

# Pavement Preservation

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# Agenda

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- A history of pavement
- Pavement Preservation
  - Purpose: Proactive v Reactive
  - The Curve
  - Pavement Condition Index
- Asphalt Distress
- Chemistry
- Asphalt preservation methods
- Innovations + Best Practices
- Q & A

# A (mostly) Serious History of Pavement

## Early Technologies

### Prehistoric

-10,000 BC

Early humans and animals created natural, unpaved pathways.

### Early Civilization

-4,000 -3,000 BC

Stone-paved and brick-paved streets in Indus Valley and Mesopotamia for wheeled transport



More durability = more mobility

# A (mostly) Serious History of Pavement

How do we build it?

## Ancient Egypt

-2600-2200 BC

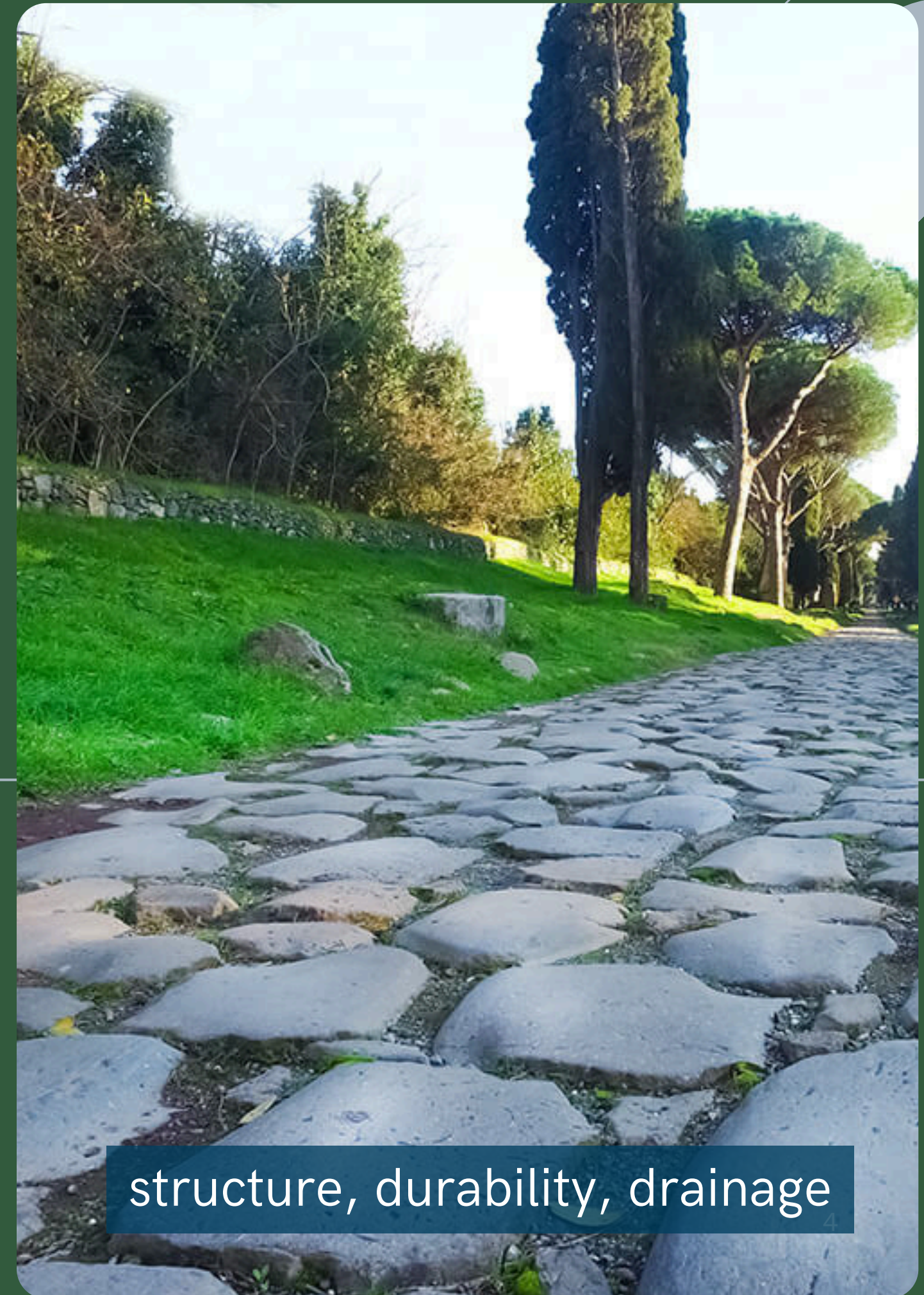
Earliest known engineered road constructed with flagstone.

## Romans / Appian Way

312 BC

Multi-layer construction, drainage, and paving

structure, durability, drainage



# A (mostly) Serious History of Pavement

How do we design it?

## Macadam

18th-19th Century

Pierre-Marie-Jérôme Trésaguet (France) and John Loudon McAdam (Scotland)

## Asphalt + Concrete

19th-20th Century

Tar, bitumen, and concrete paving.



vehicles, traffic, layered support

# A (mostly) Serious History of Pavement

How do we make it last longer?

## Interstate Era

1956

President Eisenhower signed the Federal-Aid Highway Act of 1956, creating the modern US Interstate system.

## Modern Materials

1980s-present

Ultra-high-performance concrete and sustainable materials



sustainability, durability, performance

# A (mostly) Serious History of Pavement

Design, Construct, and Leave it Alone

## Build it and Forget It

Post WWII Expansion

"If it isn't broken, don't fix it."

## Superpave Mix Design

Advanced mix design standards

The Innovation Gap: Why are we still using many of the same chemistries from the 1950s?

## Pavement Preservation

Proactive management

The Shift: Moving from Reactive (fixing failures) to Proactive (extending health).

# Pavement Preservation

## The Definition

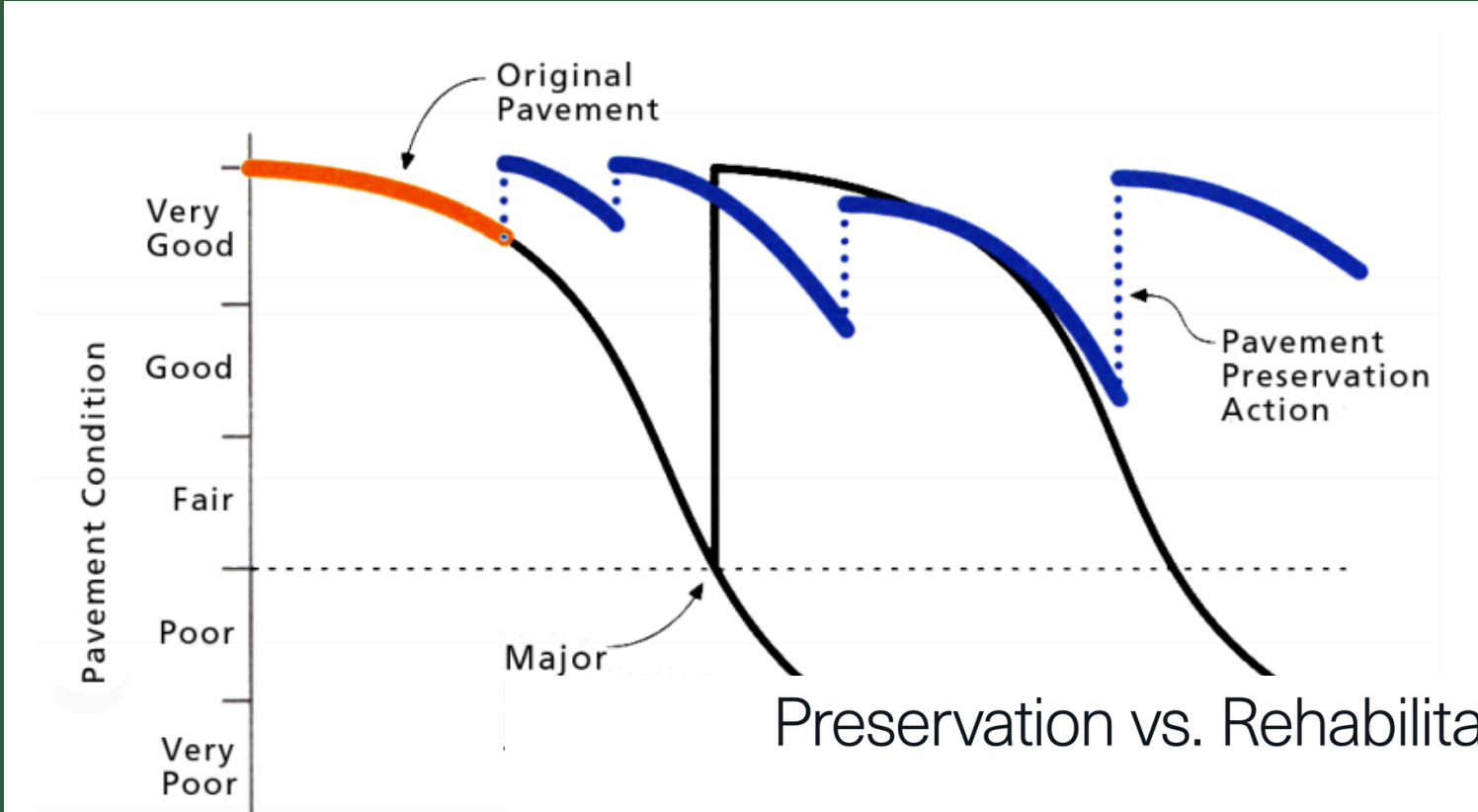
A program of activities to extend the life of existing roadways without increasing capacity or structural strength (yet).

