Performance Engineered Mixtures

National Concrete Pavement Technology Center

IOWA STATE UNIVERSITY
Institute for Transportation

Performance Engineered Mixtures

- How do we get what we need?
  - Later
- How do we know we got it?
  - Pooled fund?
- How does the agency specify it?
  - FHWA Implementation funds

How does the agency specify it?

- ETG met April 3-4
  - Gina Ahlstrom
  - Doug Hooton
  - Cecil Jones
  - Colin Lobo
  - Maria Masten
  - Paul Tikalsky
  - Suneel Vanikar
  - Tom Yu
  - Tom Cackler
  - Ken Hover
  - Tyler Ley
  - Steven Kosmatka
  - Peter Taylor
  - Mike Tholen
  - Jerry Voigt

The Agenda

- What controls longevity?
- How do we measure them?
- How do we specify them?
- What do we do next?

- Aim to move the needle – today
- Focus on materials
- Allow adoption of more sustainable materials

The Agenda

Point of View

**Performance-
Specificati
for Concr**

BY PETER TAYLOR

The topic of performance-based specifications for concrete is raising considerable discussion in the concrete construction industry. Current construction specifications are predominantly prescriptive with some performance aspects. Most agree that the balance between prescriptive and performance-based specifications needs to be changed to improve the probability of new construction achieving the desired service life at reasonable cost and with minimal disputes. This article presents a hybrid approach to altering current specifications that is feasible for implementation in today's construction environment.

PERFORMANCE-BASED SPECIFICATIONS

A pure performance-based specification would read very simply: "The concrete structure must provide *N* years of service in the environment in which it is placed with a maximum of *X* amount of maintenance and repairs." This approach would have the following effects:

- Primary risk would be placed onto the contractor and suppliers; and

This point of view article is presented for reader interest by the editors. However, the opinions expressed are not necessarily those of the American Concrete Institute. Reader comment is invited.

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Prepared by:

John Bickley
R. Doug Hooton
Kenneth C. Hove

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A Synthesis of Knowledge of Potential Durability of Concrete

**Long-Life Concrete:
How Long Will My Concrete Last?**

Peter C. Taylor, PhD
October 2013

Sponsored through
Technology Transfer Concrete Consortium (TTCC) Pooled Fund Study
TPF-5(139) with funding from Colorado, Illinois, Iowa, Kansas, Michigan, Minnesota, Ohio, Oklahoma, and Pennsylvania

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The process...

- Structural Design
- Mixture Design
- Mixture Verification
- Acceptance

Structural Design Based On

- Strength
- Modulus
- CTE
- Region
- Foundations
- Loading (traffic, trucks)
- Features (steel, shoulders, …)

- Assumes durability
- So what about the mixture…

What controls longevity?

- Aggregate issues (ASR, d-cracking)
- Cold weather (freezing / salts / joints)
- Fatigue (strength / thickness / support)
- Cracking (moisture / thermal)
- Corrosion (permeability, protection)
- Bond (overlays)
- Abrasion / polishing (aggregates)

How do we control them?

• Aggregates	Pre-qualify
• Cold	AVS, permeability
• Strength	w/cm, binder, consolidation, segregation
• Permeability	w/cm, binder, uniformity, curing
• Cracking	Shrinkage, temperatures, CTE, sawing
• Corrosion	Permeability, binding
• Bond	Surface prep

How do we measure them?

- Aggregates — AASHTO PP65, pore index Quarry inspection, Tarantula
- Binders — Calorimetry, indicators
- AVS — SAM, AVA, foam drainage, foam index
- w/cm — Microwave, batch records, ray gun?
- Permeability — Resistivity, RCPT, sorptivity, other?

How do we measure them?

- Uniformity — Slump, unit weight
- Workability — Slump, VKelly,
- Segregation — Dipstick
- Strength — Cylinders, maturity
- Shrinkage — Ring, C157, bFlat
- Bond — C1583

When do we measure them?

• Aggregates	Design / delivery	QC
• Binders	Delivery	QC
• AVS	Behind the paver	AA
• w/cm	At paver	AA
• Permeability	Design	AA

When do we measure them?

• Uniformity	At paver	QC
• Workability	Design / at paver	QC
• Strength	At paver	AA
• Shrinkage	Design	AA
• Bond	Design	AA

How Much?

- Design inputs
- Historical
- Based on lab data
- Extrapolated from field experience
- Guess…

- Tolerances
- Action limits / Stop limits

Summary - What should we measure for acceptance?

- CTE
  - Why? – Design input
  - When? – Design
  - How? – AASHTO T 336
  - Limits? – As per design
  - What else – Should be done before structural design

Summary - What should we measure for acceptance?

- Shrinkage
  - Why? – Influences cracking
  - When? – Design
  - How? – Ring, Bar
  - Limits? – 500 με
  - What else – ASTM C157 takes months.

Summary - What should we measure for acceptance?

- Air
  - Why? – Cold weather
  - When? – Behind the paver – or calibrate loss
  - How? – SAM
  - Limits? – Ask Tyler
  - What else – do warm places need this?

Summary - What should we measure for acceptance?

- w/cm
  - Why? – Controls properties
  - When? – At delivery
  - How? – Microwave
  - Limits? – 0.4
  - What else – what about aggregate moisture?
    - Is there a better way?

Summary - What should we measure for acceptance?

- Strength
  - Why? – Fatigue resistance
  - When? – At delivery
  - How? – Cylinder, maturity
  - Limits? – From design
  - What else – Familiar

Summary - What should we measure for acceptance?

- Resistivity
  - Why? – Indicates permeability
  - When? – At delivery
  - How? – Wenner
  - Limits? – 27 kΩ.cm at 28 days
  - What else – 28 days

Summary - What should we measure for constructability

- Workability
  - Why? – Can we build it
  - When? – At delivery
  - How? – Slump, other??
  - Limits? – Monitor variability
  - What else – Need a test to report response to vibration
    - Vkelly, The Box

Summary - What should we measure for constructability

- Unit weight
  - Why? – uniformity
  - When? – At delivery
  - How? – weigh a bucket
  - Limits? – watch for change
  - What else –

Summary - What should we measure for constructability

- Setting
  - Why? – Sawing window
  - When? – At delivery
  - How? – UPV, Thermal
  - Limits? – none
  - What else – use to predict sawing, observe incompatibility

Summary - What should we measure for constructability

- Binder Chemistry
  - Why? – Affects all performance
  - When? – At delivery
  - How? – ???
  - Limits? – none
  - What else – “Mixture Verification”

Where Next?

- Prepare a revised Guide Spec
- Build test sections
  - Collect data
  - Monitor performance
- Demonstrations
  - Risk to owner and contractor
  - Constructability
  - Durability
  - Cost benefit

Where Next?

- Tests still needed
  - Shrinkage
  - Aggregate issues
  - Freeze thaw / scaling
  - Automated batch reporting in a central plant / dump truck system
- Precision / Statistics
- Mitigate poor materials
- Innovative Materials
- Better mixtures

Where next?

- Educate
  - Everyone
- Broaden scope
  - Foundations
  - Workmanship
  - “Change of ownership”
  - Maintenance