CE 380

Highway and Traffic Engineering

Lec-10

Pavement Design

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Design Stages

1. Aggregates Blend Mix

2. Asphalt mix Design

3. Pavement Layers Design

1- Aggregates Blend Mix

Sieve Size		1’’	0.5’’	No.4	No.10	No.40	No.80	No.200
P%	C.A.	100	62	20	10	7	3	2
	F.A.	100	100	100	92	55	38	2
	M.F.	100	100	100	100	100	98	89
	S.L.	100	70-85	40-55	30-45	20-30	12-22	5-10

Proportioning the Aggregates

Sieve Size		1''	0.5''	No.4	No.10	No.40	No.80	No.200
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1. Take the average of standard limits at No. 1o
2. This average represents the percentage of sand in your mix (P_2).
3. Assume mineral filler 6% (P_3).
4. The remaining is the coarse (gravel) percentage (P_1).
5. Calculate the new proportions of your mix:

$P_{\text{sieve no.}} = P_1 \times$ coarse passing percent $+ P_2 \times$ fine passing percent $+ P_3 \times$ Mineral passing percent

Adjust the proportions of aggergates due to Bitumen Mixing

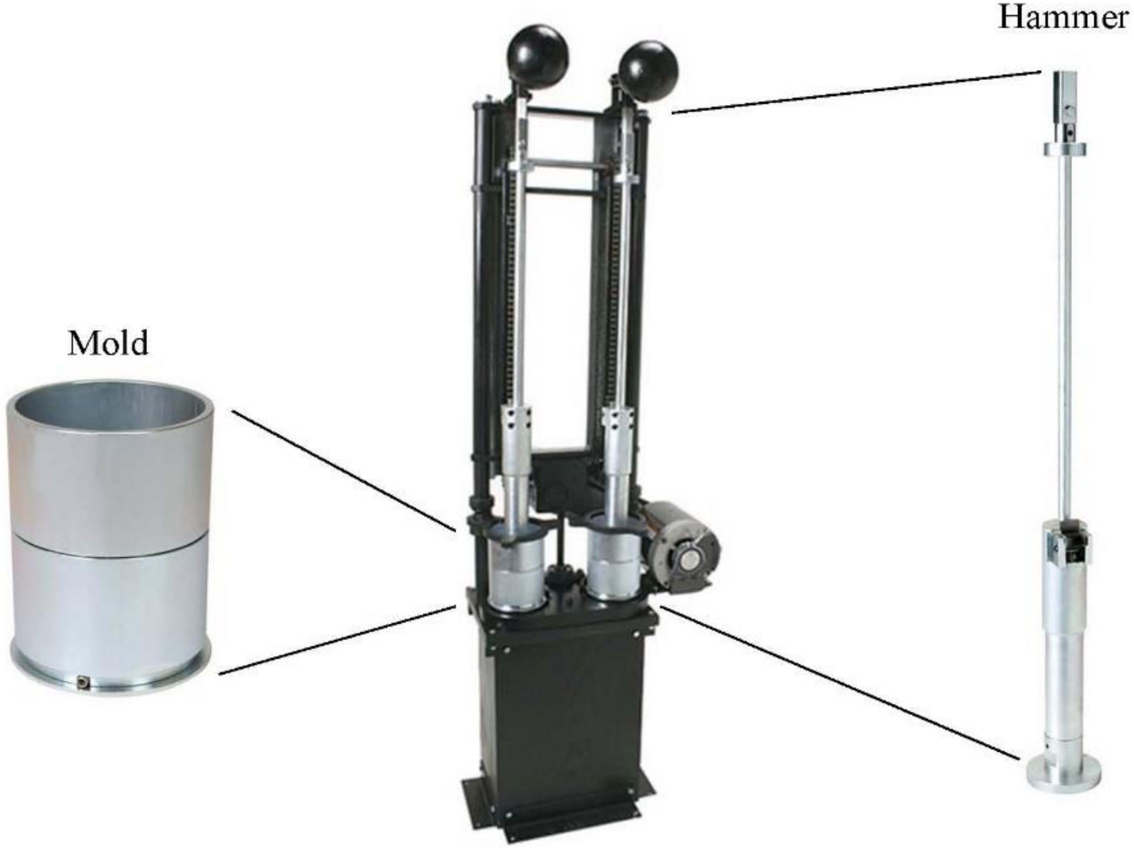
1. Determine the percentage of bitumen by weight $P_{AC.}$
2. $P_{1\ new\ or\ final} = P_{1\ old} \times (1- P_{AC})$
3. $P_{2\ new\ or\ final} = P_{2\ old} \times (1- P_{AC})$
4. $P_{3\ new\ or\ final} = P_{3\ old} \times (1- P_{AC})$

