Ken Hover's Role in P2P*

*(Pre to Post-Chutimous Concrete)

R. Douglas Hooton,

Concrete Durability associates inc
& Professor Emeritus
University of Toronto
Dept. Civil & Mineral Engineering

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Deb, the force behind the legend

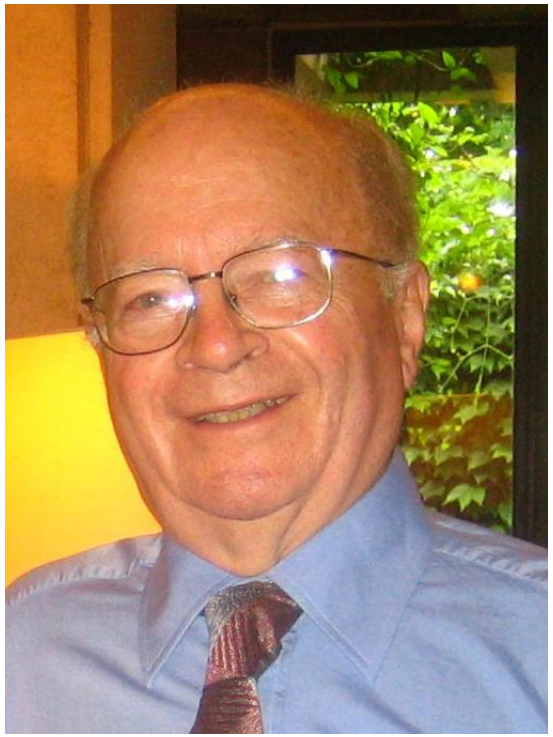
But first, his name is pronounced Hover, not Hoover

a Hoover

a Hover

From 2005-2008 this gang of ne’re-do-wells worked on reports for the NRMCA’s P2P program

This involved several multi-day cross-border meetings including much humor both in Toronto and in a motel along the New York Thruway



