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

Presentation Focus

- 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?

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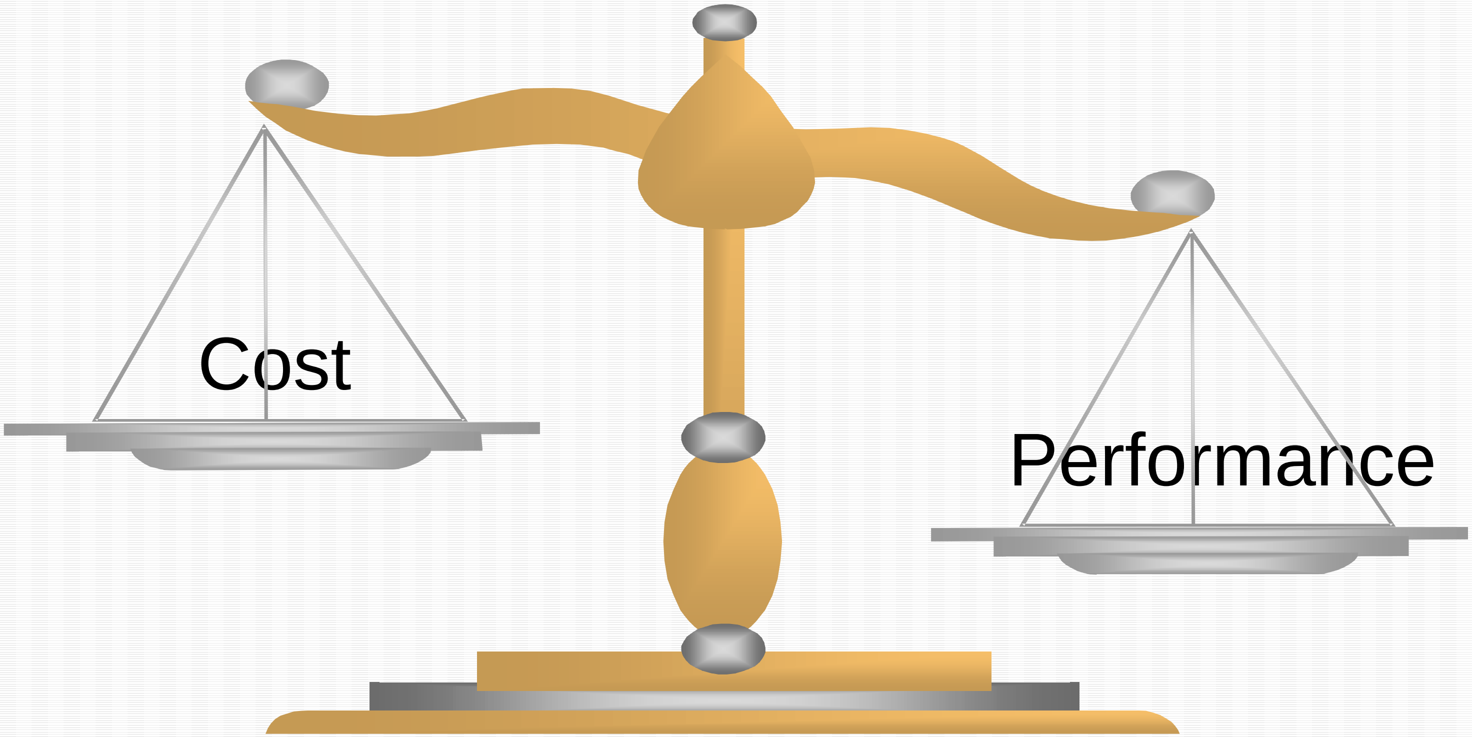
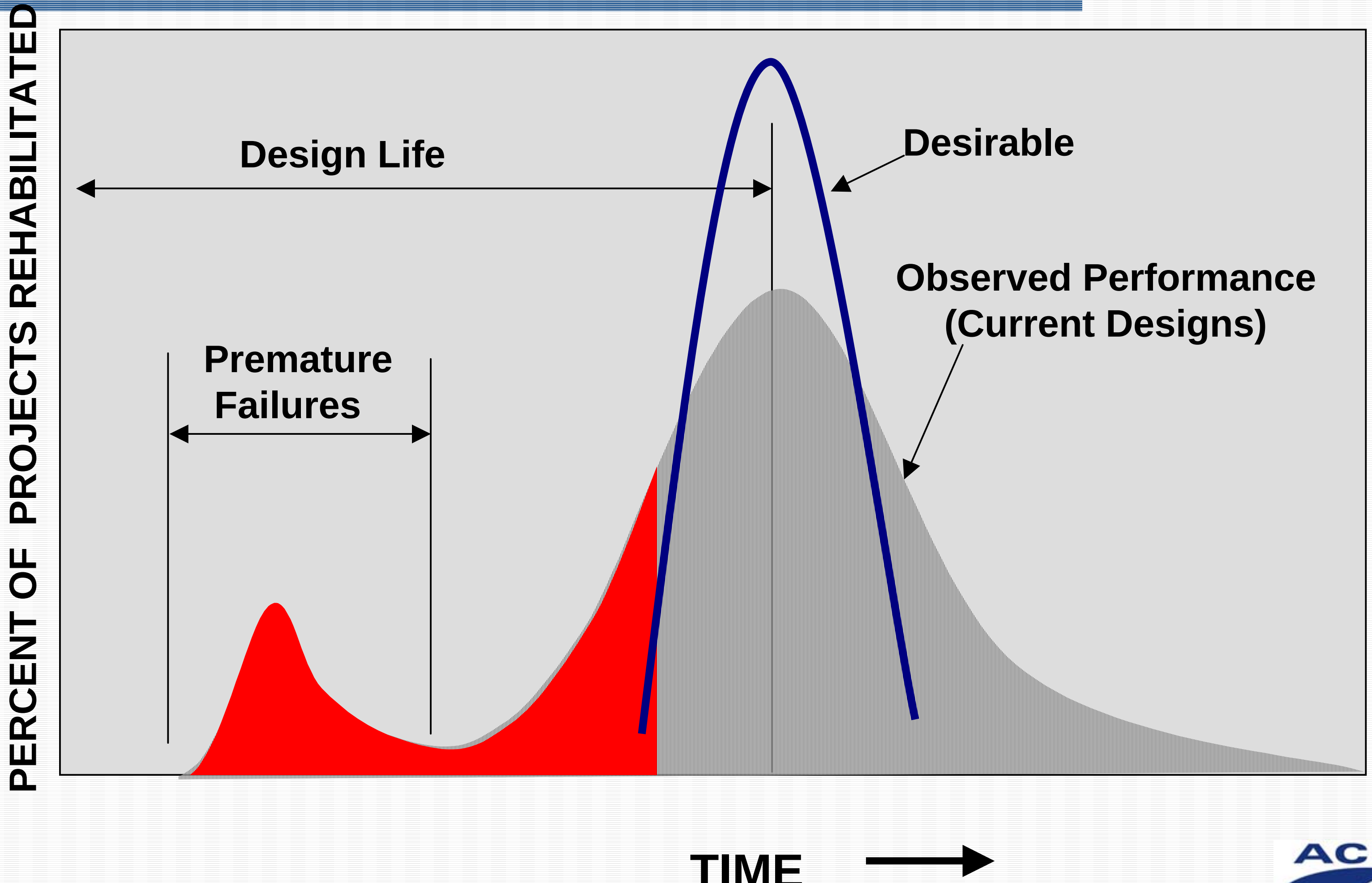
Design Optimization



