Government of Nepal
Ministry of Physical Infrastructure and Transport
Department of Roads
Maintenance Branch

Guideline for Design and Construction of Surface Dressing

(2024)

FOREWORD

Surface dressing has been utilized in Nepal for the construction and maintenance of low-traffic volume roads due to its lower cost compared to premix and asphalt concrete. This guideline has been prepared mainly based on the following sources:

- A Guide to Surface Dressing in Tropical and Sub-Tropical Countries, Overseas Road Note 3, TRL, UK
- Standard Specifications for Road and Bridge Works, Department of Roads (DoR), Nepal
- Standard Specifications and Code of Practice for Design and Construction of Surface Dressing, IRC 110-2005, Indian Roads Congress (IRC)
- Unpublished Training Material – Surface Dressing Training for DoR Engineers

These guidelines cover the design of surface dressing based on several factors, including: type of surface, no of commercial vehicle, vehicle per lane per day, existing surface, climatic condition and type of chips.

Additionally, the guidelines outline the construction procedure for surface dressing, including Preparation of the Existing Surface, Application of Binder, Spreading of Chips, Rolling, Aftercare and Maintenance .

I hope these guidelines will assist road engineers in achieving better performance in surface dressing works at a low cost.

Thank you

Er. Ram Hari Pokharel
Director General
Department of Roads
June 2024

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I express my sincere thanks and gratitude to DoR Director General Mr. Ram Hari Pokharel, former DoR Director General Mr. Sushil Babu Dhakal, and the Maintenance Branch team.

Additionally, I extend my heartfelt thanks to the members of the review committee and experts for their efforts in developing this guideline.

I believe that this guideline will be instrumental for road engineers in achieving better performance in surface dressing works.

Thank you

Er. Prabhat Kumar Jha
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June 2024

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Abbreviation

AADT	Annual Average Daily Traffic
AASHTO	American Association of State Highway and Transportation Officials
AC	Asphalt Concrete
ALD	Average Least Dimension
ASTM	American Society for Testing Material
BC	Bituminous Concrete
CST	Centi Stroke
DBSD	Double Bituminous Surface Dressing
DOR	Department of Roads
IRC	Indian Road Congress
IS	Indian Standard
MC	Medium Curing
Mm	Millimeter
ORN	Overseas Road Note
ROS	Rate of Spread
SBSD	Single Bituminous Surface Dressing
Sq.m	Square meter
TRL	Transport Research Laboratory
VG	Viscosity Grade

1 SURFACE DRESSING

1.1 Introduction

Surface dressing, in various forms, has been used in Nepal as a road Construction and maintenance procedure for last 50 years . The Surface Dressing work consists of application of thin film of bitumen/emulsion of appropriate grade on a previously prepared surface followed by application of a coat of aggregates of almost single-sized (usually 6 mm to 19 mm) as cover material and well rolled. This document is focused only on the surface dressing done with the bitumen binder.

The thin film of bitumen act as water proofing seal preventing the entry of water into the road structure whereas aggregate protect this film of binder from damage by vehicle tyres, and form a durable, skid-resistant and dust-free wearing surface. Depending upon the type of surface dressing the process may be repeated to provide double layers.

The surface dressing can comprise several layers of reducing stone size but is usually limited to a single layer for the purpose of resealing works or a double layer for the new construction. It should be regarded as a protective seal and indeed many specifications use such terms as “seal coat” and “re-sealing”, sometimes called as “chips seal” too.

1.2 Principles of surface dressing

The basic functions of surface dressing have been outlined above i.e. to seal the road against water penetration and provide anti- skid properties (good surface texture). The success of a surface dressing depends primarily on the adhesion of the chippings to the road surface, hence both the chippings and the road surface must be clean and free from dust during the surface dressing process. Inappropriate specifications, poor materials and workmanship can also drastically reduce the service life of a surface dressing.

The following point may not include every possible aspect, but it highlights important features to think about when designing the surface dressing, choosing materials, planning construction, and ensuring quality control

a. The bitumen to be used must adhere to the chippings applied at the road surface temperature

b. The bitumen must be capable of being sprayed safely, and evenly.

c. The thickness of the bitumen film must be sufficient to retain the chippings but not excessive

d. Chippings must adhere to the bitumen film and be retained under the action of traffic.

e. The size of chippings used must be appropriate for the site characteristics.

f. The completed dressing must be durable and effective; it must be acceptable to and safe for road user. Durability depends very largely on correct design initially, good materials and good construction practice. Safest for the road user is often compromised or negatively affected by failure to remove loose chippings after initial opening to traffic; poor traffic control during construction is another cause

1.3 Type of surface dressing and their application

Surface dressings can be constructed in a number of ways to suit site conditions. The common types of dressing are

a) Single surface dressing

b) Double surface dressing

c) Racked in Surface dressing

d) Pad coat plus single surface dressing

e) Sandwich

While other methods like Racked in Surface Dressing, Pad Coat plus Single Surface Dressing, and Sandwich exist, our focus remains on Single Surface Dressing and Double Surface Dressing as these two approaches align perfectly with our requirements and existing practices.

1.3.1 Single surface dressing

Single surface dressing is mainly used for a maintenance activity over a bituminous surface i.e. for the resealing purpose. Single surface dressing will function as waterproofing of the existing pavement surface, delay the deterioration and restore the skid resistance.

For this purpose a layer of the bitumen binder is spread over the previously prepared pavement surface followed by spreading one layer of cover aggregates and rolling. Single bituminous surface dressing (SBSD) and Single bituminous surface treatment (SBST) are synonymously used for the single surface dressing.

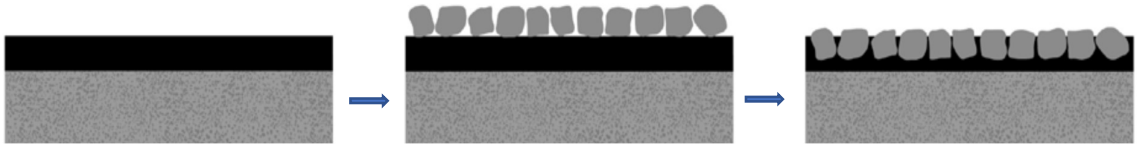

Figure 1 Schematic diagram of single surface dressing

1.3.2 Double surface dressing

A single surface dressing would not normally be used on a new road base because of the risk that the film of bitumen will not give complete coverage. It is also particularly important to minimize the need for future maintenance and a double dressing should be considerably more durable than a single dressing for the case of new road base.

In double surface dressing, the structure is formed by spraying a layer of binder and then spreading of one layer of cover aggregate and rolling, followed by a second layer of binder, spreading of another layer of cover aggregates and rolling. The size of second layer of aggregates is generally of half size than that of the first layer aggregate.

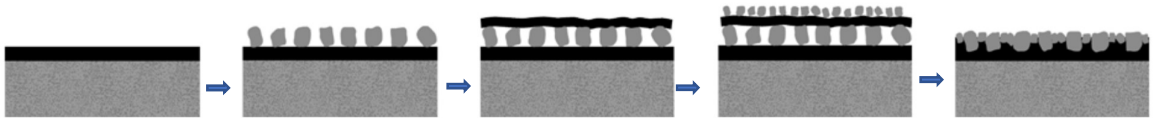

Figure 2 Schematic diagram of double surface dressing

Double bituminous surface dressing (DBSD) and Double bituminous surface treatment (SBST) are synonymously used for the double surface dressing.

Double surface dressings are robust and should be used when:

- A new road base is surface dressed.
- Extra 'cover' is required on an existing bituminous road surface because of its condition (e.g. when the surface is slightly cracked or patched).

- There is a requirement to maximize durability and minimize the frequency of maintenance and resealing operations.

The effectiveness of a double surface dressing can be significantly improved by allowing traffic in the initial dressing for at least 2-3 weeks, preferably longer, prior to applying the second dressing This allows the chippings of the first dressing to adopt a stable interlocking mosaic which provides a firm foundation for the second dressing.

However, traffic and animals may cause contamination of the surface with mud or soil during this period and this must be thoroughly swept off before the second dressing is applied. Such cleaning is sometimes difficult to achieve and the early application of the second seal to prevent such contamination may give a better result.

1.4 Limitations of surface dressing

It is important to note that a surface dressing does not contribute to the strength of the pavement layers i.e. it has no structural significance. Neither can improve the shape and riding quality of road which has become deformed, usually due to fatigue.

Finally, surface dressing is only appropriate for roads which are, in general structurally sound. This is often the case even though the surface may have become worn/ravelled/ potholed; if potholes, edge defects, local failures etc. are repaired a single or double surface dressing will prolong the life of the road significantly.

Advantages and disadvantages of Surface dressing is listed in Table 1.

Table 1 Advantage and Disadvantage of surface dressing

Advantages	Disadvantages
Resists premature cracking due to early bitumen embrittlement.	Weather conditions very important during construction
Equipment suited to local contractor purchase an ownership.	Good traffic control needed during construction and for 3-4 hours after
Relatively low initial capital cost and rehabilitation cost therefore supports the. concept of affordable risk management	Low tolerance of axle overloading due to pavement flexibility.
Flexible construction provides a degree of tolerance in areas prone to differential settlement (side cut/fill in the hills).	
High skid resistance.	

2 MATERIAL REQUIRED FOR SURFACE DRESSING

2.1 Aggregates/ Chippings

The stone chips (cover aggregate) shall confirm the requirement as specified in Table 2 and Table 3. They shall be clean, hard, and durable, of cubical shape, free from dust and soft or friable matter, organic or other deleterious substances.

