New Technology Initiatives in Rural Roads and Use of Marginal Materials

SURFACE DRESSING
DESIGN AND CONSTRUCTION

National Rural Infrastructure Development Agency

Ministry of Rural Development

National Institute of Technology

Warangal, Hyderabad

Lecture 7

SURFACE DRESSING
DESIGN AND CONSTRUCTION

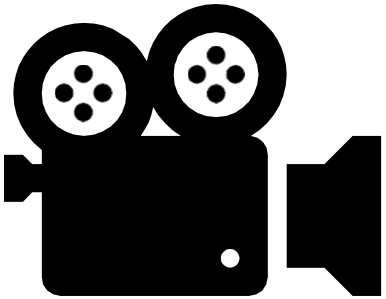
Presentation Out Line

- Surface Dressing and when should be used
- Requirement of Martials for Surface Dressing
- Material Selection and Requirements
- Equipment used for Construction
- Surface Dressing VS Premix Carpet and Design
- Works of Surface Dressing in India!

There is no need for training or demo to use simple older technology such as surface dressing. Most states already have this item in their BSR.

What is Surface Dressing (Chip Seal)

- Spraying a binder and covering with clean crushed aggregates
- Rolled to press the aggregates into the binder
- Cannot restore the pavement's surface evenness.
- Cannot contribute to the pavement's structural strengthening
- IRC/MoRTH/MoRD recommended
  - Bituminous Concrete
  - Semi-Dense Bituminous Concrete
  - Pre-Mix carpet With Seal Coat
  - Surface Dressing
  - Mix Seal Surfacing



Purpose of Surface Dressing

- **Common and cost-effective form of surface treatment**
  - + Provide a dust-free wearing surface over a granular base.
  - + Provide surface impermeability against rainwater
  - + Arrest disintegration of the road surface.
  - + Provide a non-skid riding surface.
  - + Serve as a renewal coat for periodic maintenance

Bridge cracks wider than ¼." Address ruts > ½" deep

Does not enhance the structural strength, nor does it restore the riding quality but, it is effective in waterproofing

Poor Candidate - Wider Cracks

Poor Candidate-Structural Failure!

Poor Candidate-Structural Failure!

