Chip Seals

State of the Practice

2008 Rocky Mountain Pavement Preservation Partnership Conference

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ncpp
National Center for Pavement Preservation

References

1. NCHRP Synthesis 342, “Chip Seal Best Practices”, Transportation Research Board, Washington, D.C., 2005
2. “Maintenance Technical Advisory Guide (MTAG)”, California Department of Transportation, Sacramento, CA, 2003
3. “Analysis of New Zealand Chip Seal Design & Construction Practices”, Gransberg, Douglas D., et al.

Web Contacts

Australia

- Roads and Traffic Authority (RTA, NSW)
  www.rta.nsw.gov.au
- Road Corporation (VicRoads, Victoria)
  www.vicroads.vic.gov.au

New Zealand

- Transit New Zealand (TNZ)
  www.transit.govt.nz

Chip Seals

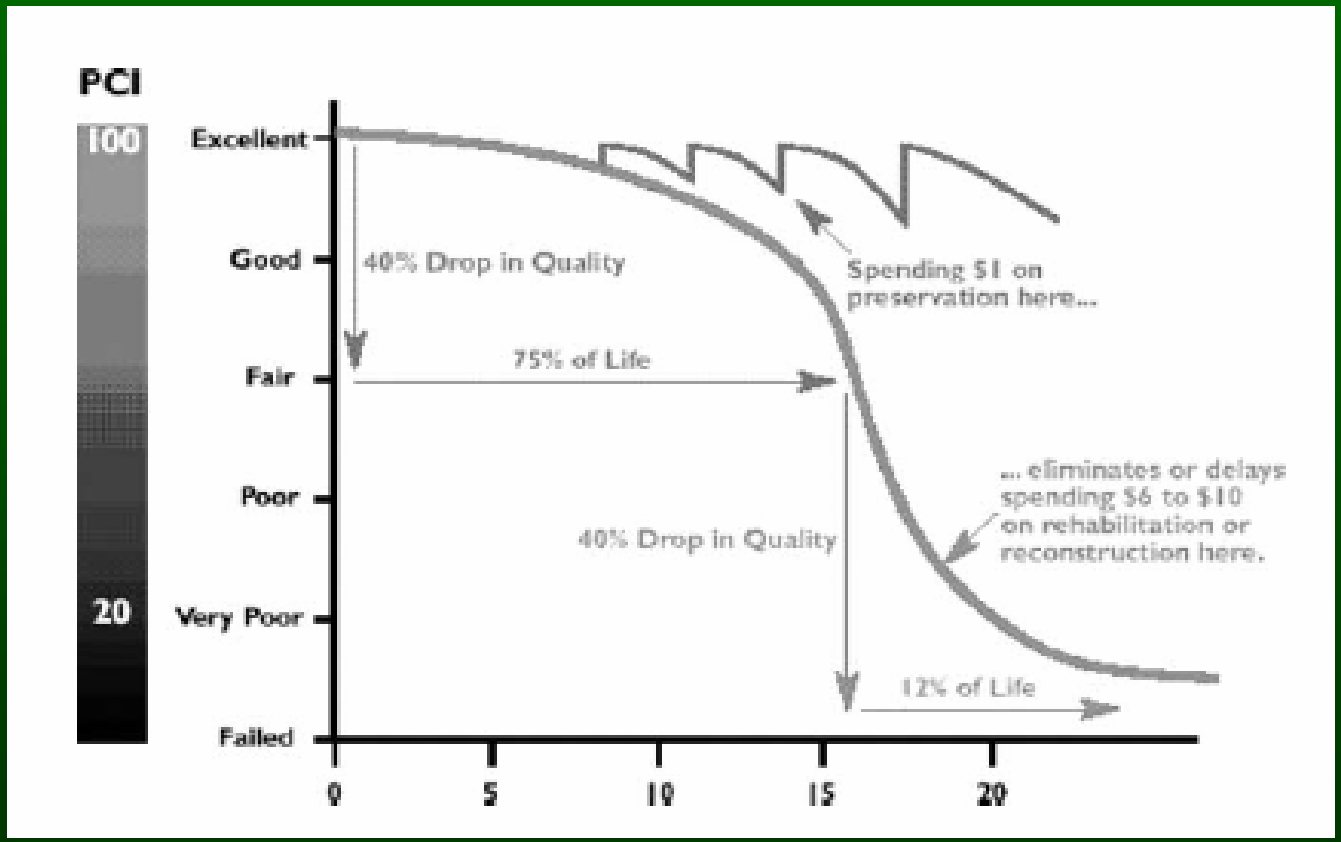
Workhorse of Pavement Preservation

Pavement Preservation

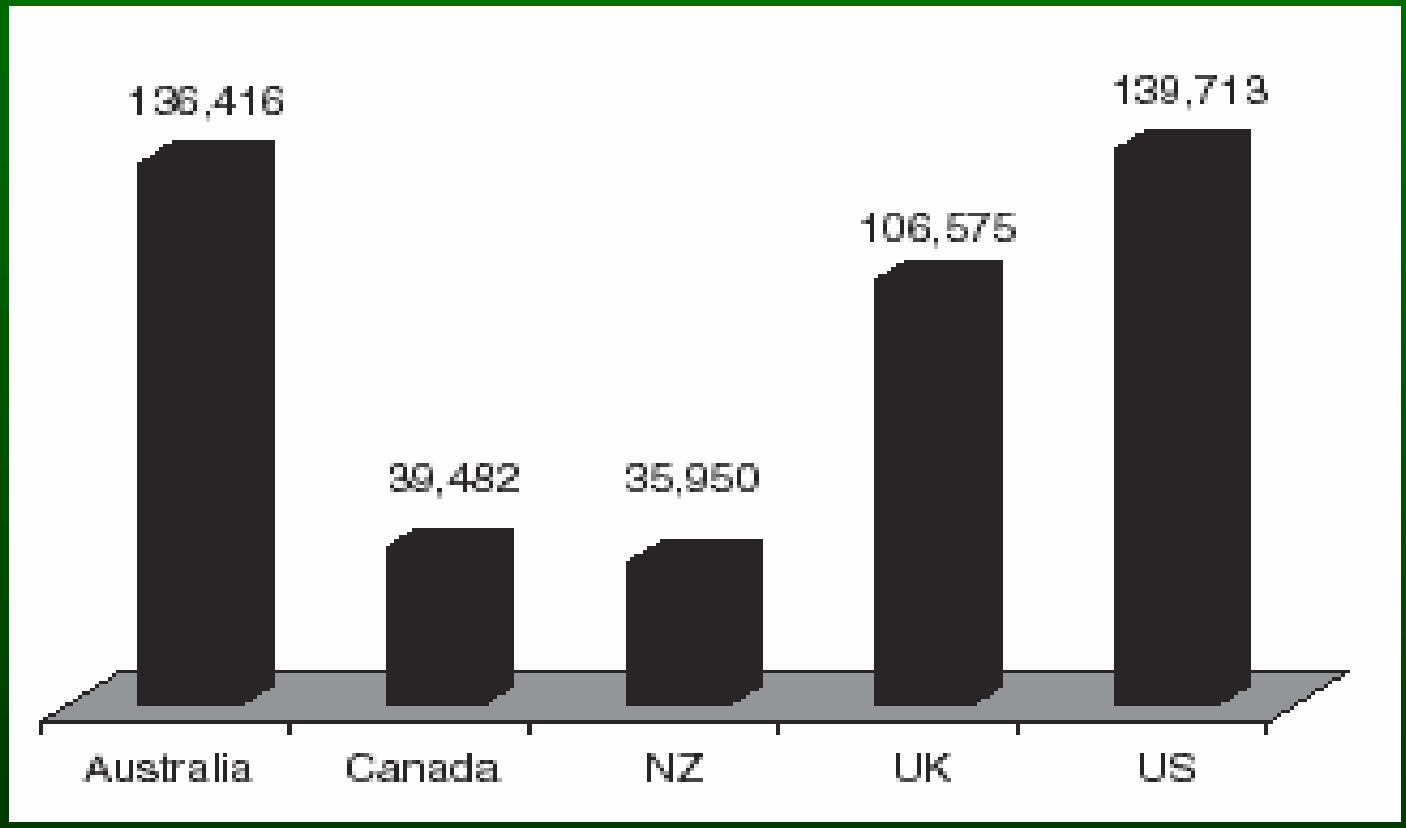
Definition:

"Program employing a network level, long-term strategy that enhances function pavement performance by using an integrated, cost-effective set of practices that extend pavement life, improve safety, and meet motorist expectations"