Table 2 Physical Requirement of Aggregate [1]

Property.	Test	Specification / Requirement	Test Method
Cleanliness(dust)	Grain size analysis	Max 1.5% passing 0.075 mm sieve	IS : 2386 (Part-1)
Particle shape	Combine Flakiness and Elongation Indices (Total) *	Max 35 %	IS : 2386 (Part-1)
Strength	Los Angeles Abrasion Value or Aggregate Impact Value	Max 35 % Max 27 %	IS : 2386 (Part-4
Durability	Soundness: Sodium sulphate or Magnesium sulphate	Max 12 % Max 18 %	IS : 2386 (Part-5)
Water Absorption	Water absorption	Max 1%	IS : 2386 (Part-3)
Stripping	Coating and stripping of aggregate mix	Minimum retained coating 95%	IS: 6241
Polishing	Polished Stone Value	Min 60	BS:812-114

** To determine this combined proportion, the flaky stone from a representative sample should first be separated out. Flakiness index is weight of flaky stone metal divided by weight of stone sample. Only the elongated particles be separated out from the remaining (non-flaky) stone metal. Elongation index is weight of elongated particles divided by total non-flaky particles. The value of flakiness index and elongation index so found are added up.*

Table 3 Grading Requirement[2]

Sieve size (mm)	Percentage passing by weight			
	Nominal size			
	19	13	10	6
26.5	100			
19.5	85-100	100		
13.2	0-40	85-100	100	
9.5	0-7	0-40	85-100	100
5.6		0-7	0-35	85-100
4.75			0-10	
3.35				0-30
2.36	0-2	0-2	0-2	
0.6				0-10
0.075	0-1.5	0-1.5	0-1.5	0-1.5

[1] Standard Specification of Road and Bridge (2nd Amendment 2078)

[2] Standard Specification of Road and Bridge (2nd Amendment 2078)

The size of aggregate shall depend upon the type of surface on which it is laid and the traffic intensity which is described in the design section.

The most critical period for a surface dressing occurs immediately after the chippings have been spread on the binder film. At this stage the chippings have yet to become an interlocking mosaic and are held in place solely by the adhesion of the binder film. Dusty chippings can seriously hamper adhesion and can cause immediate failure of the dressing. The effect of dust can sometimes be mitigated by dampening them prior to spreading them on the road. The chippings dry out quickly in contact with the binder and good adhesion develops more rapidly than when the coating of dust is dry

2.2 Binder

The binder shall be either bitumen conforming to IS: 73 or rapid setting cationic bitumen emulsion (RS-2) conforming to IS: 8887.This guideline deal only with the bitumen confirming to the IS 73. Choice of Grade of bitumen depend upon the climatic condition of the area where surface dressing is to be done and is selected based on the Table 13.1 of Standard Specification of Road and Bridge work and is presented in Table -4

Table 4 Selection Criteria for Viscosity-Graded (VG) Paving Bitumen Based on Climatic Conditions

Lowest Daily Mean Air Temperature, °C	Highest Daily Mean Air Temperature, °C		
	Less than 20°C	20 to 30°C	More than 30°C
More than -10°C	VG-10	VG-20	VG-30
-10°C or lower	VG-10	VG-10	VG-20

Both the highest daily mean air temperature and the lowest daily mean air temperatures mentioned in Tables 4 can be obtained for the weather station nearest to the project site from the Department of Hydrology and Meteorology (DOHM). This daily mean high temperature on a specific day is the same as daily "normal" high temperature for that day as usually reported in some newspapers. The highest of the 365 daily mean high air temperatures (which usually occurs on some day May or June) is used in Table 4. Likewise, the lowest daily mean air temperature (which usually occurs on some day in January) can also be obtained from the DOHM. Since these are mean temperatures based on the average of 30-40 years data, these temperatures are significantly lower than the absolute maximum temperatures, which may have occurred in a specific year. Sample for selection of the bitumen is presented in the Annex-1.

The bitumen so selected must fulfill the following test requirements.

Table 5 Requirement of Paving Bitumen (IS73 or NS 230)

Characteristics	VG-10	VG-20	VG-30	VG-40
Penetration at 25°C, 100g/5s), 0.1mm, Min	80	60	45	35
Absolute viscosity at 60°C, Poises	800-1200	1600-2400	2400-3600	3200-4800
Kinematic at 135°C, cST, Min	250	300	350	400
Flash point (Cleveland open cup), °C. Min	220	220	220	220
Solubility in trichloroethylene, Min	99	99	99	99

Characteristics	VG-10	VG-20	VG-30	VG-40
Softening Point (R&B), °C. Min	40	45	47	50
Test on residue from rolling thin film oven test:				
a) Viscosity ratio at 60°C,Max	4	4	4	4
b) Ductility at 25°C, cm, Min	75	50	40	25

The binder so selected will be converted to the different viscosity depending upon the surface temperature during the surface dressing. This will be separately discussed on section 3.3.

2.3 Anti stripping Agent

Some aggregates, e.g. quartzite, show a greater affinity for water than for bitumen (hydrophilic aggregates); such materials are prone to stripping under certain conditions in the presence of water, although other factors such as aggregate texture may determine the behaviour of the aggregate/bitumen system. Wet weather damage, however, is probably the major risk if the aggregate used is hydrophilic and if in doubt the engineer should have his material tested for adhesion properties.

Where laboratory tests indicate that an aggregate may be prone to stripping problems the use of an adhesion additive may enable the aggregate to be used in surface dressing. Such additives are usually added to the bitumen and mixed thoroughly immediately before spraying; the amount required will be determined by the laboratory.

Where the proposed aggregate fails to pass the stripping test then an approved antistripping agent may be added to the binder in accordance with the manufacturer's instructions. The physical property of the Anti-stripping agent as mentioned in the standard specification of road and bridge 2nd amendment is presented in table -6

Table 6 Specification for the Anti stripping Agent

Description	Test method	Requirements
Appearance	Visual	Dark Brown Liquid
Specific Gravity at 27^0C	IS 1448	0.85 ±0.1
Pour point	IS 1448	Max 42
Flash point	IS 1448	>150^0C
Moisture content	IS 1448	Max 1.0 %
Solubility in Diesel Oil in the Ratio 2:98 at 50^0 C	IS 6241	Min 95%
Stripping Value with Bitumen Containing 1 % Agent 40^0 C for 24 Hours	IS 6241	No Stripping
Under water coating test	IS 6241	Min 95%
Thermal stability at 163^0C	IS 6241	Stable

The effectiveness of the proposed anti-stripping agent must be demonstrated by the contractor before the approval by the Engineer.

The adhesion agent should not be used in an attempt to overcome problems which are not attributable to aggregate properties. e.g.

- Spraying at too low a temperature
- Using bitumen of incorrect viscosity
- Failure to apply chippings soon after the bitumen spray
- Using dusty chippings

3 DESIGN OF SURFACE DRESSING

Surface dressing is not recipe type work i.e bitumen and chippings are spread at fixed, mandatory rates. It should be known very clearly that this thinking and practice is totally wrong and should be ignored. **Any surface dressing must be designed individually.**

The following factors are predominant in determining the durability of the surface dressing and are carefully considered in the design process**.**

Table 7 Factors affecting Surface Dressing

Factor	Significance
i) Traffic	Heavy vehicles and/or large numbers of lighter vehicles force (Embed) chippings into the road surface. If embedment is high less Bitumen will be needed to hold the chippings.
ii) Existing surface	Hard surfaces resist embedment and more Bitumen is needed to hold chippings. Bitumen-rich surface are Often soft and spray rates need to be reduced.
iii) Climate	Vary hot and dry climates will be characterised by softer surfaces (Result; high embedment, less bitumen needed).Cool and wet climates not only have low embedment surfaces but Possibly a risk of stripping also.(More binder holds chipping Securely)
iv) Condition of chippings	Their predominant characteristic should be considered. Flaky Chippings require less bitumen to be firmly held than cubical Chippings of the same nominal size. Dusty chippings and rounded Chippings also tend to require more bitumen.

3.1 Design method

The surface dressing design method to be used here is that described in overseas Road note 3(TRL, UK) and referred to now as ORN 3.Design of surface dressing basically means the determination of the type and spray rate of the binder and chips in the prevailing condition.

For the determination of the basic spray rate of the bitumen Average least dimension (ALD) of the chipping and overall weighing factor are required. Since aggregate particles evenly lie on their flattest side, the average thickness of the Surface Dressing is the average of least dimension of the aggregates. This is referred as Average Least Dimension (ALD) of the aggregates (Fig. 3). The thickness of the finished layer approximates ALD. ALD of the Chipping is the function of both the average size of chipping and degree of flakiness. Similarly the overall weighing factor is the sum of four factor that represent the level of traffic, the condition of existing surface ,the climate and type of chipping we use.

Figure 3 Average least dimension

3.1.1 Traffic, Nominal size of chips and surface Hardness

The significance of traffic is important in two ways:

a. The selection of chipping size

b. The calculation of bitumen spray rate

The relation between the traffic and surface hardness with appropriate size of chipping are mentioned in Table 8. The number of commercial vehicles (weighing over 3 tonnes laden) is counted over a 24-hour period within the designated lane of the highway. This counting process is repeated for 3 consecutive days to calculate an average value of commercial vehicles, which is then used to determine the appropriate chipping size for the road surface.

Table 8 Recommended Nominal size[3]

Type of surface	Traffic intensity in Terms of Number of commercial vehicles (all type of buses and trucks) per day currently in the lane under consideration. (base year traffic)		
	1000-2000	200- 1000	20-200
Very hard	10	6	6
Hard	13	10	6
Normal	13	10	6
Soft	19	13	13
Very soft		19	13

The road surface hardness is determined by the Probe penetration test (TRL.1916).Alternatively the hardness of the existing road surface may be determined on the basis of the judgments with the help of the definition given in the table 9

Table 9 Categories of road surface hardness[4]

Category of surface	Penetration at 30^0c	Definition	Remarks
Very Hard	0-2	Concrete or very lean bituminous structures with dry stony surfaces. There would be negligible penetration of chippings under the heaviest traffic.	
Hard	2-5	Likely to be an asphalt surfacing which has aged for several years and is showing some cracking. Chippings will penetrate only slightly under heavy traffic.	
Normal	5-8	Typically, an existing surface dressing which has aged but retains a dark and slightly bitumen-rich appearance. Chippings will penetrate moderately under medium and heavy traffic	
soft	8-12	New asphalt surfacing or surface dressings which look bitumen-rich and have only slight surface texture. Surfaces into which chippings will penetrate considerably under medium and heavy traffic.	Prepared base course surface is considered as soft surface
Very soft	>12	Surfaces, usually a surface dressing which is very rich in binder and has virtually no surface texture. Even large chippings will be submerged under heavy traffic.	

