The Institute of Asphalt Technology
Irish Branch

'Road Surfacing and Materials – An update for 2018', 13th March, 2018

DN-PAV-03074 (HD 300)

TII Surface Dressing Design Method

Brian Mulry,
Chartered Engineer,
PMS Pavement Management Services Ltd.

Surface Dressing within the TII Process

- Surface dressing has become increasingly important since the introduction of standards for skidding resistance on National roads, e.g. AM-PAV-06045 (HD28)
- TII have developed a new analytical design approach for Surface Dressing on National roads.
- Objective of achieving **consistency** in the design and installation of Surface Dressing.

Surface Dressing within the TII Process

- **CC-SPW-0900 (Series 900) - SPECIFICATION**
  - Clause 7.2, Surface Dressing
- **DN-PAV-03074 (HD300) - DESIGN**
  - Chapter 4, Design of Surface Dressing
- **DN-PAV-03024 (HD37) – PROCESS/PROPERTIES**
  - Chapter 8, Surface Dressing

Performance and Durability

Surface Dressing;

- while in theory is a relatively simple surface treatment, it is in fact quiet a complex process
- seen as a relatively low cost maintenance, but poor value for money if it goes wrong.

TII DN-PAV-03024 (HD37):
"Early failures are almost always the result of inadequacies in one or more of the **4 stages** in the production and installation of a surface dressing.

1. Specification
2. **Design**
3. Materials
4. Execution including aftercare"

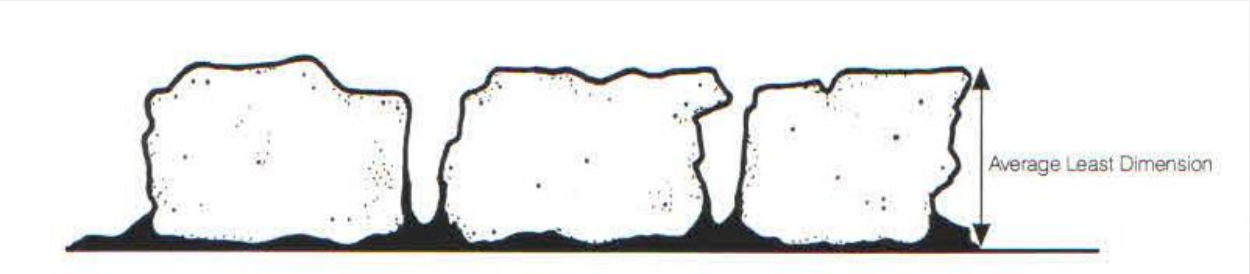
TII Analytical Design Approach to Surface Dressing

- Based on
  - Sound engineering principles
  - Site specific engineering data
  - Evidence based quality management programme

- Based on best practice in other countries, primarily New Zealand.
- Provides a more comprehensive methodology for assessing the quality and shape of the aggregate chippings.

Analytical Design Approach

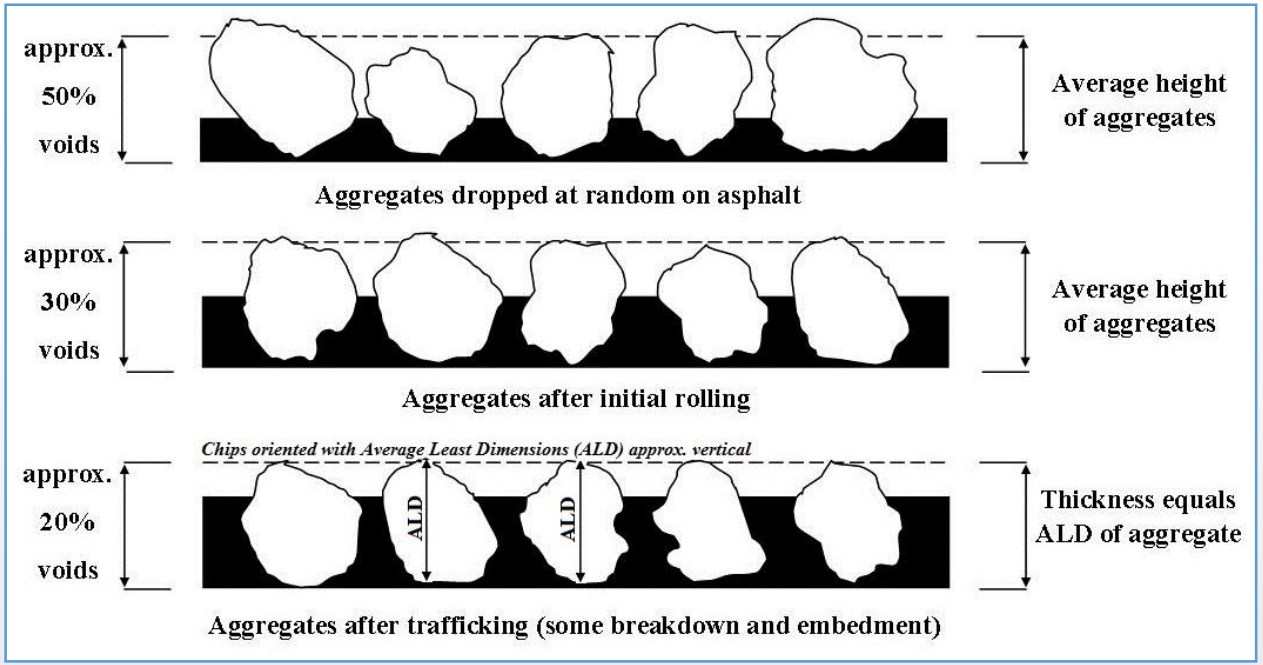
- Engineering approach developed **F M Hanson** (1935, NZ).
- Considers the volume of voids between the chippings after spreading and rolling, and the orientation the chippings adopt after trafficking.
- The volume of voids in the covering aggregate, which will be partially filled with binder, is controlled by the **Average Least Dimension (ALD)** of the aggregate chips being used.



