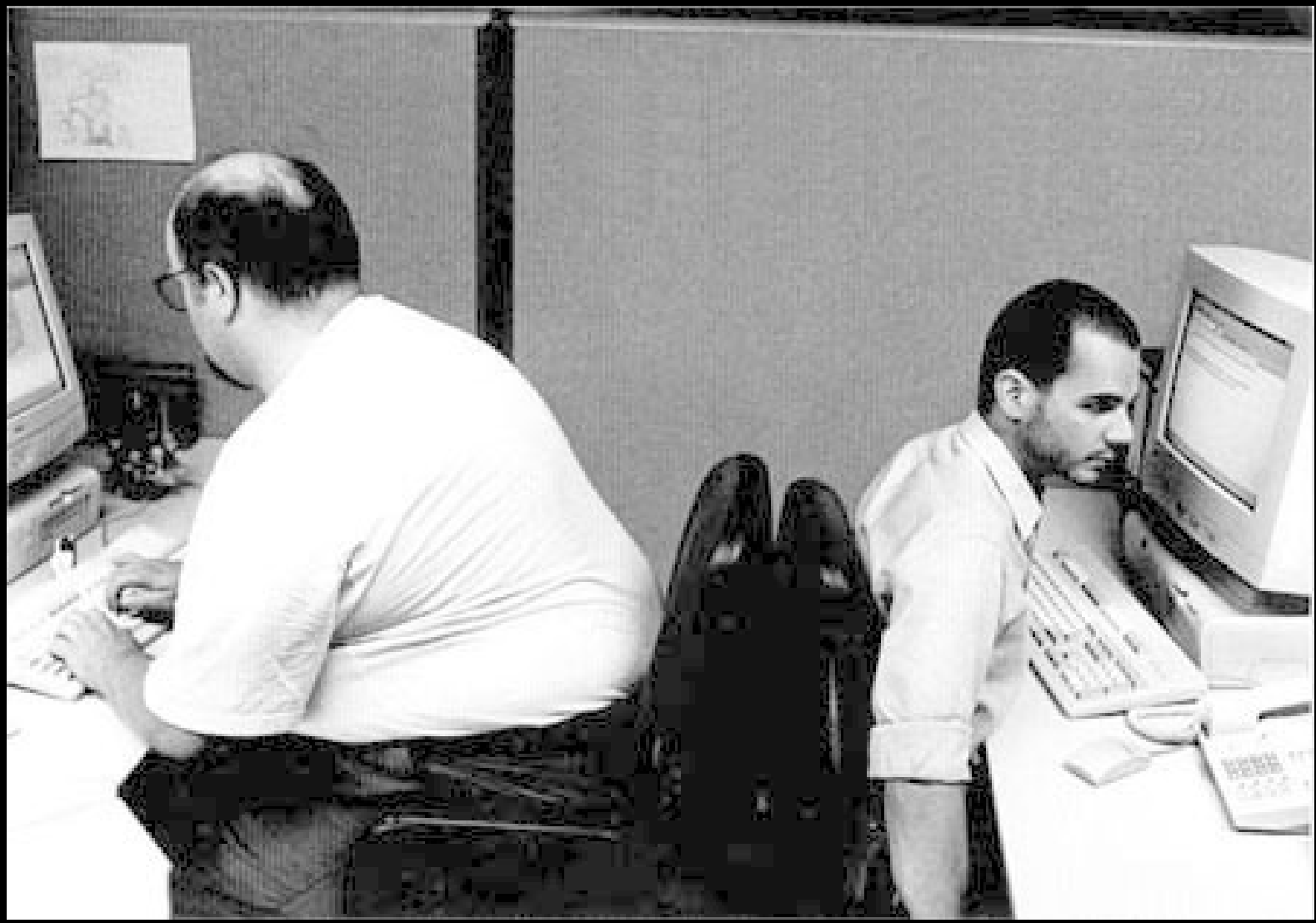
Airfield Concrete Pavement CPR Workshop

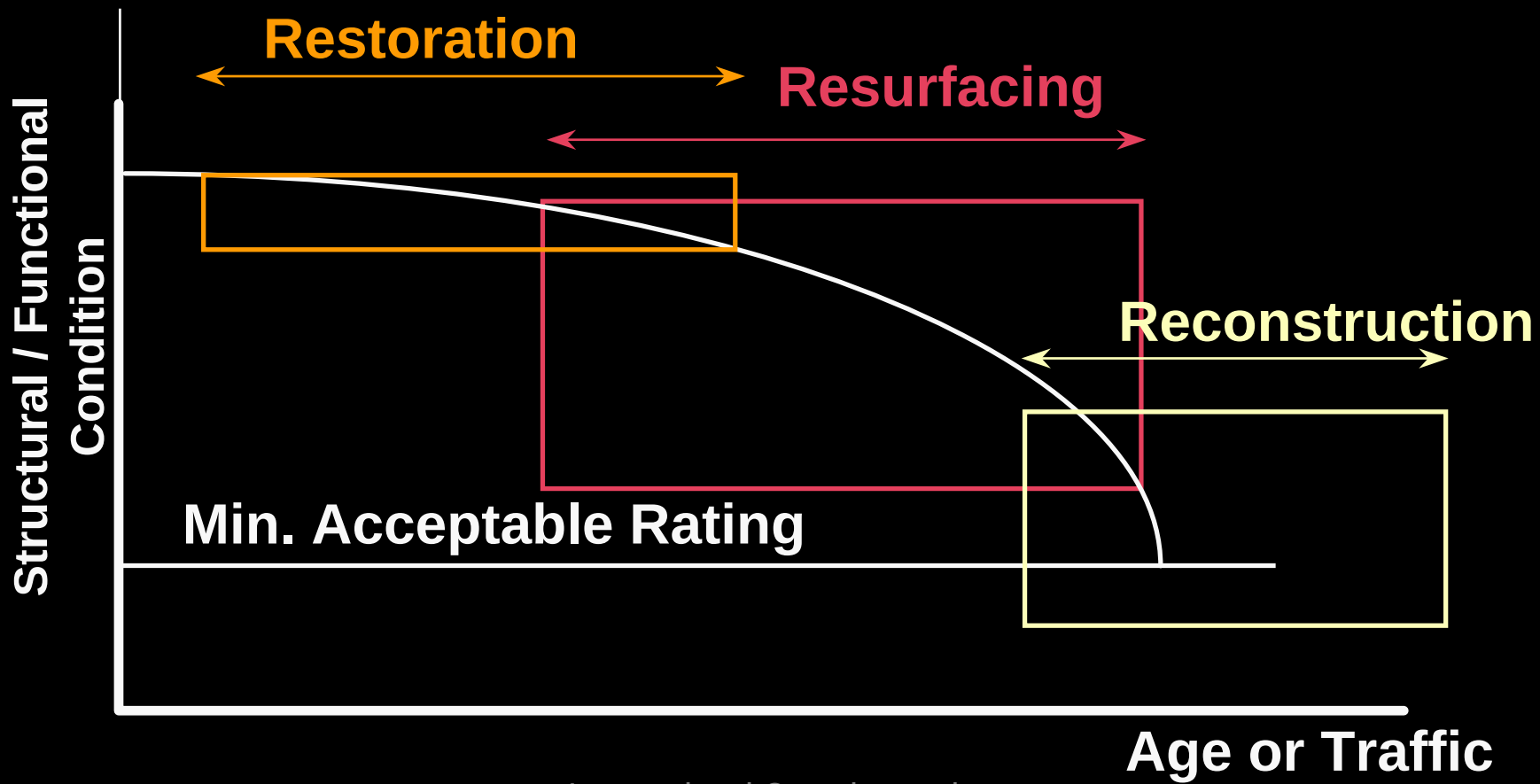
CPR Techniques and Applications for Airfield Pavements



Rehabilitation Strategies

- Restoration
  - Repairs isolated areas of deterioration.
- Resurfacing
  - Repairs a pavement with medium to high severity levels of distress.
- Reconstruction
  - Used at the end of the pavement's life, when it has very high severity levels of distress.

Rehabilitation Timing

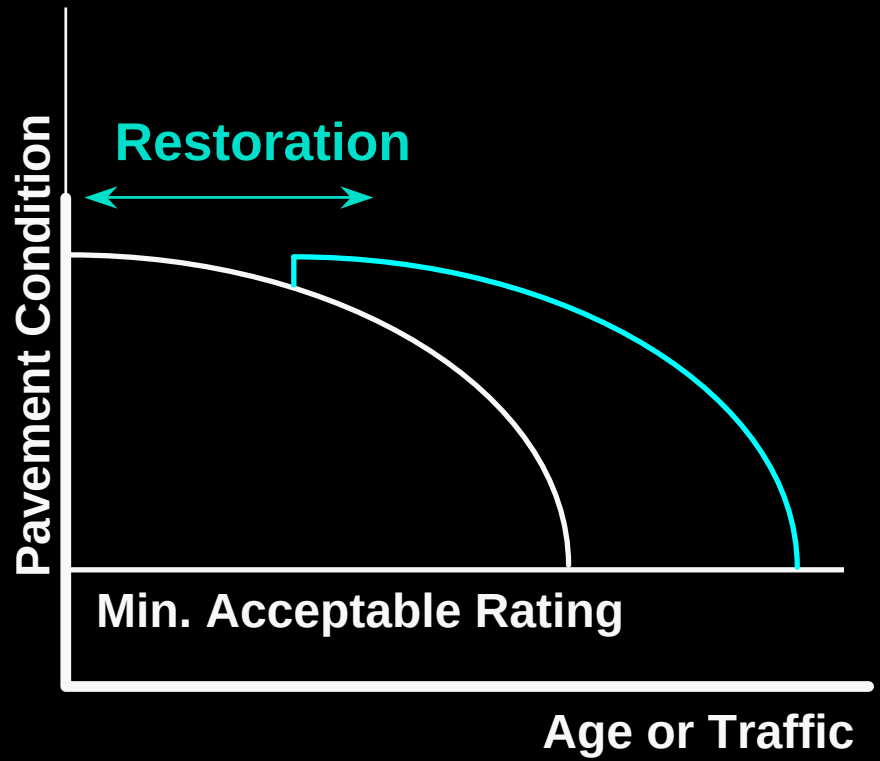


Restoration - CPR

- First level of response for deteriorating concrete pavements should always be CPR
  - Least cost
  - Best return on investment
  - Least service disruption

Purpose of CPR

- Used early when pavement has little deterioration.
  - Repairs isolated areas of distress.
  - Repairs some construction defects
  - Manage the Rate of Deterioration



Why CPR on Airports ?

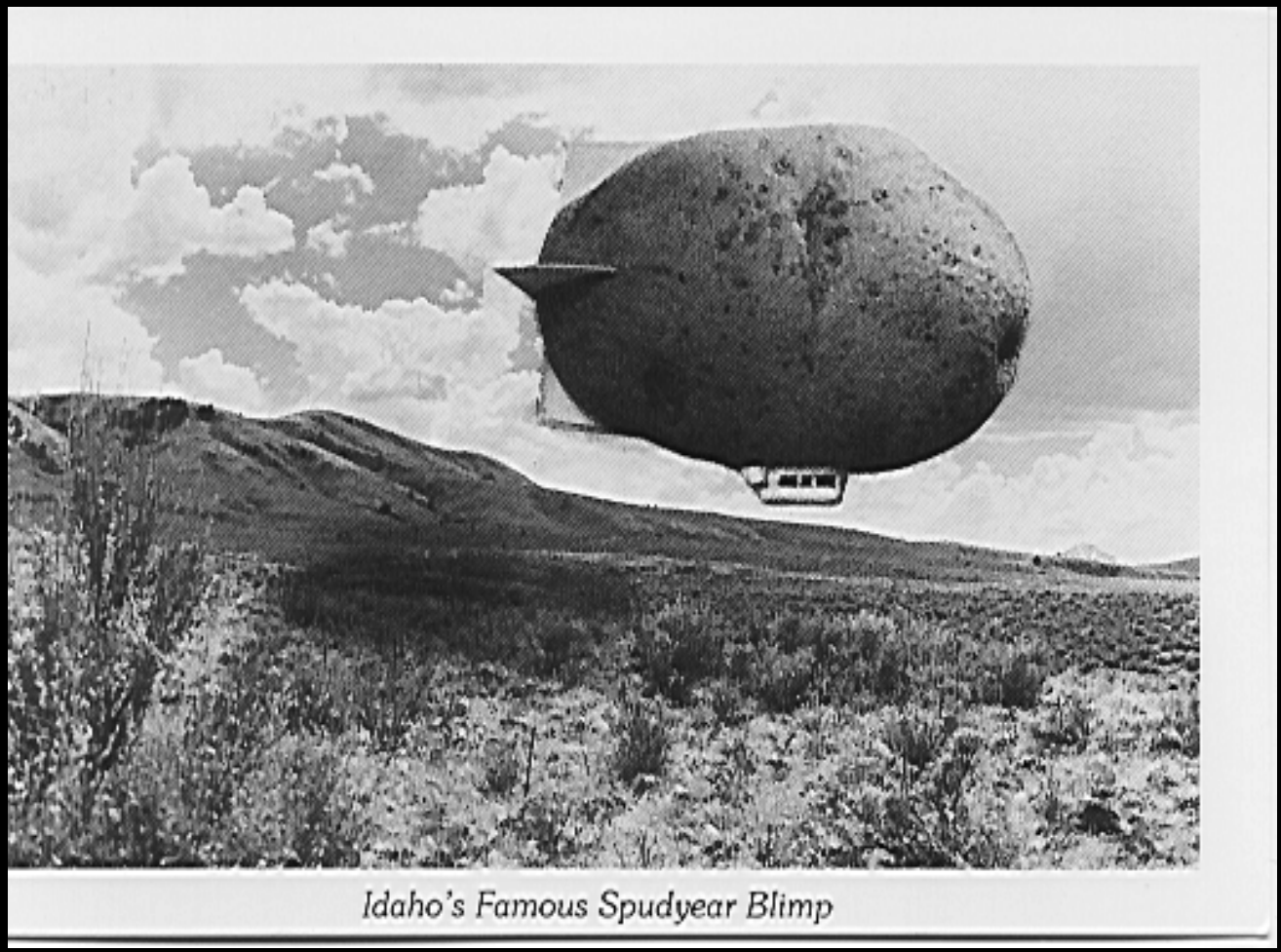
- Pavement deterioration
  - Foreign Object Damage (FOD)
- Eliminate pavement roughness
  - Extend the life of pavements and planes
- Reduced down time due to major repairs

CPR Benefits

- Agencies using preventative maintenance for concrete pavements indicate an increase of life of 9-10 years.
- Each $1 invested in appropriately timed preventative maintenance saves $3 to $4 in future rehabilitation costs.

