Pavement Materials & Design

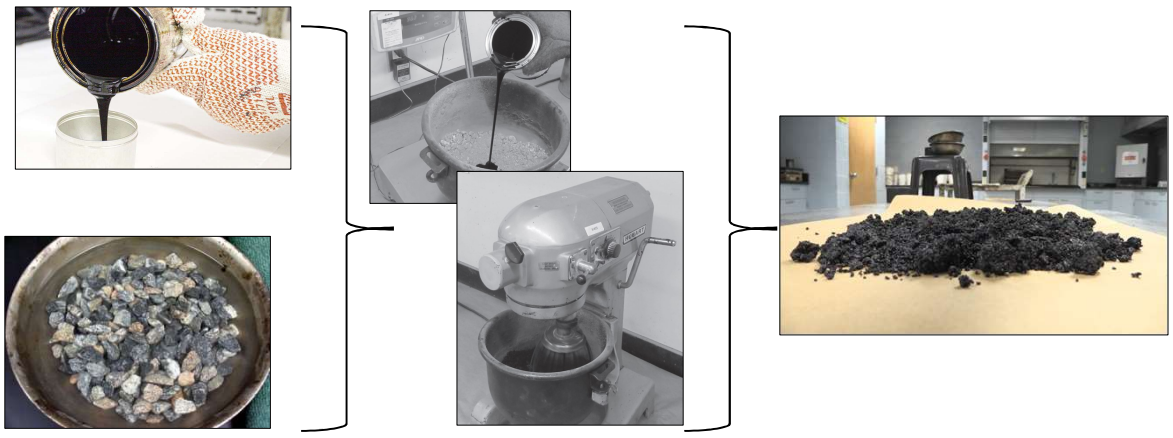
Marshall Stability and Flow of Asphalt Mixtures

1

Mix preparation

2

2



Raw materials

Mixing Process

Loose Asphalt Mixture

3

3

Preparation of Marshall Specimen

C-5: Mix the aggregate with the specified binder content

Video source: https://www.youtube.com/watch?v=BCctjp8Rt2Q&t=174s

4

4

Marshall Specimen Preparation

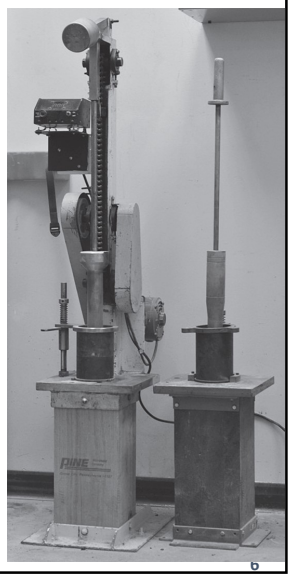
5

5

Preparation of Marshall Specimen

C-8: Compact the specimen at the required Blow/side according to Marshall specifications.

- The laboratory compaction effort is intended to replicate the ultimate or final compacted condition of the pavement after being exposed to several years of traffic loading.
- **Experience** has shown that pavements that maintain an air void level of around 4 percent provide the best long-term performance in the field.
- The Impact compaction is the method for volumetric mix design and quality control testing compaction used in Marshall



6

6

Preparation of Marshall Specimen

- Place a filter or nonabsorbent paper disk cut to size in the bottom of the mold.
- Place the entire batch in the mold with collar, and then spade the mixture vigorously with a heated spatula or trowel 15 times around the perimeter and 10 times over the interior. Smooth the surface to a slightly rounded shape.
- The temperature of the mixture immediately prior to compaction shall be within the limits of the compaction temperature established in paragraph otherwise, it shall be discarded. In no case shall the mixture be reheated

7

7

Preparation of Marshall Specimen

Video source: https://www.youtube.com/watch?v=SuJMH5RDFcQ

8

8

Preparation of Marshall Specimen

- The number of blow/side is function with design traffic level

Marshall Method Criteria[1]	Light Traffic[3] Surface & Base		Medium Traffic[3] Surface & Base		Heavy Traffic[3] Surface & Base	
	Min	Max	Min	Max	Min	Max
Compaction, number of blows each end of specimen	35		50		75	

