

BRAUN
INTERTEC

the science you build on

Trial Batching Fun in a Drum

Alf Gardiner, PE
Director / Principal Engineer

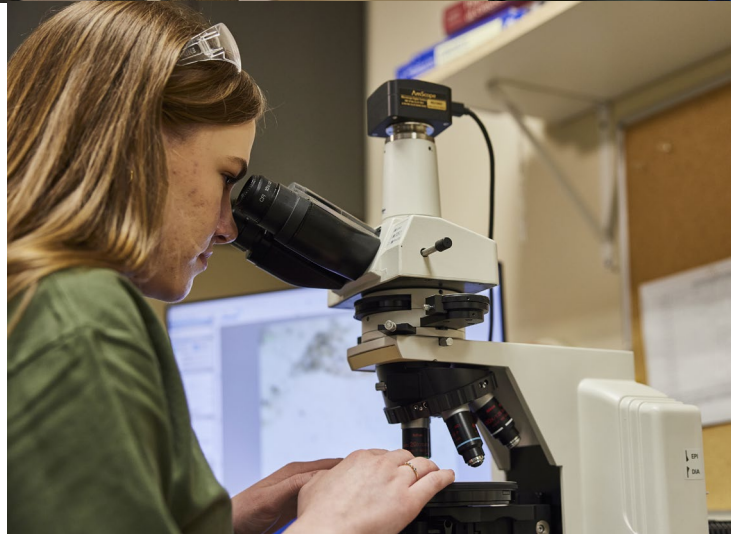
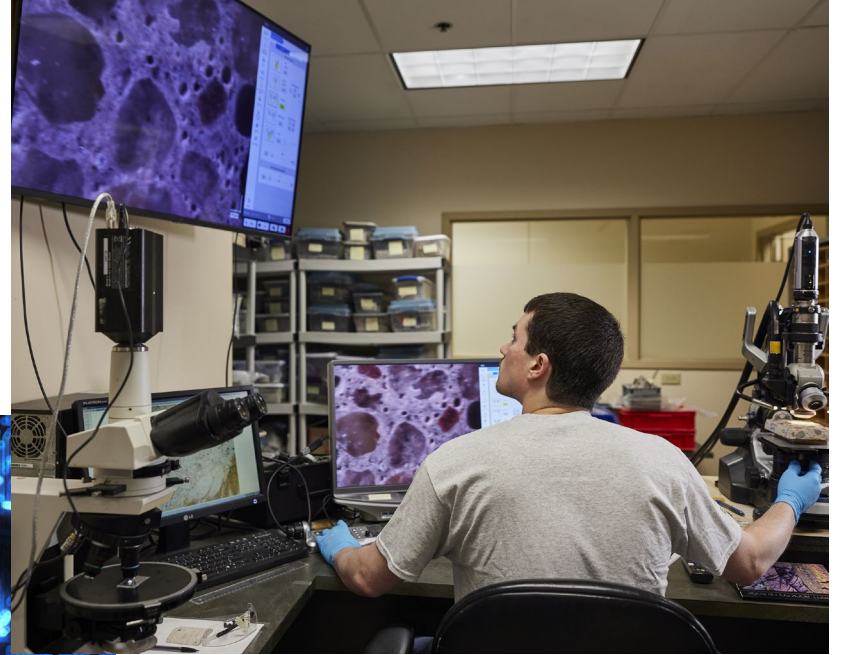
Labcrete



Realcrete



Researchcrete



Trial Batching



BRAUN INTERTEC

the science you build on

Trail Batching in the Field

- Less Controlled but closer to reality.
- Different mixing.
- Different accuracy



Why Trial Batching?

- ▶ Meet design requirement of a specification
- ▶ Verify a proposed mix design
- ▶ **Evaluate Materials – New or old and any changes**
- ▶ **Reduce Risk of Failure**
- ▶ Chase issues – develop a testing matrix

Trial Batching

- ▶ ACI – A batch of concrete prepared to establish acceptable proportions of the constituents.
 - Cementitious
 - Aggregates
 - Water
 - Admixture
 - Fibers
- ▶ Measuring
 - Slump
 - Air Content
 - Unit Weight
 - Temperature
 - Strength



Performance

- ▶ More complicated issues need to be evaluated
 - Workability
 - Finishability
 - Placability
 - Pumpability
 - Durability
 - Anti-washout (underwater concrete)
 - Box Test or V-Kelly
 - Pot life



Understand Placement Requirements

- ▶ Slip Form Paving
- ▶ Hand placement
- ▶ Pumping
- ▶ Finishing
 - Troweled
 - Broomed
 - Architectured
- ▶ Curing procedures

Understand In-place Performance

- ▶ Freeze/Thaw Exposure
- ▶ Corrosion
- ▶ Sulfate Resistance
- ▶ Abrasion Resistance
- ▶ Construction Timeline



Trial Placement



Graco Anoka Expansion

- ▶ 190,000 sq feet of warehouse slab addition
- ▶ Owner – Graco
- ▶ Contractor – Mortenson
- ▶ Engineer of Record – HGA
- ▶ Concrete Supplier – Cemstone
- ▶ Slab Design and Consulting – Braun Intertec
- ▶ The Story



