APPENDIX 5

A DESIGN GUIDE FOR SUBDIVISION PAVEMENTS IN VIRGINIA

(Also see Hampton Roads Planning District Commission's Web Site
www.hrpdc.org/RegionalStandards/Rsopeningpage.shtml
for additional information)

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I. INTRODUCTION

The design method for subdivision is based on AASHO Road Test Results and Virginia's design experience. For flexible pavements, it is divided into two parts: (1) the evaluation of the soil support value of the subgrade, the thickness equivalencies of the paving materials, and the traffic in terms of vehicles per day; and (2) design considerations such as the determination of the required thickness index of the pavement and the selection of the materials and layer thicknesses to meet the design thickness index. For portland cement concrete pavements, it is based on traffic only.

The design method is to be used as an alternative to paragraph 3 (pages 4-10), "Base and Pavement Design", of Revised Subdivision Standards as conveyed by a memorandum dated October 3, 1968, from the Deputy Commissioner and Chief Engineer to the Board of Supervisors of the All Counties in the Secondary System.

Specifications for all materials and construction can be found in the current "Virginia Department of Highways' Road and Bridge Specifications" or appropriate supplemental specifications. Specific testing procedures can be found in "Virginia's Test Methods Manual" or its revisions. Copies of these two documents may be obtained from the Materials Engineers located in Virginia Department of Highways' District Offices of the Virginia Department of Highways, Materials Division, 1221 E. Broad Street, Richmond, Virginia 23219. The design of flexible pavement is covered on pages 4 to 12. The concrete pavement design is given on pages 18 and 19.

II. THE EVALUATION OF VARIABLES

A. Average California Bearing Ratio (CBR) of the Project

In all cases, "The Virginia Test Method for Conducting California Bearing Ratio Tests" (Designation VTM-8) is to be used for evaluating the CBR. For each project sufficient CBR tests should be run to determine the true average CBR value of various soils in the subgrade.

The average CBR value of the project is the average of the CBR test values after rejecting the very low and very high values.

B. Resiliency Factor (R.F.)

The subgrade soils have been divided into five classifications based on their resiliency properties. The resiliency factors are given in Table 1. The resiliency factor of a soil could be obtained if its soil classification is known as shown in Appendix I, page A-1.

TABLE 1

RESILIENCY FACTORS FOR SOILS

Degree of Resiliency	R.F.
High	1.0
Medium	1.5
Medium low	2.0
Low	2.5
Very low	3.0

The predicted regional resiliency factors are given in Figure 1 (page 3) and Appendix II) pages A-2 to A-6). These factors are valid when the moisture content of the subgrade soil is at or near optimum moisture content. The optimum moisture content is determined by AASHO Test Method Designation T-99-70. This test is usually not necessary unless visual observations indicate it to be. Soils with moisture contents 10 percent above the optimum will need special treatment of will be undercut.

Note: When the soil moisture content is in excess of the plastic limit and approaches the liquid limit because of a high water table or other reasons, this chart should not be used to determine the SSV. In such cases the SSV should have a maximum value of 2.

