TRU-80-11.32 Truck Parking (121698)
Back-door calculations to assign flexible pavement build-up with similar strength to 9" 451 on 6" 304.

Serviceability & Reliability	**201-1** July 2016 **Reference Section** **201 & 204**

SERVICEABILITY FACTORS		
	Rigid	**Flexible**
Initial Serviceability	4.2	4.5
Terminal Serviceability	2.5	2.5
Design Serviceability Loss	**1.7**	**2.0**

RELIABILITY LEVELS (%)		
Functional Classification	**Urban***	**Rural***
Interstate and Freeway (01, 02)	95	90
Principle Arterial, Minor Arterial (03, 04)	90	85
Collectors (05, 06)	90	85
Local (07)	80	80

* The designer must determine if the location is urban or rural in character. The ODOT Highway Functional Classification System Concepts, Procedures and Instructions document available from the Office of Program Management should be used as a guide.

OVERALL STANDARD DEVIATION	
Flexible Pavement	0.49
Rigid Pavement	0.39

RATIO OF B:C COMMERCIAL VEHICLES		
Functional Classification	B:C Ratio	
	Urban*	Rural*
Interstate (01)	4:1	7:1
Other Freeway or Expressway (02)	3:1	
Principal Arterial (03)	2:1	5:1
All Other (04, 05, 06, 07)	1:1	2:1

ESAL CONVERSION FACTORS				
Functional Classification	Rigid		Flexible	
	B	C	B	C
Interstate (01), rural*	1.53	0.37	0.98	0.29
Principal Arterial (03), rural*	1.67	0.44	1.06	0.33
All Other (04, 05, 06, 07), rural*	1.26	0.76	0.79	0.48
Interstate (01), urban*	1.46	0.46	0.93	0.34
Expressway & Freeway (02), urban*	1.38	0.72	0.90	0.47
All Other (03, 04, 05, 06, 07), urban*	1.64	0.53	1.04	0.41

* The designer must determine if the location is urban or rural in character. The ODOT Highway Functional Classification System Concepts, Procedures and Instructions document available from the Office of Program Management should be used as a guide.

DESIGN LANE FACTORS		
Number of Lanes per Direction	Lane Factor (LF) (%)	Directional Distribution (D) for two-way traffic (%)
1 - Lane	100	50
2 - Lanes	95	50
3 - Lanes	80	50
4 (or more) - Lanes	70	50

One-way --> 100%

MATERIAL PROPERTIES	
Modulus of Rupture (S'_c)	700 psi
Modulus of Elasticity (E_c)	5,000,000 psi
Load Transfer Coefficient (J) - Doweled, Edge Support*	2.7
Load Transfer Coefficient (J) - Doweled, No Edge Support*	3.2

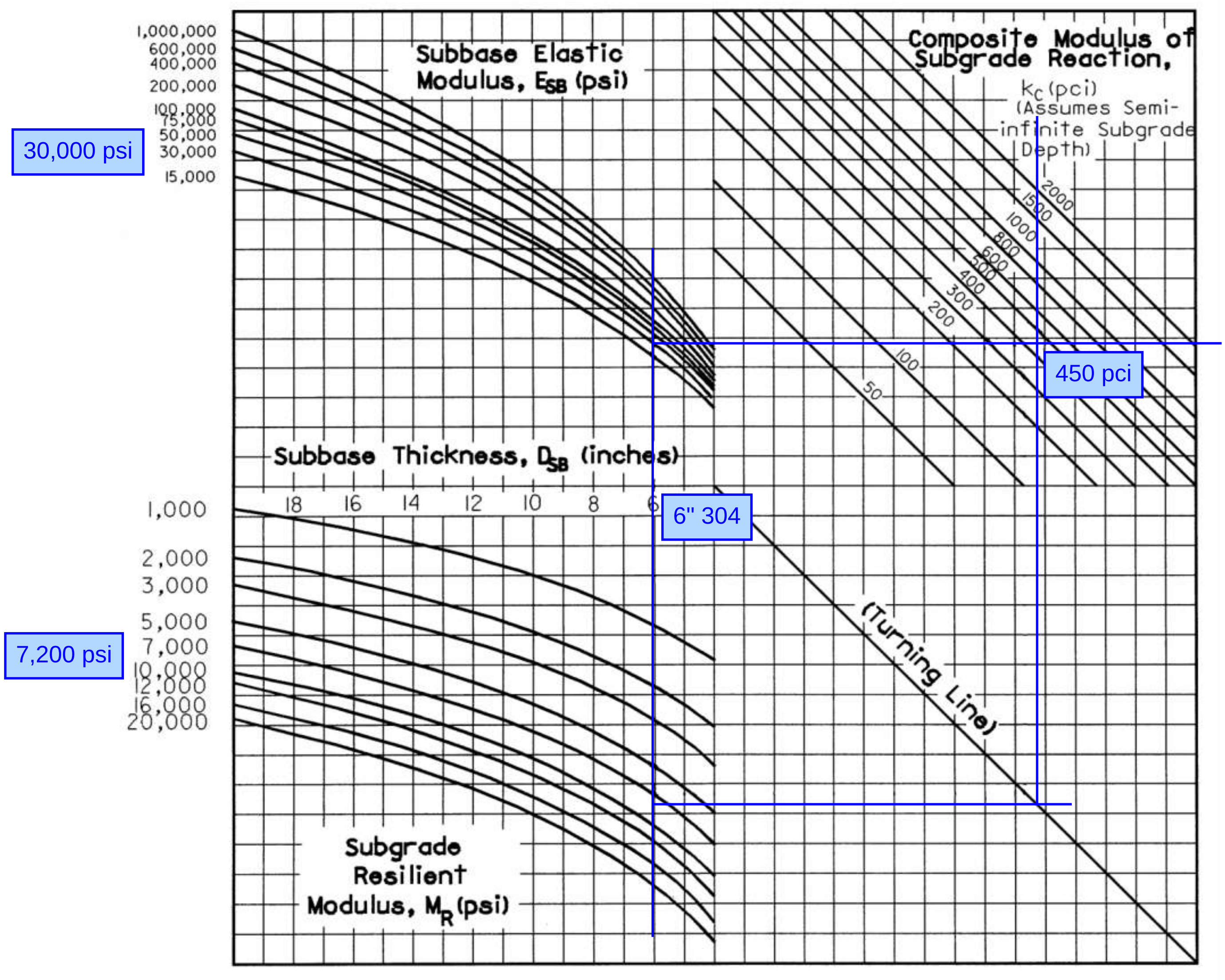
* Edge support includes tied concrete shoulders, integral curb, widened lane, etc. Widened lane refers to concrete slabs built 14 feet (4.2 m) wide or wider, but striped for a standard 12-foot (3.6 m) lane, leaving 2 feet (0.6 m) outside the traveled lane to provide edge support.