TR News; Sept-Oct 1996

CPR is NOT Rocket Science



Idaho's Famous Spudyear Blimp


MASONRY
LOCAL
343

Restoration Techniques

- Partial-depth repair
- Full-depth repair
- Slab stabilization
- Retrofitting dowels
- Cross-stitching long. cracks/joints
- Diamond grinding
- Diamond grooving
- Joint & crack resealing

Partial-Depth Patching Operations

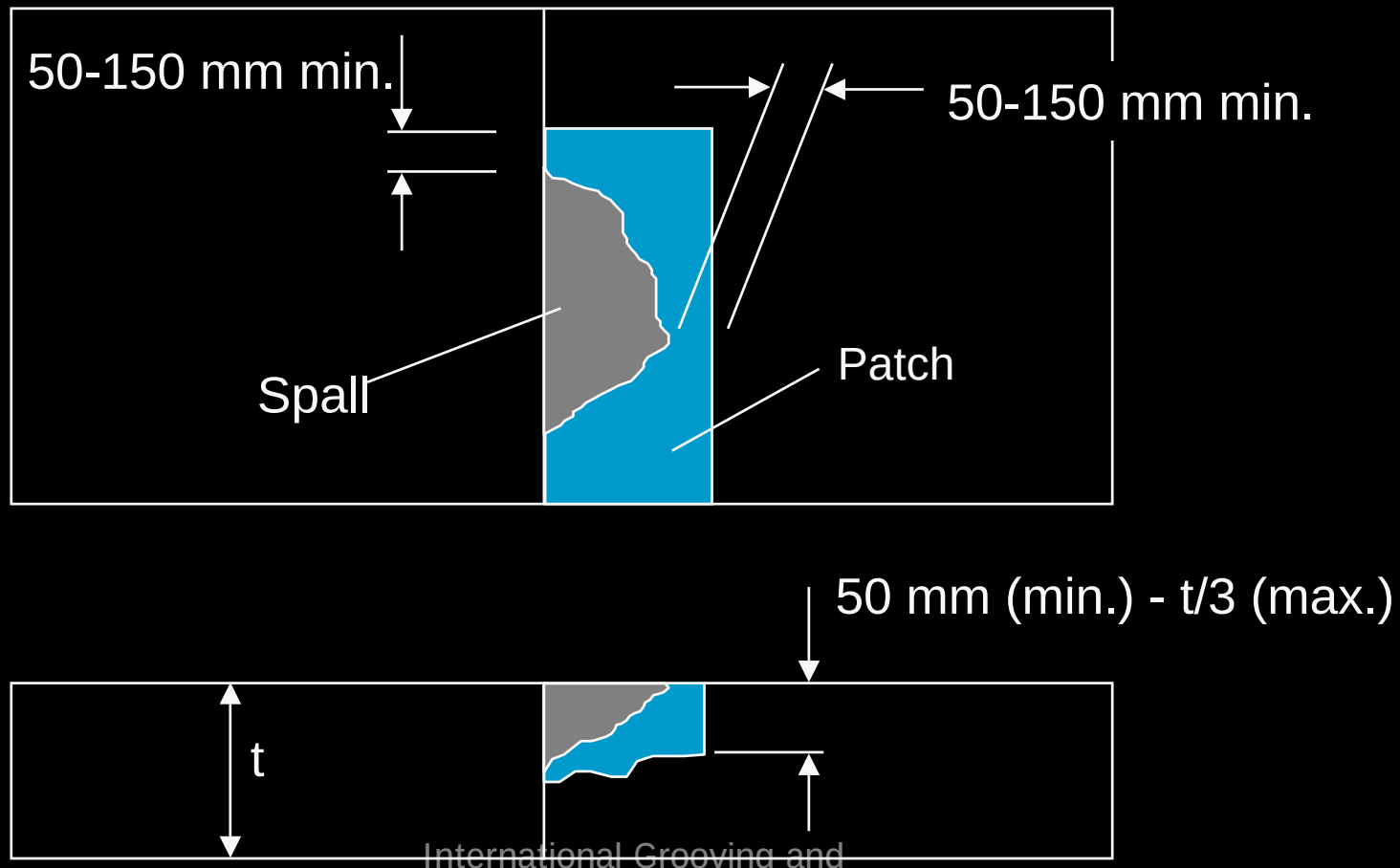
Partial-Depth Patching

- Purpose
  - Repair surface distresses
  - Reestablish joint reservoir
- Used for:
  - Mid-slab surface spalling
  - Joint spalling
  - Severe scaling

Size of Patches

- Minimum length 300 mm
- Minimum width 100 mm
- Go beyond problem by 75-100 mm
- Combine close patches (<0.6 m)
- Repair entire joint if more than 2 patches

Patch Layout



Combine Patches

Material Selection

Depends on:

- Time available before opening to traffic
- Air temperature during construction
- Funding
- Desired service life
- Size & depth of patches

Patch Materials

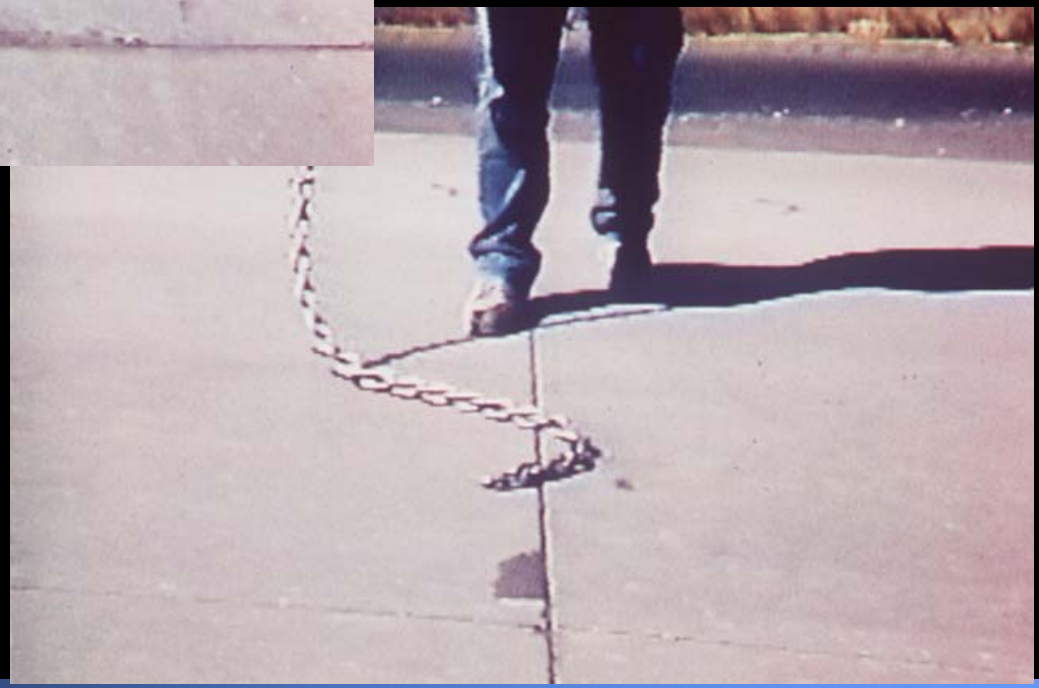
- Normal Set PCC
- High-Early Strength PCC
- Rapid Strength Proprietary Materials
- Epoxy Resin Mortar or Epoxy Concrete

Finding Unsound Concrete

Sounding the pavement:

- Hammer
- Steel rod
- Steel chain

Sounding the Pavement



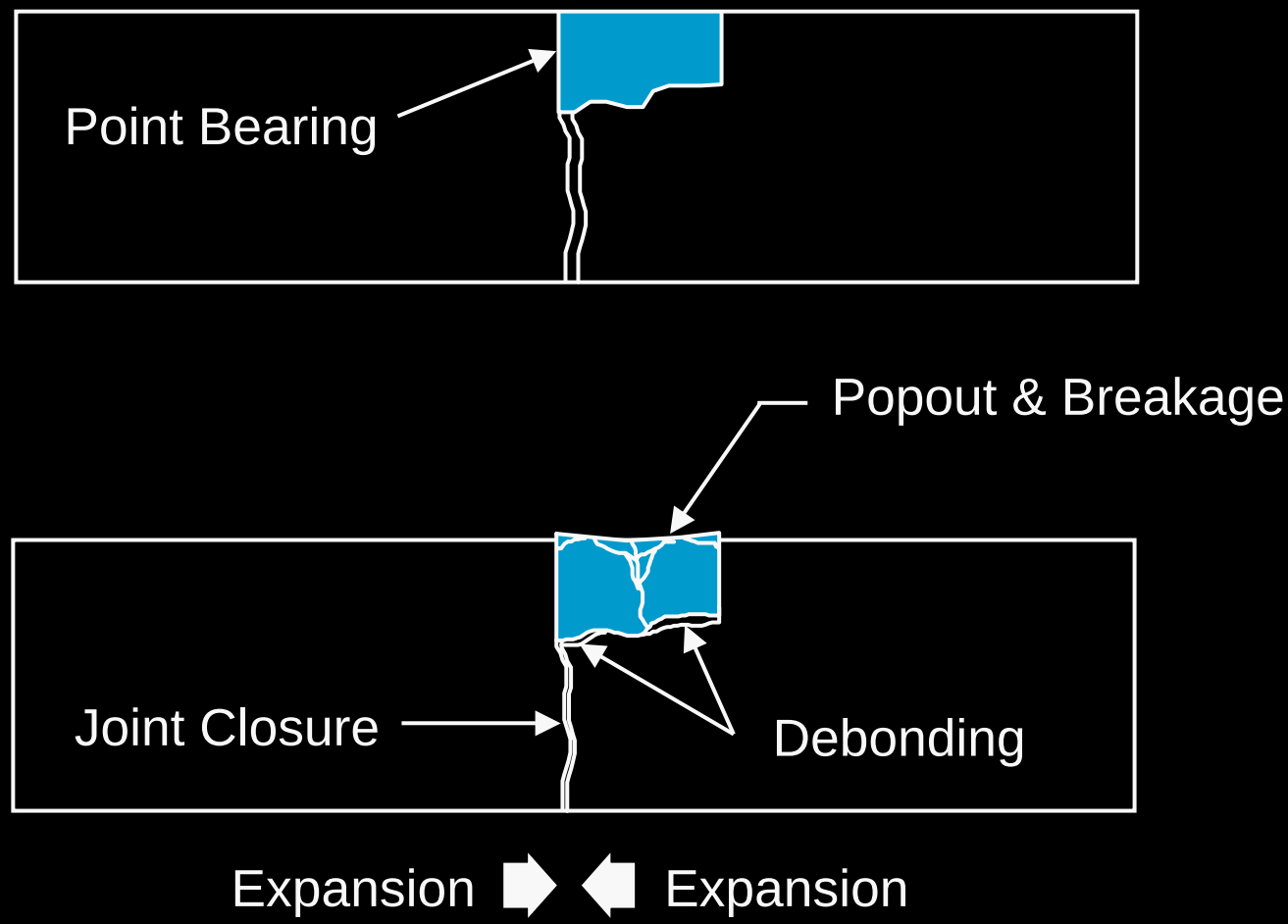
Measuring & Marking Boundaries

Sawing

- Vertical cut at perimeters
- Diamond blade
- Depth to 50 mm
- Overcut slightly

Chipping

- Break to minimum depth of 35 mm (1/3 slab thickness maximum)
- 13.5 kg maximum hammer
- 7 kg hammer preferable for control
- Spade bits preferable to gouge bits


Point Bearing
Popout & Breakage
Joint Closure
Debonding
Expansion
Expansion

PDR Usage on Full Depth Cracks

Checking patch cleanliness

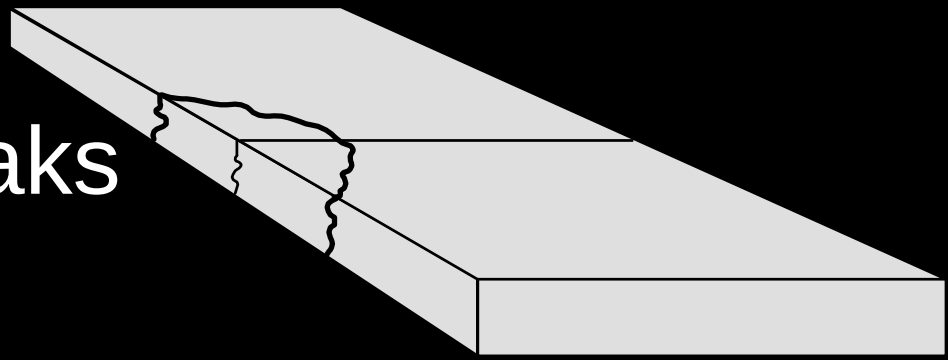
Full-Depth Patching Operations

Full-Depth Patching

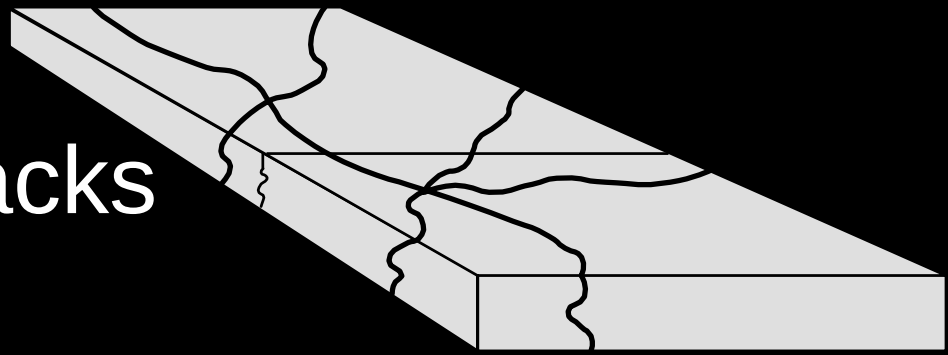
- Purpose
  - Restore structure
  - Restore ride
- Used for
  - Joint/crack deterioration
  - Broken slabs
  - Corner breaks

Full-Depth Patching

Corner Breaks



Multiple Cracks



Sizing a Patch

- Go beyond deterioration
- Remember to check for below-surface spalling
- Minimum length 2 meters
- Adjust as necessary
- Combine closely spaced patches

Pre-cast Pavement Panels

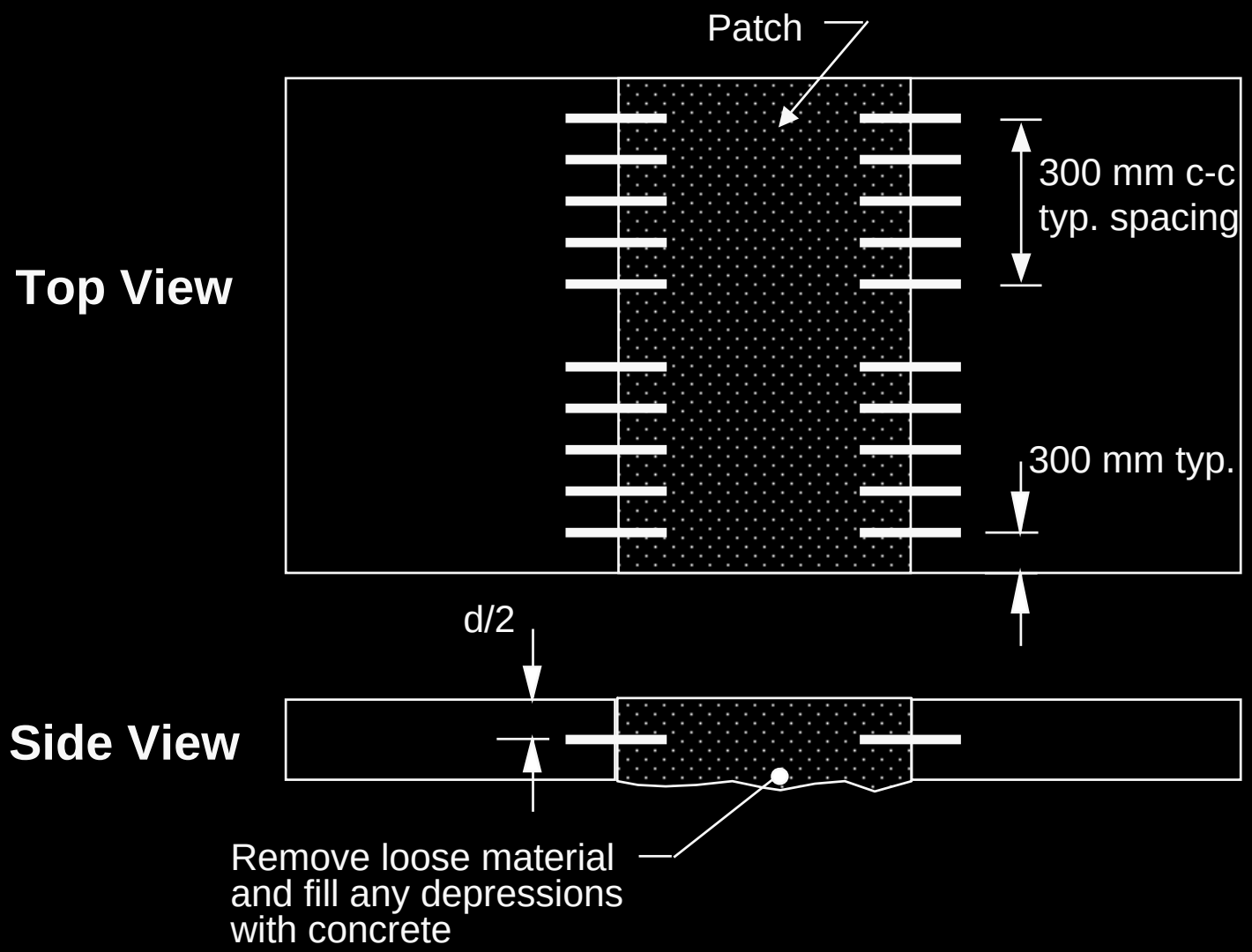
Insitu Full Depth Repair

Sizing a Patch

- Go beyond deterioration
- Remember to check for below-surface spalling
- Minimum length 6 feet
- Adjust as necessary
- Combine closely spaced patches

