Development of a Specification for Surface Dressing

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Background

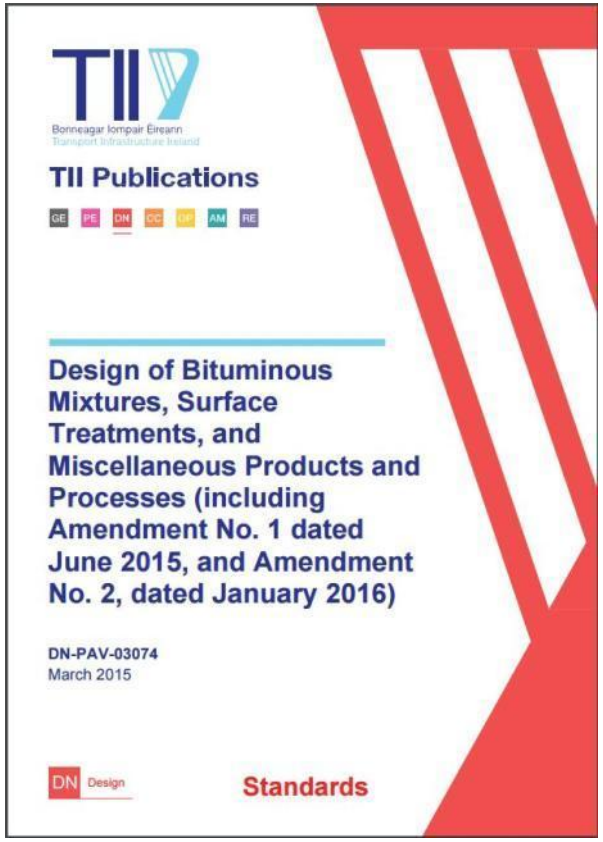
- TII objective for consistency in design and specification of pavements – HD300
- Fundamental principle Analytical approach
- Documentation to be site specific

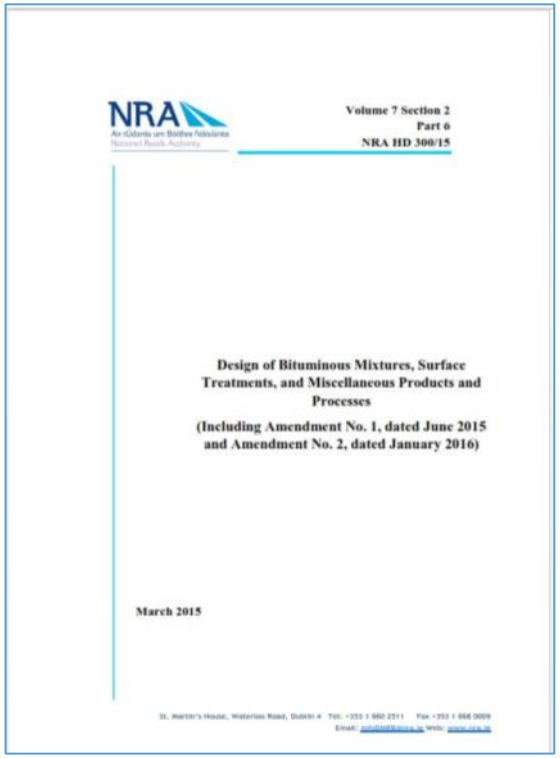
Applicable Standards

- **DN-PAV-03074 (HD300/15); Chapter 4**
- Design of Surface Dressing

- **DN-PAV-03024 (HD37/15)**
- Bituminous Mixtures, Surface Treatments & Miscellaneous Products and Processes
- Chapter 8, Surface Dressing

- **DN-PAV-03023 (HD36/15)**
- Surfacing Options incl. Surface dressing (PSV, AAV etc)





Performance and Durability

DN-PAV-03024 (HD37/15):

Early failures are almost always the result of inadequacies in one or more of the **4 stages** in the production of a surface dressing.

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

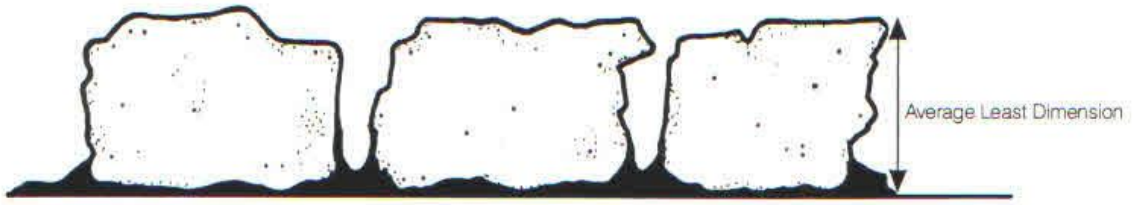
Surface Dressing within TII Delivery Process

- Requires an Analytical Design approach based on
  - Engineering principles and site specific engineering data
- Requires Site Performance Criteria
  - Evidence based quality management
- Analytical approach reduces the uncertainty and variability associated with surface dressing design and construction
- Based on best practice in other countries, primarily New Zealand
- Consistency of approach to Design and Construction

Analytical Design Approach

Analytical Design Approach

- **Hanson** (1935, NZ) developed an engineering approach to the selection of optimum rates of spread of binder and chippings.
- The procedure considered 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.