Poor Candidate –Deep Ruts

Poor Candidate

Good Candidates- Raveling, Oxidation and loss fines

Good Candidate

Good Candidates

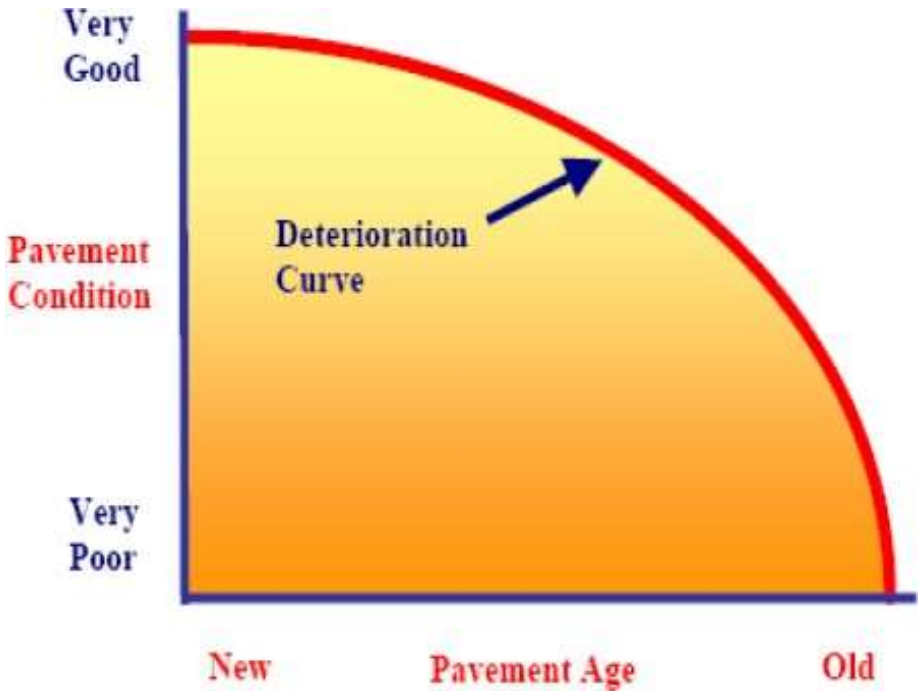
Minor flushing and loss of friction

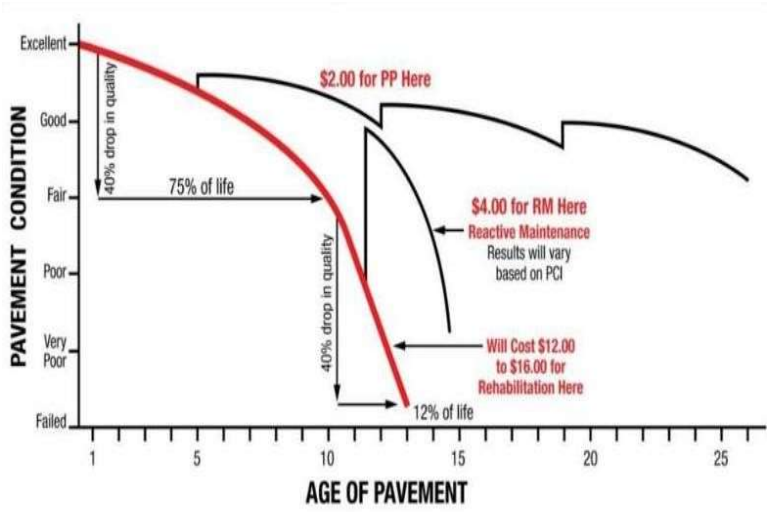
Surface Dressing Do not withstand shear very well