Load Transfer

Jointed Pavements:



Patch Materials

- ASTM C 150 Types I, II, or III portland cement (CAN/CSA A5-M88)
- Target slump: 50 - 100 mm
- Entrained air: 4.5 - 7.5%
- Accelerators common for early strength gain
  - Non-chloride accelerators will cause early set time (within 30 minutes)
  - workability decreases with accelerators

Construction of Full-Depth Repairs

7 steps:

- Isolate deteriorated area
- Remove old concrete
- Repair subbase, drain rainwater (if necessary)
- Provide load transfer at joint faces
- Place & finish new concrete
- Cure & insulate concrete
- Saw & seal perimeters

Defining Repair Limits

Avoid Acute Angles

Sawing Boundaries

- Use diamond bladed saws
- Saw full-depth through the joints so base of blade reaches boundary (except where aggregate interlock needed)
- Isolate transverse, longitudinal and shoulder
- Provide pressure-relief cut within patch if saws bind


TARGET

Removal

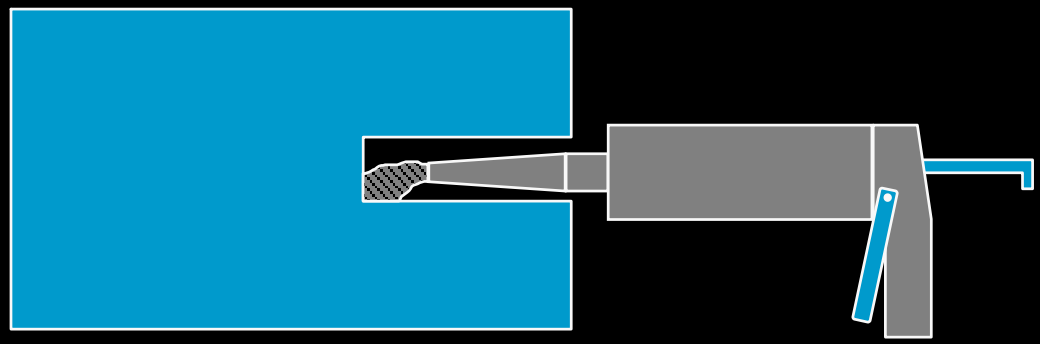
- Liftout
  - Pin and chain
  - Claw
- Breakup
  - Handheld pneumatic hammers
  - Drop Hammers or rams

Installing Dowels

- Feed material to back of hole
- Insert dowel properly - twist 1 full revolution to spread grout evenly on bar
- Use grout retention disk, or trowel grout around bar if none available

Installing Dowels

1

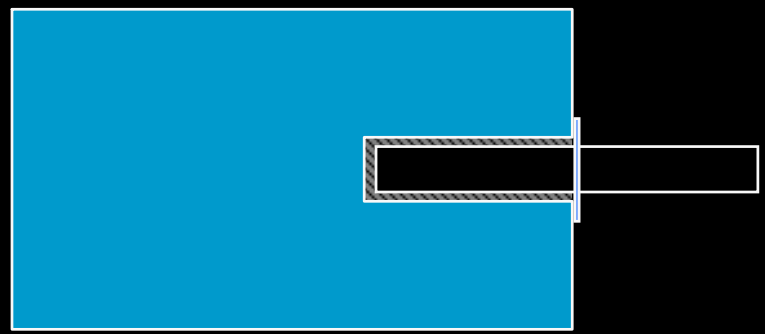


Inject Grout
to Back of Hole

2

Twist one turn
while pushing
in dowel

3



Place grout
retention disk to
hold in grout

Injecting Grout

Grout Retention Disk

Troweling of Grout around Bar

Placing Concrete

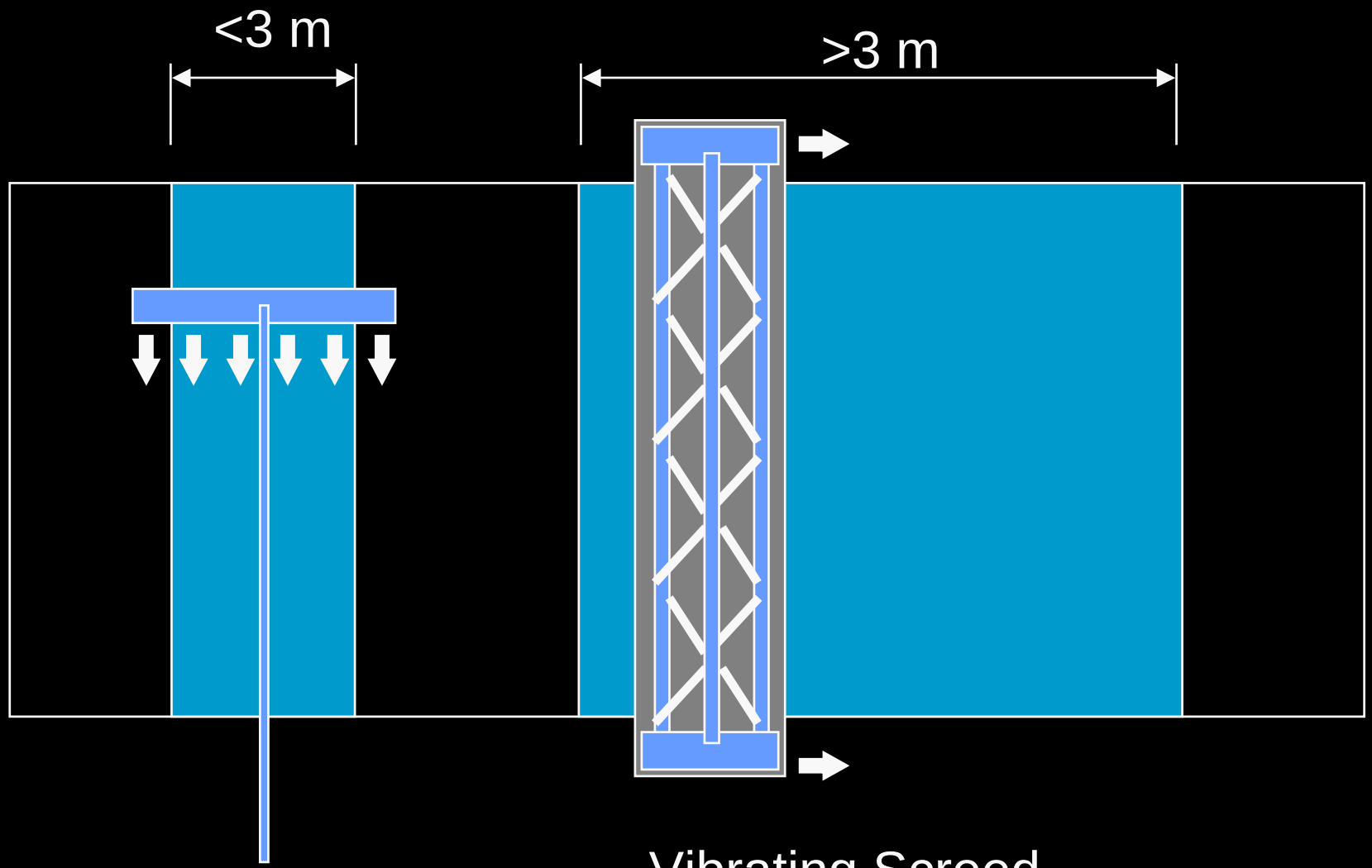
- Distribute evenly
- Avoid excessive shoveling
- Vibrate uniformly
  - Use vertical penetrations of vibrator
  - Do not drag!!

Concrete Placement

Finishing

- Vibratory screeds or 3m straight edges
- For short repairs (<3m), pull finishing tool along transverse boundary
- For longer repairs, finish the concrete longitudinally using vibratory screed

Finishing



Curing

- Liquid-membrane-forming compound that meets ASTM C 309
- Apply evenly
- Pigment is helpful to see coverage
- Insulation mats useful for:
  - Accelerating strength gain
  - Cold temperatures
- Place polyethylene sheeting between patch and insulation

Joint Sealing

- Form or saw joint sealant reservoirs at all patch boundaries
- Sealed joints reduce spalling

Slab Stabilization

Slab Jacking

Under-sealing

Sub-Grade repair

Slab Stabilization

- Purpose
  - Fill voids underneath the pavement
  - Reestablish uniform support
  - Reduces stress and deflections
- Voids From
  - Pumping under traffic
  - Consolidation from overloading
  - Subgrade bearing failure from saturation

Concrete's long life

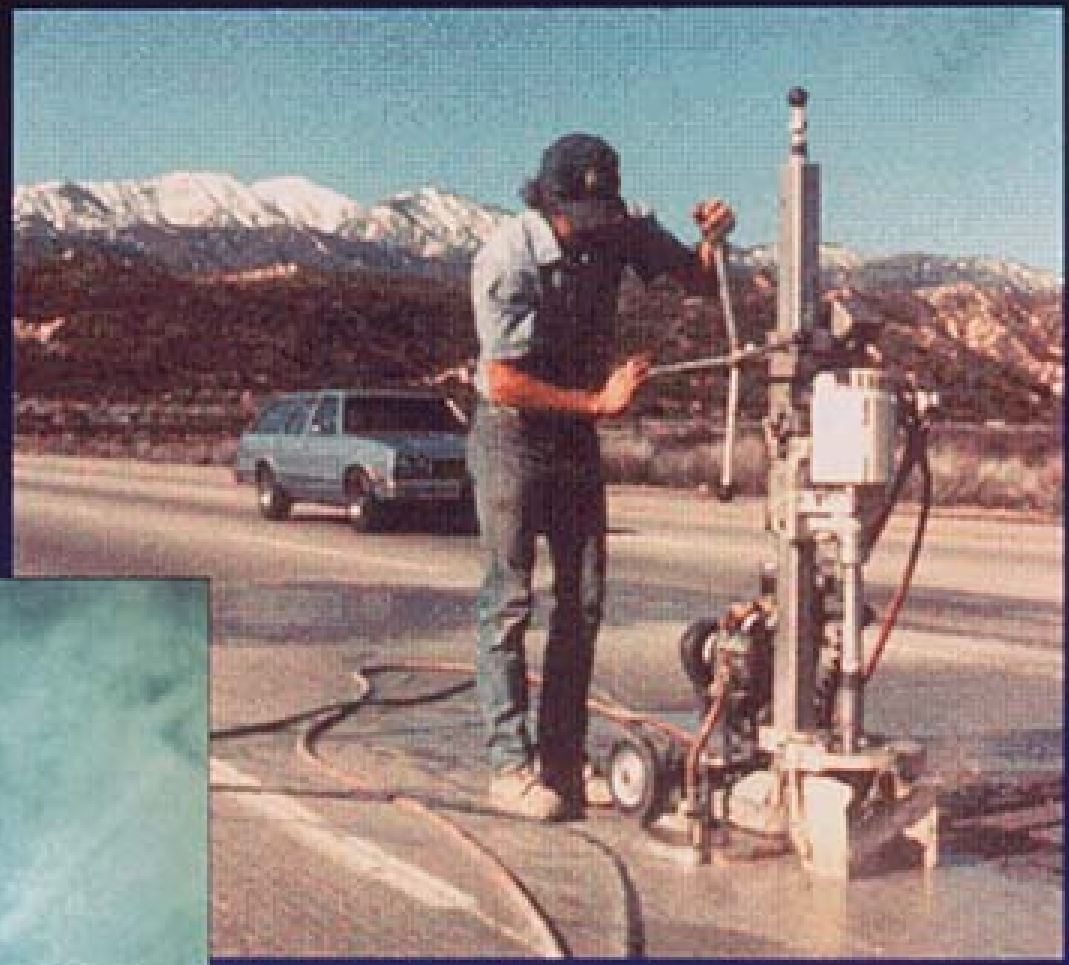
- It is not uncommon for concrete to out live the life of the subgrade, fill, and base materials.

- It is now possible to correct the underlying problems either independently or in conjunction with other standards of Concrete Pavement Rehabilitation

Primary Signs of Failure of Base and/or Sub-Grade

- Dips
- Slab Cracking
- Faulted Concrete
  - Longitudinal
  - Transverse
- Loss of Cross Slopes

Faulted - Longitudinal



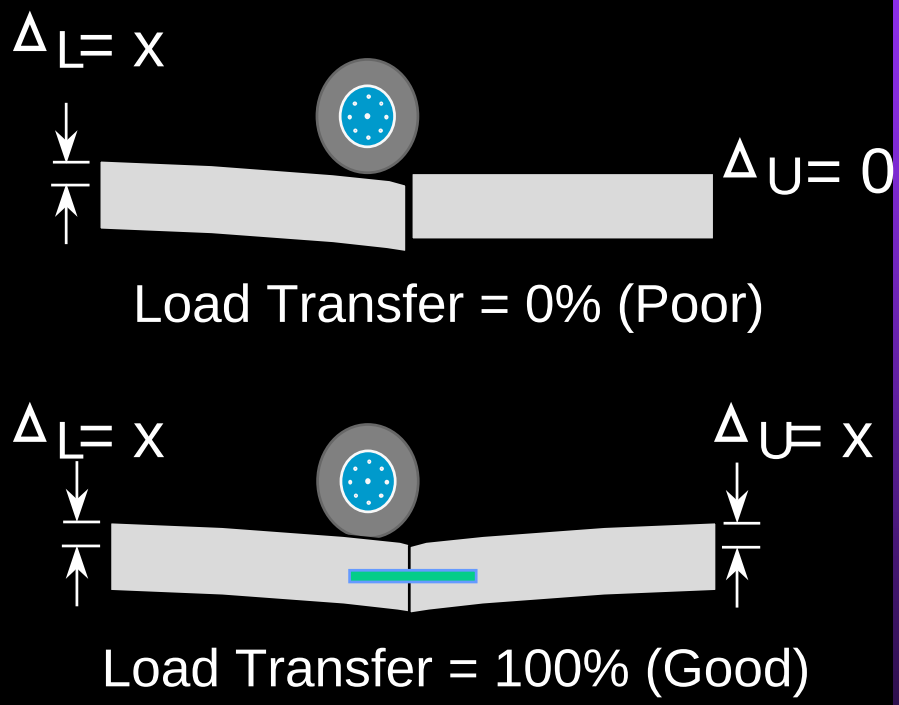
Andrews AFB - Runway

LOAD TRANSFER RESTORATION

By
Dowel Bar
Retrofit

Purpose of Dowel Bar Retrofit

- Reestablish load-transfer across joints or cracks
  - Load-transfer is a slab's ability to transfer part of its load to its neighboring slab
- Used in JRC and JPC pavements to limit future faulting



