Specification Requirement for Dense Graded Bituminous Mixes (DBM/BC)

Er. Prabhat Kumar Jha
Senior Divisional Engineer
9841360244
geoprabhat@gmail.com
https://techwingdor.blogspot.com/

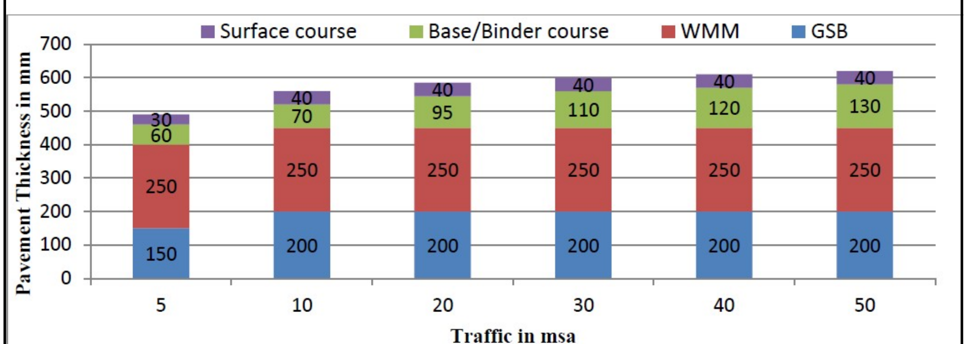


Figure 12.2 Catalogue for pavement with bituminous surface course with granular base and sub-base - Effective CBR 6% (Plate-2)