Potential Savings



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

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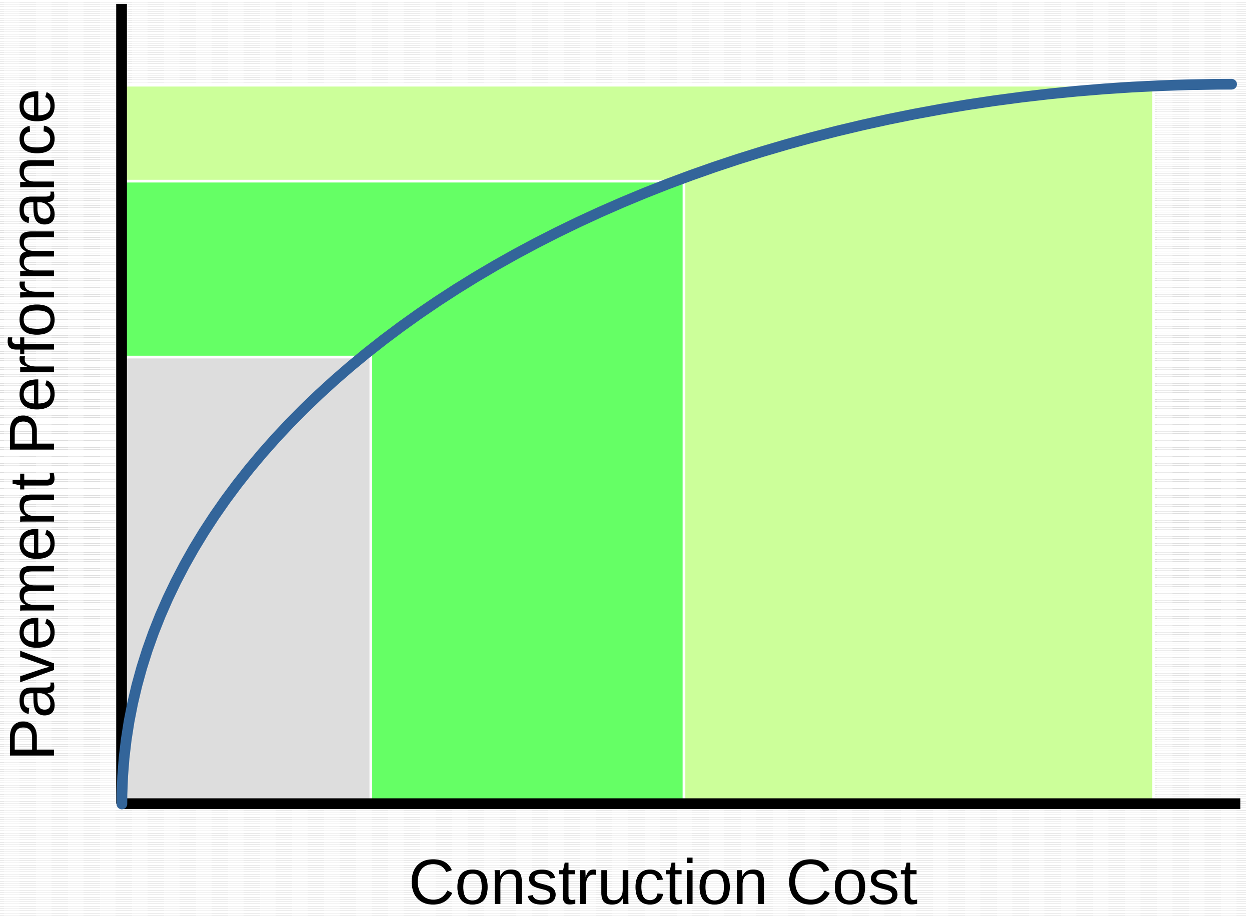
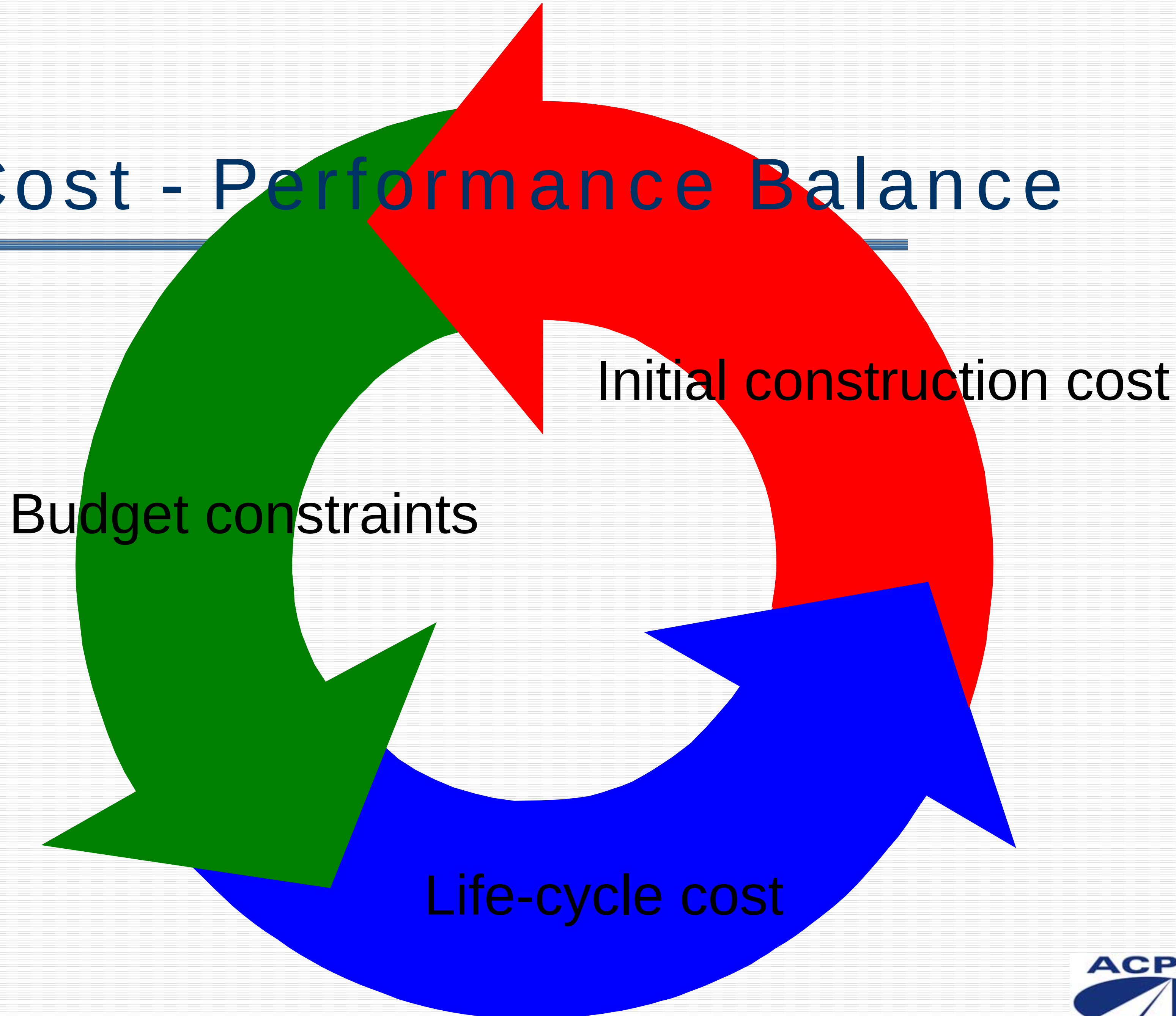
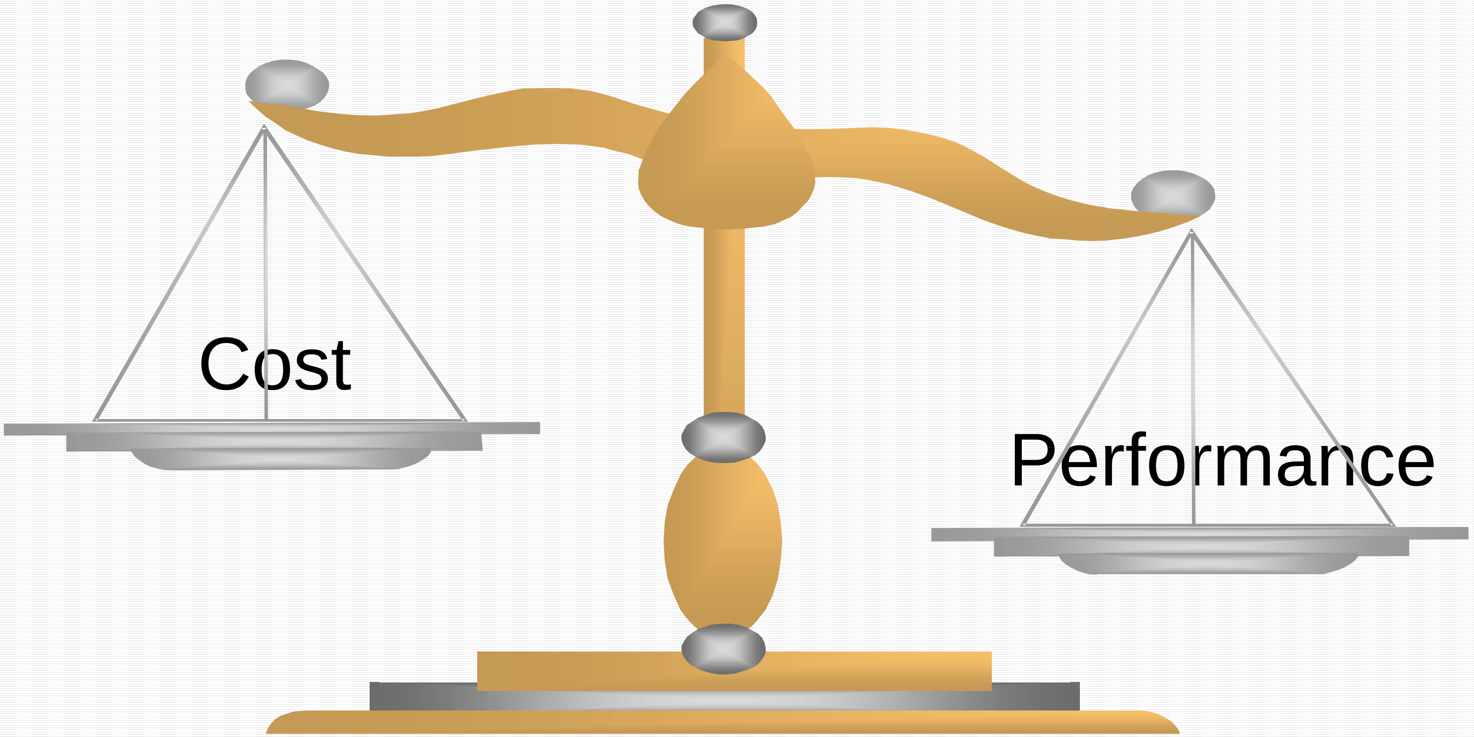
Law of Diminishing Returns