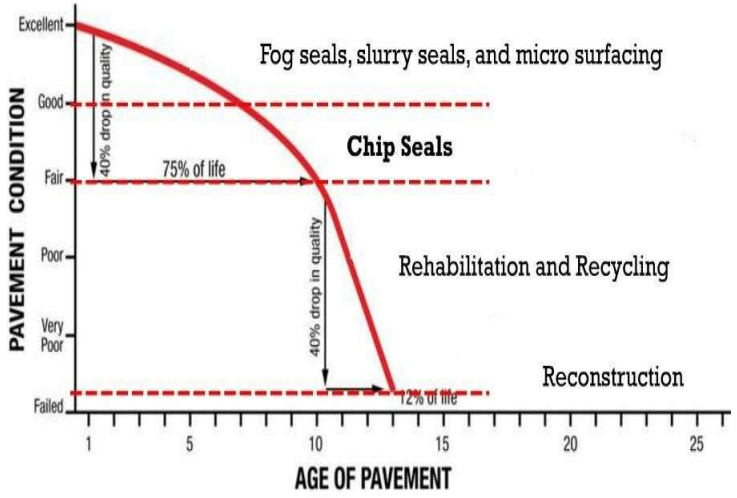

Chip Seals
Irregular areas can be difficult

Site Selection-Good Candidates

Pavement Condition Index

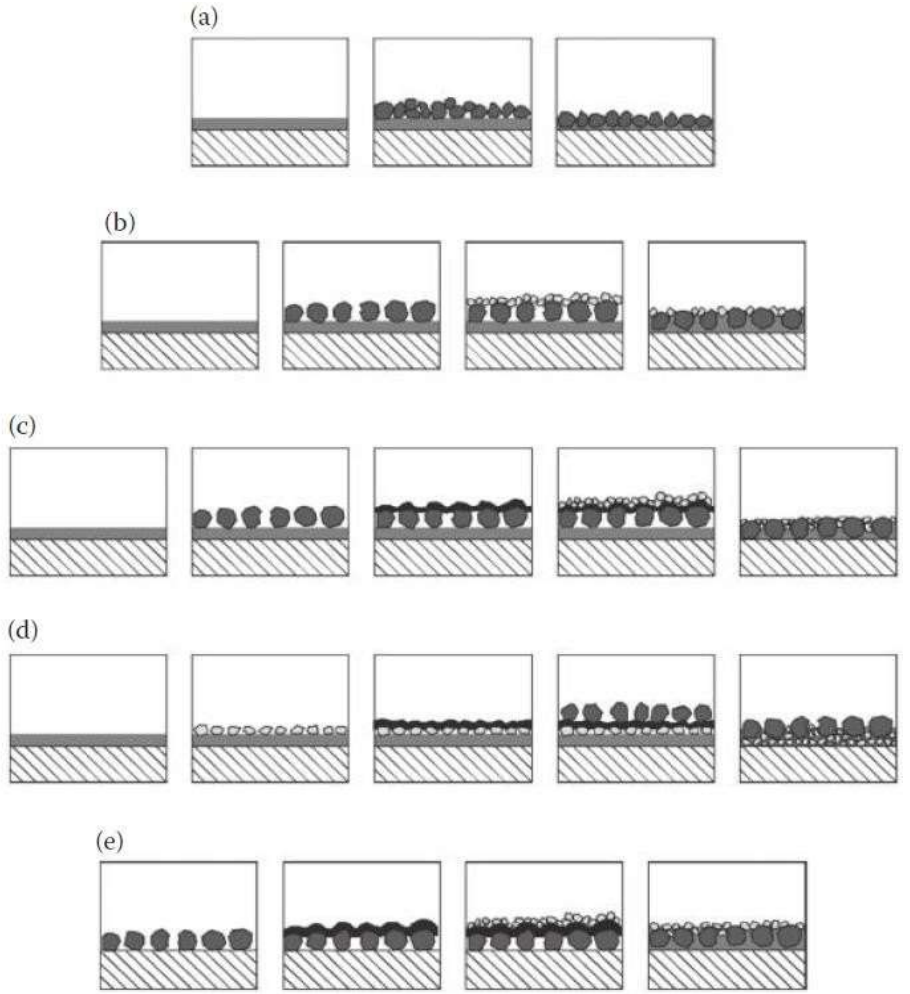






Types of Surface Dressing

- Single Coat Surface Dressing (a)
- Two Coat Surface Dressing (d)
- Racked in Surface Dressing (b)
- Inverted Double Surface Dressing (c)
- Sandwich Surface Dressing (e)



Single Surface Dressing

Spraying a layer of binder on the previously prepared pavement surface, spreading one layer of cover aggregates and rolling,
size of chippings is usually 6.3 or 10 mm.

Two Coat Surface Dressing

Spraying a layer of binder, then spreading one layer of cover aggregate and rolling, followed by a second layer of binder, spreading another layer of cover aggregates and rolling.

The size of the second layer of aggregates is smaller than that of the first layer aggregate.

Single-coat SD is a versatile treatment for low to medium-traffic Single-coat SD is a versatile treatment for low to medium-traffic Traffic on road should be opened on the following day (20 kmph)

Rack in Surface Dressing

Laying of one layer of binder and two layers of chippings, the second layer being of a smaller size.

The size of the chippings is typically 14 mm on fast heavily trafficked roads.

The second layer of smaller chippings (6 mm) fills gaps and achieves mechanical interlocking.

The advantages of this method are high initial texture depth, early stability of dressings and a major reduction in the initial loss of large chipping

Inverted Surface Dressing

Laying of the first layer of binder and the first layer of chippings followed by a second layer of binder and the second layer of chippings, the second layer of chippings being of a larger size.

Inverted double surface dressing is used on existing very hard (concrete) or hard surfaces with high and variable macro-texture

The size of the chippings for the first layer is usually 6 mm and that for the second layer is 10 or 14 mm.

Aggregate Functions and Factors

- **Functions of the aggregate are,**
  - To resist traffic abrasion,
  - To transmit wheel loads
  - Improve the surface friction and safety

- Flat, rounded, angular and cubical
- Toughness
- Gradation
- Cleanliness
- Absorption
- Compatibility

Natural

Synthetic

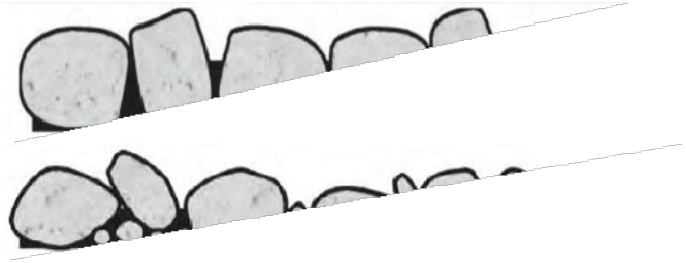
Contd….

Gradation: Single-sized aggregate is preferred due to,

- Maximum friction
- Less sensitive to variations in binder application rate
- Better drainage

Graded aggregate

- Fewer voids

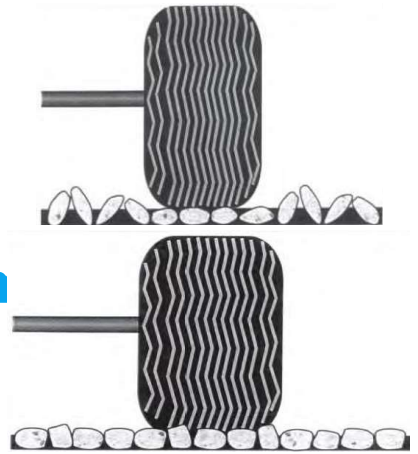


Particle Shape-Flat

- Susceptible to bleeding or excessive chip loss

Cubical

- Traffic will not affect the orientation
- Chip seal height and chip embedment will be uniform
- Quantity can be determined by FI



