18-00843 Economic Analysis of Pavement Preservation Techniques

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WHAT STARTS HERE CHANGES THE WORLD

Introduction

Objectives

- Develop and implement a methodological framework, using economic analysis, to evaluate the cost-effectiveness of preventive maintenance treatments
- Study the effect of facility type, traffic volume and loads

Justification

- Timely maintenance
- Hardly any data
- Methodology to quantify the benefits

Preventive Maintenance Treatments

Chip Seal

- Improve surface friction
- Reduce permeability
- Seal small cracks
- Used as a wearing course

Microsurfacing

- Improve surface friction
- Reduce permeability
- Correct surface irregularities
- Prevent raveling

Thin Overlay

- Less than 2 in. of hot mix asphalt
- Improve surface friction
- Reduce permeability
- Correct surface irregularities

Case Study

Database

- 14,372 PM treatment projects from 1994 to 2015
- PM treatments: chip seal, microsurfacing, and thin overlays
- Censored and uncensored data
- Information about the of traffic volume, traffic load, and facility type

Effective Life

- Life between two consecutive treatments applications
- Survival analysis was applied, it allows the incorporation of both observed and censored data: obtained the scale (α) and shape (γ) parameters of the **Weibull** probabilistic distribution

$$f(x|\alpha,\gamma)=\frac{\gamma}{\alpha}\left(\frac{x}{\alpha}\right)^{\gamma-1}e^{-(x/\alpha)^{\gamma}}$$

x is a random variable, $\alpha > 0$ is the scale, and $\gamma > 0$ is the shape parameter

Cost

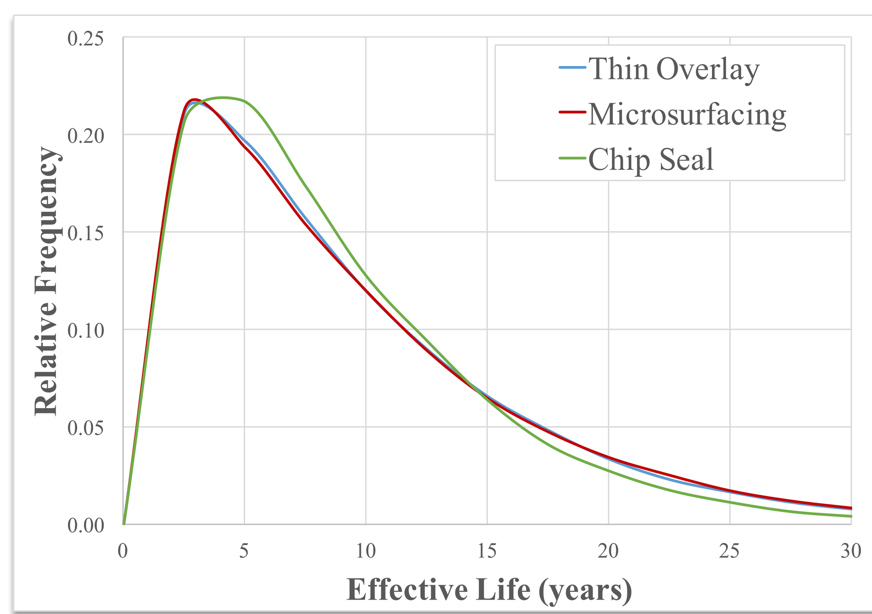
- Obtained from the final cost of each project, estimated once the treatment was placed
- Units: 2016 USD per lane-mile
- Modeled using a **Log-normal** probabilistic distribution

$$f(x|\mu,\sigma)=\frac{1}{x\sigma\sqrt{2\pi}}e^{-\frac{(lnx-\mu)^b}{2\sigma^2}}$$