2- Asphalt Mix Design

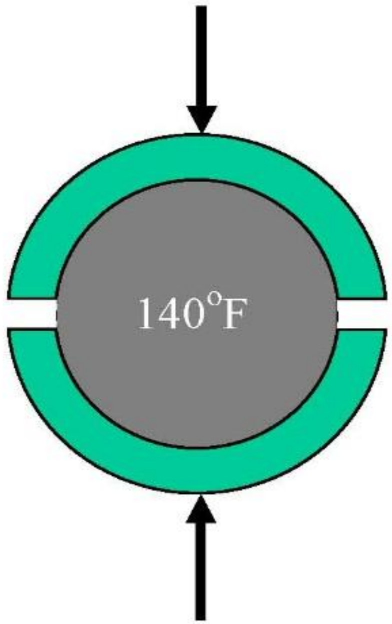
Marshall Mix Design Steps

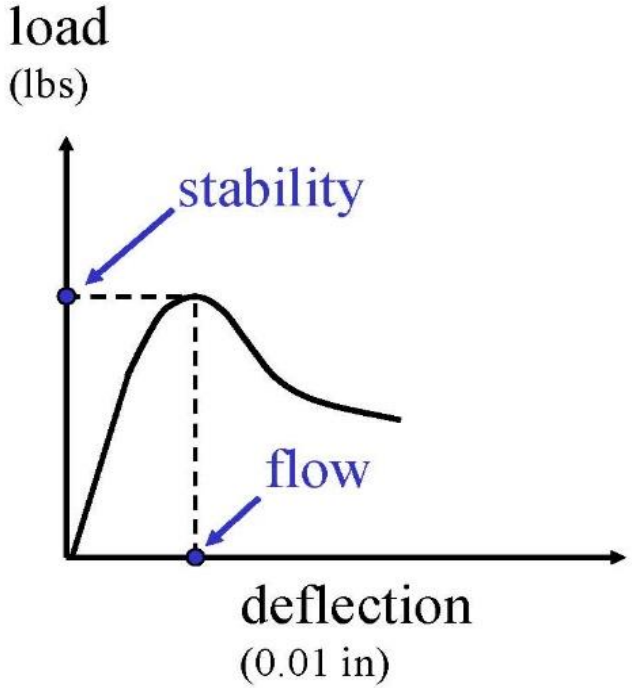
1. Create aggregate blend to meet gradation specifications.
2. Establish mixing and compaction temperatures from the viscosity-temperature chart.
3. ontents spanning the expected optimum asphalt content.
4. Determine the relative density of each specimen and the mix volumetrics (G_m , VTM, VMA, VFA).
5. Measure the performance properties of the each specimen (140°F).

