

GREEN HIGHWAYS – RECYCLING TECHNOLOGY

Advantages of Recycling

- Reduced cost of construction
- Conservation of aggregate and binders
- Preservation of existing pavement geometrics
- Preservation of environment
- Conservation of energy
- Less user delay

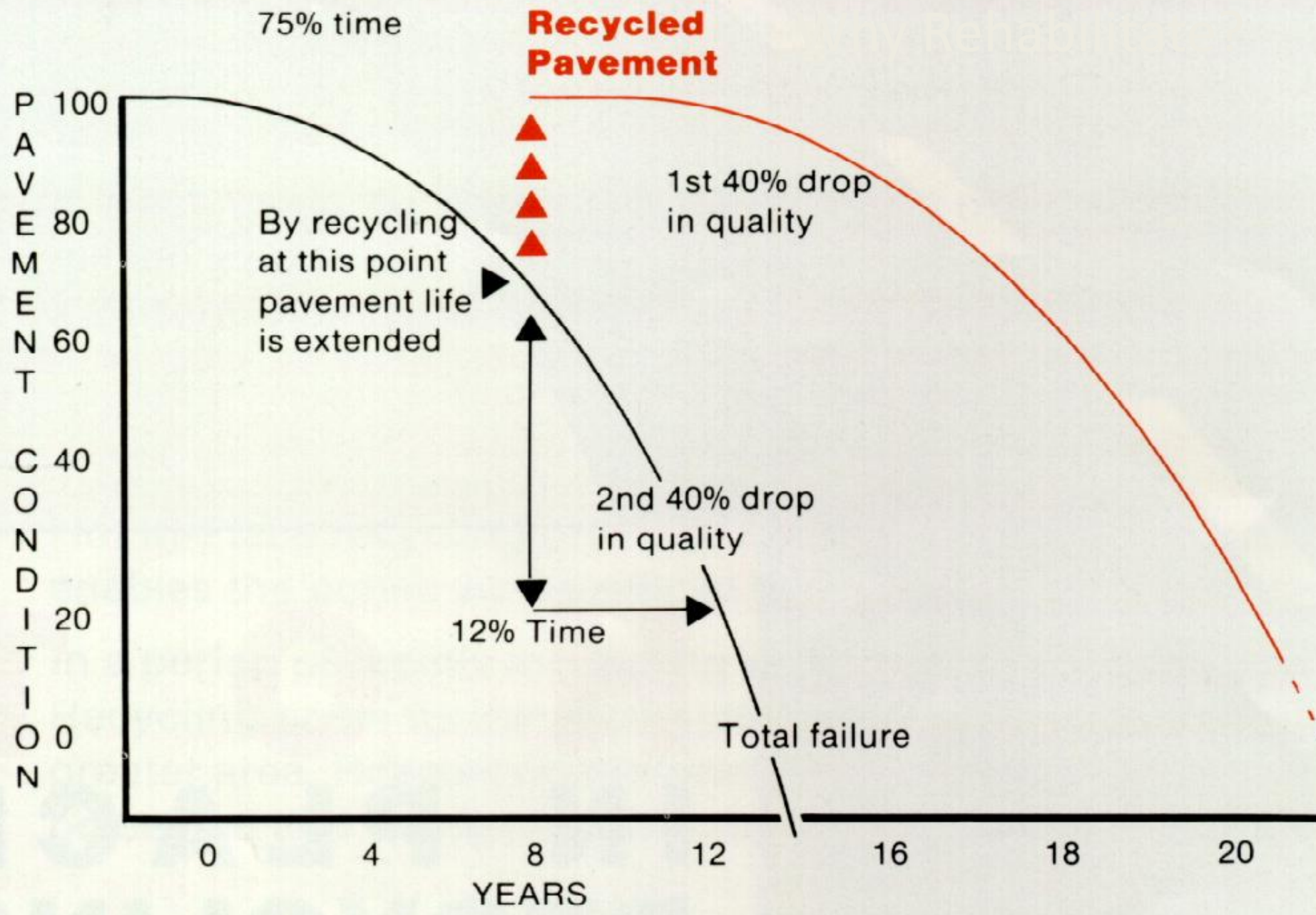
Future of Recycling

- **Increased reuse of materials**
- **Landfills becoming more and more scarce**
- **New equipment and admixtures versus vested interest in existing technology and equipment**
- **The same pavement can be recycled over and over again**

Recycling is one of several
rehabilitation alternatives

Reasons that Rehabilitation is Needed

- Inadequate ride quality
- Excessive pavement distress
- Reduced surface friction
- Excessive maintenance requirement
- Unacceptable user costs
- Inadequate structural capacity for planned use or projected traffic volumes



75% time

Recycled Pavement

By recycling at this point pavement life is extended

1st 40% drop in quality

2nd 40% drop in quality

12% Time

Total failure

P
A
V
E
M
E
N
T

C
O
N
D
I
T
I
O
N

0

4

8

12

16

18

20

YEARS

Maintenance

- Corrective – corrects or prevents deterioration from environmental effects
- Preventive – activities intended to extend or preserve the service life of a pavement, no increase in structure