Preventive Maintenance Concept



Where are Chip Seals Used?



Chip Seals - Advantages

- Cost-Effective Treatments
- Good Durability
- Ease of Construction
- Improved Skid Resistance

Chip Seals - Disadvantages

- Cure Time
- Flying Chips
- Noise Considerations
- Weather Considerations
- Performance

Chip Seal Programming Different Purposes

North America

- Distress
- Prevention of water infiltration

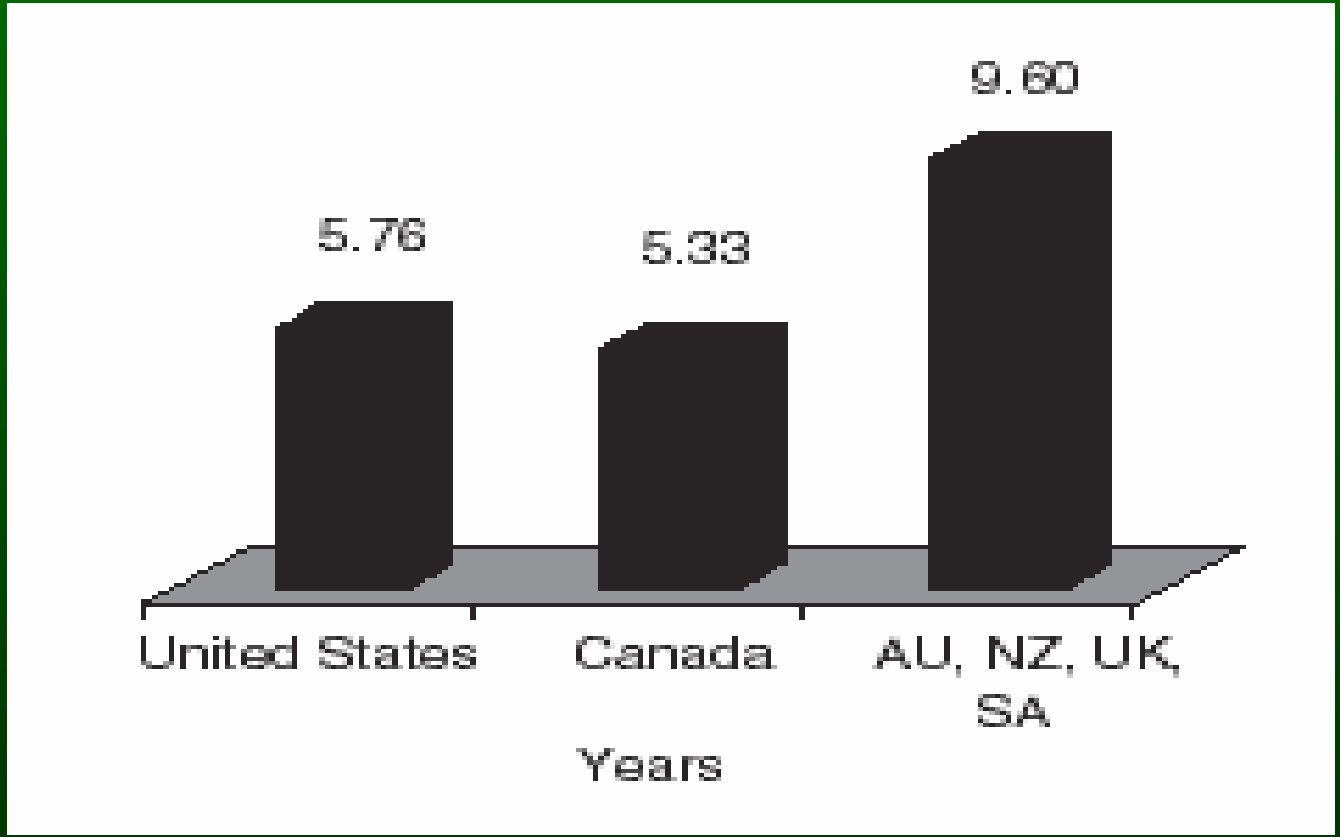
Overseas

- Low skid numbers
- Need for wearing surface

Evolution of Chip Seals

Characteristic	North America	Overseas
Philosophy	Art	Science
Agency Realm	Maintenance	Construction
Forces	In-House	Contractor
Design	Recipe	Engineering Principles
Risk	Agency	Contractor
Pavements	Variable	Textured (Sand Circle)
Surface Hardness	No	Yes
Outcome	Uncertain	Predictable

Chip Seal Service Life



Chip Seal Design

Potential Improvement

The greatest potential for improvement is in the area of design – accurate characterization of the surface to measure macro-texture and hardness allows suitable binder types to be chosen and aggregate gradations that are compatible with the surface.

