# Library Lane Underground Parking Facility Ann Arbor, MI -2012

**Presented by:**
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**Euclid Chemical Co.**

# The Library Lane Project was a featured article ‘The Challenges of Design and Constructibility’ in October 2012 Concrete International Magazine

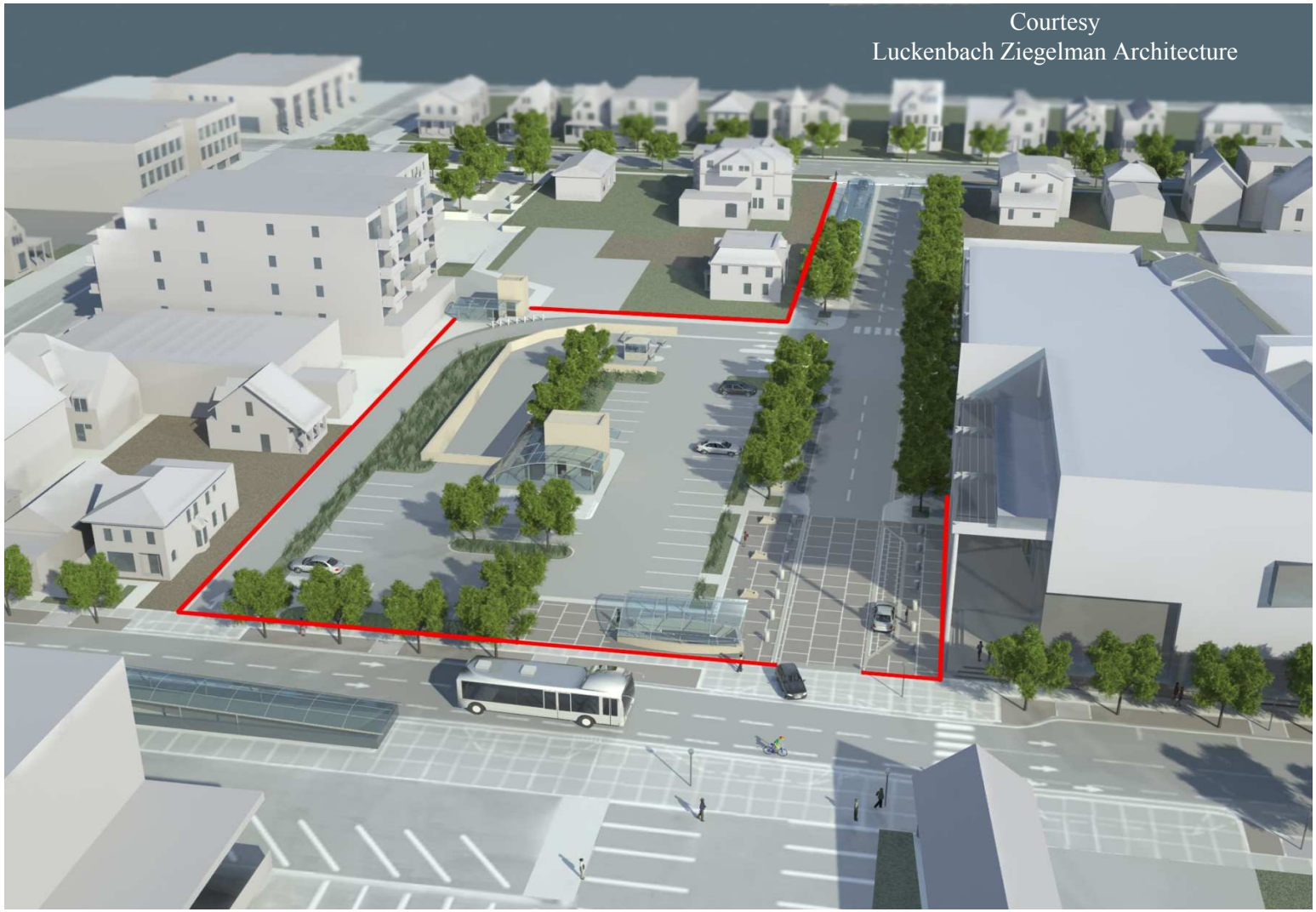
## A Special Thanks to the 'TEAM'