Recycling Methods

- Hot In-place Recycling
- Cold planing
- Hot Mix Recycling (central plant)
- Cold Mix Recycling (central plant)
- Cold In-place Recycling
- Full Depth Reclamation

Hot In-place Recycling: Process

- Existing asphalt surface is heated
- Scarified to a depth from 20 to 60 mm
- Scarified material combined with aggregate, asphalt binder, and/or recycling agent
- Compaction

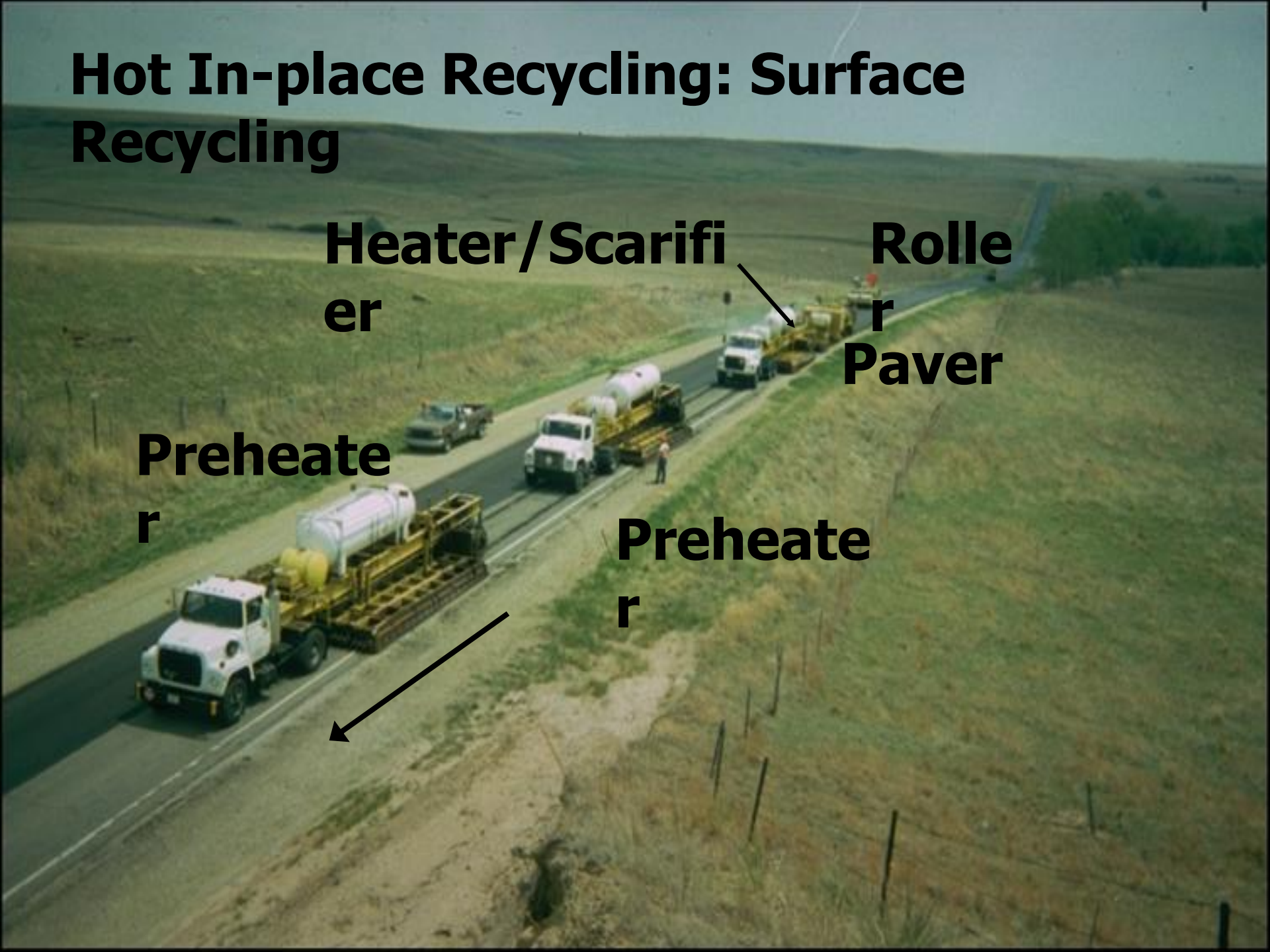
Hot In-place Recycling: Surface Recycling