- 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*

9

9

SGC

Wheel roller

Marshall

10

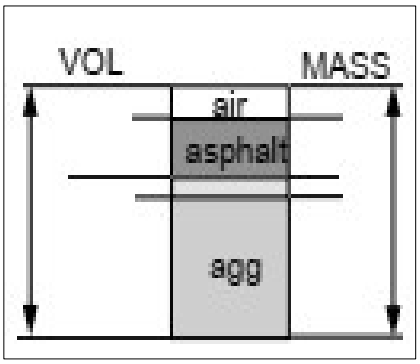
10

Compacted Specimens

11

Preparation of Marshall Specimen

- Determine the Bulk Specific Gravity, G_{mb}



https://www.youtube.com/watch?v=U6-8C1hRdDk

12

12

Marshall Mix Design

Marshall stability and flow test

ASTM D6927

13

13

Marshall Mix Design Method Procedures

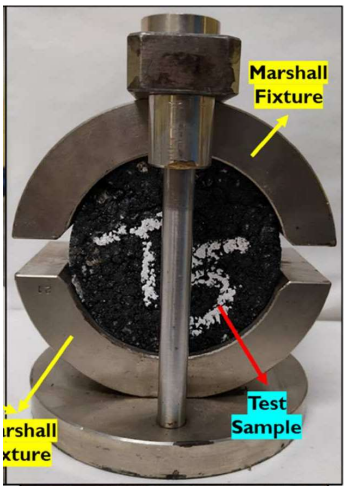


Image source: https://www.civil.iitb.ac.in/~vmtom/1100_LnTse/407_lnTse/plain/

14

14

15

15

Marshall stability and flow test

Procedure

16

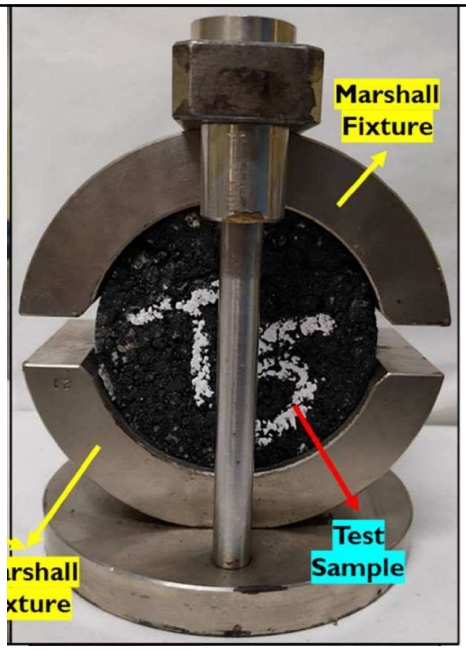
16

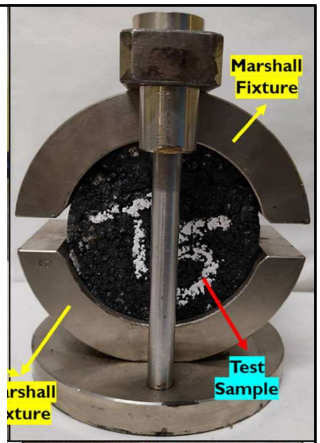
6. Procedure

6.1 A minimum of three specimens of a given mixture shall be tested. The specimens should have the same aggregate type, quality, and grading; the same mineral filler type and quantity; and the same binder source, grade and amount. In addition, the specimens should have the same preparation, that is, temperatures, cooling, and compaction.

17

17





https://www.youtube.com/shorts/LmvBokJwsr0

(c)