Orientation of Chippings After Trafficking (Shell Bitumen Handbook, 5th ed.)

Analytical Design Approach – Volume of Voids

States of Embedment of Surface Dressing Chippings (Hanson 1935)

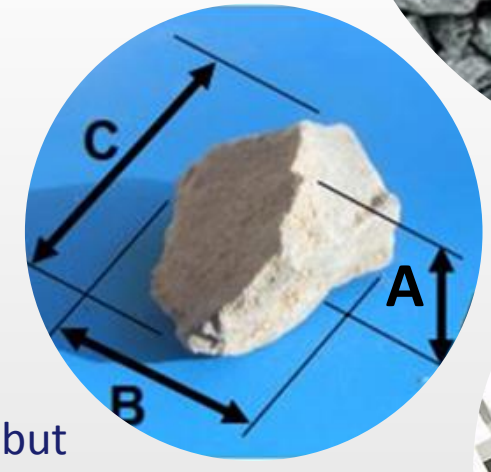


- Volume of Voids is controlled by Chip ALD.
- The average depth of the layer of chippings, after construction and trafficking compaction, is approx. equal to the ALD of the chippings used.

Analytical Design Approach – Chip Shape

- **Average Least Dimension (ALD)** of the chipping is an essential parameter in the analytical design approach.

- **ALD** can be assessed by **Direct Measurement,** or by the **Dumas Computational Method** using the grading and the flakiness index data.



- Significant overlap with the Flakiness Index, but the Flakiness Index alone does not fully capture the required shape properties of the chippings.

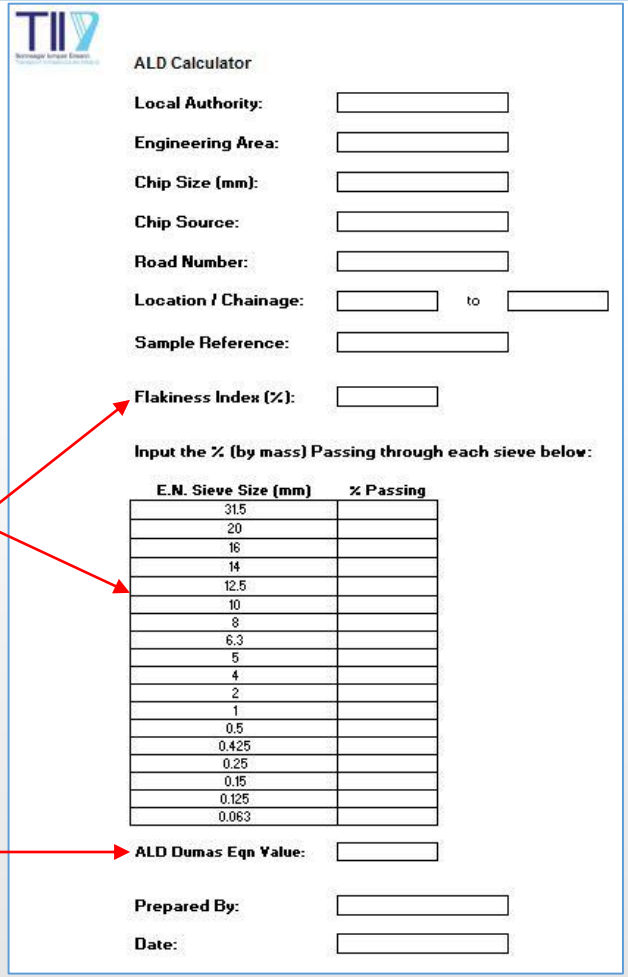
ALD_{Dumas} can be calculated from the Grading and FI data using an Excel spreadsheet available on the TII Web Portal.

Chip ALD_{Dumas}: Table 17 CC-SPW-0900 (Series 900)

Chip Size	Min (mm)	Max (mm)
14/20	11	14
10/14	8	10
6/10	5	7
2/6	2.5	4

Input: Grading and FI data

Output: ALD_{Dumas}


ALD Calculator

Local Authority:

Engineering Area:

Chip Size (mm):

Chip Source:

Road Number:

Location / Chainage: to

Sample Reference:

Flakiness Index (%):

Input the % (by mass) Passing through each sieve below:

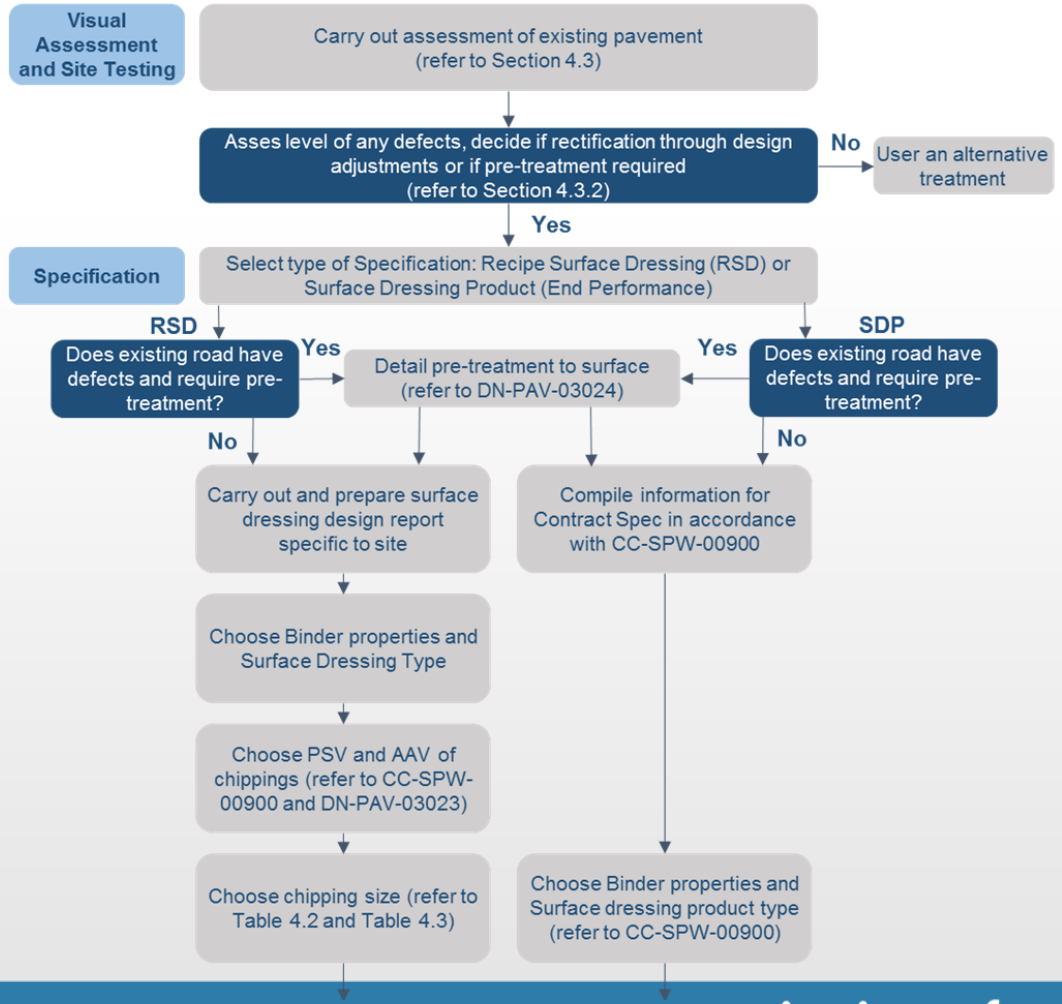
E.N. Sieve Size (mm)	% Passing
31.5	
20	
16	
14	
12.5	
10	
8	
6.3	
5	
4	
2	
1	
0.5	
0.425	
0.25	
0.15	
0.125	
0.063	