Physical Requirement of Aggregates

Property	Method of test	Value
Abrasion value Los Angeles machine or, Aggregate impact value	IS2386 (Part 4) IS2386 (Part 4)	Max 40% Max 30%
Combined Flakiness and Elongation index	IS2386 (Part 1)	Max 30%
Stripping value	IS6241	Minimum retained coating 95%
Polished stone value	BS812 (Part 114)	Min 60
Water absorption	IS2386 (Part 3)	Max 1%
Soundness: (a) Loss with sodium sulphate-5 cycles (in case of slag only) (b) Loss with magnesium sulphate-5 cycles	 IS2386 (Part 5) -do-	 Max 12% Max 18%
Unit weight or bulk density (in case of slag only)	IS2386 (Part 3)	Min 1120 kg/m^3

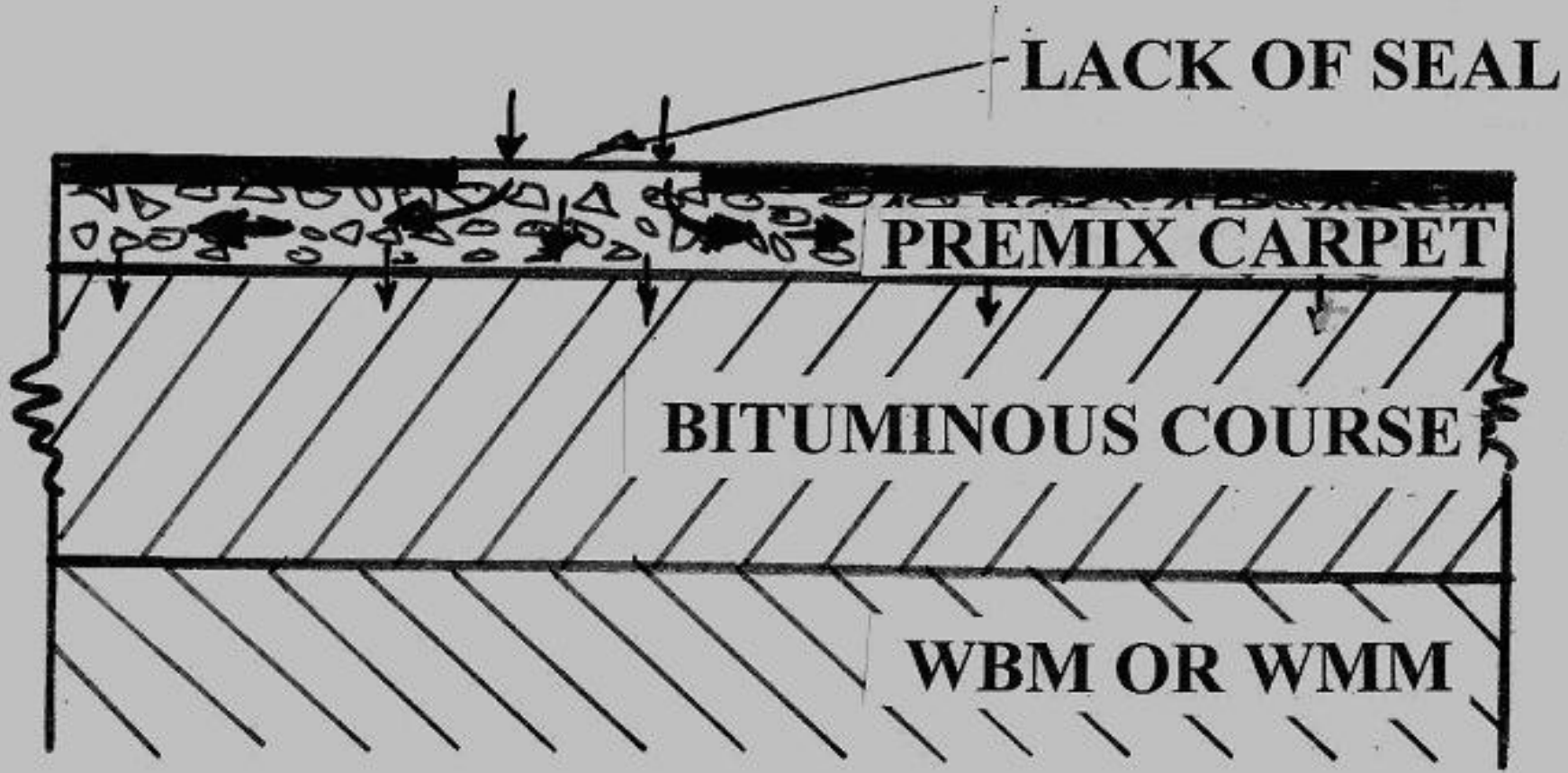
Grading Requirements for Aggregates used for Surface Dressing

