OFFICE OF THE CITY ENGINEER
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Pavement Design Example

Known Parameters:

1. Residential Street (Local Road)
2. California Bearing Ratio (CBR) as determined by Geotechnical Engineer = 3.
3. ADT = 3200 – determined by TIS
4. 24 Hour Truck Traffic = 5%
5. 20-year Design Period

Based upon the above information, and the City of Lebanon Pavement Design Standards, the following information can be determined from Figure 201-1 of the ODOT *Pavement Design and Rehabilitation Manual.*

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	95	90
Principle Arterial, Minor Arterial	90	85
Collectors	90	85
Local	80	80

OVERALL STANDARD DEVIATION	
Flexible Pavement	0.49
Rigid Pavement	0.39

1. Design Serviceability Loss = 2.0
2. Reliability Level = 80%
3. Overall Standard Deviation = 0.49

From Figure 202-1 the following information can be taken:

RATIO OF B:C COMMERCIAL VEHICLES	
FUNCTIONAL CLASSIFICATION	B:C RATIO
Rural Interstate (01)	7:1
Rural Principal Arterial (02)	5:1
All Other Rural (06, 07, 08, 09)	2:1
Urban Interstate (11)	4:1
Urban Freeway & Expressway (12)	3:1
Urban Principal Arterial (14)	2:1
All Other Urban (16, 17, 19)	1:1

ESAL CONVERSION FACTORS				
FUNCTIONAL CLASSIFICATION	RIGID		FLEXIBLE	
	B	C	B	C
Rural Interstate (01)	1.86	0.66	1.23	0.51
Rural Principal Arterial (02)	2.42	0.95	1.45	0.58
All Other Rural (06, 07, 08, 09)	1.55	1.40	0.89	0.75
Urban Interstate (11)	1.92	0.84	1.21	0.62
Urban Expressway & Freeway (12)	1.80	0.86	1.22	0.50
All Other Urban (14, 16, 17, 19)	1.72	0.80	1.03	0.55

LANE FACTORS		
Number of Lanes	% Trucks in Design Lane	Directional Distribution (%)
2 - Lane	100	50
4 - Lane	90	50
6 (or more) - Lane	80	50

1. Ratio of B:C Commercial Vehicles = 1:1
2. ESAL Conversion Factors:

   B=1.03
   C=0.55
3. Lane Factors:

   Percent Trucks in Design Lane = 100%
   Directional Distribution = 50%

The Subgrade Resilient Modulus is determined using Equation 203.1 ODOT *Pavement Design and Rehabilitation Manual*:

$$M_r = 1200 * CBR$$

Therefore, since the given CBR = 3:

$$M_r = 1200 * 3 = 3600$$

ESALs for B & C trucks shall be determined using the following formulas:
B ESALs = ADT*%T24*D*%B*CF
C ESALs = ADT*%T24*D*%C*CF

Where ADT = Average Daily Traffic
%T24 = 24-Hour Truck Percentage of ADT
D = Directional Distribution
LF = Lane Factor
CF = Appropriate Truck Conversion Factor

