Long Life PCC Pavements

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The Basic Questions

- How do you define long life pavements?
  - Facility type often dictates need for long life pavements
  - Pavement longevity may range from less than 2 years to greater than 60 years

- Can we afford long life pavements?
  - It depends on the ultimate goal for the highway network
  - What is the long-term cost/benefit

- Do we have the technology to build truly long life pavements?
  - YES!!!!
Benefits of Long Life Pavements

- Drastic reduction in “down time” for maintenance and rehabilitation (construction times are not necessarily longer)
- Greatly improved safety (work zone and other)
- Reduced user costs (a predominant feature, if fully considered)
- Improved cost effectiveness
Pavement Selection

- Life Cycle Cost Analysis (LCCA) is typically used to determine whether PCC or AC is the “better choice” for a specific roadway.
- LCCA can also be effectively used to determine appropriate design features.
- Realistic LCCA requires substantial historical data or generic models to evaluate performance and rehabilitation or maintenance requirements.
Deterministic LCCA

- Deterministic LCCA is the more traditional method of LCCA.
- This method assumes that the timing of maintenance and rehabilitation is well known and can be targeted for a specific project.
- It also assumes that the costs to perform these activities are known with a high level of certainty.
- Is this applicable to long life pavements?
Probabilistic LCCA

- Probabilistic LCCA is an “improved” version of the deterministic method.
- The timing and costs associated with performing maintenance and rehabilitation activities are considered statistically.
- In other words, instead of assuming the future is known with certainty, the most probable scenario is analyzed.
This presentation is focused on developing long-life design alternatives and the selection of PCC design features.

The information presented is meant to provide insight into the process.

The relative values shown should not be used in actual practice, they are for illustration only.
What are We Building?
Is it Cost Effective?
Design Optimization

Cost  Performance
Potential Savings

PERCENT OF PROJECTS REHABILITATED

Design Life

Premature Failures

TIME

Desirable

Observed Performance (Current Designs)
Concrete Pavement Design Requires Selection of Appropriate Features

- Subgrade modification
- Drainage System
- Subbase
- Joint Spacing
  - 20 ft (6.1 m)
  - 15 ft (4.3 m)
- Dowels
- Thickness
  - 8 in (200 mm)
  - 10 in (250 mm)
  - 12 in (300 mm)
- Reinforcement
- Joint Sealant
  - None
  - Hot pour
  - Silicone
  - Preformed
- Surface Texture
  - Transverse tine
  - Burlap drag
- Shoulder
  - Asphalt
  - Concrete
Law of Diminishing Returns

Pavement Performance vs. Construction Cost
Cost - Performance Balance

- Initial construction cost
- Budget constraints
- Life-cycle cost
For Each Added Design Feature
Contractor Survey

A survey was conducted to determine and document, in relative terms, the effects of various PCC pavement design features on initial pavement cost.
Contractors Surveyed
Reference Section

- Transverse joints: 20 ft (6.1 m) uniform with no skew and no dowels
- Single-width saw cut to 3/8 in. (75 mm) with hot-poured filler
- Lanes: 12 ft (3.6 m); tied with #4 deformed bars 30 in. (75 mm) centers
- Subgrade prepared by scarifying to depth of 6 in. (150 mm) and recompacting at optimum moisture content.

Relative Cost = 100
Survey Instructions

- Base on common circumstances and conditions
- Project 5 miles (8 km) long and within 50 miles (80 km) of home office
- Assume typical materials and construction procedures by state DOT
- Existing grade and alignment is adequate - no earthwork
Features

- Slab Thickness
- Subbase Type
- Shoulders
- Reinforcement
- Joint Spacing
- Transverse Joint Load Transfer
- Transverse Joint Sealant
Slab Thickness

Reference Section:
10 in (250 mm) thick
20 ft (6.1 m) joint spacing
Cost = 100

Average Relative Cost

- 6 in (150 mm) thick 12 ft (3.7 m) joint spacing
- 8 in (200 mm) thick 15 ft (4.6 m) joint spacing
- 12 in (300 mm) thick 20 ft (6.1 m) joint spacing
Subbase Type

Average Relative Cost

Reference Section:
6 in (150 mm) thick dense-graded subbase
Cost = 100
**Shoulders**

Reference Section: Gravel shoulders on 6 in (150 mm) granular subbase  
Cost = 100

**Average Relative Cost**

- **Asphalt on Granular 6 in/6 in (150mm/150 mm)**: 111
- **Widened Lane & Asphalt**
- **PCC on Granular 6 in/6 in (150 mm/150 mm)**: 124
- **Full-Depth PCC**: 132
Transverse Joint Design

1 1/2 in (38-mm) Dowels 20 ft (6.1 m) Jt. Spacing
1 1/2 in (38-mm) Dowels 15 ft (4.6 m) Jt. Spacing
CRC - #6 bars @ 8 in (200 mm) spacing

Average Relative Cost

Reference Section: 10 in (250 mm) thick undoweled 20 ft (6.1 m) joint spacing Cost = 100
Transverse Joint Sealant

Reference Section:
Single 3/8 in (75-mm) cut filled with hot-pour sealant
20 ft (6.1 m) joint spacing
Cost = 100

Average Relative Cost

- No sealant
- Silicone sealant in reservoir
- Preformed compression seals
Methods to Determine Cost-Effectiveness

- Experience
- Life-cycle cost analysis
  - Initial cost
  - Future cost
  - Performance
- Benefit/Cost analysis
  - Initial cost
  - Performance
Long Life Concrete Pavement Requirements

- Adequate design thickness and realistic options
  - ME-PDG will facilitate improved designs
  - Materials, support conditions, load transfer, etc. are considered to a greater extent
- Good construction practices
- Realistic expectations considering cost versus performance
Current Long Life Design Features

- Thicknesses up to 14 inches
- Optimized concrete mix design
- Rigid specifications on placement, curing, sawing, etc.
- Widened lanes (or tied concrete shoulders)
- Drainage, stainless dowels, others???
Historical Trends in Longevity

- Concrete pavements have significantly exceeded their design lives in most cases.
- The existing AASHTO design procedure (1972, 1986 and 1993) is very conservative for concrete.
- Many factors not incorporated in the existing design have a significant impact (i.e. strength gain over time, innovative materials and so on).
## Survival Analysis Results - I-

### 40 in OK

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<td>30</td>
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**Note:** Over 50% of PCCP Sections Have Not Failed (>30 Years)

PCCP/ACP = 2.5
Survival Analysis Results

Avg. Mean life

![Bar chart showing survival analysis results with categories for TN, SD*, UT**, OK***, and PCC, JPCP, CRCP, JRCP, ACP, FDACP]
Typical Section in 2001

12 in (300 mm) PCC

Full-depth PCC Shoulders

4 ft (1.2 m) 12 ft (3.6 m) 12 ft (3.6 m) 10 ft (3.0 m)

Prepared Subgrade

4 in (100 mm) Stabilized open-graded subbase on dense-graded subbase (with outlet pipes)

Widened transverse joints with silicone sealant

Increase in construction cost over 1970’s era design = 46%
How much longer will it last?
Summary

- Life-cycle cost analysis is a useful tool to compare design features/sections
- User delay costs appear essential to justify certain design options
- Long life is achievable at reasonable cost
- Attention to detail in design and construction is critical
Questions?