Plate in IRC 37:2018 : DBM for all case

Government of Nepal

Ministry of Physical Infrastructure and Transport

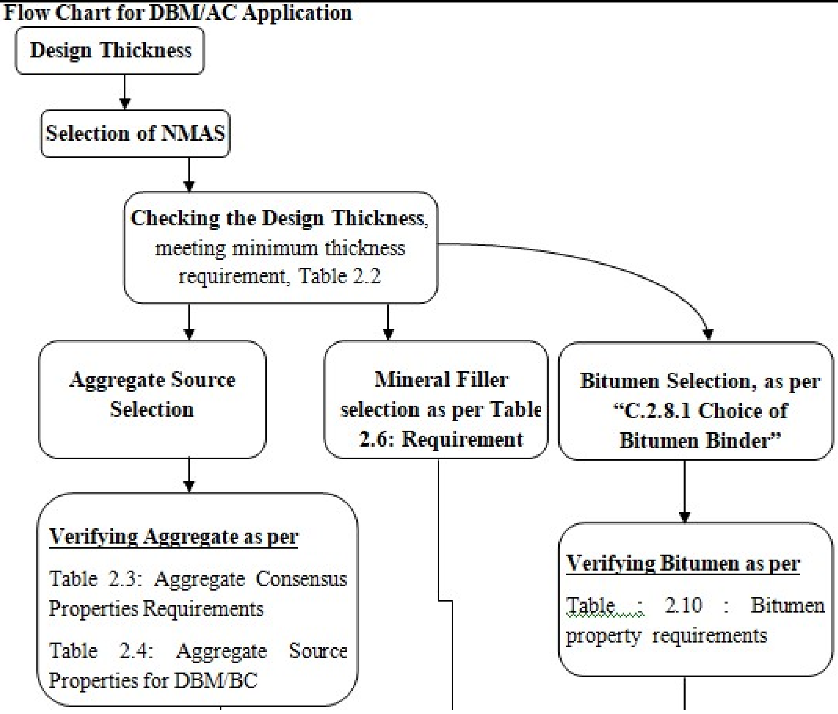
Department of Roads

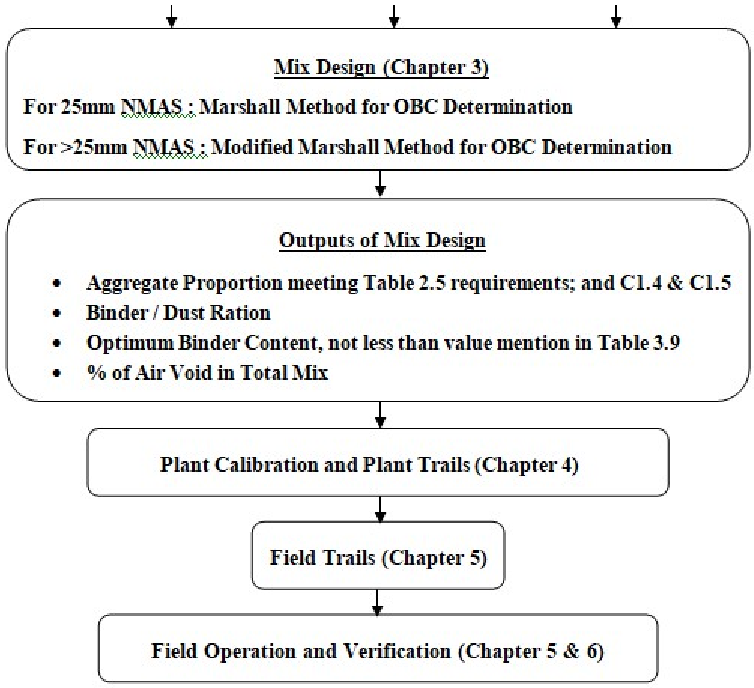
Maintenance Branch

Manual for Dense Graded Bituminous Mixes (DBM/BC)
(Final)

2018

Flow Chart for DBM/AC Application





Theoretical maximum specific gravity of an asphalt mixture (G_{mm}) is not determined by any mix designer,

resulting error in calculation of
effective specific gravity of the aggregate G_{se}

causing faulty
% Air Void (Pa)
% VMA &
% VFA calculation.

Thus, the mix design practicing is wrong.

Table 2.2: The limits on permissible lift thickness with reference of IRC :111:2009, Specification for Dense Graded Bituminous Mixes and the New York State Highway Design Manual

Specification	Purpose	No. of Layers	Minimum lift thickness	Maximum lift thickness
DBM	Base/Binder Course. Overlay for Strengthening	Single or Multiple	For NMAS 35.5mm : 100mm For NMAS 26.5mm: 75mm	For NMAS 35.5mm : 150mm For NMAS 26.5mm: 150mm
Bituminous Concrete(BC)/	Wearing Course	Single	For NMAS 19mm : 60mm For NMAS 13.2 mm: 40mm	For NMAS 19mm : 75mm For NMAS 13.2 mm: 50mm

Table 2.3: Aggregate Consensus Properties Requirements

Design ESALs[1] (In Millions)	Coarse Aggregate Angularity (CAA) (Percent), minimum		Un-compacted Void Content of Fine Aggregate Angularity (FAA) (Percent),		Sand Equivalent (SE) (Percent), minimum	Flat and Elongated[3] (F&E) (Percent), maximum
	≤100 mm	> 100 mm	≤100 mm	> 100 mm		
< 0.3	55/-	-/-	-	-	40	-
0.3 to < 3	75/-	50/-	40	40	40	10
3 to < 10	85/80[2]	60/-	45	40	45	10
10 to < 30	95/90	80/75	45	40	45	10
≥30	100/100	100/100	45	45	50	10

Table 2.4: Aggregate Source Properties for DBM/BC

Property	Test	Specification	Method of Test
Deleterious materials: Cleanliness (dust)	Grain size analysis	Max 5% passing 0.075 mm sieve	IS:2386 Part I
Toughness/Strength	Los Angeles Abrasion Value or Aggregate Impact Value	DBM : Max 35% BC : Max. 30% DBM: Max 27% BC : Max. 24%	IS:2386 Part IV
Durability	Soundness either: Sodium Sulphate or Magnesium Sulphate	Max 12% Max 18%	IS:2386 Part V
Polishing	Polished Stone Value	Min 55	BS:812-114
Water Sensitivity	Retained Tensile Strength*	Min 80%	AASHTO 283
Water Absorption	Water Absorption	Max 2%	IS:2386 Part Ill
Stripping	Coating and Stripping of Bitumen Aggregate Mix	Minimum retained coating 95%	IS: 6241