…. Reference 3 (Douglas Granberg's Paper)

Chip Seal Design Methods
Two Philosophies

Empirical (Art)

- Past experience (Art)
- Purchased as bulk commodity

Engineered (Science)

- Engineering algorithms
- Highly customized

Chip Seal Design Methods (1)

North America

(Ranked by prevalence)

- Empirical / Past Experience
- No Design
- Own Method
- McLeod (1960s) / Asphalt Institute
- Kearby (1953) / Modified Kearby
- Hanson (1934 / 1935)(Obsolete)

Hanson Method (1934 / 1935)

- Earliest formal method
- Developed for liquid asphalt (cutback)
- Based on average least dimension (ALD)

Kearby Method (1953)

- Binder rate based on average thickness, aggregate embedment, voids
- Recommended uniformly graded aggregates
- Embedment based on aggregate hardness (increase for hard, decrease for soft)
- Larger aggregates / less embedment – high ADT
- Medium aggregate/ more embedment – low ADT

McLeod Method (1960s)
(Most Common)

- Officially adopted by Asphalt Institute in 1969
- Based partially on Hanson
- Aggregate rate based on gradation, specific gravity, shape, wastage / correction factors
- Binder rate based on aggregate gradation, pavement condition, traffic volume, asphalt type (absorption)
- Marks effective end of chip seal design research

Chip Seal Design Methods (2)

Overseas

- Kearby and McLeod (1953)
- UK TRL Road Note 39 (1996)
- AustRoads (2001)
- New Zealand P17 (Mod of Australia)
- TRH 3 (Hybrid of UK & Australia)

Road Note 39 Procedure

- Binders selected based on viscosity
- Polymer-modified binders encouraged
- Binder grade based on traffic, season
- Aggregate size based on traffic, pavement hardness, desired friction
- Binder rate based on aggregate, surface texture, embedment by traffic
- Aggregate rate based on size, shape, relative density

AustRoads Sprayed Seal
Design Method

- Performance-based method
- Binder and aggregate rates based on
  - Aggregate angularity
  - Traffic volume
  - Road geometry
  - Aggregate ALD
  - Aggregate absorption
  - Pavement absorption
  - Texture depth
- Aggregate one layer thick

New Zealand P17
Design Factors

Aggregate
- Size
- Angularity
- Average Least Dimension
- Absorption
- Embedment

- Traffic volume
- Road geometry
- Pavement absorption
- Texture depth
- Application immediacy (2nd seal)

South African Method

Technical Recommendations for Highways (TRH 3)

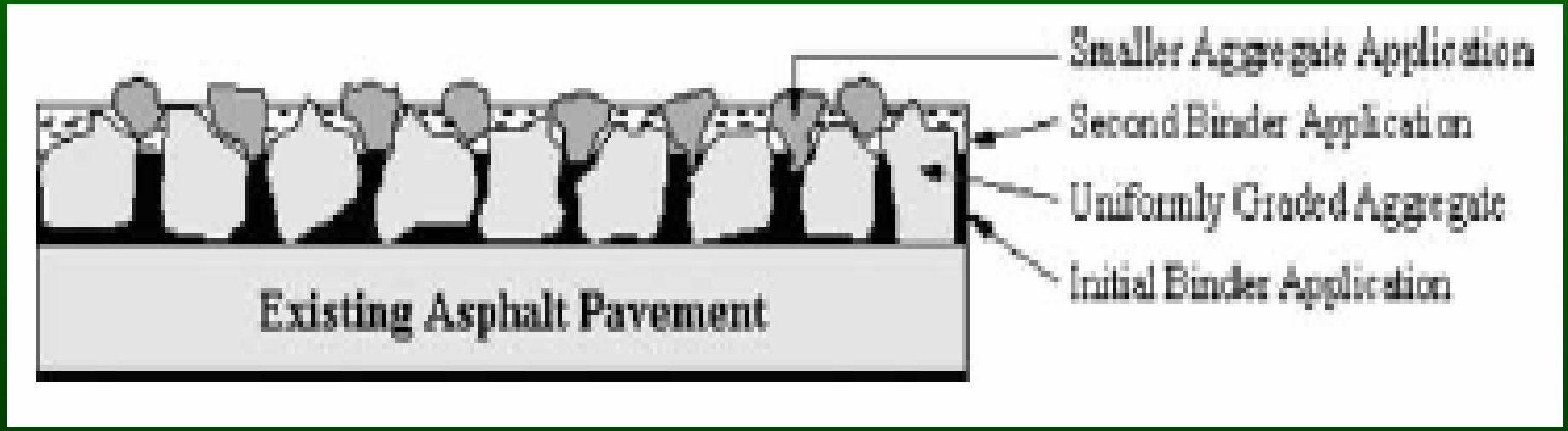
- Used on roads up to 50,000 ADT
- Primary inputs: Traffic, preferred texture depth, surface hardness
- Adjustments made for climate, gradients, existing coarse texture, hot applications, preferred aggregate matrix, polymer-modified binders
- Hybrid of Road Note 39 and AustRoads

