About the Presenter

- **James Krstulovich** is the Engineer of Concrete & Soils for the Illinois Department of Transportation.
- He holds a Bachelor of Science degree in Civil Engineering from the University of Illinois at Urbana-Champaign and is a registered professional engineer in Illinois.
- His duties with the Department include researching emerging concrete and cementitious technologies, developing specifications, and implementing testing standards and procedures.
- Areas of professional interest include: mix design methodology, concrete durability, materials-related distress, research implementation, and specifications development, with an emphasis on performance-related criteria.

DEVELOPING SPECIFICATIONS FOR LIGHTWEIGHT CELLULAR CONCRETE

LESSONS LEARNED

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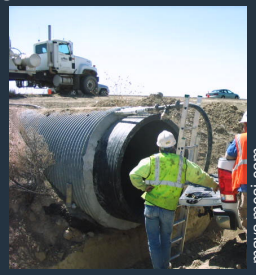
WHERE DID WE START?

SECTION 543 INSERTION LINING OF CULVERTS

- Relining existing culvert
- Constructing a bulkhead with conventional concrete
- Filling the annular space with grout or lightweight cellular concrete



mays-mcsi.com

'BASIC' SPECIFICATIONS

SECTION 1029, CELLULAR CONCRETE

- Cement, fly ash, water, fine aggregate, admixtures
- *Foaming agent*
- Batching and delivery equipment
- *Foam generator*
- *150 psi at 28 days (Article 543.03)*

cellularconcrete.com

'BASIC' SPECIFICATIONS

SECTION 1029, CELLULAR CONCRETE

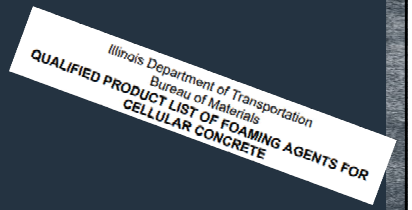
- *Foaming agent*
  - ASTM C869
- *Foam generator*
  - Calibrated daily
- *150 psi at 28 days*
  - ASTM C495
  - Four 3x6-in. cubes
  - Field curing box for 24-72 hrs at 60-80 °F

automaticcompressionmachines.com

QUALIFIED PRODUCT LIST

QPL FOR FOAMING AGENTS

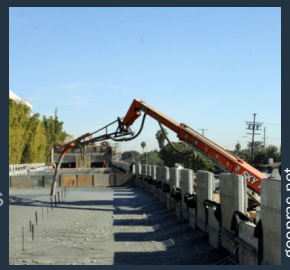
- *Product submittal requirements*
  - Specific product name
  - Independent lab test results complying with C869
  - Infrared spectrophotometer trace no more than 5 years old
  - SDS and Technical Datasheet



LIGHTWEIGHT CELLULAR CONCRETE FILL

STARTED TO SEE INCREASED USE OF CELLULAR CONCRETE FOR MSE WALL FILL

- *Contract special provisions provided by design consultants*
  - Inconsistency between contracts
  - Contradictions with established specs
  - Varying levels of detail and specificity



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LIGHTWEIGHT CELLULAR CONCRETE FILL

SOME EXAMPLES OF PROBLEM SPECS

- *Prohibiting supplementary cementitious materials*
- *Specifying density measurement but not referencing a standard*
- *Density and strength requirements based on ???*
- *How to cure and test strength specimens (e.g., cylinder size, test age, number of specimens per test)*
- *Freeze-thaw testing requirements (e.g., number of cycles)*
- *Ignoring current Department practices*

LIGHTWEIGHT CELLULAR CONCRETE FILL

WE REALIZED WE NEEDED TO STANDARDIZE THE DEPARTMENT'S APPROACH TO LCCF

- *Gathered District and contract special provisions*
- *Attempted to reconcile with ACI 523.1R,* Guide for Cast-in-Place Low-Density Cellular Concrete