ALD Dumas Eqn Value:

Prepared By:

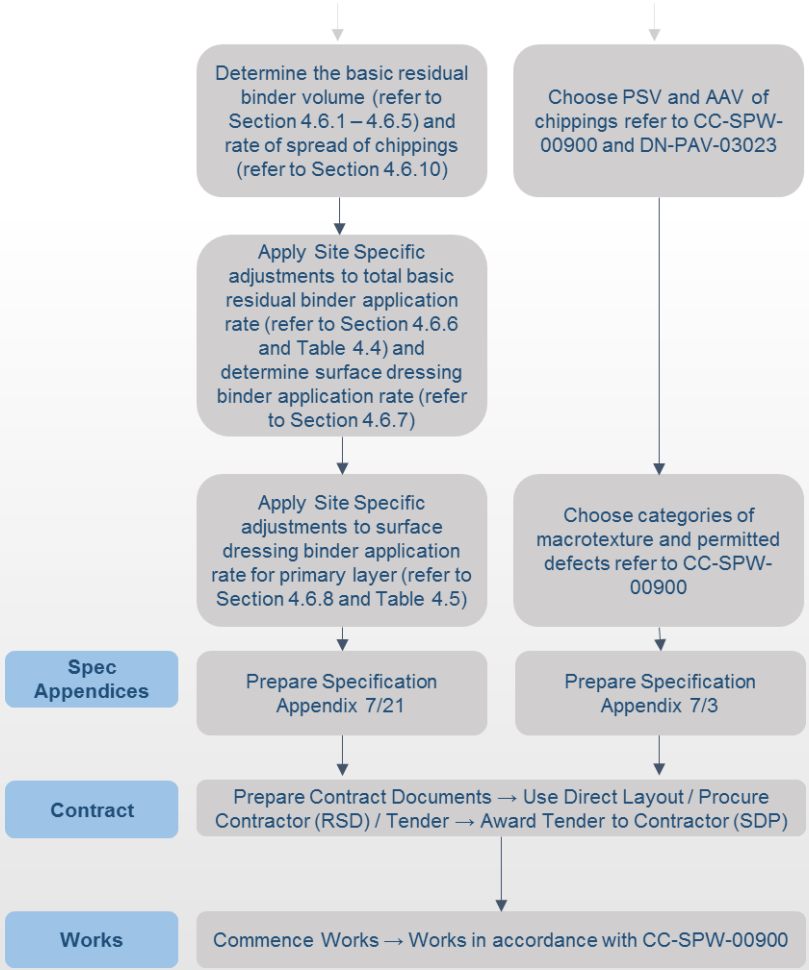
Date:

Process Flowchart for the Design of Surface Dressing (Fig. 4.1, HD300)



Process Flowchart

(Fig. 4.1, HD300)



Variability within Design Sections

The surface dressing design shall be carried out for a homogeneous section of road in terms of traffic, texture, hardness and site conditions/stress.

If conditions vary along a section, the road should be dealt with as follows:

a) where practicable, **pre-treatment** of the existing road prior to surface dressing should be carried out to form homogeneous sections of sufficient length for surface dressing; or

b) alternatively, where possible sub-divide the road into **homogeneous sections** with similar engineering properties, with appropriate treatment identified and designs prepared for each subsection.

Factors to Assess the Homogeneity of a Site

1. Existing road condition
2. Road Hardness
3. Texture
4. Traffic volume
5. Traffic speed
6. High stress sites
7. Site topography and orientation
8. Site category
9. Structures/Drainage
10. Any pre-treatments which may be required.

Where the **surface conditions change, or constituent materials change**, a new or modified surface dressing design or surface dressing type, for the different conditions needs to be carried out.

