**AN INTRODUCTION TO CELLULAR CONCRETE AND ADVANCED ENGINEERED FOAM TECHNOLOGY**

Not just products... Solutions

Nico Sutmoller
Lightweight Fill Specialist

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**AERIX INDUSTRIES**

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**LOW-DENSITY CELLULAR CONCRETE 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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**A BRIEF HISTORY OF CELLULAR CONCRETE**

- **Early 1900's**
  - Invented in Sweden
  - Used commercially across Scandinavia

- **End of WWII 1945**
  - Hydrolyzed, protein-based foam liquid concentrates introduced
  - Technology gained traction throughout Europe and much of the rest of the globe

- **1990's**
  - Synthetic-based foam liquid concentrates introduced
  - Feature relatively stable air cells and acceptable density control
  - Feature highly stable air cells with extended maximum life in the plastic state
  - Excellent longevity and durability
  - Introduction of hybrid foam liquid concentrates – mixture of protein and synthetic ingredients

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**CONFORMS TO ACI INDUSTRY STANDARDS**

Types of Foam

- **Preformed**
  - Produced by Foam Generator
  - ACI 523

- **Agitated**
  - Produced by the mixing action of a concrete mixer
  - ACI 229

Cellular Concrete

Cellular concrete can be flowable fill (ACI 229 – Chapter 8) but flowable fill (CLSM) cannot be cellular concrete because of the density being higher than 50pcf.

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**CONFORMS TO ACI INDUSTRY STANDARDS**

Preformed

Produced by Foam Generator

ACI 523
**CELLULAR CONCRETE 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.

**CELLULAR CONCRETE 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.

**PERVIOUS & NON-PERVIOUS**

**CELLULAR CONCRETE BATCHING PROCESS**

**TYPES OF ON-SITE INSTALLATION EQUIPMENT INCLUDE**

- High production self-contained unit for large volume projects
- Mobile mixing units
- Self-contained trailer and road system

**ADVANTAGE OF A MORE ENVIRONMENTALLY FRIENDLY THAN ALTERNATIVE METHODS**

- Less pieces of equipment
- Less fuel
- Less Carbon emissions
- Less congested jobsites
**Typical Guidelines Cellular Concrete Mixes**

<table>
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<tr>
<th>Value</th>
<th>20</th>
<th>30</th>
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<td>19.2</td>
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<td>48.7</td>
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<td>75.7</td>
<td>65.5</td>
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**Typical Strength Curve of Cellular Concrete**

![Graph showing typical strength curve of cellular concrete.](image)

**ASTM Test Methods that Apply to Cellular Concrete**

- **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"

**Quality Control is Always Measured in the Field**

**Compressibility Testing on Cellular Concrete Validates Ability to Resist Bubble Collapse from Pressure**

- The cellular concrete level was 12 inches at zero pressure.
- At 30 psi pressure, the cellular concrete was reduced in height to 9 inches.  
  *Note: There was no visible collapse of the cellular concrete after the test.*  

**The Cellular Concrete Fully Rebounded to the Original Fill Height**

- The cellular concrete fully rebounded to the original fill height.
  *Note: The clear cylinder limits the pressure that can be applied to the cellular concrete during the test. The test is designed to evaluate the stability of cellular concrete under pressure.*
FOAM TECHNOLOGY HAS MADE HUGE ADVANCEMENTS WITH STABLE BUBBLE TECHNOLOGY

- 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
  - 4-20 foot lift thickness
  - Pumping distance increased to more than 14,000 feet
  - Permeable is also an option
  - Thicker material
  - Higher fly ash usage and slag cement usage

GEOTECHNICAL APPLICATIONS

- Tunnel Backfill and Annular Fills
- Subgrade Modification
- Tremie Applications
- Bridge Approach
- Retaining Wall Backfills
- Fill Underground Tanks & Pipelines
- Fill for Abandoned Mines
- Fill Around Conduits and Pipes

CELLULAR CONCRETE IS AN IDEAL SOLUTION FOR ANNULAR AND TUNNEL BACKFILL

- Highly flowable 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

CULVERT OR ANNULAR APPLICATION

- 150 yd³ (114 m³) of 500psi (3.4 MPa) pumped 100ft (30.5m) under SR 1 for MaineDot