[3] Standard Specification of Road and Bridge (2nd Amendment 2078)

[4] Overseas road note -3

Table 8 shows that larger chippings are required on the soft surface or where the traffic is heavy while small chippings are best for the hard surface and low traffic

In selecting the nominal size of chippings for double surface dressings, the size of chipping for the first layer should be selected on the basis of the hardness of the existing surface and the traffic category as indicated in Table 8. The nominal size of chipping selected for the second layer should preferably have an Average Least dimension (ALD) of not more than half that of the chippings used in the first layer. This will promote good interlock between the layers.

A separate count however is made of total vehicles/lane/day for the purposes of designing bitumen spray rate.

3.1.2 Determining ALD of chipping

ALD of the chipping can be determined by the following two methods.

a. Using Nomogram

For the determination of the ALD using Nomogram median size of the aggregate and the flakiness index of the proposed aggregate is required. The median size is determined from the sieve analysis graph and is simply the sieve size from which the 50% of the chipping pass. Refer fig 4.

Flakiness index is determined by following the procedures describe in IS 2386 Part I. Flakiness index is weight of flaky stone metal divided by weight of stone sample. Reader should not be confused with the combine flakiness and elongation index as mentioned in the Table 2.

Once the median size and Flakiness Index for the chips is determined a nomogram as shown in fig5 [5] is used to determine the ALD of the proposed chippings.

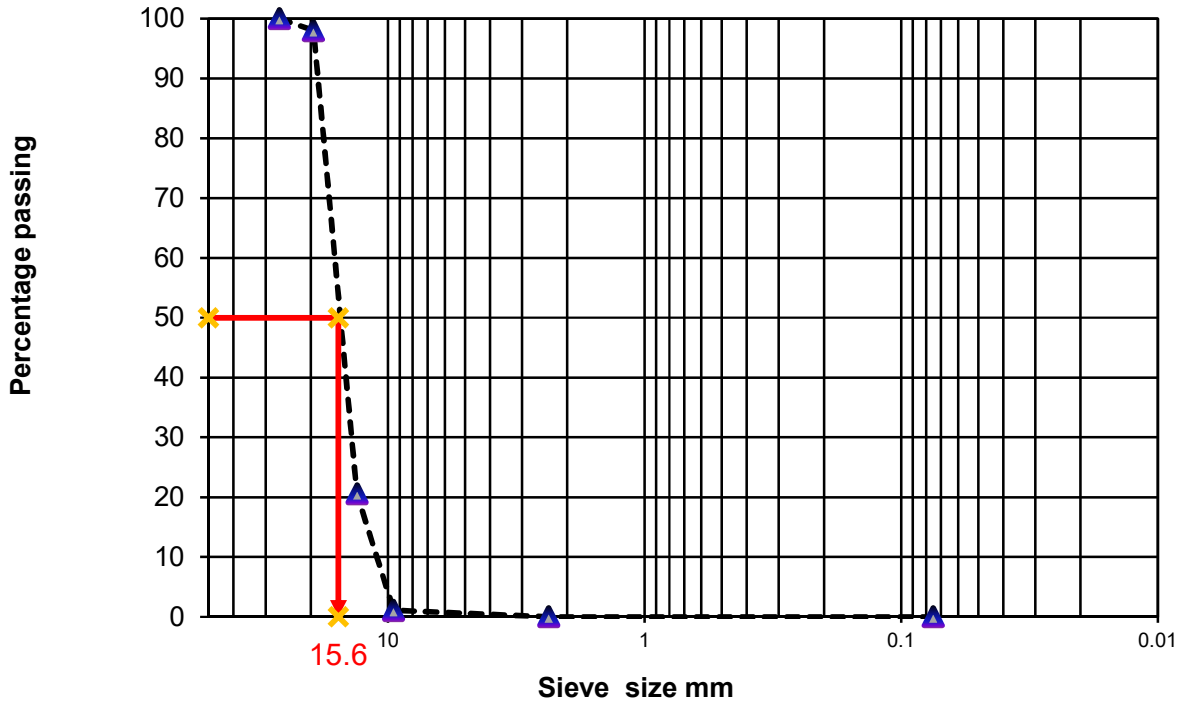

Figure 4 Determination of Median size

[5] Overseas Road Note -3

For e.g the median size for the aggregate gradation shown in fig 4 is 15.6 and FI is 27% say. Then the ALD of the proposed chips is determine by joining the median size point in A with the Flakiness point in C and reading the value where the line joining point A to C crosses the B . In the following example the ALD is 10.5 mm.

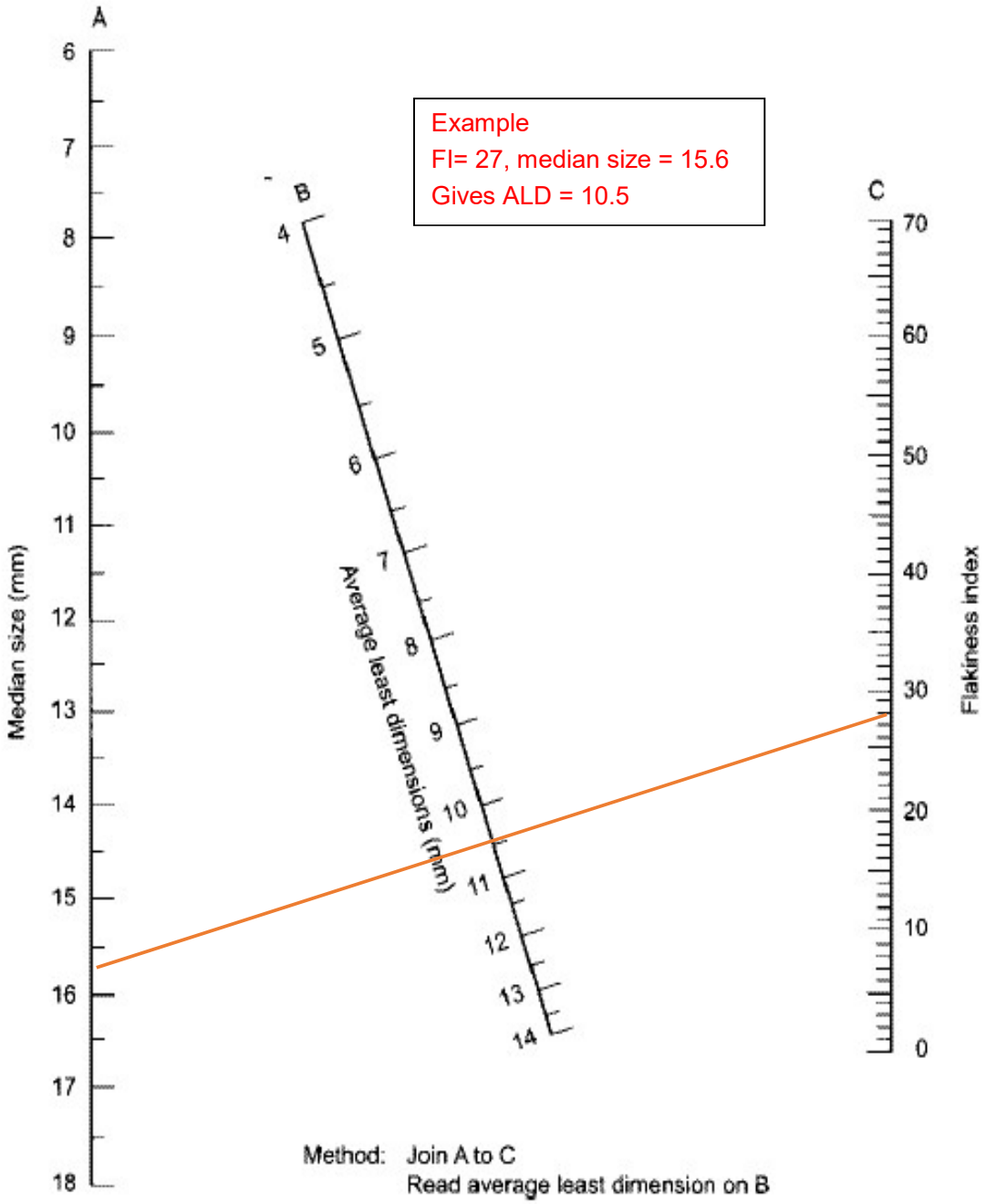

Figure 5: Determination of Average least dimension

b. Averaging Least Dimension

Representative sample of the chippings is carefully subdivided to give approximately 200 chippings. The least dimension of each chipping is measured manually and the ALD, is calculated by averaging the measured least dimension.

c. Formula from RRS

Following Formula developed by Er. Rajendra Raj Sharma can also be used for determining the average least dimension

$$ALD = (0.3538*FI^2-0.7609*FI+0.8645)*D_{50} \text{ ----------(1)}$$

Where,

FI - flakiness index (in absolute value, **NOT in %**)

D_{50} - median size of chipping,

3.1.3 Determining overall weighting factor 'F'

The overall weighting factor F' is determined by adding together four factors that represent: the level of traffic, the condition of the existing road surface, the climate and the type of chippings that will be used. Designer select the factors appropriate to the site to be surface dressed from following Table for four different parameter and are added up to give the overall weighing factor F.

Table 10 Weighing factor for surface dressing design [6]

Traffic (all class on base year excluding 2 & 3 wheelers)	Vehicles/lane/day	Factor
Very light	< 50	+3
light	50- 250	+1
Medium	250 – 500	0
Medium-heavy	500- 1500	-1
Heavy	1500 – 3000	-3
Very heavy	>3000	-5
Existing Surface		Factor
Untreated or primed base		+6
Very lean bituminous		+4
Lean bituminous		0
Average bituminous		-1
Very rich bituminous		-3
Climatic Condition		Factor
Wet and Cold		+2
Tropical (wet and hot)		+1
Temperate		0
Semi-arid (hot and dry)		-1
Arid (very dry and very hot)		-2
Type of Chippings		Factor
Round and dusty		+2
Cubical		0
Flaky (FI greater than 15 %)		-2
Pre coated		-2

[6] Overseas Road Note -3

Example : For a heavy traffic (portion of commercial vehicle less than 20%), in primed surface, in tropical climate and using rounded and dusty chips the overall weighing factor shall be : - 3+6+1+2=6

Following points as listed in the ORN-3 shall be consider while selecting the above factors

- If the existing surface is rough it should be treated as very lean bituminous even if its colour is dark with bitumen
- when determining the rate of spread of binder for the second layer of a double surface dressing, the first layer should also be rated 'very lean bituminous'.
- The factor for the traffic is based on the numbers of vehicles only. However, if the proportion of commercial vehicles in the traffic stream is high (say more than 20 per cent) the traffic factor selected should be for the next higher category of traffic than is indicated by the simple volume count.

