An Application of VCCTL in the Ready-Mixed Concrete Industry

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Overview

- Background
- Real World Problem
- Expedited Solution Needed
- Advantages / Disadvantages
- Summary
- Questions
Background

- Jon Belkowitz, M Sc

- Concrete Enthusiast

- Connecting Nano and Micro to “Real World”
VCCTL Walkthrough
VCCTL Walkthrough

- Microstructure Development
- Growth from parent compound to hydrated product
  - Thermal Analysis
  - Hydrated Microstructure
- Bridging of hydrated product and aggregate
- Finite Element Analysis
  - Mechanical Properties
Real World Problem

How does Water impact Concrete?

\[ f'c = \frac{K_1}{K_2 w/c} \]

Green B. (2011) – Concrete from around the World
Real World Problem

How does Water impact Concrete?

Real World Problem (2005 – West US RMX Supplier)

1. Concrete Field Samples were NOT meeting designs strengths
2. RMX Supplier was losing $10,000s per day - Retaining Walls, Foundation and Core Walls be ripped out and replaced
3. Investigation of Plant yields NO CAUSE for Low Strengths
Real World Problem
How does Water impact Concrete?

Real World Problem (2005 – West US RMX Supplier)

4. RMX Truck Drivers had been told NOT to leave the Yard until their RMX Truck were SHINING

5. Quality Control stake-out revealed RMX Drivers spent an average of 10 – 12 minutes cleaning their Drums Fins
Real World Problem

How does Water impact Concrete?

Normally:
1. Concrete is checked for Quality BEFORE RMX Truck are cleaned
2. Empty RMX Truck has approximately 1 wheel barrow full of water left over
3. **Open Hose Jet for 60 seconds ~ 80 lbs of Water**
### Increase in Water/Cement in 10 Minutes

**Assuming 10 cubic Yards of Concrete in Truck**

<table>
<thead>
<tr>
<th>Material</th>
<th>Starting Batch Wt (lb/cy)</th>
<th>After 1 min of Cleaning (lb/cy)</th>
<th>After 5 min (lb/cy)</th>
<th>After 10 min (lb/cy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I/II Cement</td>
<td>560</td>
<td>560</td>
<td>560</td>
<td>560</td>
</tr>
<tr>
<td>67/57 Rock</td>
<td>1530</td>
<td>1530</td>
<td>1530</td>
<td>1530</td>
</tr>
<tr>
<td>Concrete Sand</td>
<td>1570</td>
<td>1570</td>
<td>1570</td>
<td>1570</td>
</tr>
<tr>
<td>Water</td>
<td>252</td>
<td>260</td>
<td>292</td>
<td>332</td>
</tr>
<tr>
<td>w/c</td>
<td>0.45</td>
<td>0.47</td>
<td>0.52</td>
<td>0.60</td>
</tr>
<tr>
<td>Extra Water from Cleaning Truck (lb/truck)</td>
<td>---</td>
<td>80</td>
<td>400</td>
<td>800</td>
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**PROBLEM!!!**
VCCTL Saves the Day!

1. Cause of Problem Validate at 10 AM, Monday
2. Solution Needed to Developed and Delivered by 7 AM, Tuesday
3. All Non-Critical Job-Sites on HOLD
4. Emergency Conference for RMX Drivers developed in 21 hours
5. VCCTL developed RESULTS on 3 Mixes in 4 Hours

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VCCTL Results – Concrete Compressive Strengths

Part of the RMX Truck Driver Training
VCCTL Results – Concrete Compressive Strengths

Part of the RMX Truck Driver Training

- 4500 psi required at 28 Days
- 2500 psi acquired at 28 Days

Diagram showing the compressive strength over cure time for different w/c ratios.
Advantages of Modeling and Simulation

- Concrete Design Mixture (1.0 – 3.0 cf)
  - Technician Time @ $54 / Hour
  - Batching, Mixing, Casting, Breaking
  - Compressive Breaks: 24 Hr, 7 Day, 14 D and 28 D

- Experimentation Scenarios
  - 1 Laboratory Concrete Mixture = 10 hours @ $540
  - 3 Laboratory Concrete Mixtures = 30 hours @ $1620
  - Total Time to reach results in Laboratory ~ 35 Days
Advantages of Modeling and Simulation

1. Save Time
2. Save Money
3. Run Multiple Projects at the Same Time
4. Eliminate Human Error associated with:
   1. Mixing, Casting, Curing, Breaking
5. Can be run anywhere – no need for a Laboratory

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Disadvantages of Modeling and Simulation

1. Approximate Results
   1. Uncertainty can be reduced

2. Does not take into account swings in materials
   1. Unless a test is specifically run taking analyzing materials changes

3. Nothing will ever replace making and breaking concrete samples
   1. Laboratory Trials = Scale MODELS

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Possible VCCTL Scenarios

• Change Mixture Constituents
  – Cement Change Ramifications
  – Aggregate Type / Gradation
    • Aggregate Change due to pit closure
    • Aggregate Blends to optimize mixture
  – Secondary Cementitious and Pozzolanic Additions
    • Performance Based Concrete for:
      – Increased Strengths
      – Increase Durability
Summary

• A Real World Problem
• VCCTL Helped out the Concrete Industry
• Retrospect – Time and Cost Savings
• Problem Solved – VCCTL Saves the Day
• Advantages and Disadvantages
QUESTIONS?
References

- Garbozci, E and Bentz, D. Multiscale Picture of Concrete and its Transport Properties. NIST. 1996.