


**Advanced Pavement Materials, Analysis, and Design**

Concrete Pavement Technology

presented to:


**Midwest Transportation Consortium – Transportation Seminar**  
11 April 2003 – Ames, IA

presented by  
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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**



## Outline

- ✓ **HIPERPAV**
- ✓ **Mix Optimization**
- ✓ **Whitetopping**




## HIPERPAV

What is it?

**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 ....



What is it?

## HIPERPAV

### Assist Engineers and Contractors

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



How did it start?

## HIPERPAV

### 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.



How did it start?

## HIPERPAV

### SP 201 (Fast-track) Findings

Very positive results with two major concerns:

1. What value to open to traffic?
2. What about temperature management?



How did it start?

## HIPERPAV

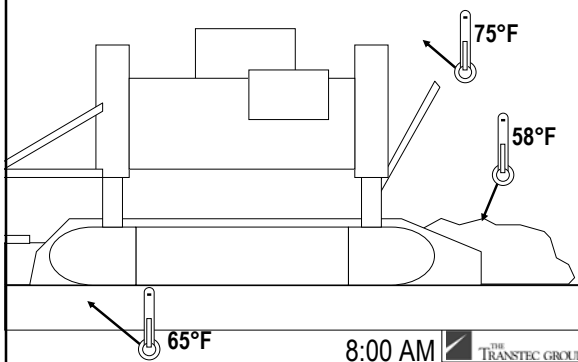
### Fast-track Findings

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



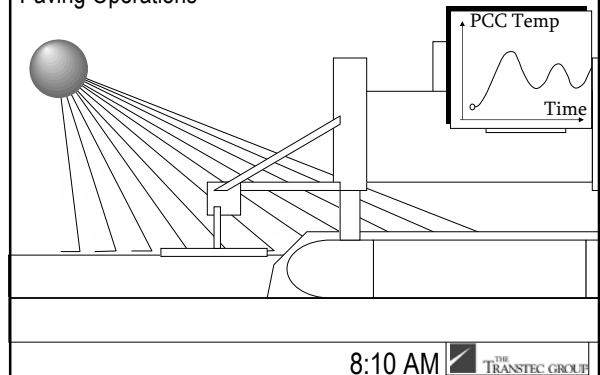
Paving Operations

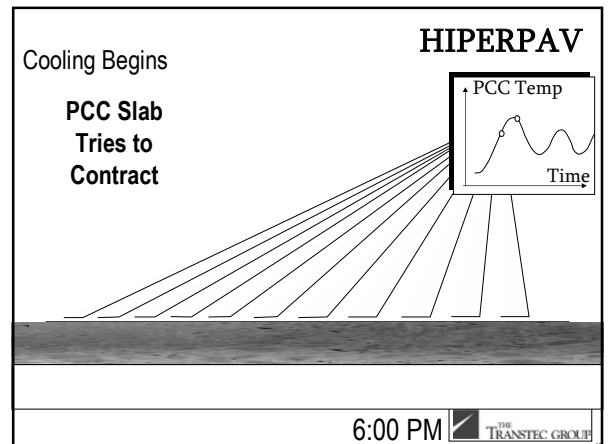
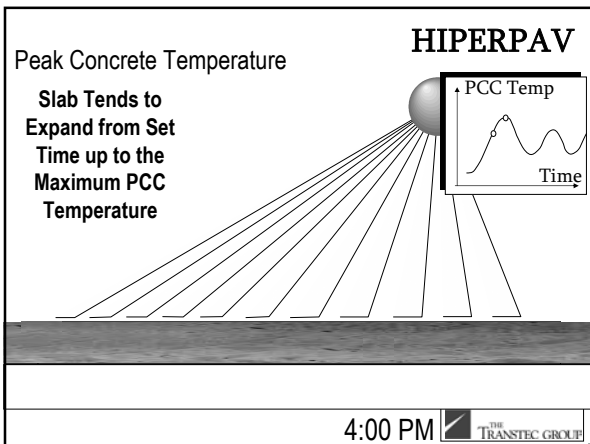
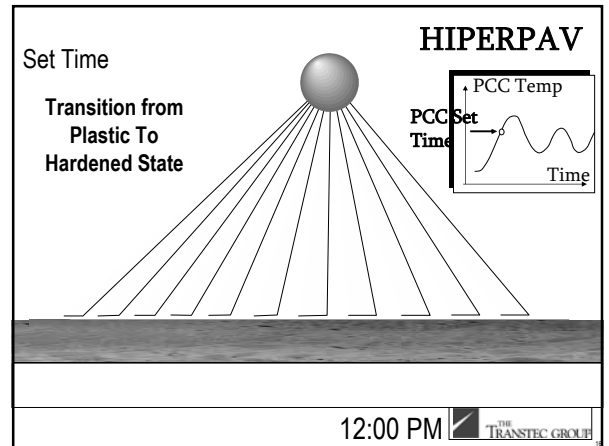
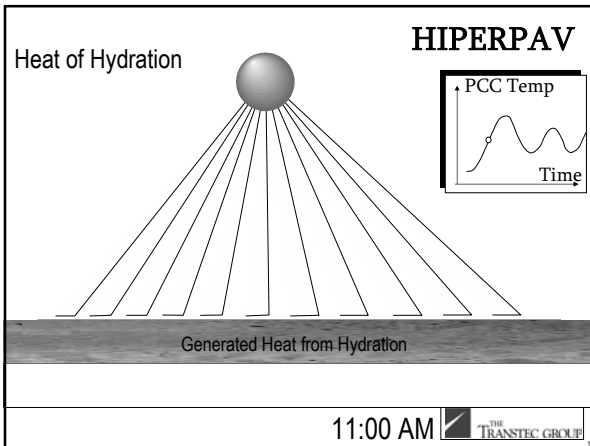
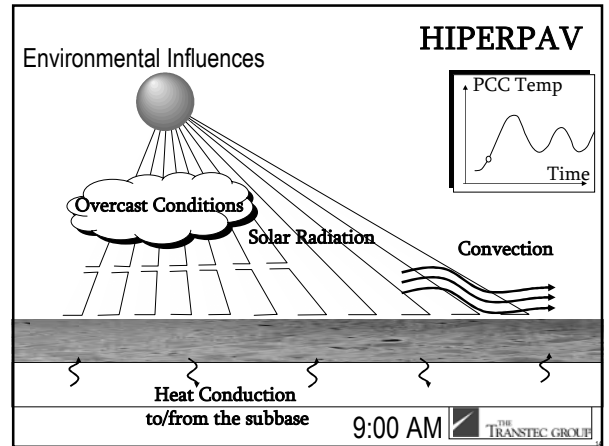
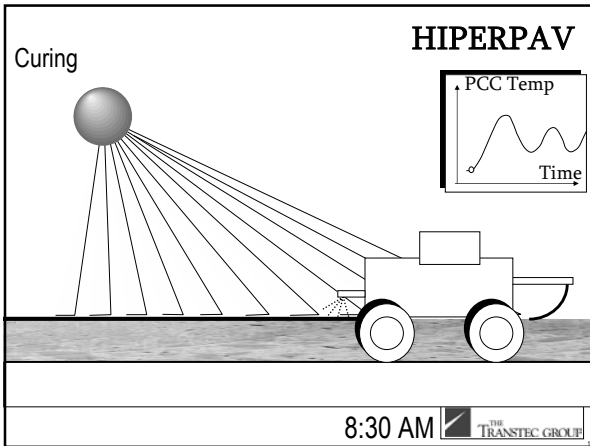
## HIPERPAV