**Carl Walker, Inc Kalamazoo, MI**
**The Christman Co. Lansing, MI**
**Christman Constructors, Inc Lansing, MI**
**The Doan Companies Ann Arbor, MI**

# Project Overview

- Approximately 55,000 yards of concrete used to construct the facility
- A blend of engineered high performance concrete admixtures were used to produce a high strength, low shrinkage, mix design
- Over ten million pounds of reinforcing steel of various gauges utilized
- More than 100,000 tons of site sand and gravel were excavated from the site

# Ground Level Rendering



# Project Photo

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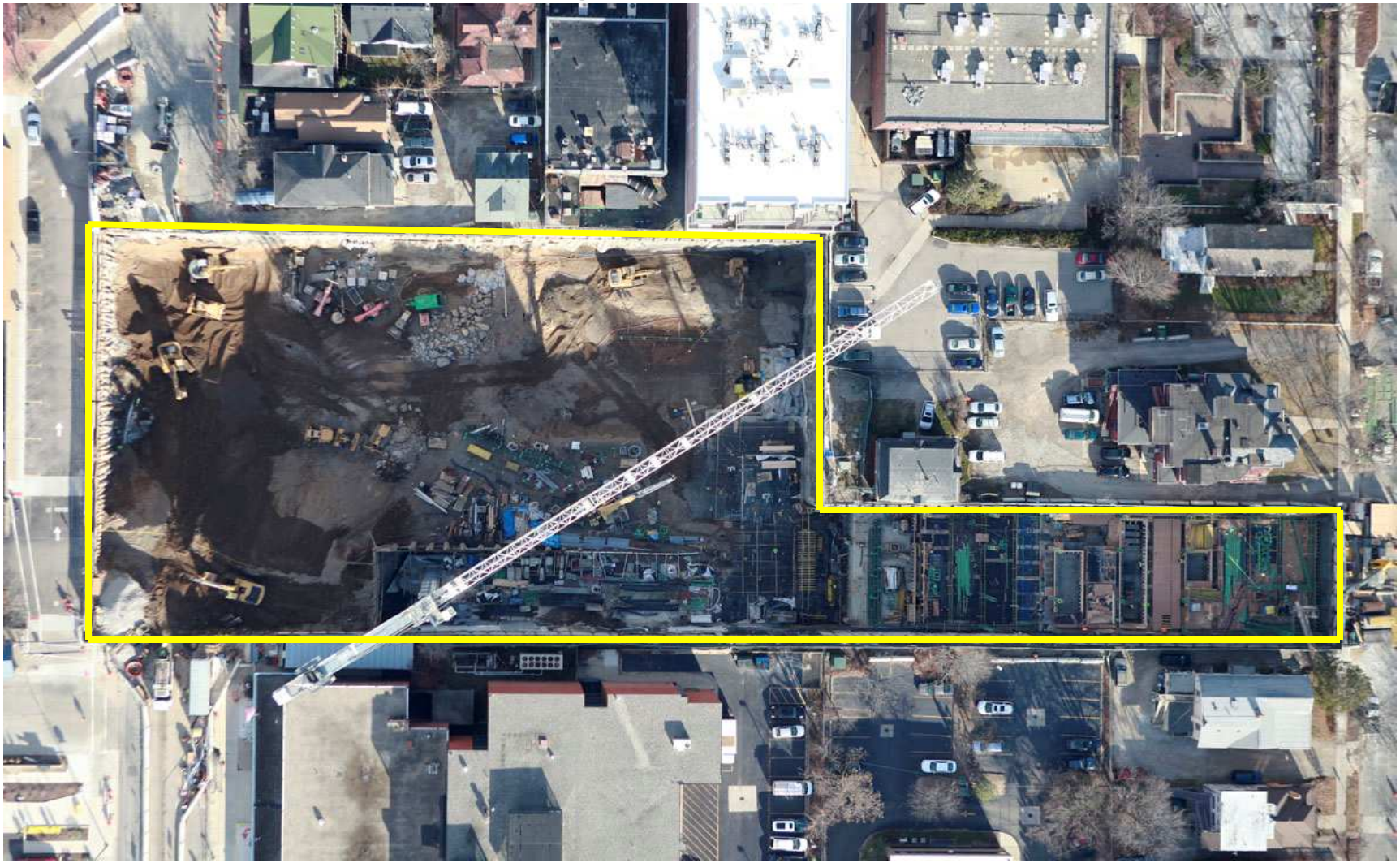