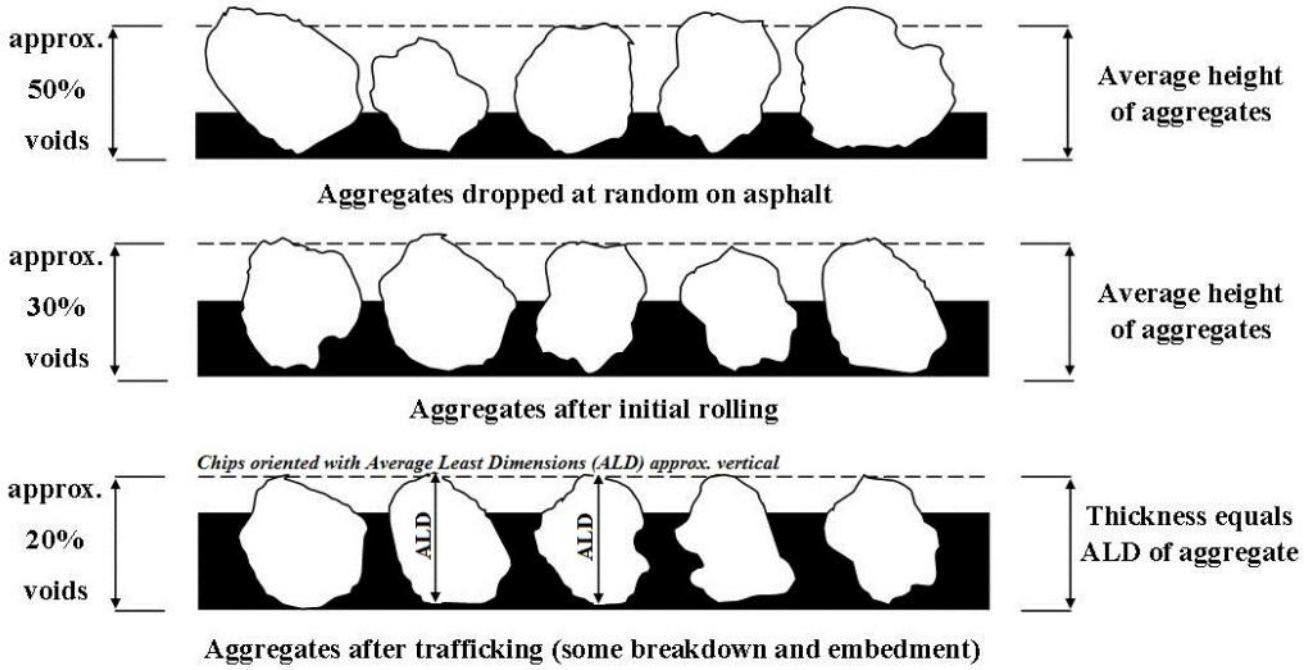


Orientation of Chippings After Trafficking (Shell Bitumen Handbook, 5th ed.)

Analytical Design Approach

Hanson's Theory

- in a loose single layer of chippings, the percentage of voids are initially about 50%, decreasing to around 30% after construction rolling, and to 20% under the action of traffic.
- The amount of binder required is related to the volume of voids between the aggregate. The quantity should be such that between 60 and 70% of the voids in the final compacted layer should be filled with binder.
- The average depth of the layer of chippings, after construction and trafficking compaction, is approx. equal to the ALD of the chippings used.
- Designed using mathematical formulae



States of Embedment of Surface Dressing Chippings (Hanson 1935)

Analytical Design Approach

Sensitivity of the Algorithm

- The binder application rate derived from the Analytical Design procedure is sensitive to changes in the following variables:
  - Traffic Volume
  - ALD of the chip
  - Texture Depth
  - Pavement Hardness

- Other adjustments to be applied include absorptive surface, grade, shade, time of year.

Homogeneous Sections

- The surface dressing design should be applied to homogeneous sections of road.
- Homogeneity in terms of Traffic, Texture, Hardness and Site conditions/stress.
- Where the surface conditions change (or constituent materials change), a new or modified surface dressing design for the different conditions needs to be considered.