GRAVITY SEWER ANNULAR FILL KANEHOE KAILUA TUNNEL, HONOLULU, HI

1. Site selection and surveying
2. Excavation of tunnels
3. Placement of annular fill
4. Sheeting for excavation

- 28,600yd³ 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

“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
**GAS PIPE LINE ABANDONMENT**  
**ATLANTA GAS LIGHT (AGL)**

- 12 ½ mile abandonment  
- 1,000-1,500 ft placement points  
- 6,500 yd³ of 40pcf  
- Non-pervious  

- 20km abandonment  
- 300 – 450 meter placement points  
- 8,540 m³ of 640kg/m³  
- Non-pervious  

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**UTILITY/TUNNEL ABANDONMENT**

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**NC 72, FAYETTEVILLE, NC**

- Hurricane Matthew Oct ‘16  
- Washed out backfill  
- Void of 900 cubic feet  
- CC placed in three hours  
- Using ready-mix trucks  

**ABANDONMENT OF ROOSEVELT AVE DRAWBRIDGE COUNTERWEIGHT WELL PITS**

- Rapid installation without disturbing traffic pattern  
- Minimize bearing pressure  

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**INDOOR POOL ABANDONMENT**

**BACKFILLING OF POOLS**  

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GEOTECHNICAL APPLICATIONS
- Tunnel Backfill and Annular Fills
- Subgrade Modification
- Tremie Applications
- Bridge Approach
- Retaining Wall Backfills
- Fill Underground Tanks & Pipelines
- Fill for Abandoned Mines

USE CELLULAR CONCRETE FOR SUBGRADE MODIFICATION WHEN EXISTING SOILS ARE UNDESIRABLE

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

CELLULAR CONCRETE USED TO REPLACE UNSTABLE SOILS AT THE UNIVERSITY OF CONNECTICUT

- Football stadium constructed on unstable soils
- Lightweight Cellular Concrete sub-base equally distributed the loads
- 40,000 yds (30,600 m³) of 35pcf (480kg/m³) material placed at 150 cy per hour (115 m³/hr)

SR 50, OCHEE, FL

- Information provided by CDI Smith, Orlando, FL & Aerix Industries
LIGHTWEIGHT CORE IN LEVEE APPLICATION

120 DAY WATER ABSORPTION STUDY*

Non-Pervious Cellular Concrete

<table>
<thead>
<tr>
<th>Sample-ID</th>
<th>Net Cast Pcf</th>
<th>Net @ 120 dayspcf</th>
<th>Avg Absorption %</th>
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<tr>
<td>30 pcf</td>
<td>36.1</td>
<td>34.6</td>
<td>16.6</td>
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<tr>
<td>36 pcf</td>
<td>34.9</td>
<td>38.7</td>
<td>12.5</td>
</tr>
<tr>
<td>42 pcf</td>
<td>41.5</td>
<td>45.4</td>
<td>12.4</td>
</tr>
</tbody>
</table>

GEOENGINEERING APPLICATIONS

- Tunnel Backfill and Annular Fills
- Subgrade Modification
- Tremie Applications
  - Bridge Approach
  - Retaining Wall Backfills
  - Fill Underground Tanks & Pipelines
  - Fill for Abandoned Mines

THE FLUIDITY OF CELLULAR CONCRETE MAKES IT FAVORABLE FOR TREMIE APPLICATIONS

- Coastal piers compromised
- Placed sheet pile around existing piers, to isolate wood from water
- 70 pcf Cellular Concrete used as fill between the sheet pile and the pier

GEOTECHNICAL APPLICATIONS

- Tunnel Backfill and Annular Fills
- Subgrade Modification
- Tremie Applications
  - Bridge Approach
  - Retaining Wall Backfills
  - Fill Underground Tanks & Pipelines
  - Fill for Abandoned Mines

CELLULAR CONCRETE IS IDEAL RETAINING WALL BACKFILL

Cellular Concrete Advantages

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

*Haller Laboratory Report (No. L4538-2-R)
**SEGMENTAL WALL CONFIGURATION**

- Elimination of lateral loads as well reduction in vertical loads
- Three new ramps for lane change requirements

**SEGMENTAL WALL CONFIGURATION**

- 22,000 yd³
- 6 phases over 2 years
- 1000yd³ per day of production
- 24-30pcf @ 40psi

**STRAPPING CONFIGURATION**

- 18,000 cubic yards of cellular concrete
- 24-30pcf / 40psi
- 4 phases over a 2 year duration
- Daily production rates > 1000 cubic yards