**DESIGNERS and ENGINEERS NEEDS and the NEEDS of the CONCRETE CONTRACTOR DON'T ALWAYS COINCIDE!**

**In the article I posed the question:**

# Can a perfect mix be designed and produced to satisfy both the DESIGNER and CONTRACTOR?

# ‘CHALLLENGES OF DESIGN AND CONSTRUCTIBILITY’

Or should I say

# DESIGN vs. CONSTRUCTIBILITY

# Two Main Mix Design Challenges

- **5500psi Mass Concrete ranging from 6’-16’ thick**
- **6000psi Post Tensioned (PT) air entrained concrete**

# MASS CONCRETE

- **Original specification called for a maximum 70°F concrete temperature at time of placement.**
- **Instead of focusing on the beginning concrete temperature, the TEAM agreed that the maximum internal temperature and the ΔT between the inner and outer concrete temperature of the mass placements, were the important factors.**

## Mass Concrete Continued

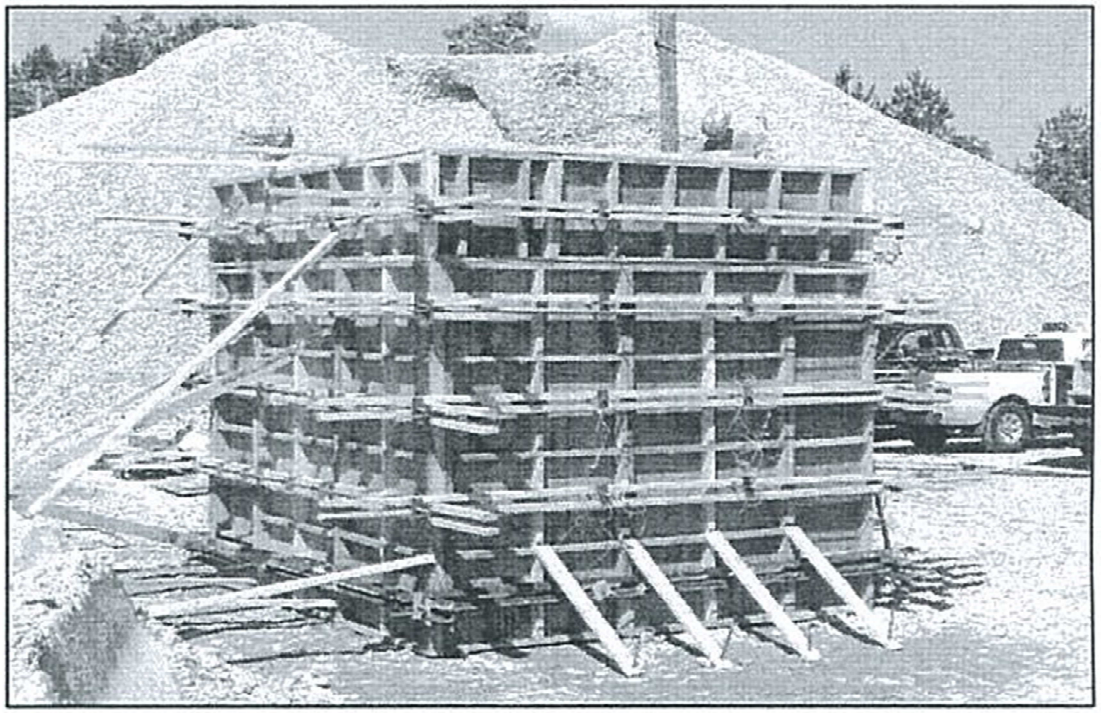
- **Maximum ultimate internal temperature 160°F**
- **Maximum ΔT of 35°F between internal temperature and 1” below the surface of the Mass placements.**

# Mass Concrete Mix Design

- 517# Total Cementitious
- 258 Type I Cement
- 129# Slag Cement
- 130# Type C Flyash
- Mid Range WR 6oz/cwt
- W/C=.49

- Calculated Adiabatic Temp Rise 67°F

# Pre-Job Mock Ups Were Required



CONCRETE MOCK-UP
Doan Companies - 10’x10’x10’
Dimensions that Included Thermal Couples

# Concrete Temperature Requirements

Majority of the Mat placements wound up taking place in cold weather.

