

CHAPTER 4 FRICTION COURSE POLICY

4.1 FRICTION COURSE OPTIONS

There are two general types of friction courses currently in use by the Department, dense graded (FC-9.5 & FC-12.5) and open graded (FC-5). Their thickness is shown on the plans with spread rates determined by specification formula and paid for by the ton.

The Maximum Spread rate used for estimating quantities is as follows:

FC-9.5	110 lb/yd ²
FC-12.5	165 lb/yd ²
FC-5	80 lb/yd ²

Actual pay quantities will be based on the actual maximum specific gravity of the mixture used.

Friction Courses FC-12.5 and FC-9.5 are dense graded mixes which are typically placed 1½-in and 1-in thick respectively. These friction courses provide smooth riding surfaces with adequate friction numbers for skid resistance.

The FC-9.5 dense graded mix will allow a 1-in lift of friction course. On some projects, this thinner lift may allow room for an additional structural or overbuild lift, as in some curb and gutter sections, without milling into the base or overlaying friction course into the gutter.

The other friction course, FC-5, consists of an open graded material. FC-5 is placed and shown on the typical section as ¾-in thick. FC-5 provides a skid resistant surface. The open graded texture of the mix provides for the rapid removal of water from between the tire and the pavement to reduce the potential for hydroplaning at higher speeds.

A friction course will be placed on all roads and ramps with a design speed of 35 mph or higher, except for low volume two lane roads having a five-year projected AADT from the opening year of 3,000 vehicles per day or less.

Use FC-5 on multi-lane flush shoulder roadways with a design speed of 50 mph or greater.

Use FC-12.5 or FC-9.5 on all other flush shoulder or curbed roadways. However, if there is a history of wet-weather crashes in a high-speed curbed section, FC-5 should be considered. **Table 4.1** summarizes these requirements.

The appropriate Traffic Level is to be shown for dense-graded friction courses FC-9.5 and FC-12.5. For Traffic Levels B and C, PG 76-22 should be called for in the friction course. For Traffic Level E, PG 76-22 or High Polymer (HP) should be called for in the friction course. Note that FC-9.5 should not be used for Traffic Level E.

**TABLE 4.1
 FRICTION COURSE POLICY**

Design Speed (mph)	Two Lane	Multilane
Flush Shoulder Roadways		
≤ 45	FC-12.5 or FC-9.5	FC-12.5 or FC-9.5
≥ 50		FC-5
Curbed Roadways		
All	FC-12.5 or FC-9.5	FC-12.5 or FC-9.5
NOTES:		
1. Include a friction course on all roads and ramps with a design speed ≥ 35 mph or higher , except for two lane roads having a five-year projected AADT (from the opening year) of 3000 vehicles per day or less.		
2. FC-5 should be considered for multilane curbed roadways with design speeds ≥ 50 mph when there is a history of wet weather crashes.		

Commented [HMJ1]: Cleanup. This is redundant to the >= symbol already in the sentence.

4.2 FRICTION COURSES 12.5 AND 9.5 (FC-12.5 and FC-9.5)

The following are some of the features of the use of FC-12.5 and FC-9.5:

- FC-12.5 and FC-9.5 are allowed directly on top of any structural course mix.
- FC-12.5 and FC-9.5 are considered part of the structural layer and may be considered as both a structural and friction course.
- Coordinate with the District Pavement Design Engineer to determine the appropriate friction course to use on limited access ramps. The type of friction

course used must be evaluated for long term maintenance, surface drainage, existing crash patterns, and pavement structural value.

- Dense graded friction course is typically used on ramps with heavy volumes of truck traffic and/or turning and stopping movements.
- FC-5 is typically only used on high speed ramps with long tangent sections and/or large radii (e.g., a ramp connecting two limited access facilities).

4.3 FRICTION COURSE 5 (FC-5)

The following are some of the limitations on the use of FC-5:

- **On all roads that require FC-5:**

- Open graded friction courses such as FC-2 and FC-5 should not be overlaid (due to its potential to allow water into the pavement system) except when approved by the District Materials Engineer.
- FC-5 should not sit after construction for more than four (4) months before being opened to traffic. If necessary, the FC-5 may need to be let under a separate contract.
- FC-5 may be placed directly on the milled surface provided the underlying layers are in good structural shape.

- **On multi-lane non-limited access facilities:**

- the FC-5 will typically covers the deceleration areas of turn lanes and shoulder pavement. This is illustrated in Figure 4.1.
- FC-5 is not to be placed in median openings, turn outs, or gore areas on these facilities. This is illustrated in Figures 4.1 and 4.2. An exception to this is low volume intersections as shown in Figure 4.3.

- ~~FC-5 may be placed directly on the milled surface provided the underlying layers are in good structural shape.~~

- On non-limited access facilities, the friction course FC-5 is to be placed over the entire paved shoulder.
- FC-5 should not be placed in the turning area of signalized intersections, as shown in Figure 4.3. An exception to this is where both of the intersecting roads qualify for FC-5, then the entire intersection should use FC-5.

- **On limited access facilities:**

Commented [HMJ2]: Updates in this section are to:
1. Clarify where FC-5 should be used, and where it should not be used.
2. Organized requirements by facility type.
3. Added new requirement for how to treat signalized intersections.

Commented [HMJ3]: Moved bullet up to here to be under the general bullets that apply to all roads.

Commented [HMJ4]: This is covered by the bullet below that says FC-5 is to be placed over the entire paved shoulder.

Commented [HMJ5]: This last sentence is being deleted because it is unclear. The new figure should eliminate any ambiguity.

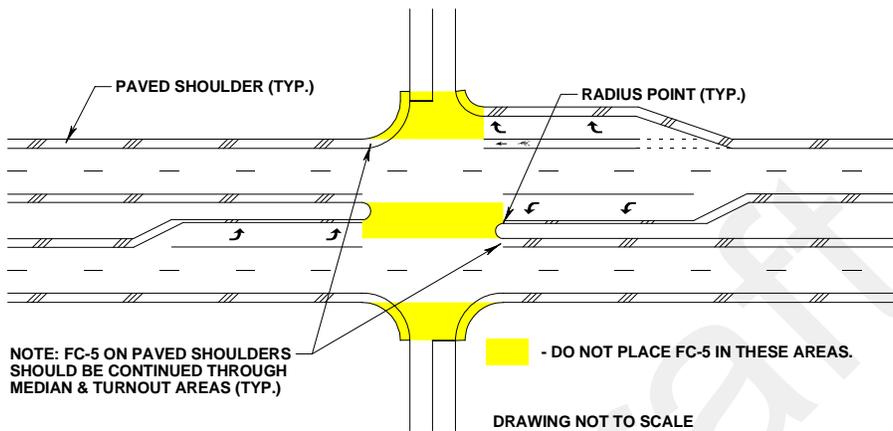
Commented [HMJ6]: Suggested by SMO Bituminous Section to address issues with raveling and shoving specifically in suburban areas.

- FC-5 is to extend 8-in beyond the edge of the travel lane, onto the paved shoulder.
- FC-5 is not to be placed in median crossovers, ~~turn outs,~~ or ~~gore areas of multi-lane, high-speed facilities.~~
- ~~In order to~~ To minimize raveling/deterioration due to pavement sawcuts, FC-5 is not required on flexible pavement within proposed Toll facilities that utilize electronic data collection requiring loop installation in the pavement surface.

Commented [HMJ7]: Not applicable to LA facilities.

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FIGURE 4.1
TYPICAL LIMITS OF FC-5
FOR MULTI-LANE NON-LIMITED ACCESS FACILITIES
NON-SIGNALIZED INTERSECTION/MEDIAN OPENING



Commented [HMJ8]: This is a new figure. It's a modified version of the Figure 4.3 that's in the 2022 FPDM.

Added callouts for clarity.

Exclusion limits are different from the previous version to match the change made to the text in this section. We now show the typical application of FC-5 within the deceleration area of turn lanes, with the exclusion of FC-5 within the median openings and turnout areas.

