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"Count on Concrete for Performance"

Defining the Attributes of Well-Performing Long-Lasting Jointed Portland Cement Concrete Pavements

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Outline

- Introduction
- Research Objective
- Data Collection
- Data Analysis
- Proposed Future Research
- Summary

Introduction

- The interaction between the concrete pavement structure and pavement foundation is very complex, and due to such nature of the pavement systems, more research is needed in this area to identify the common characteristics of long-lasting and well-performing JPCPs

Introduction

- In Iowa and across the nation, there are pavements that were built more than 20 years ago continuing to provide very good service to the public
- Need to learn what went into those pavements

Long Life Concrete Pavements: One of the research tracks in the CP Road Map

Introduction

The Concrete Pavement (CP) Road Map is a comprehensive and strategic plan for concrete pavement research that will guide the investment of research dollars for the next several years.

In short, the CP Road Map will result in a new generation of concrete pavements for the 21st century.

Introduction

CP Road Map: Long Life Concrete Pavements

Long Life Concrete Pavements Track : The need for pavements that last longer between maintenance, restoration, or rehabilitation is integrated throughout the CP Road Map. However, this track draws attention to some specific research that may address pavement life approaching 60 years or more.

Introduction

CP Road Map: Long Life Concrete Pavements

- Develop clear and detailed definitions of long-life pavements
- Identify pavement strategies for long life
- Identify design and foundation features that are likely to result in long-life concrete pavements
- Identify restoration treatments for preserving long-life concrete pavements

Introduction

CP Road Map: Long Life Concrete Pavements

- Identify concrete and other material tests and requirements for long-life pavements
- Identify QC/QA procedures that will ensure quality long-life pavement construction
- Construct test highways of the most promising concrete pavement types that include features that will ensure long-life concrete pavements

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Research Objective

- The objective of this research was the analysis of existing state, county, and city route pavement records in Iowa to determine what design characteristics, materials, and operational characteristics contributed to the long-lasting performance of the concrete pavements that are still in operation.

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Data Collection

- Review of the Iowa Department of Transportation (Iowa DOT) Pavement Management (local and state) records for well-performing concrete pavements
  - Subset of sample for field and office review of project records
- Survey of the counties and cities for examples of well-performing pavements
  - 6 Iowa DOT District Offices, 99 counties, and some 40 cities of over 5,000 population
- Well-performing pavements: less than 10% patched slabs or joints, acceptable ride quality, and minimal maintenance costs.

Data Collection
Initial Contact Form

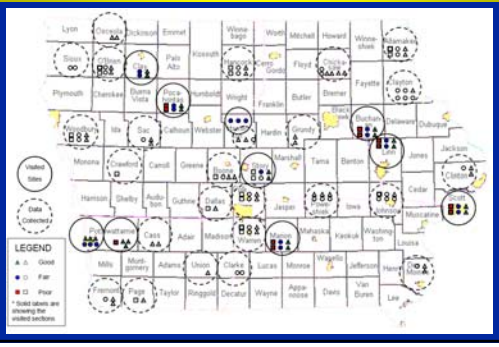
- Geographical project location (route and termini)?
- Pavement age (years)?
- Type of concrete pavement (doweled or not)?
- Pavement width (feet)?
- Pavement depth (inches)?
- Base type (granular, stabilized, none)?
- Pavement joint spacing (feet)?
- Shoulder surface type (ACC, PCC, granular, earth)?
- No. of traffic lanes in each direction?

Data Collection
Initial Contact Form

- Transverse joint angle (skewed, rectangular)?
- Current traffic volume (ADT and %trucks)?
- Current surface condition (good, poor)?
- Are material and pavement construction records available (yes, no)?
- Of the pavements reported in this survey please rank this pavement in terms of performance (1 – best, to 6 – poorest performing)

Upon data collection, a field survey was conducted to obtain detailed pavement information (53 pavement sections)

Data Collection
Research Sites



Data Collection
Detailed Form for Selected Sites

- Pavement design information
  - Project location, functional class, type, design life, pavement construction date, design procedure used, etc.
- Pavement performance information
  - Slab cracking, patching, IRI, faulting, occurrences of pumping, and other pavement distresses (D-cracking, ASR, etc.)?