SUBBASE FACTORS			
ODOT Specification	**Recommended Thickness (in.) (D_{SB})**	**Elastic Modulus (psi) (E_{SB})**	**Loss of Support (LS)**
Item 301, 302 Asphalt Concrete Base	4	300,000	0
Item 304 Aggregate Base**	6	30,000	1
Natural Subgrade***			2

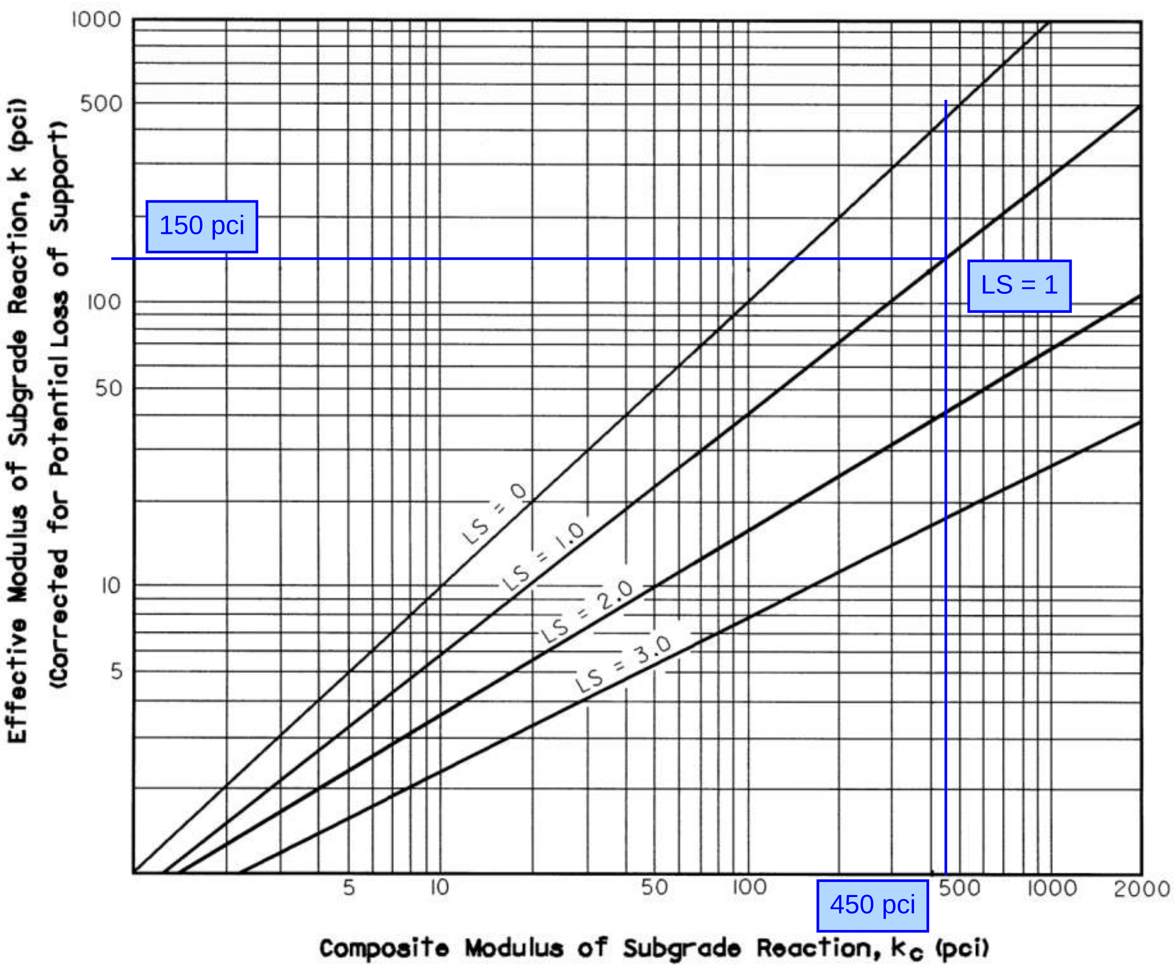
** When the entire subgrade is chemically stabilized (global chemical stabilization), the elastic modulus of the Item 304 Aggregate Base is increased to 36,000 psi.