FIGURE 4.2
TYPICAL LIMITS OF FC-5
FOR MULTI-LANE NON-LIMITED ACCESS FACILITIES
MEDIAN OPENING (NO TURN LANES)

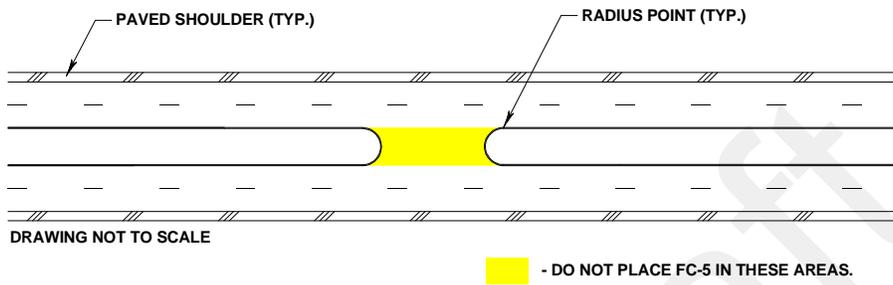


FIGURE 4.3
TYPICAL LIMITS OF FC-5
FOR MULTI-LANE NON-LIMITED ACCESS FACILITIES
SIGNALIZED INTERSECTION

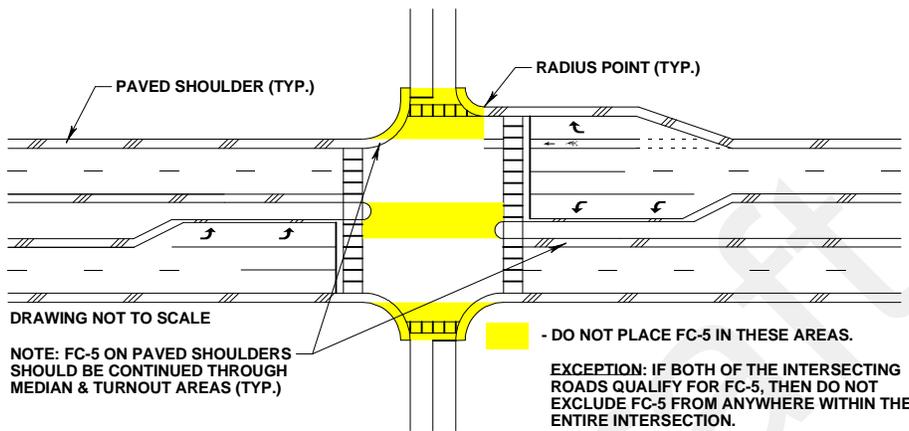
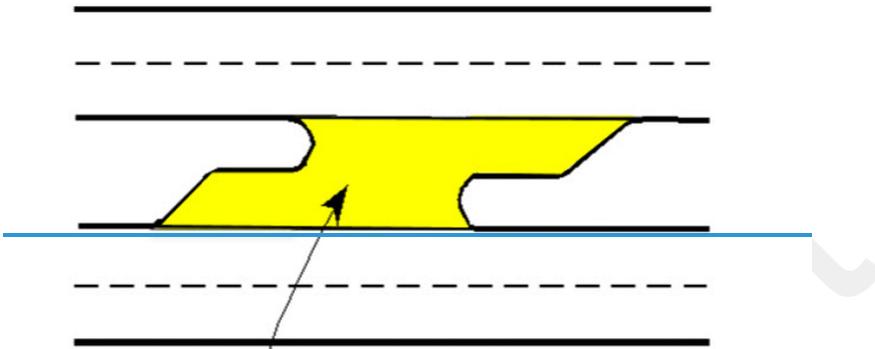


FIGURE 4.1
ILLUSTRATION SHOWING LIMITS OF FRICTION COURSE
FC-5 AT INTERMEDIATE MEDIAN CROSSOVER



**Do not place FC-5
within these limits**

Commented [HMJ9]: These figures (from this one thru the end of the chapter) are being deleted. They've been replaced with the new figures above.

FIGURE 4.2
ILLUSTRATION SHOWING LIMITS OF FRICTION COURSE FC-5 AT
INTERMEDIATE MEDIAN CROSSOVER

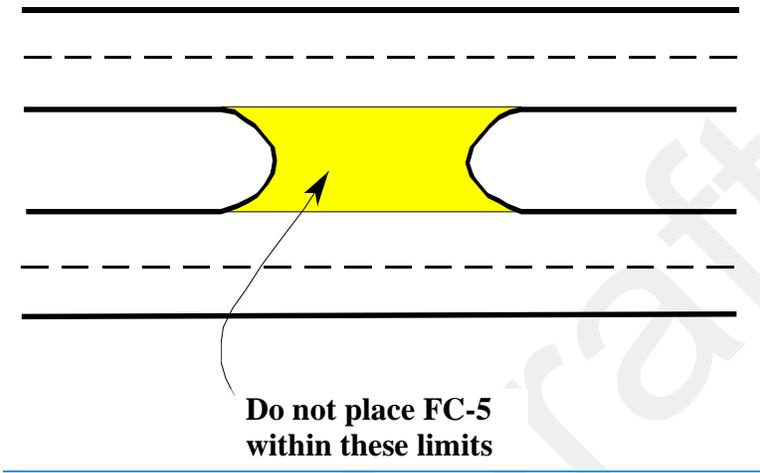
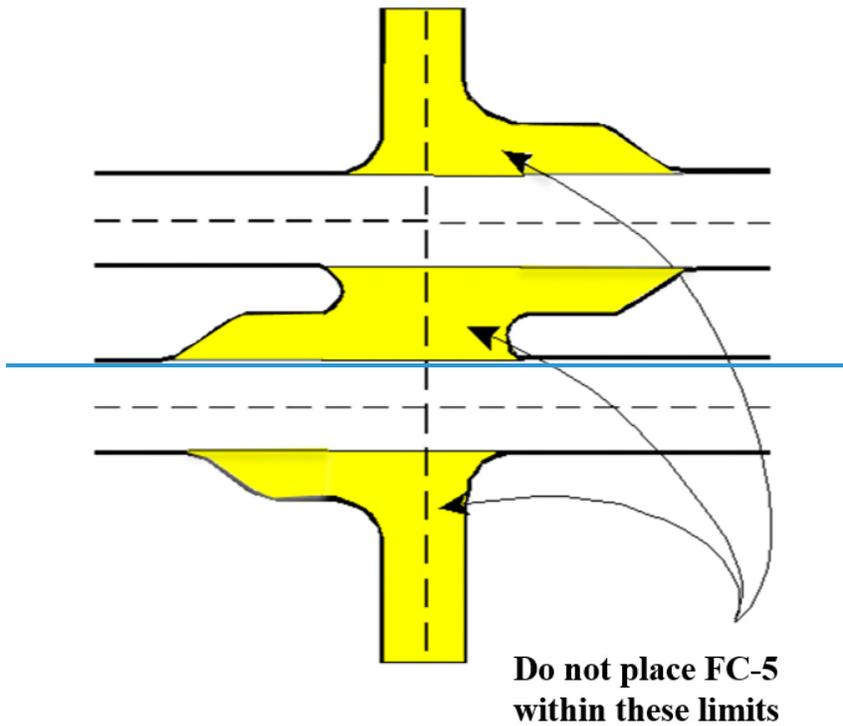


FIGURE 4.3
ILLUSTRATION SHOWING LIMITS OF FRICTION COURSE
FC-5 AT MEDIAN AREAS OF LOW VOLUME INTERSECTION



CHAPTER 5 PAVEMENT THICKNESS DESIGN PROCESS FOR NEW CONSTRUCTION OR RECONSTRUCTION

5.1 OVERVIEW

This process is applicable to new construction or total reconstruction projects in Florida where the Pavement Design Engineer must calculate the pavement layer thickness using the AASHTO Procedure.

For new lane additions, short pavement sections (approximately 1,000-ft or less) such as bridge replacement, crossroads, short turnouts, etc., the principles provided in **Chapter 6** of this manual shall apply.

5.2 REQUIRED STRUCTURAL NUMBER (SN_R) CALCULATIONS USING THE AASHTO DESIGN GUIDE

The following is a summary of the steps to be taken to solve for the Required Structural Number (SN_R):

- The 18-kip Equivalent Single Axle Loads 18-kip ESAL's are obtained from the District Planning Office. This process can be found in the Project Traffic Forecasting Handbook Procedure (Topic No. 525-030-120) using the Project Traffic Forecasting Handbook. **Appendix D** provides a simple procedure for calculating the accumulated 18-kip ESAL's or ESAL_D for the appropriate design period.
- The Resilient Modulus (M_R) used to characterize the strength of the roadbed soil is obtained from the State Materials Office, through the District Materials Office using direct resilient modulus laboratory testing. As an alternative for low volume roads, the Design Limerock Bearing Ratio (LBR) value which is based on 90% of the anticipated LBR's exceeding the Design LBR is discussed in **Section 5.2.4**. The relationship between the Design LBR and Resilient Modulus (M_R) sample values are shown in **Table 5.1**.
- A safety factor is applied using a Reliability (%R) value from **Table 5.2**. Recommended values range from 75% to 99%. A Standard Deviation (S_O) of 0.45 is used in the calculation. The Standard Normal Deviate (Z_R) is dependent on the Reliability (%R).

Using these values, the Pavement Design Engineer will calculate the Structural Number Required (SN_R) using the design tables in **Appendix A**.

Each design table uses a different Reliability (%R) and relates Design 18-kip Equivalent Single Axle Loads ($ESAL_D$) to the Structural Number Required (SN_R) for multiple Resilient Modulus (M_R) values. **Table 5.3** provides an example of an FDOT design table.