Heater/Scarifier

Roller
Paver

Preheater

Preheater

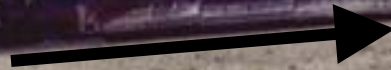


Hot In-place Recycling: Repaving

Repaving
Machine

Heater

New Mix



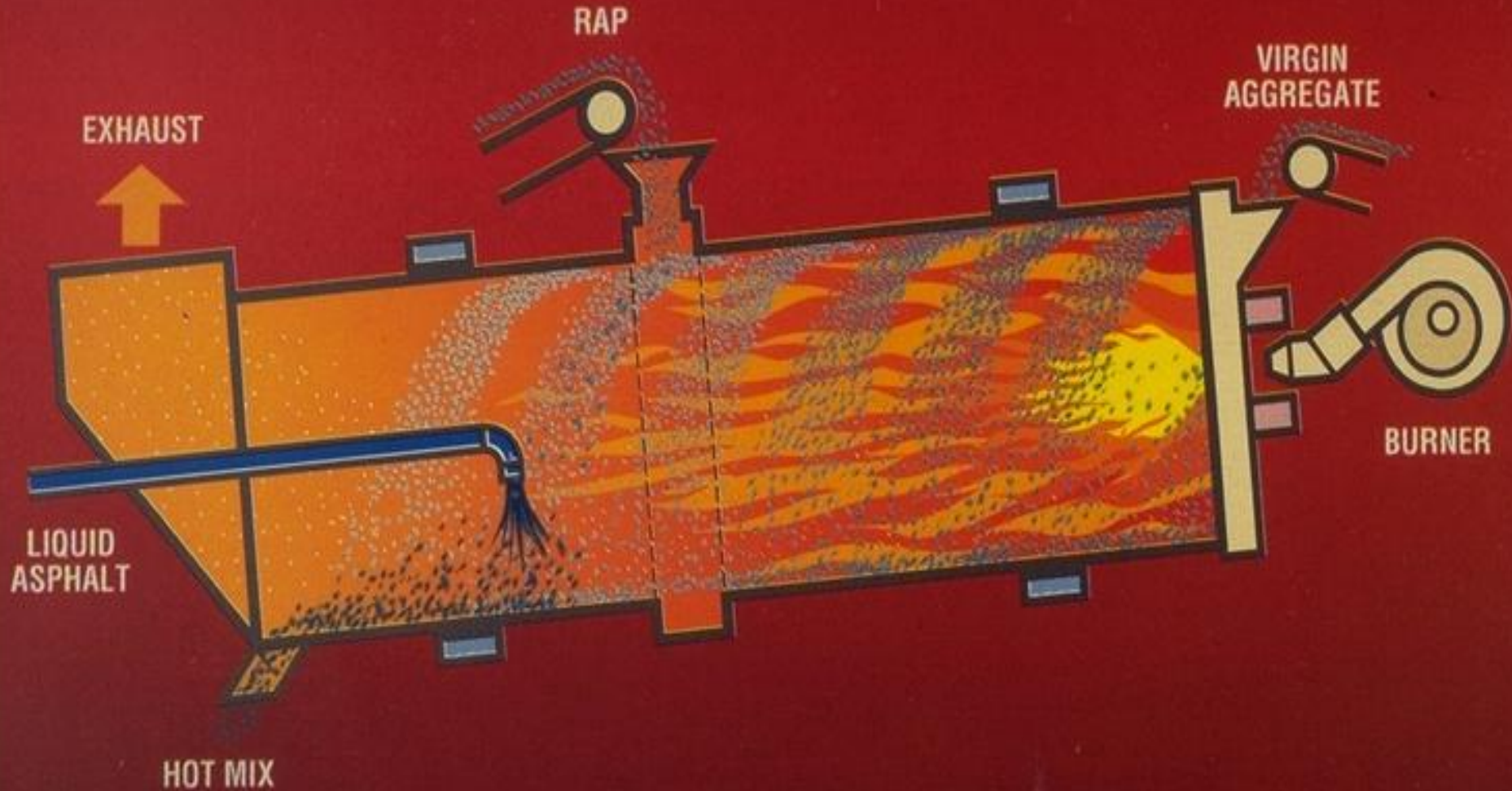
Hot In-place Recycling: Remixing

Remixing
Machine

Virgin
Material



Drum with Center Entry



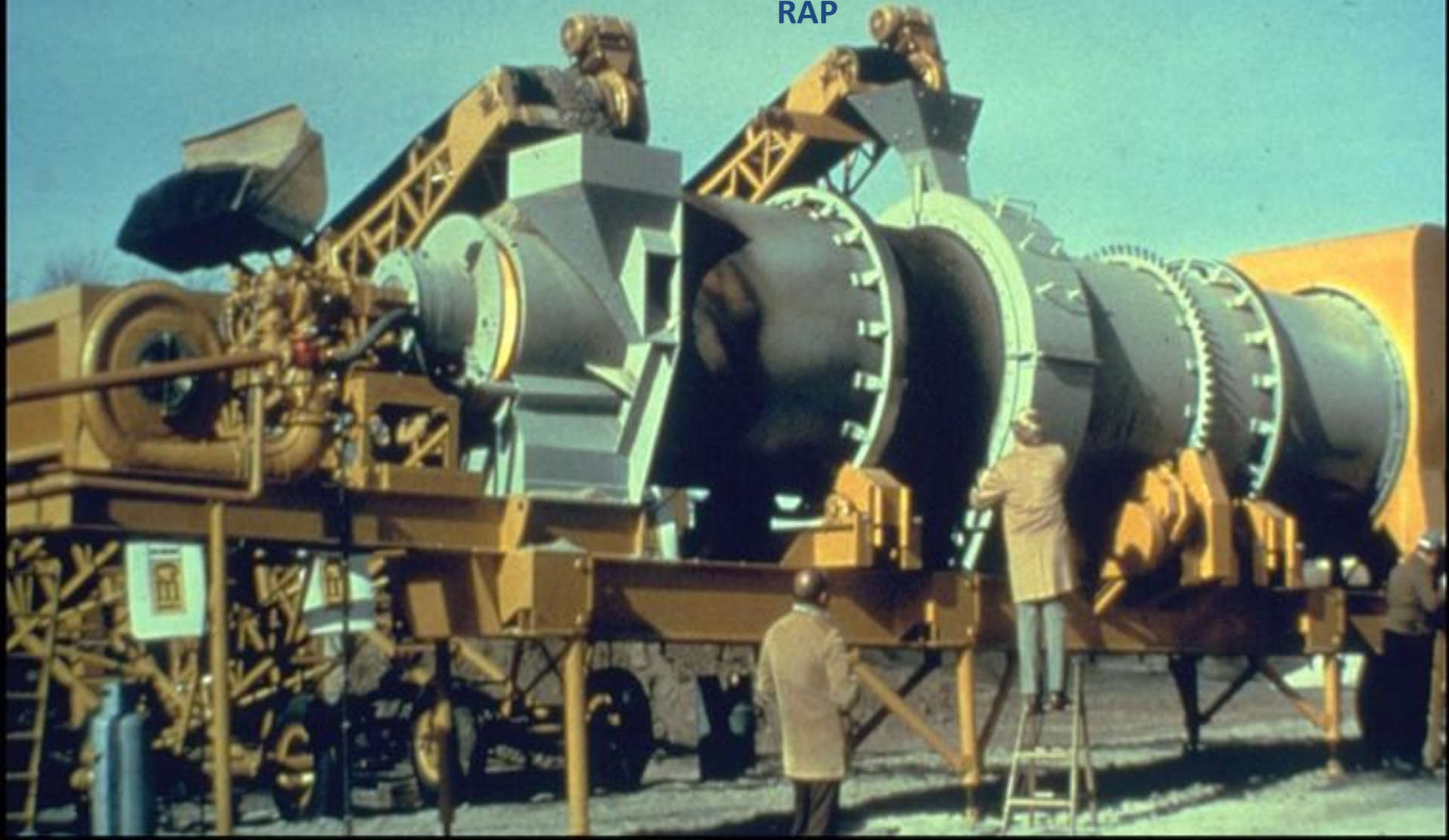


Shed Used for Storing RAP

Drum Plant Showing Center Entry

Virgin Aggregate

RAP



Hot Mix Recycling in a Drum Mix Plant

Virgin
Aggregate

RAP



Cold Mix Recycling (at central plant)

- RAP and reclaimed aggregate (if any) mixed with new asphalt binder and new aggregate (if needed) to produce cold, recycled mix without application of heat
- Recycled mix is produced at a central plant rather than in-place.