Test Placements



Curing is Key

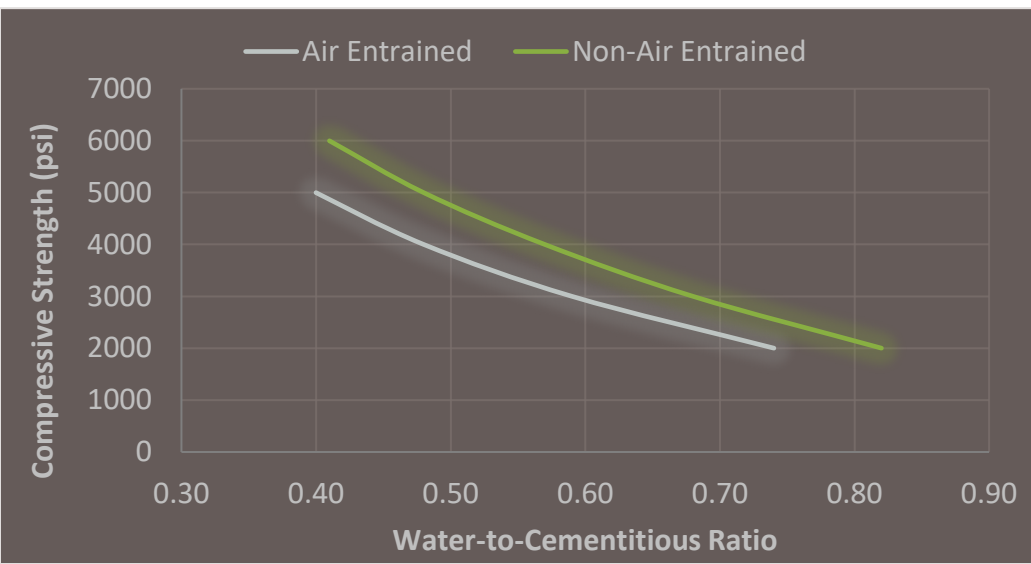
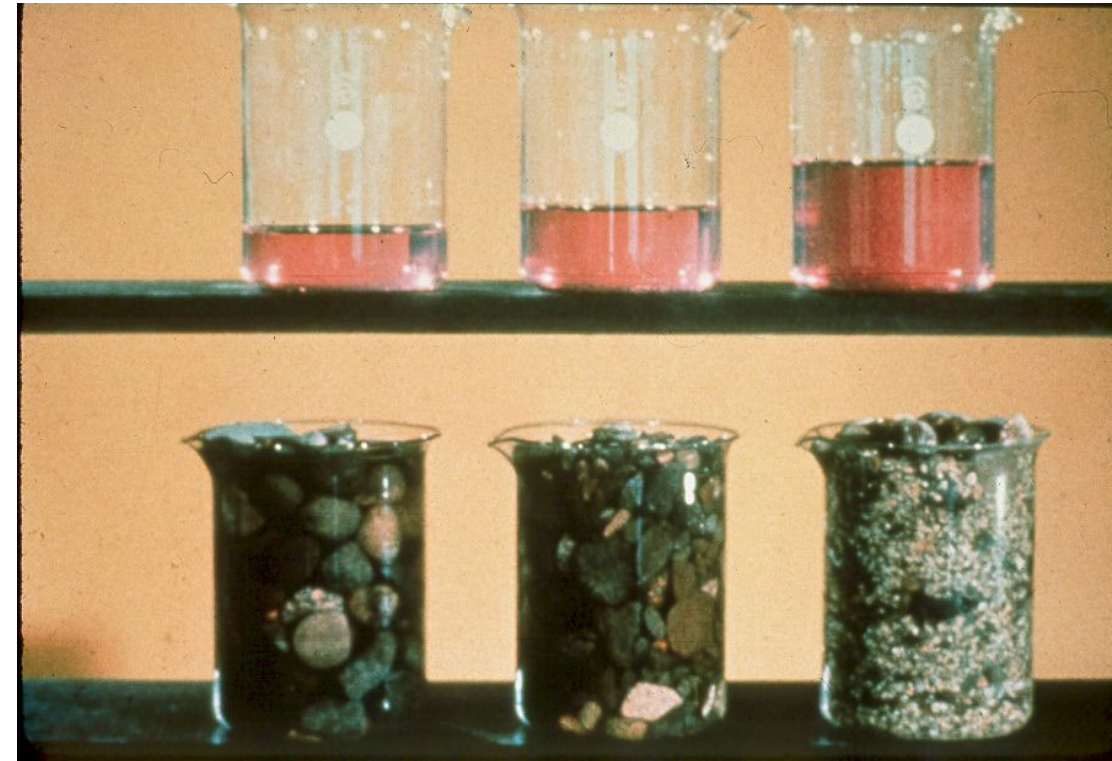
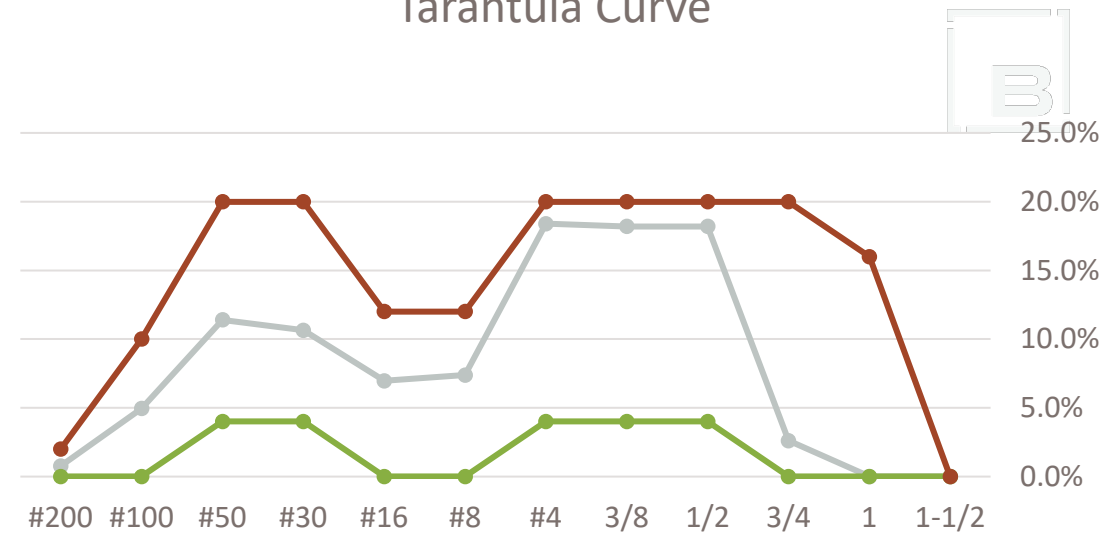