Formal Design Factors

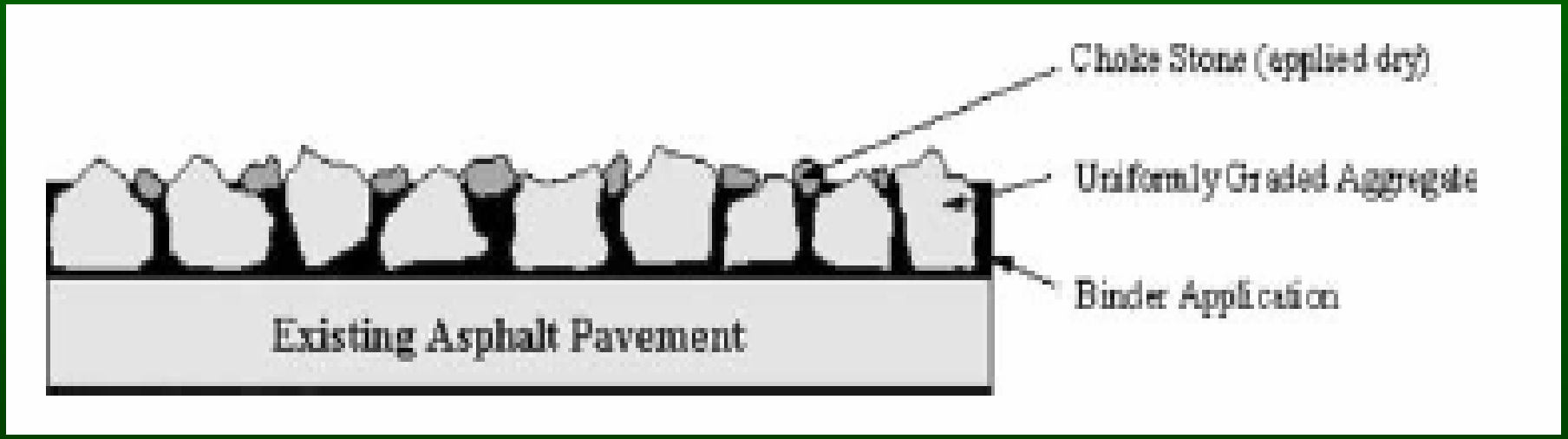
- Surface texture
- Traffic conditions (ADTs, speed,% commercial, etc.)
- Climate, season
- Chip seal type
- Aggregate selection
- Binder application rate
- Daily construction hours

