Performance Engineered Mixtures (PEM) for Concrete Pavements

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History

Concrete Paving Specs have not kept up with innovations in testing technologies.

- Strength, air and slump

Mixtures are more complex:

- Chemical admixture
- Supplemental cementitious materials

As well as:

- Increase in traffic
- More aggressive winter maintenance
- Get in and get out as quickly as possible.

History

Recognizing the need a partnership was formed – April 2015

- Federal Highway Administration (FHWA)
- American Concrete Paving Association (ACPA)
- Portland Cement Association (PCA)
- Member state of National Concrete Consortium (NCC)

Formed an Expert Task Group including seven champion states

- Indiana, Iowa, Minnesota, Michigan, Nebraska, South Dakota, Wisconsin, the Illinois Tollway and Manitoba

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Identified Properties Controlling Concrete Mixture Performance:

- Aggregate Stability – including alkali aggregate reaction and D-cracking
- Fluid Transport Properties – The ability to resist passage of wanted and aggressive fluids
- Cold Weather – The ability to resist freezing and thawing the effects of deicing salts
- Shrinkage – As it affects random cracking as well as warping
- Strength – the ability to carry static, dynamic, and fatigue loads
- Workability – As it affects the constructability of the system, and the observation that the efforts to overcome poor workability can impact durability

Aggregate Stability

D-cracking:

- AASTHO T151, ASTM C1646

Alkali Aggregate Reactivity :

- AASHTO R 80

Transport Properties

Water to Cementitious materials (w/cm) ratio:

- The required Maximum w/cm ration is selected based on freeze-thaw conditions

Formation Factor:

- Based on freeze-thaw conditions

Ionic penetration, F factor:

- Determined using guidance provided in Appendix X2

Cold Weather

Water to Cementitious materials (w/cm) ratio:

Fresh Air Content

Fresh Air Content/ SAM

Time to Critical Saturation

Deicing Salt Damage

Deicing Salt Damage

Calcium Oxychloride Limit

Shrinkage

Reducing unwanted slab warping and cracking due to shrinkage:

- Volume of paste (25%)
- Unrestrained volume change – ASTM C157 (prescriptive)
- Unrestrained volume change – ASTM C157 (performance)
- Restrained shrinkage – AASHTO T334
- Restrained shrinkage – AASHTO TP363-13
- Probability of cracking
- Quality control check

Concrete Strength

Flexural strength
- AASHTO T97

Compressive strength
- AASHTO T22

Workability

Traditional acceptance criteria would have be the slump test.

Box test- Appendix 3 (TP80)

V-Kelly test- Appendix 4 (TP80)

Next Step

Transportation Pooled Fund: TPF-5(368)

- Objective: to focus on the successful deployment of performance engineered mixtures. This will involve building off the foundational work the FHWA and the "PEM Champion States" have done, with emphasis on implementation, education and training, adjusting the specification values to relate accurately to good pavement performance in the field, and continued development of relating early age concrete properties to performance.

Pilot Project

SR 376 in Moon Township, Allegheny County

5 miles of full depth reconstruction of 11" pavement on both east and westbound lanes.

Golden Triangle Construction- thank you!

Shadow testing

What is being implemented

Tests to evaluate the mix design

- Rate of flexural strength development to 90 days
- Rate of compressive strength development to 90 days
- ASTM C157 – Unrestrained Volume Change
- Formation factor from resistivity testing
- Air content – SAM and pressure meter
- w/cm ratio ≤ 0.45
- Volume of paste

What is being implemented

Acceptance testing in field (shadow testing)

- In addition to the usual slump, air content, temperature and w/cm ratio check the following will also be done:
  - SAM
  - Formation factor from resistivity testing
  - Box test

What is being implemented

QC Plan

- In addition to the usual requirements of a QC Plan, these test will be implemented (shadow testing)
  - Unit weight
  - SAM
  - Water content (AASHTO T318)
  - Formation factor from resistivity
  - Box test

What is being implemented

Control Charts

- SAM
- Air content
- Unit weight
- Water content
- Strength
- Formation factor from resistivity

Future

As the SHA's gain experience with the performance of the PEM mixtures, it is expected that specifications will become more performance based and allow for the innovation that is needed to increase performance. The inclusion of performance measures increases the importance of quality control, as the acceptance criteria are predicted on a well designed and executed quality program.

Better test methods and equipment

- AASHTO T318 -