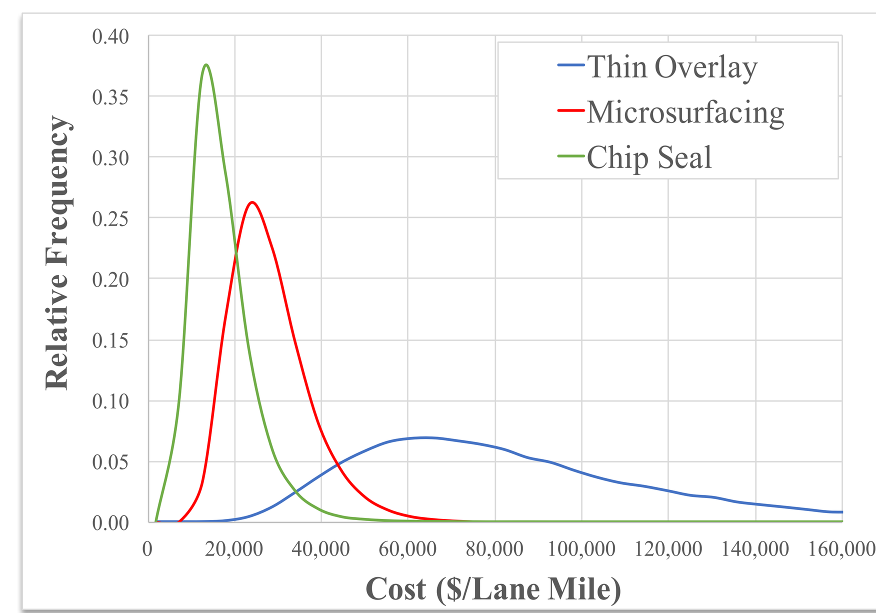
$x \geq 0$ is a random variable, μ is the location, and σ is the scale parameter