## The Goal

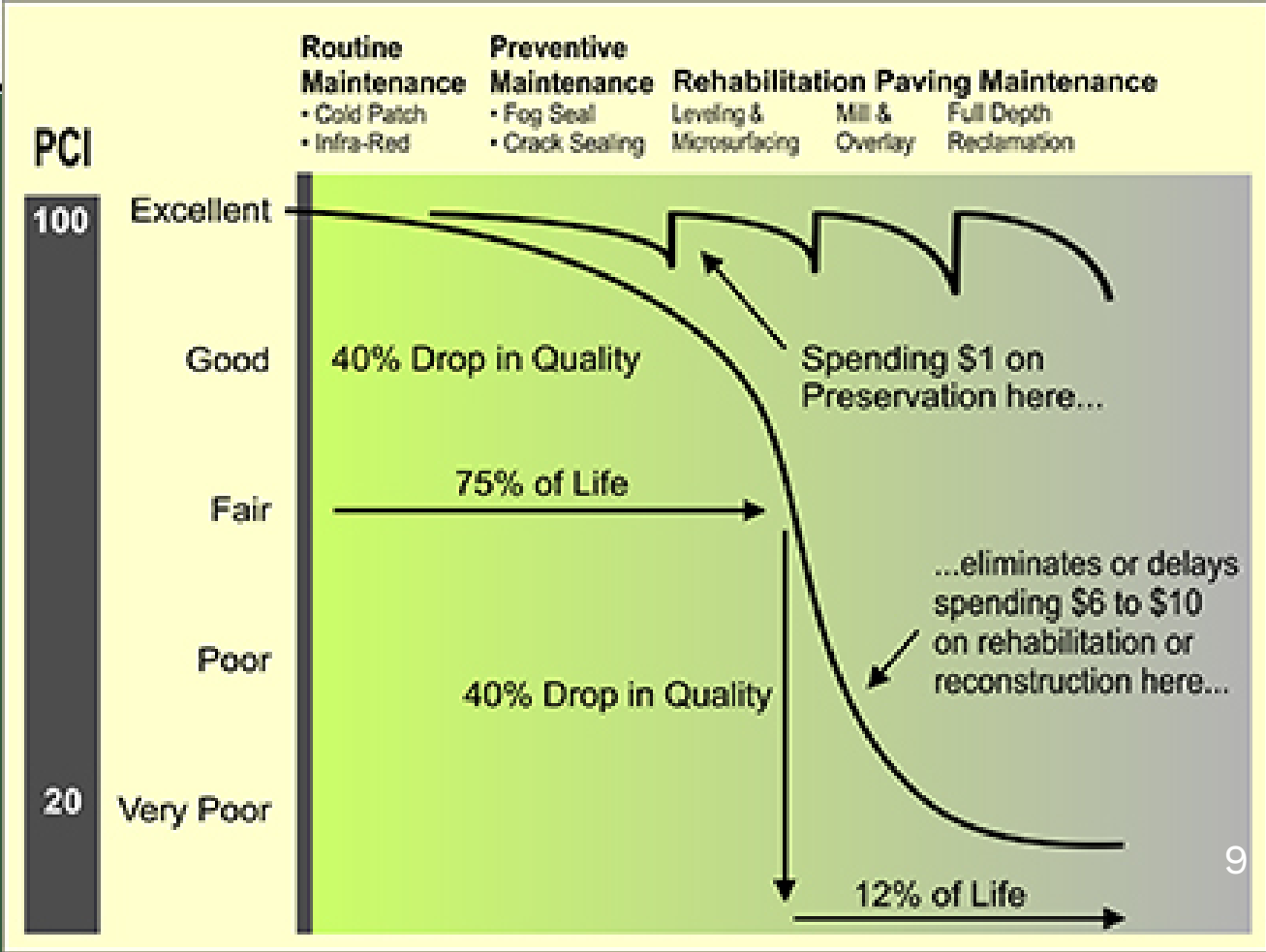
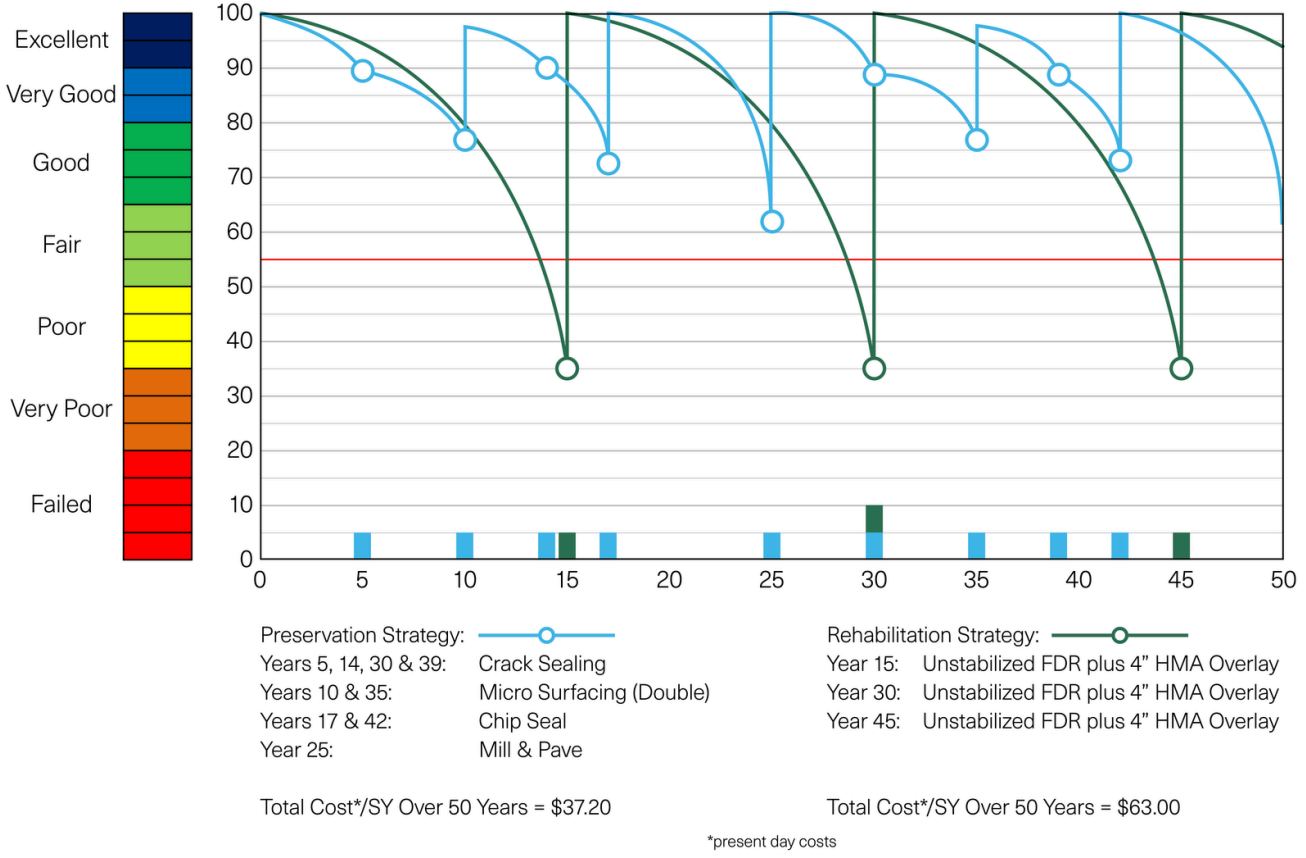
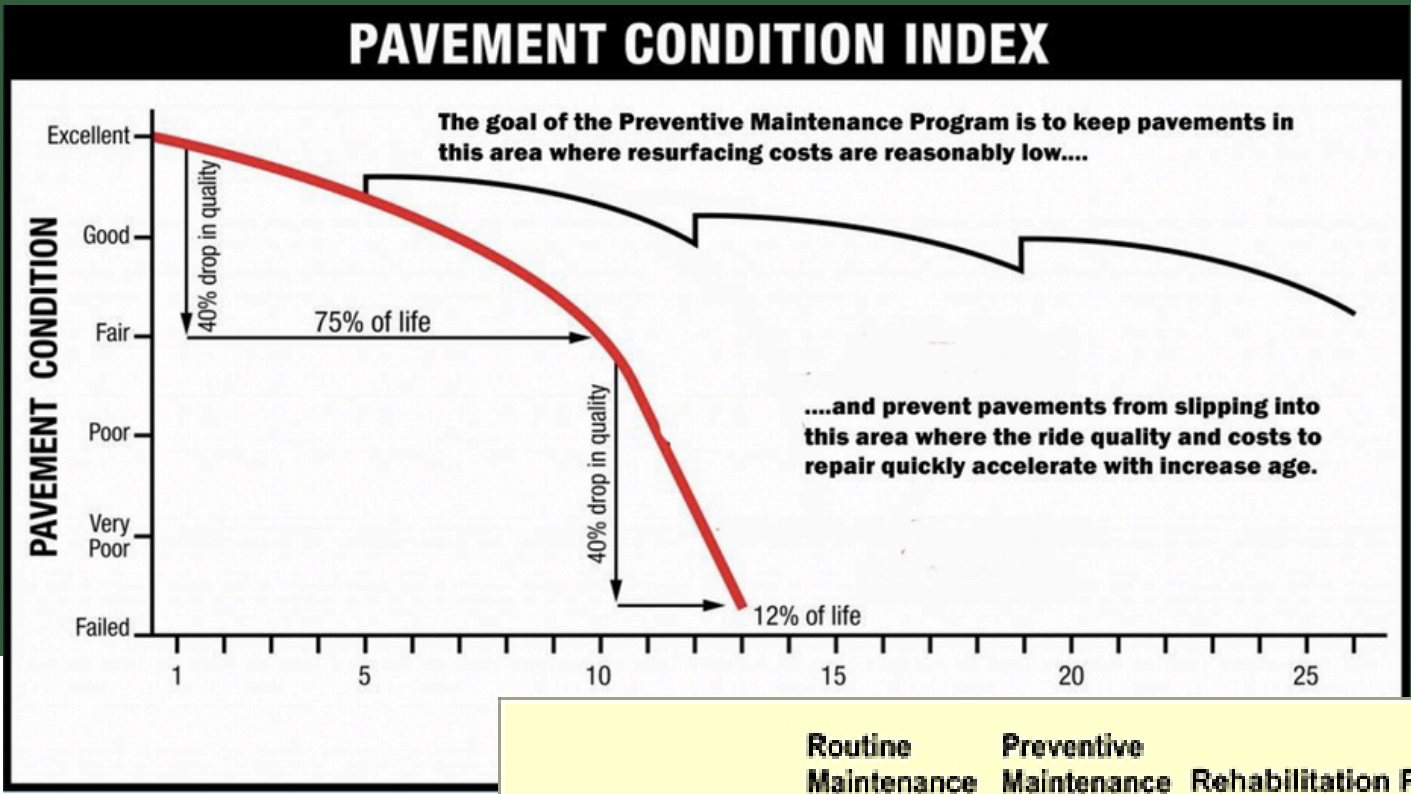
Maintaining the "Good" roads in good condition, rather than spending 10x more to rescue "Poor" roads.

**Maintenance, with strategy + timing**

# Preservation Curve



Preservation vs. Rehabilitation



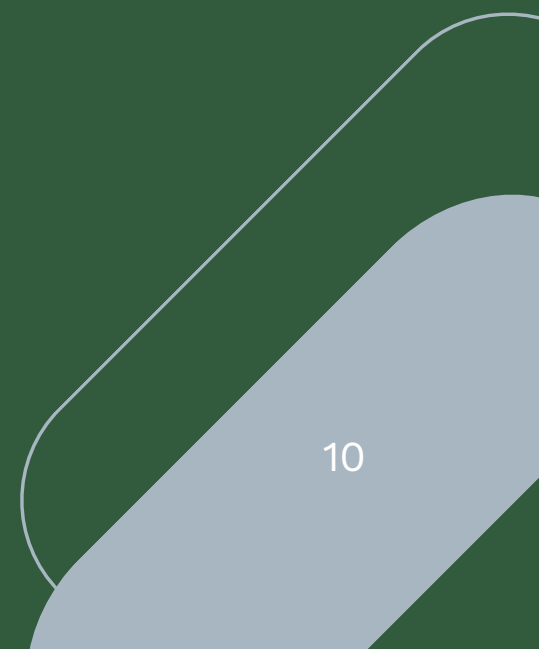
# Pavement Condition Index (PCI)

## What's the Score?

- 0–100
- Failed - Excellent

## How do they do it?

- counting cracks
- note visible raveling
- record patches, ruts, or other



10

# Asphalt Deterioration

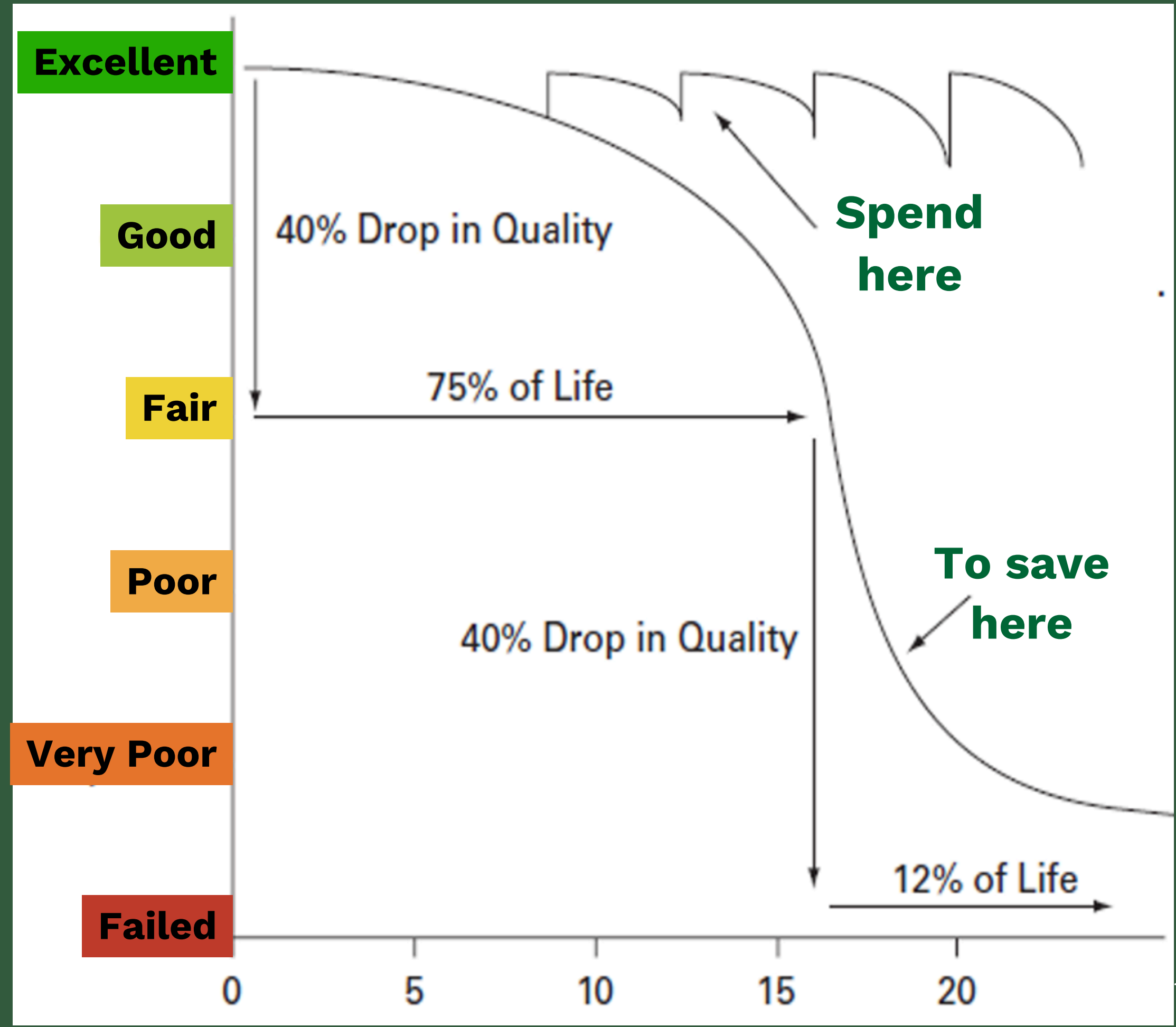
ASTM D 6433

- Alligator Cracking
- Bleeding
- Block Cracking
- Corrugation and Shoving
- Depression / Settlement
- Joint Reflection Cracking
- Lane / Shoulder Drop-Off or Heave
- Longitudinal Cracking
- Patching
- Polished Aggregate
- Potholes
- Raveling
- Rutting
- Slippage Cracking
- Stripping
- Transverse Cracking
- Water Bleeding and Pumping

# Preservtaion Curve



PCI



# Key Elements of Pavement Preservation

Feature	Preservation	Rehabilitation	Reconstruction
Pavement Condition	Good to Fair	Fair to Poor	Failing
Structural Change	None	Moderate	Complete Replacement
Cost	\$	\$\$\$	\$\$\$\$\$
Life Extension	3-10 years	10-20 years	20+ years

## **Key Takeaway:**

**Preservation is a "top-down" approach to protect the "bottom-up" investment.**

# PROACTIVE vs Reactive

- Fix early, fix **small**
- **Protect** before it fails
- Lower long-term cost
- Data-driven timing
- **Extends** pavement life
- Smooth, predictable budgets



# Proactive vs **REACTIVE**

- Fix late, fix **big**
- Respond after **failure**
- Higher long-term cost
- Crisis-driven timing
- **Shortens** pavement life
- Budget spikes and surprises



# Goals Through Preservation

## **Extend Life**

increase  
pavement  
lifespan

## **Maintain Integrity**

Protect structure

## **Minimize Intervention**

Reduces repair  
frequency

## **Optimize Costs**

Better resource  
allocation

## **Enhance Safety**

Ensure safer  
conditions

# Choosing the Right Strategy for Pavement

## Preservation

Minimal intervention, low cost and ideal for early stages.