Visual Assessment – Road Surface Condition

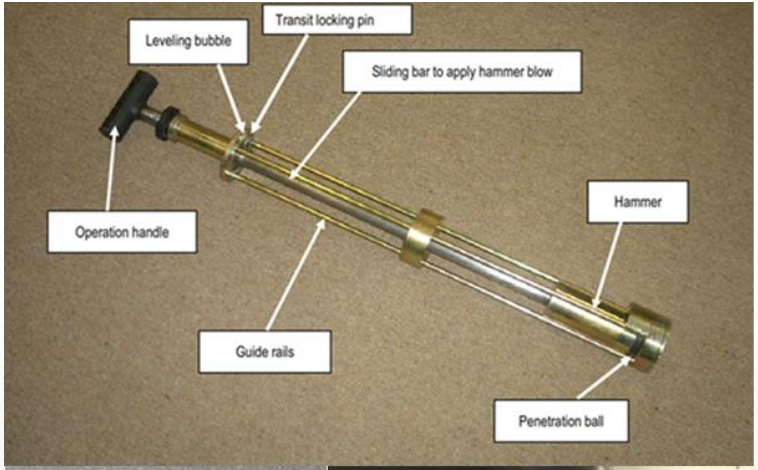
- Structural defects
- Surface defects
- Allocation of the site to one of the five categories of surface condition:
  - Very binder rich
  - Binder rich
  - Normal
  - Texture in wheel tracks
  - Binder lean/Porous

Road Hardness

- Measured on site using **Australian Modified Hammer** (based on 19mm ball bearing)
- Make readings in areas of similar visual condition that represent the predominant condition of the existing road surface, and at least every 200 metres.

- **CTRA Probe** (based on 4mm probe)
  (Coal Tar Research Association)

- Refer to DN-PAV-03024 (HD37)

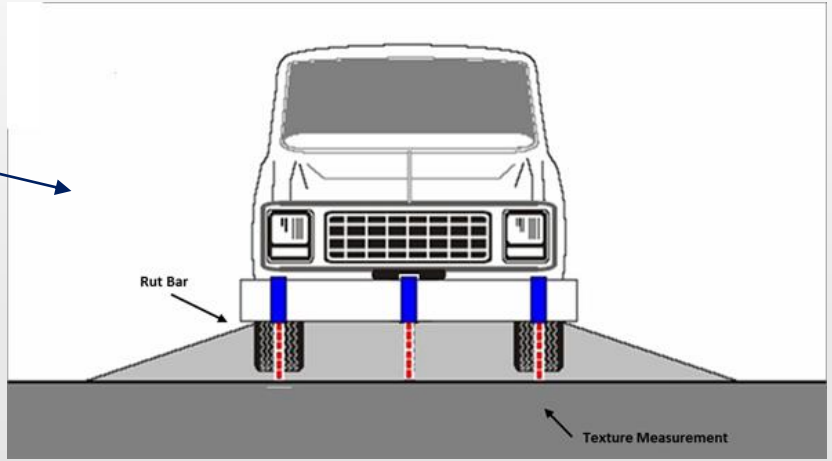


Texture Depth

- **Volumetric Patch Test** (IS EN 13036-1)
- MTD using Glass Beads
- Readings in and between the wheelpaths of each lane at circa 200 metre intervals

- MPD data from ***Road Surface Profiler (RSP)***
- TII Pavement Asset Management System (PAMS)

- Assess for Texture Variation



HD300 – Texture Variation

- Assess the level of texture variation between wheelpath and centreline

- Single
  - $\mathrm{Td}_{(\mathrm{course})} - \mathrm{Td}_{(\mathrm{average})} < \mathrm{Min\ ALD}/16$
  - $\mathrm{Td}_{(\mathrm{average})} - \mathrm{Td}_{(\mathrm{fine})} < \mathrm{Min\ ALD}/16$

- Racked-in/Double
  - $\mathrm{Td}_{(\mathrm{course})} - \mathrm{Td}_{(\mathrm{average})} < \mathrm{Min\ ALD}/10$
  - $\mathrm{Td}_{(\mathrm{average})} - \mathrm{Td}_{(\mathrm{fine})} < \mathrm{Min\ ALD}/10$

- Pre-treatment to reduce texture variation should be considered if the above values are exceeded

Traffic Volume

- Affects choice of chipping size
- Calculated in terms of the Equivalent Light Vehicles (ELV) per lane per day.
- Influence of a commercial vehicle as equivalent to ten light vehicles

$$T_{ELV} = AADF \times (1 + (0.09 \times \%HCV))$$

Where:

T_{ELV} = Equivalent Light Vehicles per lane per day
AADF = Annual Average Daily Flow (vehicles per lane per day)
%HCV = Percentage of heavy commercial vehicles

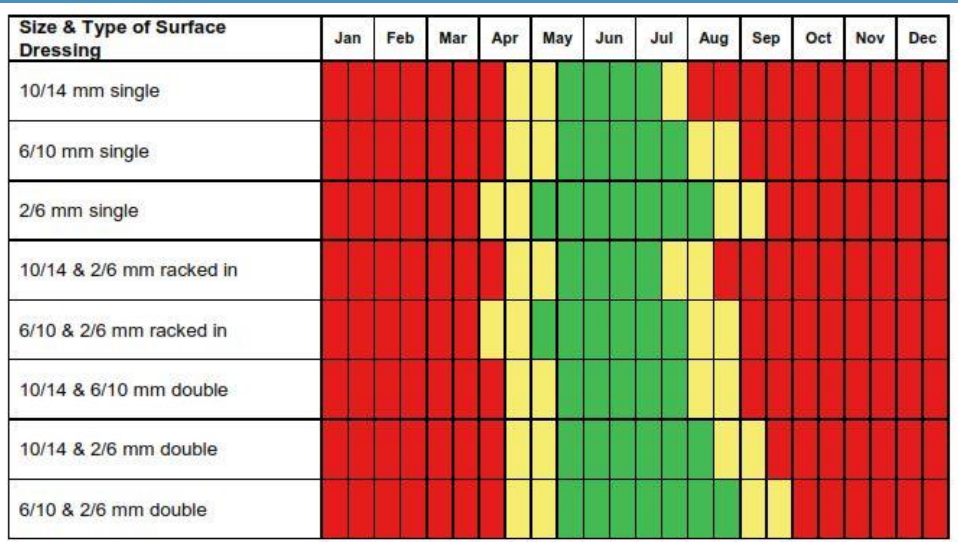
Guidance on the Suitability of Road for Surface Dressing

Existing Surface Characteristic	Traffic Category (cv/lane/day)					
	< 250	251-500	501-1000	1001-2000	2001-3000	Over 3000
Very Hard and homogeneous						
Hard and homogeneous						
Normal and homogeneous						
Soft and homogeneous						
Very Soft and homogeneous						
Bleeding in wheel tracks						
High macrotexture or fretted						
Porous						
Very variable along lane width						
Extensive patching						
Severe bleeding/extensive blackening						

	May be suitable for surface dressing.
	May be suitable for surface dressing but extra care is required.
	Surface dressing is not an appropriate treatment.