Marshall Hammer



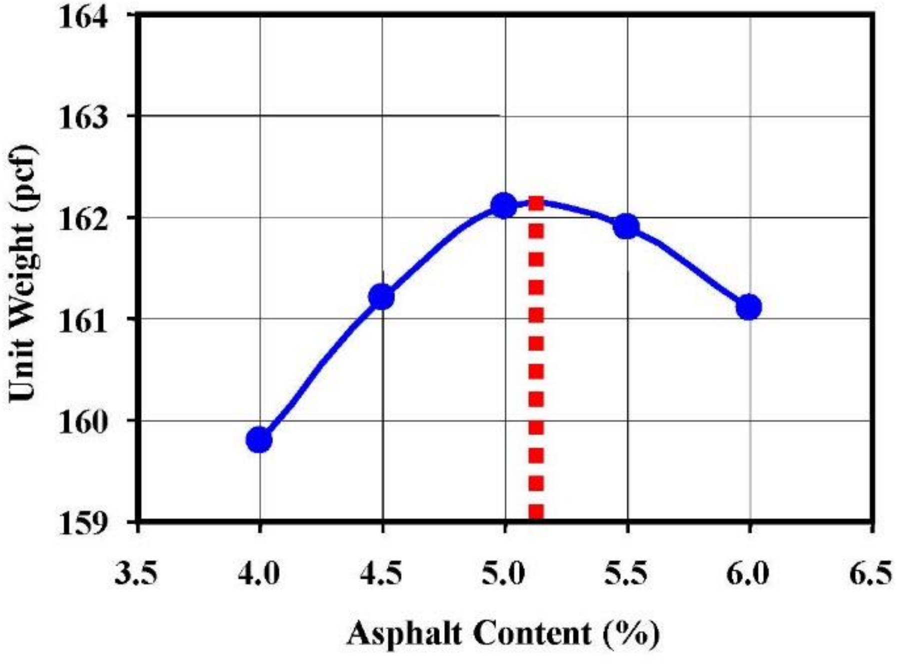
Stability and Flow Test



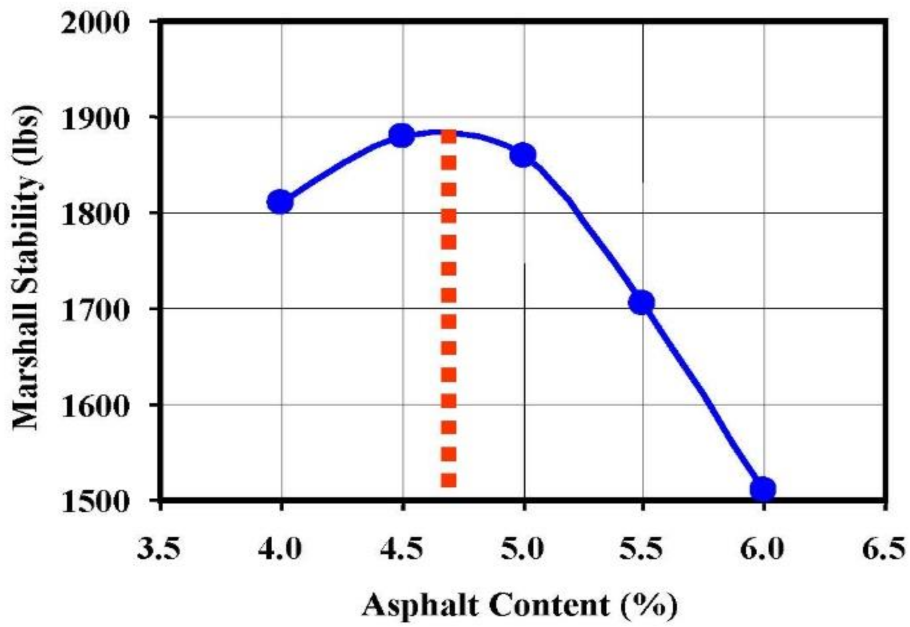


Stability and Flow Test

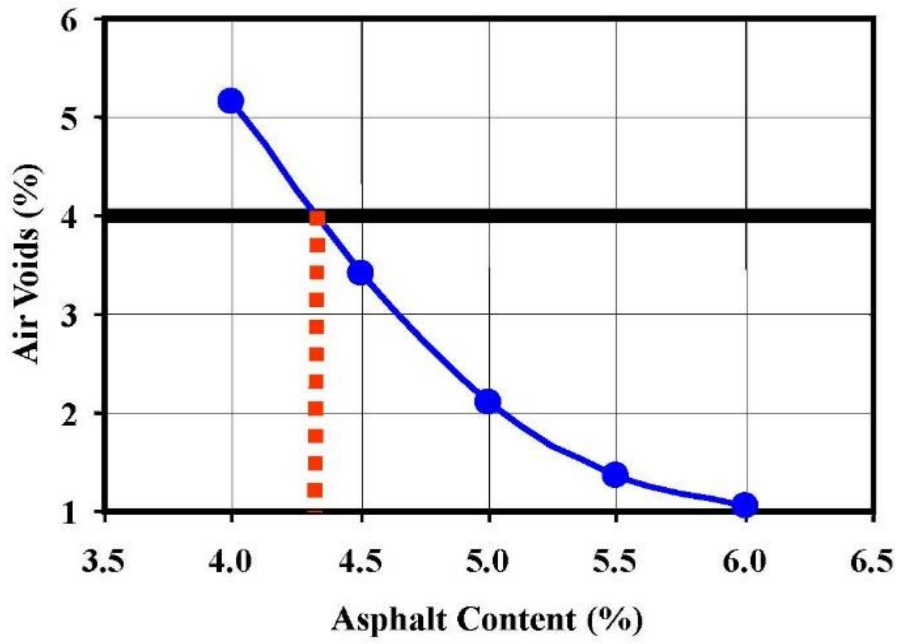
Marshall Mix Design



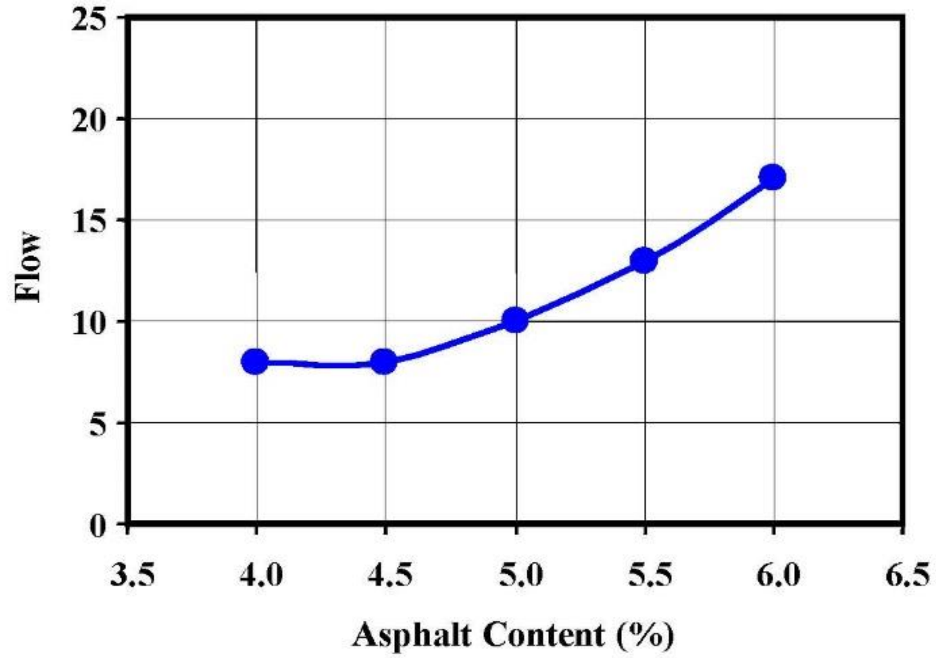
Marshall Mix Design



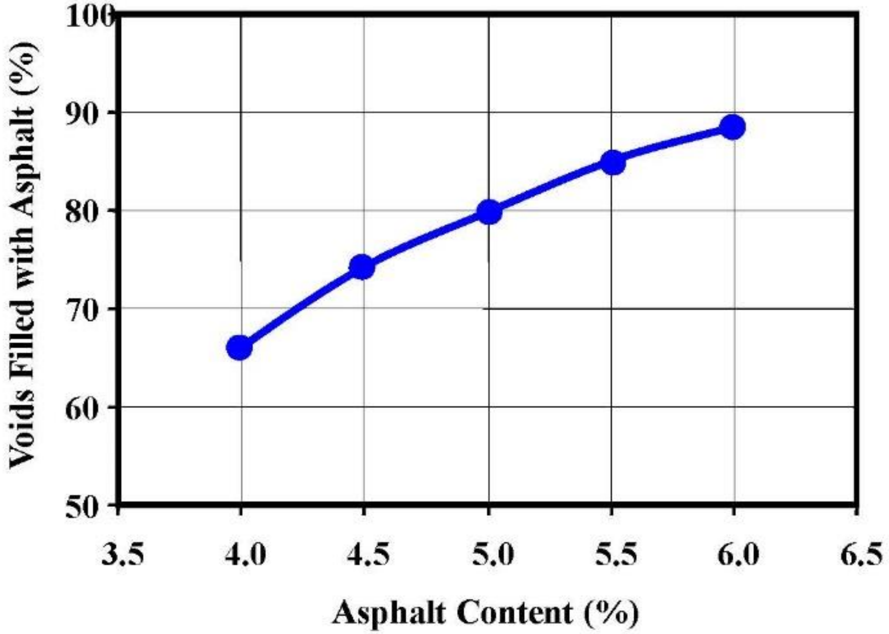
Marshall Mix Design



Marshall Mix Design



Marshall Mix Design



Marshall Mix Design

(The Asphalt Institute Procedure)

Maximum Density	Maximum Stability	4% Air Voids

$$AC = \frac{5.1 + 4.7 + 4.3}{3} = 4.7\%$$

3- Pavement Layers Design