LIGHTWEIGHT CELLULAR CONCRETE FILL

DEVELOPED NEW SPECIAL PROVISION IN 2016

- *Heavily based on ACI 523.1R*
- *Requires submittals from LCC manufacturer, including statement certifying installer, as well as foam generator and mobile site batch plant to be used*
- *Requires installation plan*
- *Requires trial batch for verifying mix proportions*

LIGHTWEIGHT CELLULAR CONCRETE FILL

NEW SPECIAL PROVISION (CONT'D)

- *Defined Classes of LCCF*

Table 1. CLASSES OF LIGHTWEIGHT CELLULAR CONCRETE

Class	Maximum Lift Height ft (m)	Maximum As-Cast Density lb/cu ft (kg/cu m)	Minimum Compressive Strength Psi (kPa) Days (Note 1) 7	28
I	4 (1.2)	30 ± 2 (481 ± 32)	30 (205)	40 (275)
II	4 (1.2)	36 ± 2 (577 ± 32)	60 (415)	80 (550)
III	2.5 (0.76)	42 ± 2 (673 ± 32)	90 (620)	120 (825)
IV	2.5 (0.76)	50 ± 2 (801 ± 32)	115 (795)	150 (1035)

LIGHTWEIGHT CELLULAR CONCRETE FILL

NEW SPECIAL PROVISION (CONT'D)

- *Included provisions for curing*
- *Added testing frequency for QC and QA*

Test Parameter	Acceptable Limits of Precision
Compressive Strength	5 psi (34.5 kPa)
Density	1 lb/cu ft (16 kg/cu m)

LESSONS LEARNED

EXPERIENCED AND PERCEPTIVE PRACTITIONERS MAY HAVE ALREADY CAUGHT SOME POSSIBLE PROBLEMS WITH OUR NEW SPECIAL PROVISION…

LESSONS LEARNED

STRENGTH TESTING

- *Our new special provision specifies 7- and 28-day tests (or 14- and 56-day tests when using fly ash)*
- *However, ASTM C495 is written exclusively around a 28-day test*
  - When to remove from mold and/or moist curing?
    - From 6.6 Curing: "If cellular concrete made using preformed foam is being tested, moist cure the cylinders from day 2 to day 25. At day 25 air dry the cylinders for 3 days at a temperature of 21 ± 6 ºC [70 ± 10 ºF] and a relative humidity of 50 ± 10 %."

LESSONS LEARNED

STRENGTH SPECIMEN CURING

- *Adjustments to accommodate 7- or 14-day tests*
  - Specimens remain sealed in molds until 24 hrs prior to testing
  - First 24 hrs, cure at 70 ± 10 °F
  - Thereafter until 24 hrs prior to testing, cure at 73.5 ± 3.5 °F
  - Final 24 hrs, air dry at 70 ± 10 °F, relative humidity 50 ± 10%
    - Also experimented with fan drying for final 24 hrs

LESSONS LEARNED

STRENGTH TESTING

- *Rate of loading?*
  - From 7.2 Rate of Loading: "Continuously apply the load without shock at a constant rate such that the maximum load will be reached in 65 ± 15 s."
  - First, assume rate based on minimum required strength?
  - Then, trial and error? *Means making sacrificial cylinders (already making 4 per test)…*

LESSONS LEARNED

STRENGTH TESTING

- *Comparing test results?*

Test Parameter	Acceptable Limits of Precision
Compressive Strength	5 psi (34.5 kPa)
Density	1 lb/cu ft (16 kg/cu m)

- Inter-laboratory precision within 5 psi?
  - *C495 allows 83 psi between two laboratories*

LESSONS LEARNED

MOVING FORWARD

- *Provide foam generator/mobile site batch plant calibration guidance in Department training manuals*
- *Remove 7- and 14-day strength requirements*
- *Look at placement curing requirement (minimum sq.ft. exposed?)*
- *Revise strength comparison limit per C495 precision statement*
- *Expand use of cellular concrete to CLSM applications, particularly where pumping is a concern*

QUESTIONS?

EMAIL ME FOR A COPY OF OUR SPECIFICATIONS

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