$$\mu = log\left(m^2/\sqrt{v+m^2}\right) \qquad \sigma=\sqrt{log(v/m^2+1)}$$

m is the mean and v is the variance of the log-normal distribution



Effective Life per treatment

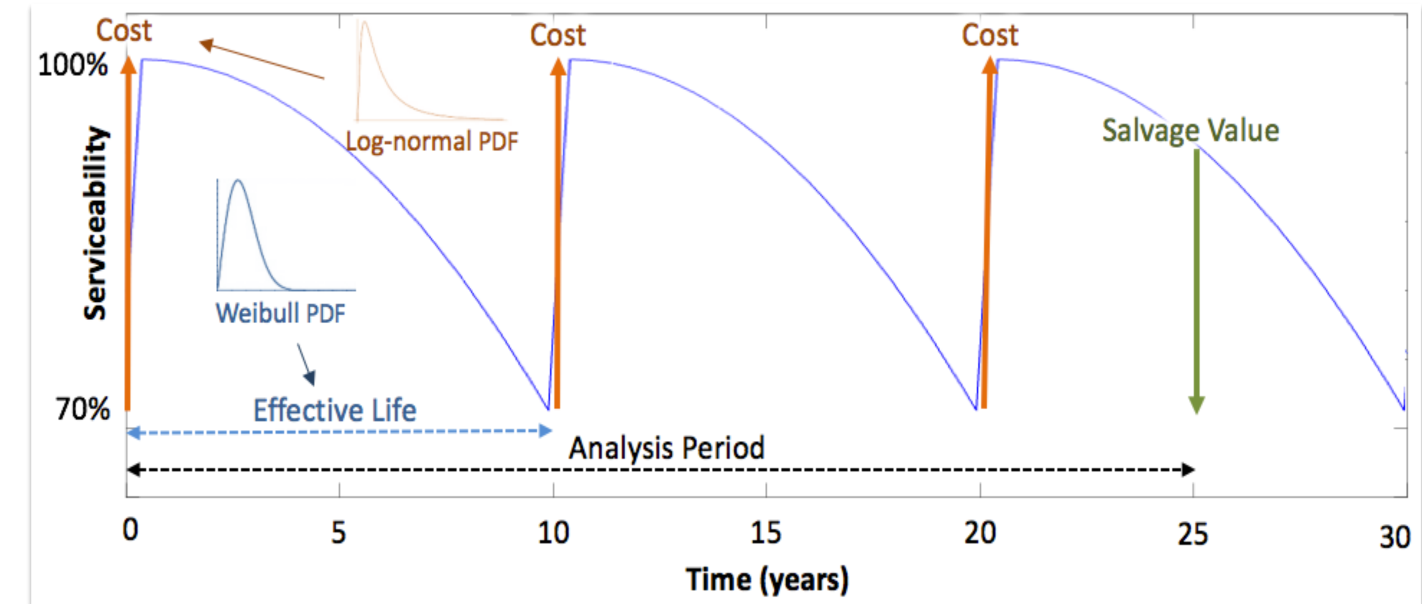


Cost per treatment

LCCA Methodology

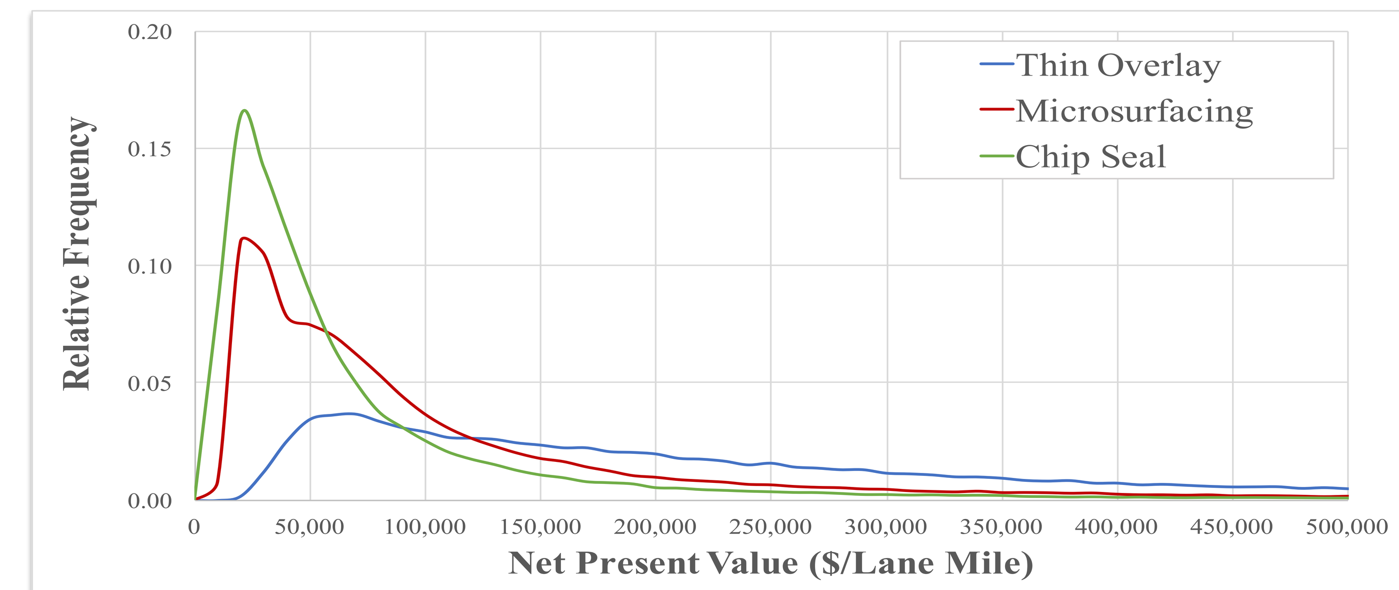
- The analysis consisted of a Monte Carlo Simulation using 100,000 repetitions.
- Consecutive application of PM treatment
- 25 years analysis period
- Probabilistic approach: net present value

$$NPV_{jk}=C_{jk}+\sum_{x=1}^{z_1-1}\frac{C_{jk}}{exp[i\cdot(x\cdot m_{jk})]}-\frac{S_{val}}{exp(25\cdot i)}$$