AASHTO 1993

- Based on the results of AASHTO road test conducted on Ottawa, Illinois.

- It is an effort that was carried out with the cooperation of all states and several industry groups.

- Many types of test section were prepared and tested.

AASHTO Design Method/ Design Considerations

- This method Incorporates various design inputs including :
  1. Pavement Performance (Loss of serviceability) **ΔPSI**.
  2. Traffic (W_{18})
  3. Subgrade soil properties (M_r)
  4. Materials of constructed Layers (a_i)
  5. Environmental effects
  6. Drainage
  7. Reliability

Pavement Performance

1. Structural performance: related to the physical condition of the pavement with respect to the factors that have negative impact on the capability of the pavement to carry the traffic load.

   – Road strength :cracking, faulting, raveling, and so forth.

2. Functional performance: is an indication of how effectively the pavement serves the user.

   – riding quality.

Pavement Serviceability Index (PSI)

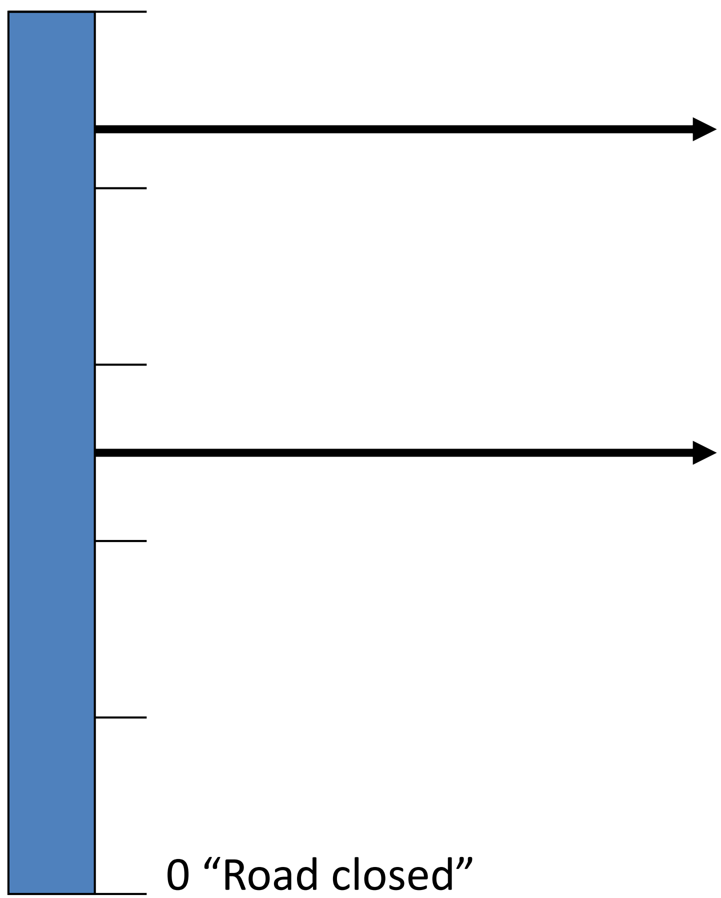
- Pavement ability to serve traffic during its life.