Surface Dressing Trials

Trials Undertaken

- Surface Dressing Trials conducted in 2015
- 12 Trial Sites in 6 LA's.
- Clare (2), Donegal (2), Kerry (4), Offaly (1), Wexford (2), Cork (1)
- 7 no. National Secondary sites
- 5 no. Regional Roads sites

- 11 trial sites were c. 300m long
- 1 "extra" highly controlled site in Cork; c. 2km

Types of Surface Dressing

- 3 Double using 10/14 + 6/10
- 4 Double using 10/14 + 2/6
- 3 Double using 6/10 + 2/6
- 1 Racked-in using 10/14 + 2/6
- 1 Single using 2/6 chip

Site No.	Road Type	Date	SD Type	1st Layer	2nd Layer	Quarry Source	Binder Supplier	AADT	%HCV
Site 5	R	24-08-15	Double	10/14	6/10	(iii)	C	2040	7.8%
Site 6	NS	27-08-15	Double	10/14	6/10	(ii)	C	2000	5.0%
Site 8	NS	07-09-15	Double	10/14	6/10	(i)	A	3820	3.5%
Site 3	NS	13-08-15	Double	10/14	2/6	(ii)	A	4500	6.0%
Site 7	NS	07-09-15	Double	10/14	2/6	(iv)	A	5162	3.5%
Site 11	NS	09-09-15	Double	10/14	2/6	(v)	C	3420	3.0%
Site 12	R	09-09-15	Double	10/14	2/6	(v)	C	2143	16.0%
Site 1	NS	12-08-15	Double	6/10	2/6	(i)	A	1170	1.3%
Site 9	NS	08-09-15	Double	6/10	2/6	(ii)	B	2500	5.0%
Site 10	R	09-09-15	Double	6/10	2/6	(ii)	B	1800	3.5%
Site 4	R	24-08-15	Racked In	10/14	2/6	(iii)	C	2650	5.8%
Site 2	R	12-08-15	Single	2/6	N/a	(i)	A	1059	3.0%

- 6 different Quarry Sources
- 3 different Binder Suppliers
- 4 different Binder types

Trials Undertaken – Site Conditions

- Range of Site characteristics (straights, bends, gradients, shading)
- Some reasonably homogeneous with little variation in texture/hardness
- Other sites had significantly different conditions both in and between the wheel paths with texture variation and significant defects present
- Defects included bleeding, rutting, wheelpath cracking, patching and utility repairs
- One site was highly stressed site with structural distress present (surface dressing wasn’t really the appropriate treatment on this site)

Trials Undertaken – Site Conditions

Control Site

- Extra control site in Cork, 2km in length.
- Comprehensive quality management programme.
- Existing site conditions fully characterised: site specific data including visual assessment, texture and hardness data collected.
- Localised repairs and maintenance were carried to any defective areas in advance.
- Designed based on homogeneous segments.
- This site has performed the best.

Site Characteristics

- Straights
- Bends

Site Characteristics

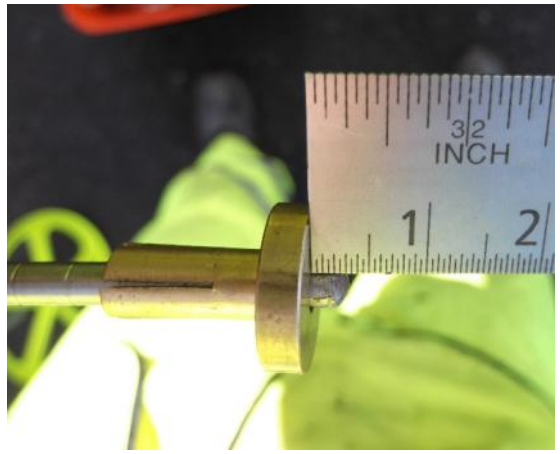
- Stress
- Shading

Site Characteristics

- Bends
- Shading

Site QC Testing

Site testing carried out during construction trials with actual site characteristics, materials and construction data recorded.



On the day of Laying

- Texture (volumetric patch test)
- Hardness Test (CTRA Probe)
- Sampling of Binder and Chippings for lab testing
- Road temperature
- Ambient temperature

Trial Site Data

- 6 Site trials completed between 12/08/15 and 27/08/15
- 6 Site trials completed between 07/09/15 and 09/09/15
- Ambient temperatures ranged from 13.5^{o}C to 19.3^{o}C
- Road temperatures ranged from 14.5^{o}C to 25.3^{o}C
- Texture depth ranged from 0.5mm to 2.5mm
- Road hardness ranged from 2 to 8 (generally on the hard side)

Site QC Testing

During Construction

- Rate of Spread of Binder (Carpet Tile Test)
- Rate of Spread of Chippings (Box test)
- Site Photos

Laboratory Testing

- Lab Testing of Chippings (Grading, FI, ALD)
- Lab Testing of Emulsions for compliance with TII standard

Post Construction Assessment

Post Construction

- Two site visits at 3 months and 6 months after construction
- Visual assessment
- Defects recorded
- Photos
- Forward view digital video

Trials Undertaken – Designs

- **Pre-Construction Designs:** carried out using available data from the LAs for each site and the proposed constituent materials.
- **Site Measured Data:** Site characteristics; Sampling of materials; and Rates of spray of binder and rates of spread of chippings, measured on site during construction.
- **Post-Construction Designs:** carried out using data measured on site for the site characteristics and properties of constituent materials actually used on site.