Back to Basics

- ▶ Sound Dependable Concrete Practices
- ▶ Permeability
- ▶ Strength
- ▶ Workability

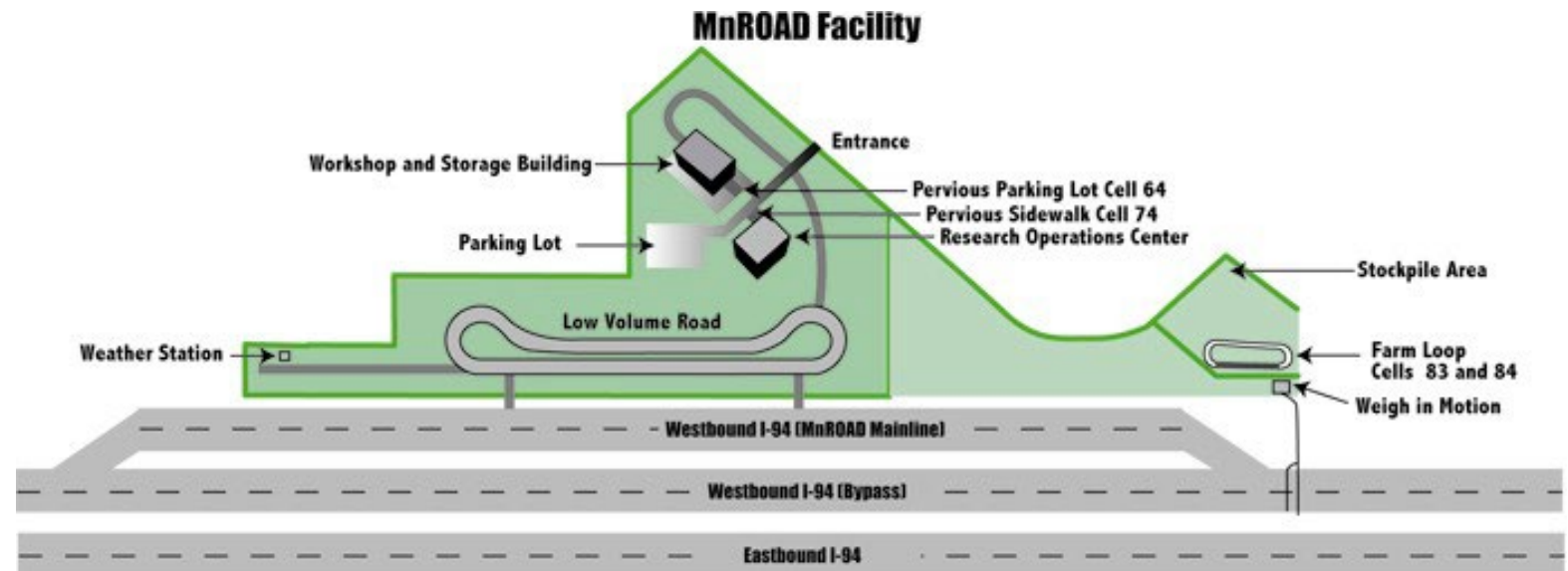


Tarantula Curve



MnRoad Low Carbon Paving 2022 and 2024

- ▶ 3.5 mile of I-94 operated by **MnDOT**
- ▶ Partnership with the **National Road Research Alliance (NRRRA)**
- ▶ 11 states, 50 industries, associations, and academia
- ▶ Designed to test new technologies in a real-world environment



2022 Material Suppliers

- ▶ Ultra High Materials – zero portland cement
- ▶ Carbon Cure – additive
- ▶ Carbon Upcycling – Processed ash
- ▶ Ash Grove – IP
- ▶ Urban Mining – Ground Glass
- ▶ Terra CO2 – Manufactured SCM
- ▶ Optimized Concrete Mixture
- ▶ Burgess Pigment – Metakaolin
- ▶ 3M – Natural Pozzolan
- ▶ Hess Pumice – Natural Pozzolan
- ▶ Continental Cement – 20% limestone

2024 Material Suppliers

- ▶ Ozinga – C1157 Cement
- ▶ C-Crete – C1157 – zero portland
- ▶ CEM Innovations – Microspheres
- ▶ Ashgrove – LC3
- ▶ Ternary Blend
- ▶ Optimized Concrete Mixture
- ▶ Amrize – Quaternary Mix

Braun Intertec's Part

- ▶ Prepare Concrete Mixtures for Paving
 - 5 to 8 percent air content
 - 500 psi flexural strength
 - Optimum workability to facilitate slipform placement
 - Maintains plastic state for at least 45 minutes

- ▶ Finding the Balance!