1. Initial PSI = F(Pavement type & construction quality) [4.2 for flexible]).

2. Terminal PSI = Lowest index that is tolerable for a pavement before it require rehabilitation [2.5 for major highways & 2.0 for other roads].

ΔPSI =

ΔPSI



- 2.5 to 3.0 for major highways

Traffic

The total load applications due to all mixed traffic within the design period are converted to 18-kip ESAL (W_{18}):

$$W_{18} = \frac{A\,[(1+r)^n - 1]}{r} \times D \times F \times 365$$

Or given

Subgrade soil properties

- **Roadbed Resilient Modulus (M_r):**

Resilient modulus is a fundamental Soil property that is similar in concept to the modulus of elasticity.

AASHTO method used the subgrade M_r to define its property.

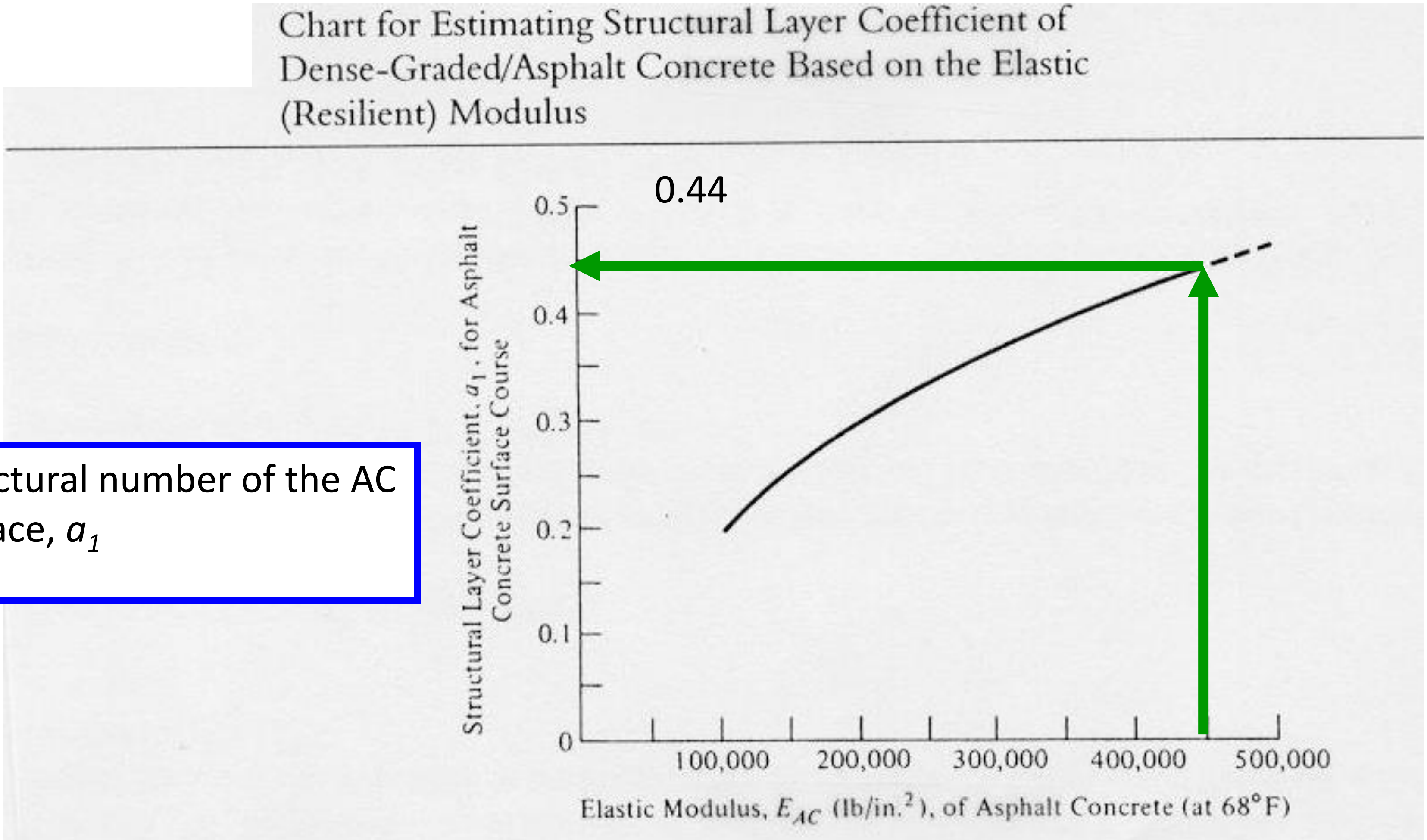
Given in psi (ib/inch^2)