There was a requirement to maintain concrete temperatures above 40 degrees F

Maintaining the $\Delta T$ of 35° became the main concern. After the concrete was finished, 2” rigid insulation was placed on the surface of the exposed concrete with insulated blankets on top the rigid insulation.

# 36 Hour Placement – 5700 Cubic Yards ! !

- Two Concrete Plants and two Concrete Pumps
- Thirty Five Trucks.
- Start Time:  5:00 AM Saturday February 26th.
- Completed Time: 5:00 PM, Sunday February 27th.
- At 6:00 PM We Went to One Plant & Fifteen Trucks using Crosstown Competitor Drivers Due to Hours of Services.
- At Twenty Four Hours 4040 Cubic Yards Had Shipped.
- Resumed Activity on Sunday using Two Plants & Thirty Trucks.
- By Sunday, 10:00 AM We Only Needed One Plant for Completion.


In certain areas the concrete measured 16 feet in thickness
Spider Boom Placement Equipment
Thermo-couples monitored concrete temperatures
02/27/2011

Prep work preceeded a 5700 yard placement.
Concrete was placed with two pumps in a 36 hour time frame with
Ann Arbor urban congestion.

# DESIGNERS NEEDS for the PT Slabs

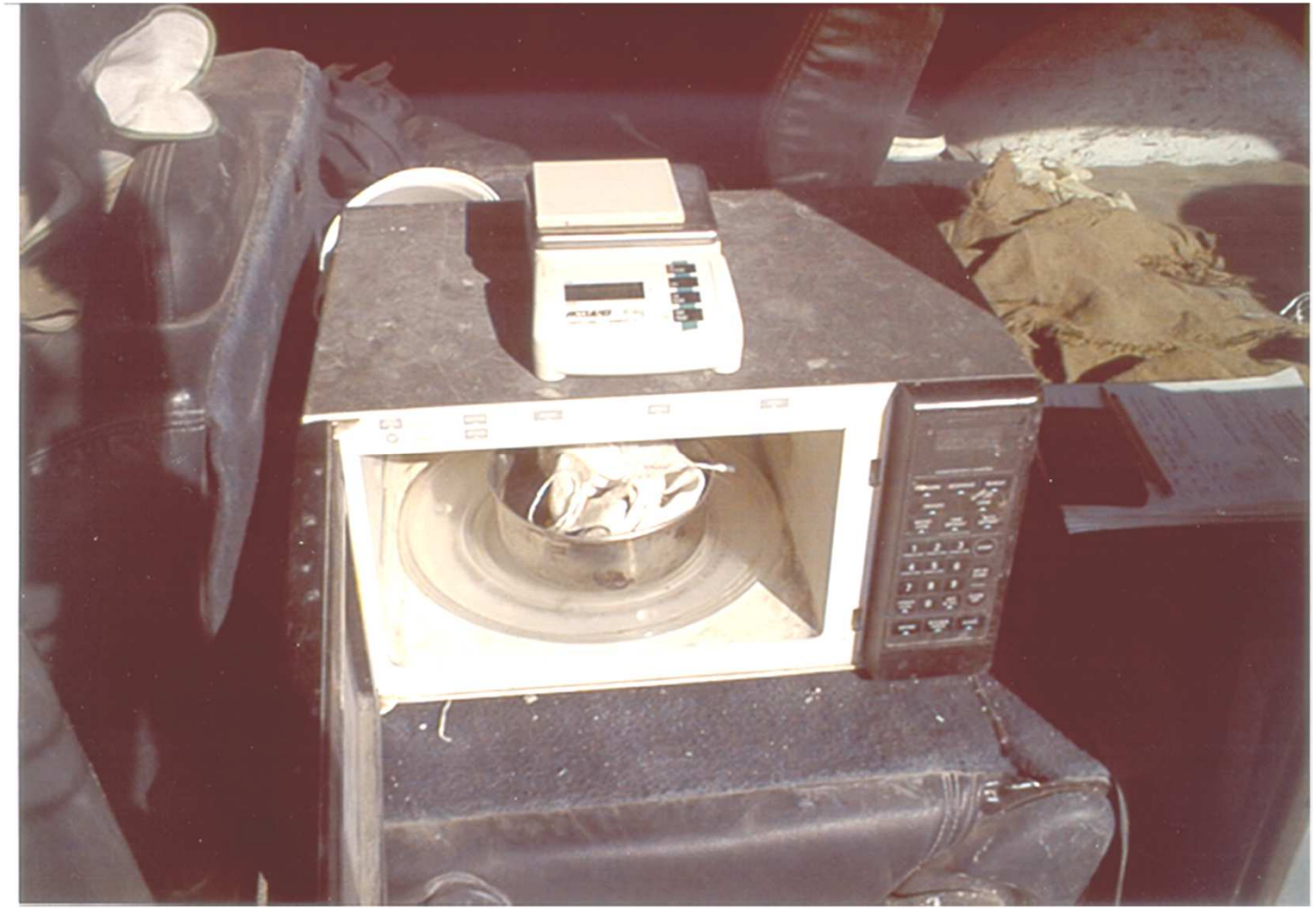
- 6000psi air entrained concrete (6.5”%±1.5”)
- w/c=.40
- Maximum shrinkage .036 @ 28 days
- Water soluble Chlorides .06% for PT concrete decks
- 4.5 gallons of Corrosion Inhibitor (30% Calcium Nitrite)
- Lots of TESTING