Advice on Surface Dressing Season

Sufficient time required to allow re-orientation and embedment of chippings.



	High Risk	Surface dressing should not be undertaken because of the probability of failure.
	Significant Risk	There is some risk of failure (higher in late season) so extra care in the design and execution of the system required. There is a good possibility of success in favourable weather conditions
	Low Risk	Normally successful provided the weather conditions are appropriate for the product.

Figure 4.3: Surface Dressing Season

Notes:

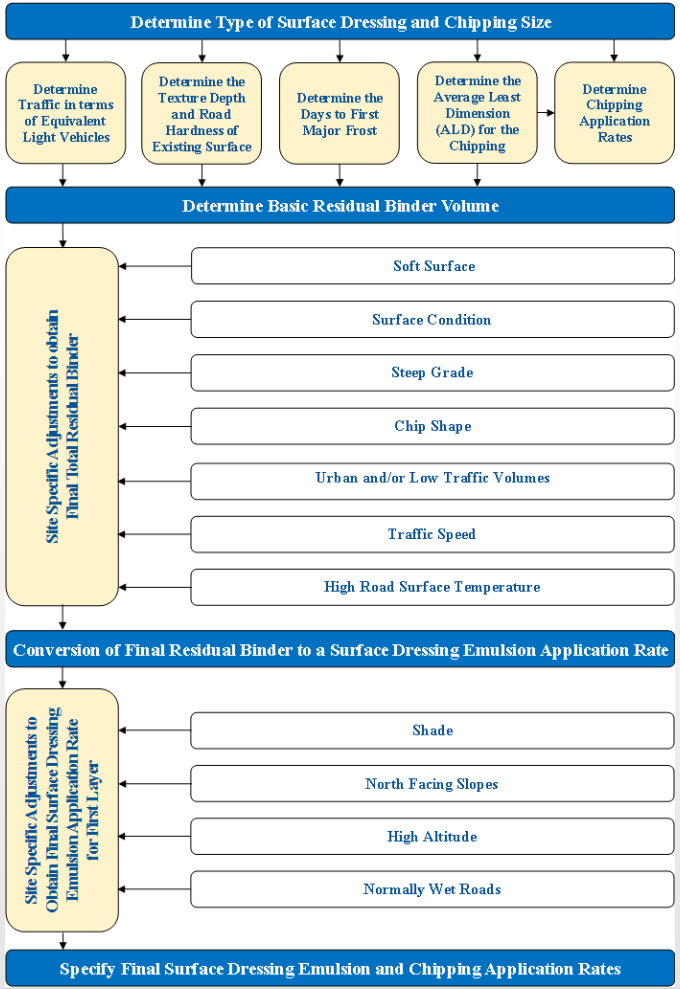
1. Late season work is very risky especially with 10/14 chip.

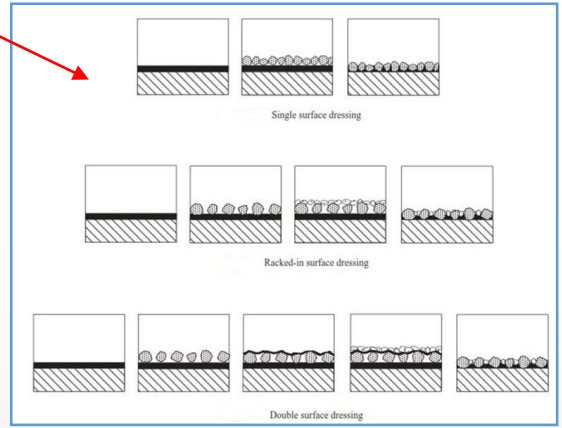
2. Late season work on high speed, heavily-trafficked roads is not recommended because of the consequences of any failure.

3. 2/6 chippings should not be substituted for 6/10 chippings just to allow late season working.

Process Flowchart for Surface Dressing Analytical Design Procedure

(Fig. 4.2, HD300)





Design is done using step by step software programme available on TII Web Portal.

Analytical Design Algorithms - Basic residual binder volume

Single surface dressing

$$V_B = (ALD + (0.7 \times T_D)) \times (0.291 - 0.025 \log_{10} (T_{ELV} \times D_F))$$

Racked-in and Double surface dressing

$$V_B = (ALD + (0.7 \times T_D)) \times (0.347 - 0.029 \log_{10} (T_{ELV} \times D_F))$$

Where:

V_B = Basic residual binder volume (litres/m^2)
ALD = average least dimension of the chippings
T_D = texture depth in (mm) of the existing surface
T_{ELV} = Traffic in terms of equivalent light vehicles/lane/day
D_F = Number of days to first major frost (Max 100)

Site Specific Adjustment Factors to Basic Residual Binder Volume

$$R = V_B + S_S + S_c + G_S + C_S + U_S + T_S + T_R$$

where:

R = Final total residual binder application rate (L/m^2)
V_B = Basic residual binder application rate (L/m^2)
S_S = Allowance for **soft substrate**
S_c = Allowance for **surface condition**
G_S = Allowance for **steep grade**
C_S = Allowance for **chip shape**
U_S = Allowance for **urban and/or low traffic volumes**
T_S = Allowance for **traffic speed**
T_R = High road **surface temperature**

Site Specific Adjustment Factors to Basic Residual Binder Volume

(Table 4.4, HD300)