3.2 Determination of basic bitumen rate of spray

ALD and 'F' values in equation 1 will give the required basic rate of spread of binder.

R = 0.625+ (F*0.023)+ [0.0375 + (F*0.0011)]*ALD ----------(2)

Where

F = Overall weighting factor

ALD = the average least dimension of the chippings (mm)

R = Basic rate of spread of bitumen (kg/m^2)

The basic rate of spread of bitumen (R) is the mass of MC3000 binder per unit area on the road surface immediately after spraying. The relative density of MC3000 can be assumed to be 1.0 and the spread rate can therefore also be expressed in l/m2.

The basic rate of spread of binder must also be modified to allow for the type of binder used. For viscosity grade the basic rate is decreased by 10%.i.e 0.9*R will be the spray rate for the base bitumen of type as determined considering the Highest Daily Mean Air Temperature, °C as mentioned in table 4.

Sample calculation sheet for the Bitumen, cutter and actual spray of binder at site is presented in appendix-1

3.3 Binder modification with respect to surface temperature

The grade of the bitumen is determined considering the Highest Daily Mean Air Temperature, and lowest daily mean air temperature as mentioned in table 4.

The viscosity of binder at the time of surface dressing is largely controlled by road temperature at and shortly after the time of construction.

For spraying on the road surface the viscocity of the bitumen as selected from table 4 needs to be adjusted to the suitable viscosity of the binder by adding cutter(kerosene) in appropriate quantity. The required type of the binder of suitable viscosity depends on the temperature of the road surface at the time of construction and the traffic. The binder type is selected from the graph as shown in fig 6 so as to fall within the permissible range shown in white-colored window.

In general the viscosity at bitumen at surface temperature is 10^5.

An example of binder selection is shown below.

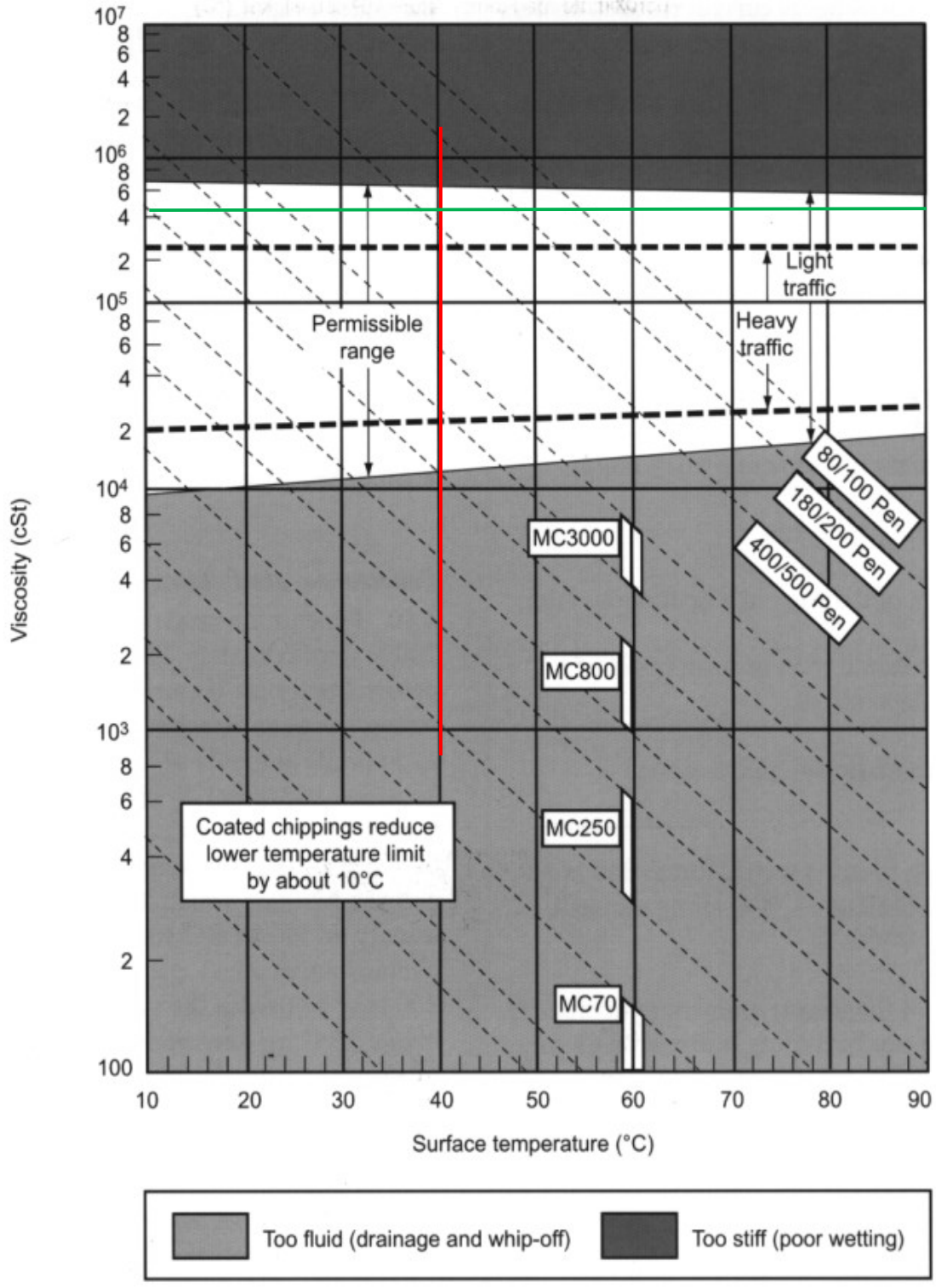

Figure 6: Surface Temperature / choice of binder

Example

Road temperature is 40^0C

Traffic: heavy traffic

From the chart in Figure 6

- MC 3000 would be only just viscous enough.
- 400/500 penetration grade bitumen would be on the limit of being too viscous,
- **Preferable to cut-back the bitumen to a 500/600 penetration grade**

Following table shows the preferred binder for the different road surface temperature we generally found in executing surface dressing in Nepal.

Table 11 Preferred binder for different road temperature

Road Surface temperature , ^{o}C	Preferred cutback	Remarks
30	MC3000	Extracted from fig 6
40	500/600 pen	
50	400/500 pen	
60	180/200 pen	

In general the viscosity of the binder at the paving temperature shall be 10^5 centistroke

3.4 Chippings

An estimate of the rate of application of the chippings assuming that the chippings have a loose density of 1350 kg/m^3, can be obtained from the following equation:

Chipping application rate (kg/m2) = 1 .364*ALD

The best rate of application of chipping is that in which the chipping are tightly packed together, i.e. one layer thick. To achieve this, a slight excess of chippings must be applied so that some will be moved by the traffic and will tend to fill small areas where there are insufficient chippings. If any exposed binder remains after spreading the chippings, it indicating too low a rate of application of chippings and if chippings are resting on top of each other it indicate too high application rate. Too excess chippings will increase the risk of whip-off and windscreen damage.

For example,

Average Least Dimension, ALD	***12.00***
Chipping Application Rate, Kg/m^2	***16.368***
For Estimate purpose, add 10% value for whip-off	

4 CONSTRUCTION EQUIPMENT

4.1 Bitumen Distributors

Bitumen distributors shall be truck mounted and shall have sufficient power to maintain uniform speeds for the proper application of the binder. The truck shall be equipped with an accurate tachometer showing the driver the speed in meters per minute. The truck shall be fitted with a gauge bar and chain or any other acceptable device clearly visible to the driver to enable him to follow the required edge. The distributor tank shall have a capacity of at least 4,000 litres. It shall be equipped with heaters capable of maintaining temperatures up to 200^{O}C and be fitted with an accurate thermometer.

The circulation system shall permit pumping around the tank and around the spray bar without actually spraying. Spray bars shall be available for spraying in widths varying from 0.5 m to 4 m and shall be adjustable transversely so that the operator can follow the required edge independently. The spray nozzles shall be arranged to give a uniform spray and the shut-off shall be quick-acting with an antidrip device. The pressure in the spray bar shall be sufficient to give a good distribution and spraying of the binder.

Distributors shall be capable of applying bituminous binder within the limits of ± 5% of the specified rate of application over any portion of the surface.

Distributors shall be checked and calibrated before starting any work or when required by the Engineer. This shall include the calibration of all the metering devices and checking the uniformity of the transverse distribution of spray.

4.2 Chip-spreaders

Mechanical chip-spreaders shall be capable of spreading the chippings uniformly over variable widths, from 0.5 to 3.5 m, at the rates specified.

The number and output of chip-spreaders shall be sufficient to ensure that chippings are spread immediately after the bituminous binder has been applied.

Chip-spreaders shall be checked and calibrated before starting any work or when required by the Engineer.

4.3 Rollers

The main rolling shall be carried out with self-propelled pneumatic tyred rollers, having a wheel-load of more than 2 tons. The tyres shall be smooth and their pressure shall be more than 0.4 N/mm^2.

The number and output of rollers shall be sufficient to ensure that rolling does not lag behind spreading. To the extent possible, two pneumatic tyred rollers shall be used for each chip-spreader.

4.4 Miscellaneous Equipment

Sufficient trucks and loading machinery shall be employed to ensure an adequate, prompt and continuous supply of chippings. Similarly the mechanical bromer and air compressor with sufficient length of hose pipes and air jet nozzle are essential for cleaning of surface to be sprayed with the bitumen.

5 CONSTRUCTION OF SURFACE DRESSING

5.1 Planning surface dressing work

The planning of surface dressing operation includes but is not limited to the following tasks:

1 Select lengths of road requiring surface dressing and detail the preliminary work required on each road before the surface dressing can be carried out.