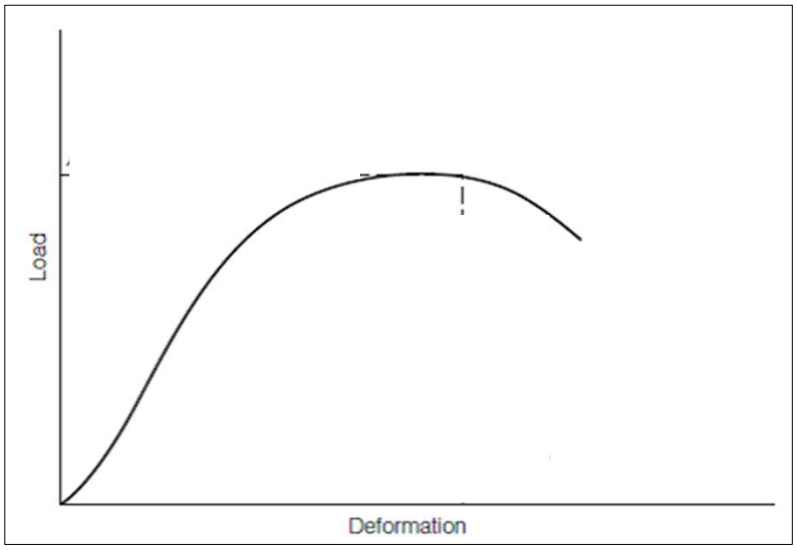
18

ASTM D6927

Test Outputs

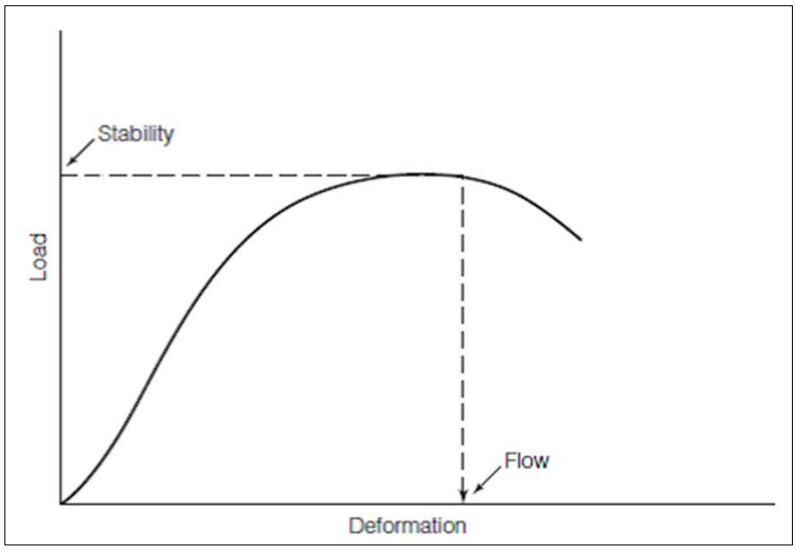
19

19



20

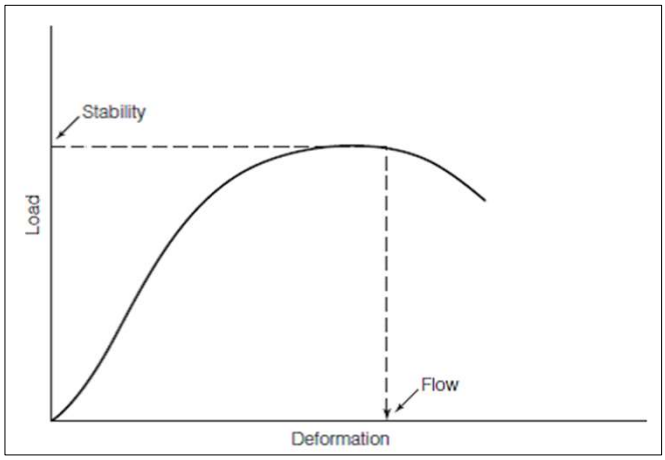
20



Flow value is reported in hundreds of an inch (0.01 inch) or (0.25 mm).
Stability value is reported in unit of load N, Ib, Kg

21

21



Stability = 1875 ibs =8340 N

Stability value is reported in unit of load N, Ib, Kg

Flow value is reported in hundreds of an inch (0.01 inch) or (0.25 mm).

flow = 14 (0.01in) = 14 (0.25mm)

