Performance Engineered Mixtures for Airfield Pavements

Dr. Peter Taylor, PE (IL), FACI

IOWA STATE UNIVERSITY
Institute for Transportation

National Concrete Pavement Technology Center
Tech Center

Traditional Test Methods

- Slump
- Strength
- Thickness

- Poor correlation with durability…

Current Test Methods

- Quality Assurance
  - Slump
  - Strength
  - Thickness
  - Air

3

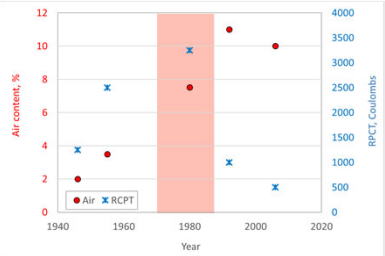
But What Do We Need?

- Performance Engineered Mixtures
  - Understand what makes concrete “good”
  - Specify the critical properties and test for them
  - Prepare the mixtures to meet those specifications
- Ask for what is needed, and no more

4

What is Good concrete?

- Constructible (Workable)
- Dimensionally stable
  - Aggregates
  - Shrinkage
- Impermeable (Transport properties)
- Cold weather resistant
  - Freeze thaw
  - Salt attack
- Strong (enough)



5

Workability

- Not too wet / Not too dry
- Right for the equipment you are using
- Response to vibration
- Thixotropy

- Prequalification

6

Workability

- VKelly and Box

7

Workability

- Segregation
  - No test

Workability

- Finishability



9

Transport properties (permeability)

- All deterioration mechanisms involve fluid movement
- Keep water out = longer life
- Measurement has been difficult

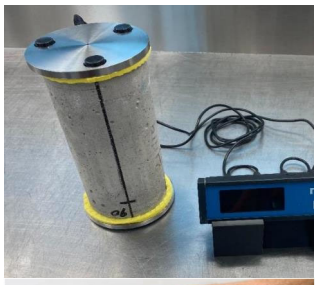
- Prequalification
- QC
- Acceptance

10

Resistivity

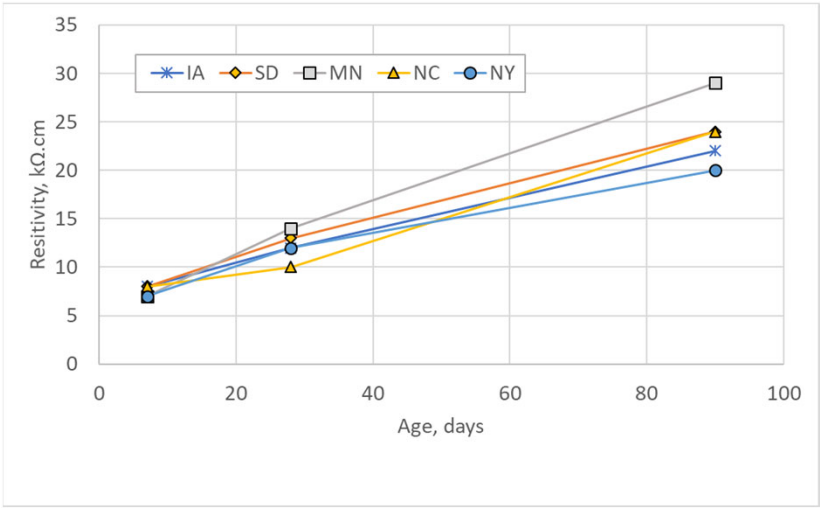
- Resistivity
  - Curing: Fog room
  - Pull out at desired age
  - Read and put back
  - Repeat

Classification	Resistivity (kΩ · cm)	Formation Factor
High	<5.2	<520
Moderate	5.2–10.4	520–1,040
Low	10.4–20.8	1,040–2,080
Very low	20.8–207	2,080–20,700
Negligible	>207	>20,700



11

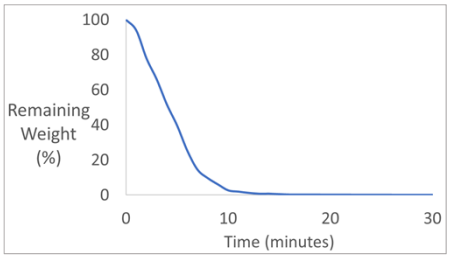
Resistivity



12

Phoenix (w/cm)