2 Implement the necessary preliminary work such as patching, shoulder and edge repairs, drainage works, reinstatement of service trenches etc. Allow as much time as possible for trafficking before commencement of surface dressing operations.

3 Decide on the type of surface dressing, the binder to be used and nominal chipping sizes, i.e. use the road surface hardness probe and make a preliminary design, taking into account constraints on the supplies of binder and chippings and limitations of plant and labor.

4 Ensure that the chippings will be of adequate quality with suitable ALD value(s). Stockpile chippings at convenient points along the road to be surface dressed so as to minimize haul distances during construction with ease in washing when required. Sample the chippings and confirm their suitability, modify the surface dressing design if necessary.

5 Order the appropriate binder for the anticipated weather conditions, or make provision for blending and adding adhesion agents as required.

6 Ensure that all the plant and equipment of the unit is in good working order.

7 Instruct the construction team of the details of the work program.

8 Inform the police and other organizations likely to be affected by the surface dressing operation.

9 Inform the Materials Laboratory and arrange for the testing of aggregates and binder and rate of spread checks during spraying.

5.2 Preparation of equipment, chippings stockpiles and bitumen

Prior to start of works equipment should be inspected for broken, non- operable components, direct labor, should ensure that its own equipment is kept in a serviceable condition. In addition to major equipment (distributor, chipping spreader etc.) support items, often small, tend to be overlooked. The engineer should ensure that hand tools are available and adequate labor for such jobs as sweeping, hand-chipping etc.

Chipping stockpile locations should be planned carefully, taking into account the haul distances and re-fill time for tipper trucks (elapsed time from leaving work site and return re loaded). The type of chipping spreader(s) to be used may affect the number of trucks needed. One of the major factor affecting the progress of the surface dressing is the delay in the chip spreading operation either due to insufficient trucks to transport the aggregate from the stockpile or the problems associated with the chips spreader.

When stockpiling the material Contractor should consider the nature of the local soil. Often aggregates are stored on unsuitable sites, the result being high wastage and/ or contamination when loading vehicles. When required the stockpile area shall be surfaced with 100 mm of gravel or other material acceptable to the Engineer. Any Contaminated chippings shall not be used and care shall be taken wile loading the aggregate from the stockpile to the tippers.

Figure 7 Bucket Height for Proper loading

The setting-up of a bitumen supply point must be arranged. Because of the work involved in re-locating bitumen decanter and/or storage facilities, contractor usually attempt to work on a single point basis; travel time to/from site must be considered as well as other factors e.g. access for the distributor/ delivery trucks, safety concerns, environmental impact (smoke nuisance, pollution, noise etc.)

5.3 Repairs to existing surface

These must be done well in advance of re-sealing and should not require detailed description. Potholes, depressions, cracked areas, fretting/ raveling and edge damage must all be rectified; most particularly any new patches MUST be sealed using cutback or emulsion, blinded with crusher fines or sand before opening to traffic which will then 'close-up' the surface texture before surface dressing. Failure to do this will not only leave the patch vulnerable to water penetration but will allow the surface dressing binder to drain into the patch instead of sealing the surface and retaining aggregate.

Immediately before spraying, all loose material and foreign matter shall be removed by thorough brushing with mechanical brooms and/or washing or by use of compressors or by other methods acceptable to the Engineer. All hardened mud or other foreign matter shall be loosened by scraping before sweeping. The debris shall be deposited well clear of the surface to be sprayed.

Road furniture (manholes covers etc.) shall be covered with adhesive paper or similar materials. Kerb stones, roadside, and any other objects what shall not benefit from binder spray shall be protected in a manner approved by the Engineer.

Any defect of the surface shall be made good as instructed by the Engineer and no binder shall be sprayed until the surface has been approved by the Engineer. The Engineer's approval or otherwise of the surface shall be given immediately prior to the Contractor's intention to start spraying.

5.4 Calibration of bitumen distributor

The output of the spray bar shall be determined for the given bitumen, operating temperature and distributor settings. In the case of constant pressure distributors, the operating pressure must be fixed.

Once the design spray rate and rate of delivery bitumen from the distributor is known, the required road speed of the distributor can be calculated by.

Speed of distributor = S/(R*W)

Where

S is the rate of delivery (mass) from the spray bar in kg/s

R is the design spray rate (mass) in kg/m2

W is the sprayed width in meters

The required speed will then be in m/s.

5.5 Priming new road bases

The binder for prime is usually a low-viscosity cutback such as MC30 or MC70, applied at a defined spray rate depending upon the texture and density of the surface.

Following are the functions of a prime coat.

- It assists in promoting and maintaining adhesion between the base and a surface dressing by pre-coating the base and penetrating surface voids.
- It helps to seal the surface pores in the base thus reducing the absorption of the first spray of binder of the surface dressing.
- It helps to strengthen the road base near its surface by binding the finer particles of aggregate together.
- If the application of the surface dressing is delayed for some reason it provides the road base with a temporary protection against rainfall and light traffic until the surfacing can be laid.

The surface to be sprayed shall be thoroughly cleaned by sweeping with mechanical brooms and/or washing or other approved means. All laitance of soil or binder material, loose and foreign material shall be removed. Brushing must NOT however, be excessive such as to being to de-bond coarse aggregate.

A very light dampening of the surface with water prior to priming will assist penetration but in no case the surface shall be made saturated. If the water is over applied, the surface shall be allowed to dry until dampness is uniform over the entire surface.

Figure 8 Primed surface ready for the surface dressing

The depth of penetration of the prime should be between 3-l0mm and the quantity sprayed should be such that the surface is dry within a few hours. The correct viscosity and application rate are dependent primarily on the texture and density of the surface being primed. The application rate as mentioned in the standard specification of road and bridge is mentioned in table 11. Low viscosity cutbacks are necessary for dense cement or lime stabilised surfaces, and higher viscosity cutbacks for untreated coarse-textured surfaces. It is normal to allow 24 hours for the prime to penetrate before surface dressing.

Table 12 Type and Spray rate of Prime Coat

Type of Surface	Type of Cutback	Rate of Spray (kg/sq.m)
WMM/WBM	MC 30	0.6-0.9
Stabilized soil bases/ Crusher Run Macadam	MC 70	0.9-1.2

If after application of the prime coat, the bituminous material fails to penetrate within the time specified of if the road must be used by traffic or the excess prime material remain in the surface, blinding material shall be spread in the amount required to absorb any excess bituminous material and to protect the primed surface.

Blinding material shall be spread from trucks in such a manner that no wheel shall travel on uncovered bituminous material. The binding layer, shall be crushed rock or river sand having grading within the limits of the Table 12

Table 13 Grading Envelope for Sand for Prime Coat

Sieve size (mm)	Percentage Passing (by mass)
4.75	100
2.36	80-100
1.18	60-95
0.6	30-80
0.3	20-55
0.075	10-30

While spraying the prime coat or the tack coat the nozzle orientation and height of the spray bar shall be checked prior to the actual spraying.

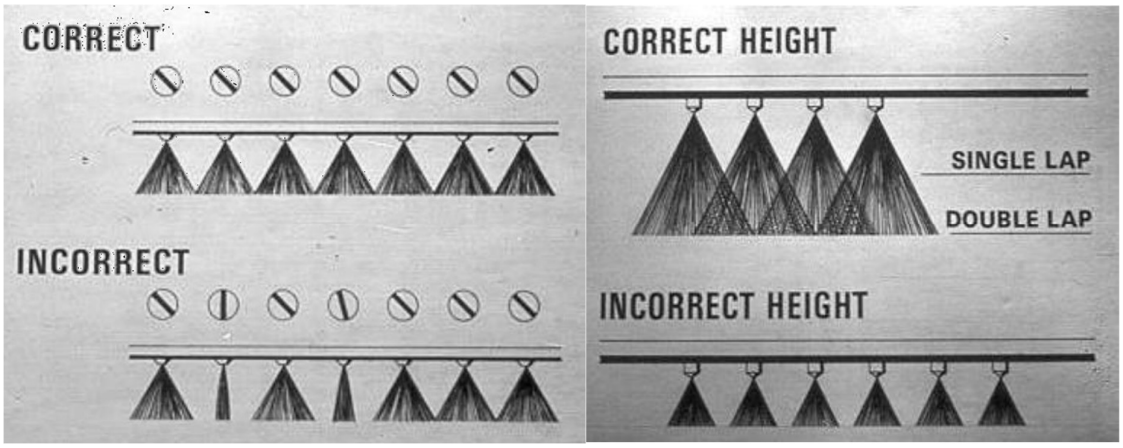

Figure 9 Correct and Incorrect Spray of Bitumen Distributor

Incorrect nozzle orientation and bar spray height will have the variation in the spray rate and sometime of absence of binder at some location causing the streaking of the surface dressing.

Weather Limitation

Application of binder shall only be under taken when the surface is dry or slightly damp, but no circumstances when wet. Preferably, the Surface Dressing work shall be carried out when the atmospheric temperature in shade is 16°C or above. No bituminous material shall normally be applied when the surface or the cover material is damp, when the weather is foggy or rainy or during dust-storm.

If in the opinion of the Engineer rainfall is likely before the application of binder or cover aggregate or the temperature of the pavement surface has time to fall below the specified minimum temperature, the Engineer will instruct the Contractor to delay surface dressing work until weather conditions are satisfactory.

Areas damaged by rainfall shall be rectified by the Contractor without additional payment, in a manner instructed by the Engineer. If in the opinion of the Engineer the ambient temperature is too cold for surface dressing, the Contractor shall delay this operation until the temperature increases to the specified minimum level.