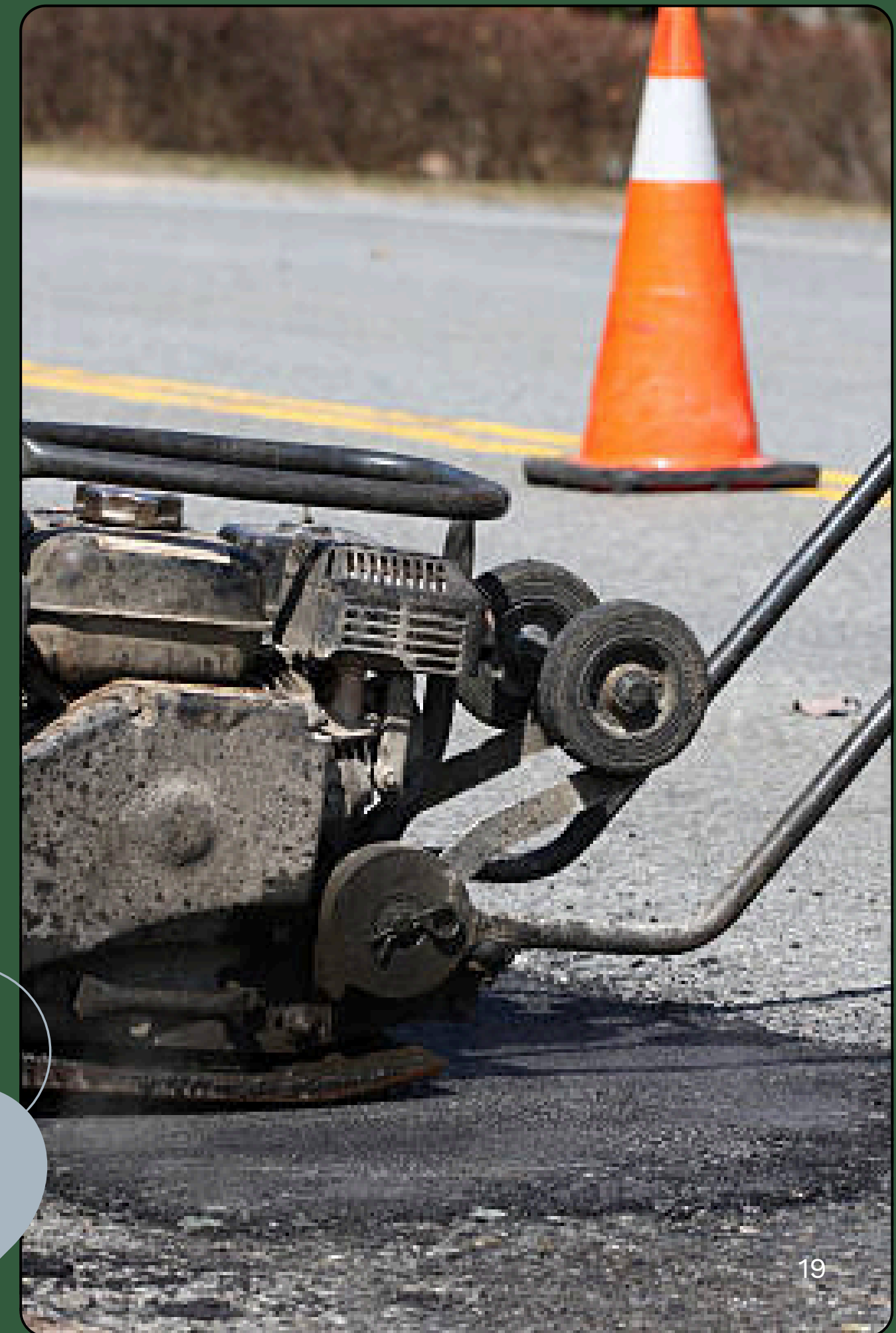
**Fix Early,  
Fix Small**



# Choosing the Right Strategy for Pavement

## Rehabilitation

Restore structure, moderate cost; suitable for mid-stage intervention.

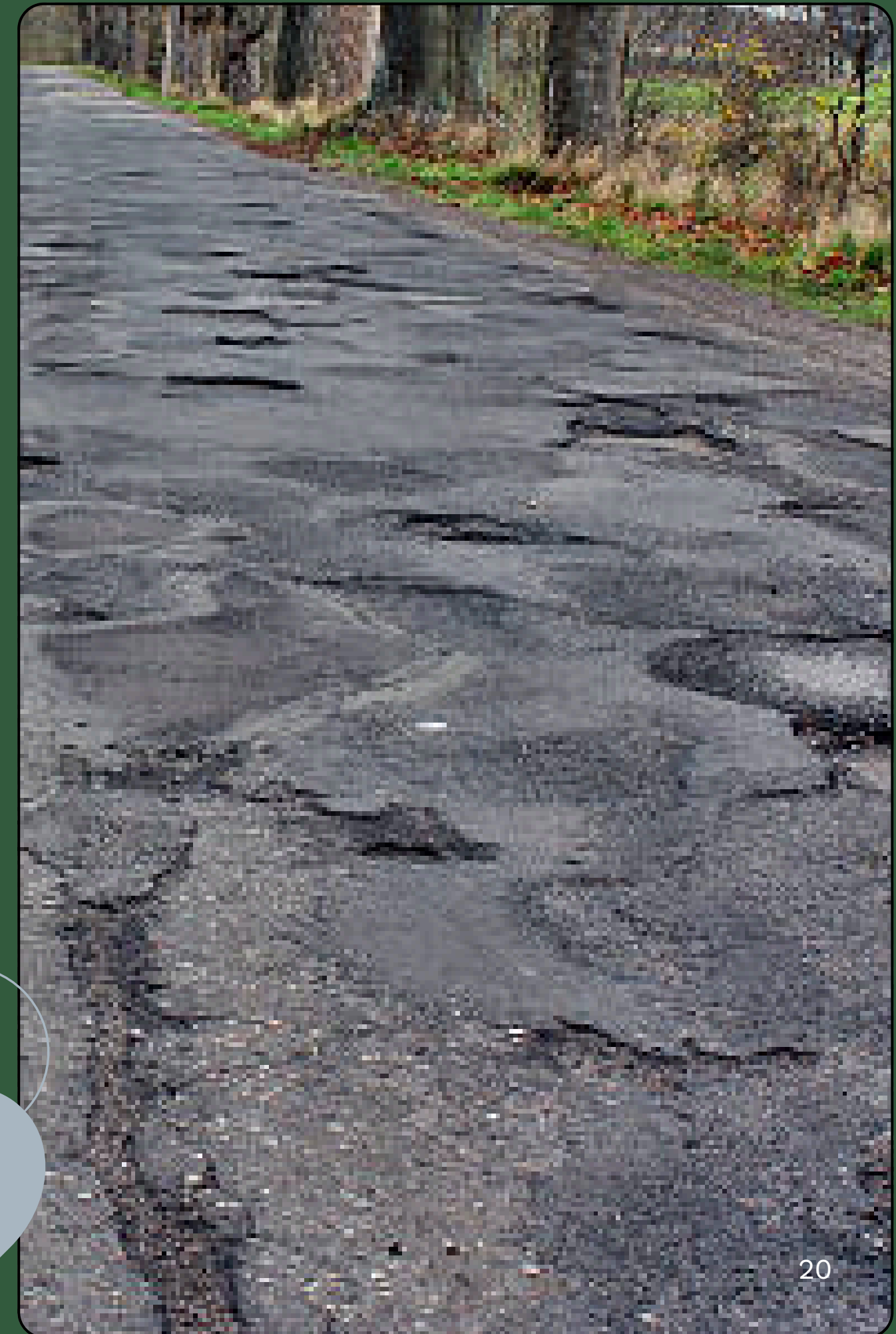


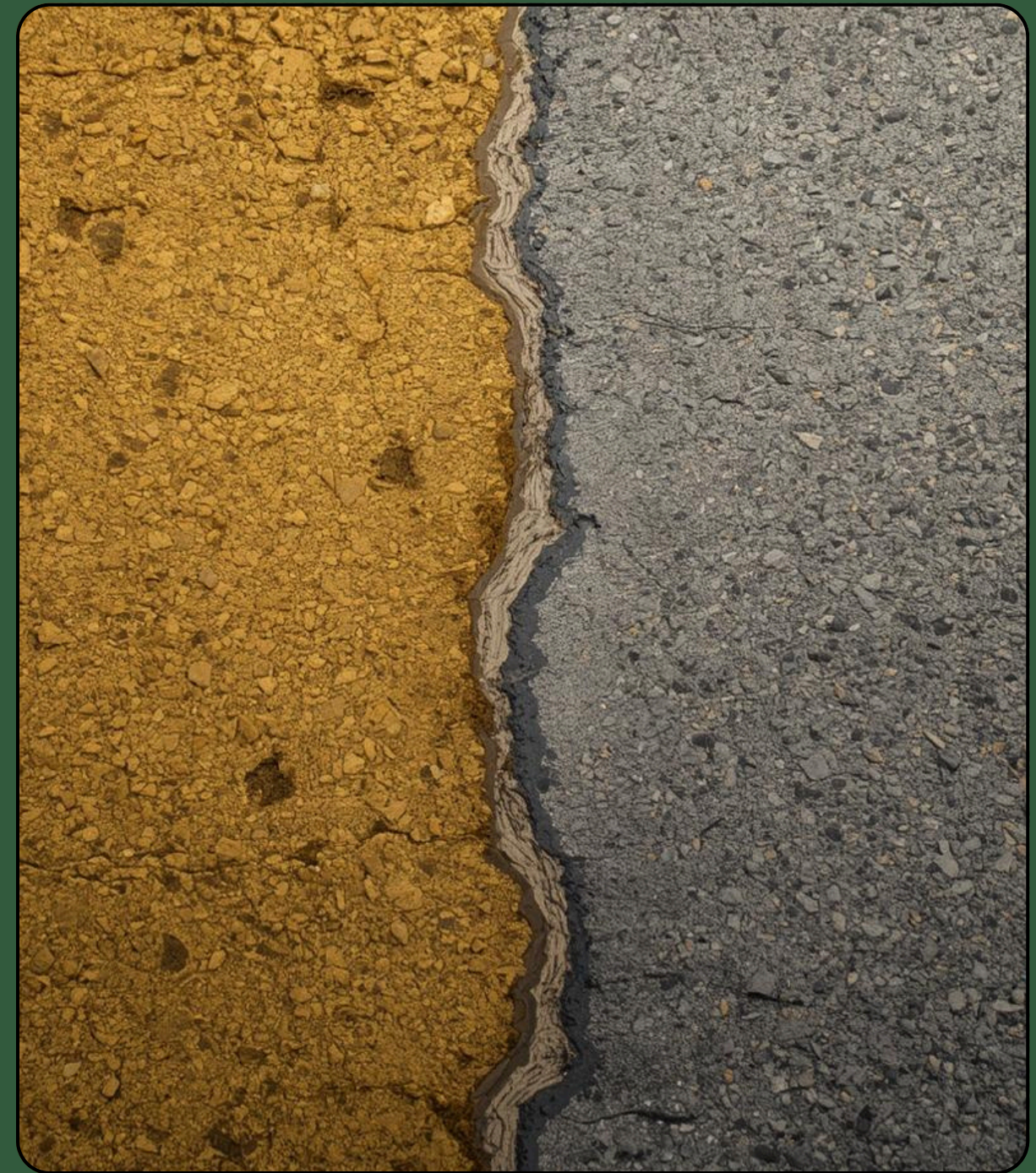
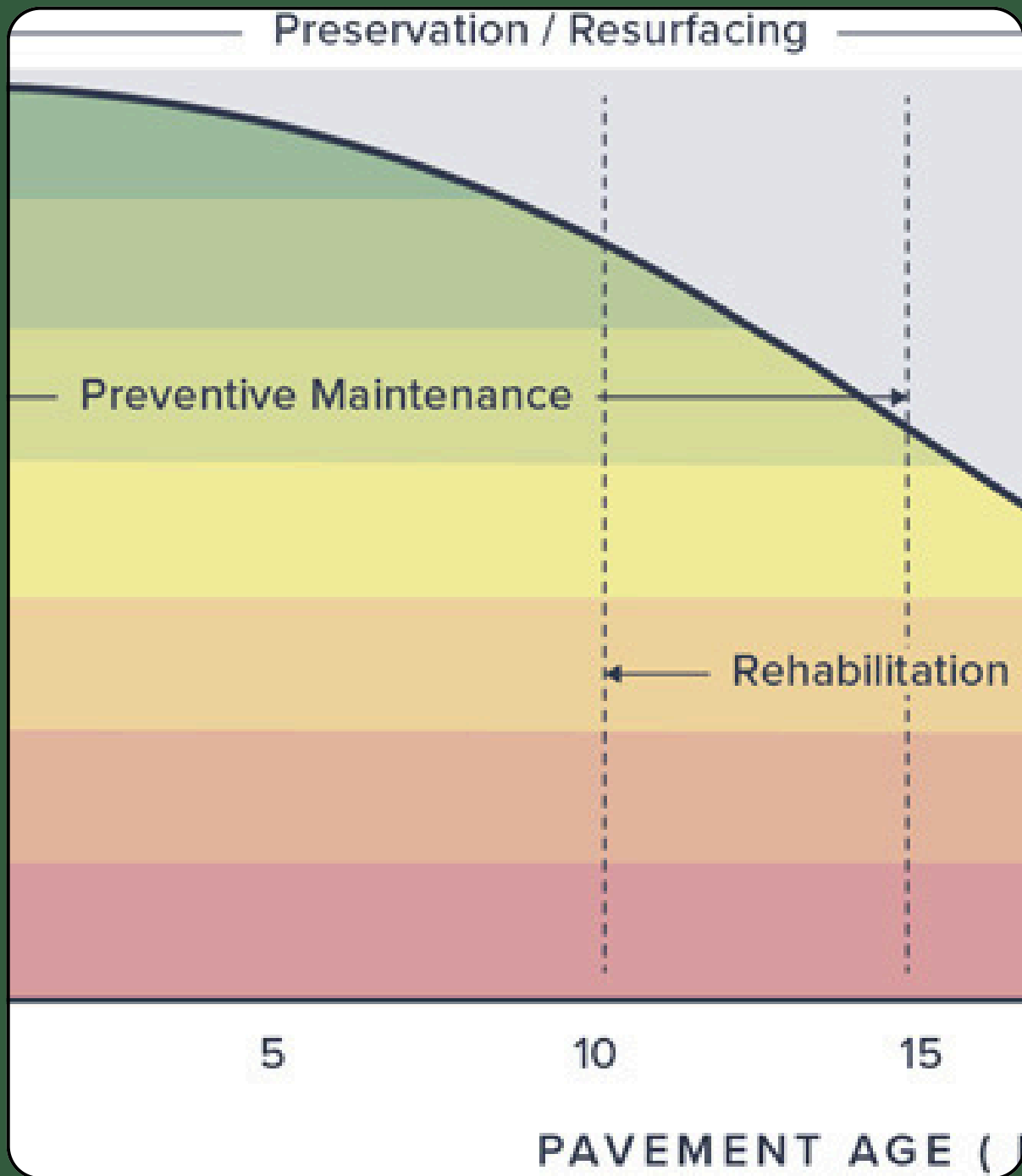
# Choosing the Right Strategy for Pavement