Control mixture

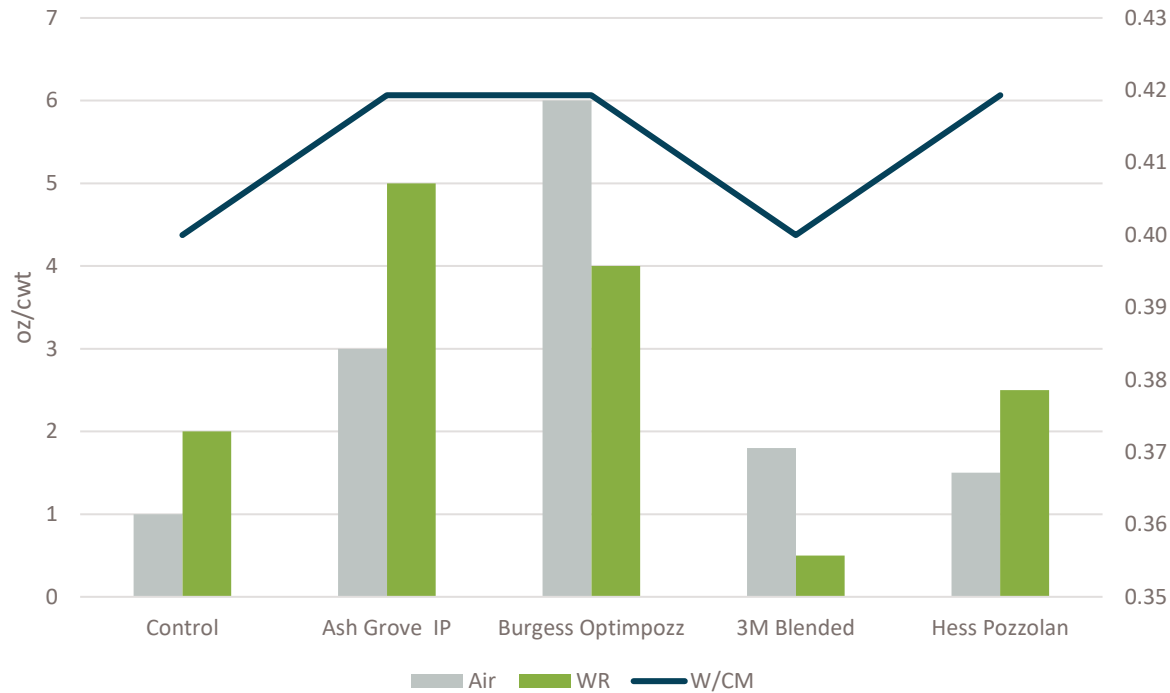
- ▶ Total Cementitious – 570 lb/yd³
 - 30% Ash
- ▶ 0.40 w/c ratio
- ▶ Four aggregate mix for well grading mixture
- ▶ 28-day compressive strength 4,300 psi
- ▶ 28-day flexural strength 565 psi
- ▶ Time of set – 4 hours 25 min
- ▶ Slump 2.75
- ▶ Air content 6.0%

Breaking Down the Testing

- ▶ Mixtures with Natural Pozzolans
- ▶ Mixtures with New SCM's
- ▶ Mixtures with less than 20% Portland Cement

2022 Natural Pozzolans

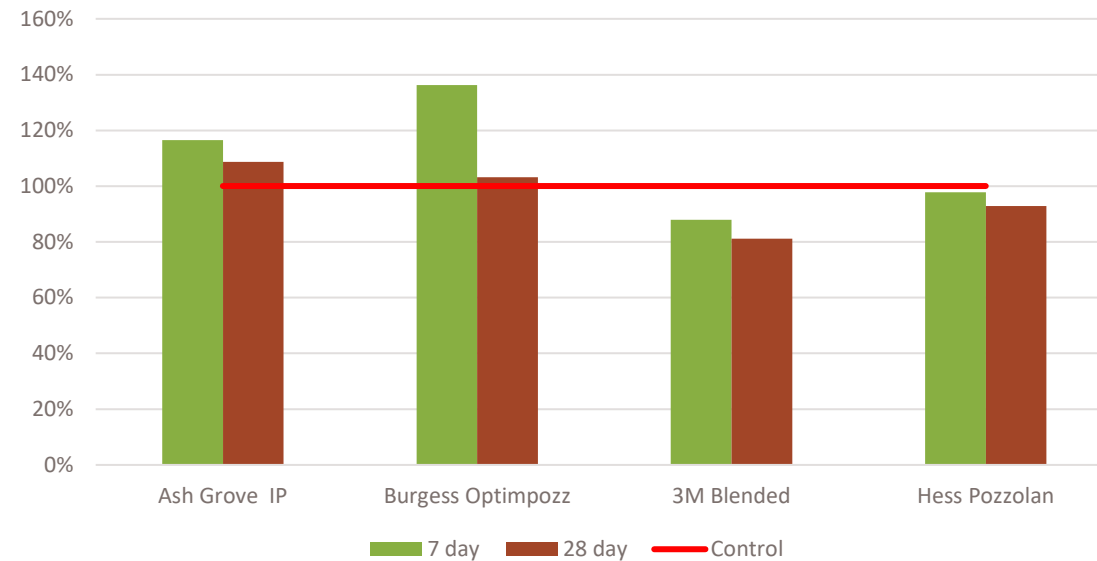
2022 Admixture Dosage



2022 Compressive Strength



2022 Flexural Strength



IP(30) - Ashgrove



Pictures from MnRoad Research Reports.

24% Ash/ 12% Natural Pozzolan - Optipozz



Pictures from MnRoad Research Reports.

30% 3M blend of NP and Ash



Pictures from MnRoad Research Reports.