Table 2.5: Gradation requirement

Composition for	BC		DBM	
Nominal Maximum aggregate size(NMAS)	13.2 mm	19 mm	26.5 mm	35.5 mm
Gradation Type	(Ref. Table1.1)			
IS Sieve (mm)	Cumulative % by weight of total aggregate passing			
45				100
37.5			100	95-100
26.5		100	90-100	63-93
19	100	90-100	71-95	-
13.2	90-100	59-79	56-80	55-75
9.5	70-88	52-72	-	-
4.75	53-71	35-55	38-54	38-54
2.36	42-58	28-44	28-42	28-42
1.18	34-48	20-34	-	-
0.6	26-38	15-27	-	-
0.3	18-28	10-20	7-21	7-21
0.15	12-20	5-13	-	-
0.075	4-10	2-8	2-8	2-8

To avoid gap grading, the combined aggregate gradation should not vary from the lower limit on one sieve to higher limit on the adjacent sieve.

Sample MD-Report

Mix Design Test Results by Marshall Method

Type: Dense Bituminous Macadam

A. Sieve analysis test results of the provided samples.

Sieve Size mm	Cumulative % Passing			
	25 mm down%	16 mm down%	10 mm down%	Dust
26.5	100.0	100.0	100.0	100.0
19.0	29.6	100.0	100.0	100.0
13.2	0.0	41.4	100.0	100.0
4.75	0.0	0.2	2.5	97.7
2.36	0.0	0.0	0.4	89.9
0.3	0.0	0.0	0.0	39.2
0.075	0.0	0.0	0.0	18.2

B.Sieve analysis of the mix aggregate for asphalt concrete.

Sive size(mm)	18	18	25	39	100	Specification Limit
	(%)	(%)	(%)	(%)	Total % Passing	
26.5	18.0	18.0	25.0	39.0	100.0	90-100
19.0	5.3	18.0	25.0	39.0	87.3	71-95
13.2	0.0	7.5	25.0	39.0	71.5	56-80
4.75	0.0	0.0	0.6	38.1	38.8	38-54
2.36	0.0	0.0	0.1	35.1	35.2	28-42
0.3	0.0	0.0	0.0	15.3	15.3	7-21
0.075	0.0	0.0	0.0	7.1	7.1	2-8

Aggregate % Mix Proportion:

25 mm down aggregate = 18.0 %
16 mm down aggregate = 18.0 %
10 mm down aggregate = 25.0 %
Filler material (dust) = 39.0 %

Specific Gravity of Provided Aggregates.

Sp.Gr. Of 25 mm = 2.623
Sp.Gr. Of 16 mm = 2.500
Sp.Gr. Of 10mm = 2.564
Sp.Gr. Of dust = 2.685
SP.Gr.Of Bitumen= 1.018

Marshall Test Results:

(Bitumen Used 60/70 Grade Bitumen

Proposed Optimum Bitumen Content After Marshall Design Test by Weight of Total Aggregate Mixture = 4.83 %

Stability at 4.8% bitumen content=14.22 KN
Air voids at 4.8 % bitumen content=3.5%
VMA at 4.8 % bitumen content=15.15 %
Density at 4.8 % bitumen content=2.340 g/cc
Flow value at 4.8% bitumen content=3.00

C2.8 Bituminous Binder

C.2.8.1 Choice of Bitumen Binder

a) As per IS 73:2013

Bitumen shall be classified into four grades based on the viscosity, and suitability recommended for maximum air temperature as given below:

Table 2.7: Recommended Bitumen based on maximum air temperature

Grade (1)	Penetration (2)	Suitable for 7 day Average Maximum Air Temperature, °C (3)
VG10	80-100	< 30
VG20	60-80	30-38
VG30	50-70	38-45
VG40	40-60	> 45

NOTE — This is the 7 day average maximum air temperature for a period not less than 5 years from the start of the design period.

b) As per DoR Specification:

Selection criteria for viscosity grade bitumen, based on highest and lowest daily mean temperatures at a particular site, Table 2.8.