5.6 Surface dressing operation

The operation can now be summarized as follows:

1. Raising the temperature of the binder in the depot tanks is started early in the morning so that the distributor can be loaded with bitumen. The temperature should, preferably, be just above the ideal spraying temperature.
2. The supervisor arrives on site with traffic control equipment and supervises the placing of warning signs, control barriers, traffic cones, etc.
3. The surface dressing unit arrives on site and the distributor is parked off the road, preferably on a level site where the tank can be 'dipped' before and after spraying. If the parking area is not level and alternative site must be located.
4. Whilst the binder temperature is adjusted using the burners; binder is circulated through the spray bar, and the jets are checked for correct operation.
5. The calibrated 'dip-stick' supplied with the distributor is used to measure the volume of binder in the tank at the start of the day's work and temperature of the binder is also noted. The range of the spraying temperature for the binder is normally 140 ^{0}c-170 ^{0}c
6. The supervisor instructs the distributor crew on the spray rate required, the corresponding road speed.
7. The chipping crew loads the tipper with chippings and the tipper line up ready to follow the distributor at the location specified by the supervisor. The rollers also prepare to follow the distributor after the chipping tipper.
8. The road is thoroughly swept and road furniture such as manhole covers, reflective studs etc, is masked so as to prevent contamination with binder.
9. Cut-off sheets of paper or other material are placed at the beginning and end of the spray run. The supervisor checks that the road is in fit condition for spraying and that laboratory staff, if present, are ready to do tray tests.

10. The burners on the distributor are extinguished and the distributor is positioned at the beginning of the spray run.
11. The driver adjusts the guide chain, the fifth wheel if available is lowered to the ground, and the height of the spray bar is adjusted.
12. The distributor then commences the spraying run, the cut-off sheets being removed immediately the distributor passes to avoid contamination of the wheels of the chip spreader or tipper lorries.
13. Spray runs will be limited to 300 meter length initially until the Contractor demonstrates his ability to plan and execute long length.
14. Laboratory technician team who are ready for the measurement of the bitumen spray rate will place the tray as spraying proceed and determine the actual spray rate
15. The chip spreader, tippers and the rollers should follow closely behind the distributor.
16. During spraying all passing traffic shall be stopped. If spray jets block, or the chipping spreader stops or any other event occurs which may affect the surface treatment process, then the spray bar operator immediately shall stop spraying. When the defective equipment or operation is rectified, spraying may restart with the Engineer's approval.
17. A strip of binder 150mm wide is left un-chipped at the edge of the lane to allow for the overlap of the adjacent run of the distributor.
18. A tipper and crew should move slowly over the new dressing, spreading chippings by hand shovels on areas where there is a deficiency of chippings.
19. The roller shall follow directly behind the spreader and shall continue to roll at speed of approximately 8-10 Kph, so as to provide minimum 6 passes over the entire treated area. Each pass shall overlap the previous pass by minimum half width of roller rolling shall be continued until all cover aggregate particle are firmly bedded.
20. Tyres shall be kept in good condition and be kept clean and smooth to avoid pick-up of bitumen and chippings.
21. After 6-8 passes of the roller and back- chipping if needed, traffic can be allowed to pass at reduced speed on the new dressing; the remainder of the road is then surface dressed, with the second and other passes (if required) overlapping the 150 mm.
22. The distributor shall be dipped and the binder temperature recorded before and after each spray run and spray length and width recorded on approved record sheets. The hot application rate shall be calculated and recorded and checked against the specified rate.
23. The calculated actual rate shall not vary by more than ± 5% from the specified rate. The actual quantity of binder sprayed corrected to 15.6oC shall be calculated.
24. Speed control and other traffic warning signs are left in position along the length of the new surface dressing.
25. Above process is repeated for the new run.
26. At the completion of the day's work the distributor spray bar is cleaned, all vehicles and plant refueled and lubricated and the supervisor checks that the bitumen heaters are loaded ready to supply the binder require for the next day.

5.7 Safety and Maintenance

Bitumen heating, pumping and spraying operations shall be entrusted only to personnel who have been adequately trained and who are competent in the use of the relevant equipment. Unauthorized personnel shall not be allowed to remain in the vicinity during the above operation. Authorized personnel shall be provided and required to wear, suitable clothing i.e. overalls, heatproof gloves, boots, helmets and goggles.

The binder shall be introduced into the distributor at a temperature equal to or just above spraying temperature after preheating in separate tanks fitted with burners and circulating pumps for this purpose. The capacity of decenters / preheating tank shall be sufficient to preheat the binder required for the full day's work. The distributer burners shall be used only to make relatively small adjustment to the binder temperature and small not be used to raise the binder from ambient to spraying temperature. Under no circumstances shall distributor burners be operated during the spraying operation, or when the level of binder in the tank is less than 150 mm over the top of the flues, or when the distributor is moving. The need for end of day maintenance of the distributor is emphasized to reduce fire risk and to ensure its adequate performance when next used for binder application. Maintenance of all equipment for the surface dressing operation shall be under the control of a competent senior mechanics, approved by the Engineer and fully experienced in the maintenance of all equipment and in the calibration of the bitumen distributor The spray bar shall be maintained in a clean condition externally and shall be purged of binder by blowing with air or by diesel flushing when spraying is suspended for length periods and always at the end of each day's work.

5.8 Traffic control and after care

The Contractor shall erect temporary traffic restriction signs, barriers and removable bumps or any other device to prevent vehicles traveling too fast over the newly laid surface dressing. Vehicle speed shall be restricted to a maximum of 30 km/h, until there is sufficient adhesion to ensure that the chippings shall not be dislodged by faster vehicles.

Where possible, the traffic shall be distributed across the road so as to obtain uniform polishing of the road surface.

After-care is an essential part of the surfacing process and consists of removing excess chippings within 24 to 48 hours of the construction of a dressing. Some of the excess chippings will have been thrown clear by passing vehicles but some loose chippings will remain on the surface and these are a hazard to windscreens and, hence, a source of public complaint. They can be removed by brooming or by purposed-made suction cleaners. Care must be taken with brooming to avoid damage to the new dressing and it is usually best to do this work in the early morning when the surface dressing binder is still relatively stiff.

It is Important to stress that over-chipping can reduce the quality of a dressing, make after-care a more time consuming process and also unnecessarily increase costs.

5.9 Second layer

Where a second surface dressing is specified, the first surface dressing shall be left open to traffic for a minimum period of 21 days and preferably a longer period before applying the second surface dressing unless special approval is obtained from the Engineer for a shorter period. Surplus chippings shall be removed by firm hand brooming or power brooming before applying the second surface dressing.

The nominal size of chipping selected for the second layer should preferably have an ALD of not more than half that of the chippings used in the first layer. This will promote good interlock between the layers.

5.10 Rectification of defects

If any defect in surface dressing work is found, the reasons of the defect shall be established and keeping them in view the defect shall be rectified as per direction of the Engineer. If required, the Engineer shall ask the contractor for redoing the defective portion. The Contractor shall rectify or redo the defective work at his own expense.

5.11 Tolerance

The final average overall width of the surface dressing measured at six equidistant points over a length of 100 m shall be at least equal to the width specified or instructed. At no point shall the distance between the centreline of the road and the edge of the surface dressing be narrower than that instructed by more than 13 mm.

The actual rate of application of binder across the lane width shall not by more than ± 5% of the rate ordered and for each single run of the spray it shall not vary from the specified rate by more than 0.03 lit/m^2.The actual rate of application of chipping along and across the lane width for each single run of the chip-spreader shall not vary by more than ± 5% of the rate ordered.

5.12 Testing

Routine inspection and testing shall be carried out to test the materials and workmanship for compliance with the requirements specified.

Any materials or workmanship not complying with the requirements specified, shall be replaced or redone with the materials or workmanship complying with the Specifications or, be repaired so as to comply with the requirements specified. The minimum testing frequency required for the process control shall be as given in the table

Table 14 Testing Frequency[7]

Test	Frequency
Bitumen (as mentioned in table 5)	One set of test for each 50000 litres of supply or part of it
LAA/AIV	For each new source and in every 200 cum or part of it
Combine Elongation and Flakiness Index	For each new source and in every 100 cum or part of it
Coating and Stripping of Aggregate mix	One test per source and whenever there is change in quality of aggregate within the source.*
Sodium Sulphate Soundness or Magnesium Sulphate soundness	
Polishing stone Value	
Water absorption of Aggregate	
Grain size analysis	Two test per day/ once per 250 cum
Rate of application of Chipping and Binder	Three test per day or 1 test per 5000 sqm
Temperature of Binder	At regular Interval

[7] As per standard Specification for Road and Bridge 2073 2nd Amendment 2078

5.13 Measurement

Each coat of surface dressing shall be measured as finished work for the area instructed to be covered, in square metres. Binding material (emulsion/bitumen, Anti-stripping agent, cutter etc. if applicable) shall be measured for adjustment as follows;

a. Design/instructed rate of application time's specified area sprayed computed in litre corrected to 15.6 °C after deduction of cutter and anti-stripping agent component.

b. Actual rate of application measured through tray tests times specified area sprayed, computed in litre corrected to 15.6°C. after deduction of cutter and anti-stripping agent

c. However, if the rate of actual spray of binder is deviate more than 10 % than the designed/ instructed rate of spray so as to impair quality of surface dressing, the Engineer shall reject the work or shall ask for appropriate rectification which the contractor shall execute at his own cost.

d. Cover aggregate (Chipping) of each nominal size shall be measured as finished work in sq.m.

e. Anti-stripping agent and Cutter shall be separately measured in litre.

f. For temperature correction following equation from ASTM D 4311-04 shall be used

$A= 1.0094684142(6.33413410744*104*T)+(1.45710416212*10-7*T^2)$

Where

A= volume correction factor

T (°c)= temperature of binder

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7 APPENDIX

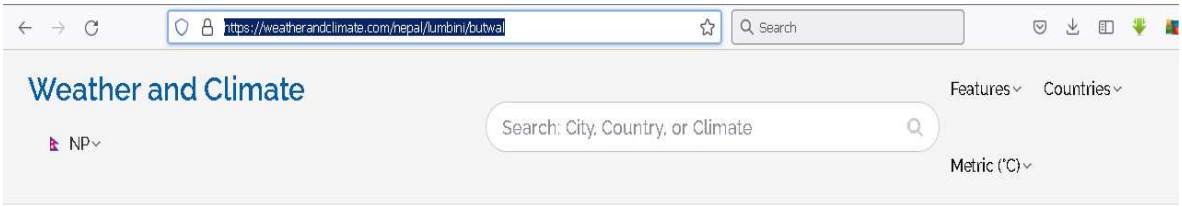
7.1 Appendix -1 Sample Calculation

1. Determination of the Viscosity Grade of bitumen based on Table -4

Location: Butwal

Determine the monthly average max and minimum temperature. For this we can use any data base. Here we use the data available in https://weatherandclimate.com/nepal/lumbini/butwal