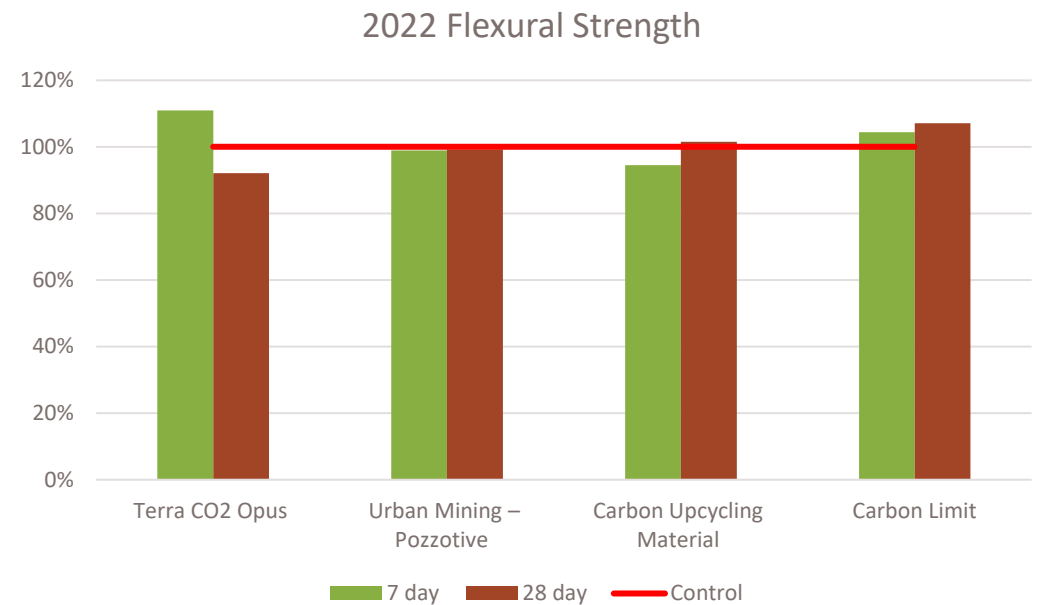
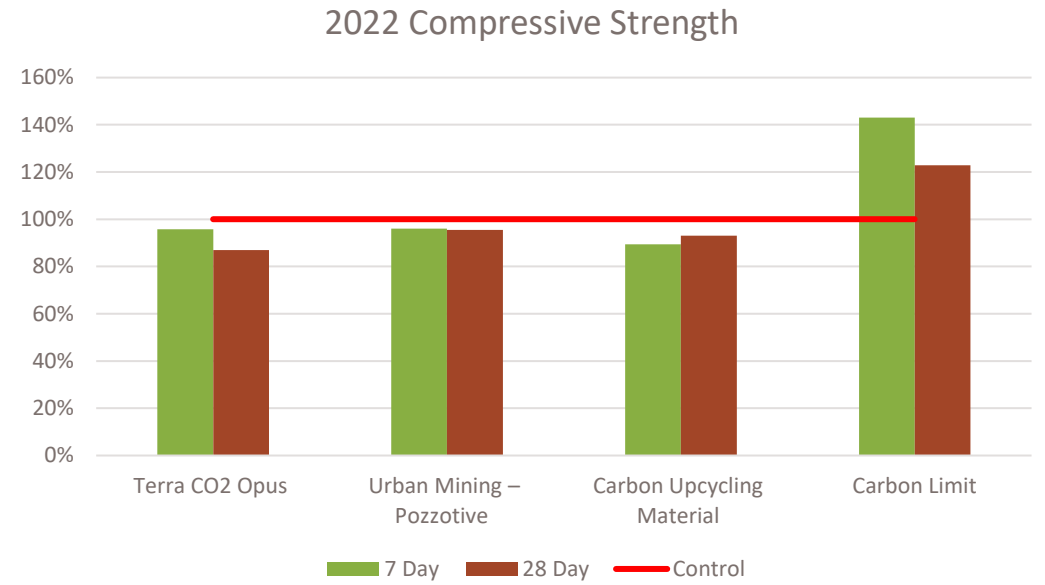
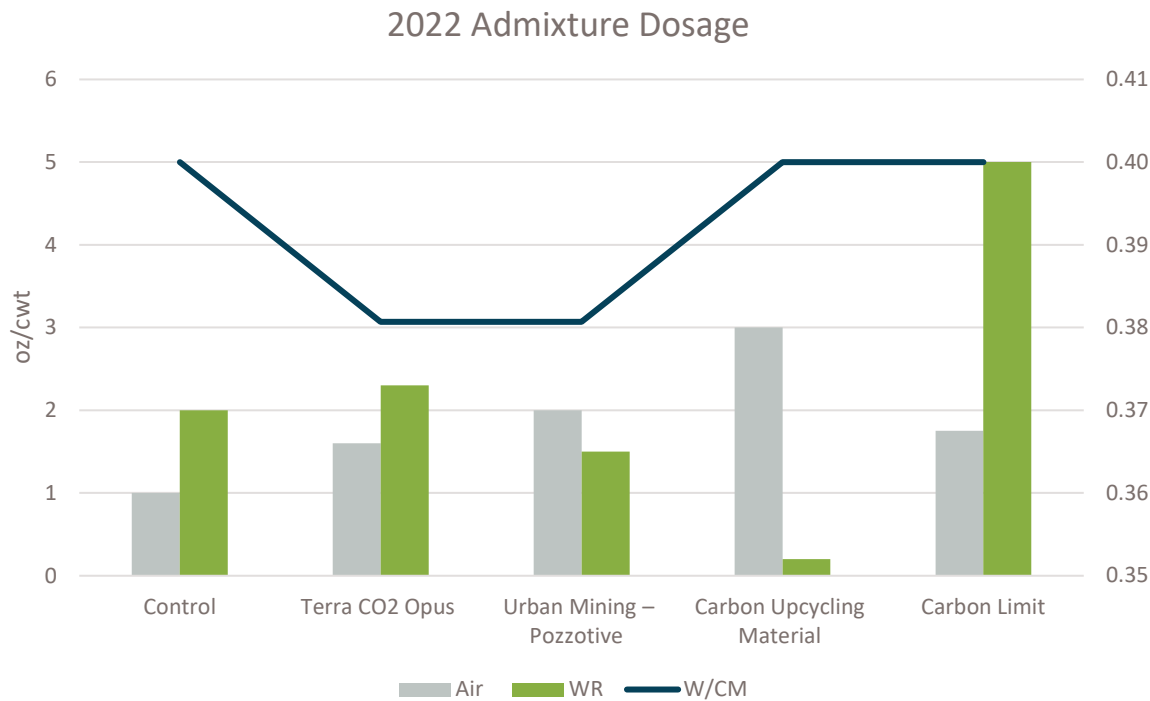
30% NP - Pumice



Pictures from MnRoad Research Reports.



2022 Alternative SCM's



Manufactured Ash – Terra CO2



(a)



(b)

Pictures from MnRoad Research Reports.

Ground Glass



Pictures from MnRoad Research Reports.

