lifespan of roof by protecting roof surface from contraction and expansion
- Insulates and cools building, reducing utility costs
- Qualifies for up to 10-20 LEED certification points
- Create habitat for birds and insects
- Reduces “urban heat island effect” by cooling urban environment through evaporative transpiration

**PLDCC Green Roof Applications**

**PLDCC Green Roof Elevation Changes**

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**Other Applications**

- Infiltration/Exfiltration Systems
  - Green Roof Applications
  - PLDCC Green Roof Applications
  - PLDCC Green Roof Elevation Changes
  - Infiltration/Exfiltration Systems
  - Growing Medium and Vegetation
  - Pervious Pavers or Pervious Pavement Concrete Slab
What conclusions can we draw about LDCC/PLDCC?

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

Contact Information

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