John Bickley

Doug Hooton

Ken Hover

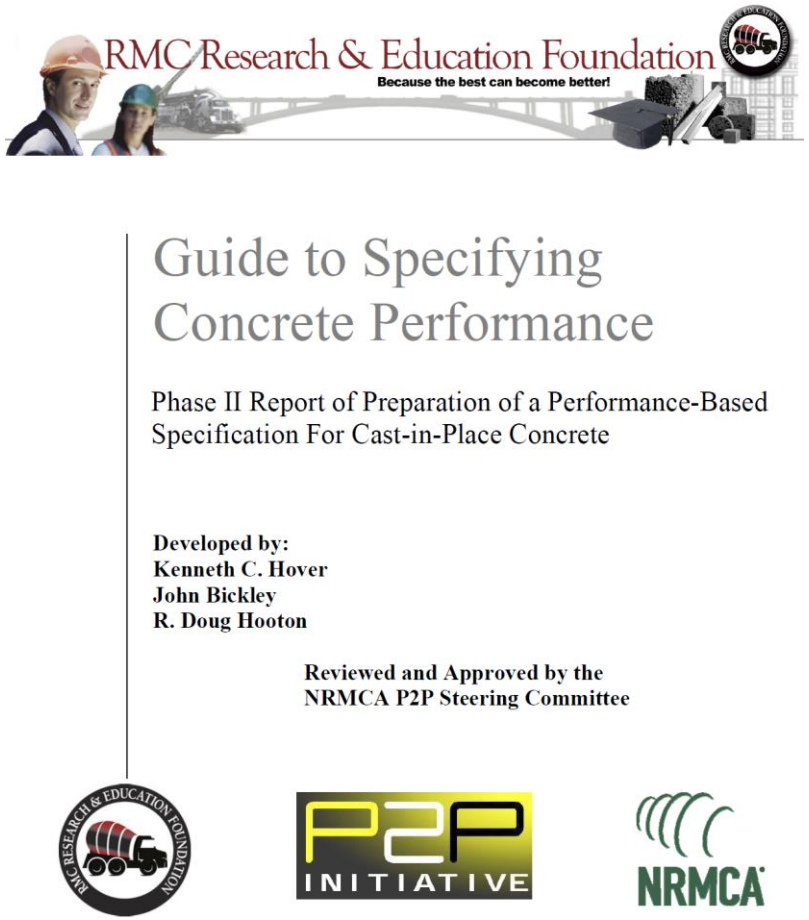
AKA: Men with Ties

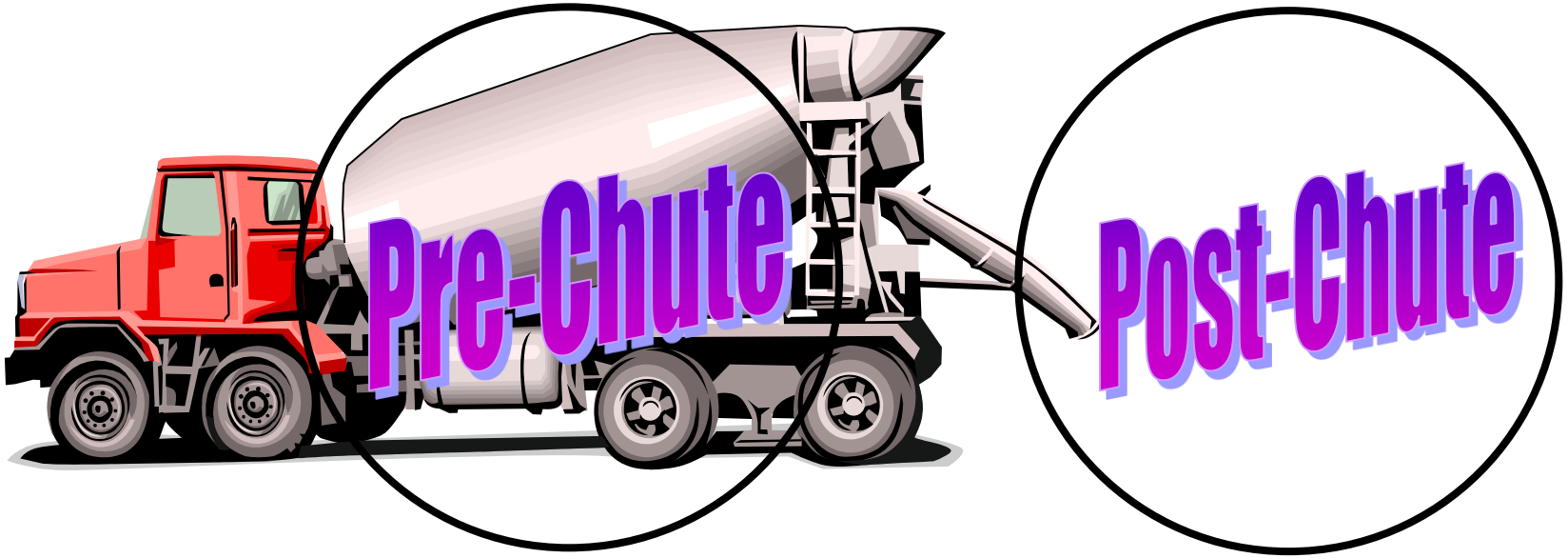
Ken's email to John and me on completion of our P2P Report in 2008

- "Personally, and I may be biased, I think this is a beautiful thing, and we are all to be permitted to shed a tear of pride as we jointly share paternity and custody."
- "I have attached a pdf for your reading pleasure in case your sleep cycle has been disturbed.
- I guarantee that if you are having trouble nodding off at night, just putting this report on your nightstand will do the job, and you will awake rested and refreshed, ready for another day of high performance!"