**Lots of Testing:**

**Air Checks on every load.**

**Microwave testing cylinders every 50 to 100 yards**

# Microwave Field Test  Photo



# Concrete Contractors Needs

- Constant flow of concrete
- The concrete had to be pumpable (600’)
- Consistent air content and slump
- Excellent consolidation properties
- Easily placed and broom finished.
- Predictable setting times
- The mix had to perform in hot and cold weather
- Rapid strength gain for post tensioning

# The Challenges

- To meet all of Carl Walkers specifications and develop a mix that acted like 70°F concrete placed on a beautiful 70°F day that would be user friendly to the contractor.
- Typically a W/C=.40 would dictate the use of a High Range Water Reducer. Perfect for lowering the W/C, but errattic setting could be devastating to the contractor.
- Calcium Nitrite based Corrosion Inhibitors are excellent for corrosion protection. They are also known for their accelerating capabilities in concrete.  This mix had 4.5gal/yd
- The mix was air entrained. The engineer is a real stickler, for obvious reasons, about the air.

# The Solutions

- First we determined how much (how little) cementitious material we would need to meet the 6000psi requirement, and also to meet the contractors desire to post tension in 24-48 hours
- After analyzing the impact each of the ingredients would have on the mix, and after numerous trial batches we determined which combination of water reducing admixtures would satisfy the W/C, shrinkage requirement, and make the concrete set like 70°F on a 70°F day

# PT Slab Mix Design

- 641# total cementitious.  60% Type I Cement, 15% Slag cement, and 25% Type C Flyash
- 1825# 1” Limestone, 1192# Concrete Sand
- 4.5gal of Corrosion Inhibitor (30% Calcium Nitrite
- 223# of Water (26.8gal)
- 6oz/cwt of a Hybrid Mid Range WR
- 5oz/cwt of a traditional lignin based WR
- 1oz/cwt airentrainment

- This combination of admixtures gave us approximately 20% water reduction
- This combination of admixtures and supplemental cementitious materials allowed us to overcome the acceleration from the 4.5 gal ofcorrosion inhibitor.