Cost - Performance Balance



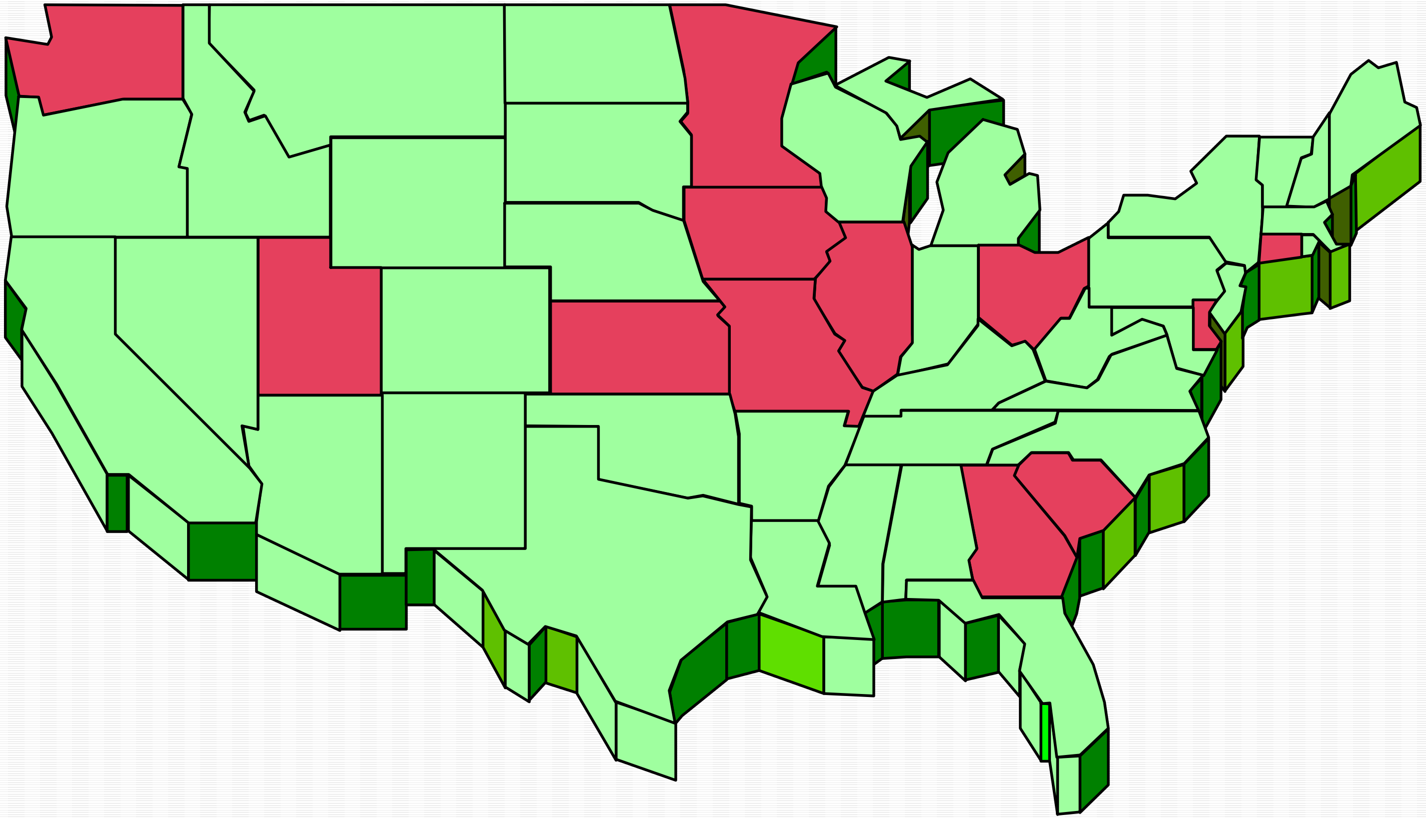
For Each Added Design Feature



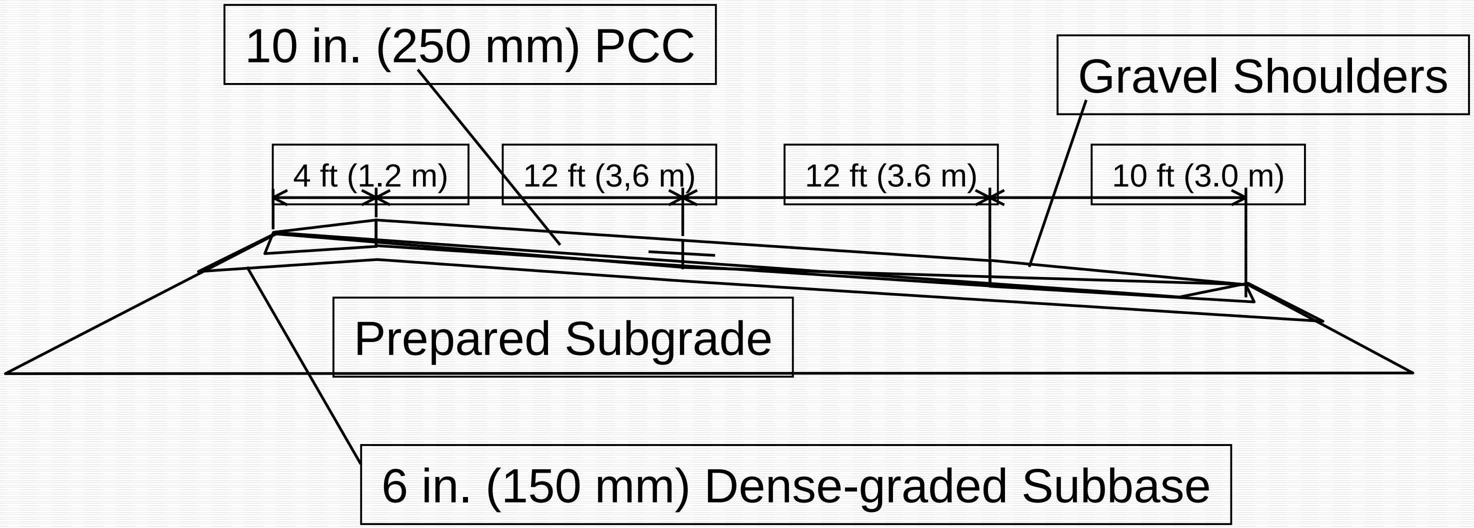
Contractor Survey

A survey was conducted to determine and