IS sieve designation (mm)	Cumulative per cent by weight of total aggregates passing for the following nominal sizes (mm)			
	19	13	10	6
26.5	100	-	-	-
19.0	85-100	100	-	-
13.2	0-40	85-100	100	-
9.5	0-7	0-40	85-100	100
6.3	-	0-7	0-35	85-100
4.75	-	-	0-10	-
3.35	-	-	-	0-35
2.36	0-2	0-2	0-2	0-10
0.60	-	-	-	0-2
0.075	0-1.5	0-1.5	0-1.5	1-5
Minimum 65% by weight of aggregate	Passing 19 mm, retained 13.2 mm	Passing 13.2 mm, retained 9.5 mm	Passing 9.5 mm, retained 6.3 mm	Passing 6.3 mm, retained 3.35 mm

Surface Dressing Equipment

Chip Spreader

- Apply cover aggregate over seal
- Apply uniform application
- Saves money on aggregate
- Increase production


LACK OF SEAL
PREMIX CARPET
BITUMINOUS COURSE
WBM OR WMM

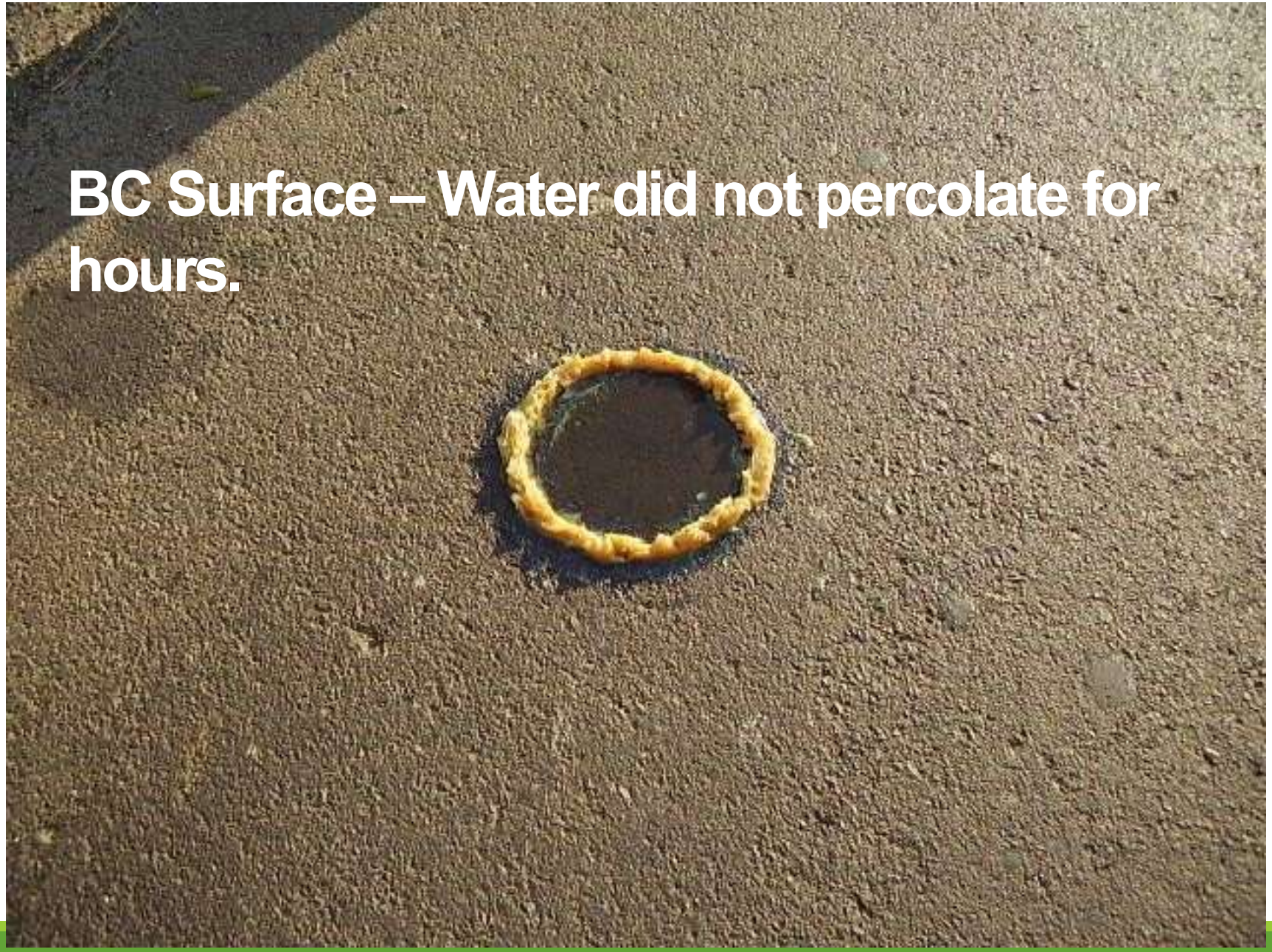

KANDHAL


KANDHAL


No Sand Seal – Water permeated in less than 5 Seconds


Moderate Sand Seal – Water percolated in 90 Seconds


Heavy Sand Seal – Water percolated in 9 mi


BC Surface – Water did not percolate for hours.

Equipment Manufacturer and Cost

S.No.	Company Name	S.No.	Company Name
a	Chamunda Engineering, Visnagar	g	S.P. Enterprise, Ahmedabad
b	Marshal Equipments, Mehsana	h	Venus Equipments, Mahsana
c	Himakshi Road-Cons. Equipments Pvt. Ltd.	i	Riddhi Siddhi Enterprise, Ahmadabad
d	Capious Roadtech Pvt. Ltd.	j	Sidharatha Equipments, Mehsana
e	Apple Equipment, Mehsana	k	Perfect Road Equipments, Mehsana
f	Universal Engineers, Ahmadabad	l	Dhruvi Road Equipment Private Limited, Mehsana

S.No.	Items	Rs. (per sqm)
A	Cost of Single coat surface dressing (without pre coating of chips)	57.45
B	Cost of Single coat surface dressing (with pre coating of chips)	66.97
C	Cost of Two coat surface dressing (without pre coating of chips)	108.21
D	Cost of Two coat surface dressing (first coat without pre coating chips & second coat with pre coating of chips)	115.84
E	Cost of Two coat surface dressing (with pre coating of both coats of chips)	125.36

Premix Carpet (PMC)

Single size (12mm) stone chips are coated with 3.5% bitumen in portable mixing plants