Data for the butwal is as follows



Climate Butwal: Weather By Month

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Nov	Oct	Dec	Year
Record high °C (°F)	32.09 (89.76)	37.44 (99.39)	43.86 (110.95)	48.14 (118.65)	49.21 (120.58)	50.28 (122.5)	44.93 (112.87)	42.79 (109.02)	41.72 (107.1)	41.72 (107.1)	36.37 (97.47)	33.16 (91.69)	50.28 (122.5)
Average high °C (°F)	25.17 (77.31)	29.1 (84.38)	35.31 (95.56)	40.7 (105.26)	42.93 (109.27)	42.18 (107.92)	37.2 (98.96)	37.26 (99.07)	36.16 (97.09)	34.71 (94.48)	31.05 (87.89)	26.62 (79.92)	34.86 (94.75)
Daily mean °C (°F)	21.4 (70.52)	25.43 (77.77)	31.75 (89.15)	37.15 (98.87)	39.49 (103.08)	39.34 (102.81)	34.97 (94.95)	35.09 (95.16)	33.89 (93.0)	31.95 (89.51)	28.0 (82.4)	23.19 (73.74)	31.8 (89.24)
Average low °C (°F)	15.39 (59.7)	18.47 (65.25)	23.29 (73.92)	27.96 (82.33)	31.07 (87.93)	32.48 (90.46)	30.49 (86.88)	30.32 (86.58)	29.01 (84.22)	26.48 (79.66)	22.31 (72.16)	17.54 (63.57)	25.41 (77.74)
Record low °C (°F)	10.7 (51.26)	10.7 (51.26)	13.91 (57.04)	21.39 (70.5)	24.6 (76.28)	19.25 (66.65)	24.6 (76.28)	25.67 (78.21)	22.46 (72.43)	20.32 (68.58)	17.12 (62.82)	9.63 (49.33)	9.63 (49.33)
Average precipitation mm (inches)	9.5 (0.37)	16.71 (0.66)	8.94 (0.35)	15.26 (0.6)	32.88 (1.29)	147.06 (5.79)	543.42 (21.39)	346.24 (13.63)	207.84 (8.18)	29.77 (1.17)	1.55 (0.06)	4.04 (0.16)	113.6 (4.47)
Average precipitation days (≥ 1.0 mm)	1.55	1.85	2.04	3.02	4.96	12.64	23.24	18.67	14.39	2.62	0.59	0.59	7.18
Average relative humidity (%)	50.84	45.34	31.03	27.34	33.83	46.42	70.23	69.85	70.88	60.48	54.82	53.82	51.27

Average High is 42.93 and is in the month of May and average low is 15.39in the month of January

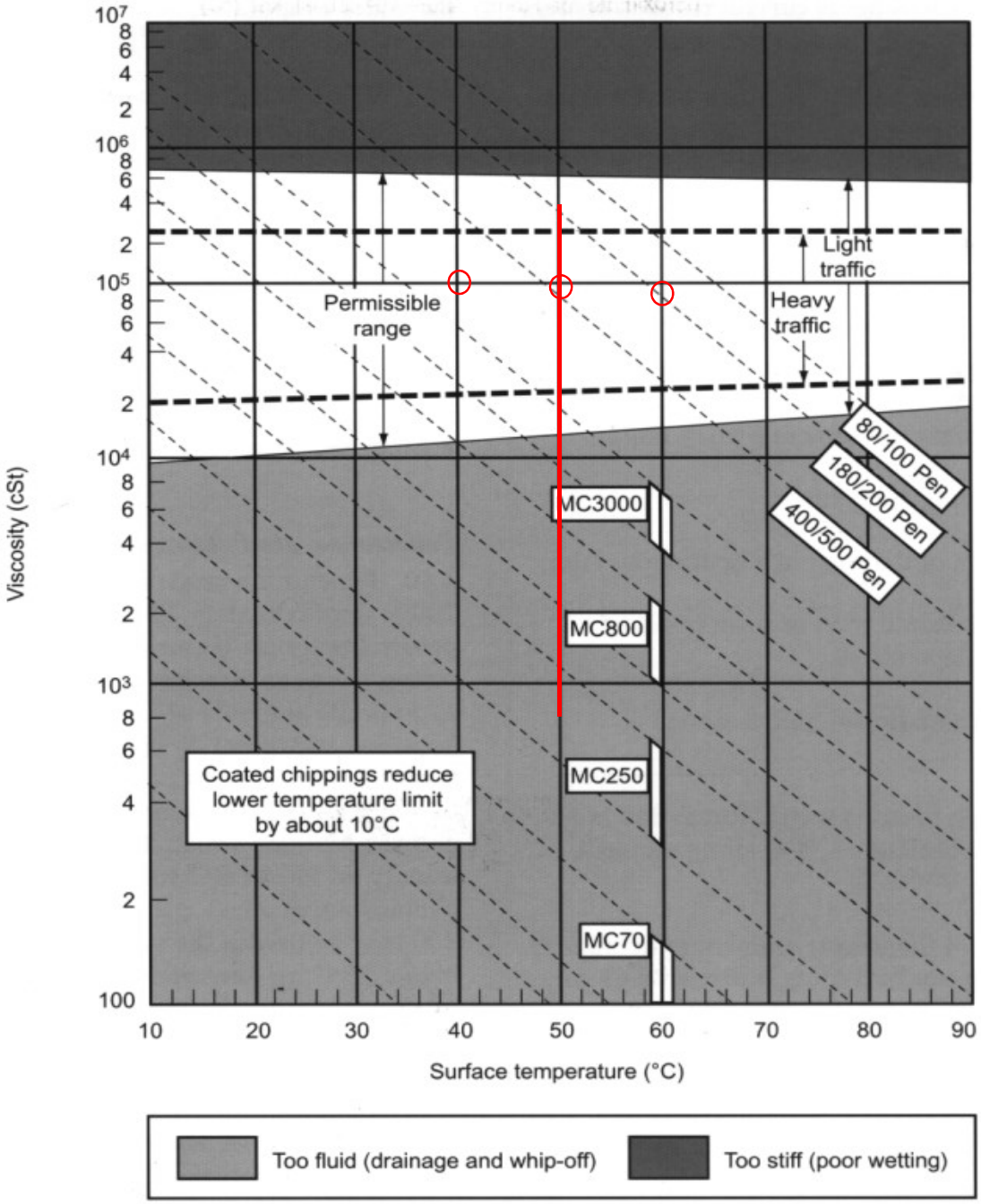
From the table below the viscosity grade of the bitumen to be used in the bituminous works is VG30

Lowest Daily Mean Air Temperature, °C	Highest Daily Mean Air Temperature, °C		
	Less than 20°C	20 to 30°C	More than 30°C
More than -10°C	VG-10	VG-20	VG-30
-10°C or lower	VG-10	VG-10	VG-20

2. Determination of binder type required based on surface temperature

Now after determination of the viscosity grade of the base bitumen depending upon the surface temperature at the time of the construction cutter shall have to be added to obtain the required viscosity as discussed in section 3.3

Suppose the surface temperature during the laying of surface dressing at Butwal is 50 degree



Based on the above graph the base bitumen VG 30 grade bitumen shall have to be cutback to 400/500 penetration in order to have the viscosity in the permissible range.

Amount of the cutter required for cut back the VG 30 grade bitumen to 400/500 penetration shall have to be determined in the laboratory.

3. Determination of the binder spray rate

Overall Weighting Factor, F	8.00	Refer Section 3.1.3
Average Least Dimension, ALD, mm	12.00	Refer Section 3.1.2
R = 0.625+ (F*0.023)+ [0.0375 + (F*0.0011)]*ALD		
(A) Spray Rate (R), for MC 3000 l/m²	*1.365*	Refer Equation (2)
*(B) Required Bitumen , R l/m2 (B= 0.9*A)*	*1.228*	
(C) For surface temperature of 50 degree Centigrade required binder	*400/500 pen*	
(D) Base bitumen	*VG 30*	
(E) Cutter (% bitumen)	*6.00%*	*Assumed* ***(to be determined in lab)***
*(F) Cutter l/m² (B*E)*	*0.0737*	
(G) For estimate purpose		
(G.1) Bitumen l/m²	*1.2281*	
(G.2) Cutter l/m²	*0.0737*	
For Field Spray rate Calculation		
(H) Spray temperature say	*170.00*	*Assumed*
(I) Temperature Correction Factor for H A=1.0094684142(6.33413410744*104*T)+(1.45710416212*10-7*T²) Where A is temperature correction factor and t is the binder temperature in °C	*0.9060*	
(J) Rate of spray including cutter (l/m²(B+G.2)/I)	*1.4369*	

4. Determination of the chipping spray rate

Average Least Dimension, ALD	*12.00*
Chipping Application Rate, Kg/m²	*16.36*
Chipping Application Rate, Kg/m² (including 10% whip-off)	18.02

It is advisable to have in hand the percentage of cutter for three possible temperatures that may encountered during the surface dressing.

For Butwal it is advisable to determine the percentage of cutter for cutback the VG 30 to 500/600 penetration (40 degree surface temperature), 400/500 penetration (50 degree surface temperature) and 180/200 penetration (60 degree surface temperature)

7.2 Appendix -2 Frequently Asked Questions (FAQs) regarding Surface Dressing

1. **What is surface dressing?**

   Surface dressing is a simple, highly effective and inexpensive road surface treatment. Surface dressing comprises a thin film of binder which is sprayed onto the road surface and then covered with a layer of stone chippings.

2. **Why surface dressing?**

   Surface dressing is a very effective maintenance technique, which is capable of greatly extending the life of structurally sound road pavement if the process is undertaken at the optimum time. Surface dressing can also provide an effective and economical running surface for newly constructed road pavements.

   Surface dressing as a maintenance process has three major aims:

   - To provide both texture and skid resistance to the road surface;
   - To stop the disintegration and loss of aggregate from the road surface; and
   - To seal the surface of the road against the ingress of water and, thus, protect its structure from damage resulting therefrom.