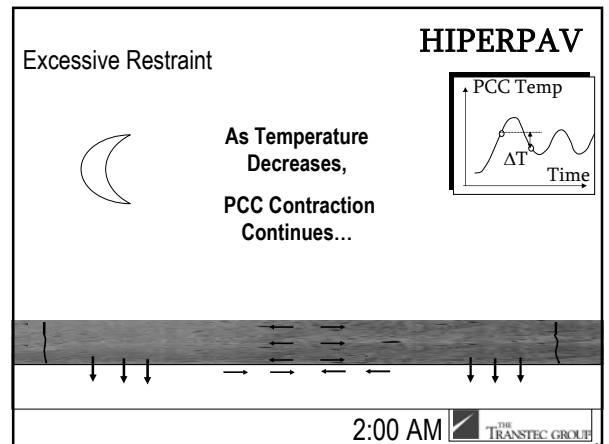
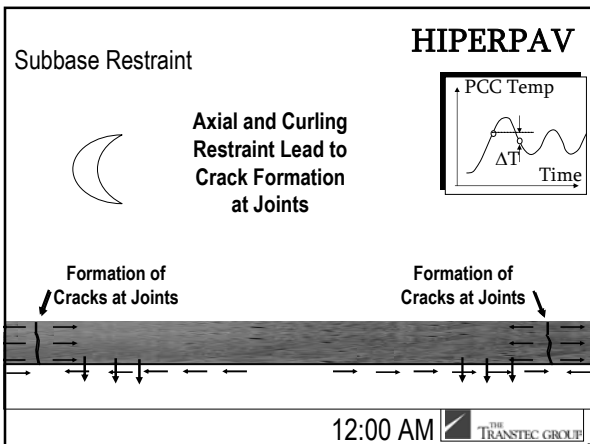
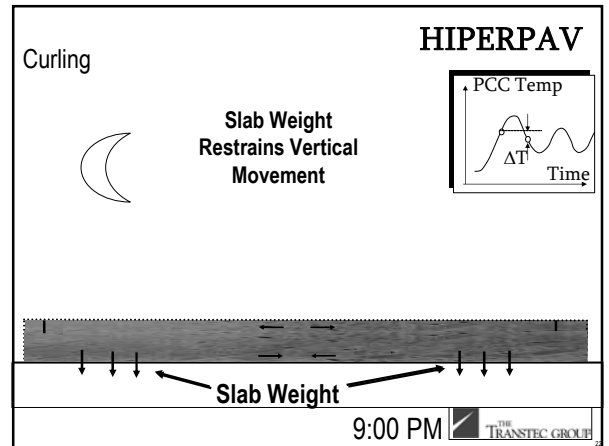
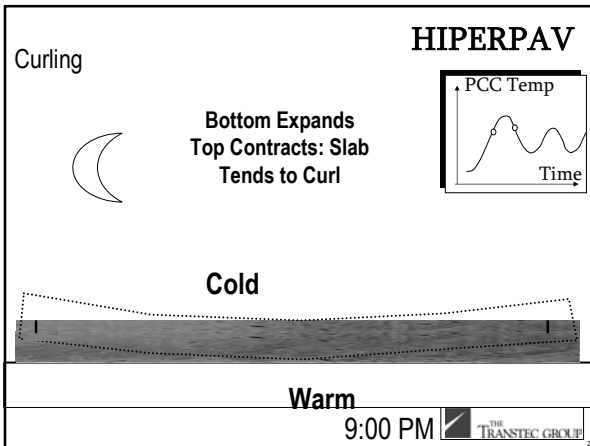
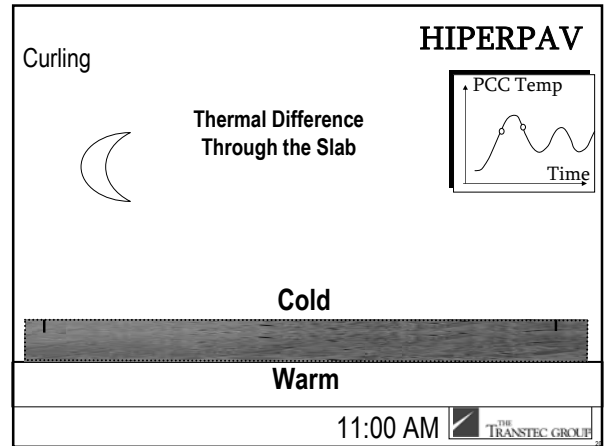
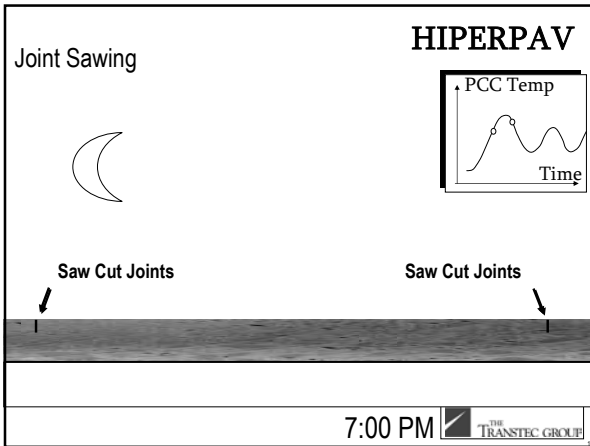