Mix laid 20 mm

PMC mix is highly porous; therefore a sand seal is applied Seal coat generally not

effective- PMC soaks in rainwater easily

and develops potholes

PMC Rs. 7.88 lakhs/km compared to surface dressing which is Rs. 2.62 lakhs. That is a 300% increase

- It has not been researched in India during the last 50 years
- Indian engineers just use it based on "conventional wisdom."

SD was used prior to the 1960s. It was manual at that time; now it is fully mechanized

Surface dressing is dying a slow death and has largely been replaced with premix carpet which is 3 times more expensive.

Bituminous Surfacing	Cost per km
20 mm PMC with sand seal coat	7.88 lakhs
Surface Dressing, single, VG-10, mechanical,13.2 mm uncoated chips	2.62 lakhs
Ditto with precoated chips	2.96 lakhs
Surface Dressing , double, VG-10, mechanical, 13.2 and 9.5 mm uncoated chips	5.24 lakhs
Ditto with precoated chips	5.58 lakhs
40 mm Bituminous Concrete Grade 2	12.00 lakhs

Nonuniform binder application - streaking

Approx. Rate of Binder Application

Aggregate Size	VG-10 (kg/sq m)	Emulsion (kg/sq m)
13 mm	1.0	1.5
10 mm	0.9	1.3

Spreading precoated chips


SKID RISK
20
Image courtesy of Tarstone

Surface Dressing Design Process

Have a design whether based on:

- Past experience
- Engineering method

Two common methods

- McLeod Method (most common)
  - Mainly used with emulsified asphalts, based on two basic principles
    - Aggregate will be one-stone thick.
    - 70% percent embedment for good performance
- Kearby and McLeod (1953)
- UK TRL Road Note 39 (1996)
- AustRoads (2001)
- New Zealand P17 (Mod of Australia)
- TRH3 (Hybrid of UK & Australia)

McLeod Method

McLeod Method

- Aggregate Application Rate is dependent on:
  - Gradation
  - Shape
  - Specific Gravity
- Binder Application Rate is dependent on:
  - Aggregate gradation, absorption and shape
  - Traffic volume
  - Existing pavement condition
  - Residual asphalt content