*** Not recommended for most applications. See Section 301.4

Composite Modulus of Subgrade Reaction (k_c)	301-2 July 2008
	Reference Section & Figure 301.4, 302-1 (step 3)



Effective Modulus of Subgrade Reaction (k)	**301-3** July 2008 **Reference Section & Figure** **301.6, 302-1 (step 4)**



Given:

- Pavement of choice: Doweled, jointed concrete
- Subbase: 6 inches Item 304 Aggregate Base
- Shoulders: Tied, jointed, concrete
- Number of Lanes: 4 (2 per direction)
- Functional Classification: Principal Arterial (Rural)
- 2018 Traffic: 15,800 ADT
- 2038 Traffic: 22,450 ADT
- 24 hour truck %: 18%
- Design Period: 20 years
- Open to Traffic: 2019
- Subgrade CBR: 5 (from Subgrade Analysis)

100%
20 years
2026
6 (assumed)

Problem: Solve for the thickness of the concrete slab.

Solution:

Step 1 - Determine the 18-kip equivalent single axle loading (ESAL).

Since the project is expected to open to traffic in 2019, the ESAL projection should be for 2019 to 2039. Calculate the mid-year (2029) ADT, rounded to nearest ten:

2029 ADT = 15,800+(22,450-15,800)(11/20)
2029 ADT = 19,460

The equations in Section 202.2 are used with

Directional distribution, D = 50% (Figure 202-1)
Lane factor = 95% (Figure 202-1)
B:C ratio = 5:1 (Figure 202-1)
ESAL conversion factor for B trucks = 1.67 (Figure 202-1)
ESAL conversion factor for C trucks = 0.44 (Figure 202-1)

100%
80%

Using the equations given in Section 202.2:

ESAL's from B trucks = 19,460(0.18)(0.50)(0.95)(5/6)(1.67) = 2,315
ESAL's from C trucks = 19,460(0.18)(0.50)(0.95)(1/6)(0.44) = 122

Total daily ESAL's = 2,315+122 = 2,437 ESAL/day

Design period ESAL's = 2,437 ESAL/day * 365.25 days/yr. * 20 years = 17,802,285
use 17.8×10^6 ESAL's

To be calc'd --> 8.5E6 ESAL

Step 2 - Determine the subgrade resilient modulus (M_r) using the formula given in Section 203.1.

M_r = 1200 * CBR
M_r = 1200 * 5
M_r = 6000 psi   7,200 psi (assumed)

Step 3 - Determine the composite modulus of subgrade reaction (k_c) using Figure 301-2.

Starting with the given subbase thickness (D_{SB}) of 6", a line is projected up to the subbase elastic modulus (E_{SB}) curve of 30,000 psi (Item 304 Aggregate Base from Figure 301-1). From this point on the 30,000 psi curve, a line is projected to the right for future intersection. Similarly, from the 6" subbase thickness (D_{SB}), a line is projected down to the subgrade resilient modulus (M_r) curve of 6000 psi. From this point on the 6000 psi curve, a line is projected to the right to the turning line and then projected up to intersect with previously projected line. This intersection results in a composite modulus of subgrade reaction (k_c) of 335 pci.

450 pci

Step 4 - Determine the effective modulus of subgrade reaction (k) using Figure 301-3.

Using the composite modulus of subgrade reaction (k_c) determined in Step 3, enter the chart on the bottom. Project a line from 335 pci up to LS = 1.0 (from Figure 301-1 for Item 304 Aggregate Base). Then project a line straight across to the vertical axis. This results in an effective modulus of subgrade reaction (k) of 110 pci.

150 pci

Step 5 - Determine the thickness of the concrete slab using Figures 302-2 and 302-3.