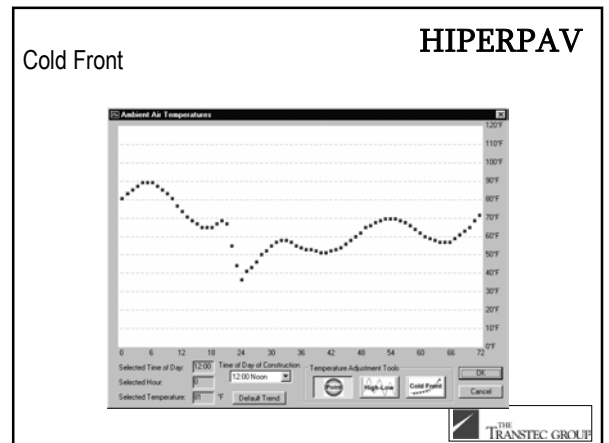
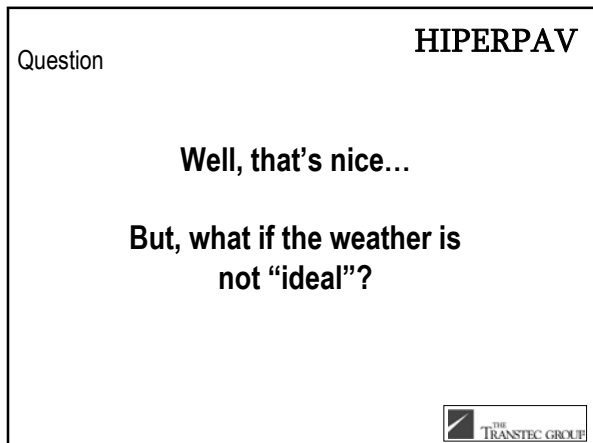
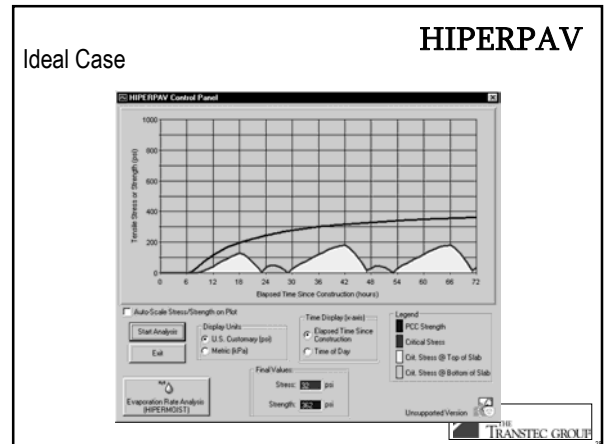
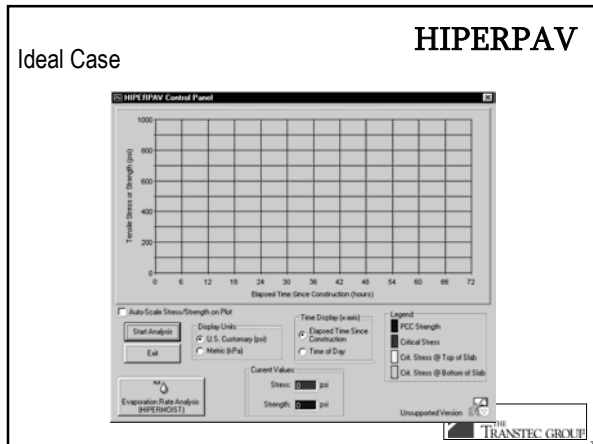
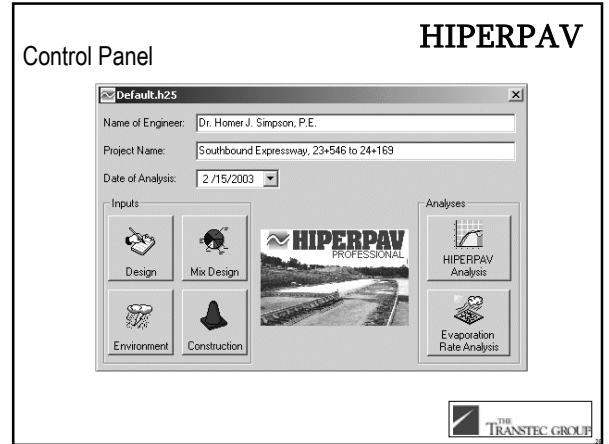
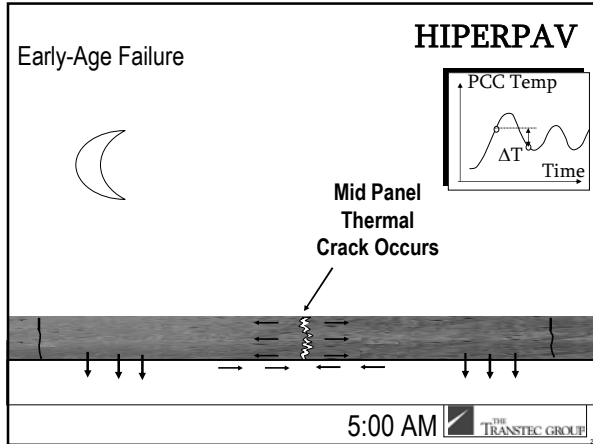
Paving Operations