Single Chip Seal

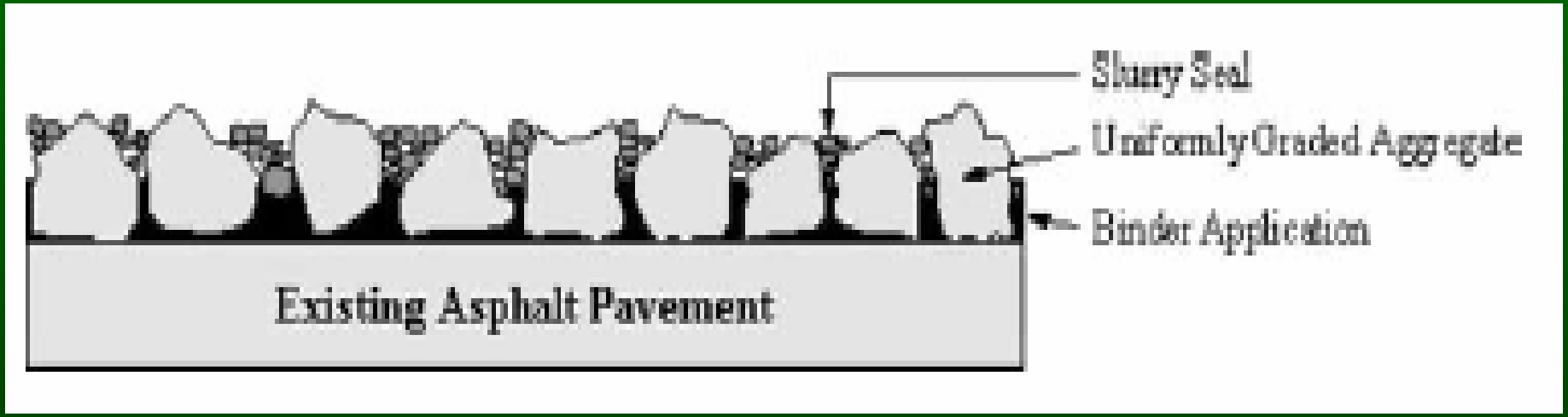
Double Chip Seal



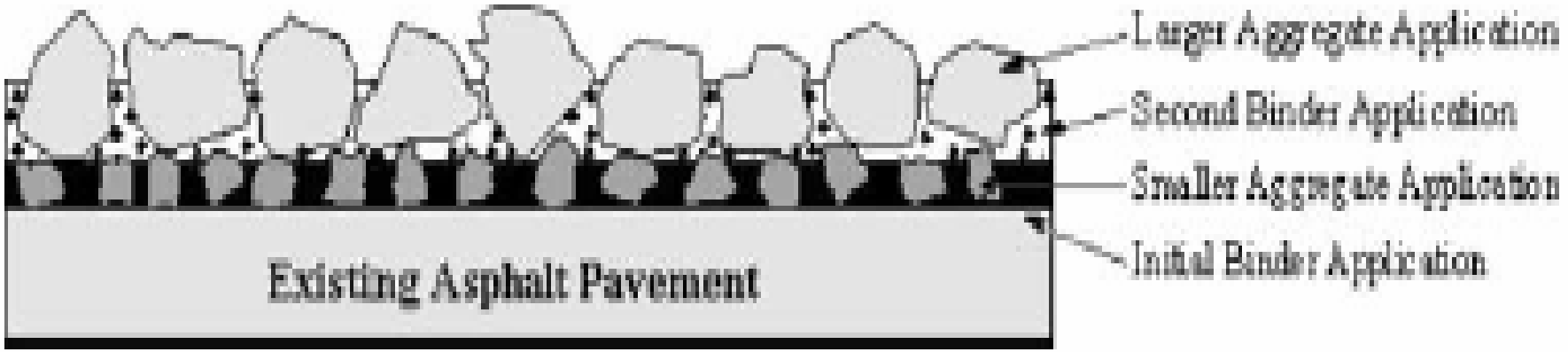
Racked-in Seal



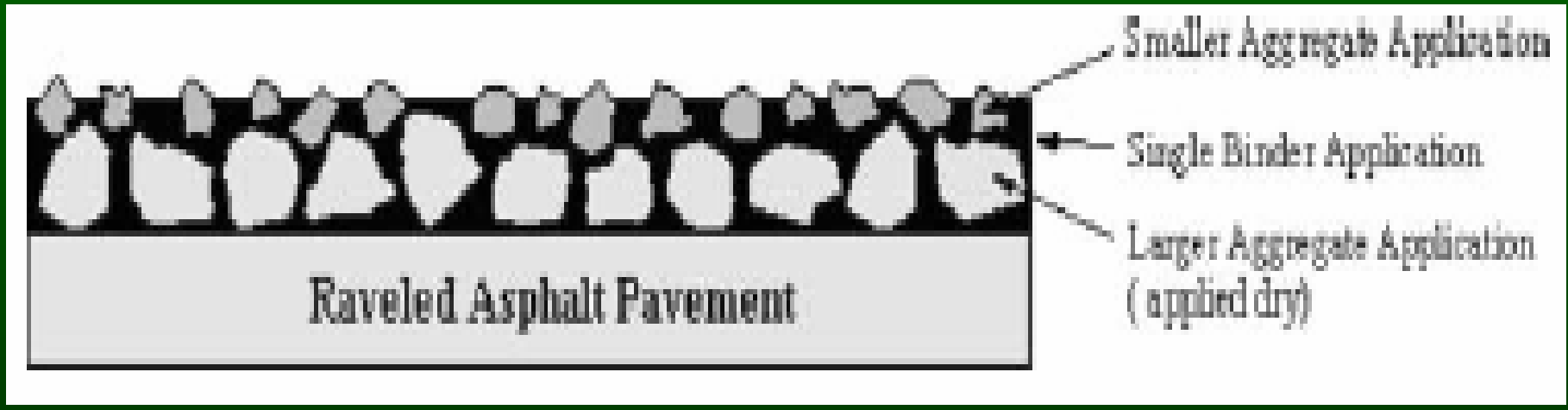
Cape Seal


Slurry Seal
Uniformly Graded Aggregate
Binder Application
Existing Asphalt Pavement

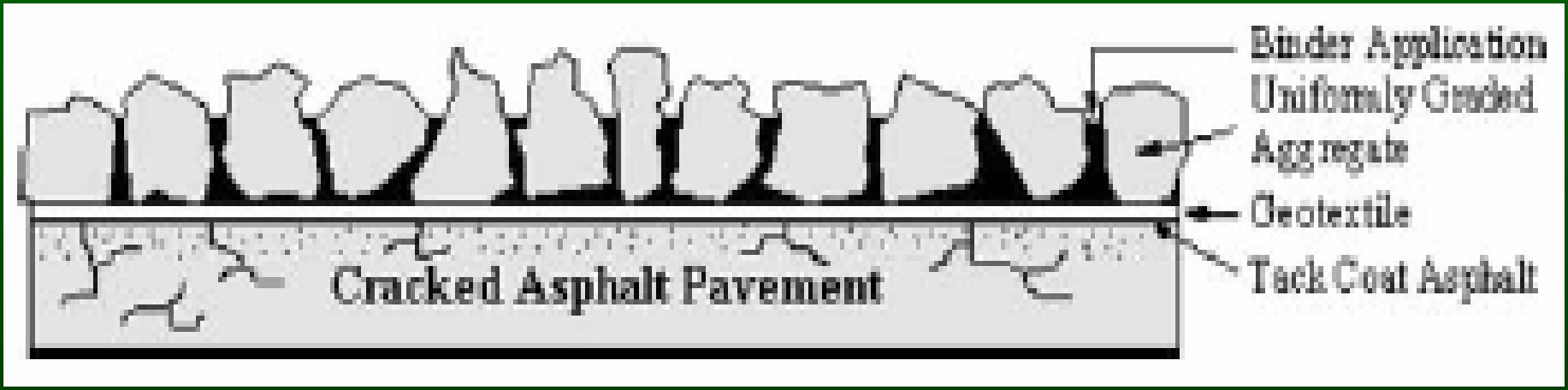
Inverted Seal



Sandwich Seal (Dry Matting)



Geotextile-Reinforced Seal



Chip Seal Materials

Common Aggregate Sizes

Single Chip Seals

- 3/8” (10mm)

Double Chip Seals

- ½” (12.5mm) (First App)
- ¼” (6.25mm) (Second App)

Pre-Coating Aggregates

- Improves binding properties
- Reduces dust
- Enhances visibility of markings
- Decreases required curing time
- Decreases chip loss
- Not used with emulsion binders (inhibits breaking of emulsion)

Aggregate Performance

Best performance from

- Single sized (if possible)
- Minimum fines (<2%»#200)
- Clean
- Free of clay
- Cubical (limited flat particles)
- Crushed faces
- Abrasion < 30%
- Binder-compatible
- Damp for emulsions
- Dry for hot binders

Overseas Aggregate Use

- Basalt, quartzite, granite most common
- Washed in water or kerosene
- Crushed to cubical shape
- Single applications – 10mm
- Uniform gradation
- Double applications – 12.5mm/6.25mm
- Angular shapes problem for turners
- Polished Stone Value (PSV): 44-48
- Some pre-coated with liquid asphalt

Binder Properties

- No bleeding when applied properly
- Cover surface w/o puddling, runoff
- Develop adhesion quickly

Binder Selection

Influenced by:

- Surface temperature
  - High - asphalt binders
  - Low - emulsions
- Aggregate
- Construction climate

Best Materials Practices

- Electrostatic chip testing before design
- Uniformly graded, high quality aggregates
- Lightweight aggregate to minimize vehicle damage
- Life Cycle Cost analysis to evaluate aggregate importation
- Polymer-modified binders for performance

Chip Seal Equipment

Water Re-Texturizing Machine

Surface Cleaning with Truck-Mounted Cutting Heads

Umbilical Ultra-High Pressure Water-cutter

Cleaned Surface

Distributor Spray Bar

Distributor Rate Control Computer

Dump Truck Spreader

Self-Propelled Aggregate Spreader

Low Drop Aggregate Spreader

Aggregate Pre-coating Loader

Pneumatic Roller

Rotary Broom (1)

Rotary Broom (2)

Best Equipment Practices

- Computerized distributors for greater control
- Matching chip seal equipment with distributor (speed of operation)
- Variable nozzles to reduce binder in wheel paths
- Plastic broom bristles to reduce aggregate dislodgement
- Water re-texturing machines to remove irregularities, bleeding
- Use of vibratory pneumatic rollers