Ripping Process



Milling with Truck Being Loaded with RAP



Cold In-place Recycling

**Milling
Machine**

Crusher

Mixer-Paver

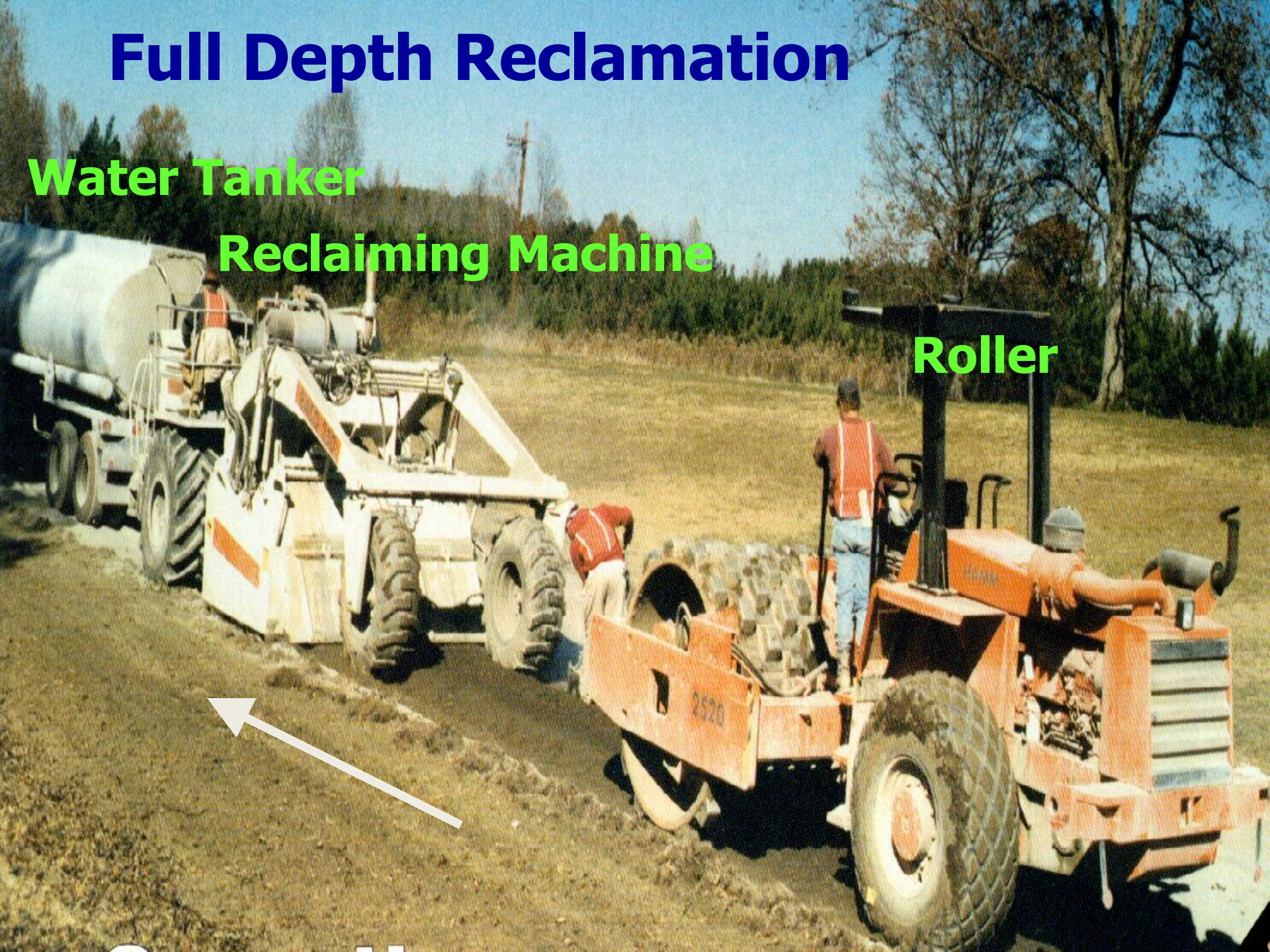


Full Depth Reclamation

Water Tanker

Reclaiming Machine

Roller



Project Evaluation

1. Pavement assessment
2. Historic information
3. Pavement properties
4. Distress evaluation
5. Preliminary rehabilitation selection
6. Economic analysis