## **Reconstruction**

Complete rebuild, high cost, necessary for end-stage conditions.





## The Deterioration Curve

- Good condition 75% of life
- Then drop off a cliff

## Sustainability

- Maintain existing surface
- reduce virgin material needs

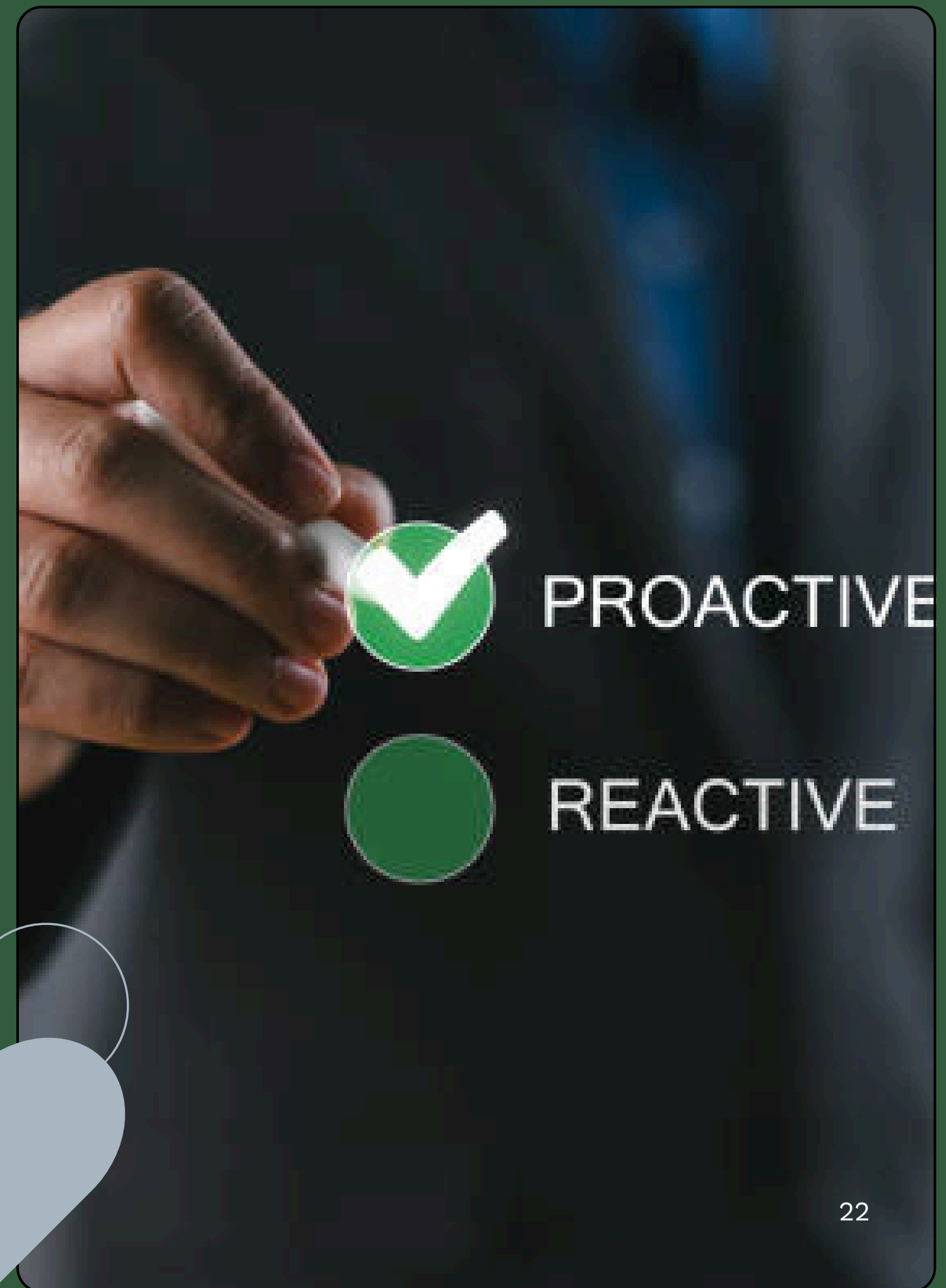
## Tax Payer ROI

- Spending \$1 today
- saves \$6-\$10 in future

# Lifecycle Management in Pavement Preservation

## Integrating Preservation into Lifecycle Decisions

1. Pavement condition
2. Understand traffic
3. Consider environment
4. Define objectives: Preservation vs. rehabilitation vs. reconstruction
5. Match available methods
6. Cost Analysis
7. Implement and track performance over time



# Site Selection Criteria

Is it oxidation, raveling, or structural rutting?

High-traffic routes and faster "return-to-traffic" times.

UV exposure and freeze-thaw cycles



## Condition

Assessing pavement status



## Traffic

Understanding vehicle loads



## Environment

Impact of local conditions

# Shift

from “pavement is a solid” to  
“pavement is a chemical system”

# Chemistry of Asphalt

The Building Blocks of Pavement Materials

## Rock and Glue

Bitumen + Aggregates (sometimes additives)

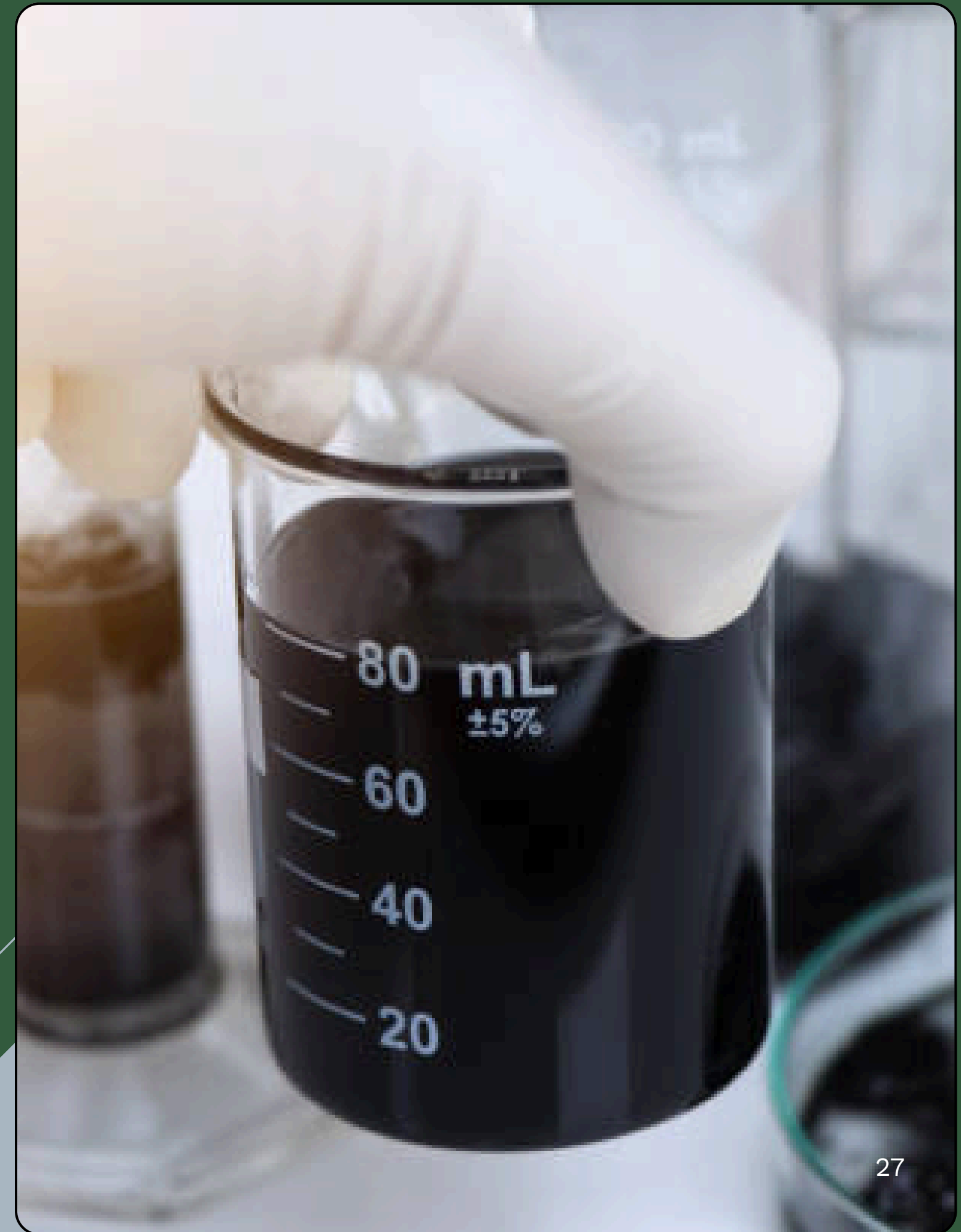
Chemical interactions define durability, performance, lifespan



**Asphalt isn't a single substance;  
it's a complex mixture**

# The Glue = Bitumen or Binder

- Sticky, black, petroleum-based material
- Coats the rocks and holds them together
- Flexible enough to move, tough enough to bind



# What's Inside the Glue

## ASPHALTENES

- Heavy, stiff, structural fraction
- Gives asphalt its strength and shape
- Think: the “solid skeleton” of the glue



# What's Inside the Glue

## MALTENES

- The lighter, oily fraction that keeps things workable
- Lets asphalt flex, relax, and self-heal (a little)
- Think: the “liquid that makes the glue sticky”



# The SARA Balance

**(S + A + R) = Maltene “flowy glue”**

- S - Saturates → light, soft oils,
- A - Aromatics → solvating oils
- R - Resins → natural tackifiers (adhesion, ductility)

**A = Asphaltene “rigid backbone”**

- A - Asphaltenes → solids for body and strength



# Takeaway

- Rocks = Aggregate
- Glue = Bitumen
- Maltenes make it sticky & flexible
- Asphaltenes make it strong & structured



## The Relationship:

Imagine a sponge (Asphaltenes) soaked in oil (Maltenes). As long as the sponge is wet, it's flexible and resilient.

# Oxidation and the “Brittle” Point

## UV + Thermal Oxidative Aging

- Sunlight + heat
- volatilize Maltenes into heavier asphaltenes

## The Imbalance

- Asphaltenes > Maltenes
- Binder becomes viscous (stiffer) and “glassy”



# Oxidation and the “Brittle” Point

## Micro-Cracking

The binder can no longer move with traffic loads.

## Raveling

The "glue" is too dry to hold the aggregate, leading to surface loss.

## Moisture Weakness

Brittle binder peels away from aggregate, allowing water to penetrate the base.