5.2.1 DESIGN EXAMPLE

The following is an example illustrating the mechanics of this procedure. Using the following input for New Construction of an Urban Arterial:

$ESAL_D = 4,900,000$ (from the Planning Office)

Use 5,000,000

$M_R = 14,000$ psi (from the State Materials Office)

%R = 80 to 90 (choose %R = 90 from **Table 5.2**)

Design 18-kip Equivalent Single Axle Loads ($ESAL_D$) and Resilient Modulus (M_R) values can generally be rounded up or down to the nearest table values. Final thickness designs are to the nearest ½-in of structural course for new construction. If desired, an interpolated SN_R value can be used. The solution is:

$SN_R = 3.57$ -in (from **Table 5.3**)

5.2.2 DESIGN BASE HIGHWATER CLEARANCE

Base clearance above high water is critical for good pavement performance and to achieve the required compaction and stability during construction operations. (Dr. Ping - "Design Highwater Clearances for Highway Pavements" research report BD543-13).

The laboratory Design Resilient Modulus obtained from the State Materials Office is based on optimum moisture content conditions which correspond to a 3-ft base clearance.

In addition to thicker pavement structure for 1-ft base clearance, significant construction problems are also likely and additional costs such as dewatering may be required to achieve compaction.

When the base clearance is less than 3-ft, the pavement designer must reduce the Design Resilient Modulus as follows:

For 2-ft Base Clearance, a 25% modulus reduction

For 1-ft Base Clearance, a 50% modulus reduction

These reductions are not to be misconstrued as having a linear relationship with the base clearance itself. Findings of FDOT Project Number BDX86 "Methods to Predict Seasonal High Ground Water Table (SHGWT) have confirmed that there is not enough confidence in reducing Resilient Modulus at any closer intervals than 1-ft. To do so would be outside the accuracy of any estimated value of SHGWT.

The pavement design engineer has the discretion to attempt refinement beyond these limits by using monitoring wells, and performing a more comprehensive soil analysis than is currently standard, where assurance can be reached that the particular soil types in the project limits are homogenous.

It is recommended that in high ground water situations, the district drainage engineer and the State Geotechnical Engineer's office at the State Materials Office (SMO) be consulted.

Note: Refer to **Section 5.6.2** for further guidance on high-water clearance and base design considerations.

5.2.3 LABORATORY RESILIENT MODULUS (M_R)

The Design Resilient Modulus (M_R) is determined by the SMO directly from laboratory testing (AASHTO T 307) for new construction and reconstruction projects based on instructions in [FDOT Soils and Foundation Handbook](#).

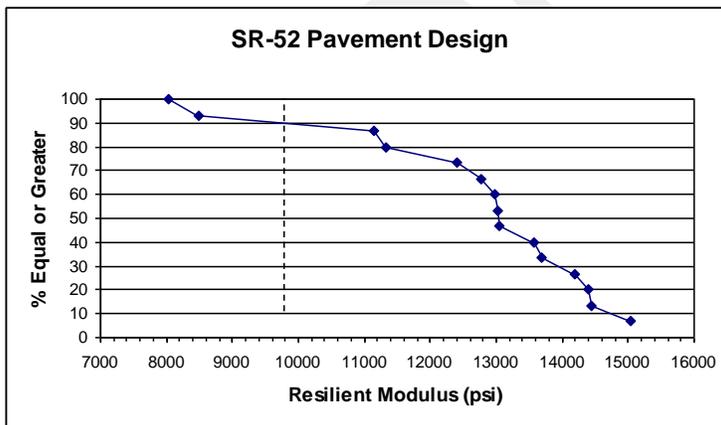
For new construction with substantial fill sections in excess of 3-ft, samples should be obtained from potential borrow areas to estimate the roadway embankment resilient modulus.

The following method (illustrated in **Figure 5.1**) is generally applied by the SMO to the M_R test data to account for variability in materials and to provide for an optimum pavement design:

90% M_R Method - Resilient modulus values using AASHTO T 307 at 11 psi bulk stress are sorted into descending order. For each value, the percentage of values, which are equal to or greater than that value, is calculated. These percentages are plotted versus the M_R values. The M_R value corresponding to 90% is used as the design value. Thus, 90% of the individual tests results are equal to or greater than the design value.

Figure 5.1 – 90% M_R Method Illustration
Ranked M_R Test Results for 90% Method

Rank	Sample Location	≥%	M_R (psi)
1	337+98	100	8,030
2	254+90	93	8,477
3	289+80	87	11,148
4	56+07	80	11,335
5	41+98	73	12,399
6	242+00	67	12,765
7	321+92	60	12,976
8	600+00	53	13,025
9	225+00	47	13,039
10	272+99	40	13,565
11	615+43	33	13,682
12	211+98	27	14,190
13	307+04	20	14,398
14	584+66	13	14,449
15	273+99	7	15,031



Based on the results shown, the resilient modulus corresponding to a 90th percentile is 9,800 psi.

5.2.4 RESILIENT MODULUS (M_R) FROM LBR

The roadbed soil resilient modulus, M_R can be estimated from the Limerock Bearing Ratio (LBR) value by the following equation.

$$M_R(PSI) = 10^{[0.7365 \cdot \log(LBR)]} * 809$$

This equation combines equation $SSV = 4.596 * \log(LBR) - 0.576$ developed by Dr. Robert Ho of the State Materials Office (2/2/93 memo to Lofroos) that relates LBR to soil support value (SSV) and equation FF.3: $SSV = 6.24 * \log(M_R) - 18.72$ from the Appendix FF, Volume 2 of the AASHTO Guide for Design of Pavement Structures, that relates M_R to SSV.

Due to the approximate relationship of LBR to M_R , a Design LBR greater than 40 should not be recommended or used to estimate the Design M_R .

If a Design LBR or M_R Value is not available from the District Materials Office, and a series of LBR values are provided, the Pavement Design Engineer may select a Design LBR Value (not to exceed a maximum of 40 LBR) based on the 90th percentile methodology. The following simple analysis is provided as an example.

GIVEN:

The following illustrates the mechanics of calculating the Resilient Modulus (M_R) obtained from a set of LBR data.

DATA:

The following field data has been provided:

<u>Sample Number</u>	<u>LBR Values In Ascending Order</u>
1	22
2	22
3	23
4	24
5	24
6	24
7	25
8	25
9	25
10	26
11	26
12	27
13	27
14	40

SOLUTION:

Sample No. 14 is considered an outlier by inspection and should be eliminated. It is satisfactory to drop a high number as in this example, but care should be taken before dropping a low number, because it may indicate a localized weak spot, that may require special treatment.

This results in 13 good samples.

$$13 \times 90\% = 11.7 \text{ (Use 12)}$$

Count back 12 samples starting with Sample Number 13 to Sample Number 1:

$$\text{Use LBR} = 22.$$

CONCLUSION:

90% meet or exceed the Design LBR = 22.

The Pavement Design Engineer can now convert the Design LBR Value to a Resilient Modulus (M_R) using **Table 5.1**. Therefore: $M_R = 8,000$ psi

TABLE 5.1
RELATIONSHIP BETWEEN RESILIENT MODULUS (M_R) AND
LIMEROCK BEARING RATIO (LBR) SAMPLE VALUES

The following are some Limerock Bearing Ratio (LBR) input values that were input into these equations to obtain Resilient Modulus (M_R) values.

Limerock Bearing Ratio (LBR)	Resilient Modulus (PSI)
10	4,500
12	5,000
14	5,500
16	6,000
18	7,000
20	7,500
22	8,000
24	8,500
26	9,000
28	9,500
30	10,000
32	10,500
34	11,000
36	11,500
38	12,000
40	12,000

TABLE 5.2

RELIABILITY (%R) FOR DIFFERENT ROADWAY FACILITIES

<u>Facility</u>	<u>New</u>	<u>Rehabilitation</u>
Limited Access	80 – 95	95 – 99
Urban Arterials	80 – 90	90 – 97
Rural Arterials	75 – 90	90 – 95
Collectors	75 – 80	90 – 95

Notes

- The type of roadway is determined by the Transportation Statistics Office and can be obtained from the Roadway Characteristics Inventory (RCI).
- The designer has some flexibility in selecting values that best fit the project when choosing the Reliability (%R).
- Considerations for selecting a reliability level include projected traffic volumes and the consequences involved with early rehabilitation, if actual traffic loadings are greater than anticipated. A detailed discussion of reliability concepts can be found in the AASHTO Guide For Design Of Pavement Structures.