**LANE EXPANSION IN PHILADELPHIA FOR RAPID INSTALLATION**

- Pumped 6,800 cubic yards (5,200 cubic meters)
- Existing soils were soft for traditional compacted fill and accelerated production schedule was needed

**GEOTECHNICAL APPLICATIONS**

- Tunnel Backfill and Annular Fills
- Subgrade Modification
- Tremie Applications
- Bridge Approach
- Retaining Wall Backfills
- Underground Utility Protection
- Fill Underground Tanks & Pipelines
- Fill for Abandoned Mines
- Fill Around Conduits and Pipes

**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
**Illustration provided by Cematrix**

### Identify 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

*Photo Courtesy of Throop Cellular Concrete*

### Water Main Abandonment
**IL Tollways Project (Alternative to CLSM)**
- 13,400 LF; 60” and 90” water main abandonments for three Tollway projects
- 13,000 cubic yards of 24-30pcf / 40psi
- Staging area for dry mix equipment (photo above) was over 1,000 feet to injection points.

*Photo Courtesy of Throop Cellular Concrete*

### Fully Excavatable & Versatile

#### Emerging Technologies and Engineered Foam Solutions
- **Pervious Cellular Concrete (PCLWC)**
  - Open Cell Technology
  - Permeability Drainage of 162” - 1600”/hr
  - Density of 25pcf – 35pcf

*Photo Courtesy of MixOnSite USA Inc., Buffalo Grove, IL*

#### Pervious vs. Non-Pervious
- Bubble Chemistry is different
  - In non-pervious we need to maintain the bubble structure
  - With Pervious we need to coalesce the bubble structure
TYPICAL USES AND APPLICATIONS FOR PERVIOUS CELLULAR CONCRETE

- Sports Field Sub-base Fills
- Bridge Approach Fills
- Retaining Wall Backfills
- Foundation Fills
- Pervious Pavement Sub-base Fills
- Pipeline Bedding Fills
- Culvert Relining Fills
- Pool Deck Sub-base Fills
- Pervious Paver Sub-base Fills

PERVIOUS CELLULAR CONCRETE USED AS A SUB-BASE AT THE NEW YORK METS BALLPARK SAVING THE OWNER OVER $500,000 DOLLARS

The site of the new ball park was on poor soils. Pervious Cellular Concrete was used as a sub-base under the playing field area to allow for drainage.

PERVIOUS CELLULAR CONCRETE USED AS A SUB-BASE AT CITIFIELD

The site of the new ball park is on organic clay. The original design called for 4' of lightweight aggregate. Cellular Concrete was proposed as a value engineering alternative.

ROSE COULEE BRIDGE
FARGO, ND

Standing water from flooding of Red River in Fargo, ND had deteriorated the bridge approach. Using pervious cellular concrete on the bridge approach allowed the flood waters to drain alleviating pooling and potential deterioration.

2,600 CUBIC YARDS OF 25PCF PERVIOUS CELLULAR CONCRETE

Pervious Cellular Concrete Advantages
- Reduced Settlement
- Increase Bearing Capacity
- Improve Seismic Stability
- Permeability of $1 \times 10^{-2}$ cm/sec
Observation of Permeability 24 hours after placement

**Permeability of Cellular Concrete**

**PCLWC Permeability / Infiltration**

**Void Factors of PCLWC**

**PCLWC Compressive Strength - UMKC**
**PENNRT RT. 30 SINKHOLE**
- Sinkhole remediation in the median
- Fast production
- Self-compacted and self-leveled
- Permeable solution

**GREEN ROOF ENVIRONMENTAL AND ECONOMIC BENEFITS**
- Reduces storm water runoff and filters pollutants; neutralizes acidity of acid rain
- Improves air quality and help offset carbon footprint
- Acts as a sound proofing 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

**PERVEROUS GREEN ROOF APPLICATIONS**

**GREEN ROOF ELEVATION CHANGES**
- Easily incorporates desired elevation changes in any green roof application
- Reduced labor costs
- Speed up construction schedule
- Economical

**WHAT CONCLUSIONS CAN WE DRAW ABOUT CELLULAR CONCRETE?**
- Broad Range of Densities
- Economical
- Versatile
- Easily Placed
- Rapid Installation
- Durable
- Permanent and Stable
- Environmentally Friendly

**QUESTIONS?**

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**Aerix Industries 303-903-4981**