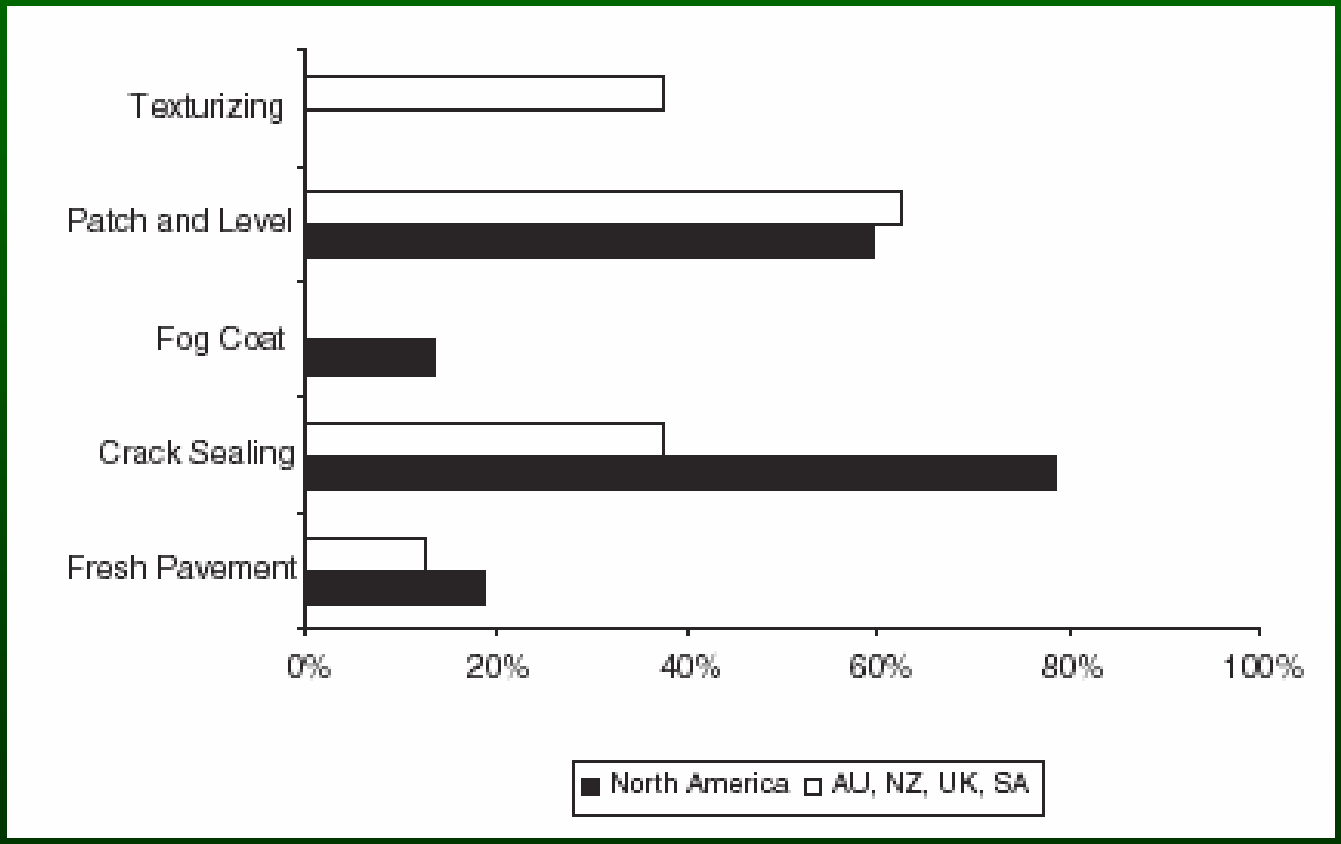
Chip Seal Construction

Ideal Weather Conditions

Air temperature	High
Relative humidity	Low
Wind velocity	None
Precipitation	None

(Low humidity critical for hot asphalt binders)

Pavement Preparation



Binder Application

Spreading Aggregate

Excess Aggregate

The Montana field-sweeping test (*Maintenance Chip Seal Manual* 2000) curtails the bias to spread excess aggregate created by paying for it by the ton. Montana requires that the amount of excess chips be less than 10% of the design rate and adjusts the pay quantities based on the sweeping test results. This may also reduce the potential for windshield damage claims.

Rolling

Sweeping (1)

Sweeping (2)

Best Construction Practices - (1)

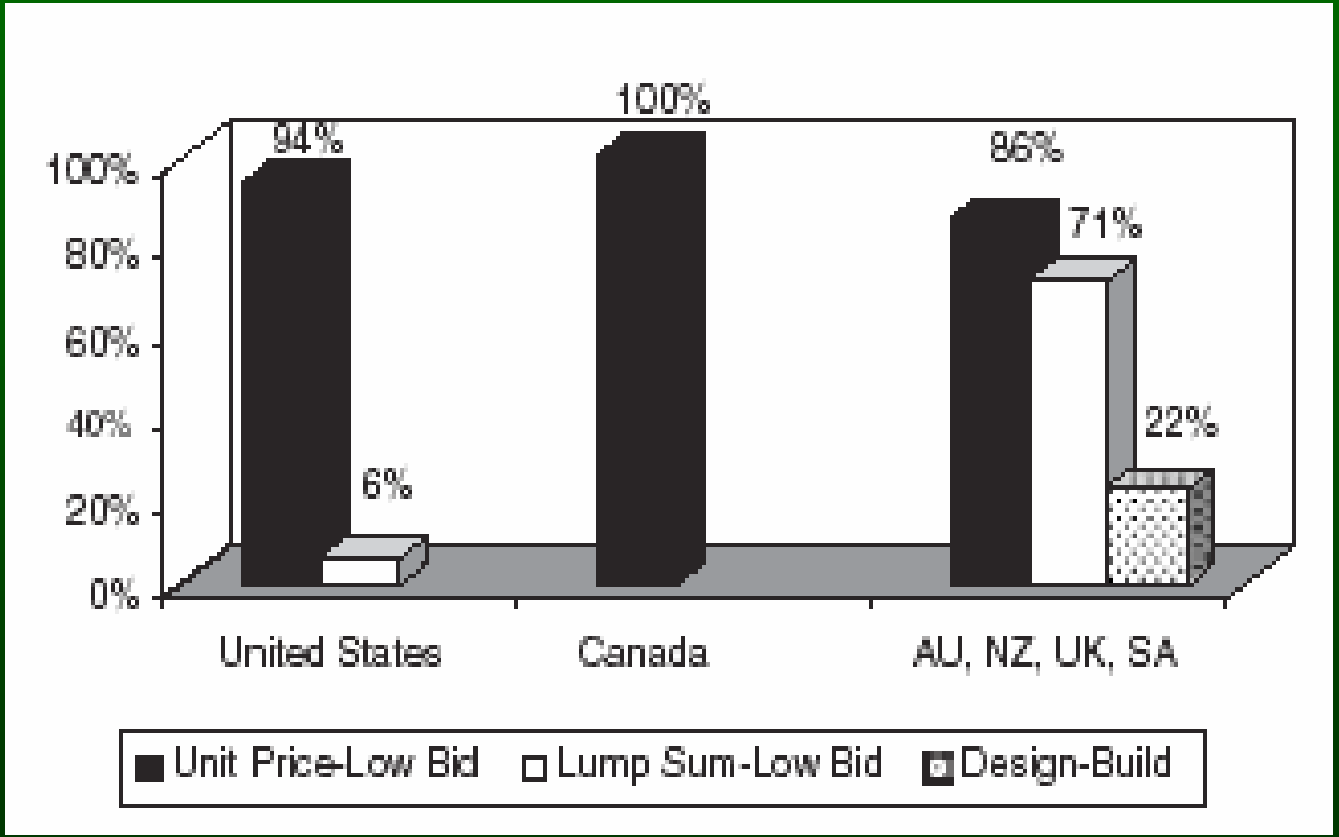
- Application in warmest, driest weather
- Ambient air temperatures
  - Emulsions (50F-110F)
  - Asphalt cements (70F-110F)
- Surface temperatures
  - Emulsions (70F-140F)
- Lead times
  - Patches 6 months
  - Crack seals 3 months
- Variable nozzles to prevent bleeding
- Roller 1 drags broom
- Prompt aggregate application
- Excess aggregate penalty