# Final PT Deck Mockup Photo

# Concrete Strengths Report- Three Trial Mixes
# Beams, Stairs, Slabs

## 28-Day (Actual Values)

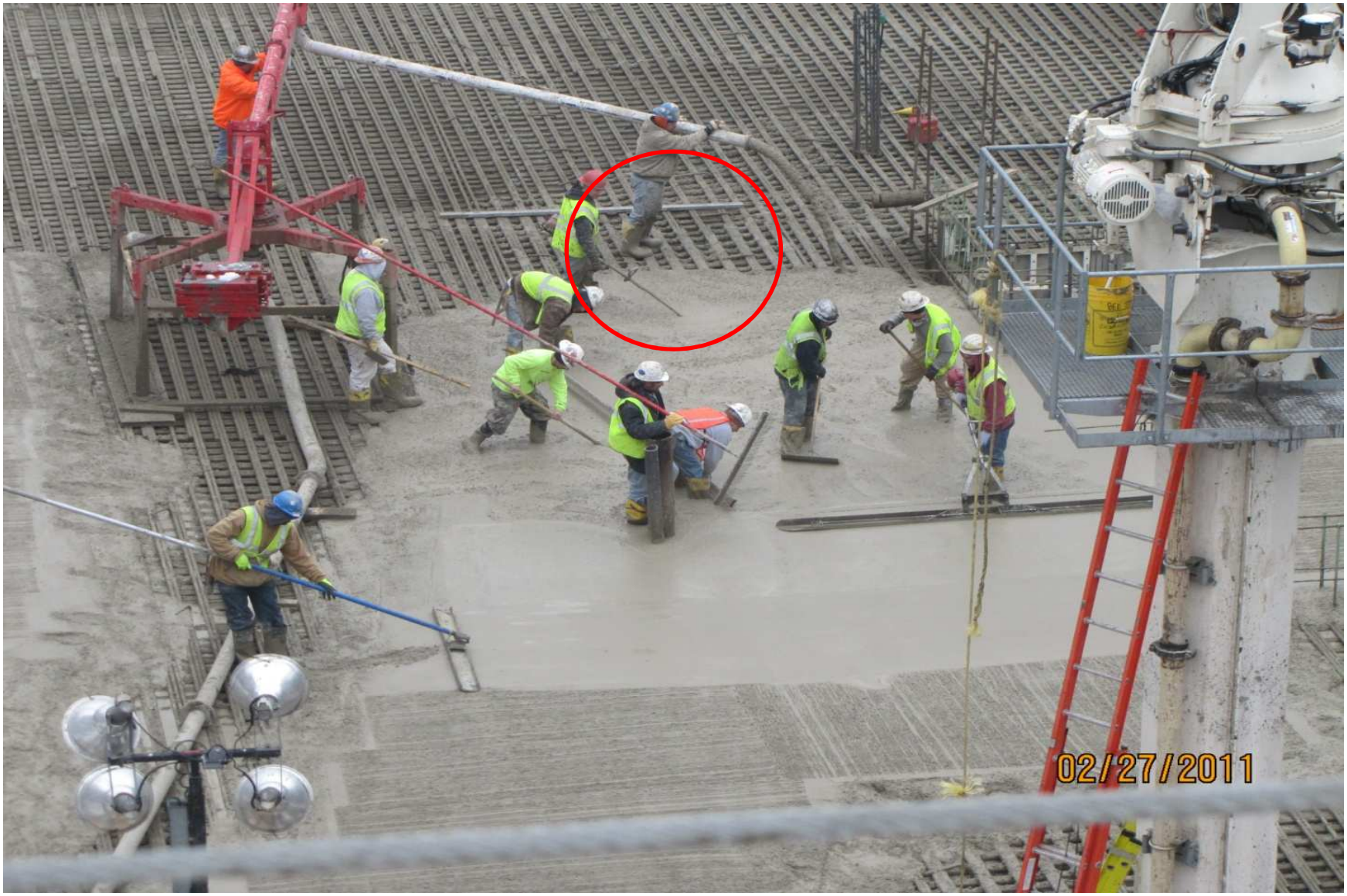
| | Mix 1 | Mix 2 | Mix 3 |
|---|---|---|---|
| **Cylinder 1** | 8625 | 8074 | 8378 |
| **Cylinder 2** | 8351 | 8521 | 7788 |
| **AVG.** | 8488 | 8298 | 8083 |