14 (0.25 mm) = 14 / 0.25 mm = 3.5 mm

14 (0.01 in) = 14 / 0.01 in = 0.14 in

1 in = 25.4 mm

0.14 in = 3.5 mm

22

22

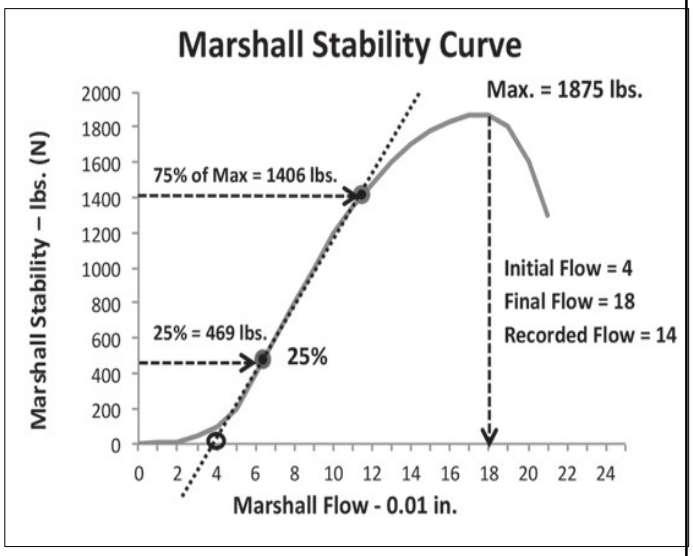
Data Correction

23

23

Curve correction when using an automatic recording

- To determine the correct start of the flow reading,
  - *A tangent line shall be drawn connecting two points on the stability–flow curve, representing*
  - *25 percent and 75 percent of Marshall stability.*
  - *Where this tangent line intersects the x-axis is the start of Marshall flow*



25

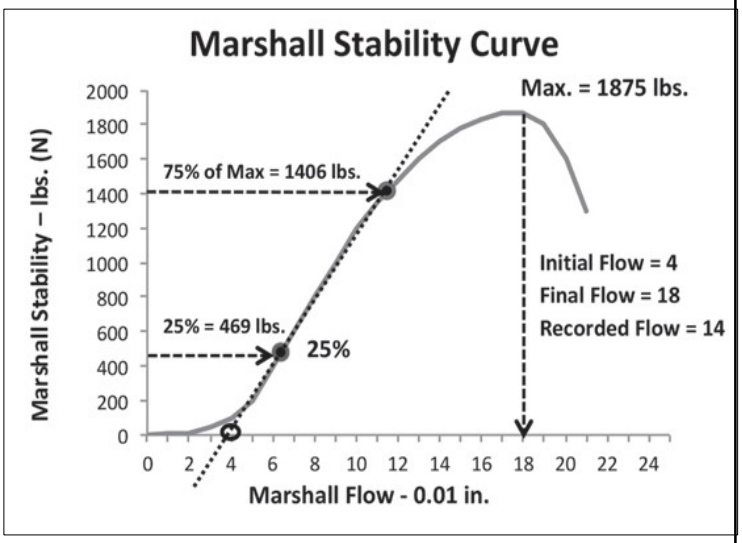
25

Stability = 1875 ibs =8340 N

Stability value is reported in unit of load N, Ib, Kg

Flow value is reported in hundreds of an inch (0.01 inch) or (0.25 mm).

flow = 14 (0.01in) = 14 (0.25mm)