document, in <u>relative terms</u>, 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

Joint Design

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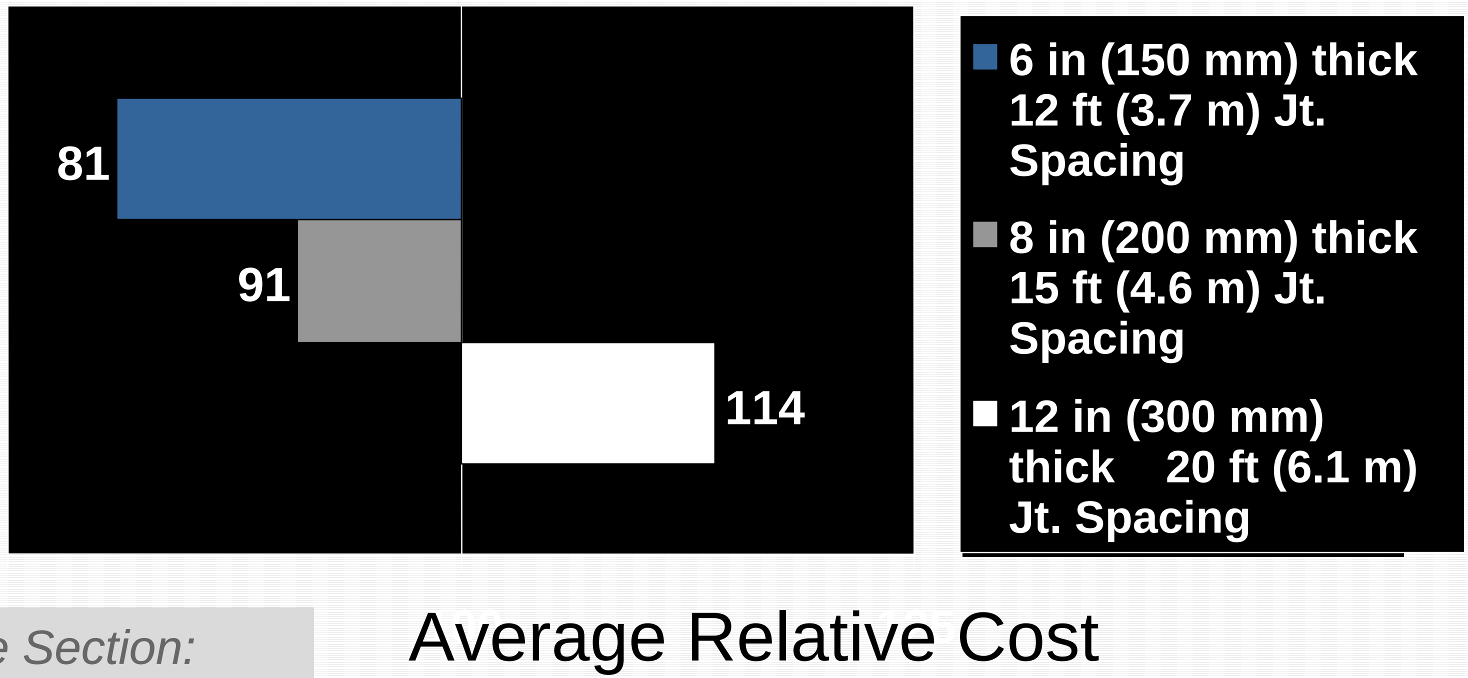
Slab Thickness