Figure 302-2 is used to solve for the match line number using the following information:

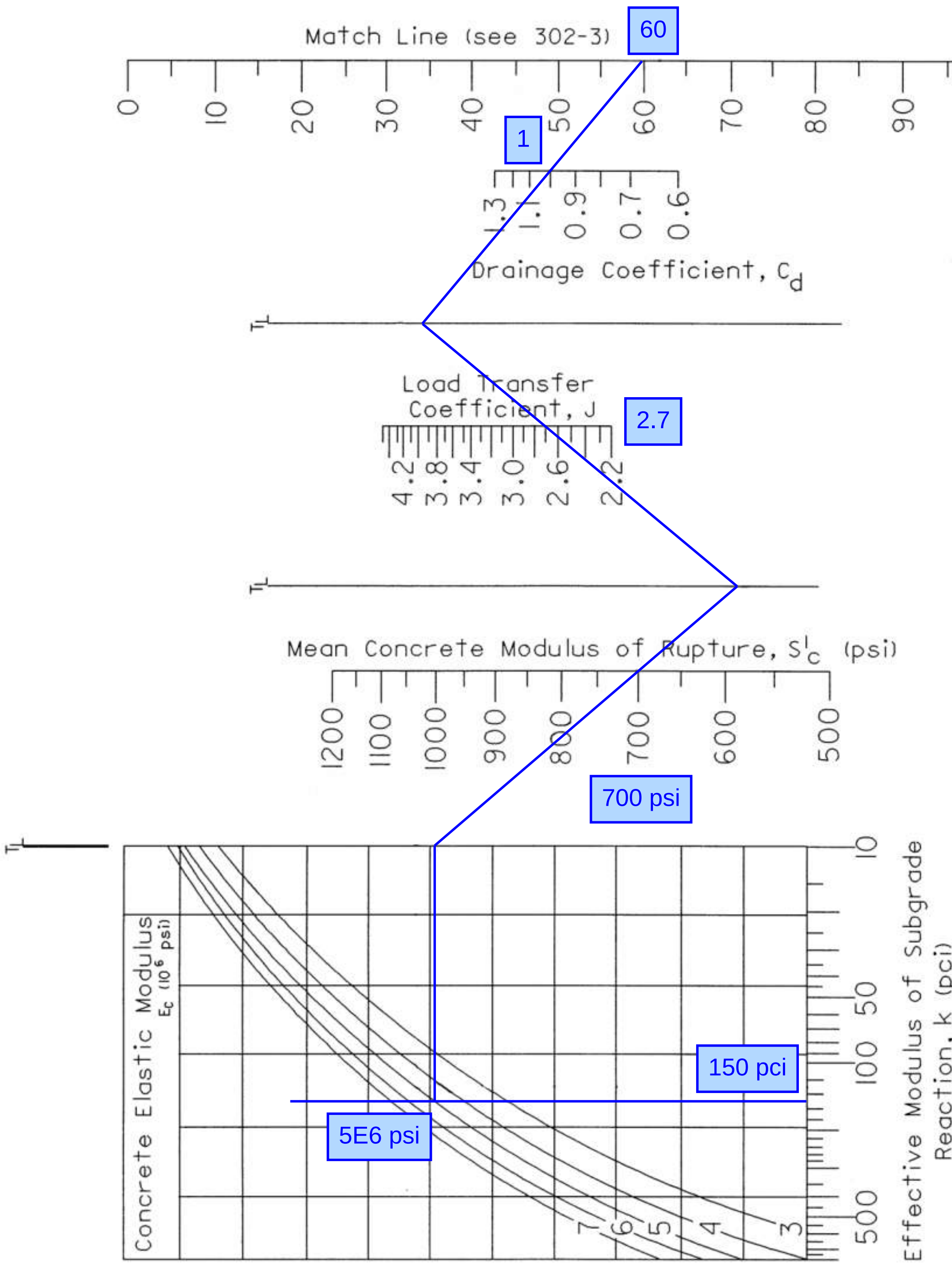
Effective modulus of subgrade (k) = 110 pci (Step 4)   150 pci
Concrete elastic modulus (E_c) = 5,000,000 psi (Figure 301-1)
Concrete modulus of rupture (S'_c) = 700 psi (Figure 301-1)
Load Transfer Coefficient (J) = 2.7 (Figure 301-1)
Drainage coefficient (C_d) = 1.0 (Section 205.2)

The resulting match line number is then used on Figure 302-3, along with the following information, to solve for the design slab thickness (D).