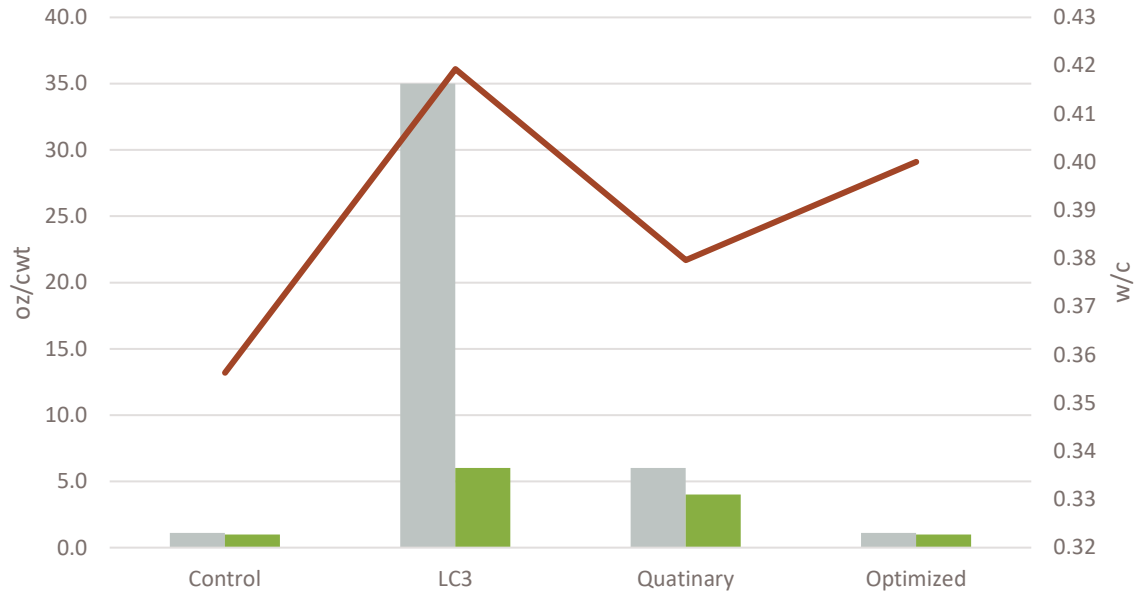
Carbon Limit



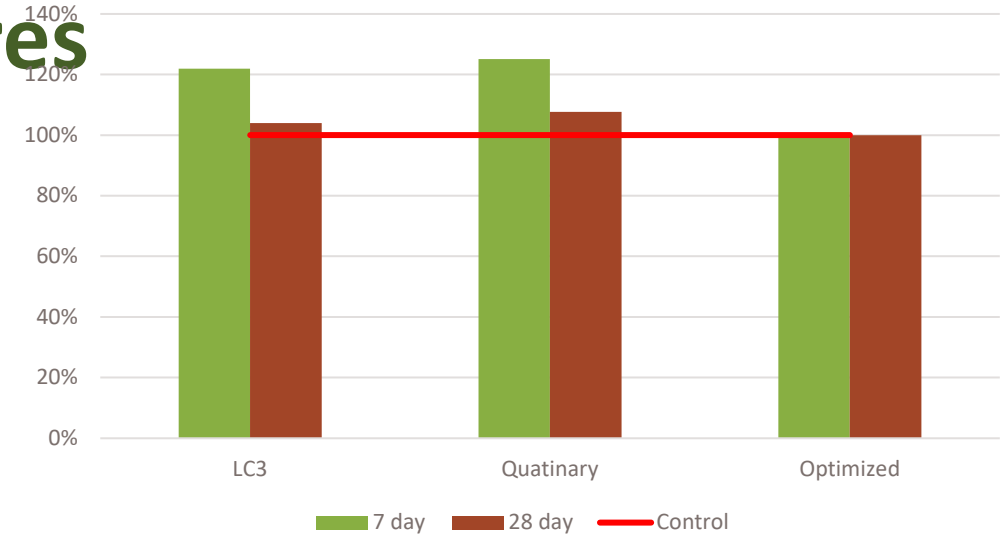
Pictures from MnRoad Research Reports.