Allowance	Property	Adjustment (L/m²)	Comments
Soft Substrate (Ss)	Road hardness (Ball penetrometer @ 25ºC)		Road hardness measured using the Ball penetrometer device. The adjustment is made to the chipping ALD based on road hardness.
	1mm or lower	Increase ALD by 1 mm	
	>1mm and <3mm	No change to ALD	
	3mm to 4mm	Decrease ALD by 1mm	
	>5mm		Substrate too soft for normal surface dressing, pre-treatment required
Surface Condition (Sc)	Very binder rich	-0.2	Large chipping should be considered for the wheelpaths as part of a double surface dressing
	Binder rich	-0.1	
	Normal	0	
	Texture in wheel tracks	+0.1	
	Binder lean/porous	+0.2	A pad coat is recommended to normalise and seal
	Very binder lean/and porous, high macrotexture, or variable and hard	Consider design	Double surface dressing is recommended for variable hard and binder lean substrates.
Steep Grade (Gs)	>5% uphill	-0.1	The gradient affects the traffic stress on the surface dressing and, therefore, the rate of embedment. The adjustment is applicable to both layers of a double surface dressing.
	<5%	0	
	>5% downhill	+0.1	
	>10% downhill	+0.2	
Chip Shape (Cs)	ALD/AGD ratio	0	Default value currently set to 0. Research is needed to investigate the ALD/AGD ratio for Irish aggregates.

Site Specific Adjustment Factors to Basic Residual Binder Volume

(Table 4.4, HD300)

Allowance	Property	Adjustment (L/m²)	Comments
Urban and /or low traffic volumes (Us)	≤50 cv/lane/day and / or effectively un-trafficked	+0.2	Urban streets surface dressed with normal application rates may suffer from chip loss along centrelines and in parking lanes; and un-trafficked areas, such as hatched sections, and also between the wheel tracks and edges of carriageways, may require more binder.
Traffic Speed (Ts)	High speed (≥80 km/h)	+0.1	Roads subject to high-speed traffic induce greater surface stress. Double surface dressings with premium binders are recommended.
	Low speed (<80 km/h)	0	
High Road Temperature (Tr)	At spraying, 35°C to 45°C	-0.1 to -0.2	Apply to single surface dressing and both layers of double surface dressing.

Conversion of Final Residual Binder Volume to an Emulsion Binder Application Rate

$$V_E = R/(V_S)$$

where:

V_E = Surface dressing emulsion binder application rate (L/m^2)
R = Final total residual binder application rate (L/m^2)
V_S = Proportion of solids in the emulsion (%)

Site Specific Adjustment Factors to Binder Application Rate for First Layer

Table 4.5, (HD300)

Allowance	Property	Adjustment (L/m^2)	Comments
Shade	Unshaded, open to sun	0	Shaded areas are cooler and, therefore, the road is effectively harder to more binder is required
	Shaded areas	+0.1 for 2/6	Double surface dressing is recommended for fully shaded areas.
		+0.2 to +0.3 for 6/10	
		+0.2 to +0.4 for 10/14	
North Facing	North facing slopes	+0.1 for 2/6 or 6/10 +0.2 for 10/14	North facing slopes are cooler and, therefore, the road is effectively harder so more binder is required. Double surface dressing is recommended.
High Altitude	Effects of altitude	+0.1 to +0.3	Adjustment single surface dressing, or first layer of double surface dressing is recommended
Normally Wet Roads	Continuously wet roads	+0.2	Double surface dressing should be adopted for these roads.

The total combined adjustments for Shade, North Facing and High Altitude should not exceed:

- 0.2 L/m^2 for 2/6
- 0.3 L/m^2 for 6/10
- 0.4 L/m^2 for 10/14

Chip Application Rates

Single Surface Dressing

R_C = 1.18 x Chip ALD (L/m^2) for 10/14 and 6/10

Double Surface Dressing

Bottom Layer R_{CB} = 1.05 x Chip ALD (L/m^2)

Top Layer R_{CT} = 1.18 x Chip ALD (L/m^2) for 6/10

R_{CT} = 4 to 5.5 (L/m^2) for 2/6 (No ALD)

