Concrete Pavement Technology

presented to:
Midwest Transportation Consortium – Transportation Seminar
11 April 2003 – Ames, IA

presented by
Dr. Robert Otto Rasmussen, P.E.
Vice President and Chief Engineer
The Transtec Group, Inc., Austin, Texas, USA

Introduction

✓ Concrete Pavement Research in the United States is currently focused in several areas:
  ◆ Expedited Construction Practices (Fast-Track)
  ◆ Smoothness and Safety Improvements
  ◆ Long-Life Pavements
  ◆ Optimization of Materials and Construction
✓ The Federal Highway Administration (FHWA), Concrete Industry, and the State Departments of Transportation (through TRB) are working more closely.

Topics

✓ 3 topics of recent research with the objective of meeting these goals:
  1. Predicting Early-Age Concrete Pavement Behavior using FHWA HIPERPAV
  2. Concrete Mix Optimization – The Road to a Performance-Based Mix Design System
  3. Whitetopping – A Proven Overlay with a New Name

Outline

✓ HIPERPAV
✓ Mix Optimization
✓ Whitetopping

HIPERPAV

FHWA-sponsored Research Project
State and Industry Involvement

✓ Guidelines for Fast-track Jointed Concrete Pavements
  or
✓ High PERformance Concrete PAVing:
  an integrated computer system that analyzes material, environmental, design, and construction variables that will ....
HIPERPAV

What is it?

**Assist Engineers and Contractors**

- to understand 72-hour behavior
- and
- to predict 72-hour behavior of concrete pavements.

HIPERPAV

How did it start?

**Mid-80’s**

- Concrete Paving Industry
  - Pave it fast
  - Time counts
  - or
  - Be ready to lose significant rehabilitation opportunities
- After that message, over 100 trial projects were completed in US under SP 201.

HIPERPAV

How did it start?

**SP 201 (Fast-track) Findings**

- Very positive results with two major concerns:
  1. What value to open to traffic?
  2. What about temperature management?

HIPERPAV

Fast-track Findings

- Hot mixes; cold days?
- Blankets? Yes? No?
- Thermal shock?
- Curling & warping?
- Strength gain and opening time?
- Saw cutting and cracking?
- Internal stresses?

Paving Operations

- 65°F
- 58°F
- 75°F

8:00 AM
Curing

8:30 AM

HIPERPAV

Environmental Influences

Heat Conduction to/from the subbase

9:00 AM

Overcast Conditions
Solar Radiation
Convection

Set Time

Transition from Plastic To Hardened State

12:00 PM

HIPERPAV

HIPERPAV

Peak Concrete Temperature

Slab Tends to Expand from Set Time up to the Maximum PCC Temperature

4:00 PM

Cooling Begins

PCC Slab Tries to Contract

6:00 PM
Joint Sawing

HIPERPAV

Saw Cut Joints

7:00 PM

Curling

HIPERPAV

Thermal Difference Through the Slab

Cold

11:00 AM

Curling

HIPERPAV

Bottom Expands
Top Contracts: Slab Tends to Curl

Cold

9:00 PM

Curling

HIPERPAV

Slab Weight
Restraints Vertical Movement

9:00 PM

Subbase Restraint

HIPERPAV

Axial and Curling Restraint Lead to Crack Formation at Joints

Formation of Cracks at Joints

12:00 AM

Excessive Restraint

HIPERPAV

As Temperature Decreases, PCC Contraction Continues...

2:00 AM
Early-Age Failure

HIPERPAV

Control Panel

HIPERPAV

Ideal Case

HIPERPAV

Question

HIPERPAV

Well, that's nice...

But, what if the weather is not "ideal"?
Ideal Case

Cold Front

What Now?
Maybe some Blankets?

Cold Front + Blankets

What happens if I have to open to traffic in 24 Hours?
Cold Front + Blankets

Cold Front + Blankets (remove @ 24 hrs.)

Question

Is there another way?

What about a Fast-Track Mix?

Cold Front + Fast-Track Mix

Design Inputs
Mix Design Inputs

Environmental Inputs

Construction Inputs

Outline

- HIPERPAV
- Mix Optimization
- Whitetopping

What is Optimization?

Mix Optimization

- Cost
- Permeability
- Strength
- Stiffness
- Workability
- Plastic Shrink.
- Performance

"Optimum" PCC Mix

- Coarse Aggregate
- Fine Aggregate
- Cement
- Water
- Mineral Admixtures
- Chemical Admixtures
- Fibers
Desirability Functions

Mix Optimization

Desirability Functions

Mix Optimization

Weighting Factors

Mix Optimization

Overall Desirability

Mix Optimization

Outline

- HIPERPAV
- Mix Optimization
- Whitetopping

Outline

- HIPERPAV
- Mix Optimization
- Whitetopping
What is Whitetopping?

- A new concrete pavement surface atop an existing hot-mix asphalt (HMA) pavement.

Why was research needed?

- We understand HMA pavements...

- For example... we know they rut...

What does this research provide?

- Asphalt and Concrete... Working Together!
Why was Research Needed?

We also know they crack...
Whitetopping

Why was Research Needed?

and crack...

We also understand PCC pavements.

Why was Research Needed?

We know they fault...

Why was Research Needed?

We also know they spall...
Why was Research Needed?

And finally... we know they crack...

But do we understand Whitetopping pavements???

Concrete and Asphalt Working Together

How thick do I build it?

- Conventional 8 in. +
- Thin 4 in. to 8 in.
- Ultra-thin (UTW) < 4 in.

How much do I saw?
Whitetopping

How much do I saw?

Whitetopping

How do I prepare the surface?

Do I mill the asphalt?

Do I use a level-up course?

If so, how much?

Whitetopping

Do I need Dowels, Fibers, Tie Bars?

Common Questions...

... requiring practical and reliable answers.

Whitetopping

Materials Characterization Models

Hot-Mix Asphalt (HMA)
Dynamic Modulus
Thank You!!!

www.transtec.us