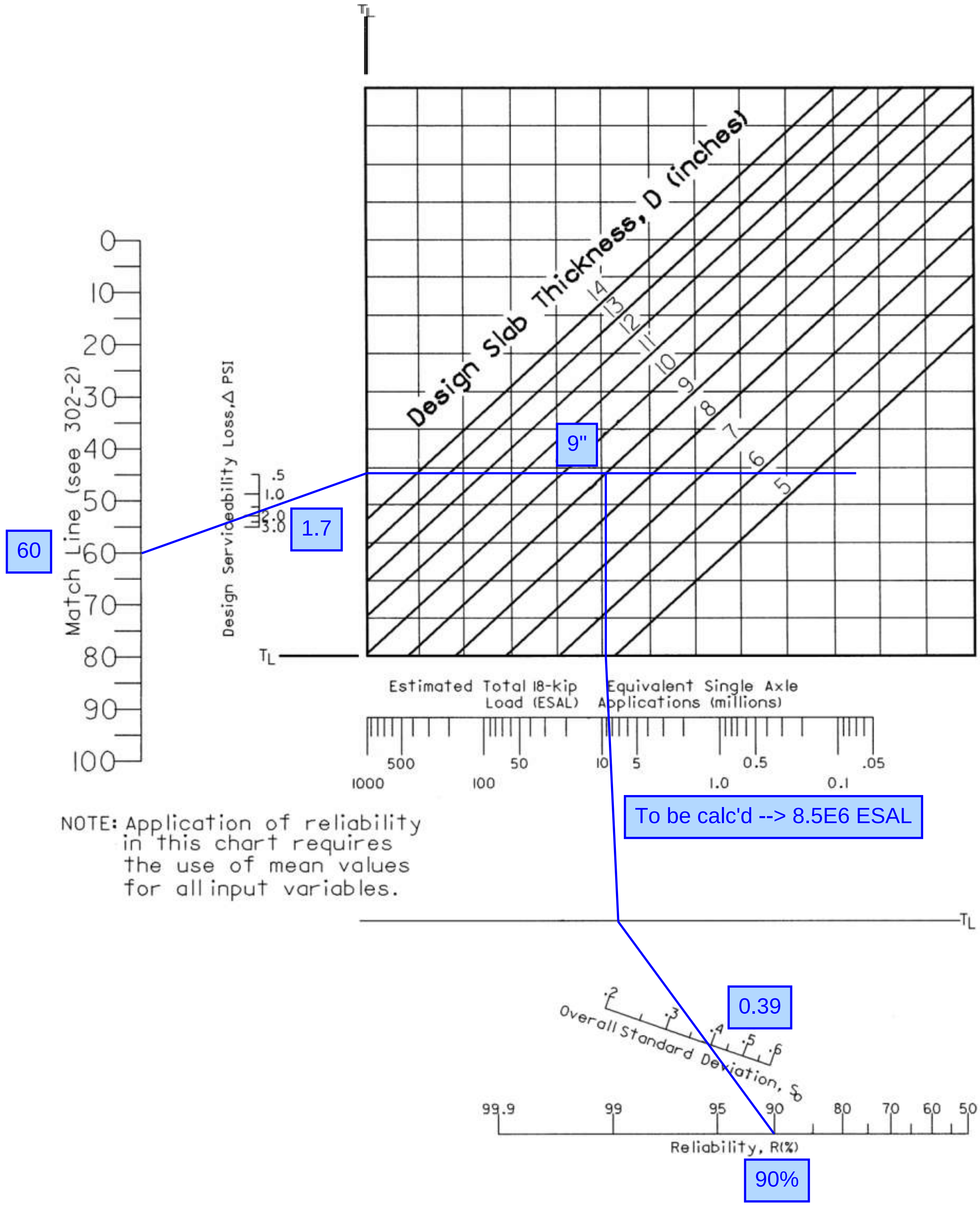
Design serviceability loss (PSI) = 1.7 (Figure 201-1)
Reliability = 85% (Figure 201-1)   90%
Overall standard deviation = 0.39 (Figure 201-1)
18-kip equivalent single axle load = 17.8×10^6 ESAL (Step 1)   To be calc'd --> 8.5E6 ESAL

Therefore: design slab thickness (D) = 10 inches

Rigid Pavement Design Chart Segment 1	302-2 July 2008
	Reference Section & Figure 302, 302-1 (step 5)



Rigid Pavement Design Chart Segment 2	302-3 July 2016
	Reference Section & Figure **302, 302-1 (step 5)**



Flexible Pavement Structural Coefficients	401-1 January 2022 Reference Section 401

ASPHALT CONCRETE STRUCTURAL COEFFICIENTS		
Material	**English Coefficient**	**Metric Coefficient**
Items 424, 441, 442, 443, 823, 826, 859 AC Surface Courses	0.43	0.0169
Items 441, 442, 823, 826 AC Intermediate Courses	0.43	0.0169
Item 880 Warranty Asphalt - top 3" (75 mm)	0.43	0.0169
Items 301, 302 Asphalt Concrete Base Courses	0.36	0.0142
Item 880 Warranty Asphalt - below top 3" (75 mm)	0.36	0.0142
Item 321 Cracked & Seated Plain Concrete	0.27	0.0106
Existing Asphalt Concrete - old, oxidized, & weathered	0.23	0.0092
Item 304 Aggregate Base*	0.14	0.0055
Item 320 Rubblized Concrete	0.14	0.0055
Item 421 Microsurfacing	0.0	0.0
Item 803 Rubberized Open Graded Asphalt Friction Course	0.0	0.0
Item 822 Hot In Place Recycling	0.0	0.0

* When the entire subgrade is chemically stabilized (global chemical stabilization), the coefficient for Item 304 Aggregate Base is increased to 0.17 (0.0067).