# Goal of Preservation

Put “light oils back in” so asphalt is less brittle, more flexible, and longer-lasting

# Influencing Chemistry

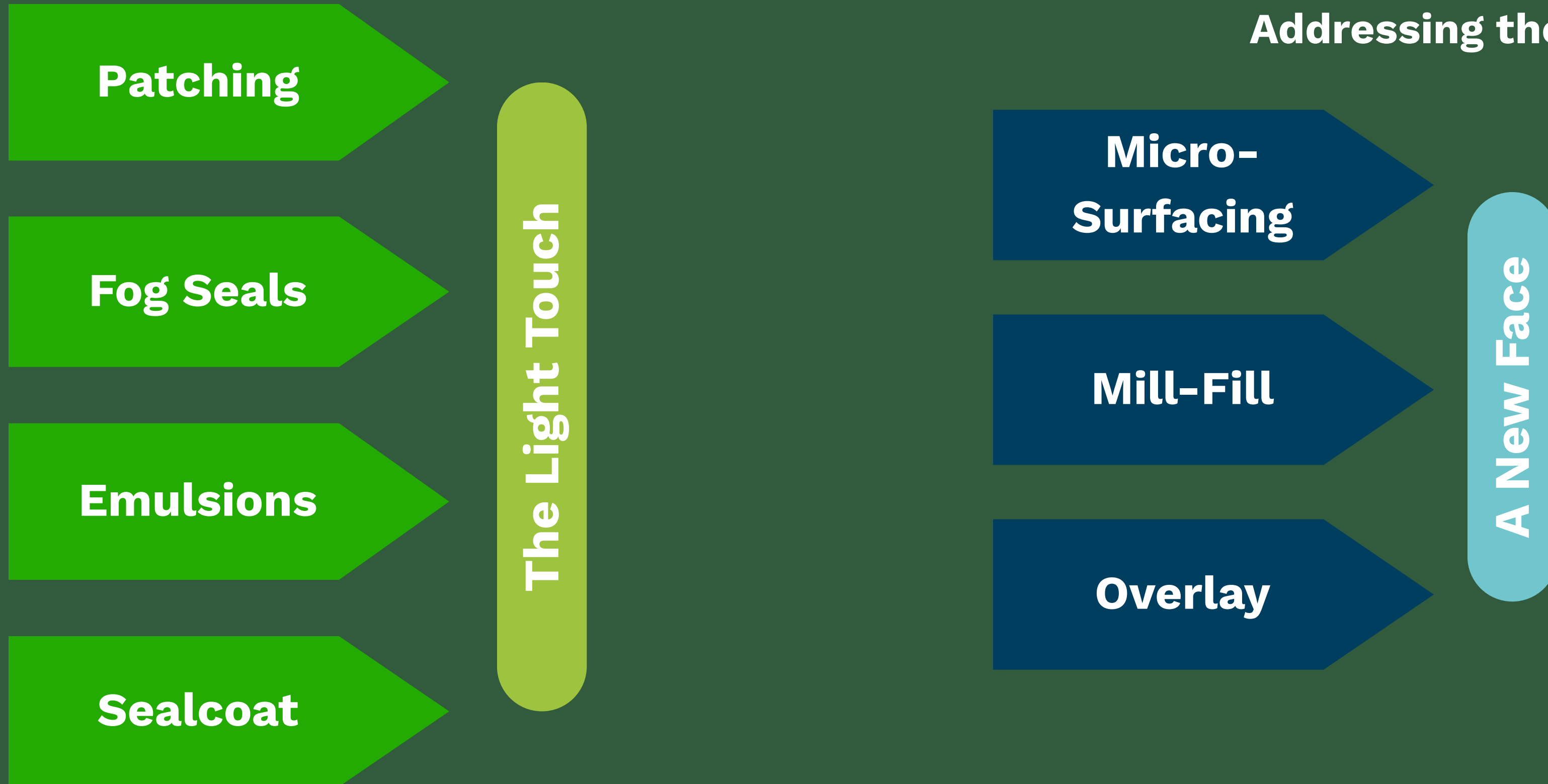
## Treatments Can:

- Replenish Aged Material
- Halt or Reverse Oxidation
- Replenish Lost Oils
- Restore Flexibility
- Add Durability and Strength
- Extend Overall Lifespan



# Traditional Restoration

Addressing the Balance



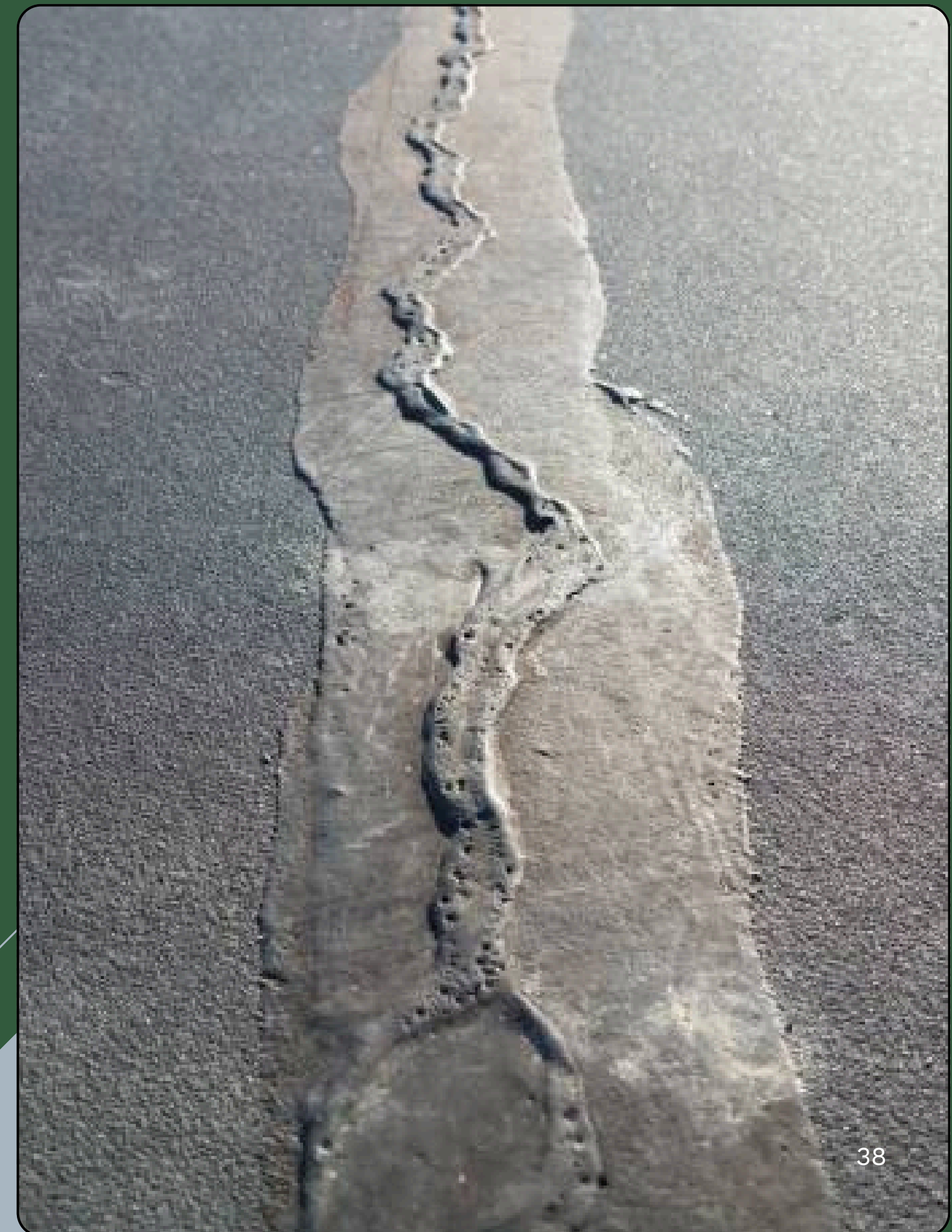
# Crack-Filling & Patching

## Definition

Targeted repair of individual cracks and potholes as a Band-Aid approach

## Technical Details

- Rubberized crack sealant
- hot/cold mix patch



# Crack-Filling & Patching Approach

## Advantages:

- Keeps water out
- Can be done quickly and locally
- Low material cost

## Disadvantages:

- Labor-intensive per square foot
- Treats symptoms, not surrounding aging
- Short life ( $\approx$  1-2 yrs)



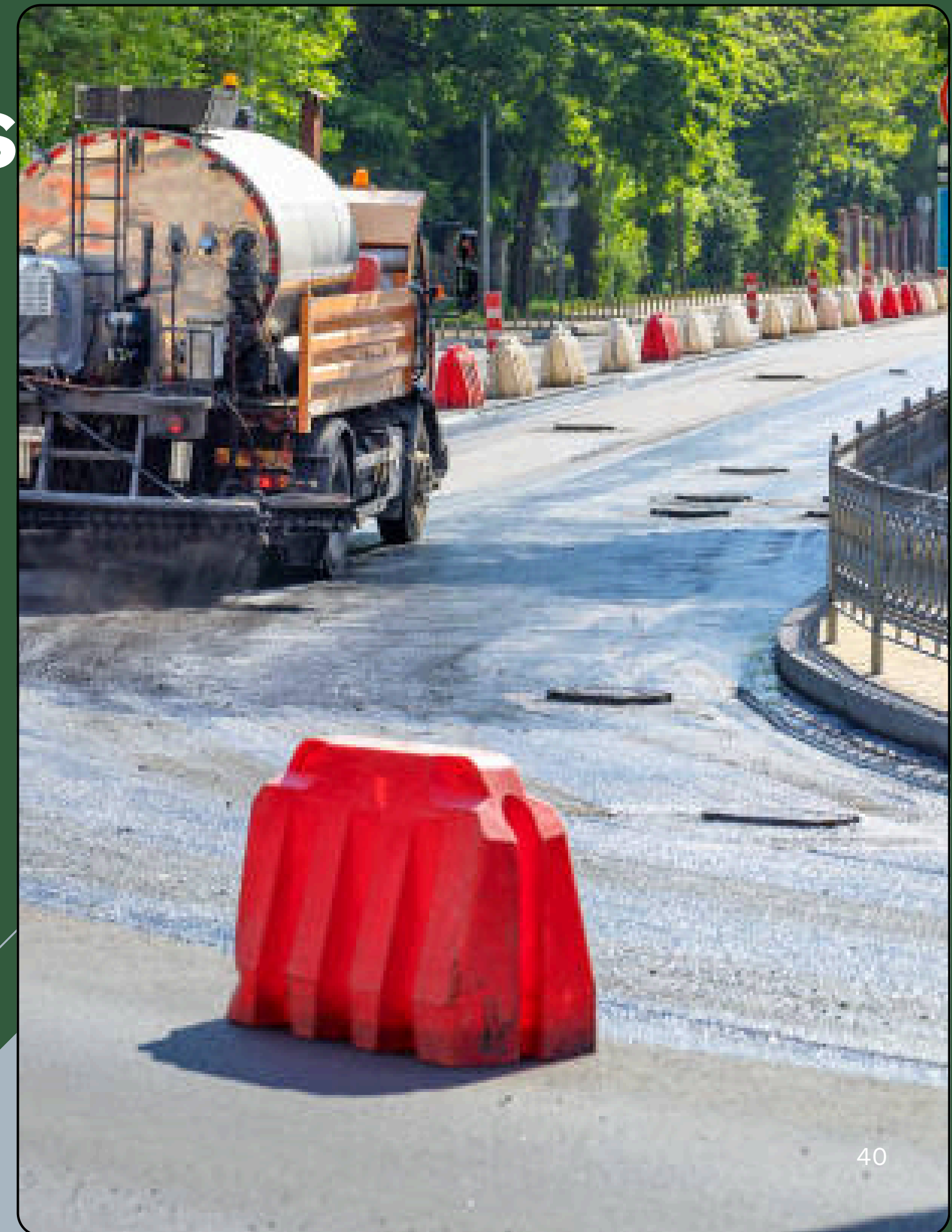
# Fog Seals & Rejuvenators

## Definition

light liquid “top off” sprayed on the surface

## Technical Details

- Diluted emulsion or specialty rejuvenator
- Applied with a distributor truck (sometimes a sand blot)



# Fog Seals & Rejuvenators

## The Liquid “Top-Off”

### Advantages:

- Fast, low-cost, low disruption
- Seals micro-cracks; slows raveling and oxidation

### Disadvantages:

- Very shallow (surface only)
- Short life ( $\approx$  1–3 yrs)
- Temporary friction reduction