M_r = 1500 x CBR

Materials of Constructed Layers

- Subbase Construction Materials
  - Quality of the material is determined in terms of the layer coefficient, (**a_3**).
- Base Course Construction Materials
  - Materials should satisfy general requirements for base course.
  - Quality of the material is determined in terms of the layer coefficient, (**a_2**).
- Surface Course Construction Materials
  - Usually HMA with dense-graded aggregate and max size of 1”.
  - Quality of the material is determined in terms of the layer coefficient, (**a_1**).

Materials of construction (AC surface), a_1



Structural number of the AC surface, a_1

Reliability (R)

- It provides a predetermined level of assurance (R) that the pavement section will survive the period for which they were designed.

- Reliability Design Factor: Accounts for chance variations in both traffic prediction & performance prediction.

Functional classification	Reliability level (%)	
	Urban	Rural
Interstate and other freeways	85–99.9	80–99.9
Principal arterials	80–99	75–95
Collectors	80–95	75–95
Local	50–80	50–80

Overall S_o

- So: Overall standard deviation that accounts for standard deviation (or variation) in materials & construction, chance variation in traffic prediction, and normal variation in pavement performance.

S_o = 0.45 for flexible pavement (0.40 -0.50)

Structural Number (SN)

The objective of the AASHTO method is to determine a flexible pavement structural number (SN) adequate to carry the projected design ESAL.