## HIPERPAV



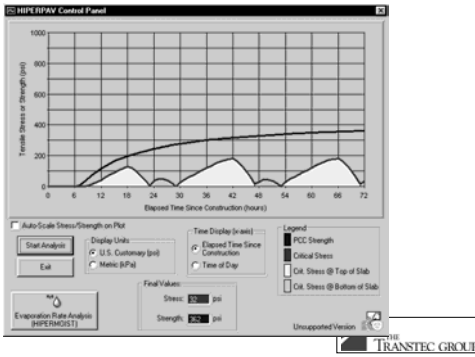






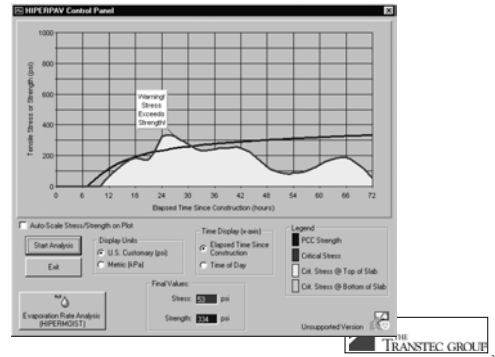
Ideal Case

## HIPERPAV



Cold Front

## HIPERPAV



Question

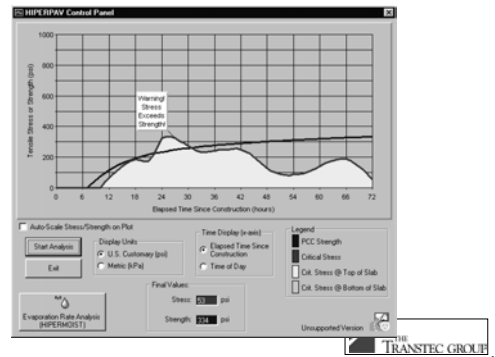
## HIPERPAV

What Now?

Maybe some Blankets?