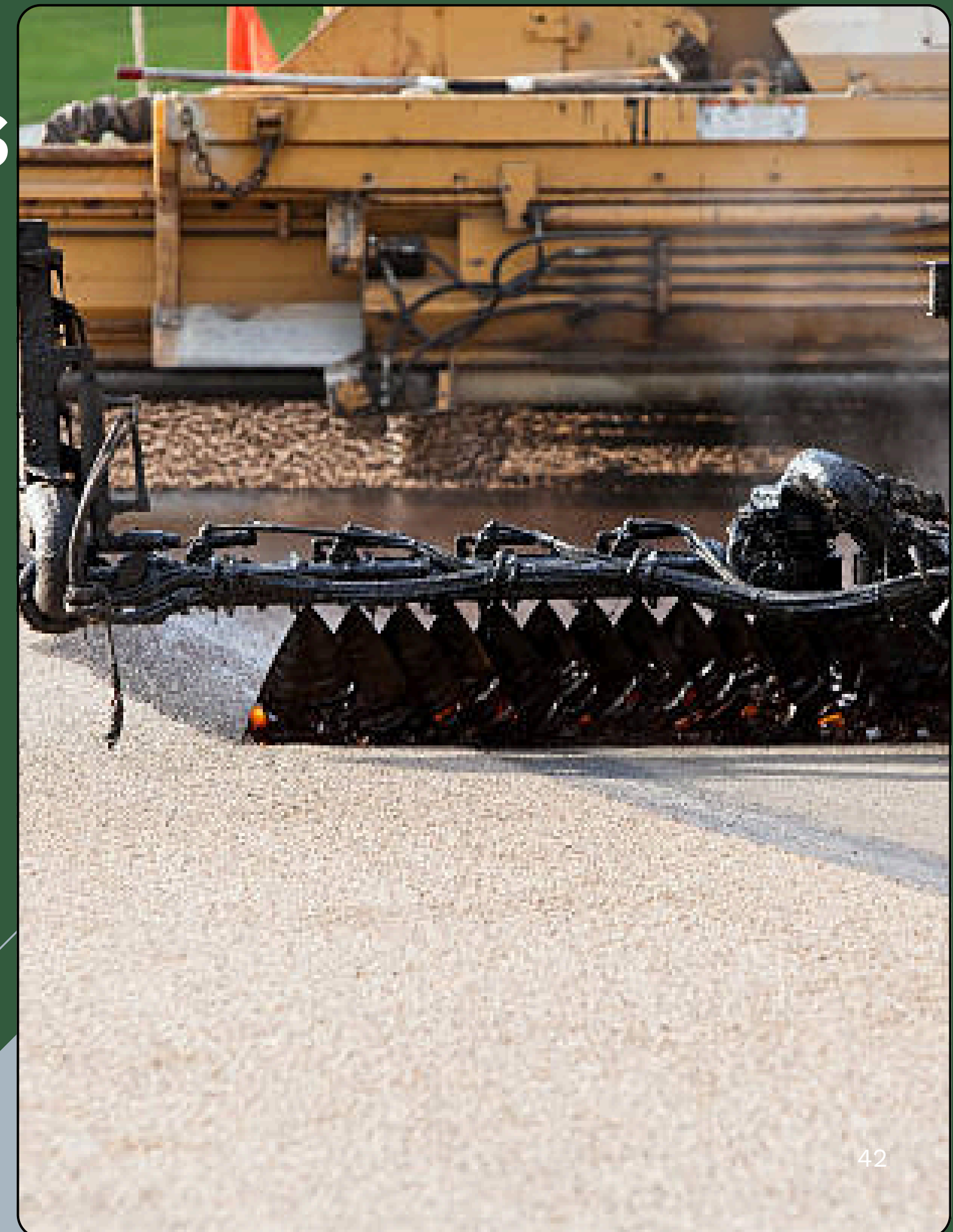
# Chip Seals & Scrub Seals

## Definition

An armor coat of liquid asphalt + a layer of small crushed rock

## Technical Details

- Emulsion sprayed → chips placed → rolled
- scrub seal adds brooming



# Chip Seals & Scrub Seals

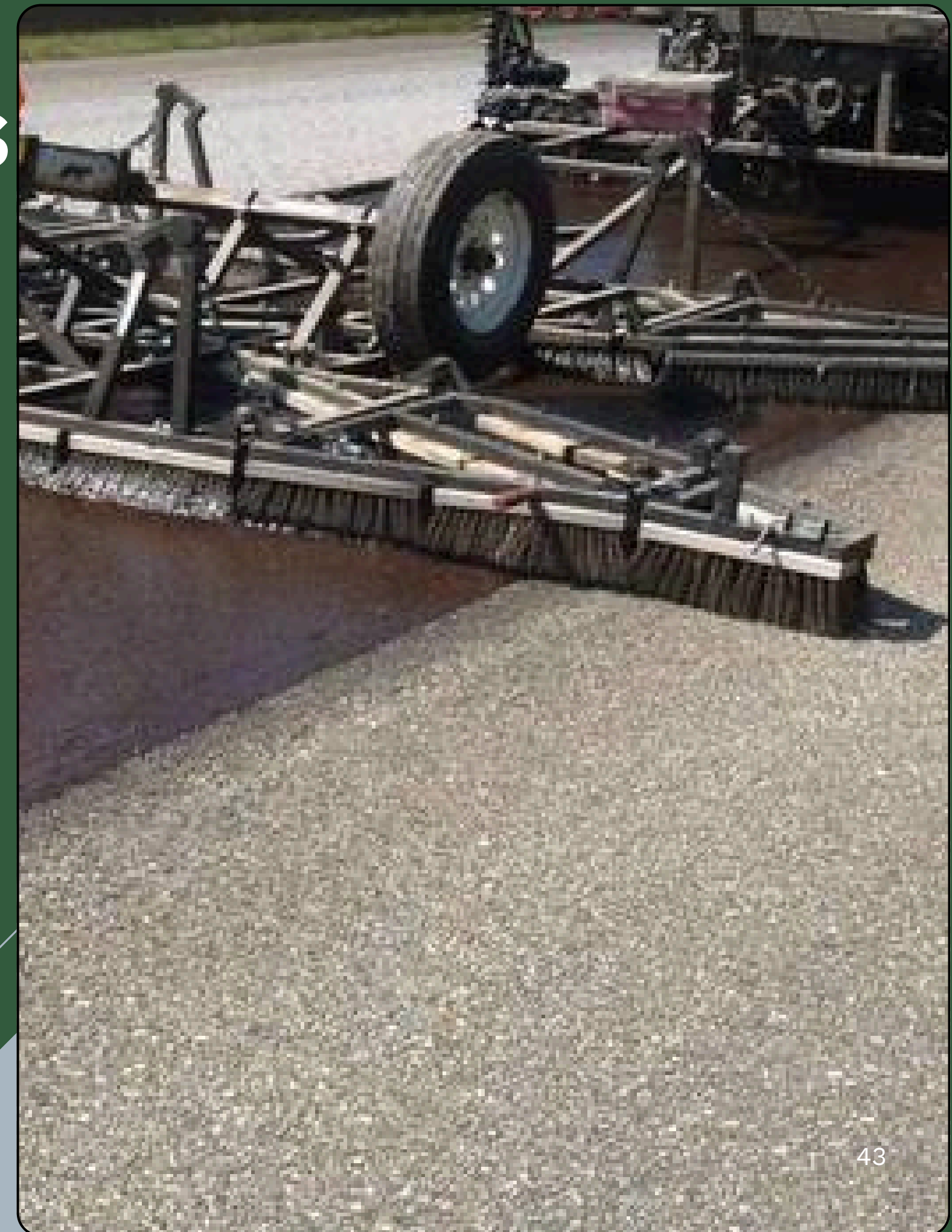
## The “Armor Coat”

### Advantages:

- Excellent waterproofing
- High friction/skid resistance
- Good value for rural/high-speed roads

### Disadvantages:

- Mostly surface treatment
- 5–7 year life
- Loose chips + higher road noise



# Slurry Seals & Micro-Surfacing

## Definition

The cold-mix chemical overcoat or additional modified binder

## Technical Details

- Fine aggregate + polymer emulsion + fillers
- Placed with a specialized slurry machine



# Slurry Seals & Micro-Surfacing

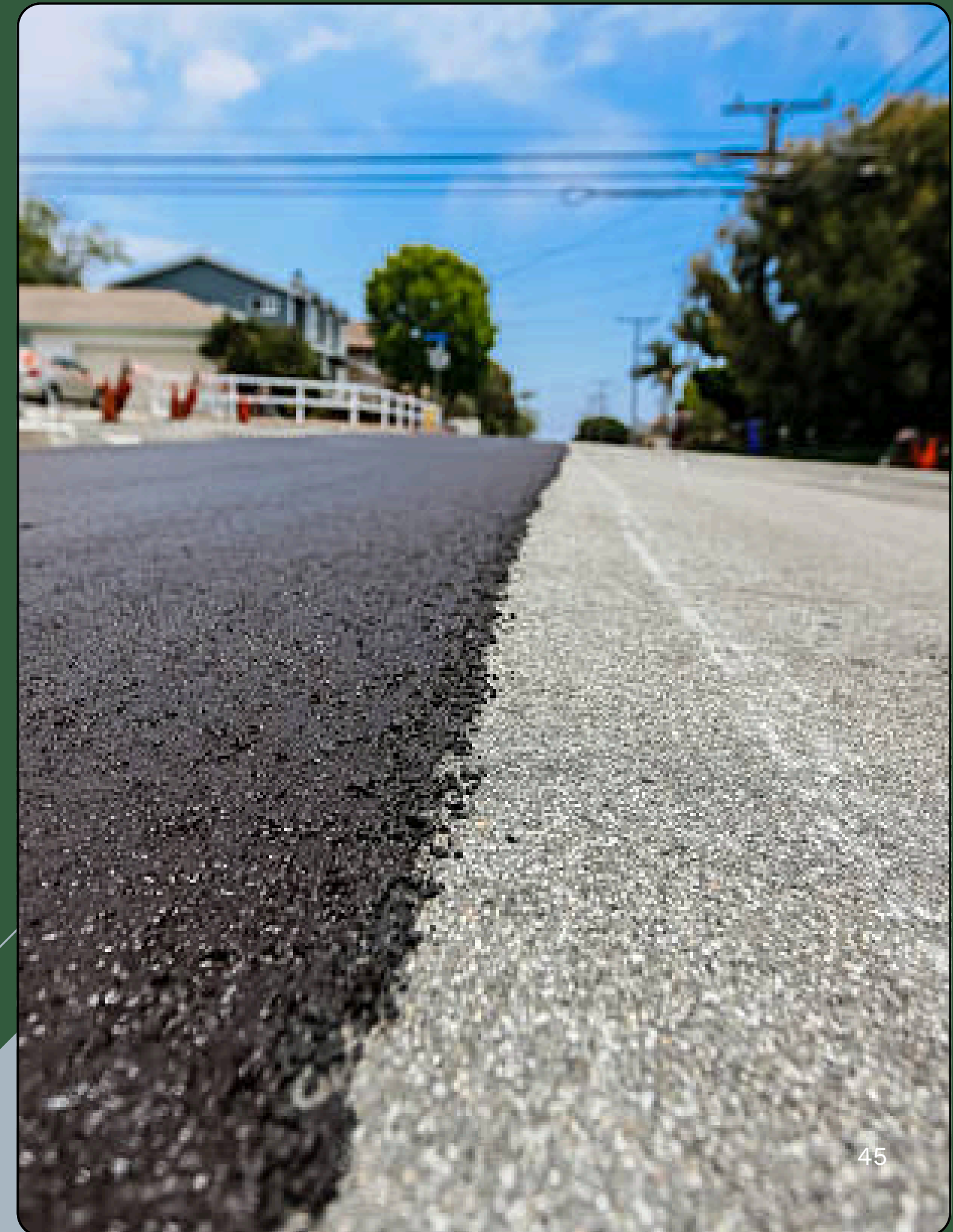
## The Chemical Overcoat

### Advantages:

- Fills minor ruts/irregularities
- Uniform, dark appearance
- Micro-surfacing returns to traffic quickly

### Disadvantages:

- It's only a wearing course
- 6-8 year life
- Higher material cost than chip seals