- Record batch ticket and aggregate properties
- Make and weigh 6”x 3.75” cylinder (1640 cm3)
- Dump cylinder into pan and weigh
- Heat for 15 min
- Weigh pan



Cold Weather

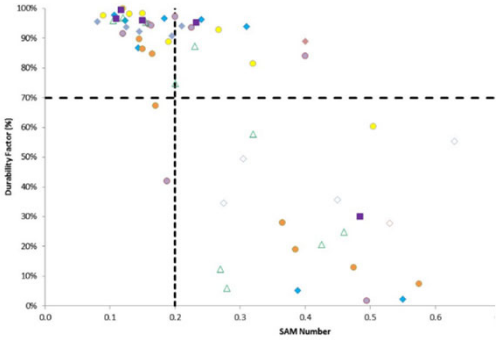
- Saturated Freeze-thaw
- De-icing salts
- Scaling

- Prequalification
- QC
- Acceptance

Super Air Meter

- Reports an index that correlates with F/T performance
- Training and machine maintenance are critical

- Prequalification
- QC
- Acceptance (later)



Salts can cause chemical attack

- Calcium oxychloride
  - Reaction between $Ca(OH)_2$ and calcium or mag chloride
  - Expands more than ice
  - Forms above 32F

- Prevention
  - Enough SCM

$CaCl_2$ @ 40° F

Tests for Oxychloride

- Low temperature differential scanning calorimetry (LT-DSC)
- Expansion

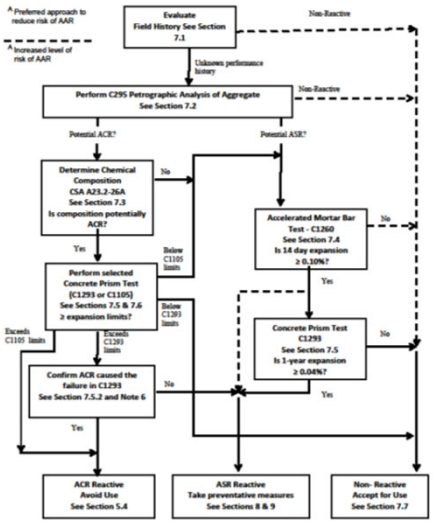
- Prequalification

17

Aggregate Stability

- Aggregate growing due to
  - Alkali silica reaction
  - (Alkali carbonate reaction)
  - D-Cracking

- Prequalification

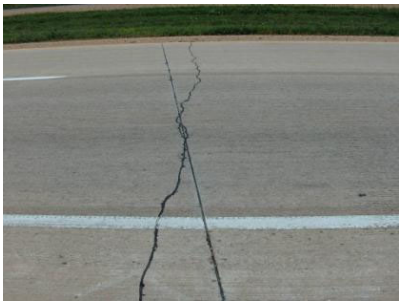


18

Shrinkage

- Influences cracking risk
- Controls warping
- Takes time

- Prequalification



19

Shrinkage

- Paste content (read the batch sheet)
  - Easy
  - Fast

Project	Gravel 1"		5/15/2017		
Mixture Proportions					
		Targets		Actual	
			Pounds	R.D.	Volume
Cement	Type I		342	3.15	1.74
SCM 1	F Ash		86	2.65	0.52
SCM 2	Slag		0	1.00	0.00
Coarse Agg	A85006		1753	2.72	10.33
Fine Agg	A25518		1318	2.66	7.94
Intermediate	A85007		340	2.43	2.24
Water			180	1.00	2.88
Air %			5.0		1.35
			4019		27.00
Cementitious		428	428	pcy	
Volume of paste			24.0	%	
Volume of aggs			76.0	%	
Volume of voids			19.2		
vp/vv		125	125.0		
w/cm		0.42	0.42		
% SCM 1		20	20	%	
% SCM 2		0	0	%	
Mass aggs		3411	3411	pcy	
Excess paste, %			4.8	%	

20

Shrinkage

- Ring test
  - Indicates cracking risk starting from minutes after mixing
  - Tricky
  - Poor repeatability
  - ASTM and AASHTO methods are not the same

21

Strength

- Strong enough to carry loads
  - (and not much more)
- Prequalification
- QC
- Acceptance

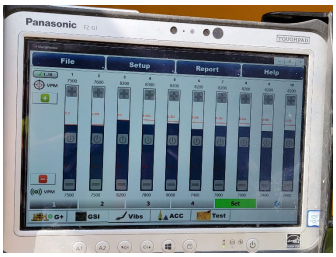
22

Other Parameters

- Consolidation
  - Unit Weight
  - Resistivity?