Average Least Dimension(ALD)

Average least dimension ½"
70% voids filled 0.39 gal/sy
Cover aggregate 22 lb/sy

Average least dimension ¼"
70% voids filled 0.15 gal/sy
Cover aggregate 18 lb/sy

Cubical

Flat and elongated

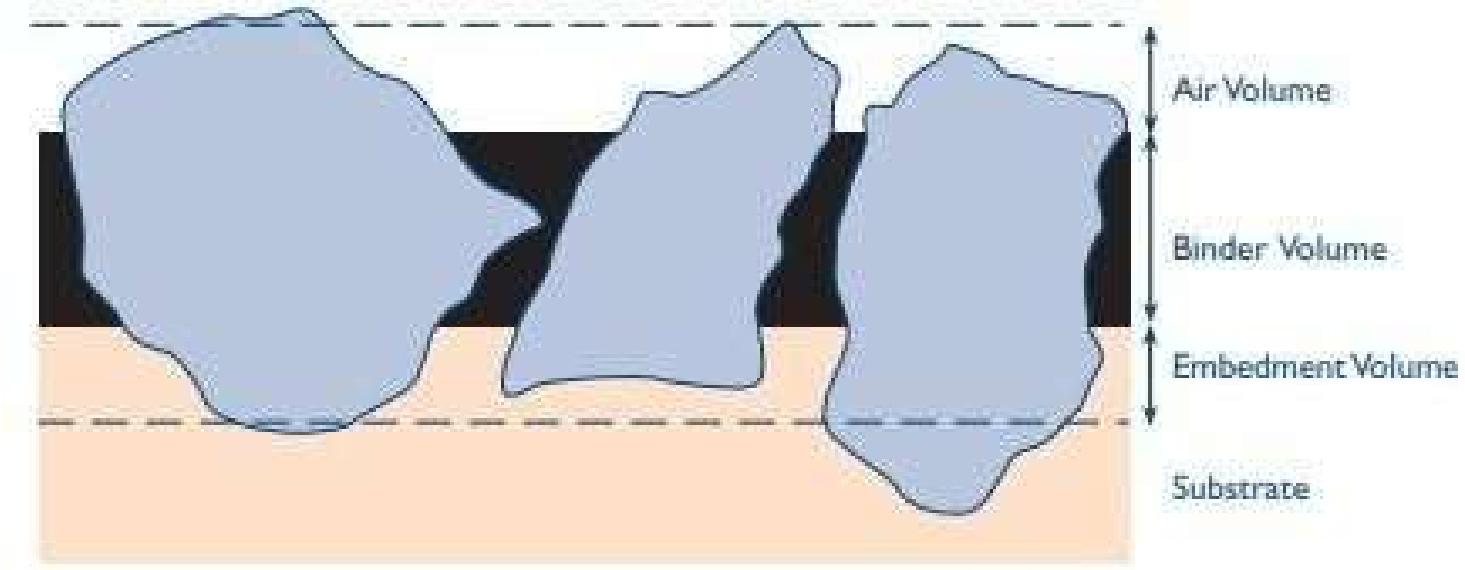
New Zealand Design Factors

Aggregate

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

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

Transit New Zealand DesignMethod



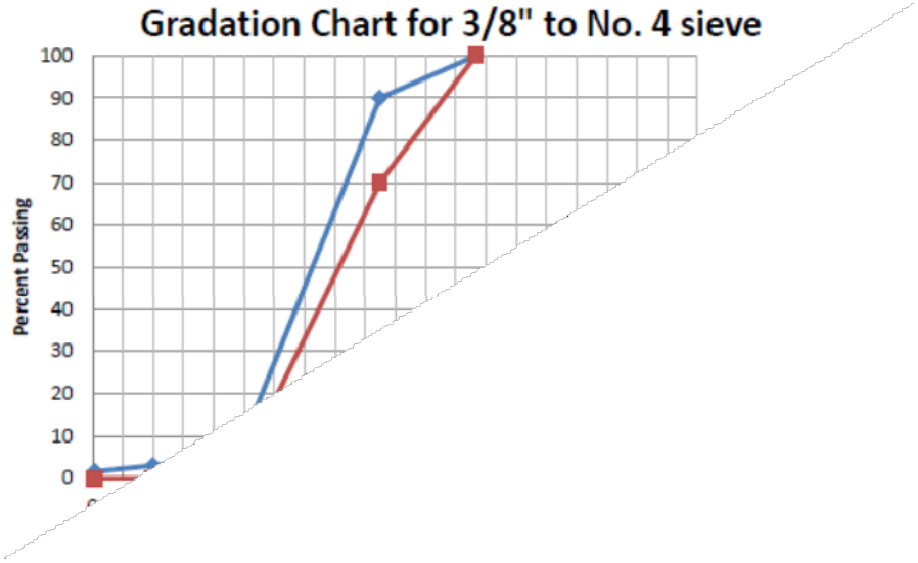
The voids between the sealing chips consists of air, binder and the amount of chip embedment.