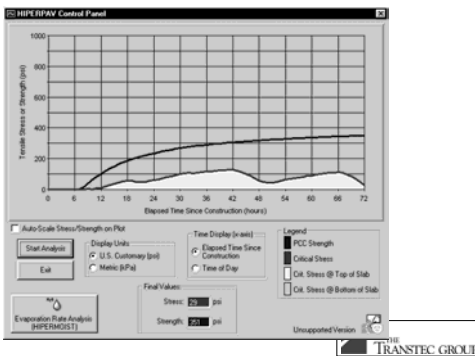
Cold Front

## HIPERPAV



Cold Front + Blankets

## HIPERPAV



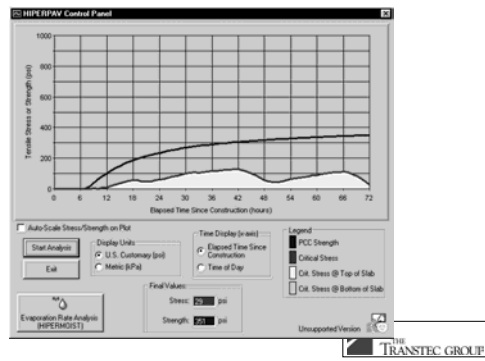
Question

## HIPERPAV

What happens if I have to open to traffic in 24 Hours?

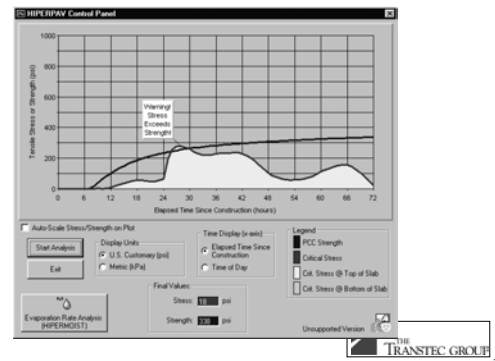
Cold Front + Blankets

## HIPERPAV



Cold Front + Blankets (remove @ 24 hrs.)

## HIPERPAV



Question

## HIPERPAV

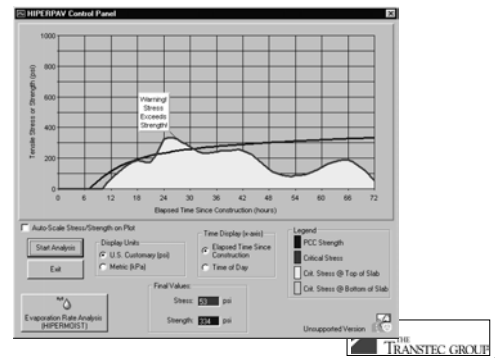
Is there another way?

What about a  
Fast-Track Mix?



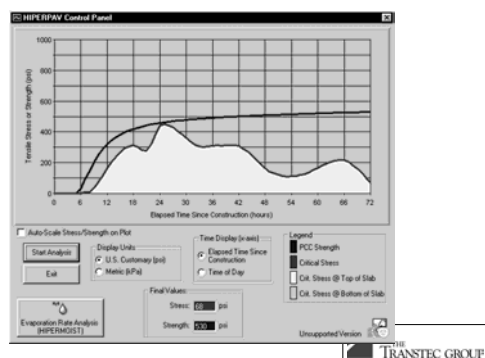
Cold Front

## HIPERPAV



Cold Front + Fast-Track Mix

## HIPERPAV



Design Inputs

## HIPERPAV

The JCP General Design Parameters dialog box contains the following fields and values:

- Geometry:**
  - Transverse Joint Spacing: 15 feet
  - Lane Width: 12 feet
  - Slab Thickness: 10 inches
  - Reliability Level: 90 %
- Laboratory Testing:**
  - Laboratory 28-Day PCC Indirect Tensile Strength (per ASTM C-496): 520 psi
  - Laboratory 28-Day Modulus of Elasticity (E): 5000000 psi
- Subbase Properties:**
  - Subbase Type: Flexible (Unbound Aggregate)
  - Use Default Slab-Subbase Friction? Yes
  - No. Use Friction Force: 2 psi
  - Movement at Sliding: 0.02 inches



## Mix Design Inputs

## HIPERPAV

**JCP Mix Design Parameters**

Cement Type:

Use Default Strength Gain? ☒ Yes ☐ No, Use Laboratory Maturity Data:

Use Default Heat of Hydration? ☒ Yes ☐ No, Use Cement Chemical Composition Data:

Coarse Aggregate Type:

Concrete Coefficient of Thermal Expansion:

**PCC Mix Volumetrics**

Coarse Aggregate Content:

Fine Aggregate Content:

Water Content:

Cement Content:

Silica Fume Content:

Class C Fly Ash Content:

Class F Fly Ash Content:

Ground Slag Content:

**PCC Volumetrics**

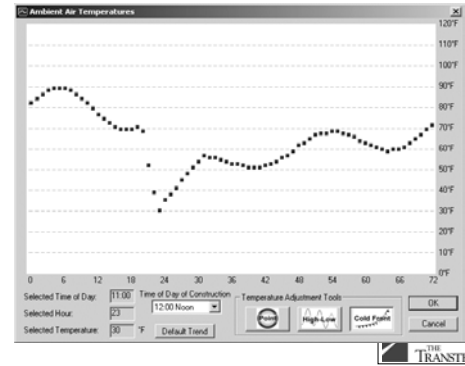
Chemical Additives:

☒ Water Reducer ☐ Retarder

☐ Super Water Reducer ☐ Accelerator

## Environmental Inputs

## HIPERPAV



## Construction Inputs

## HIPERPAV

**JCP Construction Parameters**

Time of Day of Construction:

Temperatures

Initial PCC Mix Temperature:

Initial Subbase Temperature:

Curing

Curing Method:

Age at Application of Curing:

Age at Removal of Curing:

Sawcutting Times

Age at Sawcutting:

"Skip" Sawing?:

Age at Sawcutting of Skipped Joints:

- ✓ HIPERPAV
- ✓ Mix Optimization
- ✓ Whitetopping

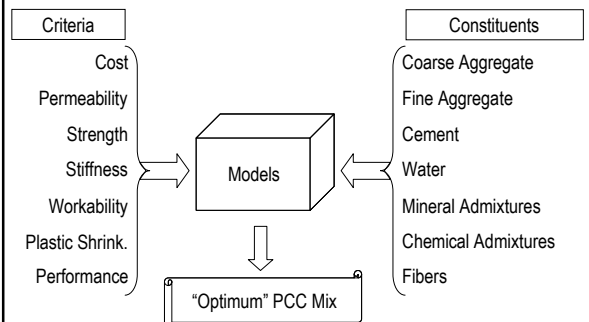
## Outline

## Outline

- ✓ HIPERPAV
- ✓ Mix Optimization
- ✓ Whitetopping

## What is Optimization?

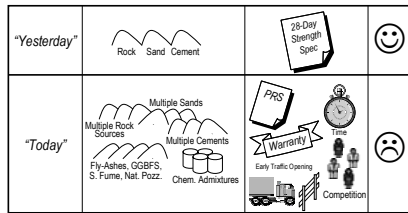
## Mix Optimization





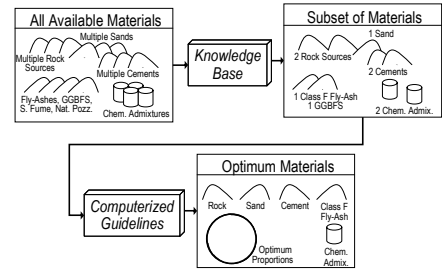
## Mix Optimization

### Mixes – Yesterday and Today



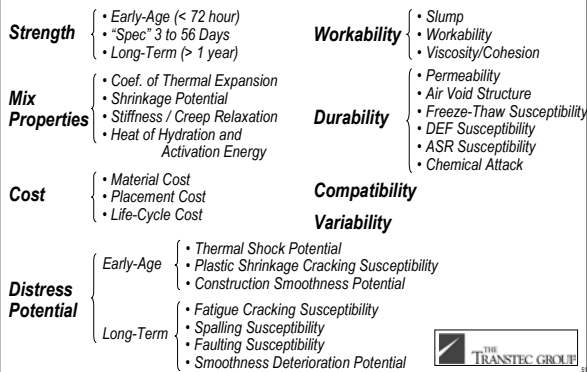
## Mix Optimization

### Refining our Choices



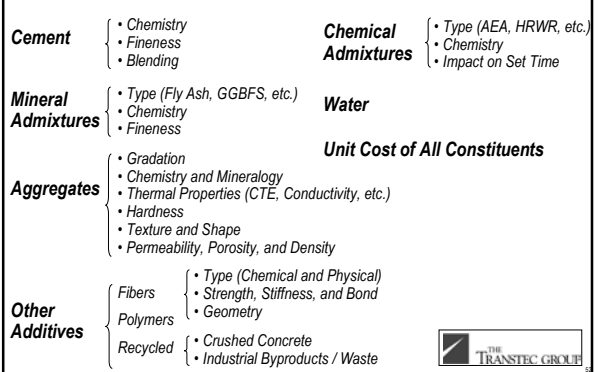
## Mix Optimization

### Property / Performance Targets



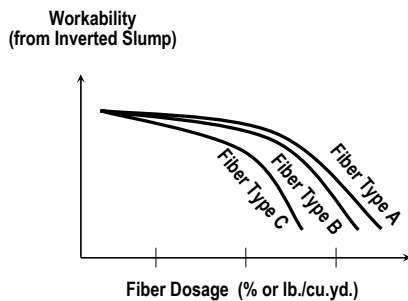
## Mix Optimization

### Materials Properties and Cost



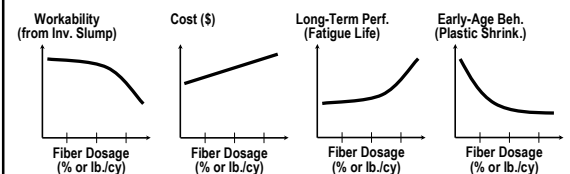
## Mix Optimization

### Material-Target Functions



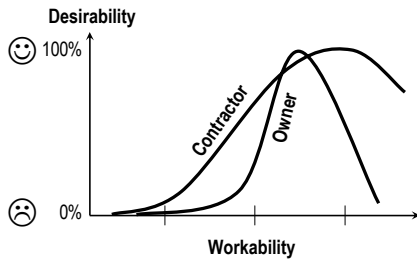
## Mix Optimization

### Material-Target Functions



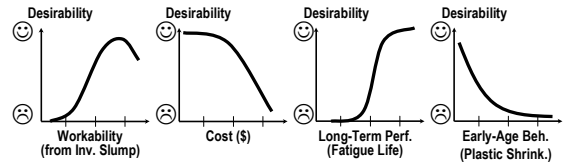
## Desirability Functions

## Mix Optimization



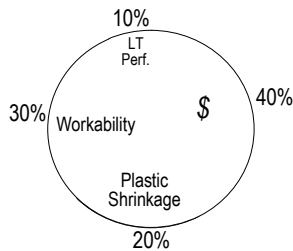
## Desirability Functions

## Mix Optimization



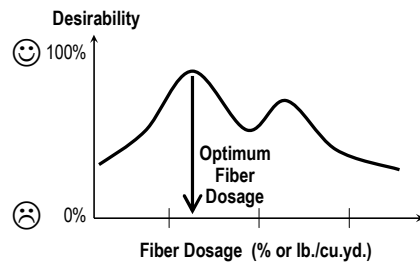
## Weighting Factors

## Mix Optimization



## Overall Desirability

## Mix Optimization



## Outline

- ✓ HIPERPAV
- ✓ Mix Optimization
- ✓ Whitetopping



## Outline

- ✓ HIPERPAV
- ✓ Mix Optimization
- ✓ Whitetopping



## Whitetopping

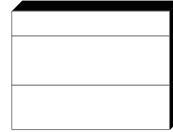
- *What is it?*
- *Why was research needed?*
- *What does this research provide?*



## Whitetopping

*What is it?*

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



## Whitetopping

*What is it?*

*Asphalt and Concrete...  
Working Together!*