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

Subbase Type

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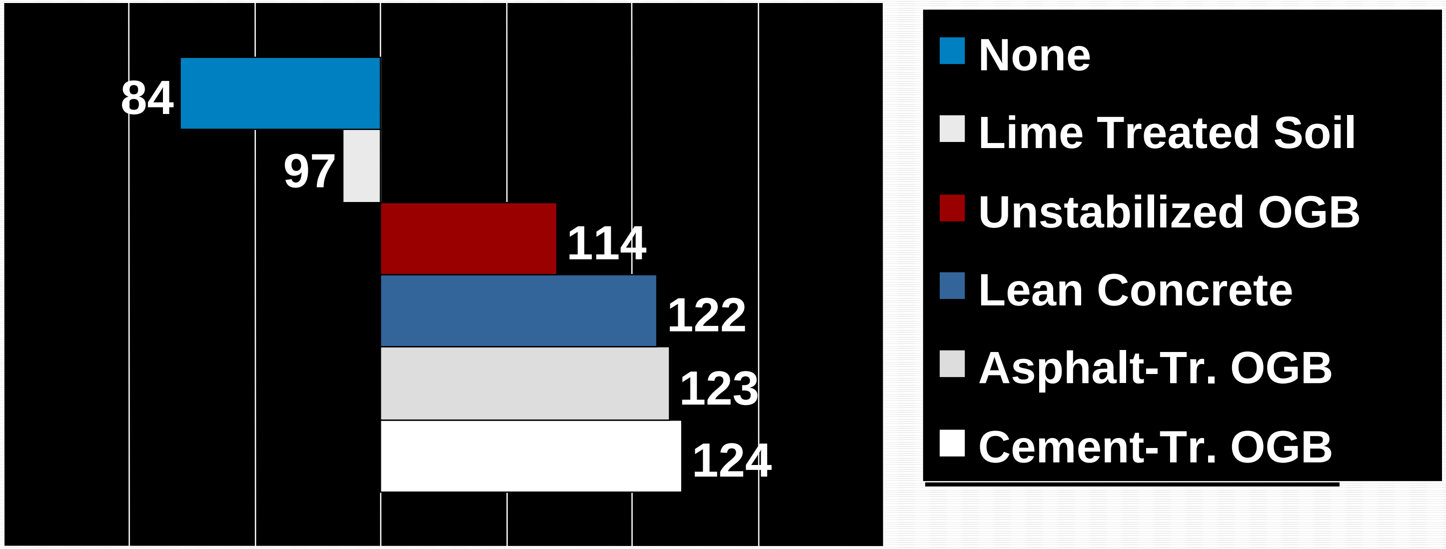

Average Relative Cost

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

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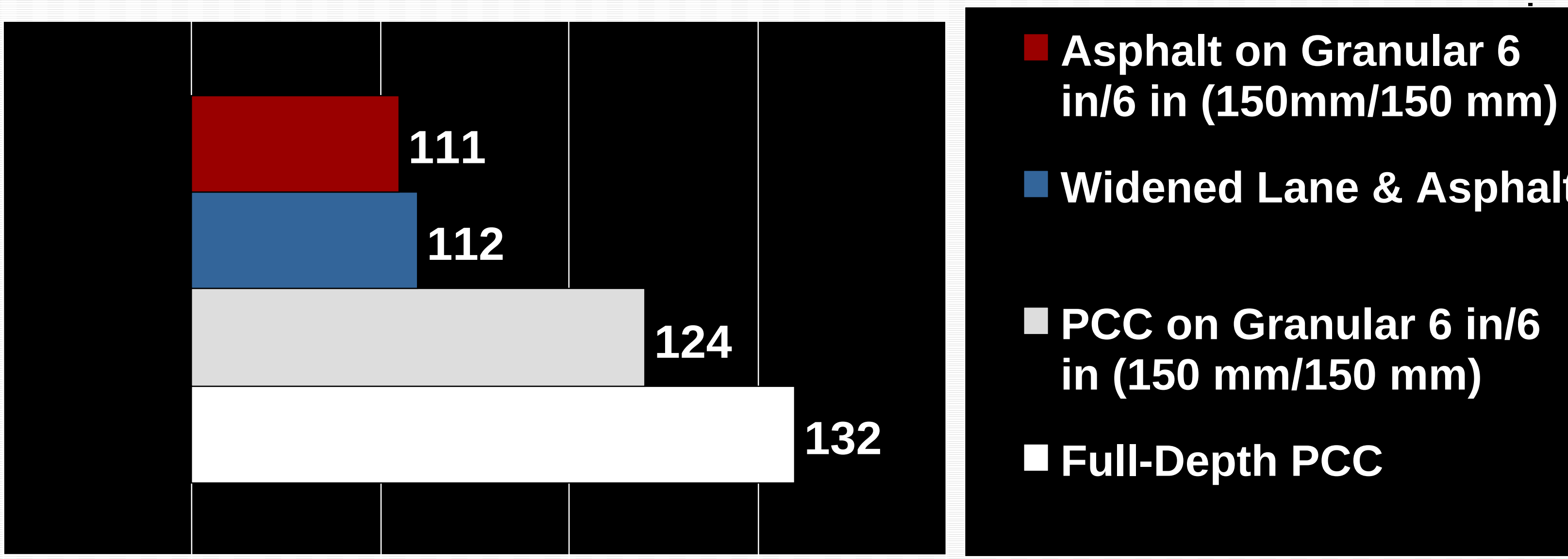
Shoulders