Asphalt Concrete Drainage Factor = 1.0

Given:

- Number of Lanes: 4 (2 per direction)
- Functional Classification: Principal Arterial (Rural)
- 2018 Traffic: 15,800 ADT
- 2038 Traffic: 22,450 ADT
- 24 hour truck %: 18%
- Design Period: 20 years
- Open to Traffic: 2019
- Subgrade CBR: 5 (from Subgrade Analysis)

3

100%
20 years
2026
6

Problem: Solve for the Structural Number and determine an acceptable flexible buildup

Solution:

<u>Step 1</u> - Determine the 18 Kip Equivalent Single Axle Loading (ESAL)

Since the project is expected to open to traffic in 2019, the ESAL projection should be for 2019 to 2039. Calculate the mid-year (2029) ADT, rounded to the nearest ten:

2029 ADT = 15,800+(22,450-15,800)(11/20)
2029 ADT = 19,460

Directional distribution, D = 50% (Figure 202-1)
Lane factor = 95% (Figure 202-1)
B:C ratio = 5:1 (Figure 202-1)
ESAL conversion factor for B trucks = 1.06 (Figure 202-1)
ESAL conversion factor for C trucks = 0.33 (Figure 202-1)

Using the equations given in Section 202.2:

ESAL's from B trucks = 19,460(0.18)(0.50)(0.95)(5/6)(1.06) = 1470
ESAL's from C trucks = 19,460(0.18)(0.50)(0.95)(1/6)(0.33) = 92

Total daily ESAL's = 1470+92 = 1562 ESAL/day

Design period ESAL's = 1562 ESAL/day * 365.25 days/yr. * 20 years = 11,410,410
use 11.4×10^6 ESAL

8.5E6 ESAL

<u>Step 2</u> - Determine the subgrade resilient modulus (M_r) using the formula given in Section 203.1.

M_r = 1200 * CBR
M_r = 1200 * 5
M_r = 6000 psi

7,200 psi (assumed)

Step 3 - Determine the design structural number (SN) using Figures 402-2 and 402-3. In Figure 402-2, solve for the match line number using the following information:

Reliability = 85% (Figure 201-1)
Overall Standard Deviation = 0.49 (Figure 201-1)
18-kip Single Axle Loads = 11.4x10^6 ESAL (Step 1)
Subgrade Resilient Modulus = 6,000 psi (Step 2)

90%
0.49
8.5E6 ESAL
7,200 psi

The resulting match line number is then used in Figure 402-3, along with the design serviceability loss of 2.0 (Figure 201-1), to solve for the design structural number (SN).

Therefore: design structural number (SN) = 5.07

Step 4 - Design the typical section using the layer coefficients found in Figure 401-1. The structural number of each layer is determined by multiplying the thickness times the coefficient. The total structural number for the pavement buildup must equal or exceed the design structural number (SN) = 5.07 (Step 3).

Check the number of trucks in the opening day traffic.
2017 ADTT = (15,800+(22,450-15,800)(1/20))*0.18
2017 ADTT = 2900