Racked In Surface Dressing

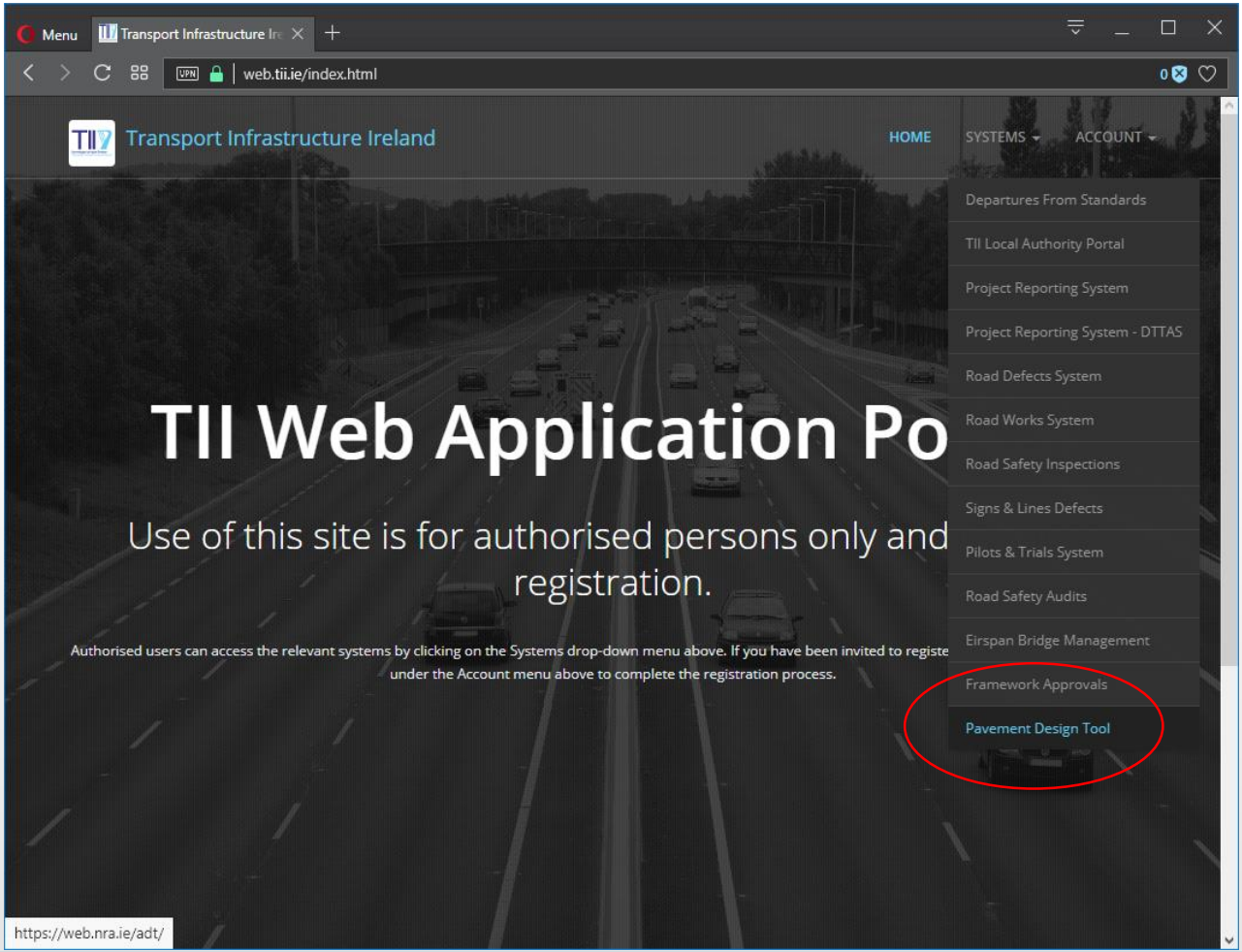
Bottom Layer R_{CB} = 0.95 x Chip ALD (L/m^2)

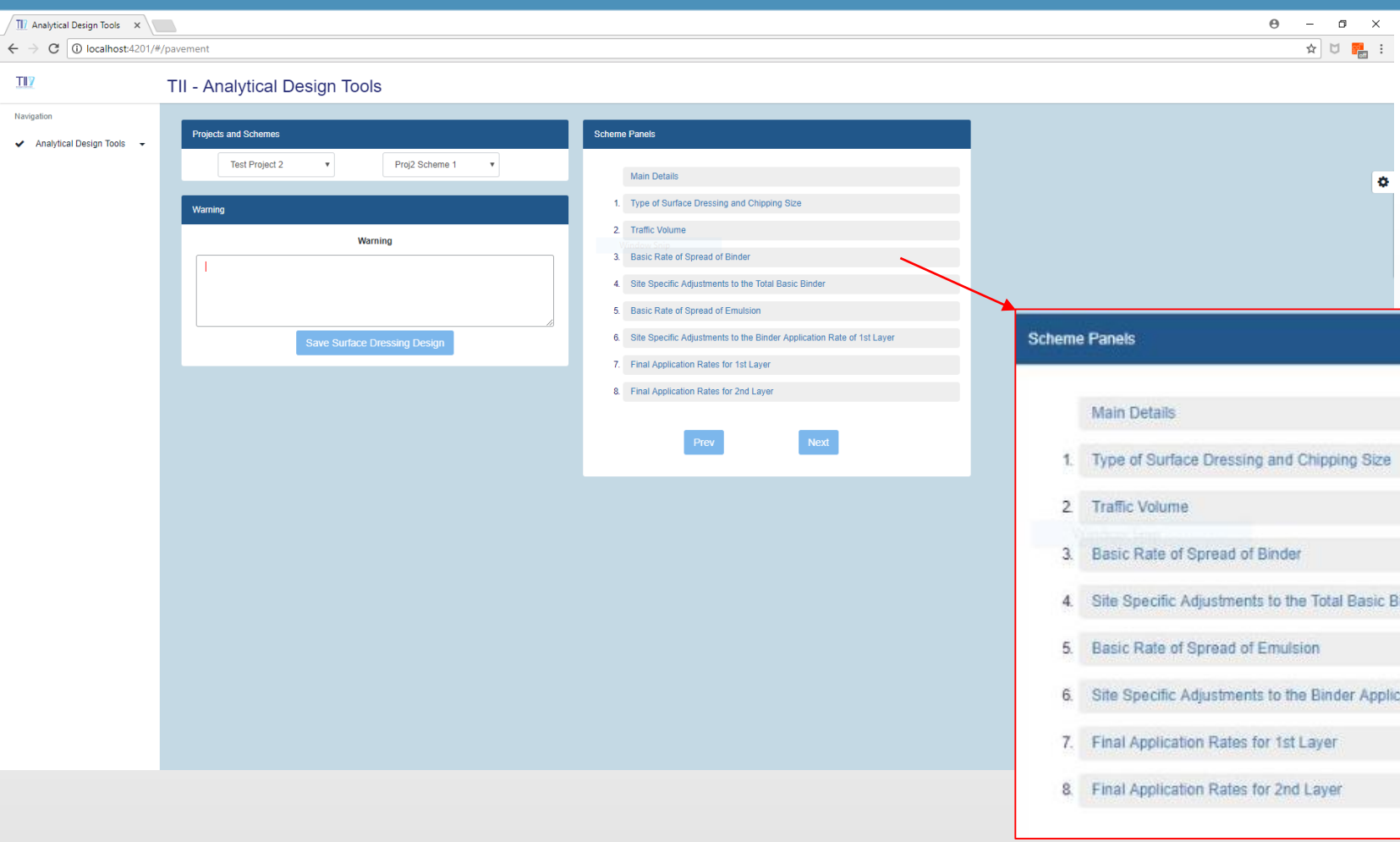
Top Layer R_{CT} = 3.5 to 4.5 (L/m^2) for 2/6 (No ALD)

TII Surface Dressing Design Software

Go to https://web.tii.ie/ and go to the Systems menu and choose Pavement Design Tool.