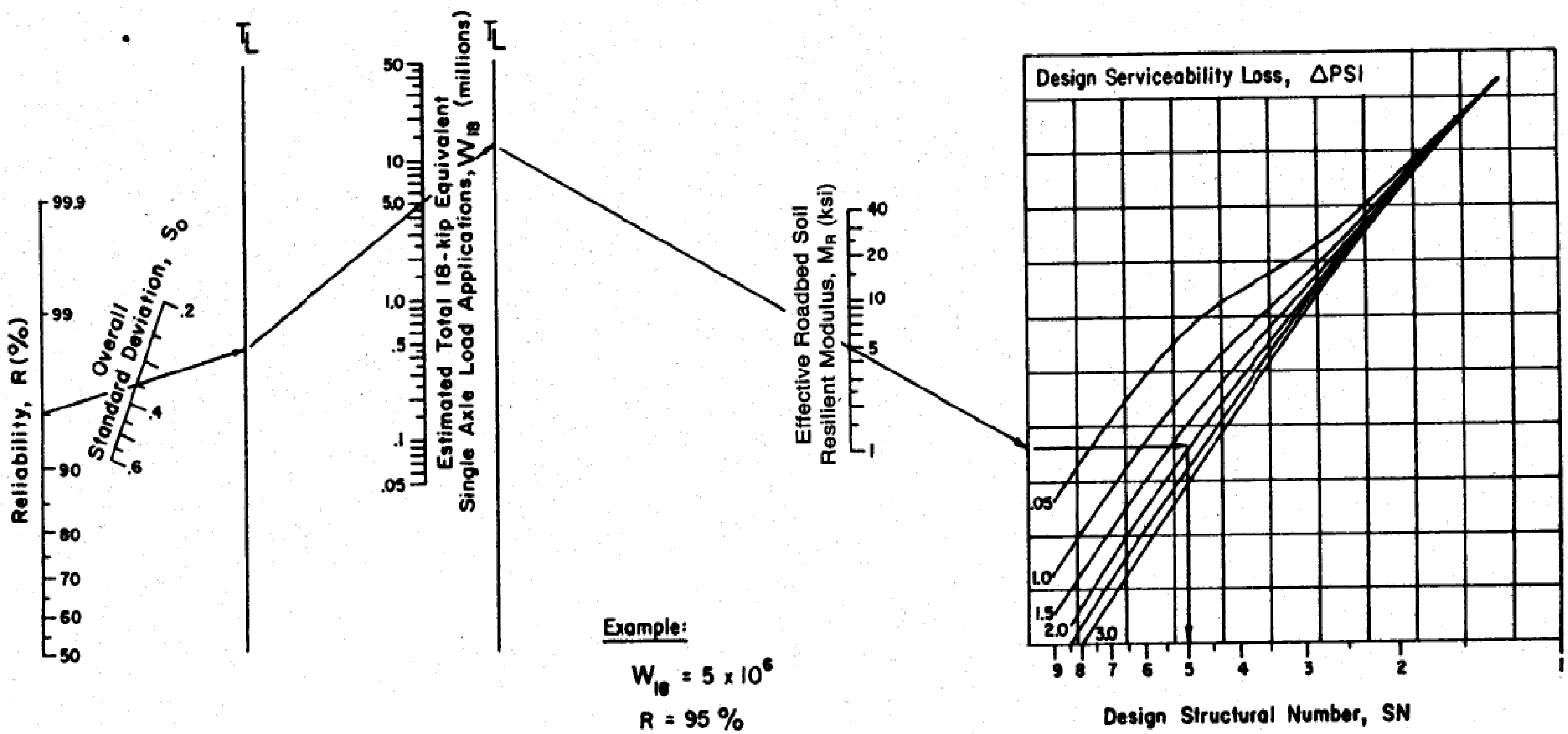
$$SN = a_1 D_1 + a_2 D_2 + a_3 D_3$$

a_i : Coefficient of layer i

D_i : Thickness of layer i

NOMOGRAPH SOLVES:

$$\log_{10} W_{18} = Z_R {*} S_o + 9.36 {*} \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2 - 1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 {*} \log_{10} M_R - 8.07$$



Example:

$W_{18} = 5 \times 10^6$

$R = 95\ \%$

$S_o = 0.35$

$M_R = 5000$ psi

$\Delta PSI = 1.9$

Solution: SN = 5.0

SN for each layer

- **$SN_1 = a_1 D_1$** **(M_{r2})**
- **$SN_2 = a_1 D_1 + a_2 D_2$** **(M_{r3})**
- **$SN_3 = a_1 D_1 + a_2 D_2 + a_3 D_3$** **($M_{r\ subgrade}$)**

General Procedure for Selection Layer Thickness