  Performingly yours,

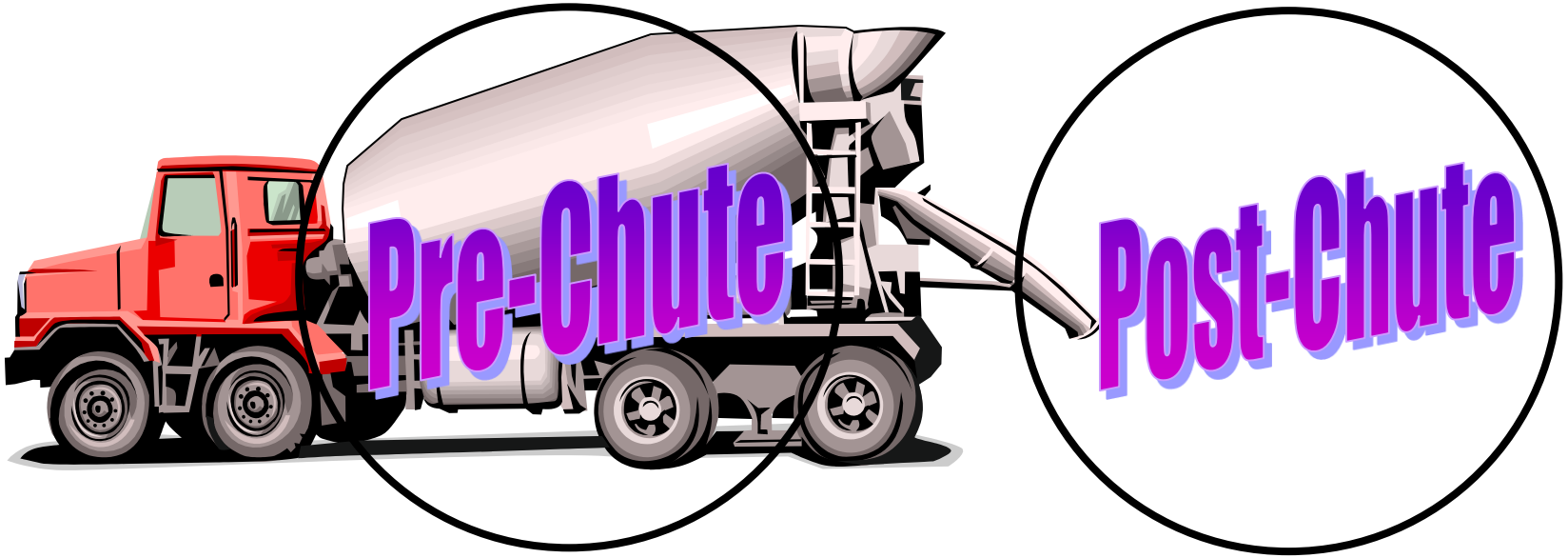
  Ken





Where do we need the Quality?

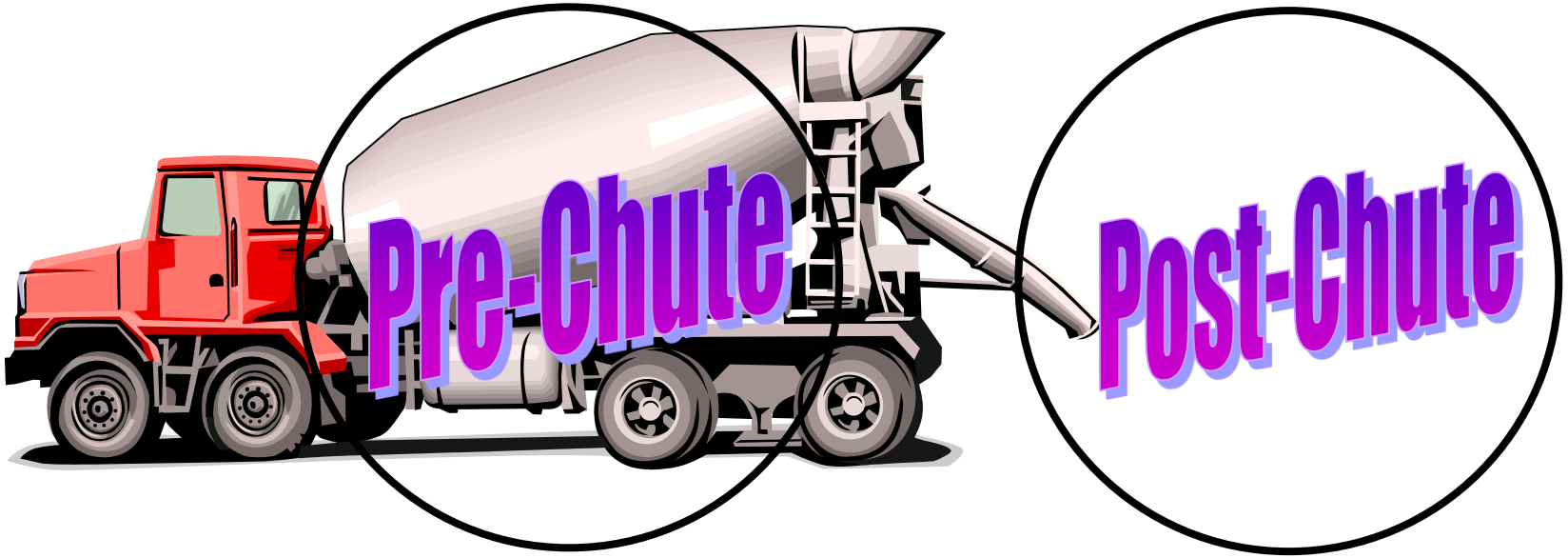
Some of Ken’s Slides explaining P2P to NRMCA