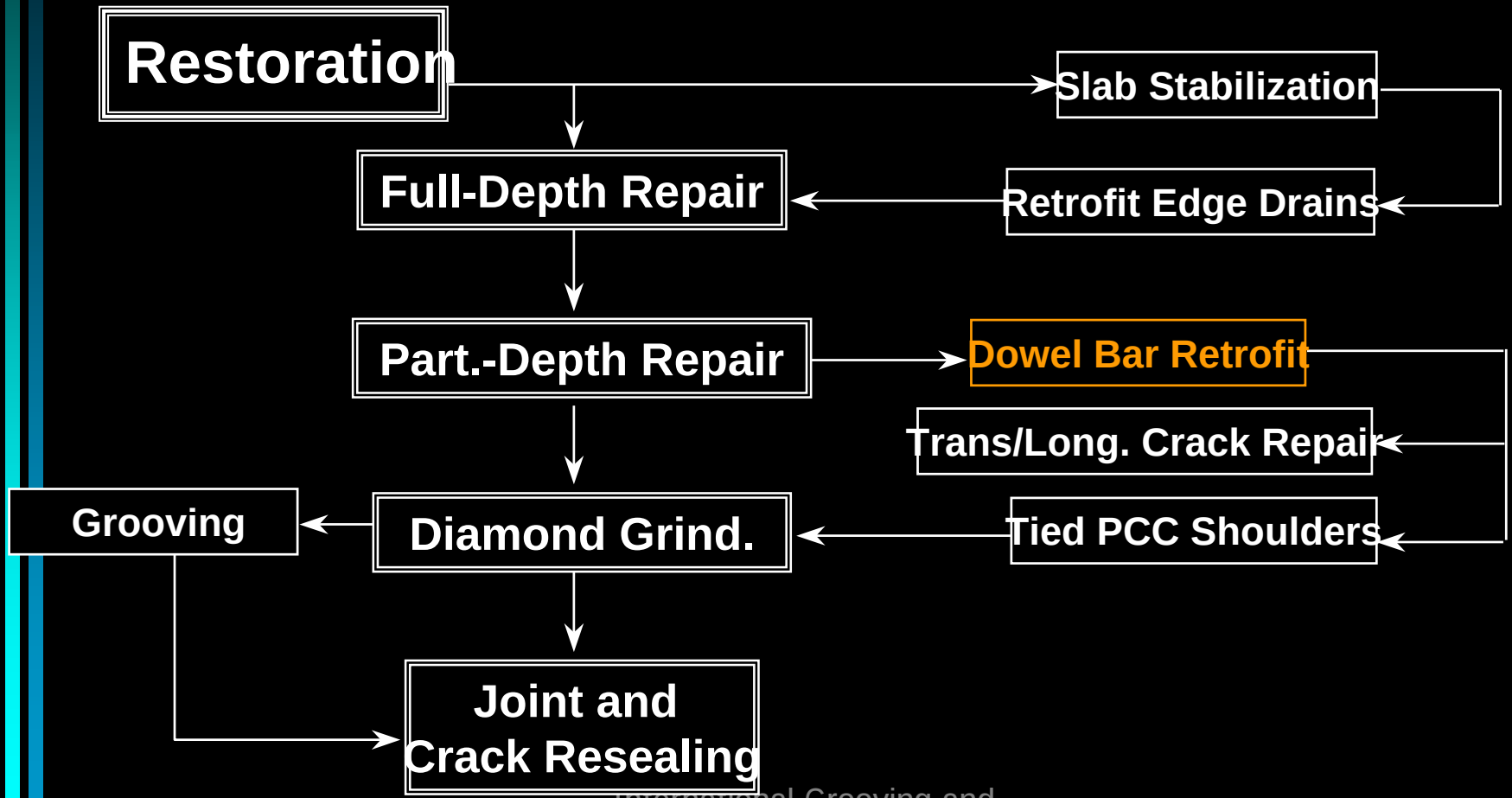
Pavement Condition

Several trigger values are possible:

1. Faulting of 3 mm or more
2. Load transfer of 50% or less
3. Differential deflection of 0.2 mm or more
4. Cumulative faulting of 525 mm/km or more.

Locations that have lost base support should not be dowel retrofitted.

Sequencing of Dowel Retrofit

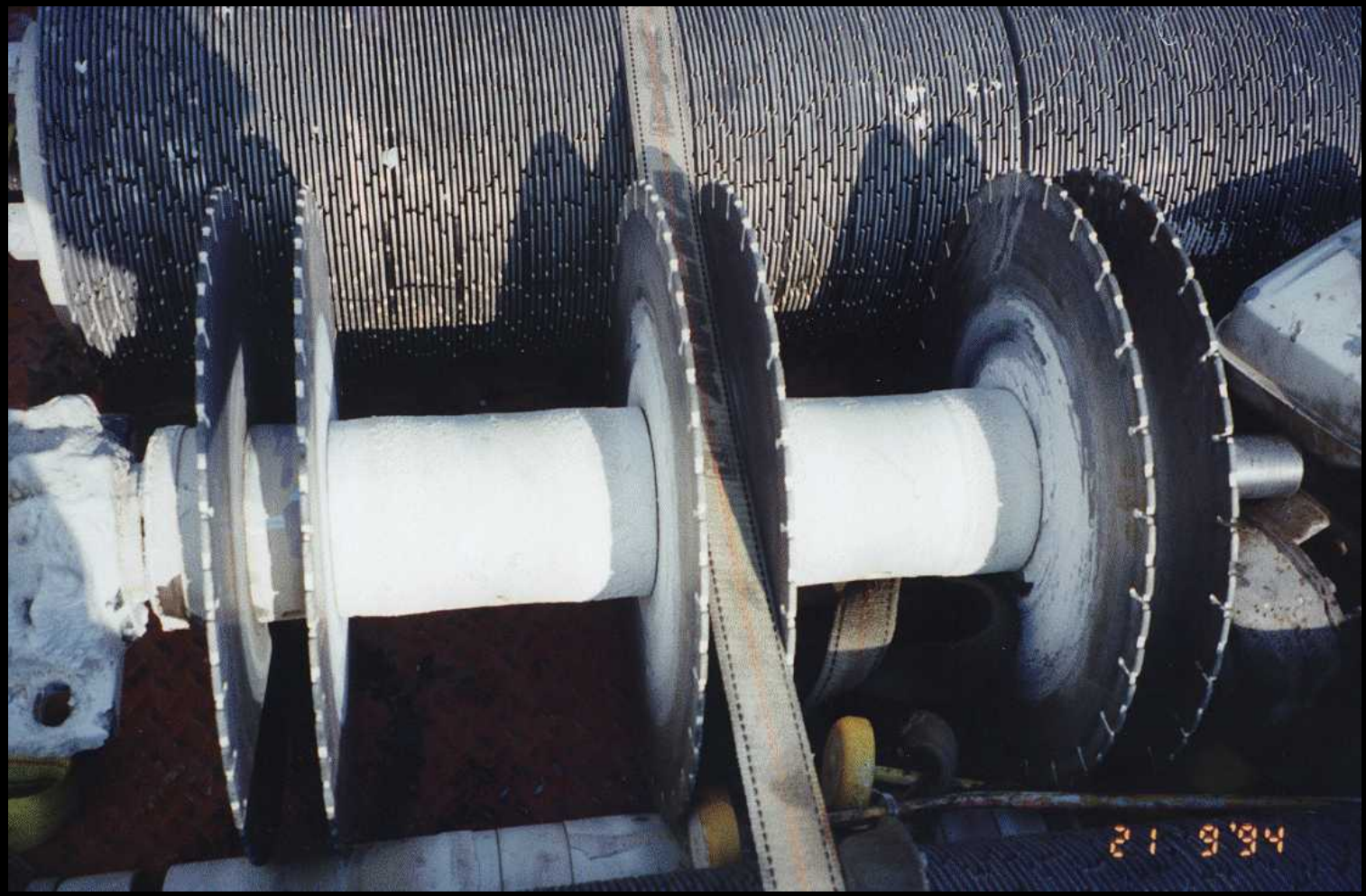


Dowel Bar Retrofit Operations

Consists of 4 main operations:

1. Cutting the slots
2. Preparing the slots
3. Preparing and placing the dowel bars
4. Backfilling the slots


CUSHION CUT
PC 600
WAY SERVICES INC.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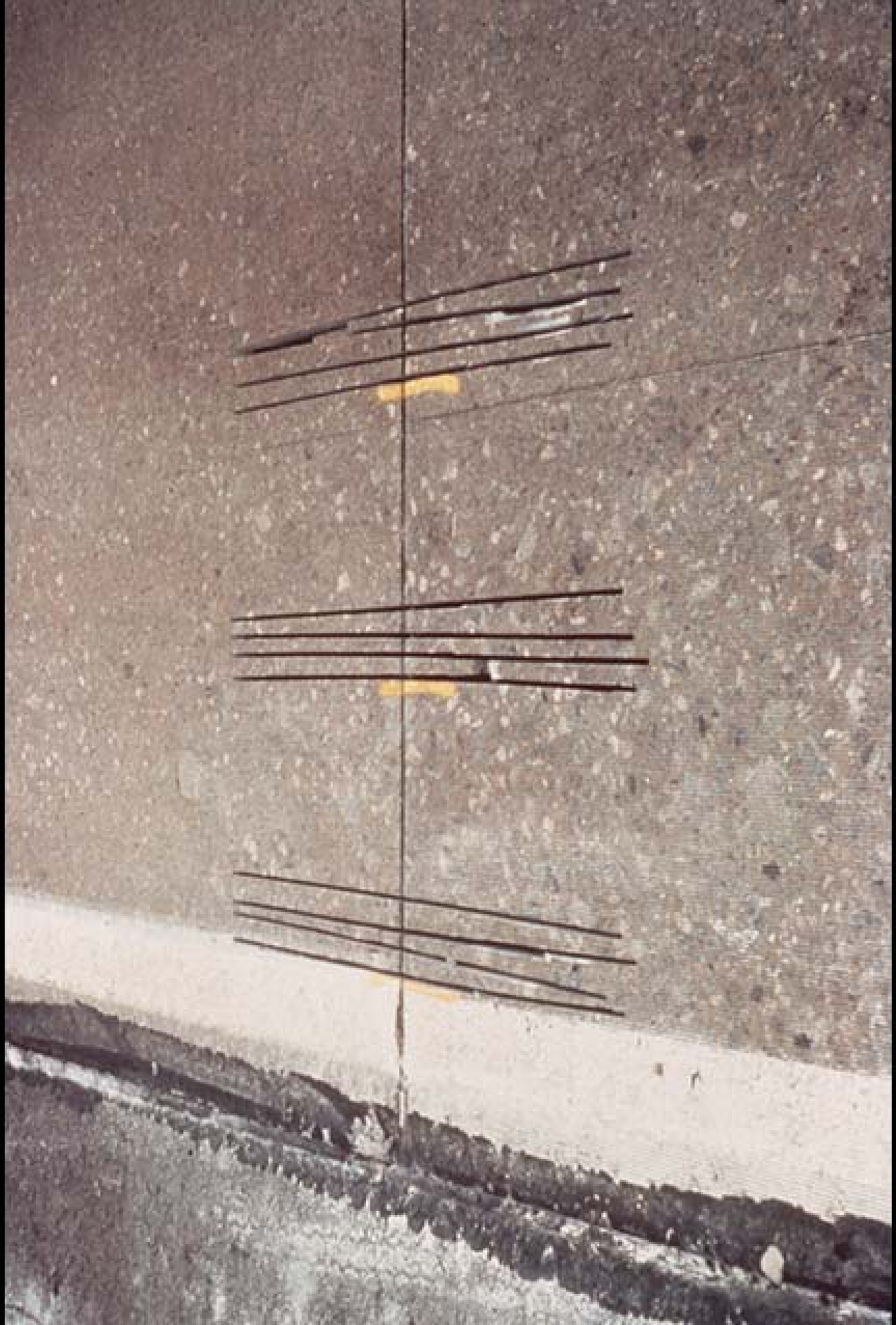
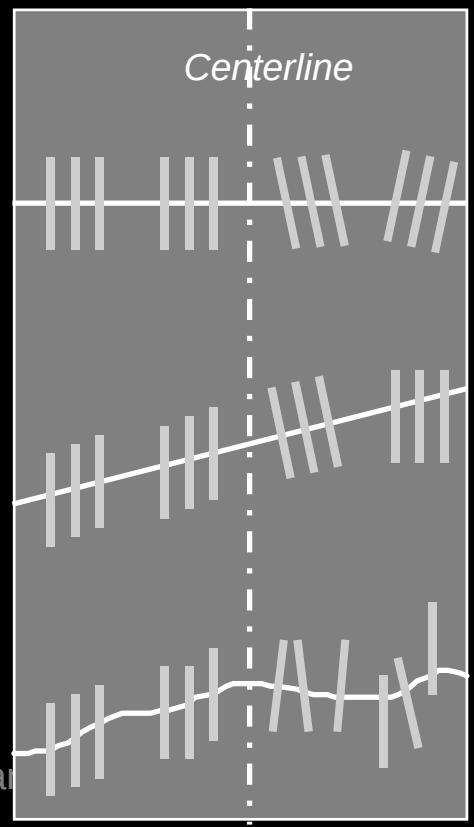


Dowel Slot Alignment

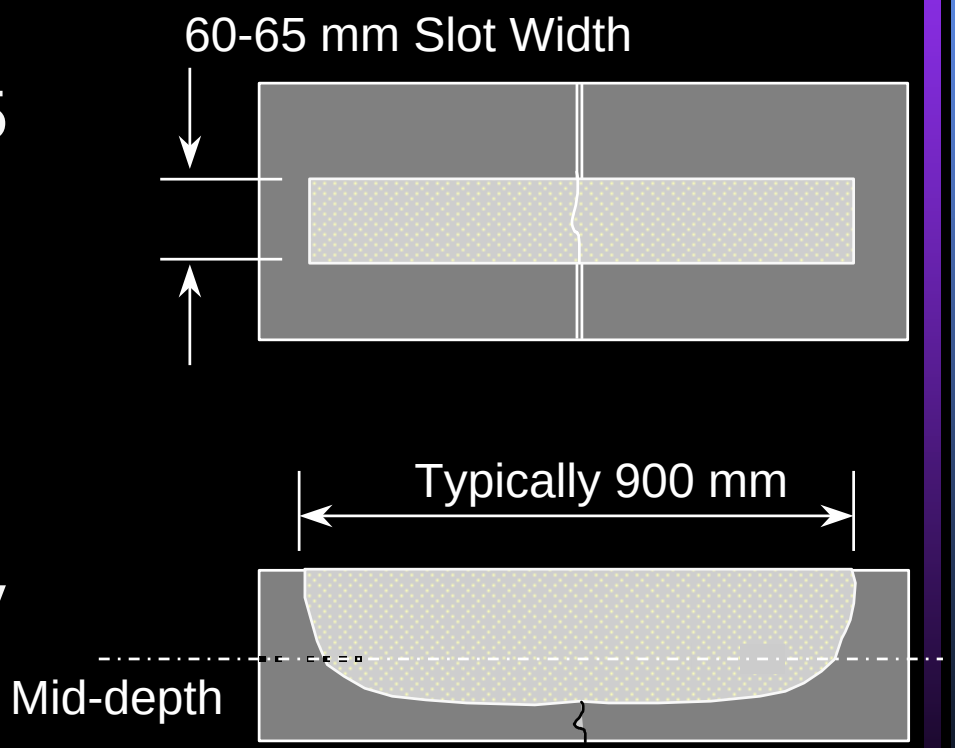
- Must always be parallel to centerline
- Must be cut so at least one-half of dowel can be on each side of the joint or crack

Correctly Aligned Dowel Slots **Incorrectly Aligned Dowel Slots**



Slot Details

- Should be flat
- Width should be 60 - 65 mm.
- Length must be long enough to encompass the dowel bar and endcaps.
- Depth should be slightly deeper than slab middepth.