TABLE 5.3 - Example Design Table (From Appendix A, Table A.4A)

**REQUIRED STRUCTURAL NUMBER (SN_R)
90% RELIABILITY (%R)
RESILIENT MODULUS (M_R) RANGE 4,000 PSI TO 18,000 PSI**

ESAL _D	RESILIENT MODULUS (M _R), (PSI x 1000)														
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
100,000	3.02	2.77	2.59	2.44	2.31	2.21	2.12	2.04	1.97	1.91	1.86	1.81	1.76	1.72	1.68
150,000	3.23	2.97	2.77	2.61	2.47	2.36	2.27	2.19	2.11	2.05	1.99	1.94	1.89	1.84	1.80
200,000	3.39	3.11	2.90	2.73	2.60	2.48	2.38	2.30	2.22	2.15	2.09	2.03	1.98	1.94	1.89
250,000	3.52	3.23	3.01	2.84	2.69	2.57	2.47	2.38	2.30	2.23	2.17	2.11	2.06	2.01	1.97
300,000	3.62	3.33	3.10	2.92	2.78	2.65	2.55	2.46	2.37	2.30	2.24	2.18	2.12	2.07	2.03
350,000	3.71	3.41	3.18	3.00	2.85	2.72	2.61	2.52	2.44	2.36	2.30	2.23	2.18	2.13	2.08
400,000	3.79	3.49	3.25	3.07	2.91	2.78	2.67	2.58	2.49	2.42	2.35	2.29	2.23	2.18	2.13
450,000	3.87	3.56	3.32	3.13	2.97	2.84	2.73	2.63	2.54	2.46	2.39	2.33	2.27	2.22	2.17
500,000	3.93	3.62	3.38	3.18	3.02	2.89	2.77	2.67	2.59	2.51	2.44	2.37	2.31	2.26	2.21
600,000	4.05	3.73	3.48	3.28	3.12	2.98	2.86	2.76	2.67	2.58	2.51	2.45	2.39	2.33	2.28
700,000	4.14	3.82	3.57	3.36	3.20	3.05	2.93	2.83	2.73	2.65	2.58	2.51	2.45	2.39	2.34
800,000	4.23	3.90	3.64	3.44	3.27	3.12	3.00	2.89	2.80	2.71	2.63	2.57	2.50	2.44	2.39
900,000	4.31	3.97	3.71	3.51	3.33	3.18	3.06	2.95	2.85	2.76	2.69	2.62	2.55	2.49	2.44
1,000,000	4.38	4.04	3.78	3.57	3.39	3.24	3.11	3.00	2.90	2.81	2.73	2.66	2.60	2.54	2.48
1,500,000	4.65	4.30	4.03	3.81	3.62	3.46	3.33	3.21	3.10	3.01	2.92	2.85	2.78	2.71	2.65
2,000,000	4.85	4.50	4.21	3.99	3.79	3.63	3.49	3.36	3.25	3.16	3.07	2.99	2.91	2.85	2.78
2,500,000	5.01	4.65	4.36	4.13	3.93	3.76	3.62	3.49	3.38	3.27	3.18	3.10	3.02	2.95	2.89
3,000,000	5.14	4.77	4.48	4.25	4.05	3.88	3.73	3.60	3.48	3.37	3.28	3.19	3.12	3.04	2.98
3,500,000	5.25	4.88	4.59	4.35	4.14	3.97	3.82	3.69	3.57	3.46	3.36	3.28	3.20	3.12	3.06
4,000,000	5.35	4.98	4.68	4.44	4.23	4.06	3.90	3.77	3.65	3.54	3.44	3.35	3.27	3.19	3.12
4,500,000	5.44	5.06	4.76	4.52	4.31	4.13	3.98	3.84	3.72	3.61	3.51	3.42	3.33	3.26	3.19
5,000,000	5.52	5.14	4.83	4.59	4.38	4.20	4.04	3.90	3.78	3.67	3.57	3.47	3.39	3.31	3.24
6,000,000	5.66	5.27	4.96	4.71	4.50	4.32	4.16	4.02	3.89	3.78	3.67	3.58	3.49	3.41	3.34
7,000,000	5.78	5.38	5.07	4.82	4.61	4.42	4.26	4.12	3.99	3.87	3.77	3.67	3.58	3.50	3.43
8,000,000	5.88	5.48	5.17	4.91	4.70	4.51	4.35	4.20	4.07	3.95	3.85	3.75	3.66	3.58	3.50
9,000,000	5.97	5.57	5.26	5.00	4.78	4.59	4.43	4.28	4.15	4.03	3.92	3.82	3.73	3.65	3.57
10,000,000	6.06	5.65	5.33	5.07	4.85	4.66	4.50	4.35	4.22	4.10	3.99	3.89	3.79	3.71	3.63
15,000,000	6.39	5.97	5.64	5.37	5.14	4.95	4.77	4.62	4.48	4.36	4.25	4.14	4.05	3.96	3.88
20,000,000	6.63	6.20	5.86	5.59	5.35	5.15	4.98	4.82	4.68	4.55	4.44	4.33	4.23	4.14	4.06
25,000,000	6.82	6.38	6.04	5.76	5.52	5.32	5.14	4.98	4.84	4.71	4.59	4.48	4.38	4.29	4.20
30,000,000	6.98	6.53	6.18	5.90	5.66	5.45	5.27	5.11	4.96	4.83	4.71	4.60	4.50	4.41	4.32
35,000,000	7.12	6.66	6.31	6.02	5.78	5.57	5.38	5.22	5.07	4.94	4.82	4.71	4.61	4.51	4.42
40,000,000	7.24	6.78	6.42	6.13	5.88	5.67	5.48	5.32	5.17	5.04	4.91	4.80	4.70	4.60	4.51
45,000,000	7.34	6.88	6.52	6.22	5.97	5.76	5.57	5.41	5.26	5.12	5.00	4.88	4.78	4.68	4.59
50,000,000	7.44	6.97	6.61	6.31	6.06	5.84	5.65	5.49	5.34	5.20	5.07	4.96	4.85	4.76	4.66
60,000,000	7.61	7.13	6.76	6.46	6.21	5.99	5.79	5.62	5.47	5.33	5.21	5.09	4.98	4.88	4.79
70,000,000	7.76	7.27	6.90	6.59	6.33	6.11	5.91	5.74	5.59	5.45	5.32	5.20	5.09	4.99	4.90
80,000,000	7.88	7.40	7.01	6.70	6.44	6.22	6.02	5.85	5.69	5.55	5.42	5.30	5.19	5.09	4.99
90,000,000	8.00	7.51	7.12	6.80	6.54	6.31	6.11	5.94	5.78	5.64	5.51	5.39	5.28	5.17	5.08
100,000,000	8.10	7.60	7.21	6.90	6.63	6.40	6.20	6.02	5.86	5.72	5.59	5.47	5.35	5.25	5.15

5.3 LAYER THICKNESS CALCULATIONS FOR NEW CONSTRUCTION

Once the Required Structural Number (SN_R) has been determined, the individual pavement layer thickness can be calculated using the following equation:

$$SN_C = (a_1 \times D_1) + (a_2 \times D_2) + (a_3 \times D_3) + \dots + (a_N \times D_N)$$

where:

SN_C = The total calculated strength of the pavement layers and has units of inches.

a_1 = Layer coefficient of the 1st layer.

D_1 = Layer thickness in inches of the 1st layer.

Layer 1 is generally the friction course.

Layer 2 is generally the structural course.

Layer 3 is generally the base course.

Layer 4 is generally the stabilized subgrade.

a_N = Layer coefficient of the Nth layer.

D_N = Layer thickness in inches of the Nth layer.

Layer coefficients have been developed which represent the relative strength of different pavement materials in Florida. The values for these materials are given in **Table 5.4**. The coefficients presented in this table are based on the best available data. Future adjustments will be made to these values by manual revisions should research or other information dictate.

Always design to the nearest 1/2-in of structural course for new construction.

Optional Bases, which are combinations of material type, thickness, and equivalent strength, have been developed as shown in **Tables 5.6** and **5.7** (Notes provided in **Table 5.8**). This permits the Department to bid Optional Base with the contractor selecting from the base materials shown on the Typical Section Sheet or from the **Standard Specifications**. If only the Base Group Number is shown in the plans then Sheet 1 of 2 (**Table 5.6** General Use Bases) is applicable. The Base Group Numbers (1 thru 15) are shown on the left of the sheet.

Each set of bases within a base group have equivalent strength. As an example, reading across Optional Base Group 6, 8-in of Limerock (LBR 100) is equivalent to 5-in of Asphalt Base in total structural number. Either Optional Base could be constructed to provide a base Structural Number within the structural range of 1.35 – 1.50 of this base group.

Note that there are restrictions placed on certain materials. For new construction, certain minimum thicknesses have been established. These minimums are based on the type of road and are shown in **Table 5.5**.

Granular subbases are used as a component of a Composite Base. Subbase layer coefficients are set at 90% of the base coefficient.

To determine how much each layer (D₂ and D₃) will contribute, a balanced approach has been provided with the use of **Table 5.9**. **Table 5.9** relates all optional bases with practical structural course thickness in ½-in increments and provides a band of recommended base and structural course thickness. Note that the structural value provided by the stabilization is not included in the Combined Structural Number shown in **Table 5.9**.