14 (0.25 mm) = 14 / 0.25 mm = 3.5 mm

14 (0.01 in) = 14 / 0.01 in = 0.14 in

1 in = 25.4 mm

0.14 in = 3.5 mm

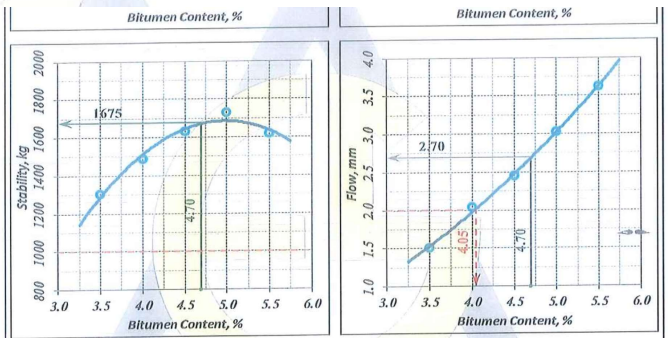
26

26

2. JOB MIX REQUIREMENTS

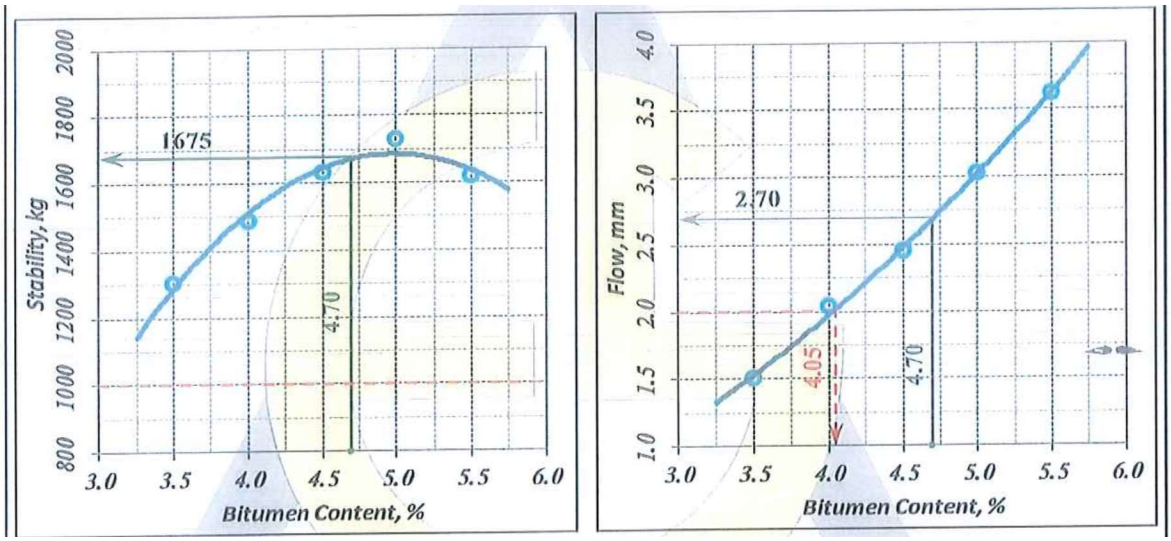
The design aimed at satisfying the job mix requirements for Wearing Course – Heavy Traffic as stated in the Project Special Specifications in addition to "Specifications for Highway and Bridge Construction-1991" of Ministry of Public Works and Housing (MPWH). Accordingly, the following job mix requirements were considered;

- Marshall Stability, kg: 1225 (min.) [12,000 N]
- Marshall Flow, mm: 2.0 – 4.0
- Voids in Mineral Aggregate (VMA), %: 14 (min.)
- Air Voids, %: 3 – 6
- Marshall Stiffness, kg/mm: 500 (m
- Loss of Stability, %: 25 (ma
- Filler/Bitumen Ratio: 0.6 – 1
- Air Voids at Refusal, %: 2 (min.
- Tensile Strength Ratio (TSR): 0.80 (r



29

29



30

30

ASTM D6927

Stability Correction

31

31

7. Calculation

7.1 Laboratory molded specimens shall satisfy the thickness requirement of 2.50 ± 0.10 in. (63.5 ± 2.5 mm). Specimens within the thickness tolerance may be corrected based on specimen volume or thickness. Stabilities determined on field cores with large variation in volume or thickness shall also be corrected. However, results with larger corrections should be used with caution. Correction factors (correlation ratios) are given in Table 1. The correlation ratio is used in the following manner.

$$A = B \times C \quad (1)$$

where:

A = corrected stability,
B = measure of stability (load), and
C = correlation ratio from Table 1.

TABLE 1 Stability Correlation Factors[A]