Flattening the Slot Bottom

- Remove burrs and bumps from base with small hammerhead
- Allows the dowel to sit level and properly aligned.

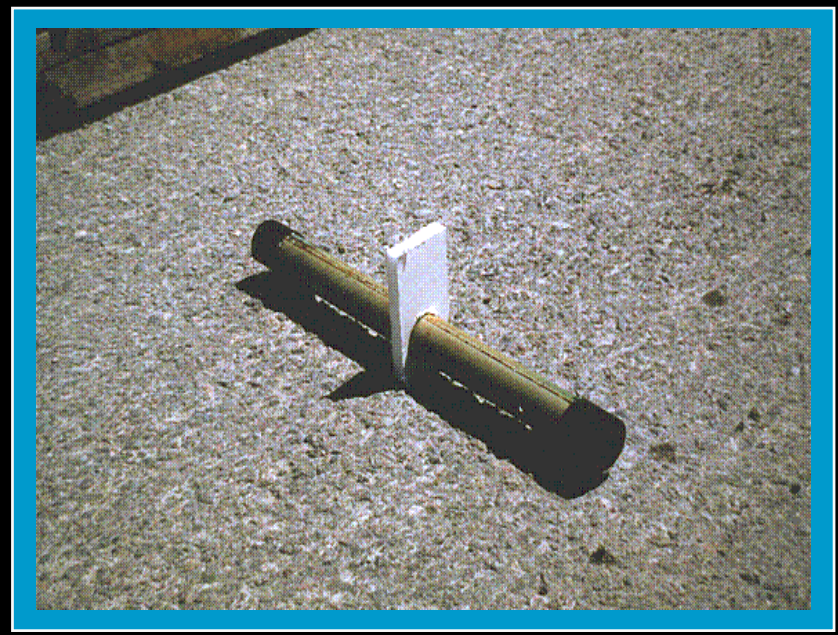
Preparing the Dowels

Dowel Bar Requirements

- Minimum diameter: 30 - 40 mm.
- Minimum length: 350 - 400 mm.
  - Need at least 150 mm on each side of the joint or crack
- Epoxy Coated
- Lubricated with some type of bond breaker

Preparing the Dowels

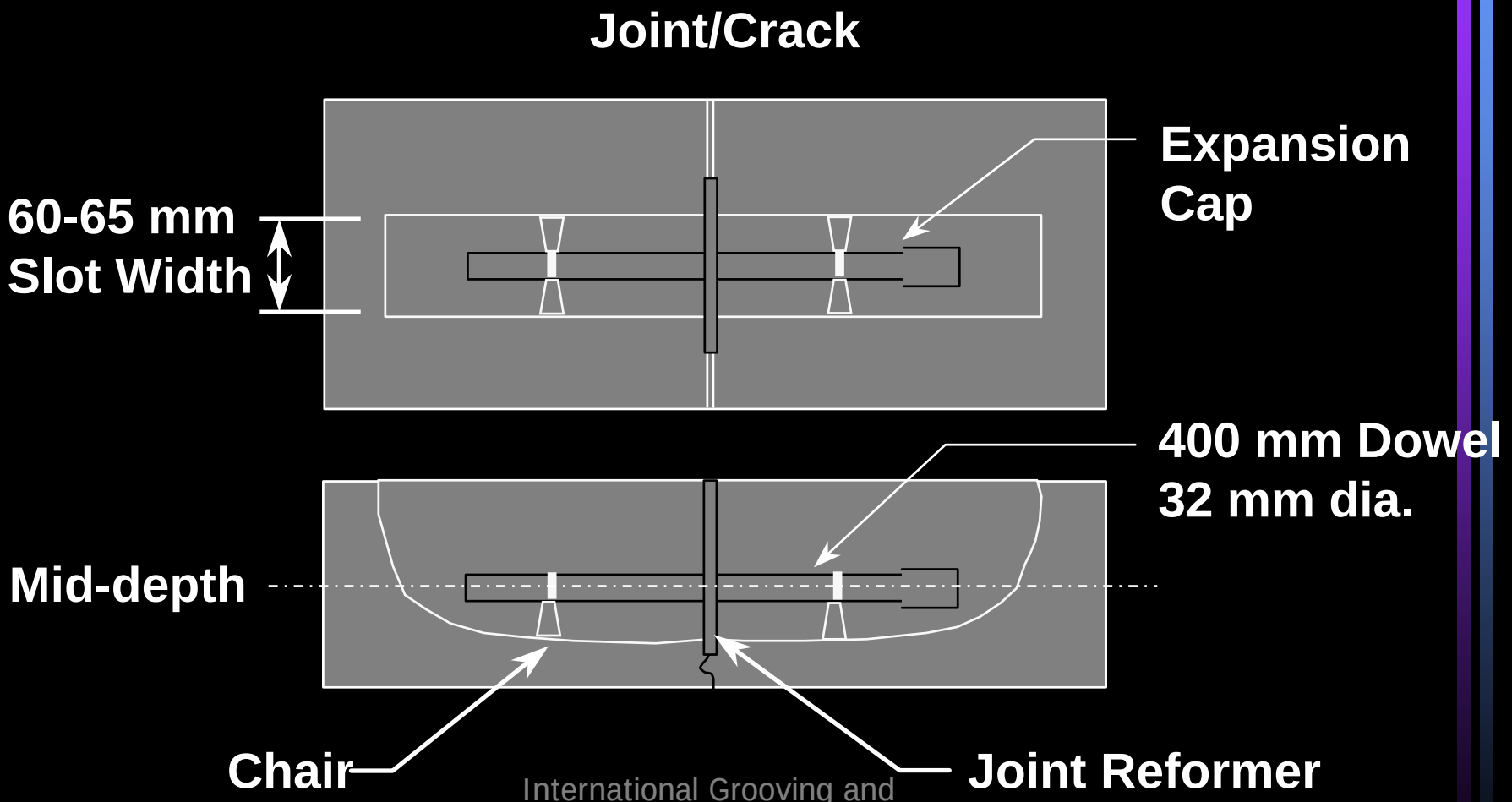
- Add joint former
  - Styrofoam
  - Fiber board
- Attach non-metallic expansion cap to one end
- Attach non-metallic chairs (sized for slot)



Joint Reformer & Dowel Bar Endcaps

- Allows movement for the slab to expand into without bearing on the patch
  - Joint Reformer
    - Maintains Joint
    - Prevents patch material from entering the joint
  - Endcaps
    - Minimum length is 6 mm.
    - Must be plastic.

Plan and side view of inserted dowel



Backfill Materials

- Basic requirement
  - Thermal properties be similar to concrete.
  - Must bond to the existing concrete
  - Should be fast setting
  - Should have little or no shrinkage
  - Must develop enough strength to allow traffic on it in a short time.

Final Steps

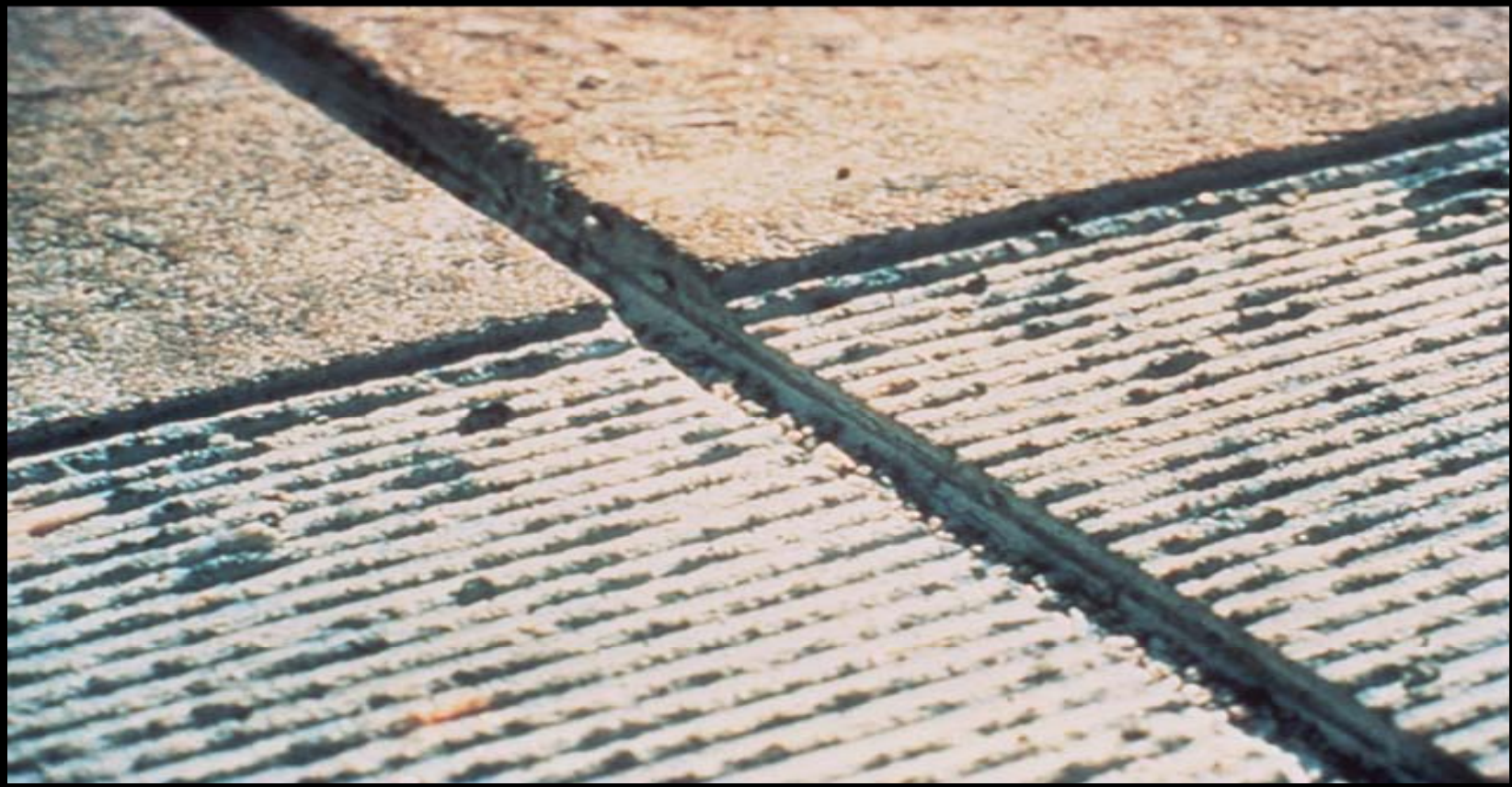
- Finish flush with surrounding surface
- Add curing compound as needed
- Saw over joint reformer

Longitudinal Crack Repair

- Cross Stitching
  - Adds reinforcement to non-working cracks by inserting tie bars.


6 1:23PM

Diamond Grinding



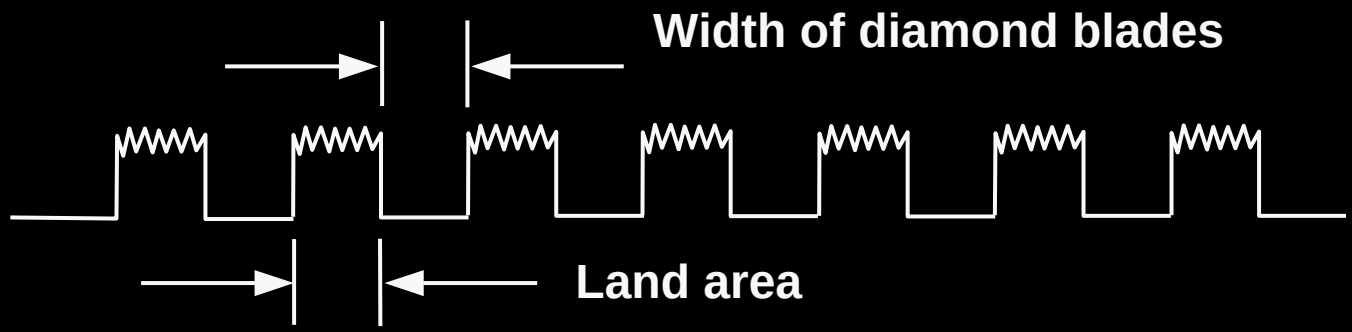
What is Diamond Grinding?

- Removal of thin surface layer of hardened PCC using closely spaced diamond saw blades
- Results in smooth, level pavement surface
- Longitudinal texture with desirable friction characteristics
- Frequently performed in conjunction with other CPR techniques, such as full-depth repairs, dowel bar retrofit, retrofit edgedrains