5.4 BINDER SELECTION ON THE BASIS OF TRAFFIC SPEED AND TRAFFIC LEVEL

By specification, the standard asphalt binder grade is a PG 67-22, which means the binder should be rut resistant up to temperatures of 67°C and crack resistant down to temperatures of -22°C.

When High Polymer binder is being considered for a project, coordinate this decision with the State Bituminous Materials Engineer's office at the SMO.

For open graded friction course mixtures, use PG 76-22 unless the underlying structural layer contains High Polymer. Use High Polymer in the FC-5 if the underlying structural layer contains High Polymer.

The Resilient Modulus (M_R) of asphalt concrete is less under a slow-moving load than under a more dynamic, high speed load. As a result of this effect, slow moving or stopped trucks have a greater potential to cause rutting. For situations with slow-moving or standing truck traffic, and particularly those sections with a history of rutting, use a PG 76-22 binder or use a High Polymer binder when recommended by the SMO.

High Polymer should only be used in travel lanes and turn lanes with slow-moving or standing truck traffic or a history of raveling, rutting, or severe cracking. When High Polymer is specified on a project, use PG 76-22 for median openings, side streets, turn-

outs, overbuild, turn lanes not meeting the above criteria, and other areas where High Polymer is not needed.

Examples:

For toll booths, intersections with slow truck traffic, pavement sections with history of rutting or severe cracking and existing weigh stations with standing traffic, use a PG 76-22 or High Polymer binder. A minimum of 1,000 tons of modified structural mix is generally recommended per project or group of projects to make the most efficient use of the material.

For traffic level E, use PG 76-22 or High Polymer binder as follows:

- 10 million to < 30 million ESALs: use, at a minimum, in the top 1.5" of the structural layer
- \geq 30 million ESALs: use, at a minimum, in the top 3" of the structural layer
- Note: the structural layer may include SP courses, FC-9.5, or FC-12.5

The PG 76-22 or High Polymer layer thickness should be shown separately on the typical section and a separate pay item used.

The appropriate Traffic Level is to be shown for structural friction courses FC-9.5 and FC-12.5. For Traffic Levels B, and C, PG 76-22 should be called for in the friction course. For Traffic Level E, PG 76-22 or High Polymer should be called for in the friction course. Note that, as with SP-9.5, FC-9.5 should not be used for Traffic Level E.

High Polymer binder may be used for Traffic Level C friction course applications in special situations. As with any use of High Polymer binder, coordinate these situations with the State Bituminous Materials Engineer.

TABLE 5.4

**STRUCTURAL COEFFICIENTS FOR DIFFERENT PAVEMENT LAYERS
(New Construction or Reconstruction)**

Layer Type	Layer Coeff. per inch	Specification Section
FC-5	0.00	337
FC-12.5, FC-9.5	0.44	337
Superpave Type SP (SP-9.5, SP-12.5, SP-19.0)	0.44	334
Limerock (LBR 100)	0.18	200
Cemented Coquina (LBR 100)	0.18	911
Shell Rock (LBR 100)	0.18	200
Bank Run Shell (LBR 100)	0.18	200
Graded Aggregate (LBR 100)	0.15	204
Recycled Concrete Aggregate (LBR 150)	0.18	911
Type B-12.5	0.30	234
Limerock Stab. (LBR 70)	0.12	230
Shell Stab. (LBR 70)	0.10	
Sand Clay (LBR 75)	0.12	
Soil Cement (500 psi)	0.20	
Soil Cement (300 psi)	0.15	
Type B Stab. (LBR 40)	0.08	
Type B Stab. (LBR 30)	0.06	
Type C Stab.	0.06	
Cement Treated (300 psi)	0.12	
Lime Treated	0.08	

TABLE 5.5
REQUIRED MINIMUM THICKNESS FOR NEW CONSTRUCTION
OR RECONSTRUCTION

In order to avoid the possibility of producing an impractical design, the following minimum thicknesses are required for New Construction. It is assumed that a 12-in stabilized subgrade (LBR 40) is to be constructed in order to establish a satisfactory working platform.

18-kip ESAL's 20-year period	Minimum Structural Course	Minimum Base Group
Limited Access	4"	9
Greater than 3,500,000	3"	9
Ramp less than 3,500,000	2"	9
300,000 to 3,500,000	2"	6
Less than 300,000	1½"	3
Limited Access Shoulder	1½"	1
Residential Streets, Parking Areas, Shoulder Pavement, Bike Paths	1"	1
Shared Use Paths	1½"	1

FC-12.5 and FC-9.5 can be considered as structural courses and are sufficient for single layer shoulder pavement.

FC-5 has no structural value and is always shown as 3/4-in thick.

See Chapter 8 for Shoulder Design Guidance.

TABLE 5.6
GENERAL USE OPTIONAL BASE GROUPS AND
STRUCTURAL NUMBERS (inches)

BASE THICKNESS AND OPTION CODES											
Base Group	Structural Range	Base Group Pay Item Number	Base Options								
			Limerock, LBR 100	Cemented Coquina, LBR 100	Shell Rock, LBR 100	Bank Run Shell, LBR 100	Recycled Concrete Aggregate, LBR 150 **	Graded Aggregate Base, LBR 100	Type B-12.5	B-12.5 And 4" Granular Subbase, LBR 100 *	RAP Base
			(0.18)	(0.18)	(0.18)	(0.18)	(0.18)	(0.15)	(0.30)	(0.30 & 0.15)	(N/A)
1	0.65 – 0.75	701	4"	4"	4"	4"	4"	4½"	Δ 4"	□ 5"	
2	0.80 – 0.90	702	5"	5"	5"	5"	5"	5½"	Δ 4"		
3	0.95 – 1.05	703	5½"	5½"	5½"	5½"	5½"	6½"	Δ 4"		
4	1.05 – 1.15	704	6"	6"	6"	6"	6"	7½"	Δ 4"		
5	1.25 – 1.35	705	7"	7"	7"	7"	7"	8½"	4½"		
6	1.35 – 1.50	706	8"	8"	8"	8"	8"	9"	5"		
7	1.50 – 1.65	707	8½"	8½"	8½"	8½"	8½"	10"	5½"		
8	1.65 – 1.75	708	9½"	9½"	9½"	9½"	9½"	11"	5½"		
9	1.75 – 1.85	709	10"	10"	10"	10"	10"	12"	6"		
10	1.90 – 2.00	710	11"	11"	11"	11"	11"	13"	6½"	4½"	
11	2.05 – 2.15	711	12"	12"	12"	12"	12"	14"	7"	5"	
12	2.20 – 2.30	712	12½"	12½"	12½"	12½"	12½"		7½"	5½"	
13	2.35 – 2.45	713	Φ 13½"	Φ 13½"	Φ 13½"	Φ 13½"	Φ 13½"		8"	6"	
14	2.45 – 2.55	714	Φ 14"	Φ 14"	Φ 14"	Φ 14"	Φ 14"		8½"	6½"	
15	2.60 - 2.70	715							9"	7"	

* For granular subbase, the construction of both the subbase and Type B-12.5 will be bid and used as Optional Base. Granular subbases include Limerock, Cemented Coquina, Shell Rock, Bank Run Shell, Recycled Concrete Aggregate and Graded Aggregate Base. The base thickness shown is Type B-12.5. All subbase thicknesses are 4" minimum.

** For restrictions on the use of Recycled Concrete Aggregate, see Specifications.

Φ To be used for widening, three feet or less.

Δ Based on minimum practical thicknesses.

□ For restrictions on the use of RAP Base, see [Standard Specifications](#).

TABLE 5.7
LIMITED USE OPTIONAL BASE GROUPS AND
STRUCTURAL NUMBERS (inches)

Base Group	Structural Range	Base Group Pay Item Number	Base Options						
			Limerock Stabilized, LBR 70	Shell LBR 70	Shell Stabilized LBR 70	Sand-Clay, LBR 75	Soil Cement (300 psi) (Plant Mixed)	Soil Cement (300 psi) (Road Mixed)	Soil Cement (500 psi) (Plant Mixed)
			(0.12)	(0.12)	(0.10)	(0.12)	(0.15)	(0.115)	(0.20)
1	0.65 – 0.75	701	5"	5"	7"	5"	5"	5"	Δ 4"
2	0.80 – 0.90	702	6½"	6½"	8½"	6½"	5½"	5½"	4"
3	0.95 – 1.05	703	8"	8"	9½"	8"	6½"	6½"	5"
4	1.05 – 1.15	704	9"	9"	10½"	9"	7½"	7½"	5½"
5	1.25 – 1.35	705	10"	10"	12"	10"	8½"	8½"	6"
6	1.35 – 1.50	706	11"	11"		11"	9"		7"
7	1.50 – 1.65	707	12½"	12½"		12½"	10"		7½"
8	1.65 – 1.75	708					11"		8½"
			Not Recommended for 20-year Design Accumulated 18-kip Equivalent Single Axle Loads (ESAL) Greater Than 1,000,000						

Note: These base materials may be used on FDOT projects when approved in writing by the District Materials Engineer and shown in the plans.