The https://web.tii.ie/adt/ link is the direct link to the system.





Scheme Panels
Main Details
1. Type of Surface Dressing and Chipping Size
2. Traffic Volume
3. Basic Rate of Spread of Binder
4. Site Specific Adjustments to the Total Basic Binder
5. Basic Rate of Spread of Emulsion
6. Site Specific Adjustments to the Binder Application Rate of 1st Layer
7. Final Application Rates for 1st Layer
8. Final Application Rates for 2nd Layer

Analytical Design Tools

localhost:4201/#/pavement/surface/7810623b-40c8-4f9f-a811-f9754239d355

TII - Analytical Design Tools

Navigation

- Analytical Design Tools

Projects and Schemes

Test Project 1 | Proj1 Scheme 1

Warning

Warning

Save Surface Dressing Design

Scheme Panels

Main Details

1. Type of Surface Dressing and Chipping Size
2. Traffic Volume
3. Basic Rate of Spread of Binder
4. Site Specific Adjustments to the Total Basic Binder
5. Basic Rate of Spread of Emulsion
6. Site Specific Adjustments to the Binder Application Rate of 1st Layer
7. Final Application Rates for 1st Layer
8. Final Application Rates for 2nd Layer

Prev | Next

1 - Type of Surface Dressing and Chipping Size

Type of Surface Dressing: Double Surface Dressing

1st Layer

Chip Size:	6/10	Quarry Source:	Quarry A
PSV:	62	ALD (mm)	6.5

2nd Layer

Chip size:	2/6	Quarry Source:	Quarry B
PSV:	61	ALD (mm)	3.9

Main Details

Designer name: Tom Davy

Date: 04/02/2018

Local Authority: Dublin County Council

DETAILS OF PROPOSED SURFACE DRESSING SCHEME

Road Number: N11

Location: Dublin

Length of Scheme (m): 2000

Road Width (m): 2

Existing Road Surface: SD

Speed Limit (km/h): 60

Hard Shoulder: ☑

Additional Comments: No Comment

Start Co-ordinates (ITM)

Easting: 7000 Northing: 7000

End Co-ordinates (ITM)

Easting: 8000 Northing: 8000

1 - Type of Surface Dressing and Chipping Size

Type of Surface Dressing: Double Surface Dressing

1st Layer

Chip Size: 6/10 Quarry Source: Quarry A

PSV: 62 ALD (mm): 6.5

2nd Layer

Chip size: 2/6 Quarry Source: Quarry B

PSV: 61 ALD (mm): 3.9

2 - Traffic Volume

AADT (Annual Average Daily Traffic): 8500

% of Commercial Vehicles: 9

Number of Lanes: 2

AADF (Annual Average Daily Flow): 4250

Equivalent Light Vehicles: 7693

3 - Basic Rate of Spread of Binder

Texture Depth (mm):	1.9
ALD of Primary Chip (mm):	6.5
Days to Firs Major Frost (Max 100):	100
Basic Rate of Spread of Residual Binder (L/m ^{2}):	1.71

4 - Site Specific Adjustments to the Total Basic Binder

Soft Substrate (Road Hardness)

- ○ Ball Penetrometer
- ◉ CTRA Probe

	CTRA Probe	
Surface Condition:	0.0 (Normal)	0
Steep Grade:	-0.1 (>5% uphill)	-0.1
Chip Shape:	0.0 (Default)	0
Urban and/or Low Traffic Volumes:	0.0 (Normal traffic)	0
Traffic Speed:	0.0 (< 80km/h)	0
High Road Temperature:	-0.1 (35degC - 45degC at spraying)	-0.1
Total Adjustments (L/m^2):		-0.2
Adjusted Rate of Spread of Residual Binder (L/m^2):		1.69

5 - Basic Rate of Spread of Emulsion

Type of Emulsion Binder:	Premium Polymer
Binder Content of the Emulsion (%):	76.5
Rate of Spread of Emulsion (L/m^2):	2.21

6 - Site Specific Adjustments to the Binder Application Rate for 1st Layer

Shade:	+0.4 (Severe)	0.4
North Facing:	0.0 (Not north facing)	0
High Altitude:	0.0 (Not high altitude)	0
Normaly Wet Roads:	0.0 (Dry roads)	0
Total Site Adjustments to the 1st Layer (L/m²):		0.4

Warning

Warning

- Percentage of Commercial Vehicles is a percentage field. Please enter a value between 1 and 100.

Save Surface Dressing Design

7 - Final Application Rates for 1st Layer

Proportion of Binder Application Rate [1st Layer] (%):	55%
Rate of Spread of Emulsion [1st Layer] (L/m²):	1.3
Rate of Spread of Chippings [1st Layer] (L/m²):	7.8

8 - Final Application Rates for 2nd Layer

Proportion of Binder Application Rate [2nd Layer] (%):	45%
Rate of Spread of Emulsion [2nd Layer] (L/m²):	1.1
Rate of Spread of Chippings [2nd Layer] (L/m²):	4.8

"**Surface Dressing – Series 900 Design & Contracts**" can be done as a stand alone module when one has completed the "Surface Dressing Advanced" Course first.

Ongoing Research

- Test method to assess ALD of 2/6 chipping
- Test method to assess Average Greatest Dimension (AGD) of chippings and the range of values for Irish aggregates
- Establish appropriate limits on ALD/AGD ratios for surface dressing chippings

- Incorporate updates to CC-SPW-0900 (Series 900) and DN-PAV-03074 (HD300)

- **CC-SPW-0900 (Series 900) - SPECIFICATION**
  - Clause 7.2, Surface Dressing

- **DN-PAV-03074 (HD300) - DESIGN**
  - Chapter 4, Design of Surface Dressing

- **DN-PAV-03024 (HD37) – PROPERTIES**
  - Chapter 8, Surface Dressing

- **TII Analytical Design Tool**
  https://web.tii.ie/adt/


Thank You
for your attention.