Under traffic, the voids decrease in volume due to reorientation of chips and leads to reduced texture. This loss of texture, results in flushing, and is the most common failure mechanism.

Design of Surface Dressing
McLeod Method

Step 1: Determine the aggregate gradation, bulk specific gravity and percent absorption.

Step 2: Determine the Median Particle Size



Sieve Name	Maximum Percentage Passing	Minimum Percentage Passing
1"	100	100
3/4"	100	100
5/8"	100	100
1/2"	100	100
3/8"	90	70
No. 4	5	0
No. 10	2.95	0
No. 200	1.5	0

ggregate absorption assumed = 0%

Contd….

Step 3. Determine Flakiness Index (FI)

The aggregate used to determine the gradation is then broken down into the five following groups.

1. Passing the 1 in. sieve but retained on the ¾" sieve.
2. Passing the ¾" sieve, but retained on the ½" sieve.
3. Passing the ½" sieve, but retained on the 3/8" sieve.
4. Passing the 3/8" sieve, but retained on the ¼" sieve.
5. Passing the ¼" sieve, but retained on the No. 4 sieve.

Flakiness Index (FI) can be calculated by the following equation:

$$FI = \frac{(Weight\ of\ Flat\ Chips)}{(Weight\ of\ Sample)}$$

Contd….

Step 4. Determine the Average Least

U.S. Customary Units

$$H = \frac{M}{1.139285 + (O.011506) * (FI)}$$

Lower H

$$H = \frac{0.303\ in}{1.1139285 + (0.011506) * (21)} = \mathbf{0.224\ inches}$$

Upper H

$$H = \frac{0.303\ in}{1.1139285 + (0.011506) * (5)} = \mathbf{0.259\ inches}$$

Contd….

Step 5. Determine the Loose Weight of the Aggregate (W)

The Loose Unit Weight (W) was calculated by the straightforward relationship:

$$W = \frac{Weight\ of\ Aggregate}{Volume\ of\ Cylinder}$$

Step 6. Determine the Voids in the Loose Aggregate (V)

Once W is determined, voids are calculated [illegible]

U.S. Customary Units

$$V = 1 - \frac{W}{62.4\ G}$$

Lower W

$$V = 1 - \frac{87\ lbs/ft^3}{(62.4) * (2.67)} = \mathbf{0.48}$$

Upper W

$$V = 1 - \frac{96\ lbs/ft^3}{(62.4) * (2.67)} = \mathbf{0.42}$$

Step 7: Application Rate

Aggregate Application Rate in U.S. Customary Units

$$C = 46.8 * \left(1 - (0.4)(V)\right) * (H)(G)(E)\right)$$

Lower C

$$C = 46.8 * \left(1 - (0.4)(0.48)\right) * (0.224in)(2.67)(1.05) = \mathbf{24\ lbs/yd^2}$$

Upper C

$$C = 46.8 * \left(1 - (0.4)(0.42)\right) * (0.259in)(2.67)(1.05) = \mathbf{28\ lbs/yd^2}$$

Step 8: Binder Design Equation

$$B = \frac{(2.244)(H)(T)(}{}$$

*Variables T, S, and A, are calculated from the traffic condition, surface condition, and Aggregate Absorption. Below are the tables where these factors can be found

Table A-2: Traffic Factor (T)

Traffic factor				
Traffic Vehicles per day				
Under 100	100 to 500	500 to 1000	1000 to 2000	Over 2000
0.85	0.75	0.7	0.65	0.6

Table A-3: Surface Condition (S)

Existing Pavement Texture	Correction, S
Black, flushed asphalt surface	-0.01 to -0.06
Smooth, nonporous surface	0
Slightly porous, oxidized surface	0.03
Slightly pocked, porous, oxidized surface	0.06
Badly pocked, porous, oxidized surface	0.09

Binder application rate in U.S. Customary Units

$$B = \frac{(2.244)(H)(T)(V) + S + A}{R}$$

Lower B

$$B = \frac{(2.244)(0.224)(0.60)(0.48) + 0.0}{0.65}$$

Upper B

$$B = ($$