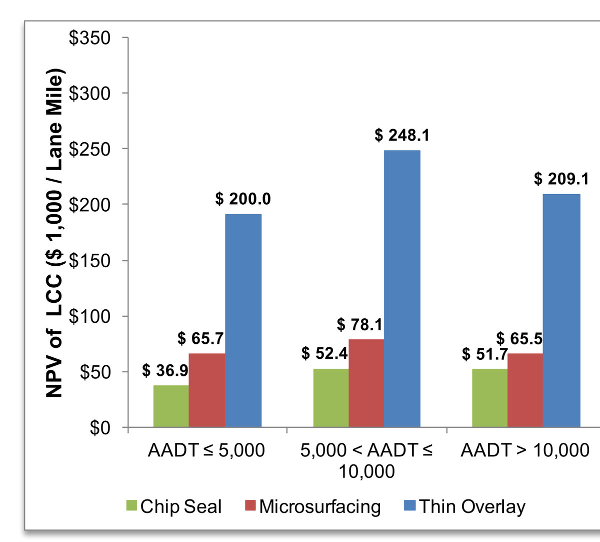


Life cycle cost analysis methodological framework

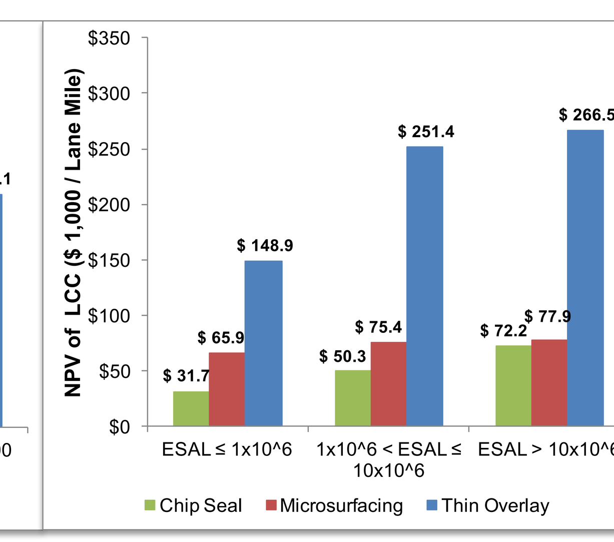
Results and Discussion



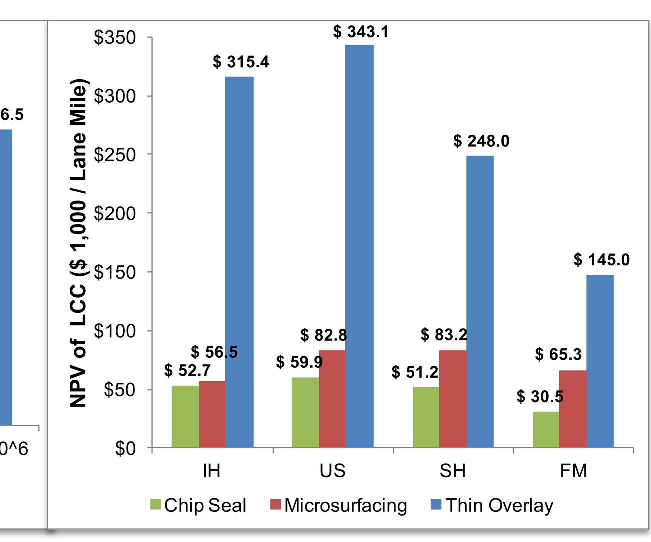
Life cycle cost analysis results



Effect of AADT



Effect of ESALs



Effect of highway type

Conclusions

- Based on actual data
- Chip Seal emerges as most cost-effective PM treatment
- Microsurfacing for higher traffic volumes
- Thin overlay use evaluated in a case-by-case basis
- Include other variables such as climate, district practices, materials type and pavement condition