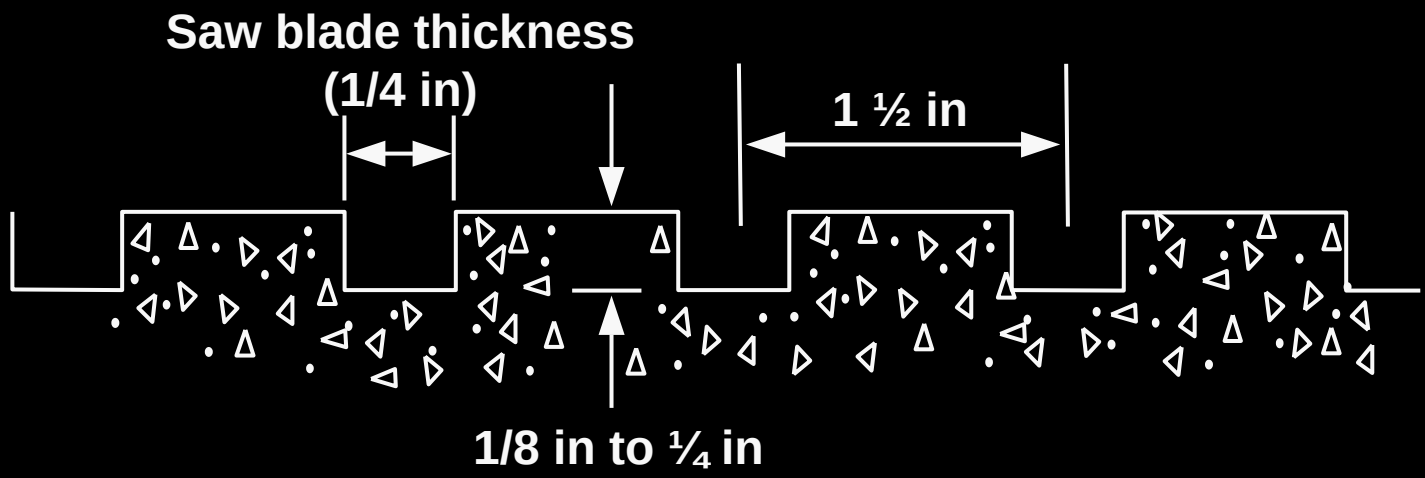
Airport Runway Grinding

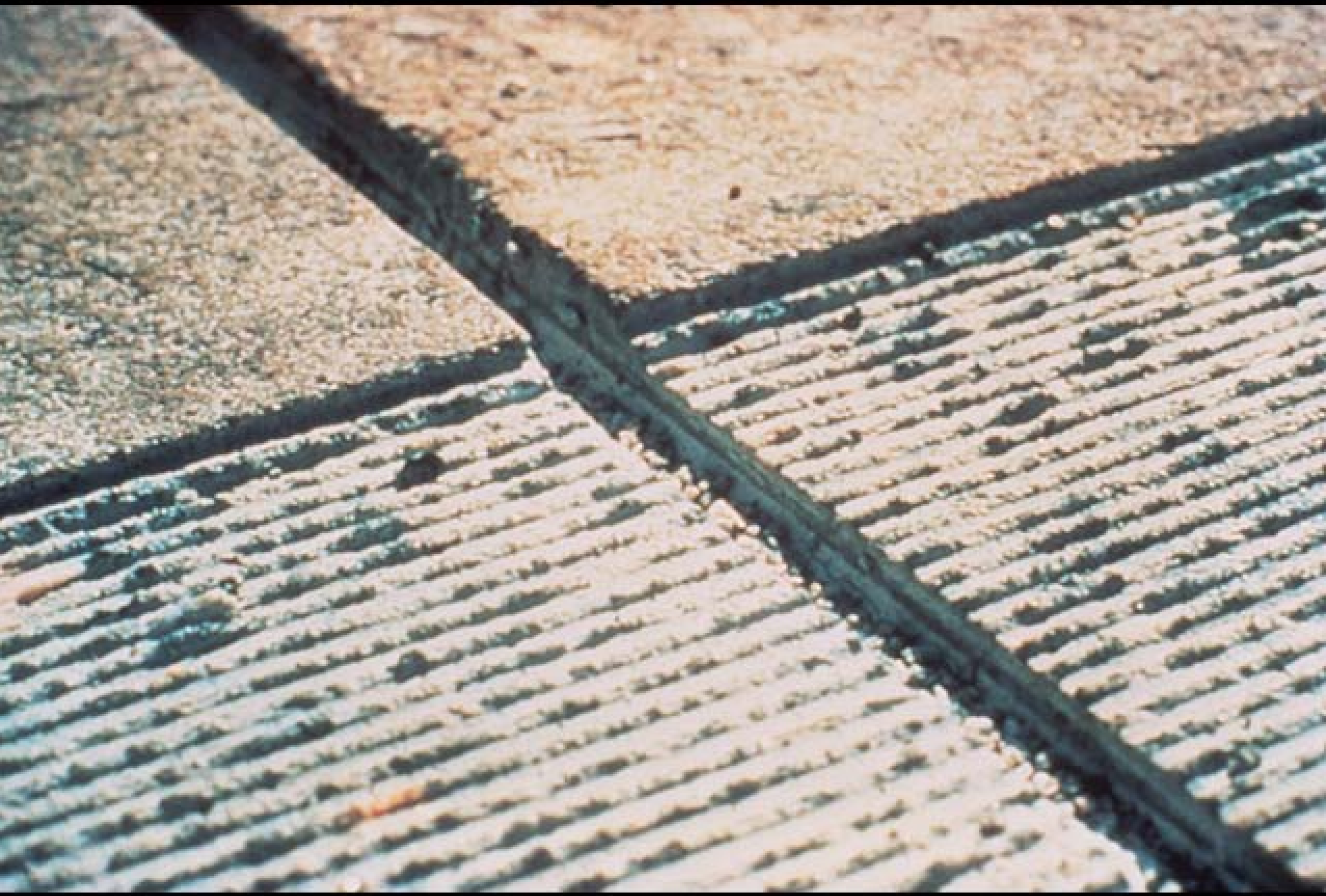
- Runway pavement is ground the same way that it is grooved, except that the diamond blades are spaced closer together and the grinding texture is longitudinal rather than transverse to the centerline

Diamond Grinding



Diamond Grooving

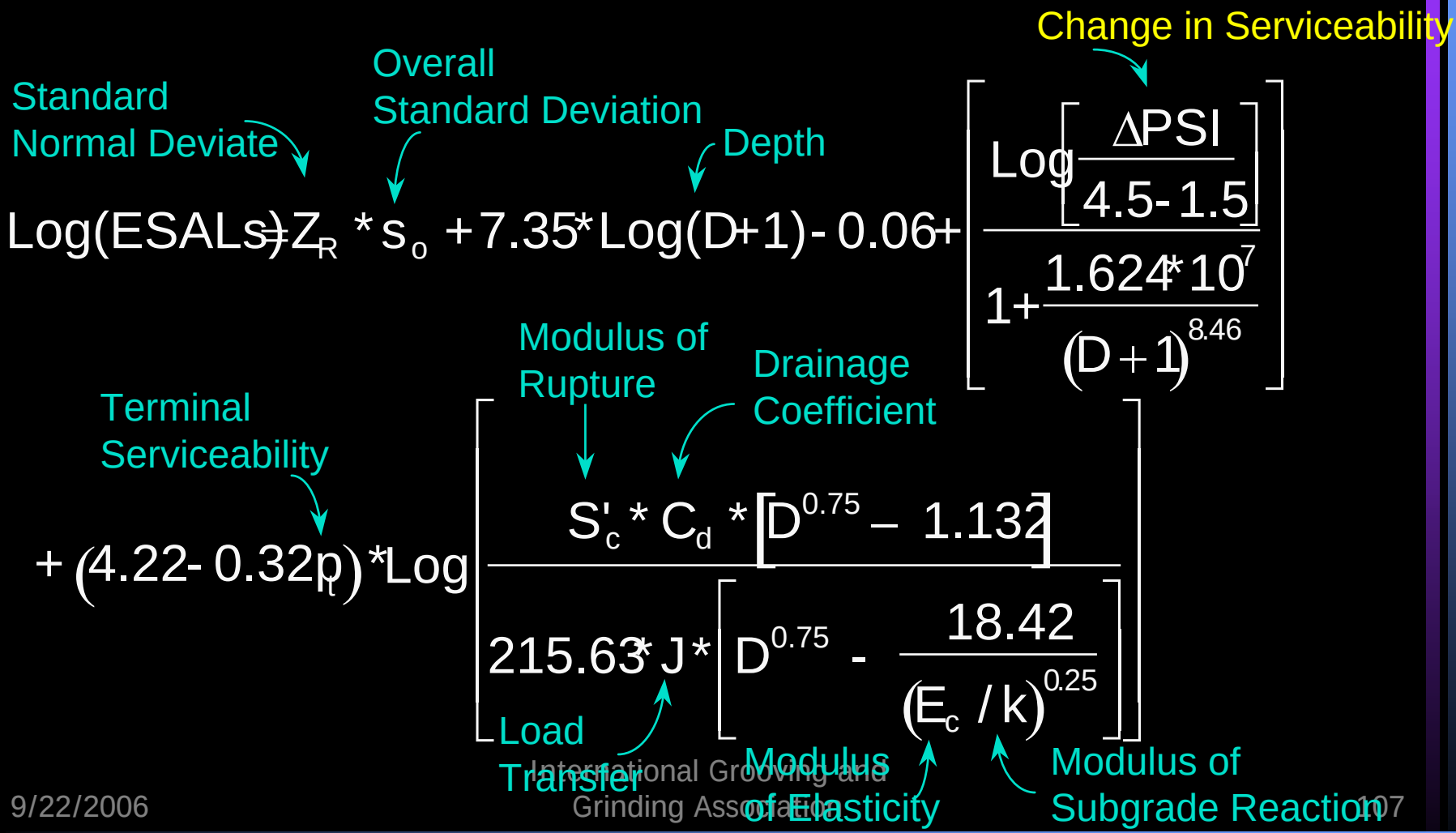




Why Grind a runway?

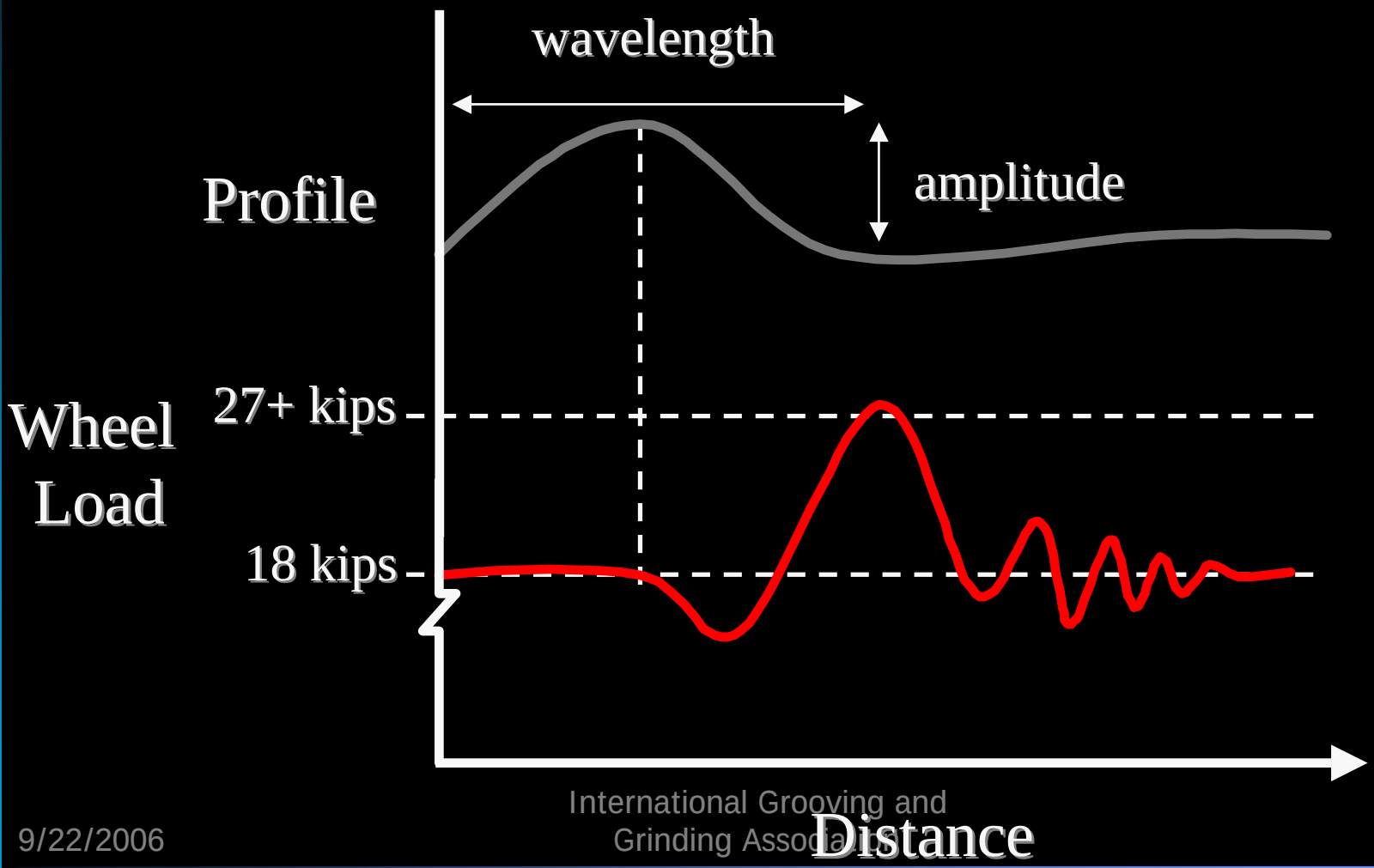
- Eliminate pavement roughness
- Correct faulted pavement
- Correct curling and warping
- Blend patched/repaired pavement with original pavement
- Eliminate pavement depressions
- Increase skid resistance

1986-93 Rigid Pavement Design Equation



SMOOTH PAVEMENTS LAST LONGER!

Rough Pavement

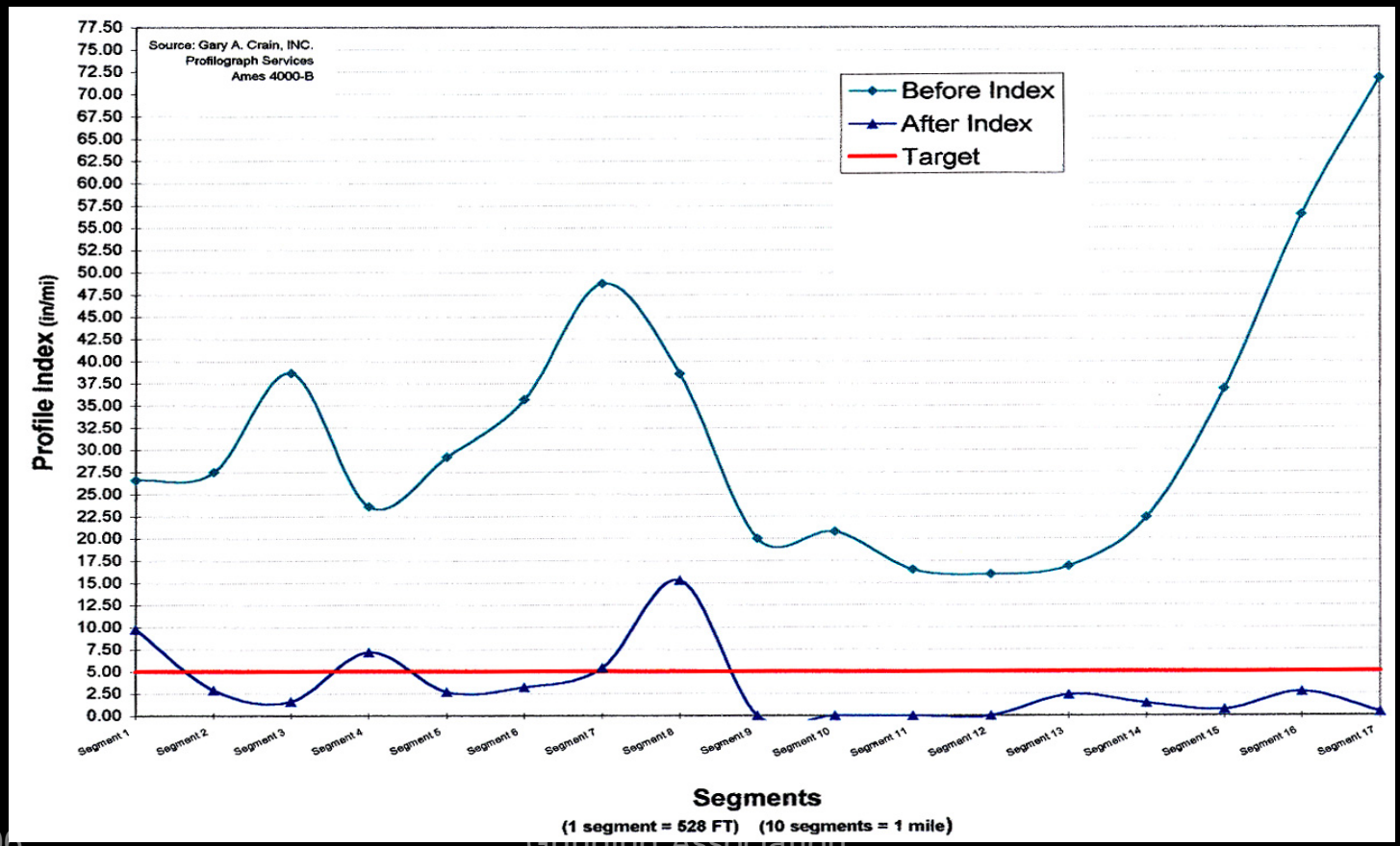


Smooth Profile

Safety

Eliminates Polished Surfaces

Before & After



Advantages of Diamond Grinding

- Costs substantially less than AC overlays
- Enhances surface friction and safety
- Can be accomplished during off-peak hours
- Grinding of a rough area does not require grinding of adjacent areas
- Blends patching and other surface irregularities into a consistent, identical surface

How is Runway Grinding Done?