Average Relative Cost

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

Transverse Joint Design

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

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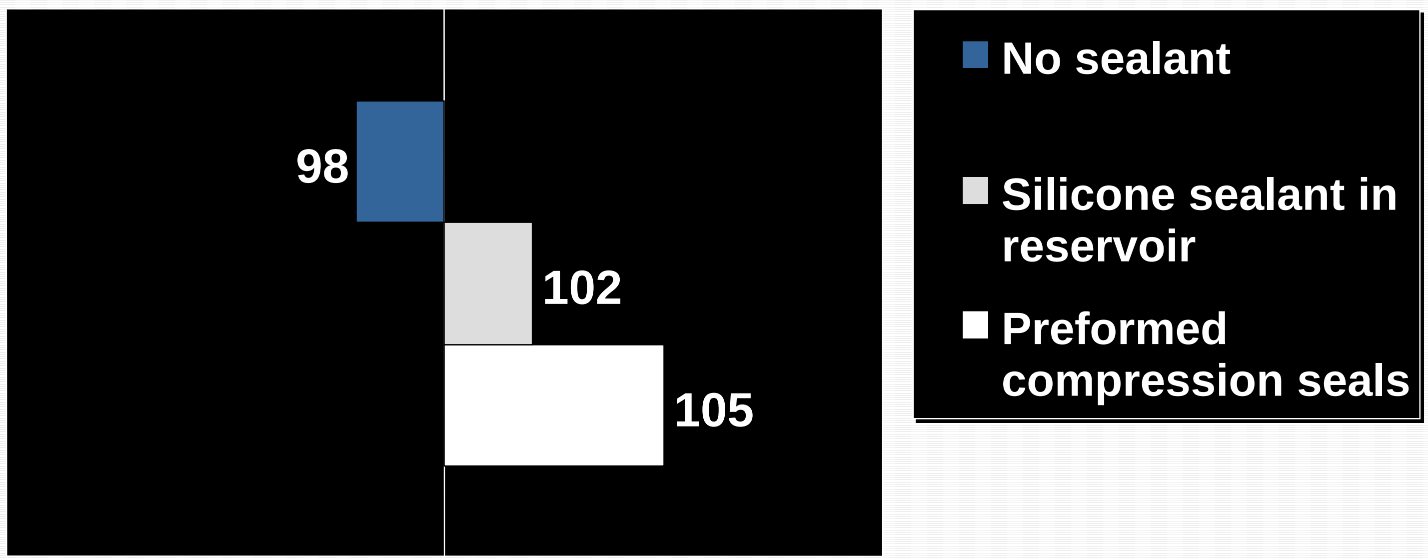
Transverse Joint Sealant



Average Relative Cost

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

Methods to Determine Cost-Effectiveness

- Experience
- Life-cycle cost analysis
  - Initial cost
  - Future cost
  - Performance
- Benefit/Cost analysis
  - Initial cost
  - Performance

User Costs?

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???

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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

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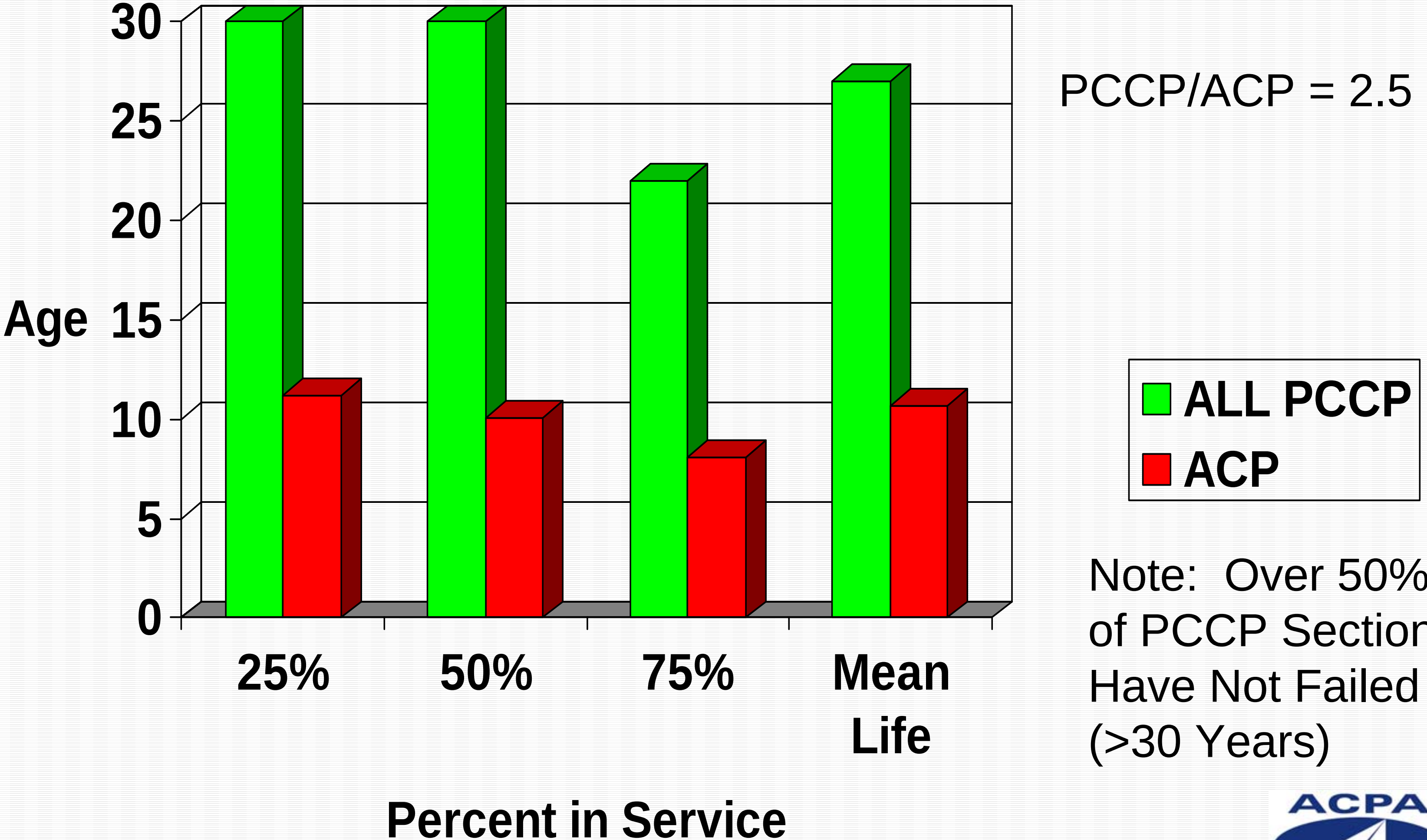
Survival Analysis Results - I-40 in OK