Goal: Quality

Post-Chutimous Concrete

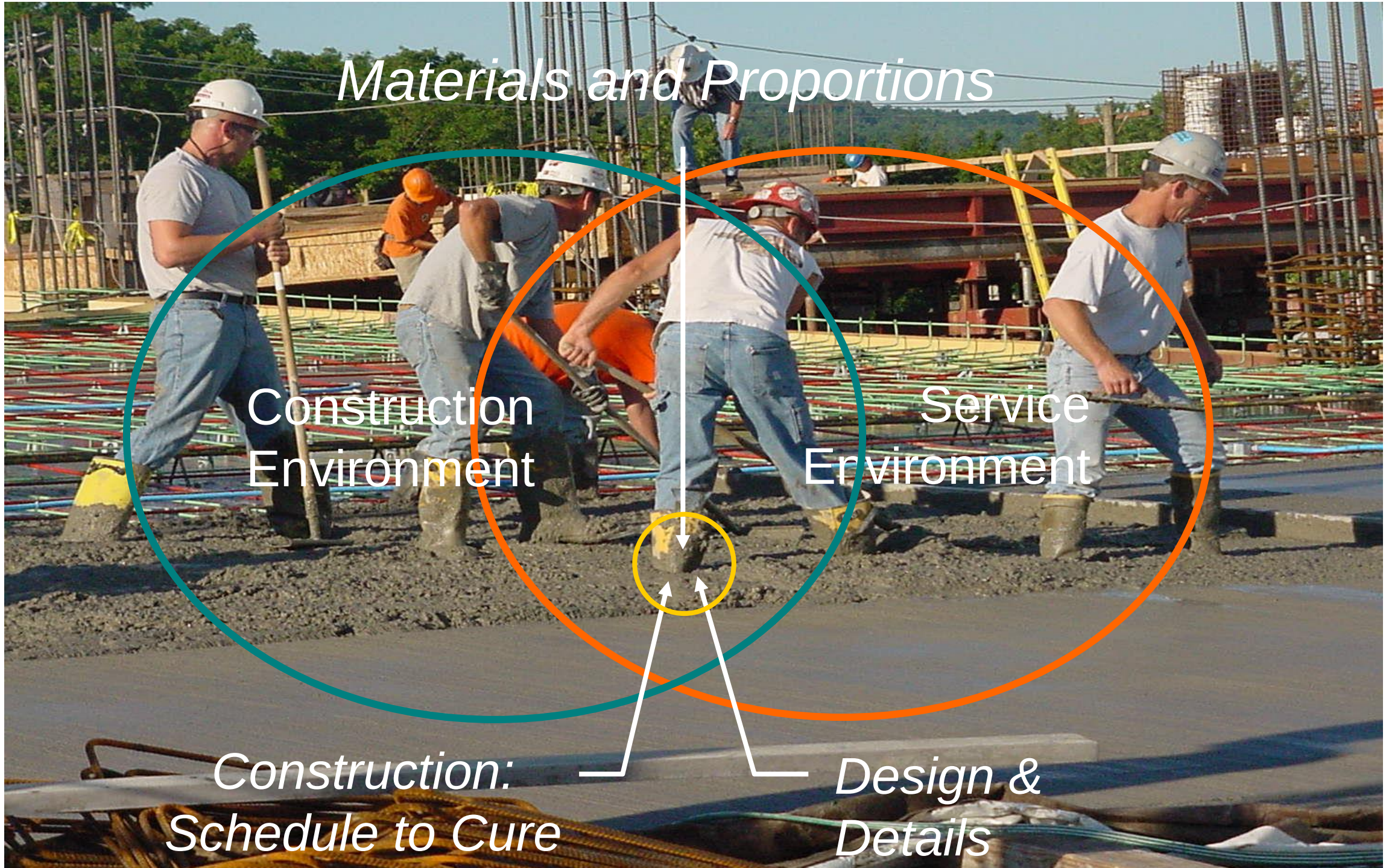
Hence the title of the talk !