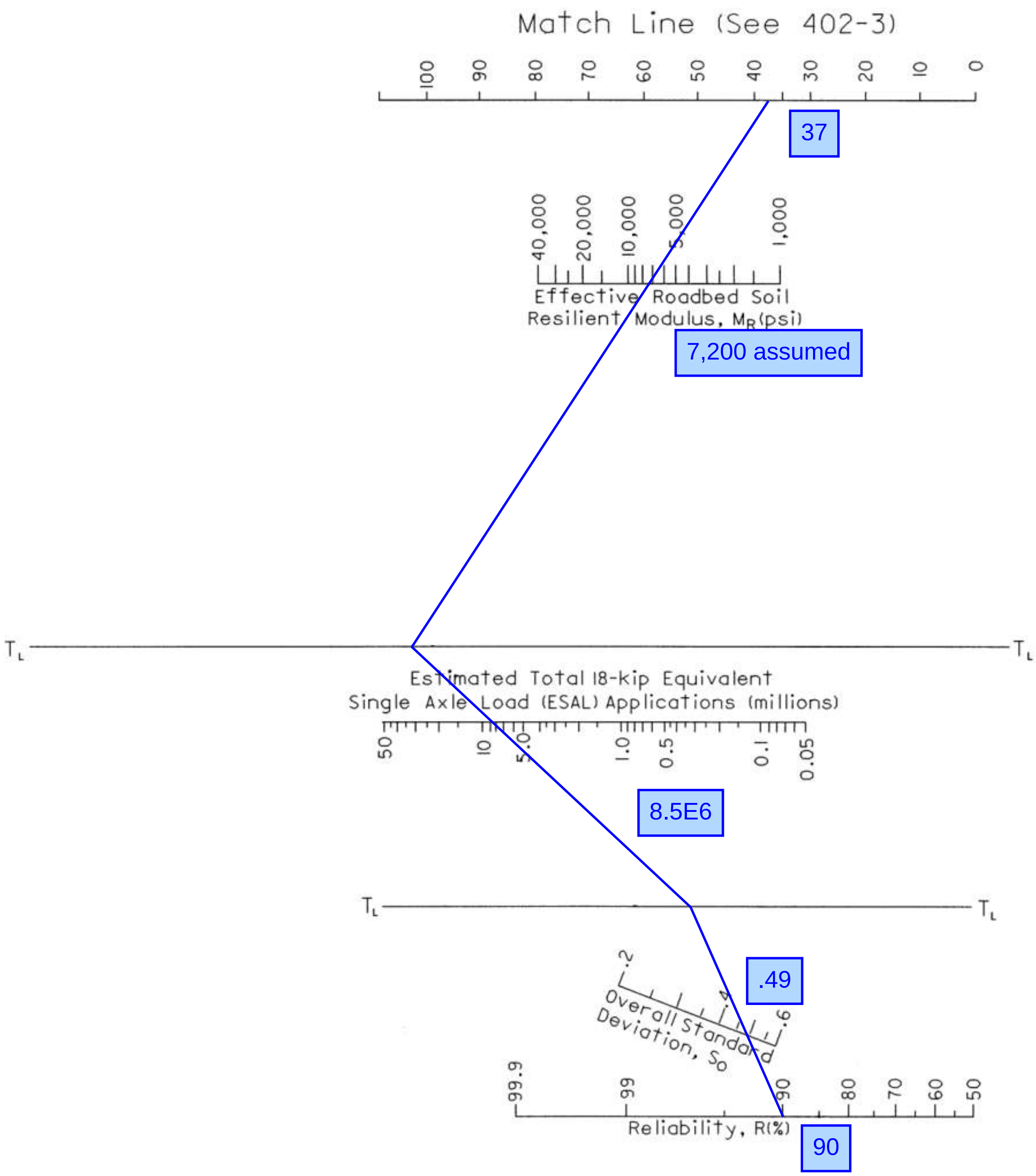
Since the opening day truck traffic is greater than 1500, Item 442 Asphalt Concrete Surface Course, 12.5mm is required.

The following buildup is the recommended solution in accordance with the guidance in Section 406.

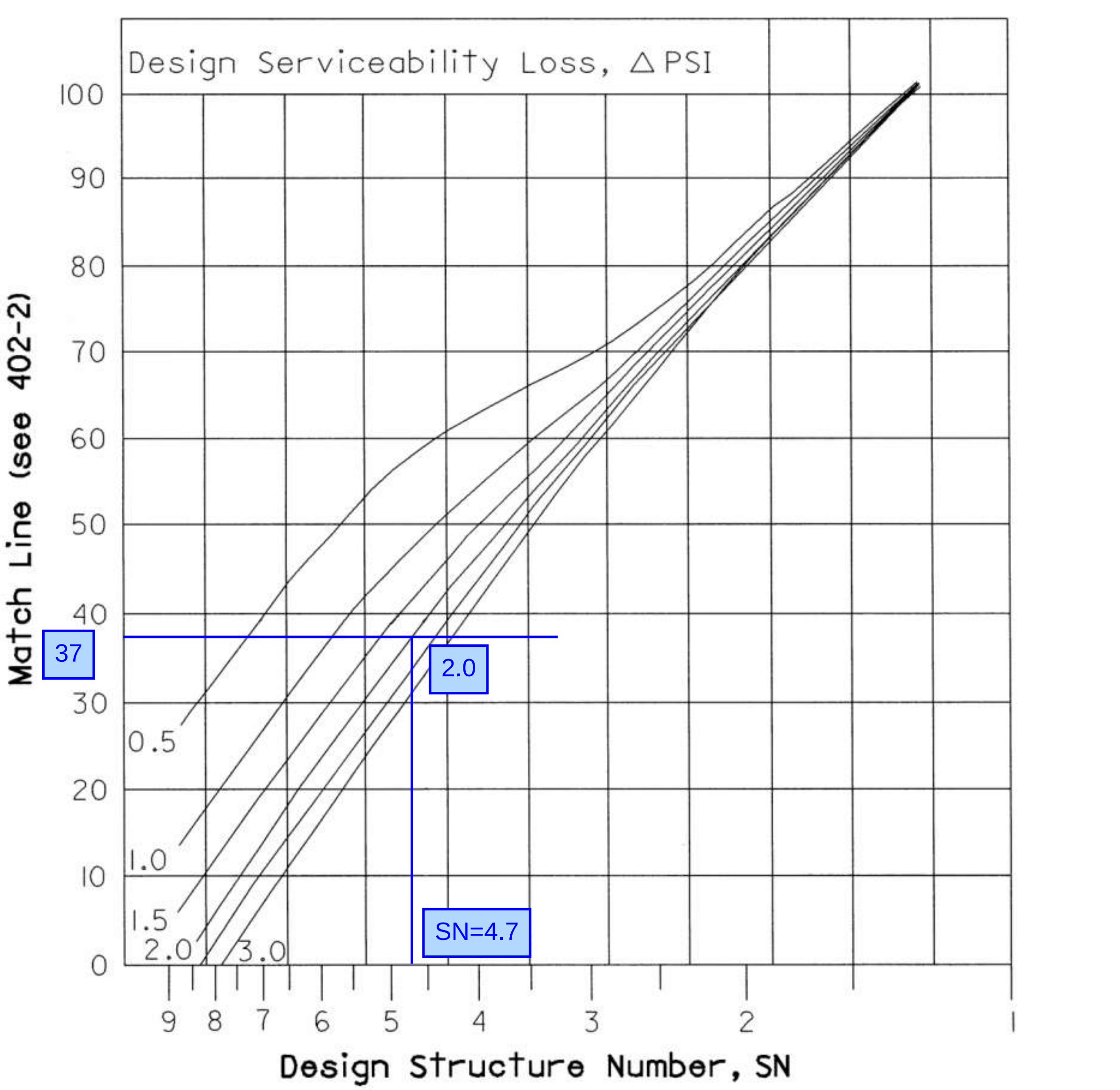
Material	Thickness	Coefficient	SN
442 AC Surface Course, 12.5mm, Type A (449)	1.5"	0.43	0.65
442 AC Intermediate Course, 12.5mm, Type A (449)	1.5"	0.43	0.65
302 Asphalt Concrete Base, PG64-22, (449)	7"	0.36	2.52
304 Aggregate Base	6"	0.14	0.84
		Total SN =	4.7