Bleeding



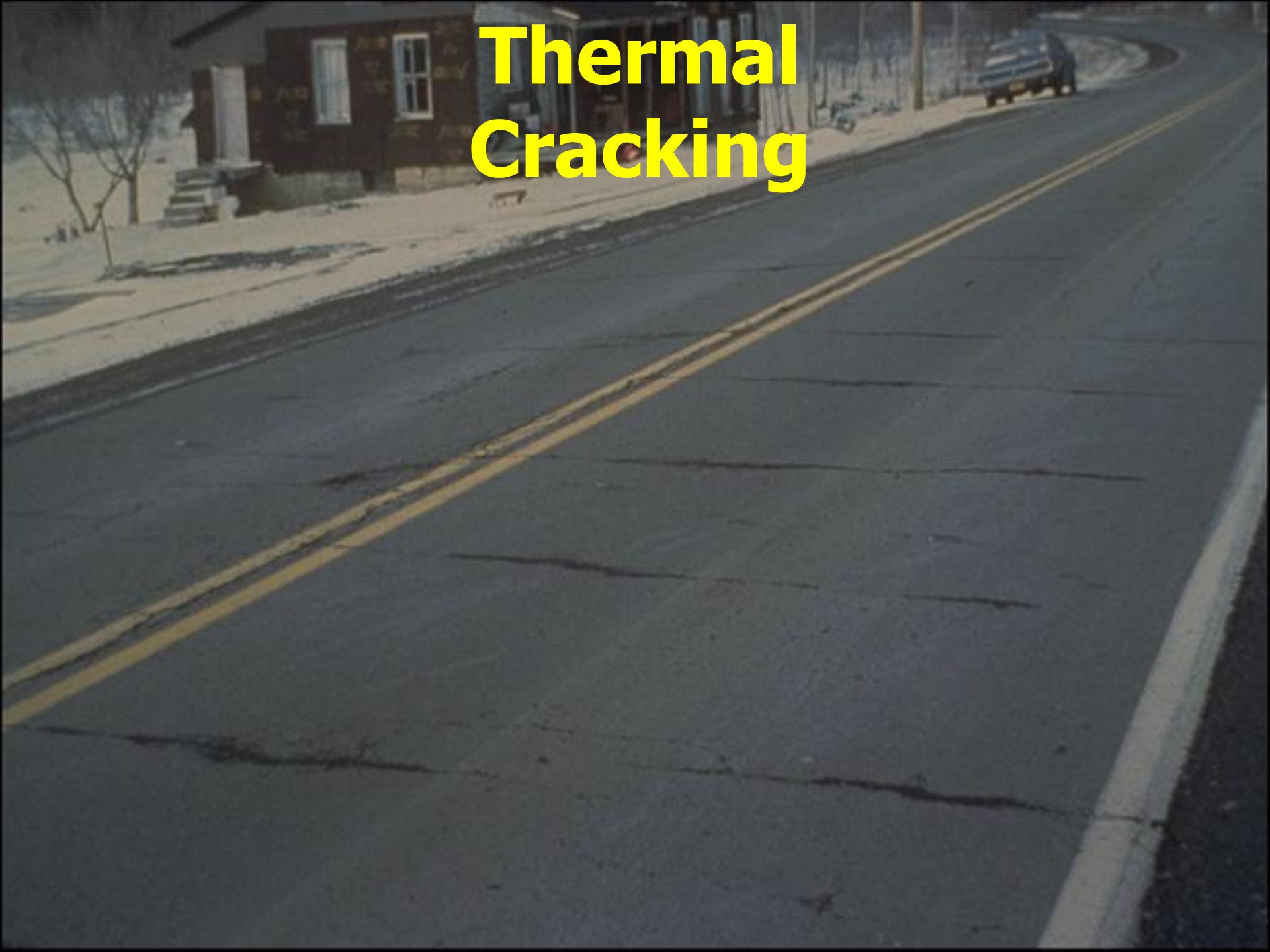
Corrugation



Rutting



Thermal Cracking



Preliminary Rehabilitation Selection (1 of 3)

- Distresses – type and severity
- Quality of material – adequate or needs improvement
- Design life
- Anticipated traffic
- Existing structural capacity
 - Sufficient for design life
 - Sufficient for rehabilitation equipment

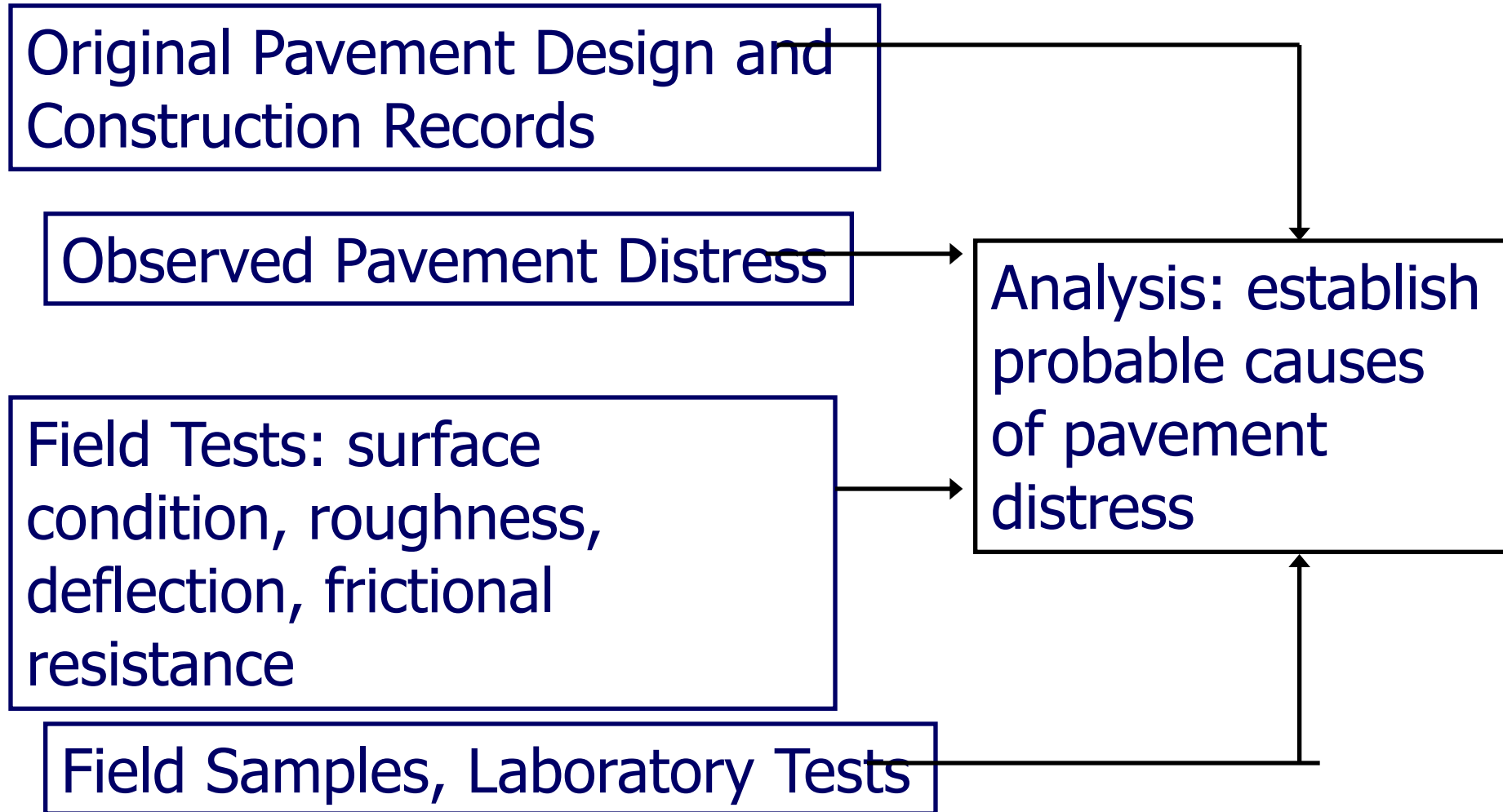
Preliminary Rehabilitation Selection (2 of 3)