Design
Specifications
Materials
Mix Design
Batching
Mixing
Transport

Handling
Placing
Consolidating
Finishing
Curing
Temperature
Testing

Each Step in this Series Impacts on Performance of the Concrete in the Structure

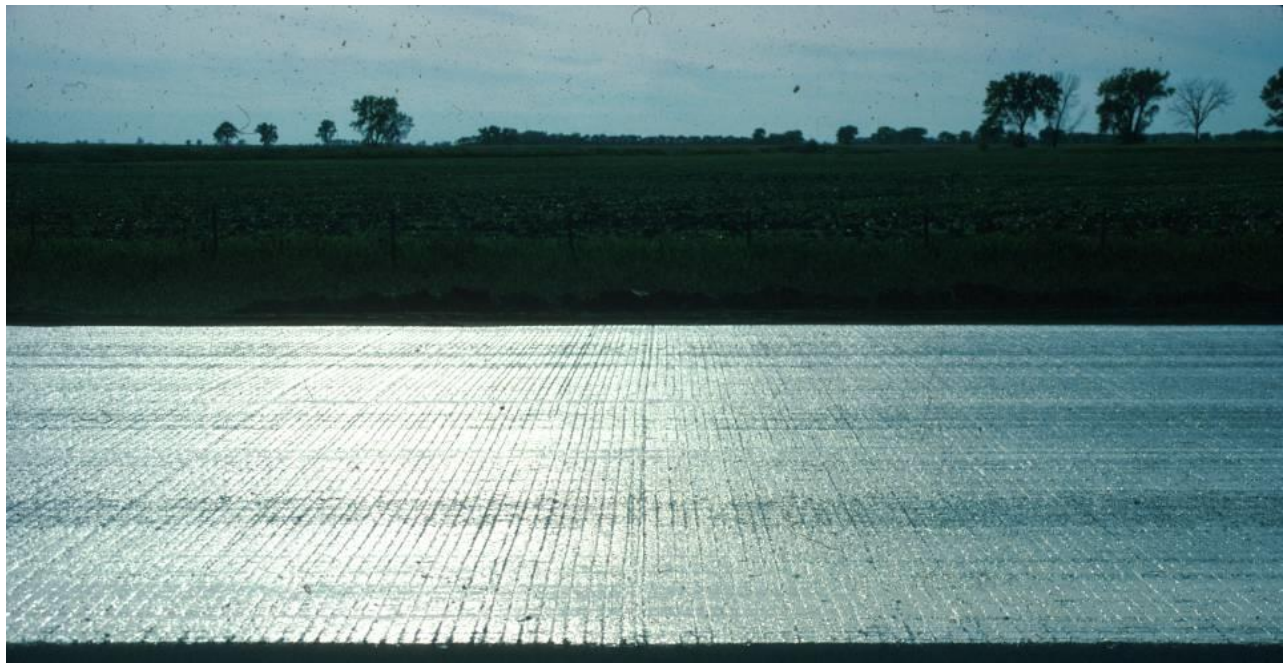

Materials and Proportions
Construction Environment
Service Environment
Construction: Schedule to Cure
Design & Details

Where is the Point of Performance?




Prequalification	Identity Testing		
	Acceptance at Chute		
		Accept at Point of Placement	
			Accept in-place

Performance to the Owner is in the Final Product, not just in the Concrete as delivered