- Runways are ground parallel to the centerline
- Runways can be ground to within 2 feet of ends and edges
- Runways are ground up to 6”, but not over 24” from recessed center line and touchdown lights or other embedments in runway

Helpful Information

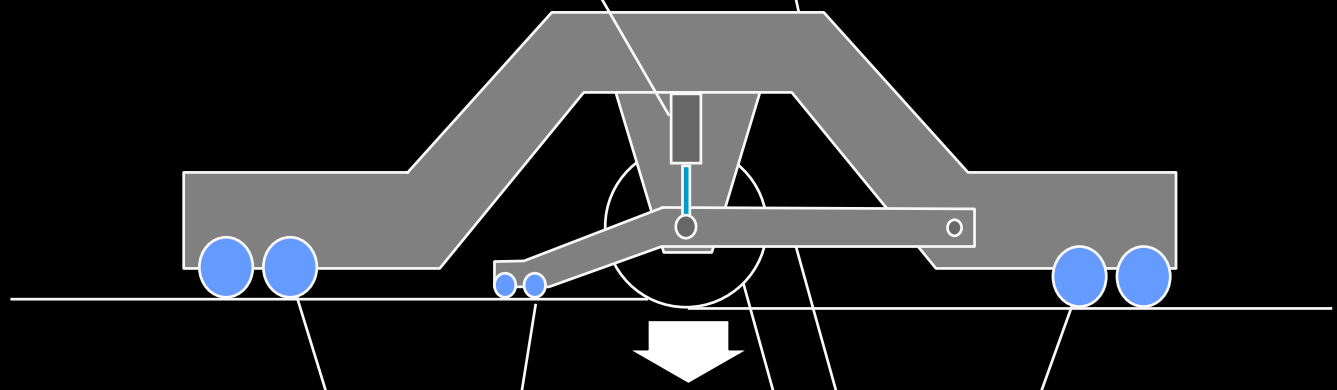
- Year the pavement was built.
- Pavement type (plain, reinforced)
- Transverse joint spacing.
- Aggregate hardness.
- Aggregate/sand abrasiveness.
- Aggregate size and exposure.
- Average depth of removal.
- Faulting index or average faulting.
- Patching quantities/locations.

Aggregate Hardness

SOFT	MEDIUM	HARD
Limestone	River Gravel	Granite
Dolomite	Trap Rock	Flint
Coral	Granite	Chert
River Gravel		Quartz
		River Gravel

60 Blades vs 52 Blades per Foot

Basic Components

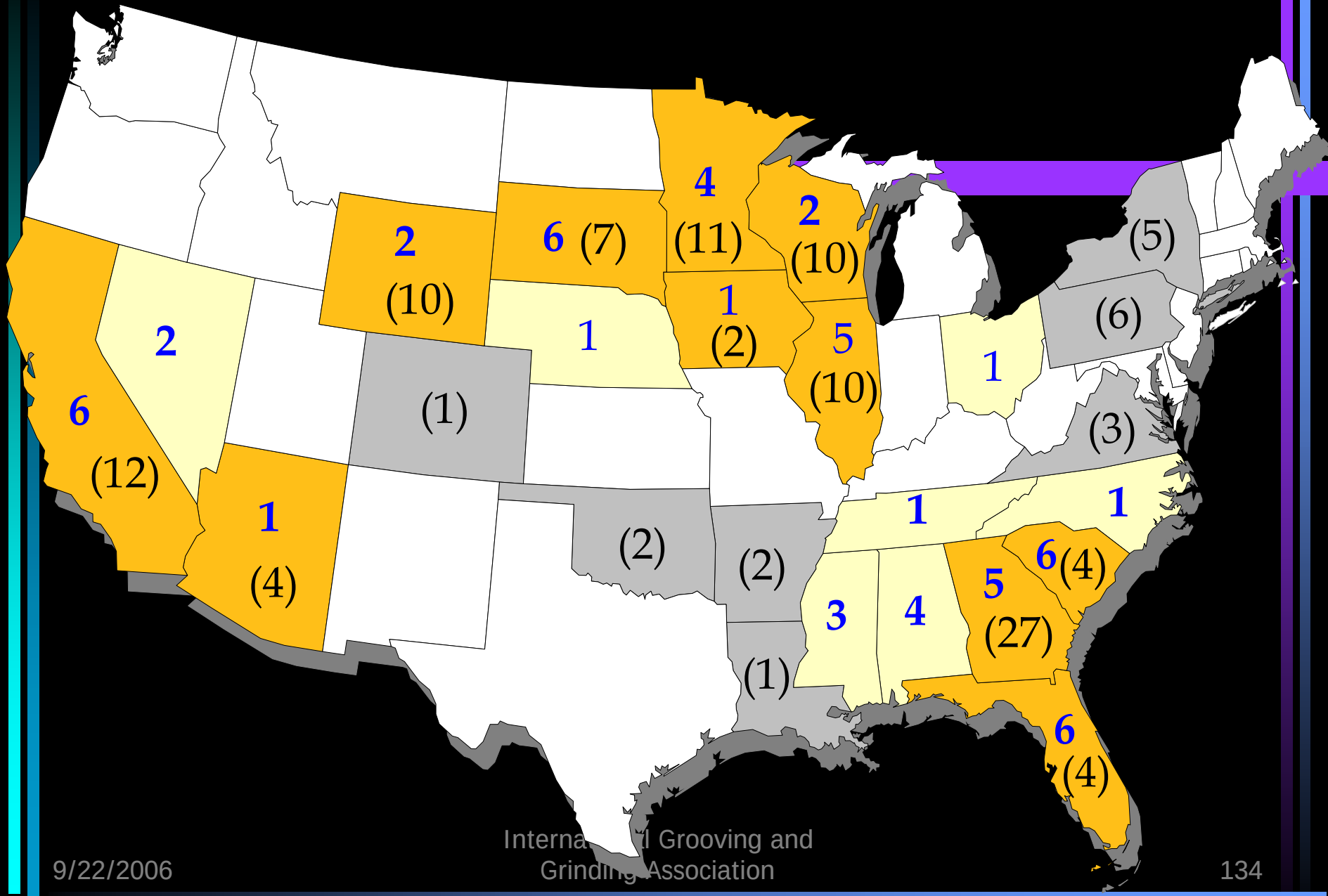



CUSHION CUT DC-5000

Longevity and Performance of Diamond-Ground Pavements

Research Objective

- Determine the effectiveness of diamond grinding as a CPR technique
- Document the performance of diamond-ground surfaces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Field Data Collection

- Faulting measurements
- Crack and distress survey
- PSR
- Macrotexture measurements

Surface Texture and Friction

- Improvement in friction number and skid resistance due to increase in pavement macrotexture
- Longitudinal texture provides directional stability and reduces hydroplaning (side-force friction)
- In Wisconsin, overall accident rates for ground surfaces were 40% less than for nonground surfaces over a 6-year period (Drakopoulos et al. 1998)

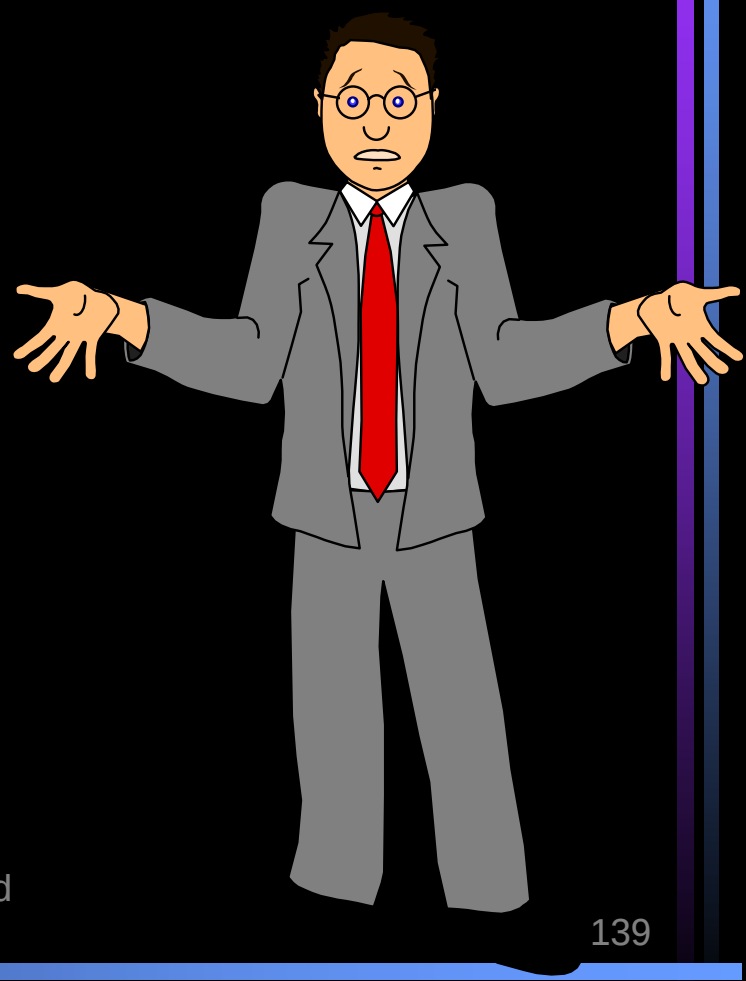
Conclusions

- Diamond grinding results in a smooth pavement surface with desirable friction characteristics
- Significant increase in surface texture and corresponding improvement in skid resistance

Conclusions

- Concrete pavement can be ground up to 3 times without significantly compromising fatigue life

So what is all this noise about diamond grinding in Arizona?!?



SR 202 56st WB PCCP Grinding

Prepared by Larry Scofield
Preliminary Draft 6/6/03

Diamond Grinding

Benefits Reported by Arizona DOT - 2003

- Improved smoothness
- Improved friction
- Improved cross slope
- Reduction in noise

Diamond Grinding

Effect on Roughness - ADOT

58 Percent decrease in IRI on average

Test Area	Lane 1	Lane 2	Lane 3
1	59%	56%	NA
2	NA	NA	53%
3	64%	60%	NA
4	NA	NA	55%

NA = Not applicable

Diamond Grinding

Effect on Friction - ADOT

27 Percent increase in friction on average

Test Area	Lane 1	Lane 2	Lane 3
1	25%	15%	NA
2	NA	NA	18%
3	41%	35%	NA
4	NA	NA	26%

NA = Not applicable

Airport Runway Grooving

What is Runway Grooving?

- A procedure that utilizes diamond tipped circular saw blades, mounted and evenly spaced on a horizontal shaft, to cut channels through which water can drain from the pavement surface.

Safety Grooving for Runways

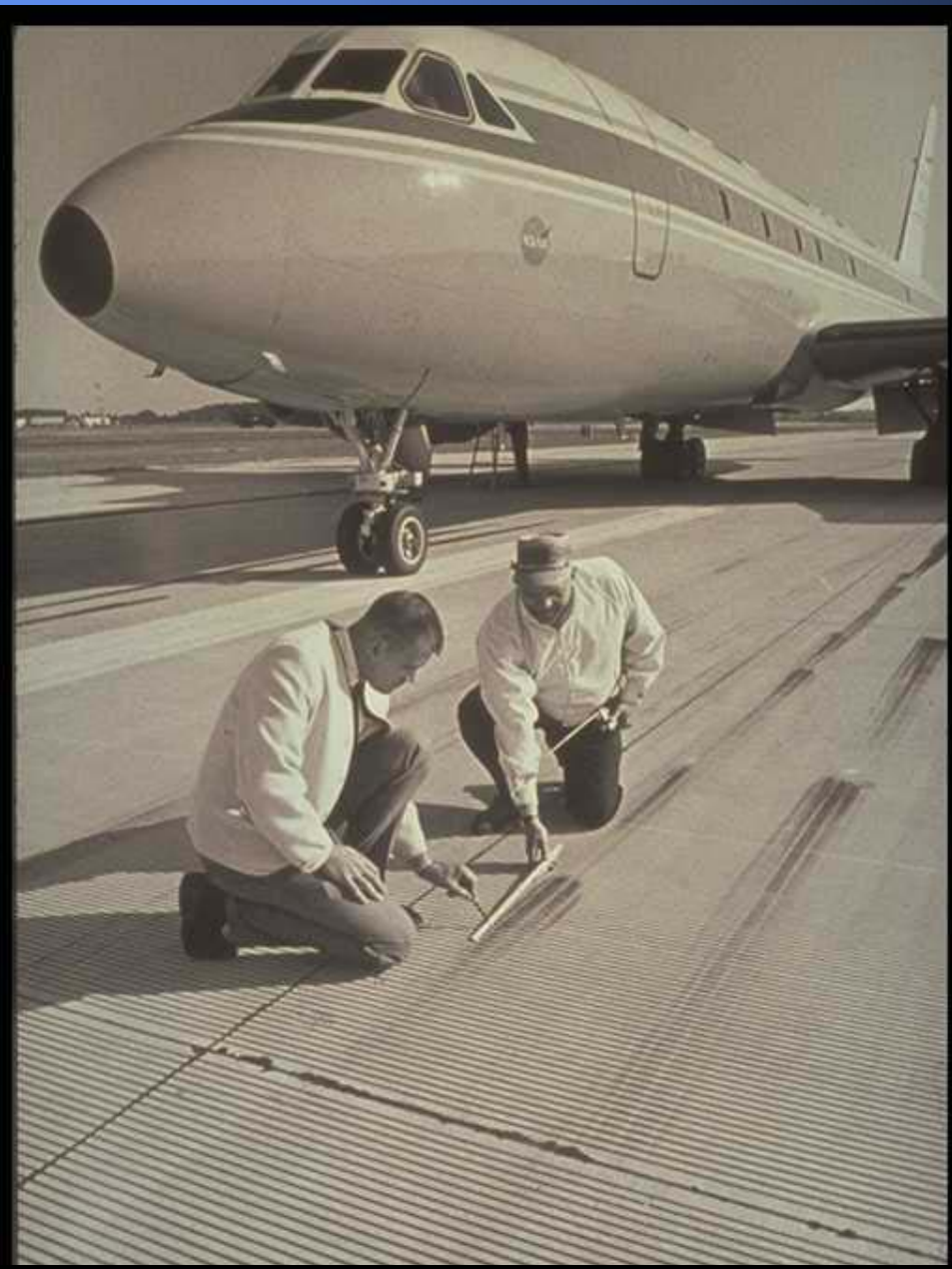
- First used by British in 1956 to improve friction characteristics of wet runways
- NASA begins runway grooving research in 1962
- Adopted as a standard technique used to improve runway characteristics in 1967

Safety Grooving for Runways

- First commercial use at Washington National Airport in 1967 – transverse grooves sawed into bituminous surface, .625” X .625” X 1”
- First commercial use on a PCC runway at Kansas City International Airport in 1968, .25” X .25” X 1.25”

Safety Grooving for Runways

- Standardized by FAA in 1978 via Advisory Circular
- Grooves sawed transverse to runway
- .25” X .25” X 1.5”
- AKA Deep Groove Concept
- Most major airports in the US contain at least one grooved runway



- “Grooving is like motherhood: you just can’t find anything wrong with it.”