Table 2.8: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

Highest Mean Temp : May or June

Lowest Mean Temp : January

S.No	Traffic Level	Surface course		Base/Binder Course	
		Mix type	Bitumen type	Mix type	Bitumen type
1	>50 msa	SMA	Modified bitumen or VG40	DBM	VG40
		GGRB	Crumb rubber modified bitumen		
		BC	With modified bitumen		
2	20-50 msa	SMA	Modified bitumen or VG40	DBM	VG40
		GGRB	Crumb rubber modified bitumen		
		BC	With modified bitumen or VG40		
3	<20 msa[1]	BC/SDBC/PMC/MSS/ Surface Dressing	VG40 or VG30	DBM/ BM	VG40 or VG30

[1]For expressways and national highways, even if the design traffic is 20 msa or less, VG40 bitumen shall be used for DBM layers.

For snow bound locations, softer binders such as VG10 may be used to limit thermal transverse cracking (especially if the maximum pavement temperature is less than 300 C).

The original Marshall method is applicable only to hot mix asphalt paving mixtures containing aggregates with maximum sizes of 25 mm or less.

A modified Marshall method has been developed for aggregates with maximum sizes up to 38 mm. Procedures for 6-inch diameter specimen are given by ASTM D5581.

Table 3.1: Approximate asphalt content of mix, percent by weight of mix for specimen preparation, based on above equation

Nominal Maximum Aggregate Size, mm	Approximate asphalt content of mix, percent by weight of mix
13.2	5.344
19.0	4.855
26.5	4.610
35.5	4.610

(b) ***Preparation of aggregates*—**dry aggregates to constant weight at 105°C to 110°C and separate the aggregates by dry sieving into the desired size fractions. ***These size fractions are recommended:***

- 38.0-25.0 mm
- 25.0 to 19.0 mm
- 19.0 to 13.2 mm
- 13.2 to 4.75 mm
- 4.75 to 2.36 mm (No. 4 to No. 8)
- Passing 2.36 mm (No. 8)

Practice : Common ration of mix. (16-10mm agg. : 10-6mm agg. : Sand : Stone dust)

Table 3.5: Approximate Batching Proportion#

Nominal Maximum Aggregate Size,mm	Approximate Batching Proportion, %				
	Aggregate passing the size				
	38-25mm	25-19mm	19-13.2mm	13.2-4.75mm	Fine(passing 2.36mm)
13.2	-	-	-	47-59	35-47
19	-	-	16-32	45-56	22-28
26.5	-	16-27	24-33	16-33	22-27
35.5	11-22	27-43	-	16-27	27-32

All individual case should be batched to meet the table 2.5

The typical allowable range for dust to binder ratio ($P_{0.075}/P_{be}$) is 0.6–1.2, with the following exceptions: for coarse-graded mixes whose gradation plots below the Primary Control Sieve (PCS) on a 0.45 power chart, the allowable range may be increased to 0.8–1.6.

If the flow at the selected optimum binder content is above the upper specified limit, the mix is considered too plastic or unstable. If the flow is below the lower specified limit, the mix is considered too brittle. The stability and flow results are highly dependent on binder grade, binder quantity and aggregate structure.

Table 3.8 Marshall Mix Design Criteria

Marshall Method Criteria[1]	As per MS-2						As per DOR Specification	
	Light Traffic[2] Surface & Base		Medium Traffic[2] Surface & Base		Heavy Traffic[2] Surface & Base		Viscosity Grade Paving Bitumen	
	Min	Max	Min	Max	Min	Max	Min	Max
Compaction, number of blows each end of specimen	35		50		75		75	
Stability, N	3336	-	5338	-	8006	-	9000	-
Flow[3,4], 0.25 mm (0.01 in.)	8	18	8	16	8	14	8	16
Percent Air Voids[6]	3	5	3	5	3	5	3	5
Percent Voids in Mineral Aggregate (VMA)[5]	NMAS, mm		Minimum VMA, percent					
			3.0		4.0		5.0	
	13.2		13		14		15	
	19		12		13		14	
	26.5		11		12		13	
	37.5		10		11		12	
Percent Voids Filled With Asphalt (VFA)	70	80	65	78	65	75	65	75