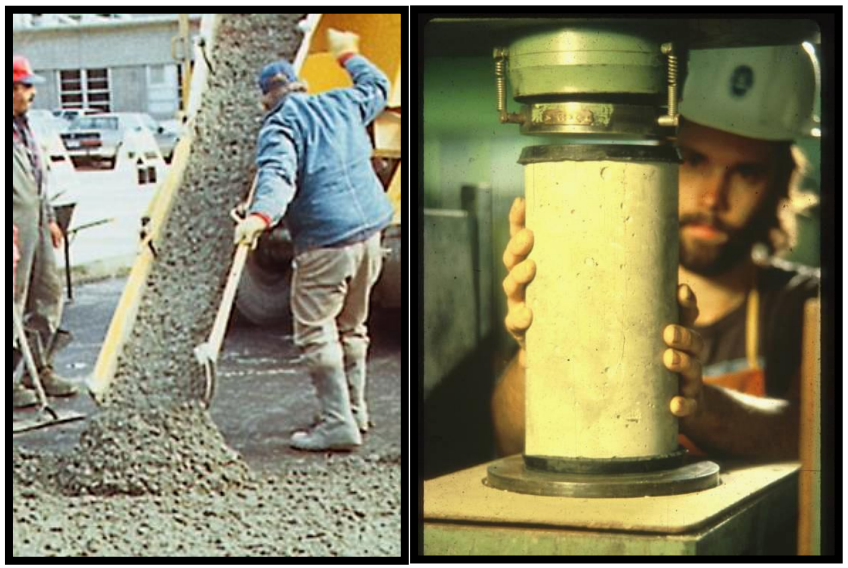


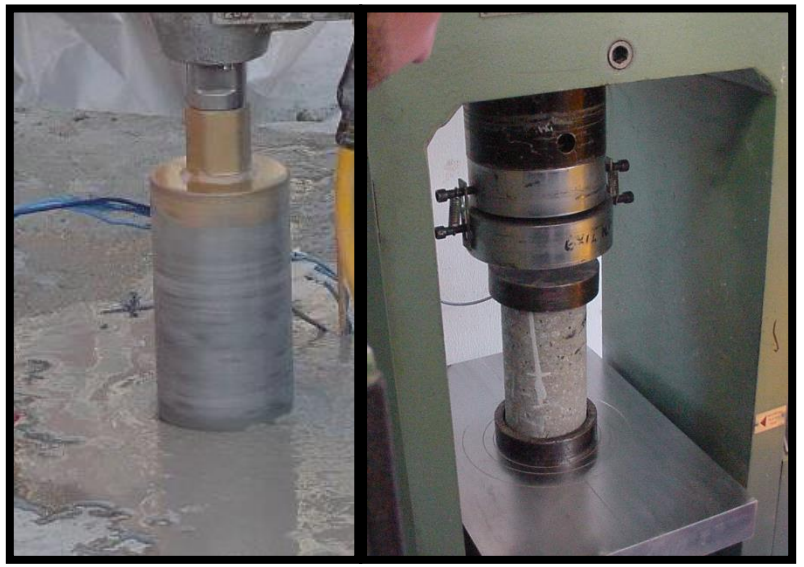
Unfortunately, the scope of the **ACI Committee 329 Performance Criteria for Ready Mixed Concrete** only addresses Pre-chutimous Concrete Performance

Setting Performance Test Limits

- Limits are set based on test results from specific standard test methods.
- These limits, should also allow for test variability by use of both average values and allowances for individual values to exceed those average limits due to variability inherent in the test method (similar to what is currently allowed in most specifications for occasional understrength test results).