Best Construction Practices - (2)

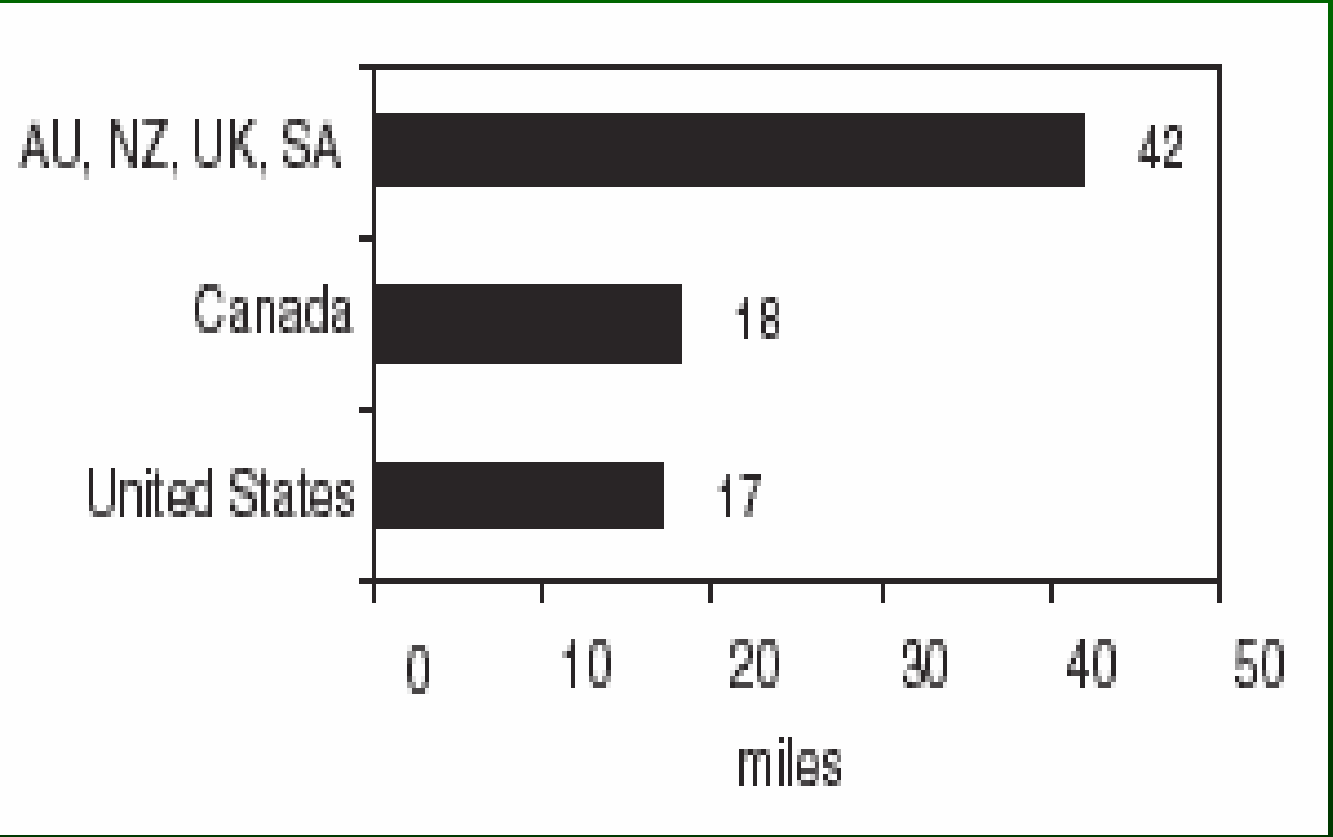
- Racked-in seals for problem areas
- Rolling rates based on aggregate size, traffic (3,000-5,000 sq yd/hr)
- N rollers based on distributor production, rolling times
- Roll close to spreader
- Maintain traffic control to allow curing
- QC/QA only by experienced personnel
- Regular calibration of distributor, spreader
- Field test aggregate-binder compatibility
- Sample / test binder, aggregate at distributor, stockpile respectively to detect degradation