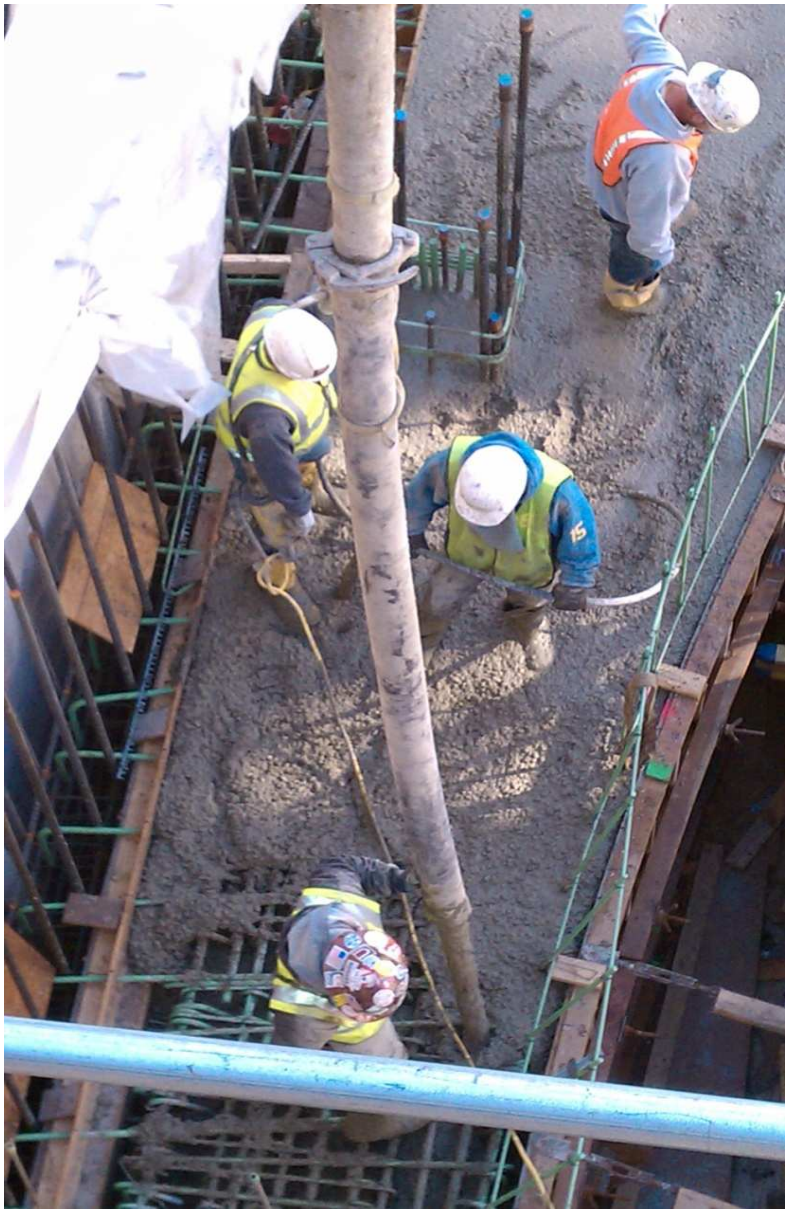
# Beams, Stairs, Slabs

ASTM C 157 Shrinkage in (%) (Actual Values)

| Days cured | Average of 3 samples |
|---|---|
| 7-day | -0.012% |
| 14-day | -0.023% |
| 21-day | -0.026% |
| 28-day | -0.031% |

# Flowable mix pumped through a 600 foot system





This photo highlights the flowable mix design

Low Shrinkage, high volume coarse aggregate had to be pumped 600 feet. The specified concrete admixtures created a very pumpable & workable mix design.

A typical deck pour

# Major factors for success with the project included:

- Significant pre-planning implemented by the admixture producer and the ready mix supplier with (1) Mix Design Testing (2) Specification Clarification & (3) Physical Property Evaluations.
- ***The Goal*:** Create a mix design to optimize performance in both cold weather & hot weather conditions to ***satisfy both the engineer & concrete contractor***

# Doug Peters, V.P. Operations
# Christman Constructors Testimonial

"Christman Constructors could not have been more pleased with the deck mix at the Ann Arbor, MI 5th Avenue Parking Facility. The Doan Company Mix performed as designed under all conditions. We pumped, placed and finished the mix as planned every time. The time-to-strength for PT stressing operations was 30-36 hours on schedule. We had no problems with hardened properties throughout the project. The air content, shrinkage values, and compressive strengths met the specifications throughout the job. This mix design performed better than any previous PT mix."

CHRISTMAN
SINCE 1894

# The Library Lane Story

In the end the project was a significant undertaking & the formula for success was as follows:

***Teamwork + Attention to detail + Pre-planning + Project coordination = Success***

**Can a perfect mix be designed and produced to satisfy both the DESIGNER and CONTRACTOR?**

**Because of the performance of the concrete on the Library Lane Underground Parking project, I can say a resounding ‘YES”.**

# Thank You!

# Questions?

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