Δ Based On Minimum Practical Thicknesses.

TABLE 5.8

**GENERAL INFORMATION FOR OPTIONAL BASE GROUPS AND
STRUCTURAL NUMBERS**

- (1) On new construction and complete reconstruction projects, when an entirely new base is to be built, the design engineer may specify the Base Group and any unrestricted General Use Optional Base shown in that base group. Note, however, that some thick granular bases are limited to widening which prevents their general use.
- (2) Where base options are specified in the plans, only those options may be bid and used.
- (3) The designer may require the use of a single base option, for instance Type B-12.5 in a high water condition. This single base option will be bid and used as Optional Base.

5.5 NEW CONSTRUCTION DESIGN SAMPLE PROBLEM

This process is applicable for new construction. The following steps will take place in approximately the order shown, with the understanding that some activities can take place concurrently.

GIVEN:

New Construction four lane, high volume, part urban, part rural, arterial.

$ESAL_D = 6,635,835$. This value is generally obtained from the District Planning Office. Round up $ESAL_D$ to 7,000,000 Traffic Level C (**Section 5.5.4**) for use in the design tables in **Appendix A**.

$M_R = 11,500$ psi. This value is obtained from the State Materials Office. Round up from the design M_R for use in the design tables in **Appendix A**.

FIND:

The pavement thickness from the information provided for a 20-year design with a design speed of 55 mph for the rural section and with a design speed of 45 mph for the urban section (curb and gutter).

DATA:

$\%R = 80$ to 90 . This value is from **Table 5.2** for an Urban Arterial New Construction. $\%R = 75$ to 90 for Rural Arterial New Construction. $\%R = 90$ was chosen by the designer because of the high volume on both sections.

SN_R can be determined from the design tables in **Appendix A** for the appropriate reliability. From **Table A.4A**:

$SN_R = 4.06$ -in (*interpolated*)

SOLUTION:

With the SN_R known, the pavement layer thickness can be calculated.

For the first part of this sample problem using a design speed of 55 mph we need to use FC-5 according to **Table 4.1**.

FC-5 has no structural value and is always shown as 3/4-in. The in-place thickness will average 3/4-in with edge rolling down to approximately 1/4-in. Also assume that a 12-in Stabilized Subgrade (LBR 40) is to be used in order to establish a satisfactory working platform. The required base and structural course layer thickness can be determined using the following equation:

$$SN_R = SN_C$$

$$SN_R = (a_1 \times D_1) + (a_2 \times D_2) + (a_3 \times D_3) + (a_4 \times D_4)$$

$$4.06" = (0 \times 0.75") + (a_2 \times D_2) + (a_3 \times D_3) + (0.08 \times 12")$$

$$4.06" = 0 + (a_2 \times D_2) + (a_3 \times D_3) + 0.96"$$

The next step is to calculate the value that the base ($a_2 \times D_2$) and structural course ($a_3 \times D_3$) must contribute. To determine this, subtract the stabilized subgrade ($a_4 \times D_4 = 0.96$) from SN_R .

$$4.06" - 0.96" = (a_2 \times D_2) + (a_3 \times D_3)$$

In this case, the base and structural course must provide the following remaining structural value:

$$3.10" = (a_2 \times D_2) + (a_3 \times D_3)$$

Rounding the structural course asphalt to the nearest 1/2-in, from **Table 5.9**, it can be seen that the following combinations would prove satisfactory:

Optional Base Group 8 with 3.50-in of structural course with a $SN = 3.25$ -in

Optional Base Group 9 with 3.0-in of structural course with a $SN = 3.12$ -in

Optional Base Group 10 with 3.0-in of structural course with a SN = 3.30-in

Because this is a pavement with $ESAL_D$ greater than 3,500,000, the minimum thickness must be checked. From **Table 5.5**, the minimum allowed for this type of road is Optional Base Group 9 with 3-in of structural course. Two of the combinations selected meet these minimum requirements.

If all the combinations were thinner than the minimum, another combination meeting the minimum requirements would be selected. A theoretical over-design using the minimums is not uncommon when a stabilized subgrade is constructed. The construction of at least these minimum thicknesses is required to provide practical designs that stay within the empirical limits of the AASHTO Road Test. If a stabilized subgrade is not constructed due to unusual conditions, the base and structural course would have to provide a structural number of 4.06-in.

$$SN_R = (a_1 \times D_1) + (a_2 \times D_2) + (a_3 \times D_3)$$

$$4.06 = (0 \times 0.75") + (a_2 \times D_2) + (a_3 \times D_3)$$

$$4.06 = (a_2 \times D_2) + (a_3 \times D_3)$$

From **Table 5.9** an Optional Base Group 10 and 5.0-in of structural course would give a structural number of 4.18-in. This would be satisfactory as the base and structural course exceed the required minimums.

For the second part of this sample problem using a design speed of 45 mph we need to use FC-12.5 or FC-9.5 according to **Table 4.1**. FC-12.5 or FC-9.5 has the same structural value as Type SP and are considered as structural layers. FC-12.5 is typically shown as 1-1/2-in thick and FC-9.5 is typically shown as 1-in thick.

For this problem, use Optional Base Group 9 with 1-1/2-in of Type SP Structural Course and 1-1/2-in FC-12.5,

<OR>

use Optional Base Group 9 with 2-in of Type SP Structural Course and 1-in FC-9.5.

CONCLUSION:

The following comparisons are provided:

For a Design Speed of 55 mph:

<u>Layer/Material</u>	<u>Coefficient</u>		<u>Thickness</u>		<u>SN_c</u>
Friction Course, FC-5	0.00	x	3/4"	=	0.00
Structural Course	0.44	x	3.0"	=	1.32
Optional Base Group 9				=	1.80
Type B Stabilization (LBR 40)	0.08	x	12.0"	=	0.96
			3.75"	=	4.08

For a Design Speed of 45 mph:

<u>Layer/Material</u>	<u>Coefficient</u>		<u>Thickness</u>		<u>SN_c</u>
Friction Course, FC-12.5	0.44	x	1-1/2"	=	0.66
Structural Course	0.44	x	1-1/2"	=	0.66
Optional Base Group 9				=	1.80
Type B Stabilization (LBR 40)	0.08	x	12.0"	=	0.96
			3.0"	=	4.08

The pavement description in the plans with a design speed of 55 mph should read:

NEW CONSTRUCTION
 OPTIONAL BASE GROUP 9
 TYPE SP STRUCTURAL COURSE (TRAFFIC C)(3")
 FRICTION COURSE FC-5 (3/4")(PG76-22)

The pavement description in the plans with a design speed of 45 mph should read:

NEW CONSTRUCTION
 OPTIONAL BASE GROUP 9
 TYPE SP STRUCTURAL COURSE (TRAFFIC C) (1 1/2")
 FRICTION COURSE FC-12.5 (TRAFFIC C)(1 1/2")(PG76-22)

Note that the Type B Stabilization is not included in the description. This becomes a part of the plan detail, shown on the typical section.

TABLE 5.9
COMBINED STRUCTURAL NUMBER (INCHES)

Optional Base Group	COMBINED STRUCTURAL NUMBER (INCHES)										
	Structural Course – Inches										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
1	1.12	1.38									
2	1.34	1.56									
3	1.43	1.65	1.87								
4	1.52	1.74	1.96	2.18							
5	1.70	1.92	2.14	2.36	2.58						
6	1.88	2.10	2.32	2.54	2.76	2.98					
7		2.16	2.41	2.63	2.85	3.04					
8		2.37	2.59	2.81	3.03	3.25	3.47	3.69			
9				2.90	3.12	3.34	3.56	3.78			
10					3.30	3.52	3.74	3.96	4.18		
11					3.48	3.70	3.92	4.14	4.36	4.58	
12						3.79	4.01	4.23	4.45	4.67	4.89
13							4.19	4.41	4.63	4.85	5.07
14							4.28	4.50	4.72	4.94	5.16
15							4.46	4.68	4.90	5.12	5.34

Stabilization Structural Numbers Not Included.

5.6 DESIGN CONSIDERATIONS

The following special areas need to be addressed by the Pavement Design Engineer as the project develops.

5.6.1 STABILIZED SUBGRADE

Since stabilized subgrade has a history of good performance and provides strength to the pavement system at a low cost, it is highly recommended that a stabilized subgrade element be included in a pavement design as shown in the FDOT Design Manual. On rural highways, stabilized subgrade should extend to the shoulder point in order to provide a stable shoulder condition. On urban projects, stabilized subgrade is usually necessary to support curb and gutter.