2024 SCM/Optimized Mixtures

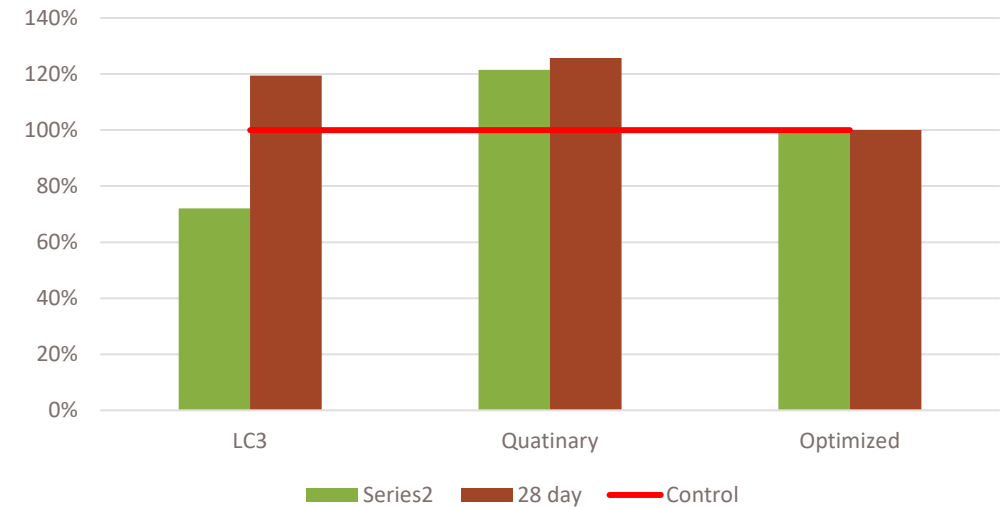
2024 Admixture Dosage Rates



2024 Compressive Strength

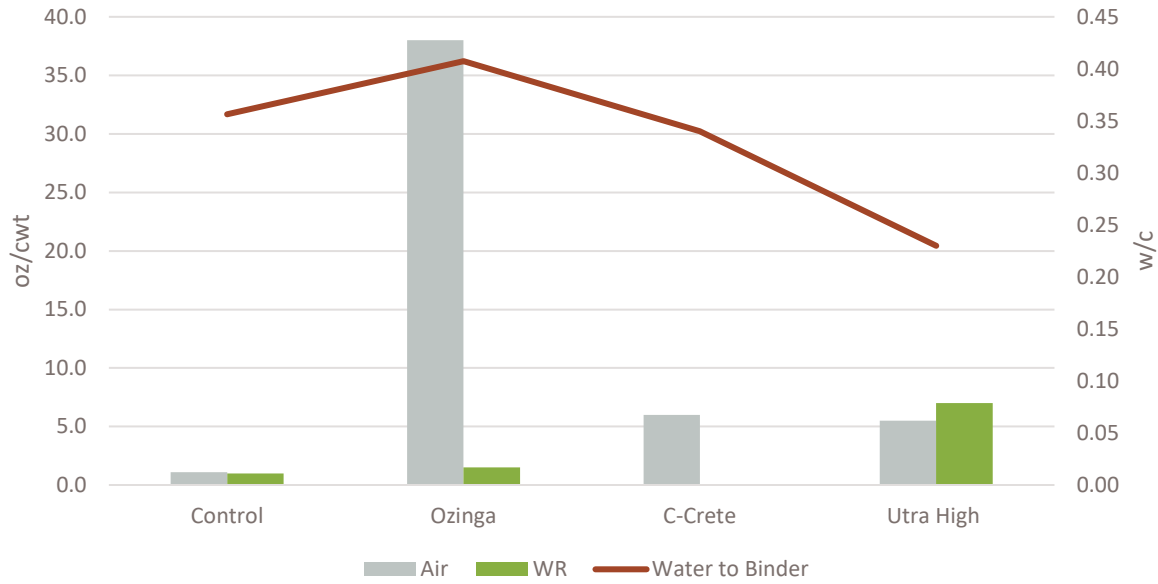


2024 Flexural Strength

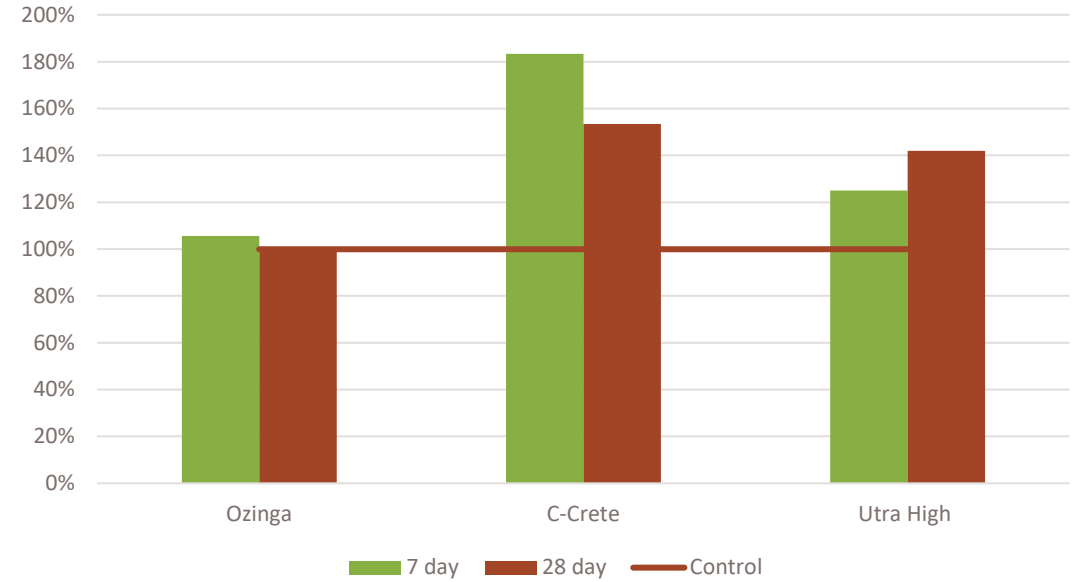


C1157 Mixtures

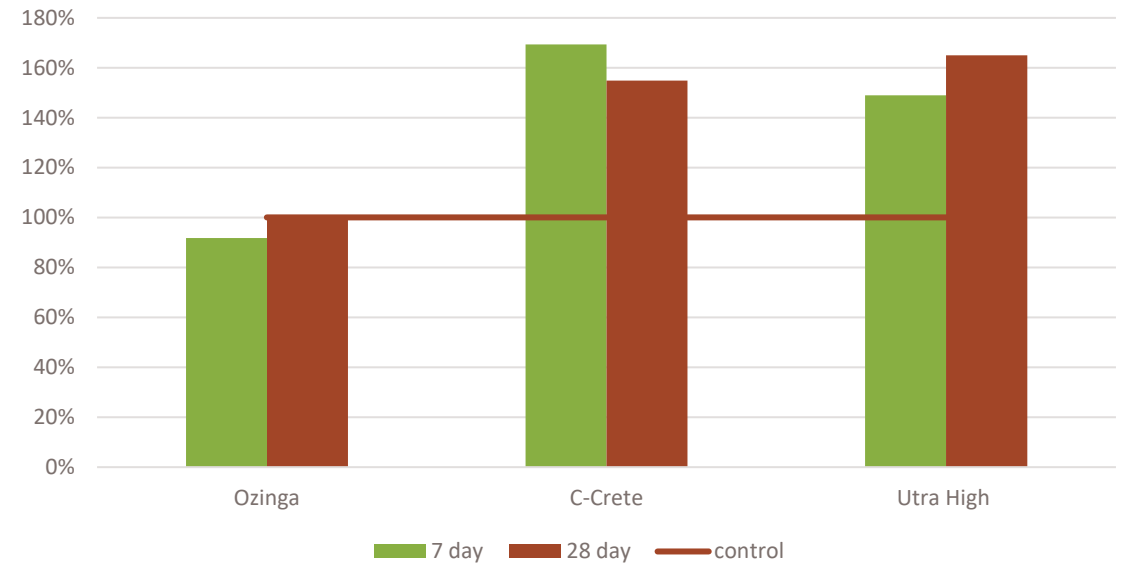
2024 Admixture Dosage Rates



2024 Compressive Strength



2024 Flexural Strength



Different Chemistry than Portland Cement



But

- ▶ We can get the mix to do this with admixtures



Final Results

- ▶ Slump – 3 inches
- ▶ Air content – 4.5%
- ▶ Time of Set – 2 hours 42 mins
- ▶ Flexural Strength
 - 7 days – 680 psi
 - 14 days – 750 psi
 - 28 days – 1000 psi