Data Collection
Detailed Form for Selected Sites

- Soils testing and classification
  - Subgrade, subbase/base: Type, Mr, CBR, DCP, QC/QA testing, etc.
- PCC layer
  - Geometric properties, joint design, compressive strength, MOR, CTE, etc.
- PCC mix design information (%air voids, w/c ratio, use of SCMs, aggregate type, gradation, cement chem., etc.)
- Traffic information
- Climatic information

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Data Analysis

- Survey results showed that:
  - There is not much data available for the subgrade and subbase layers
  - The base characteristics, particularly drainability and stability, are very effective on pavement performance
- Limited analysis on the available pavement materials related data showed that
  - The well-performing sections having a rating of 1 or 2 have an average water-to-cement ratio of 0.49, whereas the poorly performing sections with a rating of 5 or 6 have a water-to-cement ratio of 0.55
- Proposed second phase of the project aims to focus on collecting more data on the performance of pavement foundation (subgrade and subbase layers) and PCC materials

Data Analysis

50-year old PCC pavement section – residential street in City of Bettendorf, Iowa

- 6-in. PCC thickness
- 20-ft slab spacing
- Well-draining, stable subbase layer (nearby riverbed material)

Data Analysis

50-year old PCC pavement section – residential street in City of Bettendorf, Iowa
Close-up: exposed aggregates on the pavement surface

Data Analysis

Surface condition of a pavement section from Marion County, Iowa

- Possible cause of surface deterioration: concrete mix design and construction practices
- Proposed future research: use SEM to investigate the cause of distress

Data Analysis

PCC pavement section in Pocohontas County, Iowa depicting the commonly observed longitudinal cracking in relatively low-volume Iowa roads

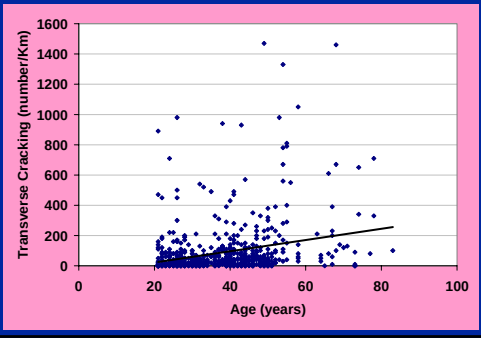
Possible reasons:

- Early-age cracking due to concrete materials, mix design, and construction-related practices
- Heavy agricultural loading and subgrade failure
- Late saw cutting of the longitudinal joints or mal-functioning vibrator

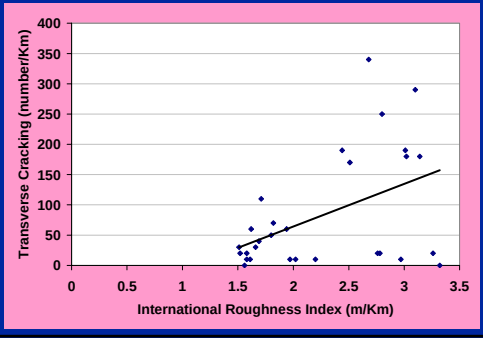
Data Analysis
Pavement Performance

- A brief pavement performance data analysis was conducted for the Iowa primary and Interstate sections during this scoping study

Data Analysis
Pavement Performance: Primary Road Sections



Data Analysis
Pavement Performance: Interstate Road Sections



Data Analysis
Pavement Performance: Summary

- Although there is no distinct relationship between the amount of transverse cracking and the pavement age, cracking tends to increase as the pavements get older
- IRI values increase with higher amounts of transverse cracking in pavement sections
- Both primary and interstate databases contain pavement sections with varying levels of performance (ranging from poorly to well-performing)
  - But, all sections have been in service for more than 20 years, well beyond the pavement design life