Chip Seal Contracting

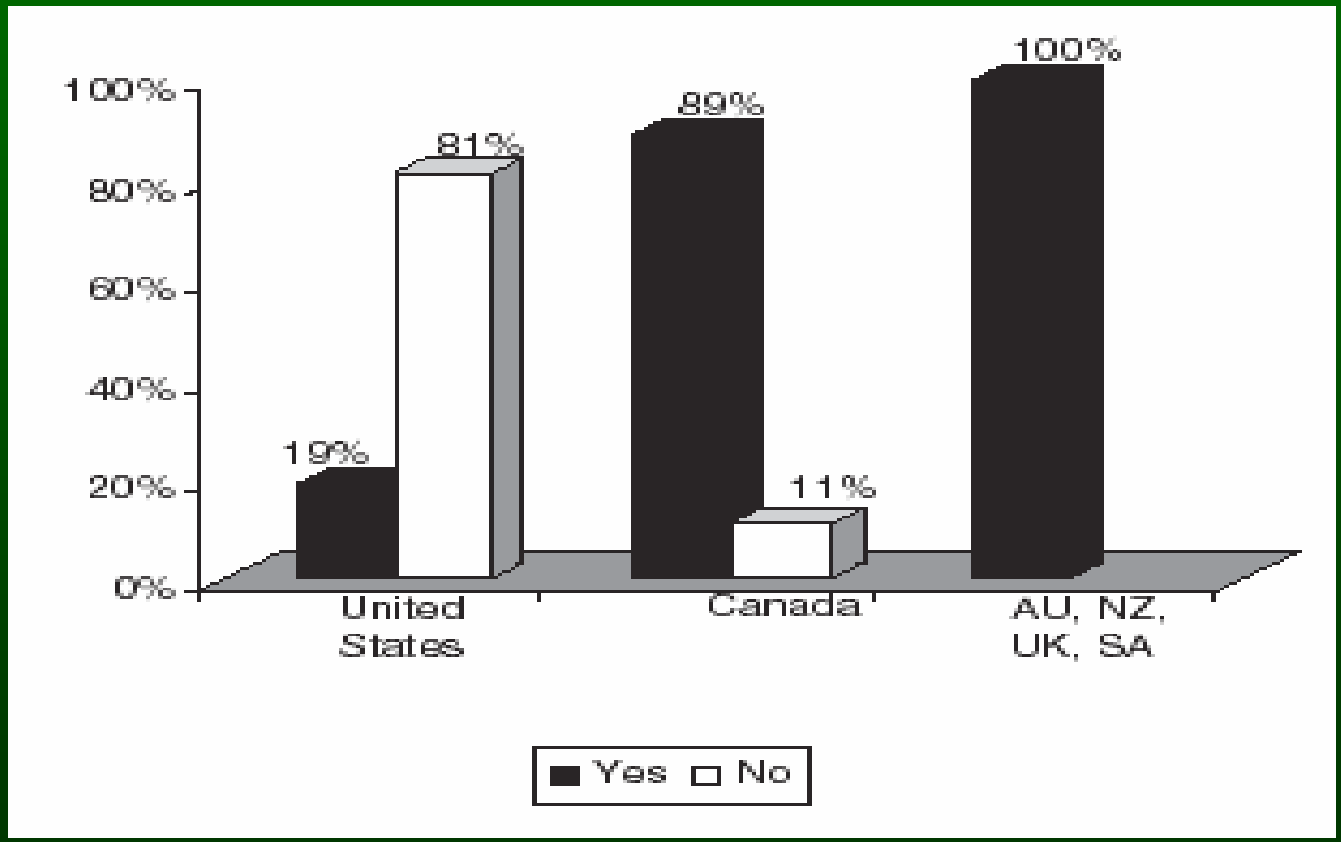
Types of Chip Seal Contracts



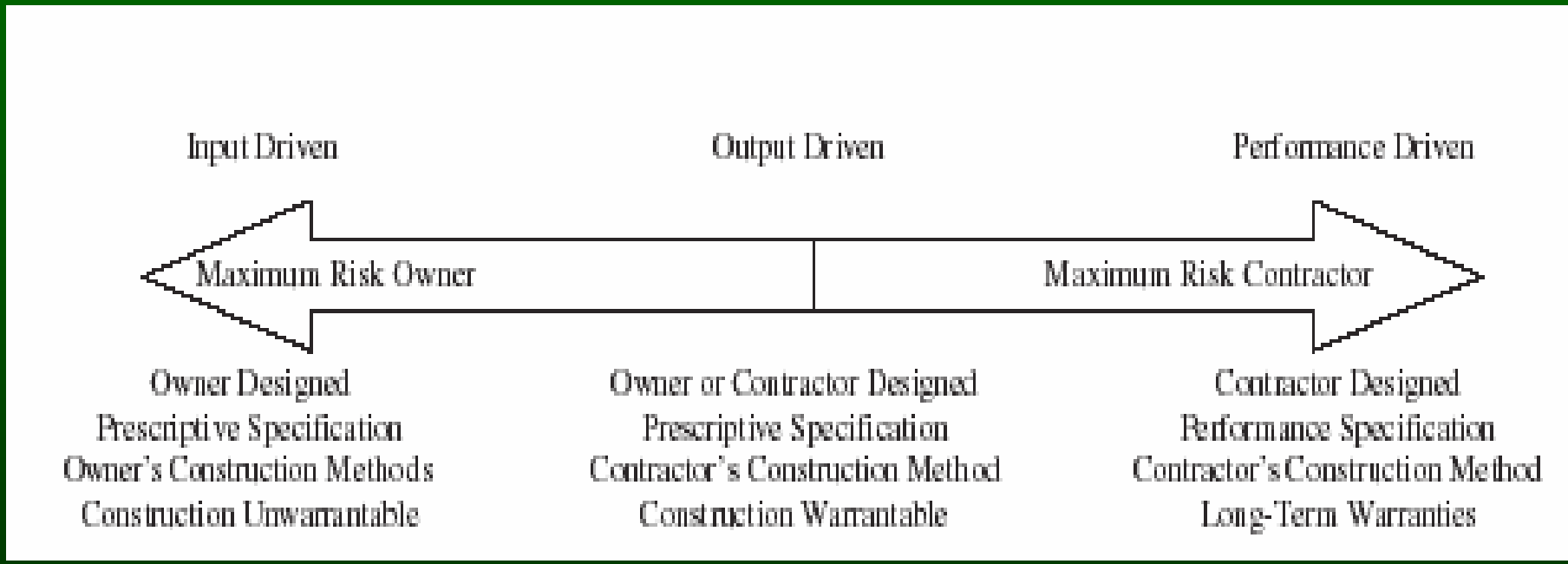
Typical Project Lengths



Warranty Requirements



Contract Risk Continuum



Best Contracting Practices

- Let chip seal contracts to allow early season construction
- Allow enough time for curing of pre-construction preparation
- Make jobs large enough to attract bidders
- Restrict warranties to jobs where contractors have sufficient control

Chip Seal Performance Measures

Performance Measures
(Quantitative)

- Cannot use traditional performance measures of asphalt pavements
- Skid Resistance based on
  - Micro-texture (Aggregate frictional properties)
  - Macro-texture (Particle size, shape, spacing)
- Texture Depth (TD)
  - Measured by Sand Patch Test (ASTM E965)
  - NZ P17 "… design life…reached when TD falls below 0.9mm on roads with V>70 kph"

Performance Measures
(Qualitative)

- Visual surface ratings
- Visual chip seal distress
- Bleeding
- Raveling
- Defects
- Ohio visual evaluation

Needed Research

- Designs based on engineering principles
- Macro-texture, surface hardness tests
- Inverted seals to correct bleeding
- Racked-in seals for problem areas
- Economics of retexturing
- Pre-coating aggregates
- Drop chip spreaders
- Rollers and their operations
- Chip seal warranties
- Chip seals and noise
- Standard chip seal glossary, standard specification

Need More Information ?

- National Center for Pavement Preservation at Michigan State University

www.pavementpreservation.org

Thank You