For DBM : The minimum stability should be 2.25 times, and the range of flow values should be 1.5 times the criteria listed in Table 3.8.

notes:

1. All criteria, not just stability value alone, must be considered in designing an asphalt paving mix.
2. Traffic classifications
   Light Traffic conditions resulting in a 20-year Design ESAL < 10^4
   Medium Traffic conditions resulting in a 20-year Design ESAL between 10^4 and 10^6
   Heavy Traffic conditions resulting in a 20-year Design ESAL > 10^6
3. The flow value refers to the point where the load begins to decrease. When an automatic recording device is used, the flow should be corrected.
4. The flow criteria were established for neat asphalts. The flow criteria are often exceeded when polymer modified or rubber-modified binders are used. Therefore, the upper limit of the flow criteria should be waived when polymer modified or rubber-modified binders are used.
5. Percent voids in the mineral aggregate are to be calculated on the basis of the ASTM bulk specific gravity for the aggregate.
6. Percent air voids should be targeted at 4 percent. This may be slightly adjusted if needed to meet the other Marshall criteria.

Table 3.9 Minimum Bitumen Content

Composition for	**BC**		**DBM**	
NMAS	**19 mm**	**13.2 mm**	**26.5 mm**	**35.5 mm**
Bitumen content % by mass of total mix	Min 5.2	Min 5.4	Min 4.5	Min 4.0
Corresponds to specific gravity of aggregates being 2.7. In case aggregate have specific gravity more than 2. 7, the minimum bitumen content can be reduced proportionately. Further the region where highest daily mean air temperature is 30°C or lower and lowest daily air temperature is - 10°C or lower, the bitumen content may be increased by 0.5 percent.				

C3.10 Modified Marshall method for large aggregate

The procedure is basically the same as the original Marshall mix design method except for these differences that are due to the larger specimen size:

- The hammer weighs 10.2 kg and has a 149.4-mm flat tamping face. Only a mechanically operated device is used for the same 457-mm drop height.
- The specimen has a 152.4-mm diameter by 95.2-mm height.
- The batch weights are typically 4,050 g.

Test Report Showing Typical Lab Data for Design by the Marshall Method

Name of Project: Location: Date:

Proportion of Aggregate fractions : 38.0-25.0 mm :: 25.0 to 19.0 mm:: 19.0 to 13.2 mm :: 13.2 to 4.75 mm :: 4.75 to 2.36 mm:: Passing 2.36 mm :

Compaction : Bitumen Viscosity Grade: Sp.Gravity of Bitumen (G_b) :

Sp.Gravity of Aggregate blend (G_{sb}) Theoretical max. Sp.Gravity of mix (G_{mm}) : Effective Sp. Gravity of Aggregate (G_{se}):

Absorbed Bitumen (P_{ba}) : Specimen Diameter (in mm) :

SN	Bitumen, % (P_b)	Filler/ Dust %	Aggregate Mix, % (P_s)	**Specification Mass, gm**			Bulk Volume, cm³	Bulk S.G. of Specimen (G_{mb})	% Air Void (P_a)	% VMA	% VFA	Stability,N		Flow
				In air	In water	SSD in air						Measured	Corrected	

Chapter 4 Hot-Mix Asphalt Plant Operations

Figure 4.8 Covered aggregate stockpiles.

Figure 4.9 Horizontal stockpiles.

Plant Trials

Table 6.1 Permissible Variations in the Actual Mix from the Job Mix Formula

Description	DBM	AC
Aggregate passing 19 mm sieve or larger	± 8%	±7%
Aggregate passing 13.2 mm, 9.5 mm	±7%	±6%
Aggregate passing 4.75 mm	±6%	±5%
Aggregate passing 2.36 mm, 1.18 mm, 0.6 mm	±5%	±4%
Aggregate passing 0.3 mm, 0.15 mm	±4%	±3%
Aggregate passing 0.075 mm	±2%	±1.5%
Binder content	± 0.3%	± 0.3%
Mixing temperature	± 10°C	± 10°C

5.3 Weather limitations

It is not desirable to place HMA on wet surfaces or in weather conditions that would inhibit the proper placement and compaction of the HMA mixture. In case of following situation, laying should be suspended:

i. In presence of standing water on the surface;
ii. When rain is imminent, and during rains, fog or dust storm;
iii. When the base/binder course is damp;
iv. When the air temperature on the surface on which it is to be laid is less than 10°C for mixes with conventional bitumen and is less than 15°C for mixes with modified bitumen;
v. When the wind speed at any temperature exceeds the 40 km per hour at 2 m height.