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Proposed Future Research

- Selection of candidate projects for in-depth study
- Field survey and data collection
  - DCP, Shelby core samples from subbase and subgrade layers for lab analysis
  - concrete cores for MARL-SEM analysis
  - longitudinal profile of the sample pavement
  - Use one portion of the tested sample pavements for analysis and the second portion for calibration of results
- Data analysis
  - SEM analysis of the concrete cores for chemical make-up and air matrix/content
  - Lab analysis of the pavement foundation materials
  - Statistical analysis of the soil, concrete, construction, distress, and maintenance information for developing relationships

Proposed Future Research

- Results calibration
  - Using the second portion of sample pavements, test the conclusions drawn from data analysis
  - Forecast pavement performance using the developed statistical relationships as well as using the new MEPDG
  - Comparison between predicted and actual performance
- Implementation
  - Provide guidelines on optimizing current methods and materials to achieve the best performing pavements for the existing conditions and design requirements
  - Builds on previous SHRP studies on PCC pavement performance
  - Ties in with CP Road Map research tracks on long life concrete pavements, advanced concrete pavement materials, and concrete pavement performance

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Summary

- This scoping study showed that there are many well-performing concrete pavements serving well over 30 years in Iowa
- Available data for those pavements was limited in some cases, but included the following

Summary

- Identification of a matrix of pavements at state and local levels that contains well and poorly performing concrete pavements
- Paving inspection notes and test results
- Mix design and materials information
- Visual distress surveys
- Traffic in terms of AADT and truck percentages
- General description of soils and base construction for the pavements
- Limitations
  - Lack of details on subgrade material types and testing results at construction
  - Lack of profile and pavement structural capacity data over time

Summary

- Proposed future research efforts
  - OBJECTIVE: Clearly identify what pavement attributes provide for pavement performance in excess of 20-30 years, as well as what makes poorly performing pavements fail before the end of their design life
  - Identify well and poorly performing concrete pavements having similar traffic loading in Iowa
  - Select deteriorated and well-performing pavements based on the major distress types such as cracking, faulting, subbase failure, the ride quality, and pavement service life
  - Perform testing starting from the subbase characteristics for both well and poorly performing pavements
  - Analyze gathered data from both well and poorly performing sections

Summary

"Zero-maintenance" Jointed Plain Concrete Pavements is a feasible concept and this will be validated using the detailed data from well-performing concrete pavement sections collected during the second phase of this study (subject to funding)

Long-Life Concrete Pavements
JPCP (Brussels, Belgium)

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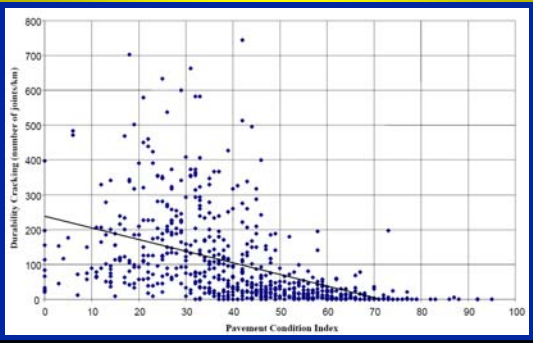
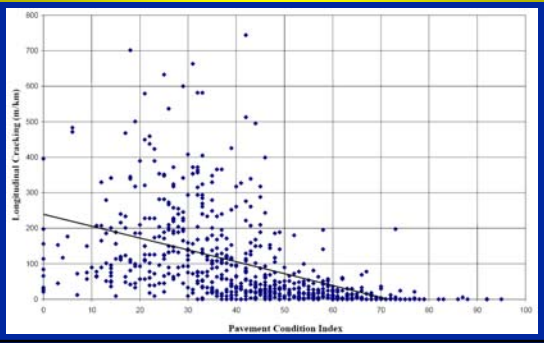
Long-Life Concrete Pavements
CRCP (Belgium)

ADDITIONAL SLIDES

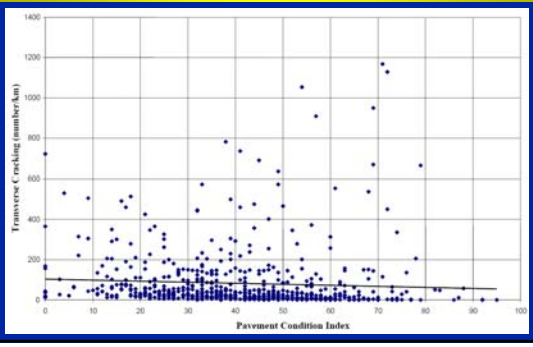
Primary Road Sections
Durability Cracking vs. PCI