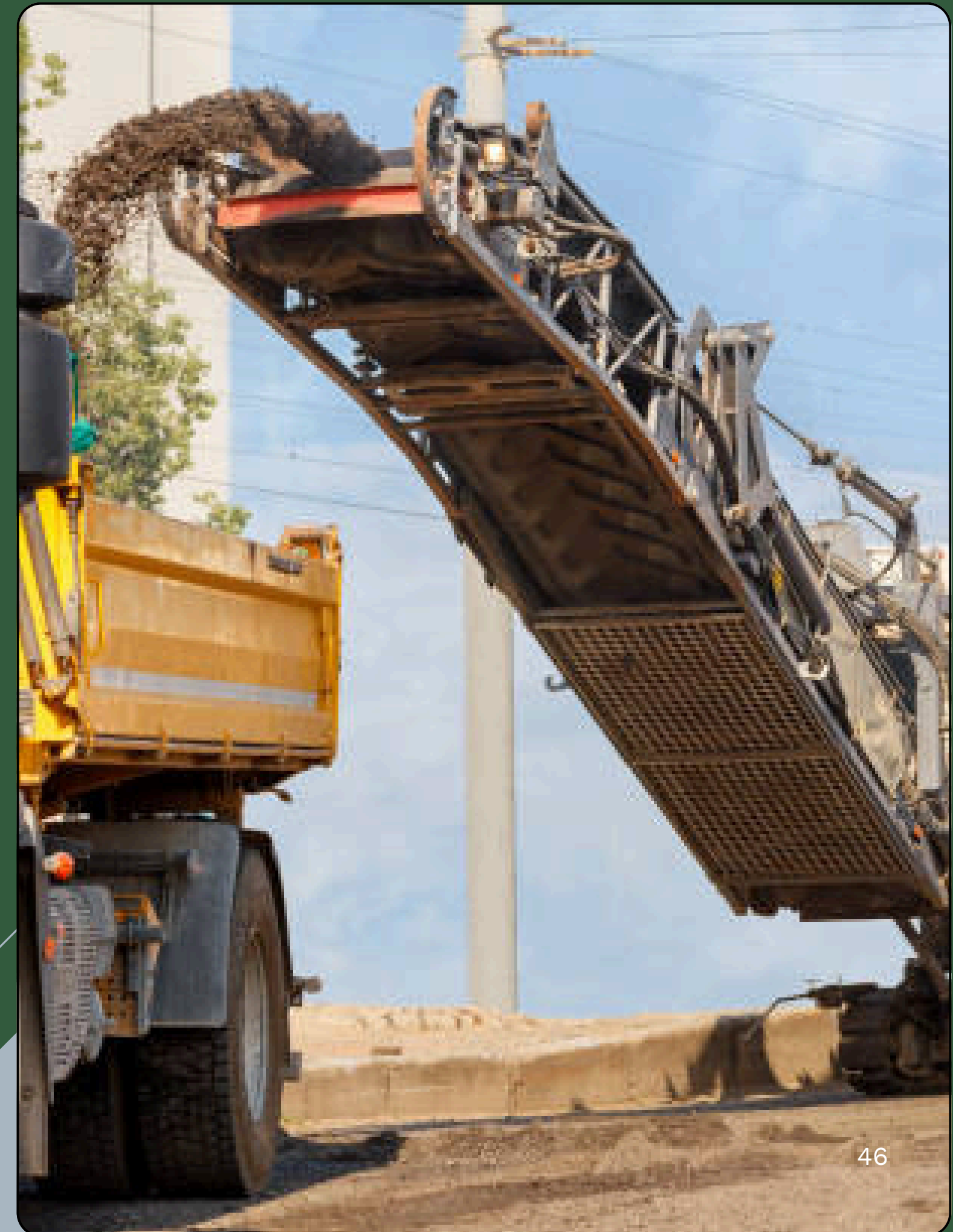
# Mill-and-Fill & Thin Overlays

## Definition

A functional reset by replacing the top layer with new hot-mix asphalt

## Technical Details

- Milling (optional) + paving + rolling with HMA



# Mill-and-Fill & Thin Overlays

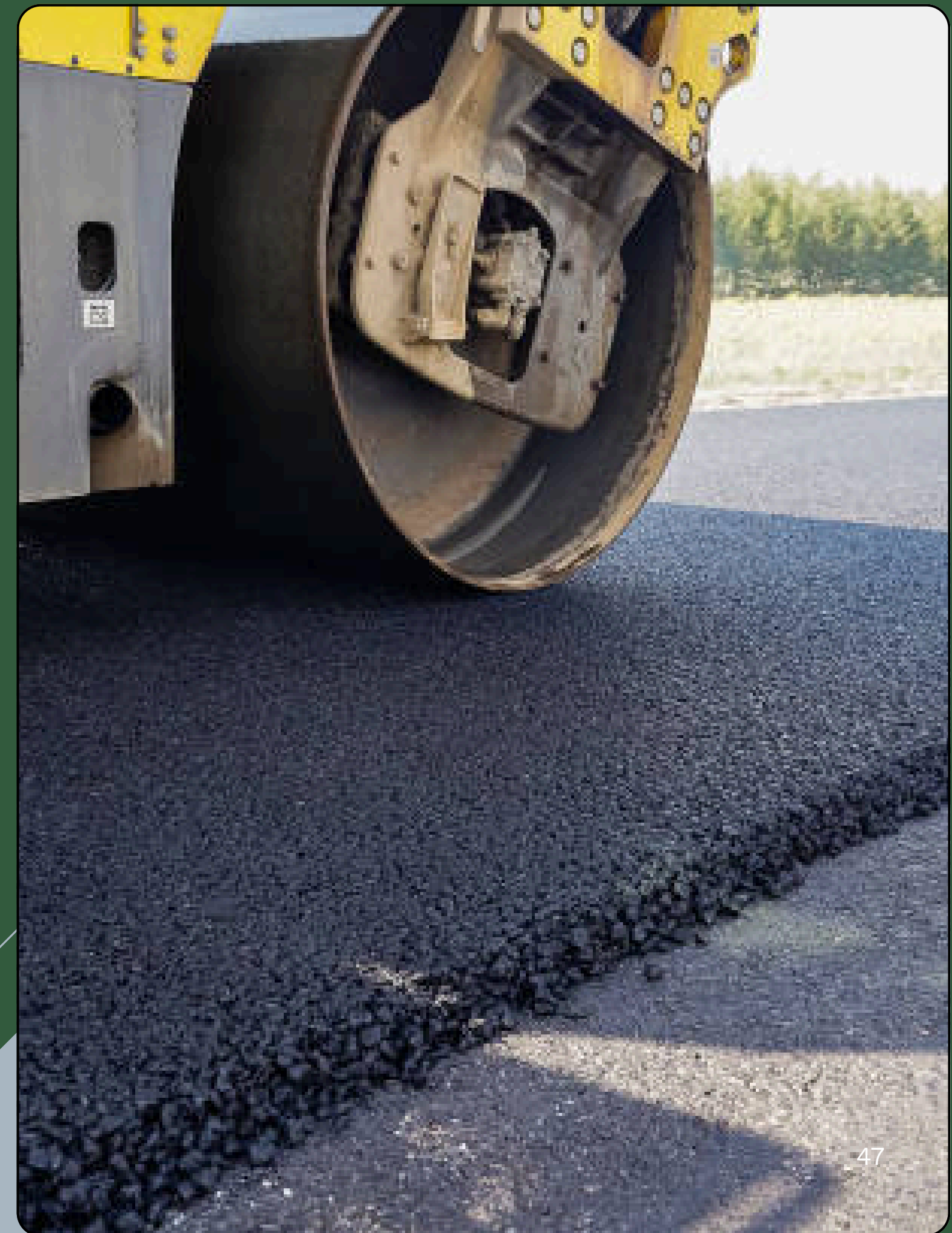
## The Functional Reset

### Advantages:

- Better smoothness / lower noise
- Fixes minor profile issues
- High public “perceived value”

### Disadvantages:

- Labor- and equipment-intensive
- 10-12 year life
- Most expensive preservation option