PCCP/ACP = 2.5

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

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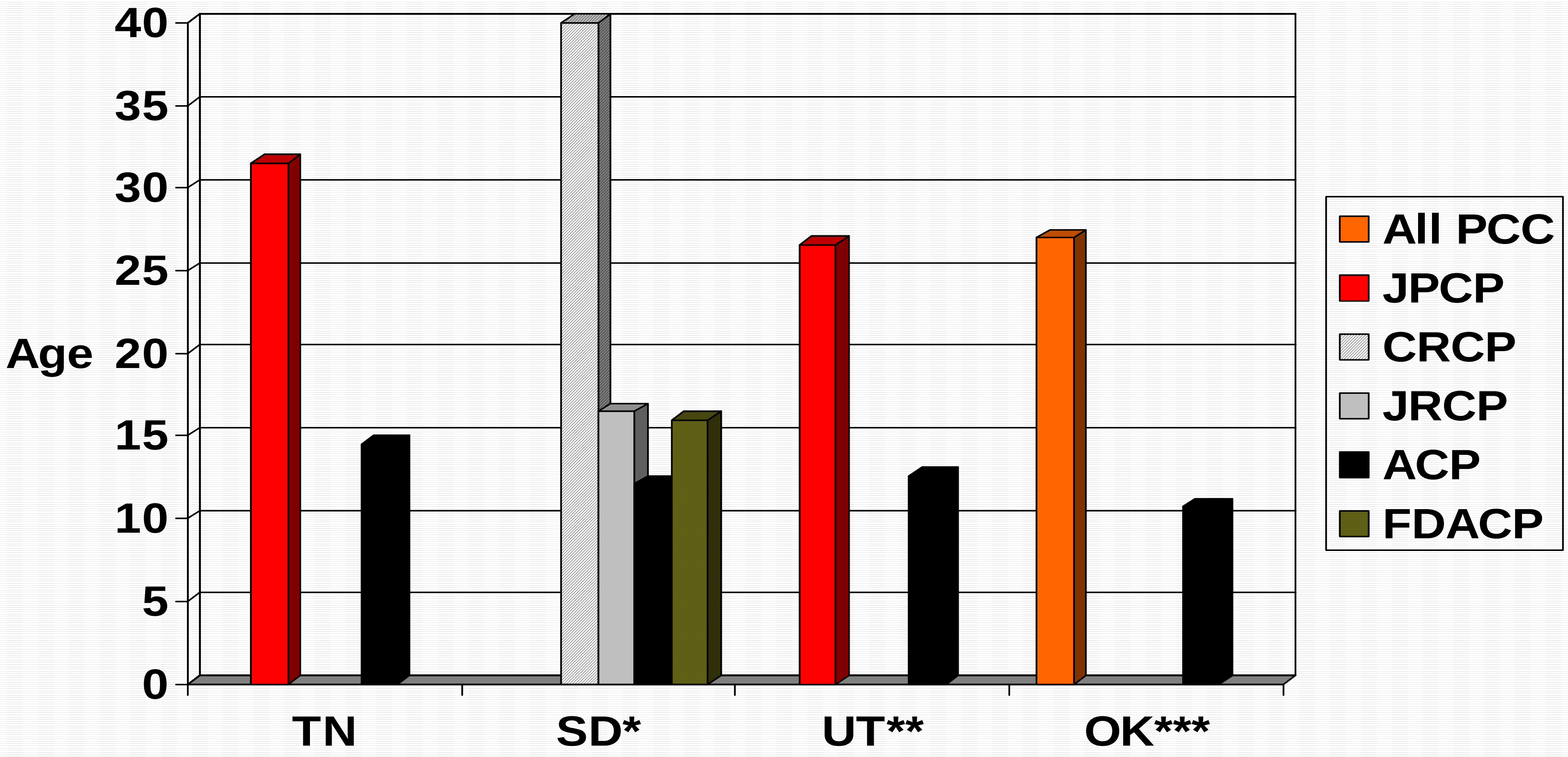
Survival Analysis Results

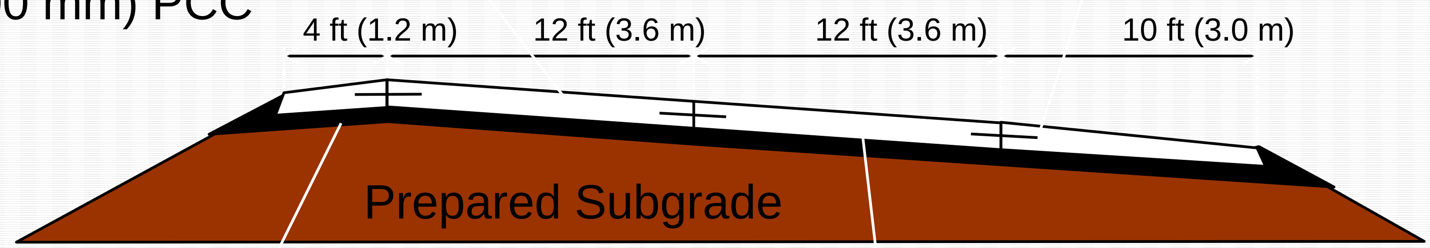
Avg. Mean life



Typical Section in 2001

12 in (300 mm) PCC

Full-depth PCC Shoulders



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?