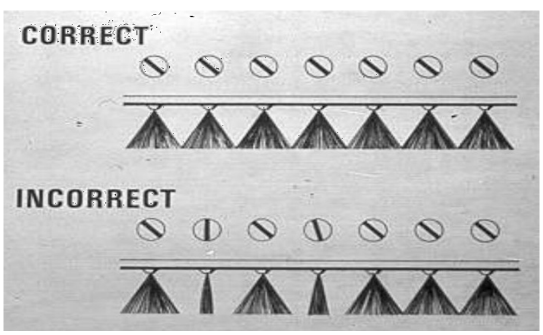
The temperature guidelines is pressented in table 5.1

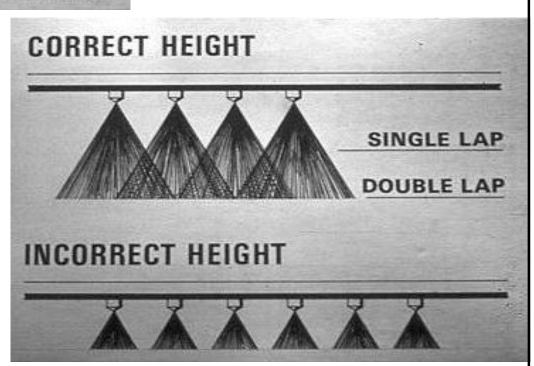
Table 5.1 Temperature and seasonal requirements

Nominal compacted lift thickness	Surface temperature minimum[1] with dry surface
• 100 mm	5ºC
• 50 mm, but <100 mm	8ºC
<50 mm	10ºC

Table 5.2 Rate of Application of Tack Coat

Type of Surface	Rate of Spray (kg/sq.m)
Bituminous surfaces	0.40-0.60
Granular surfaces treated with primer	0.50- 0.60
Cement concrete pavement	0.60-0.70





should follow the laying plant as closely as possible. The rollers should be operated with the drive roll nearest the laying plant, at a slow and uniform speed (not exceeding 5 km/h).

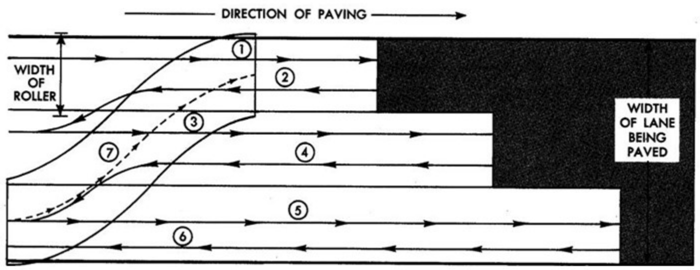
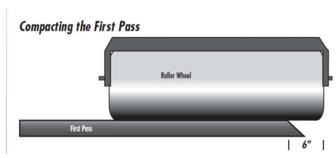