Alkali Activate Slag

- ▶ 700 lb/yd³ of binder
- ▶ Slump – 2 inches
- ▶ Air content – 3.0%
- ▶ Time of Set – 2 hours 52 mins
- ▶ Flexural Strength
 - 7 days – 830 psi
 - 14 days – 835 psi
 - 28 days – 875 psi



Different Properties when Paving



All of these has some portion of Portland Cement in the mix

Success Stories

- ▶ Carbon Upcycling – Processing of ash
- ▶ Ash Grove – IP
- ▶ Urban Mining – Ground Glass
- ▶ Terra CO2 – Manufactured SCM
- ▶ Optimized Concrete Mixture
- ▶ Burgess Pigment – Metakaolin
- ▶ 3M – Natural Pozzolan
- ▶ Hess Pumice – Natural Pozzolan
- ▶ Continental Cement – 20% limestone
- ▶ Ozinga – C1157 Cement

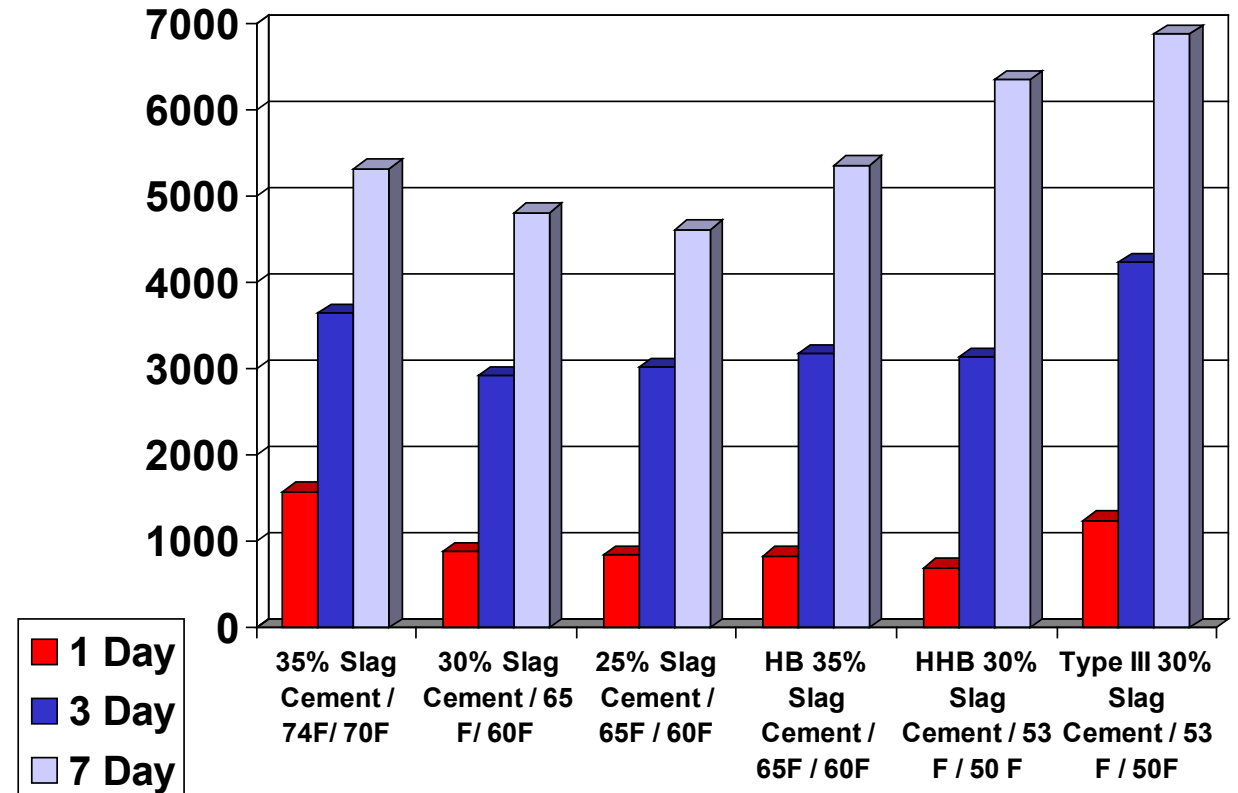
- ▶ Ashgrove – LC3
- ▶ Ternary Blend
- ▶ Optimized Concrete Mixture
- ▶ Amrize – Quaternary Mix





Be Willing to Think Outside the Box

- ▶ Lots of options for lowering the cement content in a concrete mixture
 - Most are readily available
 - Optimized Mixes
 - High volume replacement
 - Ternary Blends
 - Quaternary blends



Scary New Mixture

- ▶ The only thing constant in life is change
- ▶ MnRoad is a great place for developing new mixtures for paving
- ▶ Need more time to test the mixtures prior to paving (Improve field performance)
- ▶ New Mixtures will work.
 - Need opportunities to for field trials
 - Sidewalks
 - Approached
 - Ramps
 - Shoulders
 - Commercial Side is already doing this
- ▶ Robustness of the mix will be critical



Alf Gardiner

agardiner@braunintertec.com

612.685.5125