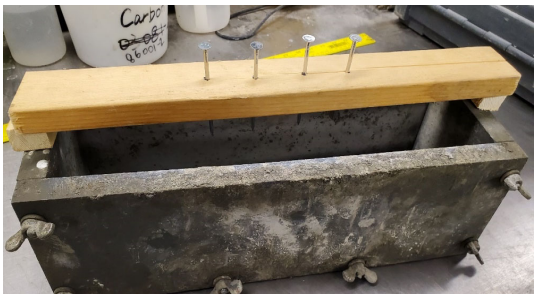
Other Parameters

- Smoothness



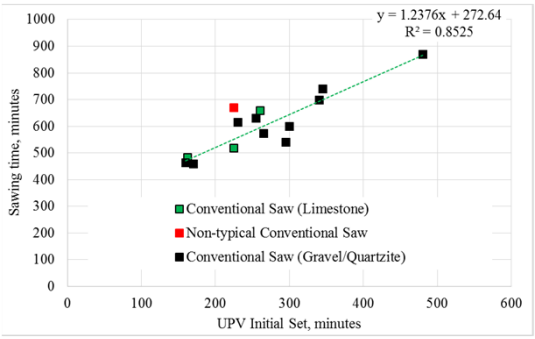
Other Parameters

- Curing



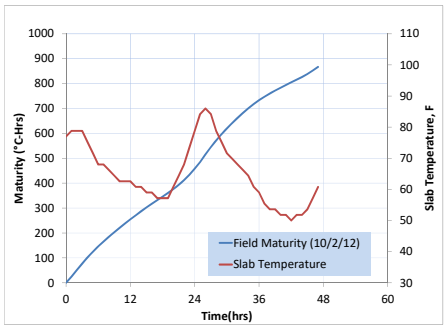
Other Parameters

- Saw timing



Other Parameters

- Maturity



The mixture

- How do we prepare mixtures that meets these needs?

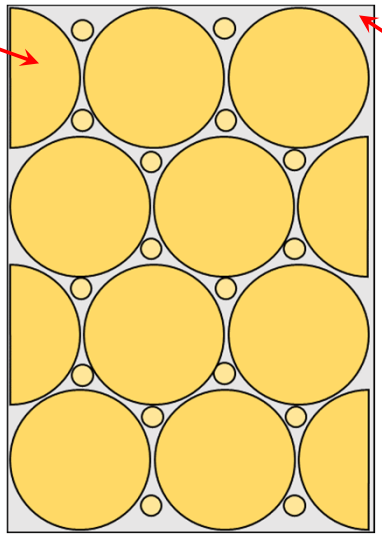
The mixture

- How do we prepare mixtures that meets these needs?

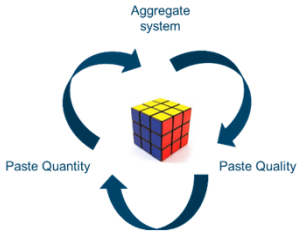
		Workability	Transport	Strength	Cold weather	Shrinkage	Aggregate stability
Aggregate System	Type, gradation	✓✓	-	-	-	-	✓✓
Paste quality	Air, w/cm, SCM type and dose	✓	✓✓	✓✓	✓✓	✓	✓
Paste quantity	Vp/Vv	✓	-	-	-	✓✓	-

The mixture

Filler
Gradation



Glue
What sort
How much



30

Does it Work?

- MNRoad

	MNDOT	Optimized
Cement	400	351
SCM 1	170	150
SCM 2	0	0
Coarse Agg	457	662
Fine Agg	1171	1303
Intermediate 1	1167	954
Intermediate 2	244	254
Water	228	200
Air	7.0	7.0
Total	3837	3874
Cementitious	570	501
vp/vv	208	180
w/cm	0.40	0.40
% SCM 1	30	30

	MNDOT	Optimized
Slump	2.0	2.0
HRWRA	2.0	2.3
Air content	6.8	7.0
Box	1 - 0	1 - 0
Initial set	6:27	6:12
Strength at 7	3,340	3,650

31

Where Next?

- Adapt the thought process for airfields!

32


National Concrete Pavement
Technology Center
Tech Center
www.cptechcenter.org
IOWA STATE
UNIVERSITY
Institute for
Transportation