- Adequate surface and subsurface drainage
- Expected performance standard
- Acceptable level of maintenance
- Geometric considerations
- Safety concerns
- Utilities

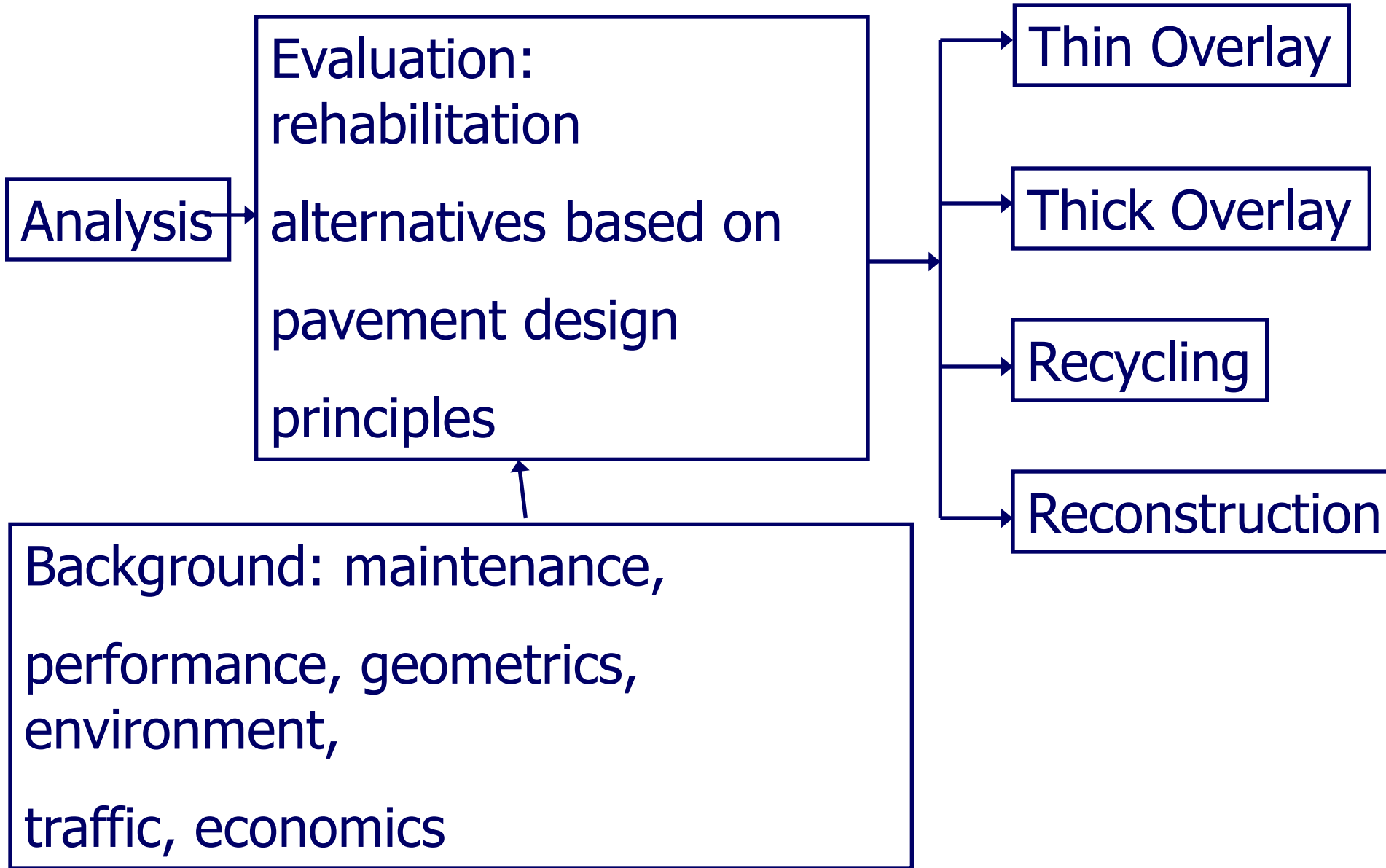
Preliminary Rehabilitation Selection (3 of 3)

- Construction considerations
 - Traffic
 - Work hour restrictions
 - Overhead clearance
 - Drainage structures
 - Experience of contractors
- Impact on adjacent business

Selecting a Rehabilitation Alternative



Selecting a Rehabilitation Alternative, cont



Economic Analysis

- Initial rehabilitation cost – project budget
- Future rehabilitation cost
- Maintenance cost
- Salvage value
- User costs
- Life-cycle costs
 - Present worth (PW)
 - Equivalent annual uniform cost (EAUC)

Recycling Benefits vs. New Construction

- Life-cycle cost savings
- Reuses natural resources (aggregates, binders, energy)
- Maintains existing pavement geometrics as well as thickness