## Whitetopping

*Why was Research Needed?*

*We understand HMA pavements...*



## Whitetopping

*Why was Research Needed?*

*For example... we know they rut...*



## Whitetopping

*Why was Research Needed?*

*and rut...*



**Whitetopping**  
***Why was Research Needed?***  
***and rut...***



**Whitetopping**  
***Why was Research Needed?***  
***and rut...***



**Whitetopping**  
***Why was Research Needed?***  
***and rut...***



**Whitetopping**  
***Why was Research Needed?***  
***and rut...***



**Whitetopping**  
***Why was Research Needed?***  
***We also know they crack...***



**Whitetopping**  
***Why was Research Needed?***  
***and crack...***



**Whitetopping**  
***Why was Research Needed?***  
***and crack...***



**Whitetopping**  
***Why was Research Needed?***  
***We also understand PCC pavements***



**Whitetopping**  
***Why was Research Needed?***  
***We know they fault...***



**Whitetopping**  
***Why was Research Needed?***  
***We know they fault...***



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



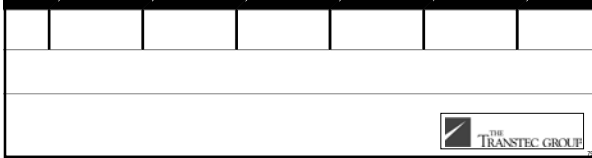
**Whitetopping**  
***Why was Research Needed?***  
***We also know they spall...***



## Whitetopping

### Why was Research Needed?

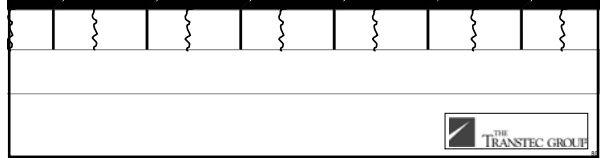
*And finally... we know they crack...*



## Whitetopping

### Why was Research Needed?

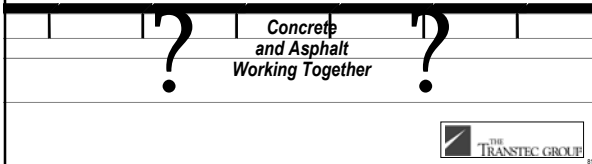
*And finally... we know they crack...*



## Whitetopping

### Why was Research Needed?

*But do we understand Whitetopping pavements???*



## Whitetopping

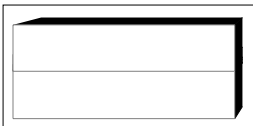
*Common Questions...*



## Whitetopping

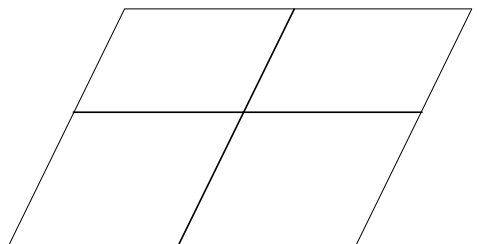
*How thick do I build it?*

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



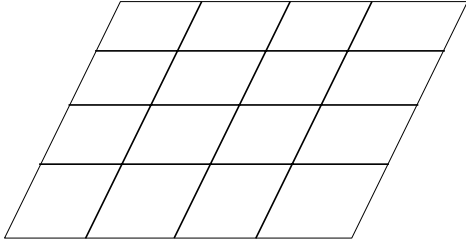
## Whitetopping

*How much do I saw?*



## Whitetopping

*How much do I saw?*



## Whitetopping

*How do I prepare the surface?*

*Do I mill the asphalt?*

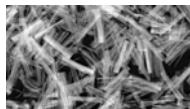
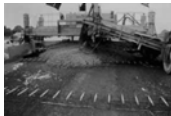
*Do I use a level-up course?*