Specified values should vary with point of evaluation



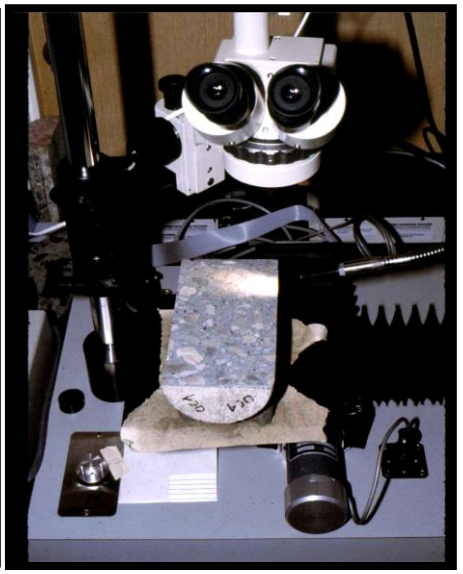


This approach is already used for Strength

$\approx 1.15\, f'c$ *Target*
Pre-qualification

In-place Cores $\approx 0.85\, f'_c$

Specified values <u>should</u> vary with point of evaluation

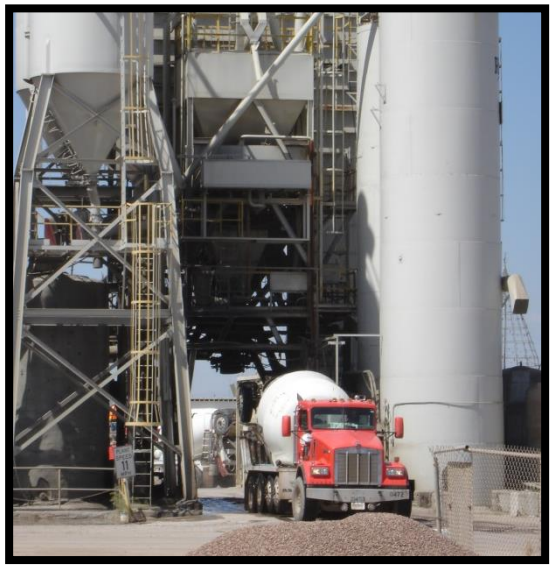


≈ 6.5% Target

If Fresh Air Content 5-8% Specified

≈ 3.5% In-place

Specified values <u>should</u> vary with point of evaluation



Target air void spacing factor

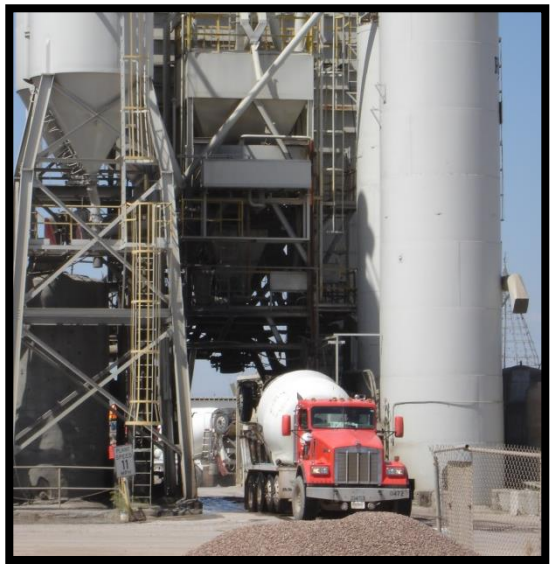
≈ 170um

Specified 230um

(0.009 in.)

In-place Average = 230um with no single value >260um

Specified values <u>should</u> vary with point of evaluation



Target ~1250 Coulombs

Specified 1500 Coulombs

In-place Average <1500 and no single value >1750 Coulombs

Key Points for post-chutimous Performance Specs.

1. **Define Roles and Responsibilities: Owner; Contractor; Supplier & Testing Agency**
2. **Establish the requirements** for a concrete production facility, the facility's QC management system, and their personnel.
3. **Encourage Suppliers/producers and contractors to work together** to ensure that the right concrete mixture is developed, delivered, placed and finished.
4. **Allow flexibility for the supplier to** provide a concrete mixture that meets the performance criteria and **satisfy the contractor requirements** for placing and finishing.
5. **Set requirements for field acceptance tests to verify** that the in-place concrete meets the **performance** criteria, as well as defining actions required if those test requirements are not met.

Performance Tests for Concrete

- Typically, concrete is qualified and accepted based on fresh properties such as slump/ slump flow and air, and 28-say strength is the only hardened property specified and measured.
- **28-day strength is not an adequate performance metric:**
  - Construction schedules are controlled by early-age strength development.
  - Concretes with high-SCM levels develop their ultimate properties at later ages (e.g. 56 or 91 days) Also, early strength of SCM-mixtures is underestimated by small mortar or concrete cube/cylinder tests stored at lab temperatures
- Limits, based on tests that are performance indicators of other properties, including durability, need to be specified.