Analysis

- Outputs from Pre-construction designs, Post-construction designs and Site measured data were compared
- Quality of materials assessed

Outcomes of the Trials

Quality of the Chippings

- **10/14 Chippings** (1st layer on **8 sites**)
  - Gradings were reasonably consistent, All complied with grading limits.
  - Very good shape, all < FI_{20} (FI ranged from 7 to 16%)

- **6/10 Chippings** (**6 sites,** 1st layer on 3 sites, 2nd layer on 3 sites)
  - Gradings were very inconsistent; 3 of 6 sites failed the grading specification
  - Poor shape, FI ranged from 15 to 25% with 4 of 6 sites >FI_{20}
  - 5 of 6 sites failed either the grading and/or FI

- **2/6 Chippings** (2nd layer on **8 sites**)
  - Gradings were very inconsistent, range of 15 to 38% passing the 4mm sieve
  - Shape was typically poor and very inconsistent (FI ranged from 19 to 49%)

Overall, quality and consistency of the 6/10 and 2/6 chippings was an issue.

Binder Data

- 4 different binder types used.
- PMB emulsion used on all sites.
- Reasonably similar binder content with all above the TII requirement of ≥ 71%.
- Non-compliant emulsion (sieve test) on 4 of the 12 trial sites.
- Reasons for failure of binder not entirely clear.
- Facilities and procedures for the local storage of emulsion binder used in surface dressing may need to be reviewed.

Outcomes – Application Rates

- The final design binder application rates from the Analytical Design method were very comparable to the RN39 and IAT methods.
- The rate of spread of binder and chippings achieved on site during construction were broadly in line with that specified by the Analytical pre-construction designs.
- The pre-construction designs were not appropriate in all cases due to last minute changes in the materials used on site.
- The post-construction Analytical designs indicated that some sites would have received slightly more binder, in particular on the 2nd layer, based on the design data (site and materials) collected during construction (IAT designs indicated similarly).

Outcomes - Performance

Condition at 6 Months After Construction

- 3 sites were in very good condition and performing well.
- 4 sites had some minor defects due to some chip loss on the 2nd layer and some minor defects mainly attributable to jointing and workmanship issues.
- 5 sites had varying degrees of failure, with 4 sites showing almost complete failure due to significant loss of the 2nd layer.

Failures – Why?

Reasons for Failures on 5 Sites:

- Late season construction may have been a major issue on 4 of the 5 sites.
- Non-compliant binder was an issue on 3 of the failed sites.
- Non-compliant chippings (6/10 and/or 2/6) was an issue on all 5 sites with failures.
- Lack of repair to structural defects prior to laying may have been an issue.
- Site Specific input data (texture, hardness and chippings).
- Workmanship issues (joints, white lines, cats eyes).
- Aftercare issues – short nature of the sites, early trafficking.

Outcomes

Site 1

- Performing well
- Generally in good condition with little or no defects

Outcomes

Site 3

- Performing reasonably well
- Some loss of 2nd layer
- Very minor/localised defects

Outcomes

Site 5

- Highly stressed site
- Structural defects not repaired
- Drainage issues
- Trench/utility cut works occurred after surface dressing

Outcomes

Site 6

- Most controlled site
- Performing very well
- Very good condition
- No defects

Outcomes

Site 12

- Failure (2nd Layer)
- Late Season
- Non-compliant binder
- Non-compliant chips

Road Hardness

- Road hardness currently measured using the TRL/CTRA Probe.
- Spring loaded penetrometer with a 4mm diameter spherical head.
- International experience indicates that narrow head tends to displace chips and may give inconsistent/misleading results.

- Alternative approaches based on a 19mm ball bearing.
- South African Hammer (SAH)
- Australian Ball Penetrometer
- Current research project is investigating the relationship between, and consistency of, the 4mm CTRA Probe and the 19mm devices for Irish road surfaces.

Road Hardness – 3 Devices

TRL/CTRA Hardness Probe

South African Hammer

BALL PENETROMETER

Digital Indicator
Cat. 82-D1261/A.IMP

Ball Penetrometer
Cat. 80-B0100.Con

AUSTRALIAN MADE

Ball Penetrometer (Embedment Hammer)

Thank You.