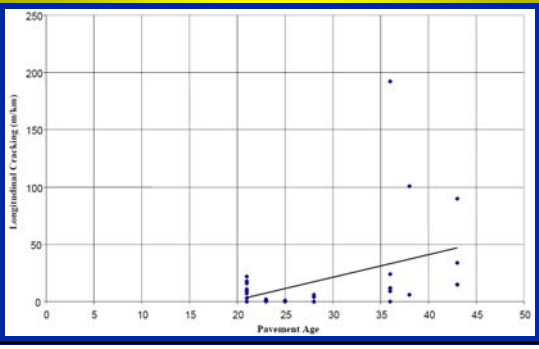
Primary Road Sections
Longitudinal Cracking vs. PCI



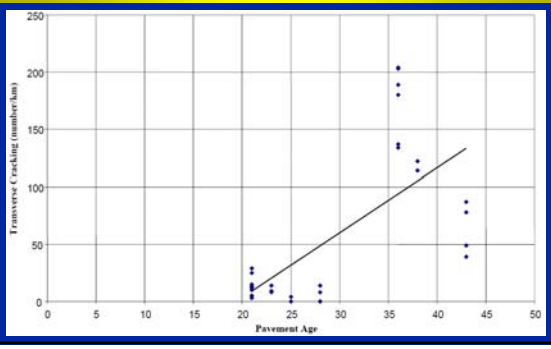
Primary Road Sections
Transverse Cracking vs. PCI



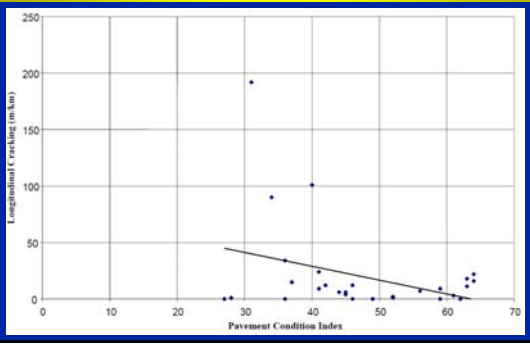
Interstate Road Sections
Longitudinal Cracking vs. Age



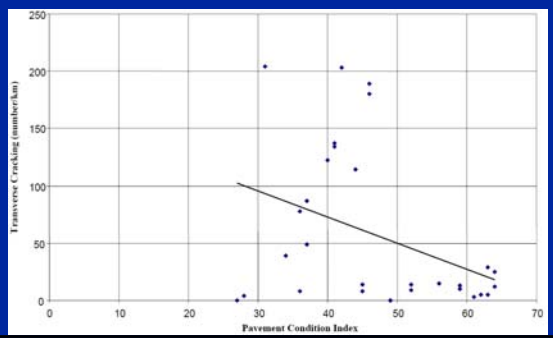
Interstate Road Sections
Transverse Cracking vs. Age



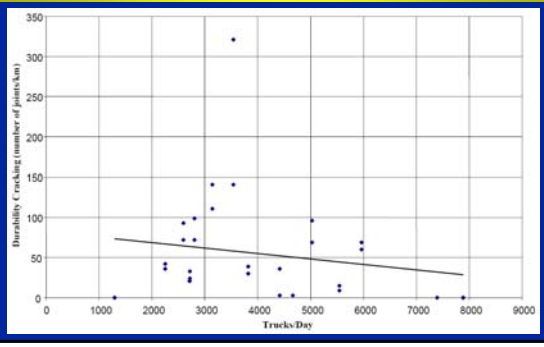
Interstate Road Sections
Longitudinal Cracking vs. PCI



Interstate Road Sections
Transverse Cracking vs. PCI



Interstate Road Sections
Durability Cracking vs. Trucks/Day



Interstate Road Sections
Transverse Cracking vs. Trucks/Day