Volume of Specimen, cm³[B]	Thickness of Specimen[B]		Correlation Ratio
	in.	mm	
200 to 213	1.00 (1)	(25.4)	5.56
214 to 225	1.06 (1 1/16)	(27.0)	5.00
226 to 237	1.12 (1 1/8)	(28.6)	4.55
238 to 250	1.19 (1 3/16)	(30.2)	4.17
251 to 264	1.25 (1 1/4)	(31.8)	3.85
265 to 276	1.31 (1 5/16)	(33.3)	3.57
277 to 289	1.38 (1 3/8)	(34.9)	3.33
290 to 301	1.44 (1 7/16)	(36.5)	3.03
302 to 316	1.50 (1 1/2)	(38.1)	2.78
317 to 328	1.56 (1 9/16)	(39.7)	2.50
329 to 340	1.62 (1 5/8)	(41.3)	2.27
341 to 353	1.69 (1 11/16)	(42.9)	2.08
354 to 367	1.75 (1 3/4)	(44.4)	1.92
368 to 379	1.81 (1 13/16)	(46.0)	1.79
380 to 392	1.88 (1 7/8)	(47.6)	1.67
393 to 405	1.94 (1 15/16)	(49.2)	1.56
406 to 420	2.00 (2)	(50.8)	1.47
421 to 431	2.06 (2 1/16)	(52.4)	1.39
432 to 443	2.12 (2 1/8)	(54.0)	1.32
444 to 456	2.19 (2 3/16)	(55.6)	1.25
457 to 470	2.25 (2 1/4)	(57.2)	1.19
471 to 482	2.31 (2 5/16)	(58.7)	1.14
483 to 495	2.38 (2 3/8)	(60.3)	1.09
496 to 508	2.44 (2 7/16)	(61.9)	1.04
509 to 522	2.50 (2 1/2)	(63.5)	1.00
523 to 535	2.56 (2 9/16)	(65.1)	0.96
536 to 546	2.62 (2 5/8)	(66.7)	0.93
547 to 559	2.60 (2 11/16)	(68.3)	0.89
560 to 573	2.75 (2 3/4)	(69.8)	0.86
574 to 585	2.81 (2 13/16)	(71.4)	0.83
586 to 598	2.88 (2 7/8)	(73.0)	0.81
599 to 610	2.94 (2 15/16)	(74.6)	0.78
611 to 626	3.00 (3)	(76.2)	0.76

[A] The measured stability of a specimen multiplied by the ratio for the thickness of the specimen equals the corrected stability for a 2½ in. (63.5 mm) specimen.
[B] Volume-thickness relationship is based on a specimen diameter of 4 in. (101.6 mm).

32

Data interpretation

33

33

Data interpretation

Flow Results

- 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*

2. JOB MIX REQUIREMENTS

The design aimed at satisfying the job mix requirements for Wearing Course – Heavy Traffic as stated in the Project Special Specifications in addition to "Specifications for Highway and Bridge Construction-1991" of Ministry of Public Works and Housing (MPWH). Accordingly, the following job mix requirements were considered;

Marshall Stability, kg:	1225 (min.)	[12,000 N]
Marshall Flow, mm:	2.0 – 4.0	
Voids in Mineral Aggregate (VMA), %:	14 (min.)	
Air Voids, %:	3 – 6	
Marshall Stiffness, kg/mm:	500 (min.)	[4900 N/mm]
Loss of Stability, %:	25 (max.)	
Filler/Bitumen Ratio:	0.6 – 1.2	
Air Voids at Refusal, %:	2 (min.)	
Tensile Strength Ratio (TSR):	0.80 (min.)	

34

34

Data interpretation

Stability Results

- If the flow at the selected optimum binder content is above the upper specified limit,
  - *the mix is considered too plastic or unstable (i.e. low stiffness)*
- If the flow is below the lower specified limit
  - *the mix is considered too brittle*

2. JOB MIX REQUIREMENTS

The design aimed at satisfying the job mix requirements for Wearing Course – Heavy Traffic as stated in the Project Special Specifications in addition to "Specifications for Highway and Bridge Construction-1991" of Ministry of Public Works and Housing (MPWH). Accordingly, the following job mix requirements were considered;

Marshall Stability, kg:	1225 (min.)	[12,000 N]
Marshall Flow, mm:	2.0 – 4.0	
Voids in Mineral Aggregate (VMA), %:	14 (min.)	
Air Voids, %:	3 – 6	
Marshall Stiffness, kg/mm:	500 (min.)	[4900 N/mm]
Loss of Stability, %:	25 (max.)	
Filler/Bitumen Ratio:	0.6 – 1.2	
Air Voids at Refusal, %:	2 (min.)	
Tensile Strength Ratio (TSR):	0.80 (min.)	

35

35