In some situations, project conditions may dictate elimination of a stabilized subgrade during design and achieving the Required Structural Number (SN_R) with base course and asphalt structural course. These conditions might include:

- Limited working areas at intersections or in medians.
- Shallow existing utilities that are impractical to relocate.
- Areas of urban projects where it is essential to accelerate construction to limit restriction of access to adjacent businesses.

Stabilized subgrade should not normally be eliminated over extensive areas, because it is necessary to provide a working platform for base construction operations. This is an especially important consideration with asphalt base course, because of the difficulty in achieving compaction of the first course placed on an unstable subgrade. The decision to eliminate or substitute stabilization materials must be coordinated with the District Pavement Design Engineer, District Geotechnical Engineer, and District Construction Engineer. If elimination of stabilized subgrade in limited or constrained areas is desired and an asphalt base course will be used, the in-situ strength of the native subgrade and ability to compact the asphalt must be approved by the Pavement Design Engineer of Record in concurrence with the District Geotechnical Engineer. The in-situ subgrade must have an LBR value of 40. (*Note: Granular Subbase substitution for stabilization (meeting [Standard Specifications](#), Section 290 as discussed below) does not require evaluation of the in-situ subgrade.*) The reasons for eliminating or substituting stabilized subgrade must be documented in the project file. If an asphalt base course is used, refer to **Section 5.6.2** for additional information.

In situations where construction time is critical, the following alternates to in-situ sampling and testing to determine the Limerock Bearing Ratio (LBR) value of a stabilized subgrade include:

- Mixing of soil and stabilized material and testing off site.
- Use of a natural occurring material that meets the Limerock Bearing Ratio (LBR) value requirement that has been tested at the source.
- Use of a Predesigned Stabilized Subgrade per a Special Provision specification covering this concept.

These alternatives should be discussed with the District Construction Engineer and the District Materials Engineer and appropriate Special Provisions included in the Project Specifications.

The **Standard Specifications** also provide that when 12-inches of Type B Stabilization requiring an LBR value of 40 is called for, the Engineer may allow, at no additional compensation, the substitution of 6-inches of Granular Subbase meeting the requirements of **Standard Specifications**, Section 290.

The Specifications provide for use of the No Soak LBR Test Method to expedite LBR testing under certain conditions. Use of this test method is at the option of the Contractor if approved by the District Materials Engineer.

5.6.2 BASE

Except as limited by **Table 5.6** or as may be justified by special project conditions, the options for base material should not be restricted. Allowing the contractor the full range of base materials will permit him to select the least costly material, thus resulting in the lowest bid price.

Unbound granular base materials are generally the least expensive. However, project conditions may dictate restricting the base course to Asphalt Base Course. The following conditions may warrant restricting the base course to Asphalt Base Course (designated as Type B-12.5) if the additional cost can be justified:

- In an urban area, maintenance of access to adjacent business is critical to the extent that it is desirable to accelerate base construction.
- The maintenance of traffic scheme requires acceleration of base construction in certain areas of the project.

- High ground water and back of sidewalk grade restrictions make it difficult to obtain adequate design high water clearance from the bottom of a thicker limerock base. The thinner asphalt base can help increase the clearance. Note that asphalt base requires a well compacted subgrade, just as limerock base. It is usually necessary to have two feet of clearance above ground water to get adequate compaction in the top foot of subgrade. In areas where this cannot be obtained, the District Drainage Engineer should be consulted for an underdrain design or other methods to lower the ground water. Refer to **Section 5.2.2** for guidance on Design Base Highwater Clearance.
- The configuration of base widening and subgrade soil conditions are such that accumulation of rainfall in excavated areas will significantly delay construction.

The Pavement Design Engineer should become familiar with the material properties, construction techniques, testing procedures, and maintenance of traffic techniques that may enter into the decision to restrict the type of base material to be used. Consultation with the District Construction Engineer and the District Materials Engineer should be done prior to making any decision.

A decision to restrict base course material to an Asphalt Base Course throughout a project must be documented and approved by the District Design Engineer. A copy of the documentation shall be furnished to the State Pavement Design Engineer.

Base courses are normally set up under Optional Base Group (OBG) bid item.

On projects where the Pavement Design Engineer would like to use Asphalt Base (Type B-12.5) on a part of a project and allow multiple base options on other parts of the projects, the Pavement Design Engineer should change the OBG Number by one and specify Asphalt Base only for the area where it is required.

An example of a project where this may occur would be on a project where OBG 6 is recommended and the Pavement Design Engineer encounters an area of high water. The option would be to use Type B-12.5 from OBG 7. Another option would be to use Type B-12.5 from OBG 5. In both cases the structural asphalt thickness can be adjusted to meet the structural number requirements and allow for separate unit prices.

The Optional Base Group should not exceed OBG 12 for unbound granular base materials, except for trench widening where up to OBG 14 may be used.

5.6.3 ASPHALT BASE CURB PAD

When asphalt base only is decided on for a curb and gutter project, it is generally advisable to show, on the typical section, an asphalt Type B-12.5 pad under the curb (see [FDOT Design Manual \(FDM\) Exhibit 306-4](#) for example). The thickness of the asphalt pad should be shown in a constructability sketch and shown in the plans, so that the bottom of the curb pad matches the bottom of the initial lift of asphalt base. This will allow the initial lift of the asphalt base to include the curb pad and to be placed prior to the curb placement. This will protect the subgrade from rain earlier and potentially speed up construction. Since the thickness of the asphalt curb pad will be less than the asphalt base, the Base Group may need to be increased to provide for a minimum of 1-½-in of asphalt curb pad.

5.6.4 STRUCTURAL COURSE

Individual asphalt layers are not shown on the Plans Typical Section, only the overall asphalt thickness. **Table 5.11** provides several examples of combinations of individual layer thicknesses for asphalt structural courses.

Variations can occur when recommended in advance by the District Pavement Materials Engineer and concurred with by the District Pavement Design Engineer. For unusual situations, the State Pavement Management Office and the State Materials Office should be consulted.

The Pavement Design Engineer shall sketch out the construction sequence of the Typical Section to ensure constructability. This sketch is to be included in the pavement design package. Emphasis should be placed on allowing the final structural layer to be placed on the mainline and shoulder at the same time. This makes construction easier for the contractor and improves the final product by avoiding a construction joint at the shoulder.

Type SP mixes are designated in the plans by Traffic Level, based on the design ESAL_D and shoulders per **Table 5.10**. The same Traffic Level as the roadway should be used for paved shoulders less than or equal to 5-ft wide, where the final layer for the upper pavement structural layer and shoulder must be the same and paved in a single pass. For shoulders wider than 5-ft, refer to **Chapter 8** of this manual.

As a practical matter, Superpave mixes for crossroads and other small sections with quantities less than 1,000 tons can be designed with the same mix (i.e., Traffic Level) as the mainline. This should be discussed on a project-by-project basis with the District Pavement Materials Engineer.

5.6.5 TRAFFIC LEVELS

TRAFFIC LEVELS FOR DESIGN EQUIVALENT SINGLE AXLE LOADS (ESAL_D) RANGE FOR SUPERPAVE ASPHALT CONCRETE STRUCTURAL COURSES

The following are the Traffic Levels for the Design Equivalent Single Axle Loads (ESAL_D) ranges for Superpave Asphalt Concrete Structural Courses. It should be noted that previous versions of this Manual included traffic levels A and D. Based on experience, it was determined that the following traffic levels could be combined: Traffic Level A is now combined with B, and Traffic Level D is now combined with E.

AASHTO DESIGN ESAL _D RANGE (MILLION)	TRAFFIC LEVEL
0 to < 3	B
3 to < 10	C
≥ 10	E

5.6.6 LAYER THICKNESS

SPECIFICATION REQUIREMENTS ON LAYER THICKNESS FOR TYPE SP STRUCTURAL COURSES

The layer thickness must be consistent with the following thickness ranges:

Type Mix	Minimum	Maximum
SP-9.5	1"	1-1/2"
SP-12.5	1-1/2"	3"
SP-19.0	2"	4"

Note: These thicknesses correspond to the requirements in [Standard Specifications, Section 334](#).

In addition to the minimum and maximum thickness requirements, the following restrictions are placed on the respective material when used as a structural course:

- SP-9.5 Limited to the top two structural layers, two layers maximum.
- SP-9.5 May not be used on Traffic Level E applications.
- SP-19.0 May not be used in the final (top) structural layer below FC-5 mixtures. Type SP-19.0 mixtures are permissible in the layer directly below FC-9.5 and FC-12.5 mixtures.

Overbuild requirements are discussed in **Section 7.8.2** and [Standard Specifications, Section 334](#).

Structural and Friction Courses are shown by thickness in plans, but bid as tonnage items. Bid quantities are estimated using a maximum spread rate of 110 lbs per square yard-inch (110 lbs/yd²-in).

Actual spread rates to construct the plan thickness are determined by specification formula for the mix selected by the contractor.