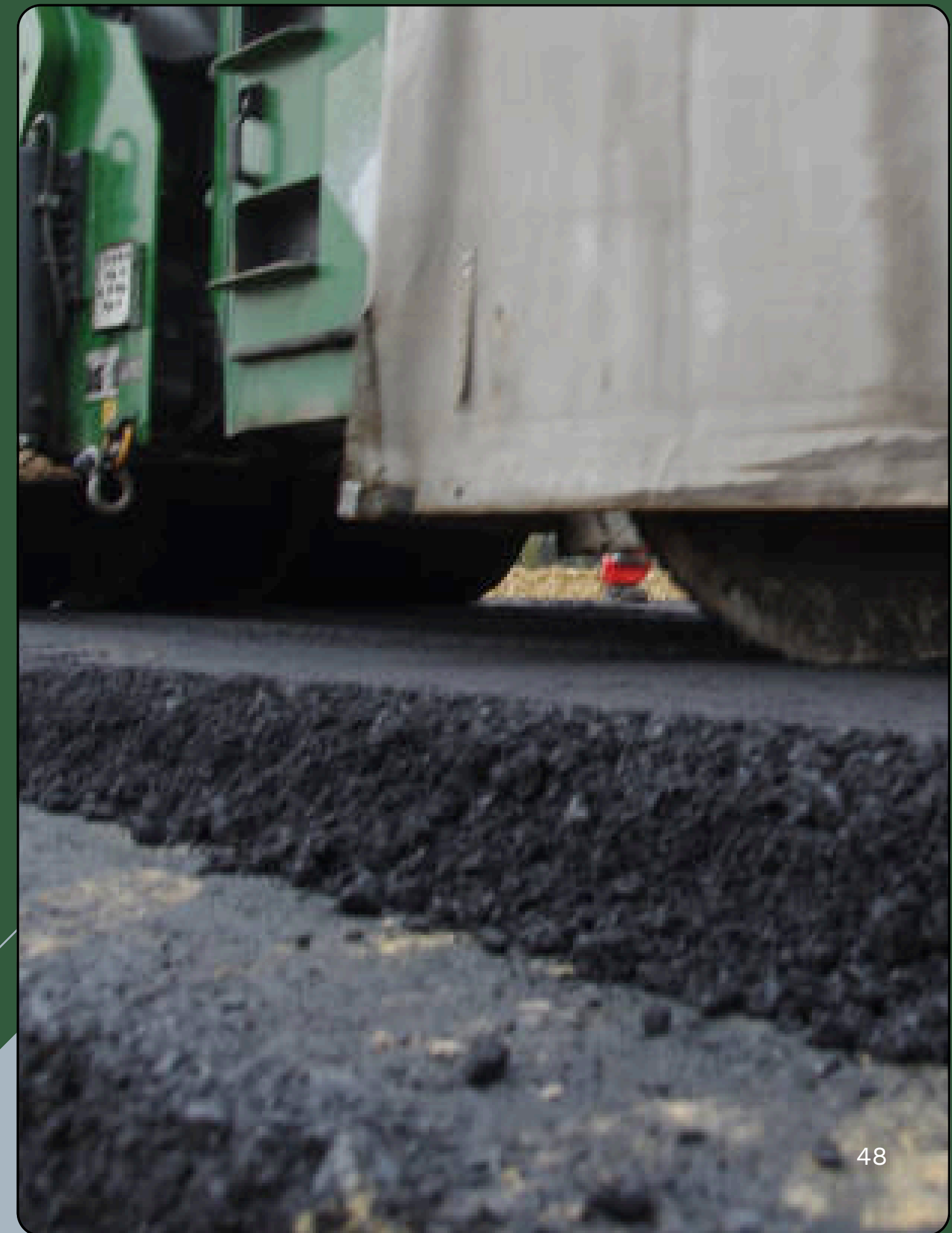
# Full-Depth Overlays & Rehab

## Definition

Thick new asphalt placed on a failing pavement as a structural lifeboat

## Technical Details

- Large paving operation; major traffic impacts



# Full-Depth Overlays & Rehab

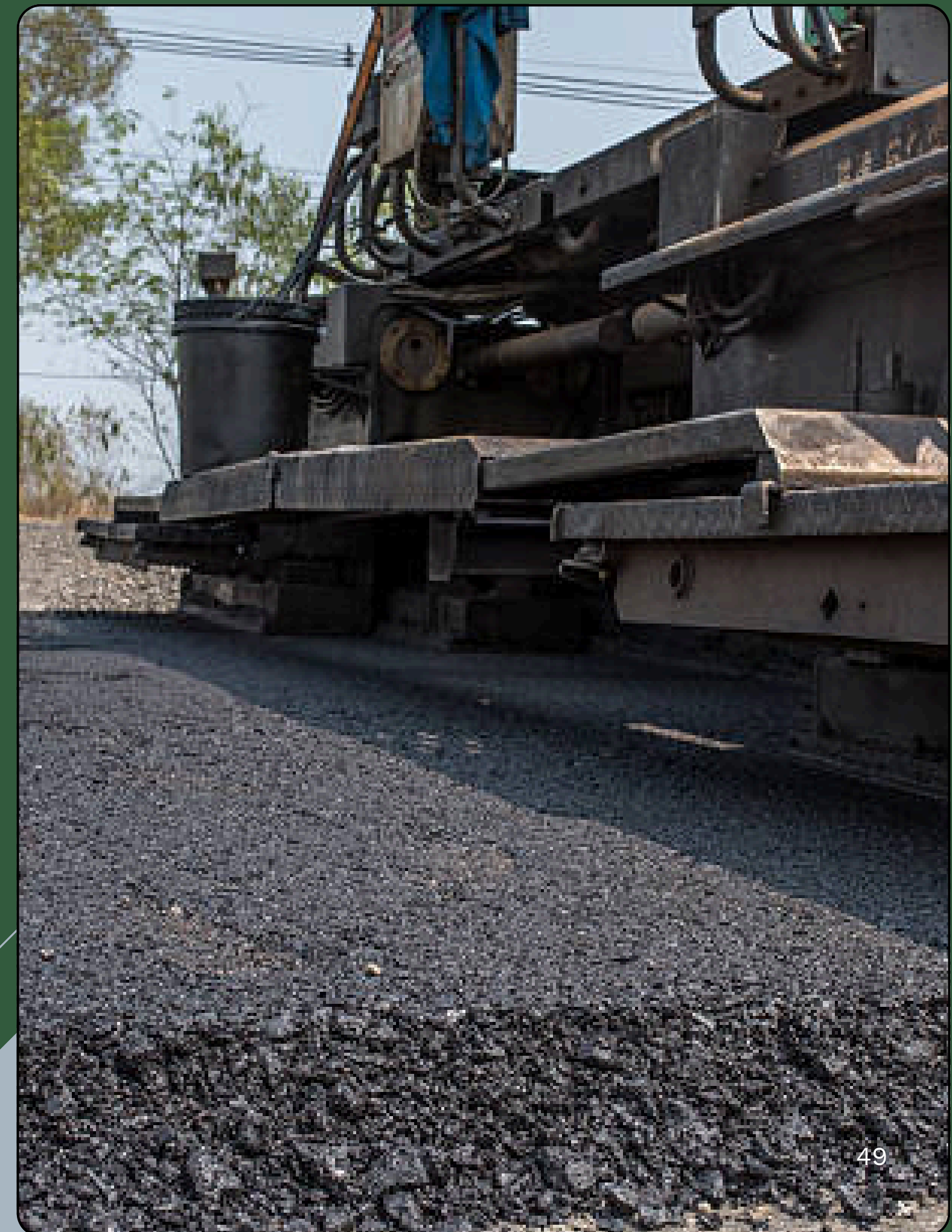
## The Structural Lifeboat

### Advantages:

- Adds real structural strength
- Longest life extension

### Disadvantages:

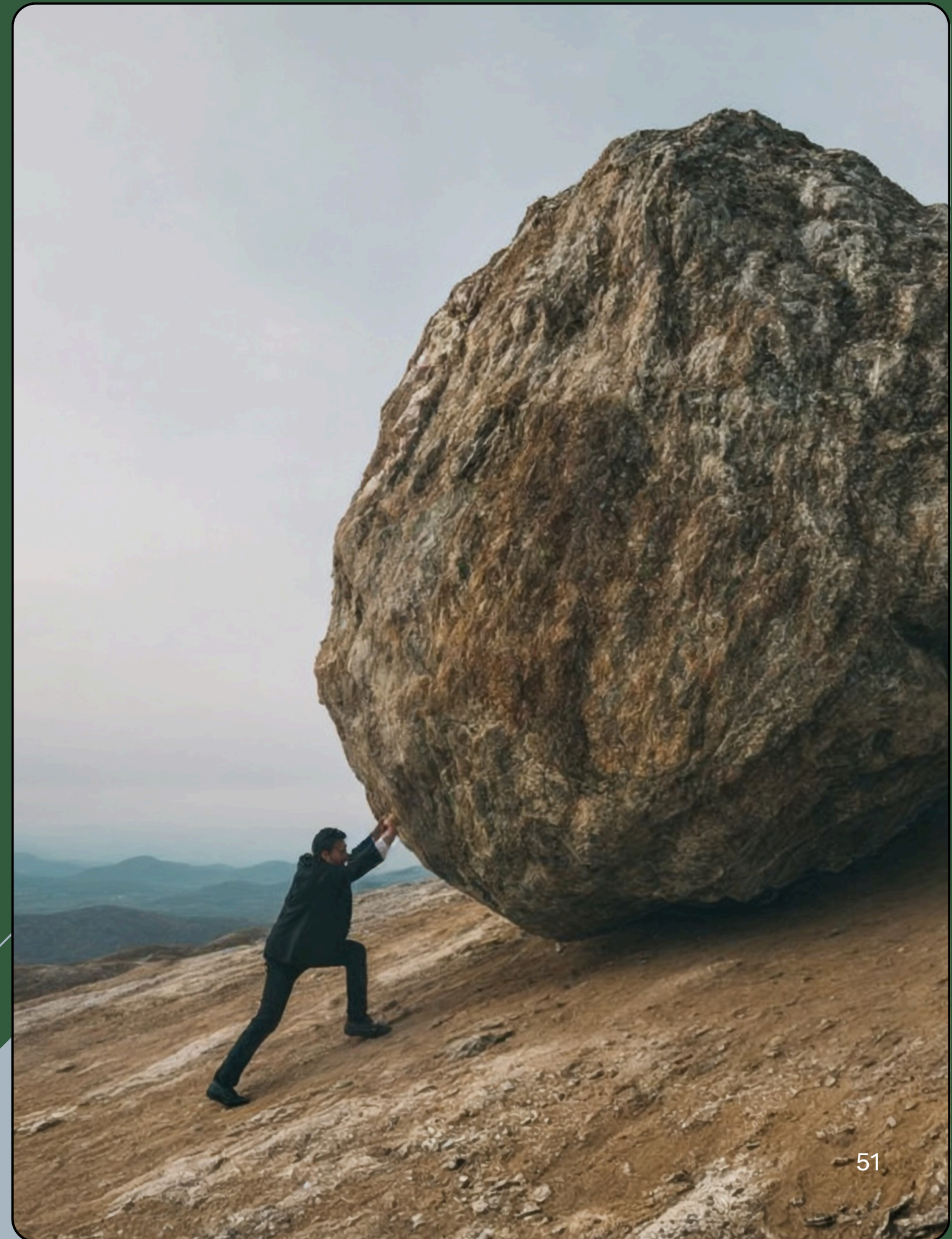
- Very high cost
- May adjust utilities/curbs
- 15-20 year life



<b>Method</b>	<b>Water used?</b>	<b>Life Extension</b>	<b>Labor Intensity</b>	<b>Penetration</b>
Fog Seal / Rejuvenator	yes	1-3	low	low
Chip Seal / Scrub Seal	yes (emulsion)	5-7	moderate	minimal surface
Slurry Seal / Micro-Surfacing	yes (emulsion)	6-8	moderate-high	minimal surface
Mill-and-Fill / Thin Overlays	yes (dust suppression or binding)	10-12	high	N / A
Full-Depth Overlays	no	15-20	very high	N / A

# Why traditional methods eventually hit a wall

Most traditional methods (from Fog Seals to Overlays) share three traits.



# The "Topical" Limitation

## They are Mechanical

They rely on physical weight or thickness to protect the road.

## They are Topical

They create a "cap" or a "sandwich" on top of the problem.

## They use "Like with Like"

They use petroleum-based binders to fix petroleum-based aging.

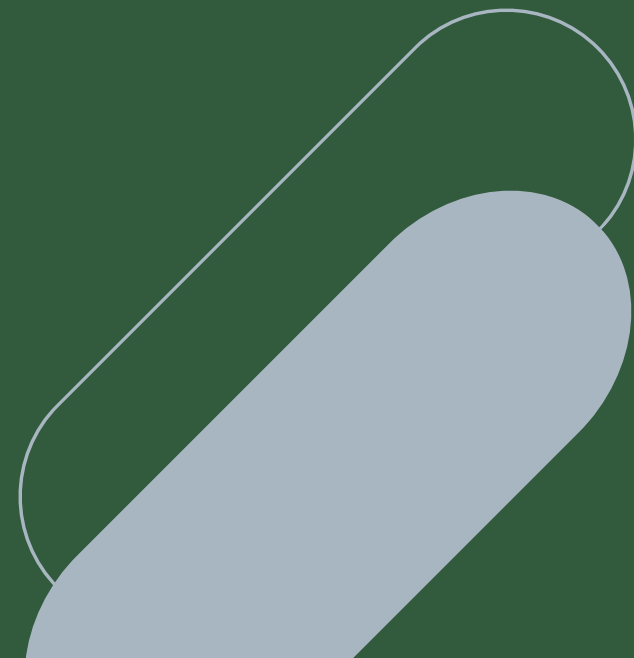


# Opportunity:

## The Problem

- asphalt binder is chemically "starved"
- brittle (the SARA imbalance we discussed)
- additional rock or films on top
- don't fix the disease / just hides the symptoms

**Physical Protection** ► **Chemical Restoration**



# Innovation

**Mobilize the remainder oils so asphalt is less brittle, more flexible, and longer-lasting**

# Biobased Frontier

- Pavement aging faster than Budget capacity
- Preservation shift: “cover it” to “restore it”
- Growing interest in both the biobased alternatives + traditional options
- Goals:
  - extend life
  - **reduce environmental footprint**
  - maintain safety
  - reallocate budgets



# Different Toolboxes: Same Goal

## Both Do Well:

- Replace light oils that have been lost
- Soften brittle asphalt and react with aged binder
- Restore flexibility and slow cracking

## Bio-Based Oils

- Typically renewable, lower odor, and lower environmental footprint

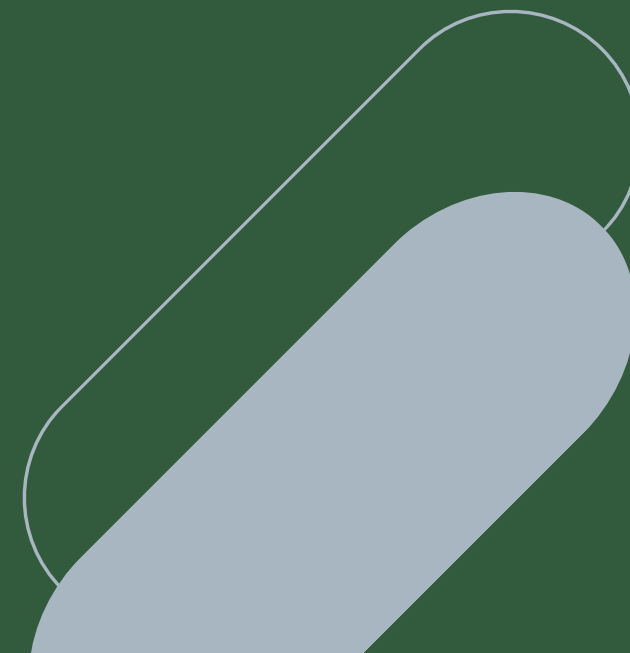
# Big Picture Difference

## Surface Coatings

- Sit mostly on top
- Add a layer
- Can change surface texture or friction

## Biobased

- Designed to penetrate
- Replenishes lost components inside the asphalt
- Helps “reset” the chemistry
- Preserves existing material



# How Biobased Oils Work

- Made from **renewable** vegetable/animal sources
- Can be **engineered** to flow more easily into aged pavement
- **Blend** with the old binder instead of just sitting on it
- Help **break up** stiff, brittle structures that form with aging
- Lower stiffness and **restore flexibility** closer to “younger” asphalt



# US 63 Columbia MO

Treated: June 2, 2021

RePlay

Untreated

Photo: December 4, 2024

# Emerging Technologies in Pavement Preservation



## Treatments

Innovative solutions to enhance pavement durability.



## Sensors

Technologies monitoring pavement conditions in real-time.



## Analytics

Data-driven insights for effective asset management.

# Implementation Innovations

## Asset Management Solutions

Software enhances decision-making efficiency

## Predictive Modeling for Performance

Anticipates future maintenance needs

## Integrating Agency Workflows

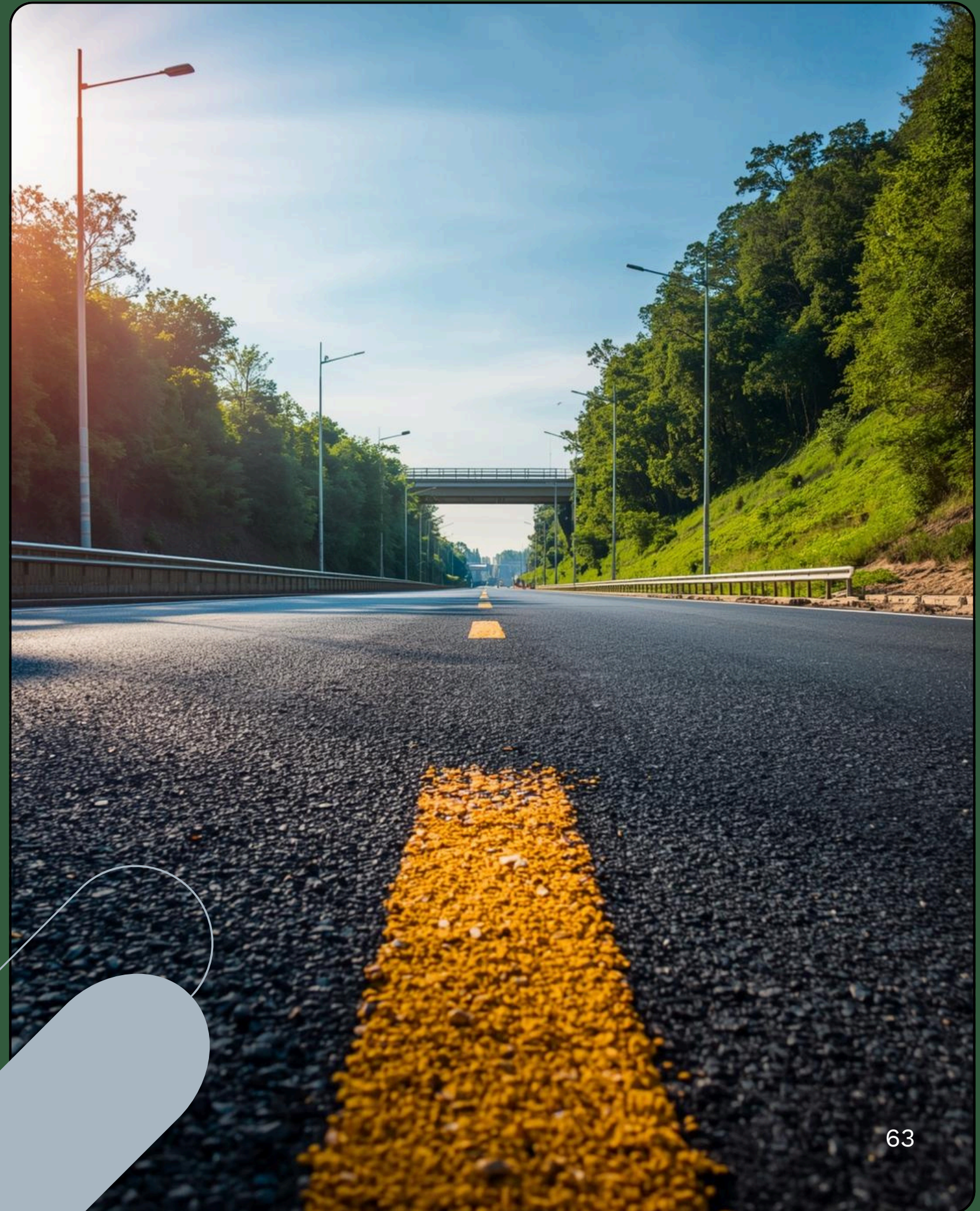
Streamlines operations for effectiveness



**We can't build our way out of the maintenance backlog—we have to chemistry our way out.**

# Pavement Preservation

- Every strategy has its place: preservation, rehab, and paving
- The right treatment, at the right time, matters most
- Pavement is both structure and chemistry
- No single method fits all pavements.
- Preservation supports — not replaces — the asphalt lifecycle



# Thank You

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