*If so, how much?*



## Whitetopping

*Do I need Dowels, Fibers, Tie Bars?*



## Whitetopping

*Common Questions...*

*... requiring practical and reliable answers.*



## Whitetopping

Materials Characterization Models

Hot-Mix Asphalt (HMA)  
Dynamic Modulus



## Whitetopping



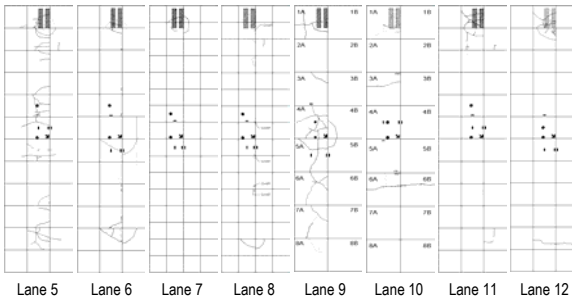
## Whitetopping



## Whitetopping



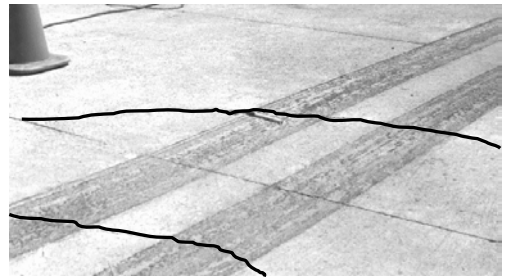
## Whitetopping



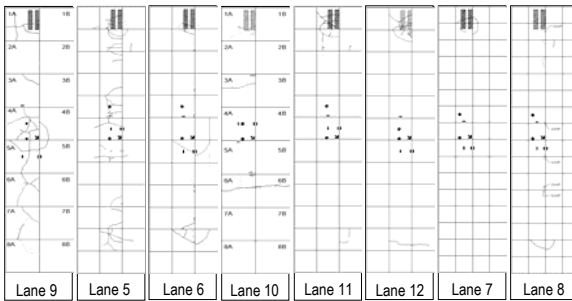
Lane 5 Lane 6 Lane 7 Lane 8 Lane 9 Lane 10 Lane 11 Lane 12



## Whitetopping



## Whitetopping



Lane 9 Lane 5 Lane 6 Lane 10 Lane 11 Lane 12 Lane 7 Lane 8



## Whitetopping

Lane 9  
Lane 5  
Lane 6  
Lane 10  
Lane 11  
Lane 12  
Lane 7  
Lane 8

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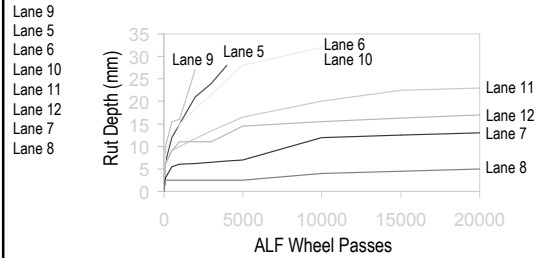




## Whitetopping



## Whitetopping



## Whitetopping

Lane 9  
Lane 5  
Lane 6  
Lane 10  
Lane 11  
Lane 12  
Lane 7  
Lane 8

Lane 9   Lane 5   Lane 6  
Lane 10

Lane 11  
Lane 12  
Lane 7  
Lane 8



## Whitetopping

Lane 9  
Lane 5  
Lane 6  
Lane 10  
Lane 11  
Lane 12  
Lane 7  
Lane 8

Lane 9  
Lane 5  
Lane 6  
Lane 10  
Lane 11  
Lane 12  
Lane 7  
Lane 8



## Whitetopping

Lane 9  
Lane 5  
Lane 6  
Lane 10  
Lane 11  
Lane 12  
Lane 7  
Lane 8

Lane 9  
Lane 5  
Lane 6  
Lane 10  
Lane 11  
Lane 12  
Lane 7  
Lane 8



## Whitetopping

Most-to-Least  
Slab Cracking

Lane 9 = Lane 9	✓
Lane 5 = Lane 5	✓
Lane 6 = Lane 6	✓
Lane 10 = Lane 10	✓
Lane 11 = Lane 11	✓
Lane 12 = Lane 12	✓
Lane 7 = Lane 7	✓
Lane 8 = Lane 8	✓

Most-to-Least  
HMA Rutting

*i Holy Frijoles!*





Thank You!!!

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