Walter Horne

NASA Director of Research

Benefits of Runway Grooving

- Improved external water drainage on runway
- Improved internal water drainage between tire footprint and pavement surface
- Improved friction characteristics due to tire/pavement interlocking

Improved External Water Drainage

- Increases macro-texture of pavement surface. Increased rainfall rates required to start surface flooding
- Polished groove channels greatly reduce water flow resistance compared with rough pavement surfaces

Improved External Water Drainage

- Adverse effects of surface winds on water drainage are reduced
- Grooved pavement drains up to 10 times faster than un-grooved surfaces


BRITISH AIRWAYS

Improved Internal Water Drainage

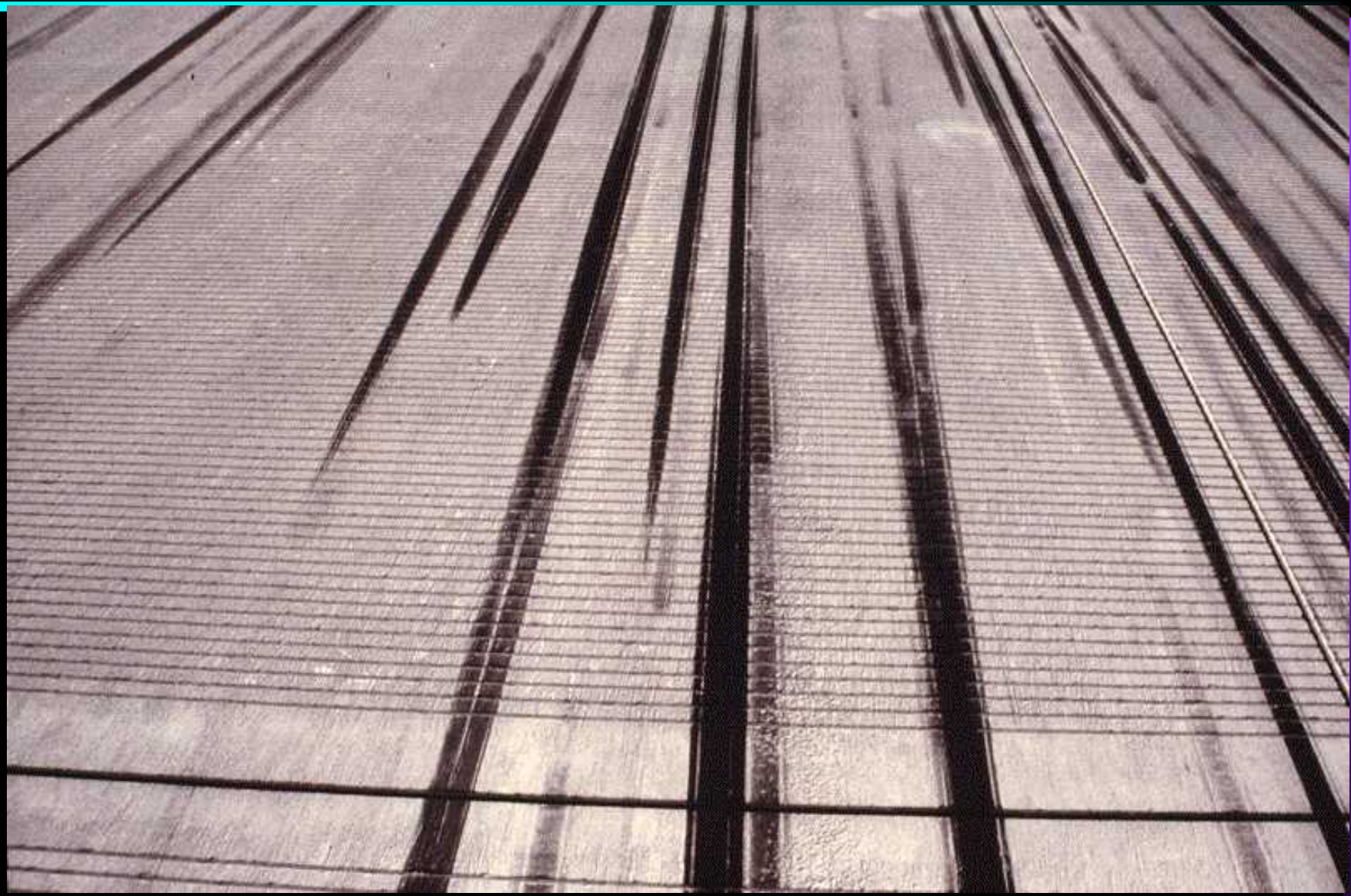
- Grooves provide “escape route” for water trapped between tire and pavement surface
- Reduces the potential for hydroplaning

Hydroplaning

- The condition that exists when a pneumatic tire rolling or sliding across a water-covered pavement is lifted away from the pavement surface onto a thin film of water. Total hydroplaning is when the tire loses the ability to develop frictional values necessary for vehicle deceleration and directional control!

Improved Friction Characteristics

- Interlock of tire tread rubber with pavement grooves increases friction coefficient
- Optimum configuration determined by NASA is .25” X .25” X 1.5” for AC and PCC
- Can restore tire friction coefficients on wet pavements to near dry pavement friction levels



Improved Friction Characteristics

- Uniform spacing of the grooves creates a homogenizing effect which produces a more uniform friction surface
- By reducing the magnitude and amount of fluctuations in the friction coefficient, a more effective braking surface is produced

Summary of NASA Report

- “The Pilot’s observations indicated that transverse grooved surfaces drastically reduced all types of skids on a wet or flooded runway and provided positive nose-gear steering during the landing roll-out.”

Summary of NASA Report

- “The overall airplane ground handling and stopping characteristics on the grooved surfaces showed a dramatic improvement over those on corresponding un-grooved surfaces with no observable adverse characteristics from the pilots point of view”

Cost of Safety Grooving

- Asphalt runway grooving, range $.50 to $1.50 per sq yd
- Concrete runway grooving, range $1.25 to $3.00 per sq yd

Factors Effecting Groove Durability

- Traffic loading and oxidation (AC surfaces)
- Shoving/distortion (AC surfaces)
- Numerous rubber removal operations can polish and/or remove pavement surface

- Note: Groove durability is greatly increased in PCC pavements!

Slurry Removal

- Slurry **MUST** be vacuumed from the runway...**NOT** just rinsed
- Deposit in grassy areas adjacent to runway
- Rinse runway with water when vacuum operation is completed

Joint Resealing

- Purpose
  - Minimize moisture infiltration
  - Prevent intrusion of incompressibles

Note: Joint resealing is not to be confused with joint clean and fill.

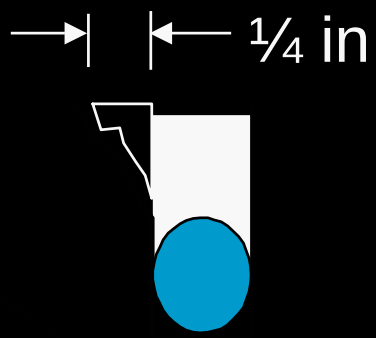
Why Reseal Pavement Joints?

- Resealing protects pavements from spalling and chipping at the joints
- Limits sub-grade softening
- Reduces the potential for pumping and faulting
- Resealing is the first defense against pavement deterioration

Effectiveness of Joint Resealing

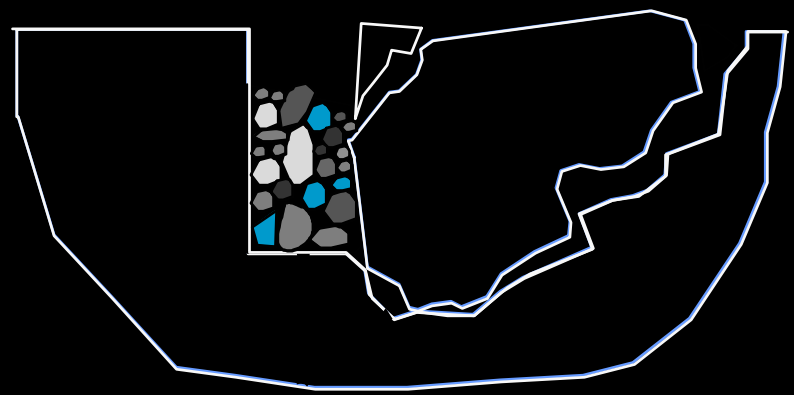
- Most beneficial on pavements that are not badly deteriorated
- Effectiveness depends on shape factor
  - Hot-poured sealants 1:1
  - Silicone sealants 2:1
- Joints should be clean and dry

Minor
Sliver Spalling



Will not affect performance of new sealant

Serious
Compression Spalling



Will not provide reasonable surfaces for sealing

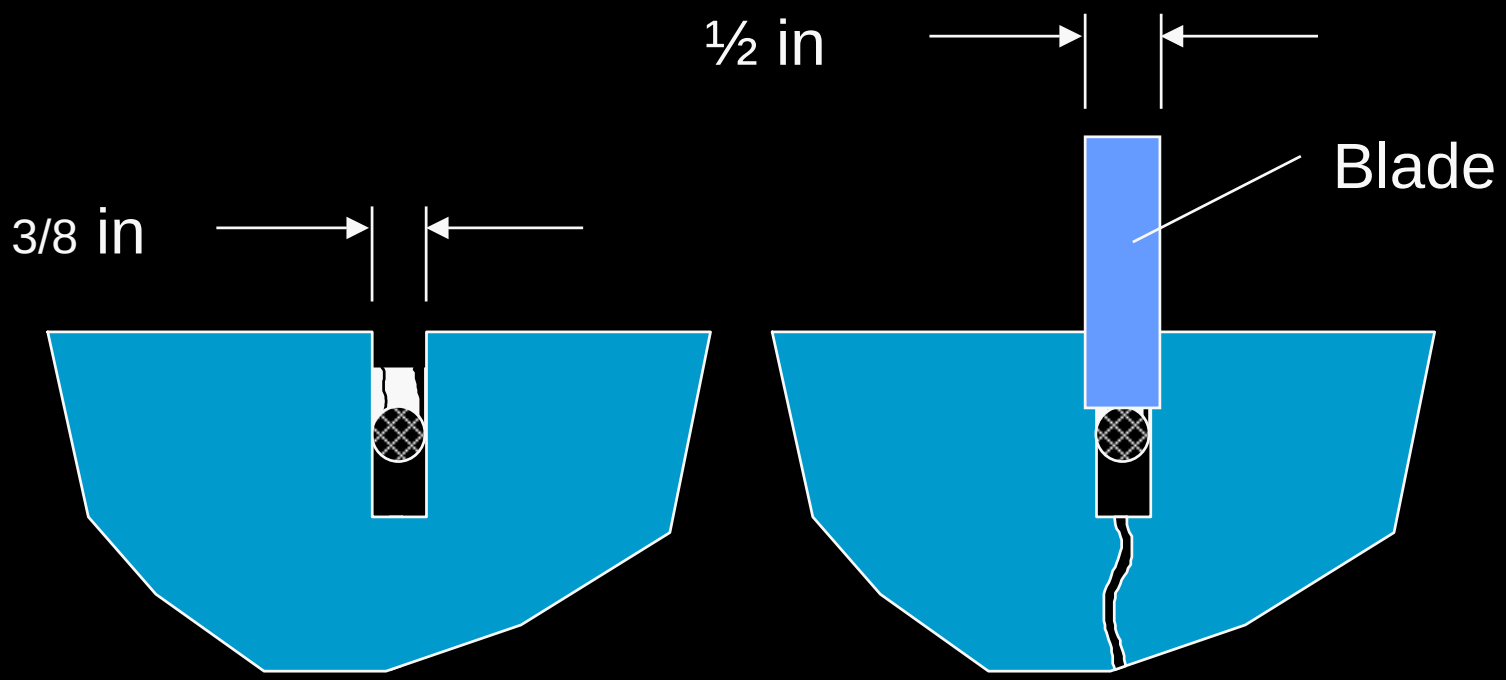
Performance of Joint Resealing

- Performance based on types of material used and quality of application
  - Silicon
  - Hot Pour
- Performance varies by region and aggregate type
- Regular resealing can extend overall pavement life

Shaping Reservoir

- After removing old sealant
- Widen as necessary
- Dislodges all old material

Blade for Slight Widening



Old Sealant

Sawing out the old Sealant

Clean Joint Reservoir

- Sealants will not adhere to contaminated surfaces
- Sand blast or water blast joint reservoir after removal of old sealant
- Air blast with oil-free compressed air to remove blasting media
- Test surfaces with wipe-test

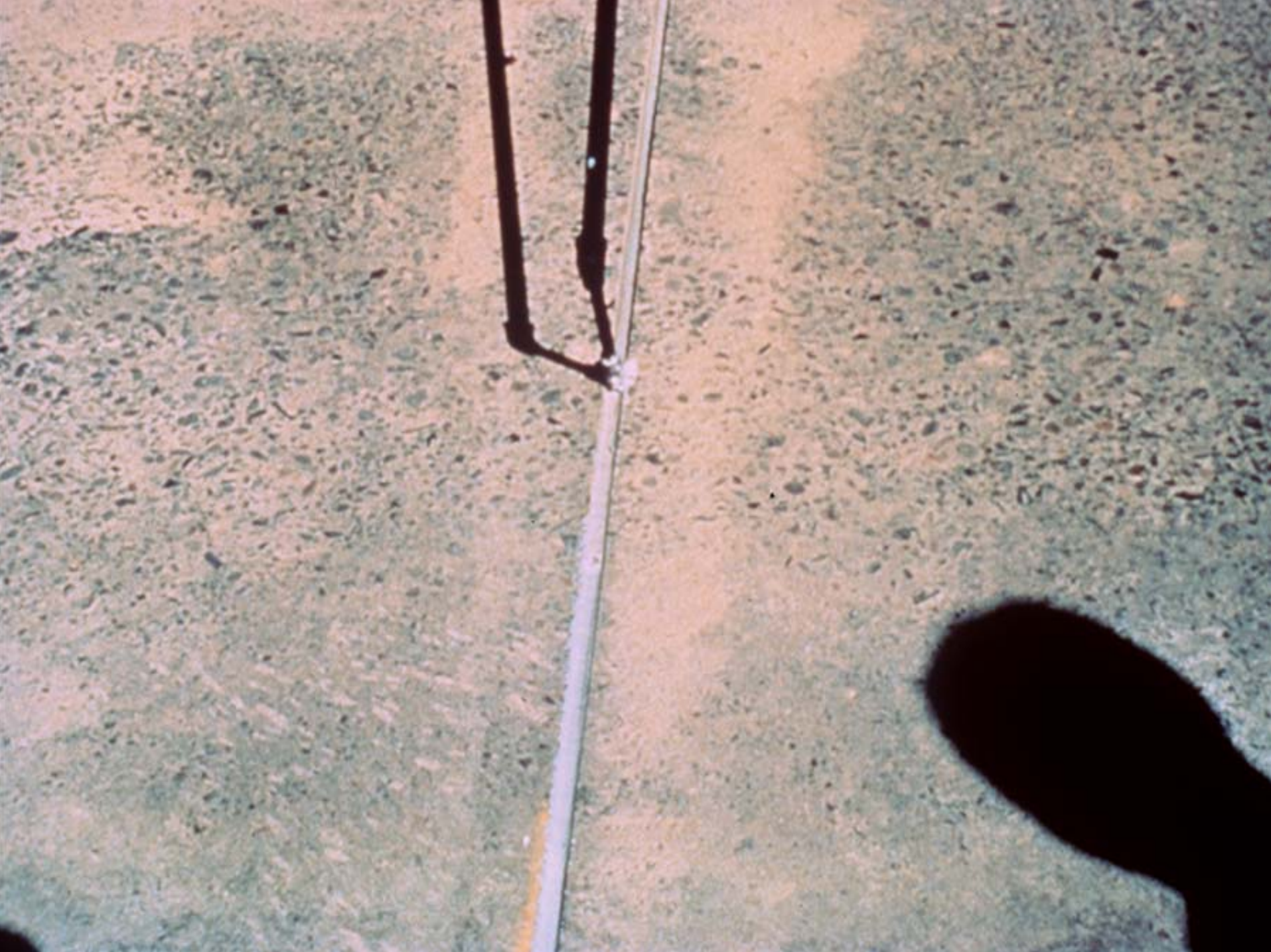
Install Backer Rod

- Conserves sealant material
- Creates proper shape-factor for better performance
- Must be installed to proper depth
- Special materials required for hot-pour sealants

Sealant Installation

- Consult product installation recommendations
- Refer to procedures outlined in ACPA Publication TB012P *Joint and Crack Sealing and Repair for Concrete Pavements*


KOSS
CAPITOL



Conclusions

- CPR saves pavement life!

Conclusions

- Many restoration techniques are available to extend the life of your pavements.
- Timely CPR is a low cost alternative to resurfacing or reconstruction.
- The IGGA, ACPA and CAC are willing and able to help with your pavement needs.
- For more information, check out www.igga.net , www.pavement.com and www.cement.ca.

Visit Us on the Web

International Grooving and Grinding Association

- igga.net