Figure 5.5 Recommended rolling pattern



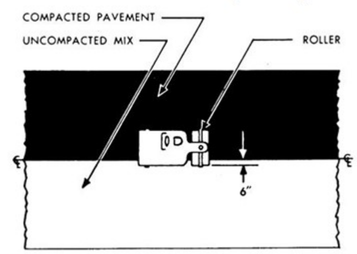


Figure 5.8 Rolling a longitudinal joint

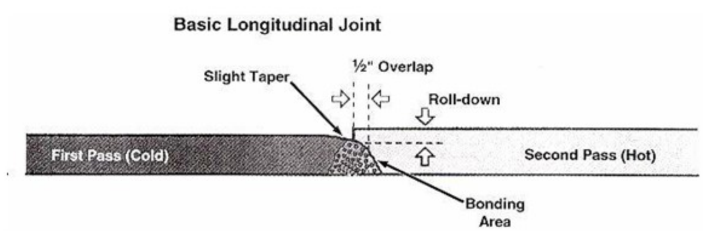
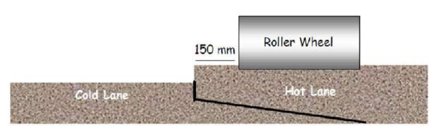
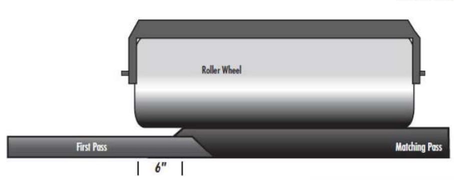


Figure 5.6 Traditional "butt" joint





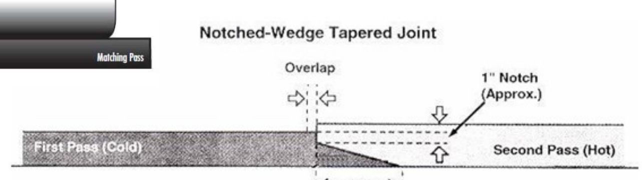


Figure 5.7 Notched wedge joint

Daily mix verification

Daily field verification tests are typically performed on random samples taken from a set quantity of material called a lot. A lot is typically a day's production or a 400 tonnage of material.

Figure 6.1 Template Placed in A Container

Figure 6.2 Sampling from a Truck Scraping Sample Off Shovel into Sample Box

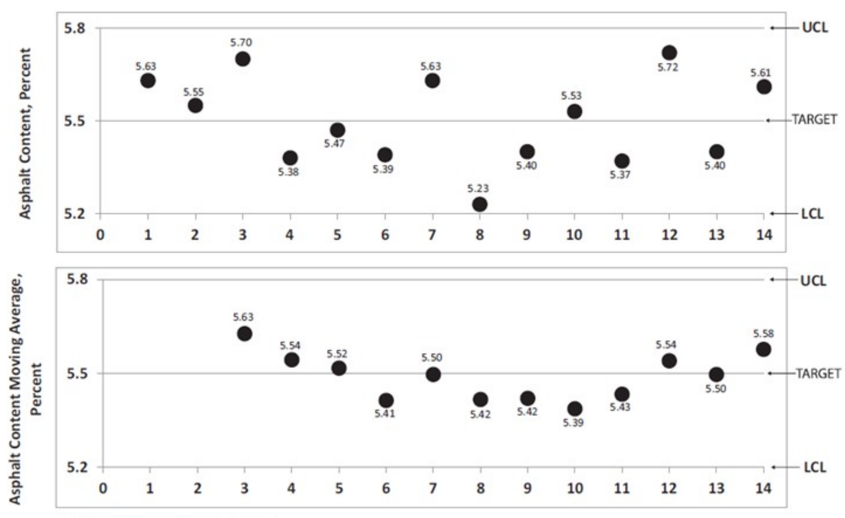


Figure 6.3 Typical mixture production quality control charts

C6.5 Density specifications

The goal of compaction is to achieve a smooth, uniform surface at optimum air voids content that ultimately determines whether the pavement will perform as expected. The in-place air voids of HMA after compaction is a very important factor that affects performance of the mixture throughout the life of the pavement. Achieving compliance with compaction specifications is the final step in the quality management of the HMA construction procedures and must be accomplished to produce a quality asphalt pavement.

The Engineer can direct additional testing as required to fulfil the requirement as specified in specification. **The acceptance criteria for tests on density shall subject to the condition that the mean value is not less than the specified value plus:**

$$\left[1.65 - \frac{1.65}{\sqrt{(No\ of\ samples)}}\right]\ x\ standard\ deviation$$

If the results of any tests show that any of the constituent materials fail to comply with this Specification, the Contractor should carry out whatever changes may be necessary to the materials and/or to the source of supply to ensure compliance.