Total ESALs = B ESALs + C ESALs

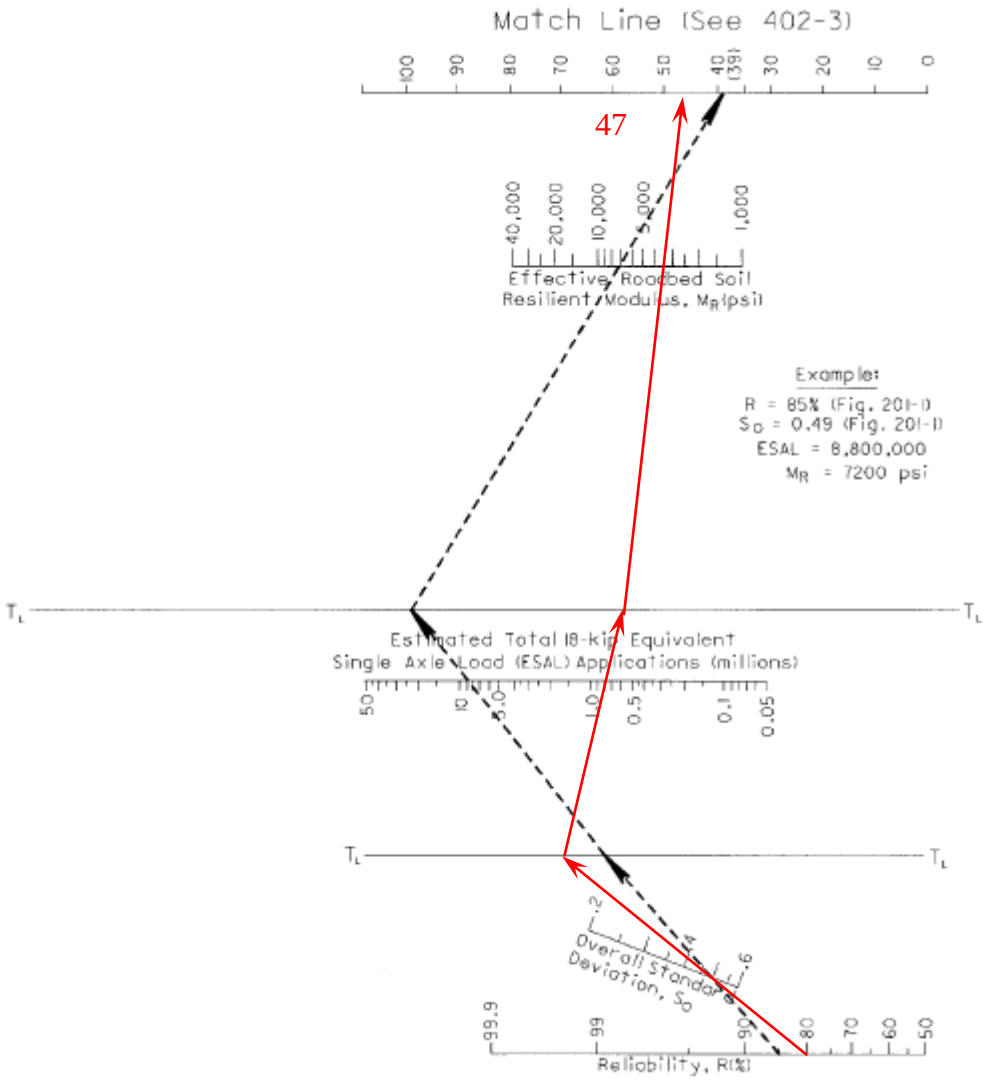
Using the information given:

B ESALs = 3200(0.05)(0.5)(1.00)(1/2)(1.03) = 82.40
C ESALs = 3200(0.05)(0.5)(1.00)(1/2)(0.55) = 22.00
Total ESALs = 82.40 + 22.00 = 104.40 per day.

Design Period ESALs = 104.40 Daily ESALs * 365.25 days per year * 20 years
= 762,642 ESALs = 0.7626 million ESALs

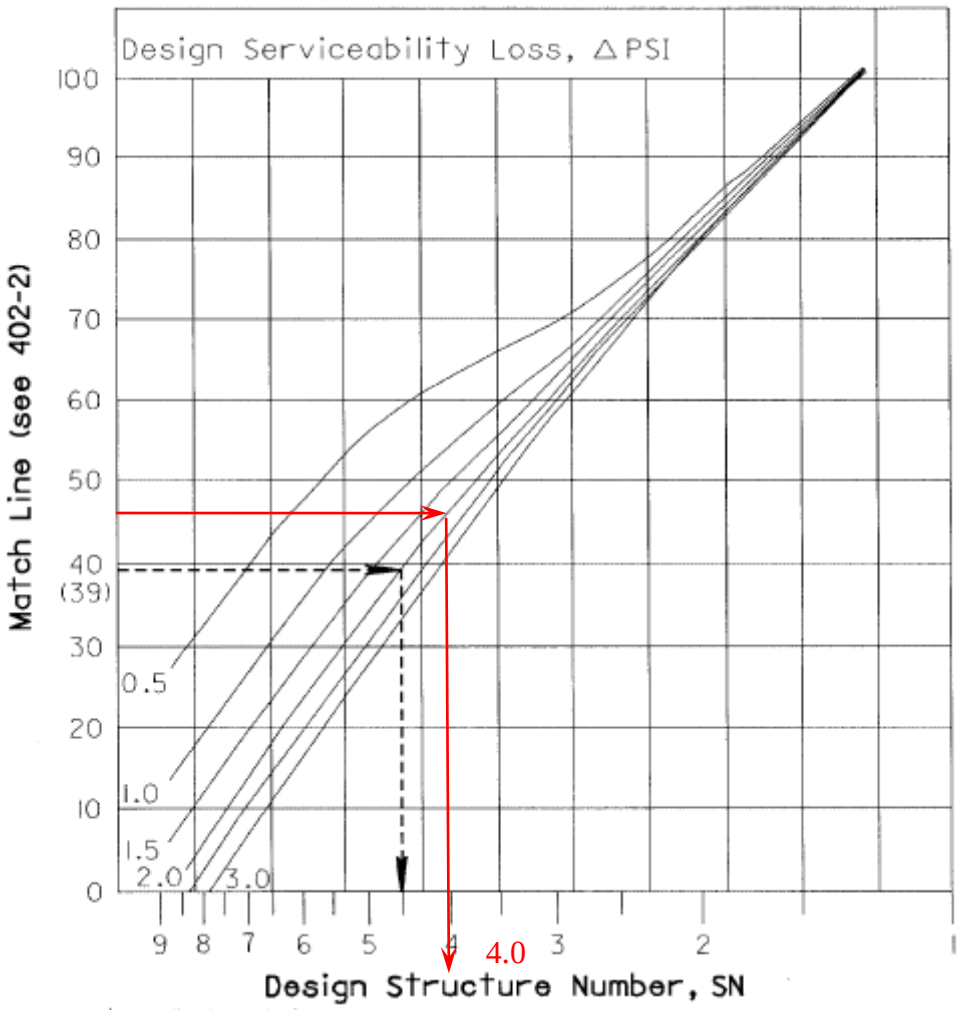
Taking the Total ESALs, Reliability, Standard Deviation and the Resilient Modulus and creating a plot on Figure 402-2 of the ODOT *Pavement Design and Rehabilitation Manual*:

Reliability Level = 80%
Overall Standard Deviation = 0.49
M_r = 3600
Total ESALs = 762,642 ESALs = 0.7626 million ESALs



The result from Figure 402-2 of the ODOT *Pavement Design and Rehabilitation Manual* is carried over onto Figure 402-3 along with the Design Serviceability Loss to determine the Design Structure Number:

Design Serviceability Loss = 2.0



Therefore the Design Structural Number will be 4.0

The pavement section structural number is determined by using Figure 401-1 from the ODOT *Pavement Design and Rehabilitation Manual.*

ASPHALT CONCRETE STRUCTURAL COEFFICIENTS		
Material	English Coefficient	Metric Coefficient
Items 424, 442, 443, 446, 448, 826, 857, 859 - AC Surface Courses	0.43	0.0169
Items 442, 443, 446, 448, 826, 857 - 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
Items 306, 307, 308 - Free Draining Base Layers*	0.14	0.0055
Items 421, 881 - Microsurfacing	0.0	0.0
Item 803 Rubberized Open Graded Asphalt Friction Course	0.0	0.0
Items 822, 886 - Hot In Place Recycling	0.0	0.0

The required pavement section structural number needs to be compared to the City of Lebanon minimum pavement section to determine if the minimum pavement section will be used or a modified pavement section is needed.

If the required pavement section structural number is less than the City of Lebanon minimum pavement section structural number, the City of Lebanon minimum pavement section shall be used.

If the required pavement section structural number is greater than the City of Lebanon minimum pavement section structural number, a modified pavement section based upon the City of Lebanon minimum pavement section shall be designed and used.

The City of Lebanon minimum residential pavement section structural number is determined by the following:

1.5” 448 Surface Course	1.5*0.43 = 0.645
2.0” 448 Intermediate Course	2.0*0.43 = 0.860
4.0” 301 Base Course	4.0*0.36 = 1.440
6.0” 304 Gravel Base	6.0*0.14 = 0.840
	SN = 3.785 = 3.8

Since the structural number for the City of Lebanon standard minimum residential street section is 3.785 and the required structural number is 4.0, the pavement section for the proposed development will need to be designed using the City of Lebanon minimum residential street pavement section as a starting point.

Adjustments shall be made in the following order:

1. Item 304 Gravel Base
2. Item 301 Base Course
3. Item 448 Intermediate Course
4. Item 448 Surface Course

All adjustments shall be made so no violations of the ODOT recommendations for course thickness are made.

In this case adjustments will be made to the Item 304 Gravel Base. The difference between the City of Lebanon minimum pavement section structural number and the required structural number is found by the following:

4.0-3.8 = 0.2

The structural coefficient of Item 304 Gravel Base is 0.14 as found in Figure 401-1 from the ODOT *Pavement Design and Rehabilitation Manual*. Therefore by dividing the difference found above by the structural coefficient for the gravel base the required thickness of additional gravel base can be found:

0.2 / 0.14 = 1.43 round up to 2

Therefore an additional 2 inches of Item 304 will be required.

The pavement section for the development will be as follows:

1.5” 448 Surface Course	1.5*0.43 = 0.645
2.0” 448 Intermediate Course	2.0*0.43 = 0.860
4.0” 301 Base Course	4.0*0.36 = 1.400
8.0” 304 Gravel Base	8.0*0.14 = 1.120
	SN = 4.025 = 4.0