When construction includes the paving of adjacent shoulders ≤ 5-ft wide, the traffic level and layer thickness for the upper structural pavement layer and shoulder must be the same and paved in a single pass, unless otherwise specified in plans.

A minimum of 1½-in initial lift of Type SP structural course is required over an Asphalt Membrane Interlayer (AMI).

Superpave mixes are classified as fine and are defined in [Standard Specifications, Section 334-3.2.2](#).

The equivalent AASHTO nominal maximum aggregate size Superpave mixes are as follows:

SP-9.5	9.5 mm
SP-12.5.....	12.5 mm
SP-19.0.....	19.0 mm

For construction purposes, plan thickness and individual layer thickness will be converted to spread rate based on the maximum specific gravity of the asphalt mix being used, as well as the minimum density level as in the following equation:

$$\text{Spread rate (lbs/yd}^2\text{)} = t \times G_{mm} \times 43.3$$

Where:

t = Thickness (in) (Plan thickness or individual layer thickness)

G_{mm} = Maximum Specific Gravity from the verified mix design

Plan quantities are based on a G_{mm} of 2.540, corresponding to a spread rate of 110 lbs/yd²-in. Pay quantities will be based on the actual Maximum Specific Gravity of the mix used.

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TABLE 5.10

**LAYER THICKNESS FOR ASPHALT CONCRETE SHOULDER
STRUCTURAL COURSES**

For projects requiring FC-5, the top structural layer of the roadway overlay and a narrow adjacent shoulder course (≤ 5 -ft wide) must be constructed in one pass. The following apply when a 5-ft-wide or less shoulder is to be constructed in conjunction with an overlay of the road.

<u>Roadway Course Thickness</u>	<u>Shoulder Structural Course Thickness</u>
1.0"	1.0" *
1.5"	1.5" *
2.0"	1.0" *
2.5"	1.0" *
3.0"	1.0" *
3.5"	1.0" *

For projects requiring FC-12.5 or FC-9.5, a single lift may be sufficient structural thickness for the shoulder pavement.

*Note: For Traffic Level E applications, SP-9.5 is not allowed.

**TABLE 5.11
EXAMPLE LAYER THICKNESS FOR
ASPHALTIC CONCRETE STRUCTURAL COURSES**

(Layers Are Listed In Sequence Of Construction)

Course Thickness (in)	LAYER THICKNESS (inches)																						
	SP-19.0 with SP-12.5 Top Layer			SP-19.0 with SP-9.5 Top Layer			SP-12.5			SP-12.5 with SP-9.5 Top Layer			SP-9.5		SP-19.0 1 st Layer with SP-12.5 2 nd Layer and Top Layer			SP-12.5 1 st Layer with SP-9.5 2 nd Layer and Top Layer					
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	1	2	3	1	2	3			
1														1									
1½								1½						1½									
2								2						1	1								
2½								2½				1½	1	1½	1								
3				2	1			1½	1½			2	1	1½	1½								
3½	2	1½		2½	1			2	1½			2	1½						1½	1	1		
4	2½	1½		3	1			2	2			2½	1½						1½	1½	1		
4½	2	2		2½	1½			2½	1½			1½	1½	1					2	1	1		
5	2½	2		3	1½			2½	2			3	1½						2	1½	1		
5½	3	1½		3½	1			3	1½	1½		2	1½	1½					2½	1	1		
6	3	2		2	2	1		2½	2½			2	1½	1½				2	1½	1½			
6½	2½	2½		3½	1½			2	1½	1½		2	2	1					2½	1½	1		
7	3½	1½		4	1			3	2										3	1	1		
7½	2	2	1½	2½	2	1		2½	1½	1½		2	2	1½				2½	1½	1½			
8	3	2½		2	2	1½		2	2	1½		2½	2	1				2	2	1½	3	1½	1
8½	3½	2		4	1½			3	2½			3	1½	1									
9	4	1½																					
9½	2½	2	1½	2½	2½	1		2	2	2		2½	2½	1				2½	2	1½	3	1½	1½
10	2	2	2	3	2	1		2½	2	1½		2½	2	1½				2	2	2			
10½	3	3		2½	2	1½		3	3			3	2	1				3	1½	1½			
11	3½	2½						3	1½	1½													
11½	4	2																					

Commented [HMJ1]: Added 1-1/4" increments as an example, to clarify that 1-1/4" lifts are ok.

Notes:

- (1) Values shown in this table are not intended to convey all possible layer thickness combinations. This table provides several options as an aide to designers. Allowable layer thicknesses are identified in [Standard Specifications, Section 334](#).
- (2) SP-9.5 not allowed on Traffic Level E applications.
- (3) SP-9.5 limited to the top two structural layers, two layers maximum.
- (4) SP-19.0 not allowed in the final (top) structural layer below FC-5 mixtures.
- (5) SP-19.0 allowed in the layer directly below FC-9.5 and FC-12.5 mixtures.

5.6.7 RAMP DESIGN

On new construction of limited access ramps, where future traffic is very uncertain, the structural number can be reduced by 25% from the mainline structural number in rural areas, and 15% in urban areas.

The reduction in structural number will be made in the thickness of the structural course. A minimum Base Group 9 and 2-in structural course will be provided. The transition from mainline thickness to ramp thickness will occur just beyond the gore. (See [Standard Plans, Index 000-525](#), Ramp Terminals).

The design assumptions used for the above guidelines were based on 25% of the mainline traffic using the ramp in rural areas and 50% of the mainline traffic using the ramp in urban areas. The Pavement Design Engineer must verify that these assumptions are appropriate for each project.

A situation where the designer would not want to reduce the design would be a case where reliable traffic data has been provided and the design thickness is greater than the reduced thickness.

From the prior Design Example given in **Section 5.5** with a mainline structural course thickness of 3-in and Design Speed of 55 mph, reduce $3" \times 0.75 = 2.25"$ (use 2.5"):

Ramp design for a Rural Area:

<u>Layer/Material</u>	<u>Coefficient</u>		<u>Thickness</u>		<u>SN_c</u>
Friction Course, FC-9.5	0.44	x	1"	=	0.44
Structural Course	0.44	x	1.5"	=	0.66
Optional Base Group 9				=	1.80
Type B Stabilization (LBR 40)	0.08	x	12.0"	=	0.96
			3.75"	=	3.86

CHAPTER 8 SHOULDER DESIGN

8.1 DESIGN GUIDANCE

On low volume roadways, or where $ESAL_D < 10$ million, shoulders can be designed using the minimum values shown in **Table 5.5**. A typical minimum design would be 1½-in of FC-12.5 or 1-in of FC-9.5 and Optional Base Group 1. ~~For very low volume two-lane roads (see **Table 4.1**) a friction course may not be required.~~

Commented [HMJ1]: Moved to new subsection 8.1.1 below.

These minimums were established assuming a stabilized subgrade in conjunction with Optional Base Group 1. The pavement evaluation process will often indicate the shoulder was stabilized during original construction and additional stabilization is not needed.

If stabilization is not used under the shoulder, the Pavement Design Engineer must determine the type of materials in the embankment and evaluate the need for increasing the shoulder base and structural course.

On higher volume type roadways ($ESAL_D = 10$ million or more), a shoulder thickness design should be performed using 3% of the $ESAL_D$ to calculate the required SN. This is an estimate of the number of trucks that will be riding or parking on the shoulder during the life of the pavement.

If the shoulders are to be used to carry substantial amounts of traffic as a part of a Maintenance of Traffic (MOT) scheme, the Pavement Design Engineer may need to design the shoulder in the same manner as a roadway. Under severe conditions, full depth shoulders matching the thickness of the travel lane pavement may be warranted.

When paved shoulders less than or equal to 5-ft wide are to be constructed in conjunction with an overlay of the roadway, the top layer of structural course of the roadway overlay and the adjacent shoulder structural course must be constructed in one pass and with the same traffic level mix unless called for differently in the Contract Documents.

For new or reconstructed curb and gutter sections in urban areas, with pavement shoulders less than or equal to 5-ft, full depth shoulders may be considered to accommodate future widening.

8.1.1 FRICTION COURSE

On non-limited access facilities, a friction course is to be placed over the entire paved shoulder. On limited access facilities, FC-5 is to extend 8-in beyond the edge of the travel lane, onto the paved shoulder.

For very low volume two lane roads (see *Table 4.1*) a friction course may not be required.

Roads with a concrete pavement mainline and asphalt shoulders may use either a friction course or a structural course for the asphalt shoulders.

Commented [HMJ2]: Adding this section to clarify our intent for friction course on shoulders, especially for asphalt shoulders adjacent to a rigid mainline. Rigid Pavement Design Manual (Section 6.2) allows for asphalt shoulders, and refers to FPDM for additional information. However, we don't specify whether or not those asphalt shoulders adjacent to concrete pavement need to include FC or not.

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