Recycling Alternatives

Type of Pavement Distress	Hot Recycling (HR)	Hot In-place Recycling (HIR)
Surface Defects		
Raveling	X	X
Bleeding	X	X
Skid Resistance	X	X

Recycling Alternatives

Type of
Pavement
Distress

HR

HIR

CIR

FDR

Deformation

Corrugations

X

X

Rutting - Shallow

X

X

Rutting - Deep

X

X

X

Recycling Alternatives

Type of
Pavement
Distress

HR

HIR

CIR

FDR

	HR	HIR	CIR	FDR
Cracking				
Alligator	X		X	X
Longitudinal	X	X	X	X
Pavemen Edge	X		X	X
Slippage	X	X		

Load Associated Cracking

Recycling Alternatives

Type of
Pavement
Distress

HR

HIR

CIR

FDR

Cracking

Block (Shrinkage)

X

X

X

Longitudinal-joint

X

X

Transverse

X

X

X

Reflection

X

X

X

Non-Load Associated Cracking

Pavement Distress Mode	Candidate Rehabilitation Techniques							
	CP	HIR	CIR	Thin HMA	Thick HMA	FDR	Combination Treatments	Reconstruction
Raveling	Green Diagonal	Red Horizontal	Blue Vertical	Red Horizontal	Green Diagonal		Red Horizontal	
Potholes		Blue Vertical	Red Horizontal	Green Diagonal	Blue Vertical	Green Diagonal	Red Horizontal	
Bleeding	Blue Vertical	Blue Vertical	Blue Vertical		Green Diagonal	Blue Vertical	Red Horizontal	
Skid Resistance	Blue Vertical	Blue Vertical	Blue Vertical	Red Horizontal	Green Diagonal	Green Diagonal	Red Horizontal	
Shoulder Drop Off	Blue Vertical							Red Horizontal
Rutting	Blue Vertical	Blue Vertical	Red Horizontal		Green Diagonal	Green Diagonal	Red Horizontal	Green Diagonal
Corrugations	Blue Vertical	Blue Vertical	Red Horizontal		Green Diagonal	Green Diagonal	Red Horizontal	Green Diagonal
Shoving	Blue Vertical	Blue Vertical	Red Horizontal		Green Diagonal	Green Diagonal	Red Horizontal	Green Diagonal
Fatigue Cracking			Red Horizontal		Red Horizontal	Red Horizontal	Red Horizontal	
Edge Cracking			Green Diagonal		Green Diagonal		Red Horizontal	Red Horizontal
Slippage Cracking		Blue Vertical	Red Horizontal		Green Diagonal	Blue Vertical	Red Horizontal	Blue Vertical
Block Cracking			Red Horizontal		Green Diagonal	Red Horizontal	Red Horizontal	Blue Vertical
Longitudinal Cracking		Blue Vertical	Red Horizontal		Green Diagonal	Blue Vertical	Red Horizontal	Blue Vertical
Transverse Cracking		Blue Vertical	Red Horizontal		Green Diagonal	Red Horizontal	Red Horizontal	Blue Vertical
Reflection Cracking		Blue Vertical	Red Horizontal		Green Diagonal	Red Horizontal	Red Horizontal	Blue Vertical
Discontinuity Cracking			Red Horizontal		Green Diagonal	Red Horizontal	Red Horizontal	Blue Vertical
Swells	Green Diagonal	Blue Vertical	Blue Vertical	Green Diagonal	Red Horizontal	Blue Vertical	Red Horizontal	Green Diagonal
Bumps	Green Diagonal	Blue Vertical	Blue Vertical	Green Diagonal	Red Horizontal	Blue Vertical	Red Horizontal	Green Diagonal
Sags	Green Diagonal	Blue Vertical	Blue Vertical	Green Diagonal	Red Horizontal	Blue Vertical	Red Horizontal	Green Diagonal
Depressions	Green Diagonal	Blue Vertical	Blue Vertical	Green Diagonal	Red Horizontal	Blue Vertical	Red Horizontal	Green Diagonal
Ride Quality	Green Diagonal	Red Horizontal	Red Horizontal	Green Diagonal	Red Horizontal		Red Horizontal	
Strength		Green Diagonal	Blue Vertical		Red Horizontal	Red Horizontal	Red Horizontal	Red Horizontal


Most
Appropriate




Least
Appropriate

Typical comparative cost analysis of 40 mm bituminous concrete surfacing per lane-km. by conventional and recycling (approximate)

Sl. No.	Item	Conventional Rs.	Recycle Rs.
1.	Aggregate and filler	1,33,044.00	0.00
2.	Bituminous and rejuvenator	2,52,000.00	1,26,844.00
3.	Hire charges	1,12,914.00	1,12,914.00
4.	Consumables	34,272.00	34,272.00
5.	Crew charges	2,800.00	2,800.00
6.	Labour	3,080.00	33,880.00
7.	Misc. (5% of 1+2+3+4)	26,611.00	13,651.00
	Total	5,64,721.50	3,23,361.50
	Saving : 43%		

Summary

Use the appropriate recycling method to address specific pavement distresses and pavement structural requirements.