Since the total SN equal to 5.12 of the proposed buildup is greater than the required SN of 5.07, the design is acceptable.

Flexible Pavement Design Chart Segment 1	402-2 July 2008
	Reference Section & Figure 402, 402-1(step 3)



Flexible Pavement Design Chart Segment 2	402-3 July 2008
	Reference Section & Figure 402, 402-1(step 3)



Asphalt Concrete Quick Reference Guide	406-1
	January 2024
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Item	Minimum Lift	Maximum Lift	Taper to 0"*	Uniform Thickness Required
301 Asphalt Concrete Base (449)	3"	6"	No	No
302 Asphalt Concrete Base (449)	4"	7" 7.75"	No	No
424 Fine Graded Polymer Asphalt Concrete, Type A (449)	0.625" (5/8")	1"	No	Yes
424 Fine Graded Polymer Asphalt Concrete, Type B (448 & 449)	0.75"	1.25"	No	Yes
441 AC Surface Course, Type 1 (446)	1.25"	1.5"	No	Yes
441 AC Surface Course, Type 1 (448)	1.25"	1.5"	No	Yes
441 AC Surface Course, Type 1 (449)	1.25"	1.5"	No	No
441 AC Intermediate Course, Type 1 (448)	1"	1.5"	No	Yes
441 AC Intermediate Course, Type 1 (449)	1"	1.5"	Yes	No
441 AC Intermediate Course, Type 2 (446 & 448)	1.75"	3"	No	Yes
441 AC Intermediate Course, Type 2 (449)	1.75"	3"	Yes	No
442 AC Surface Course, 9.5mm, Type A or B (446 & 447)	1.25"	1.5"	No	Yes
442 AC Surface Course, 9.5mm, Type A or B (448)	1.25"	1.5"	No	Yes
442 AC Surface Course, 9.5mm, Type A or B (449)	1.25"	1.5"	No	No
442 AC Surface Course, 12.5mm, Type A or B (446, **447** & 448)	1.5"	2.5"	No	Yes
442 AC Surface Course, 12.5mm, Type A or B (449)	1.5"	2.5"	No	No
442 AC Intermediate Course, 19mm, Type A or B (**446** & 448)	2.25"	3.75"	No	Yes
442 AC Intermediate Course, 19mm, Type A or B (449)	2.25"	3.75"	Yes	No
442 AC Intermediate Course, 12.5mm, Type A or B (**446** & 448)	1.5"	2.5"	No	Yes
442 AC Intermediate Course, 12.5mm, Type A or B (449)	1.5"	2.5"	Yes	No
442 AC Intermediate Course, 9.5mm, Type A or B (448)	1"	1.5"	No	Yes
442 AC Intermediate Course, 9.5mm, Type A or B (449)	1"	1.5"	Yes	No
443 Stone Matrix Asphalt Concrete, 12.5mm (446)	1.5"	2"	No	Yes

Items in **bold** indicate the most commonly used surface and intermediate courses.