3. **How does the surface dressing work?**

   The thin film of binder used in surface dressing works as a waterproofing seal preventing the entry of surface water into the road structure. The stone chippings protect this film of binder from damage by vehicle tyres and form a durable skid resistant and dust free wearing course. The success of surface dressing depends primarily on the adhesion of the chippings to the road surface, hence the chippings and the road surface must be clean and free from dust during the surface dressing process. Inappropriate specifications, poor materials, and bad workmanship can also drastically reduce the service life of a surface dressing.

4. **What are the different types of surface dressings?**

   Surface dressing can be constructed in different ways. The most common ones are: Single Surface Dressing; Double Surface Dressing;

5. **Can surface dressing be done on road with any AADT?**

   Yes. Surface dressing can be done on road with any number of AADT. Total traffic volume is one of the factors in the design of the surface dressing.

6. **What are the criteria for the selection of aggregate size in surface dressing?**

   The size of aggregate for the first layer is based on the hardness of the existing surface and the traffic (Commercial vehicles). The nominal size of chippings selected for the second layer should preferably have an ALD of not more than half that of the chippings used in the first layer. This will promote good interlock between the layers.

7. **What is ALD of aggregate? How is it measured?**

   It is the average least dimension of the aggregate. It is a function of both the average size of the chipping and the degree of flakiness. It may be determined in two ways: From a nomograph or by actually measuring the least dimension of aggregate manually.

8. **What percent of cutter is used in the preparation of cut back bitumen when surface dressing?**

   The primary functions of the binder are to: "wet" the surface of the road in a continuous film; "wet" and adhere to the chippings at road temperature; be strong enough to resist traffic forces and hold the chippings at the highest prevailing ambient temperatures. For this, the viscosity of the binder is of prime importance. Therefore, to attain the required viscosity, and depending upon the road temperature, it can be in between 2–14 percent and shall be determined in the laboratory.

9. **What happens if the chippings used are too small or too large?**

   The use of chippings that are too small will result in early embedment of the chippings into the surface leading to a rapid loss of texture depth and, in worst case, " fatting up " of the binder, which may cover the entire surface of the road. The use of too large a chipping may result in immediate failure of the treatment due to stripping of the binder from the aggregate under the applied stresses of the traffic.

10. **What are the different types of surface dressing failure?**

    The majority of surface dressing failures fall into one of the following five categories:

    - Loss of chippings immediately or soon after laying
    - Loss of chippings during the first winter
    - Loss of chippings in later years
    - Bleeding during the first hot summer
    - Fatting up in subsequent years.

11. **Can surface dressing can be used on any type of road?**

    Yes, this can be used as a maintenance treatment for roads of all kinds.

12. **Can crushed aggregate be used for surface dressing?**

    Ideally, chippings used for surface dressing should be single sized, cubical in shape, clean and free from dust, strong, durable, and not susceptible to polishing under the action of traffic. Chippings available from crushing often fail to meet all of the above criteria and if such chips are available which meet the set criteria then the crushed chips can also be used in surface dressing.

13. **What are the different criteria for the selection of surface dressing type?**

    Selection of surface dressing type depends upon the function required.

    Single Surface Dressing: As a maintenance activity on existing bituminous road surface to re-seal the road surface, arrest deterioration and to restore skid resistance. This is normally not adequate for a new road base.

    Double Surface Dressing: On new road base as wearing course, as extra cover on an existing bituminous road surface where the road surface is cracked or patched.

14. **How does the wear of vehicle tyres travelling on DBST compare with that on asphalt concrete (AC)?**

    Tyre wear would probably be greater on DBST; however, surface texture is vital, especially in the wet season and the smoother surface of AC is not necessarily as safe as DBST.

15. For Nepal roads what surface do you recommend, out of AC,DBST and SBST?

There is no single choice; treatments depend on the result required. AC is needed, usually, for heavily trafficked roads and partly to provide additional pavement strength. SBST is a periodic maintenance process. DBST, which is more costly than SBST, is often used for rehabilitation works.

16. What precautions are needed to maintain distributor nozzles in good condition?

Avoid mechanical damage (eg. Inserting steel wire to clean blockage) but mainly to flush bar thoroughly at the end of days work using diesel, not kerosene.

17. When bleeding occurs due to over-spraying, what is the remedy?

The usual remedy is to apply crusher waste (crusher dust) or possibly roll in un- coated chippings, if severe. Otherwise try to heat and scrape-off excess bitumen and apply crusher dust (DO NOT use sand).

18. How can the bitumen rate of spread be controlled in hilly areas (steep slopes)?

Rate of spread should not be a problem on steep slopes if using hot bitumen of correct viscosity. Problems would probably be experienced however if using emulsion which has a very low viscosity. (It is assumed that the bitumen distributor can move up hill at a constant speed).

19. How many passes of the roller are needed in SBST/DBST and how to determine if these are sufficient?

Usually 6 to 8 passes of the PTR are sufficient; the only practical guide is experience! (Back-rolling is always beneficial, equally the action of traffic!).

20. Is it necessary to wash chippings if they are also to be pre-coated?

If washing is done to remove dust then pre-coating is not needed. If pre-coating is specified then washing is normally unnecessary unless aggregate is very dirty.

21. How does crack-sealing prior to surface dressing affect surface condition with regard to the bitumen condition?

This is of relevance in designing surface dressing; the "Existing Surface" condition will probably be "Very Rich Bituminous". Thus extra bitumen arising from crack sealing will be adjusted in the design process.

22. For DBST, what is the relation between the chipping size of first and second seal?

The second seal nominal size is roughly half that of the first. However different size can be used depending upon the requirement.

23. What methods can be used to avoid bitumen overlapping at longitudinal joints due to half spray of end nozzles?

This is a common problem which arises from constructing a road in two halves longitudinally. A butt joint is inevitable (first half of road is already sprayed with SBST). If a half nozzle (special type) is not used then the answer is to mask the existing first seal using polythene, cardboard etc. to enable a butt joint to be sprayed.

24. Explain what is meant by 'damp' aggregate (when used in surface dressing).

The condition 'damp' is a visual assessment; the stone is visibly darker than in the dry condition but a shiny film of water cannot be seen.

25. Explain what is meant by 'Constant Pressure' and 'Constant Volume' distributors?

On a constant pressure distributor the bitumen pump maintains a constant pressure at the sprayer bar which is independent of the number of nozzles in use. Hence the quantity of bitumen passing each nozzle (per minute) is constant (Spray rate is related to the distributor speed). On a constant volume machine the volume (delivered per minute) has to be selected in advance, so that the required quantity per nozzle (per minute) can be obtained. The pump output has to be related to spraying width, spray rate required and distributor speed.

26. What is the importance of the Depot Tray Test (for bitumen distributor)?

The depot Tray Test is needed to ensure that the spray bar applies bitumen uniformly along its length (transverse distribution). Failure to achieve this will produce streaking in the completed seal. Streaks of bitumen-rich and bitumen- deficient dressing can occur, the latter leading to loss of aggregate.

7.3 Appendix -3 Tentative run length determination at field

SN	Description	Value	Remarks
a	Run Width, m	3	
b	Roller Speed, m/min	83	(5Km/hr)
c	Roller Width, m	2	
d	To &from efficiency factor	0.9	
e	Road gradient factor	0.9	(if road grade is more than 5%) assumed
f	Chips spreading factor	0.8	(For Manual gap filling) assumed
g	Acceptable Rolling completion time, min	20	(max. 20 min) assumed
h	No. of Pass in one direction to cover run width	2	
i	Total No. of pass	12	
j	**Maximum length of run (m)**	**90**	**b x f x d x e x g / i**

7.4 Appendix -4 Sample Calibration of Distributer

Road Sector Development Project

First Year Periodic Maintanance Program

Road : Sample Calibration of Distributer Date : .....

Contractor :

A) Nozzle Discharge of distributor :-

Type of binder :- Cutback bitumen (Cutter .....%)

S.No.	Nozzle No.	Time (Sec)	Nozzle Discharge (gm)	Discharge (gm/min)	Remarks
1	(1+2)	15.0	5970.00	23880.00	
2	(3+4)	15.0	5790.00	23160.00	
3	(5+6)	15.0	5990.00	23960.00	Pressure During
4	(6+7)	15.0	5930.00	23720.00	Spraying = 40 psi
5	(8+9)	15.0	5930.00	23720.00	
6	(10+11)	15.0	5700.00	22800.00	Temperature of
7	(12+13)	15.0	5745.00	22980.00	Binder during
8	(14+15)	15.0	5610.00	22440.00	Spraying = 60ºC
9	(16+17)	15.0	5770.00	23080.00	
10	(18+19)	15.0	5835.00	23340.00	
11	(20+21)	15.0	6150.00	24600.00	
12	(22+23)	15.0	5835.00	23340.00	
13	(24+25)	15.0	6095.00	24380.00	
			Average Discharge =	23492.31	gm per 2 nozzles
				11746.15	gm per nozzle per min.
				11.75	Kg per nozzle per min.

B) Transverse Distribution Check :-

Min Discharge (Nozzle No.) =	22440.00 (14+15)	gm/min
Max Discharge (Nozzle No.) =	24600.00 (20+21)	gm/min
Therefore, Variation =	8.78	%
	which is less than 10%	

C) Spray Rate Calibration :-

Description	Priming	Surface Dressing
Type of Distributor :-	Constant Pressure	Constant Pressure
Machine Make :-	PHOENIX	PHOENIX
Capacity :-	8000.0 ltrs	8000.0 ltrs
Type of Spray Jet :-	Whirling (Atomising Jets)	Whirling (Atomising Jets)
Specific Gravity :-	0.9	1.02
Target Spray Rate :-	1.0 ltr/sqm	1.02 ltr/sqm
	0.9 kg/sqm	1.04 kg/sqm
No. of Nozzle opening :	12	24
Bar Width	1.75	3.50
Total Discharge :-	141.0 kg/min	281.9 kg/min
Target Speed =	Total discharge / Target Spray Rate x Bar Width	Total discharge / Target Spray Rate x Bar Width
=	**5.37 Km/hr**	**4.65 Km/hr**