Prescriptive Barriers

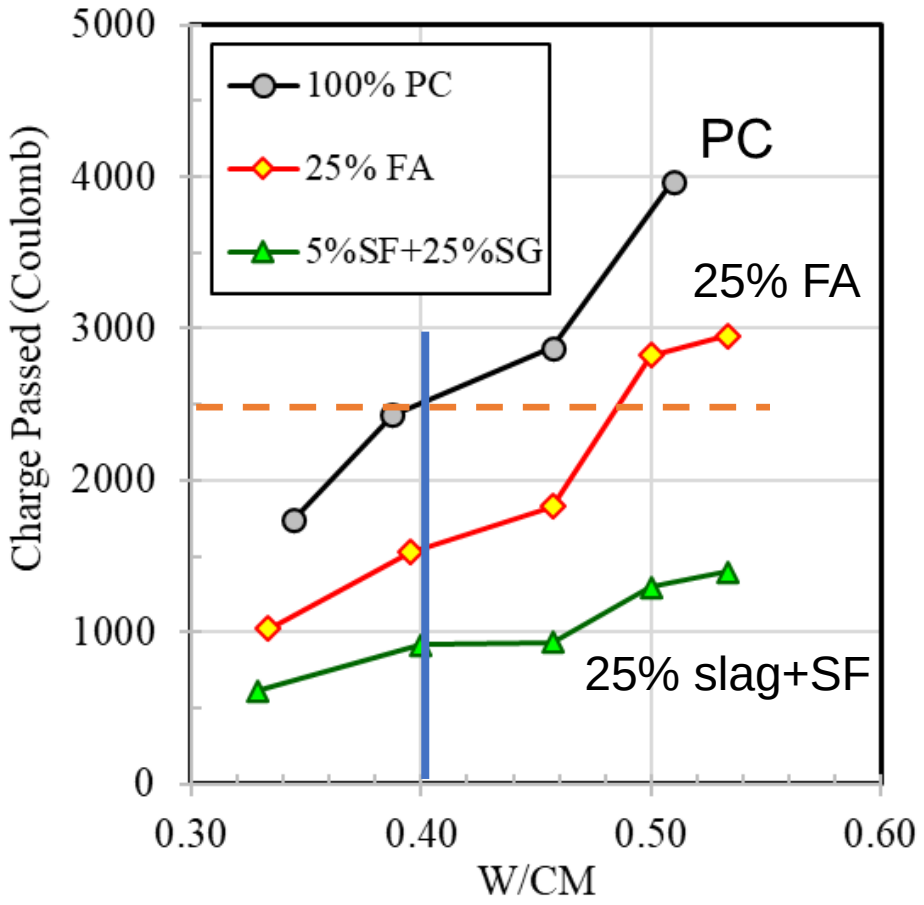
Prescription vs Performance in Concrete Codes: Durability

- **Prescriptive requirements** in most Codes, Specs and Standards make it difficult to adopt materials & mix proportions that can provide lower GWP concretes.

  For example:

  - **For durability exposures, the ACI 318 Building Code only requires meeting max. w/cm limits and minimum 28-day *strength*.**
    - e.g **for ACI C-2 Chloride exposure: 0.40 w/cm and 5000 psi (35 MPa)**
    - But **these requirements are not directly linked to durability**; i.e. resistance to ingress of aggressive chlorides.
    - These current requirements result in concretes with different levels of durability
    - **5000 psi (35 MPa) is not needed for durability**, but that the only property that is being measured.

Why w/cm limits in ACI 318 do not provide concrete of equal durability
(All three of these concretes meet ACI C-2 exposure requirements)



M. Thomas

1. **w/cm limits do not consider the impact of SCMs on chloride penetration resistance**
2. **The permeability benefits of some SCMs are not attained at 28 days. Later-age limits are more appropriate.**
3. **A SCM mixture at 0.5 w/cm may provide equivalent durability to a 0.4 w/c portland cement mixture.**
4. **The draft ACI 321 Durability Code will include performance options**

The 91-day performance RCPT 1500 coulomb limit in CSA A23.1 C-1 exposure prevents the use of plain PC mixtures

Unfortunately, ACI 318-25 will not include any new performance options for durability exposures

- We tried to introduce use of ASTM C1202 coulomb limits as a performance index of permeability into 318 for C2 exposure but that failed.
- This proposal would have allowed concrete with a lower f’c and a higher w/cm limit provided the Coulomb limit was achieved.

- The main resistance was from the concrete producers who do not trust the testing companies to properly cast, handle and test strength cylinders, let alone more complicated tests that could be used to reject concrete.

Ken Hover's expressions based on the Current Status on Industry's Willingness to Adopt Performance

The Hover
Smile-O-Meter

Pre-Chutimous: Smile

Post-Chutimous: No Smile

- In Summary, I am pleased to have had several opportunities to work with Ken.
- It has had a positive impact on both my research and in my appreciation of concrete humor.

Lastly, while most of the world is moving to 3-D printing, in Ken's honor, we invented 2-D printing