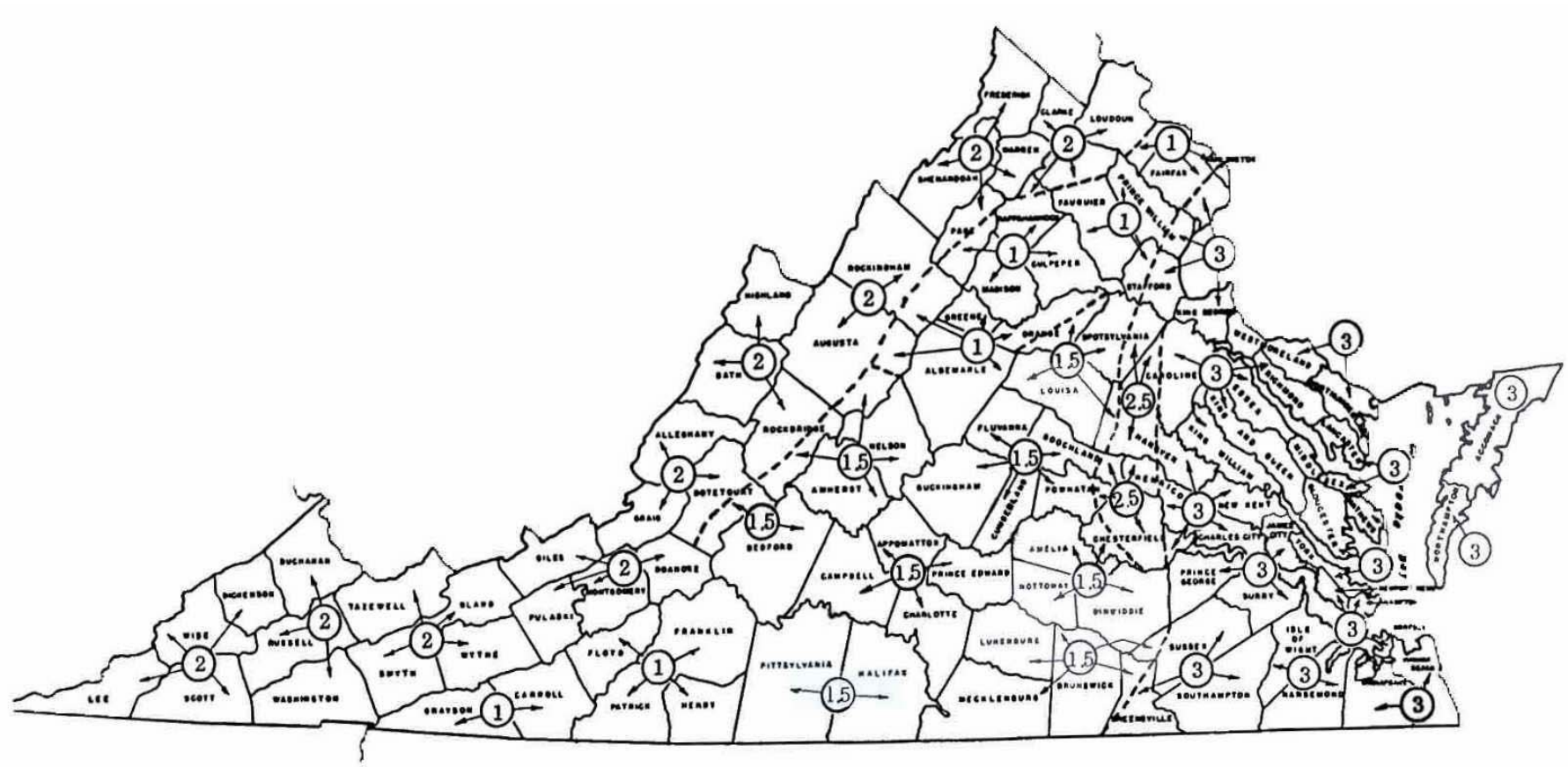


Figure 1
Soil Resilience Factors (R.F.) for Subdivision Roads

B. Traffic in Terms of Vehicles Per Day (VPD)

Traffic will be evaluated in the same manner as given in paragraph 1(page 2) "Method of Determining Traffic Usage of Revised Subdivision Standards as conveyed by a memorandum dated October 3, 1968, from the Deputy Commissioner and Chief Engineer to the Board of Supervisors of All Counties in the Secondary System.

III. DESIGN METHOD OF FLEXIBLE PAVEMENTS

A. Design Method

The subdivision roads in Virginia usually consist of one, two, or three layers of different materials of varying depth over the subgrade. The two- and three-layer systems are shown in Figure 2.

Surface	h_1	Thick. Equiv. = a_1	Surface	h_1	Thick. Equiv. = a_1
Base	h_2	Thick. Equiv. = a_2	Base or Subbase	h_2	Thick. Equiv. = a_2
Subbase	h_3	Thick. Equiv. = a_3	Subgrade		
Subgrade					
(a) Three-layer system			(b) Two-layer system		

Figure 2. Pavement sections.

The soil support value and the traffic as discussed in the preceding paragraphs lead to the determination of the strength required of the pavement. This strength requirement is termed the "thickness index" of the pavement. The thickness index requirement is satisfied by providing materials of known strength indices, termed "thickness equivalencies" of the materials. The thickness index (D) and thickness equivalencies (a) are discussed below.

B. Thickness Index

The thickness index (D) is the strength of the pavement based on its resistance to a deflection caused by a wheel load. It is obtained by the equation

$$D = a_1h_1 + a_2h_2 + a_3h_3$$

when a1, a2, and a3 are the thickness equivalencies of the materials in the surface, base, and subbase layers, and h1, h2 and h3 are the thicknesses in inches of the surface, base, and subbase layers, respectively, as shown in Figure 2.

Sometimes a subbase may not be provided, and in this case $h_3 = 0$.

C. The Thickness Equivalency

The thickness equivalency (a) of a given material is the index of strength the material contributes per inch depth of the pavement. Its value depends on the type of material and its location in the pavement.

The thickness equivalencies of the paving material are given in Table 2(page 6). AS new materials are introduced, their thickness equivalencies have to be evaluated. It should be noted that the thickness equivalencies of some materials are higher when they are placed in the base than when placed in the subbase. Thus untreated stone has a value of 1.0 when used in the base course and a value of 0.6 in the subbase course. Cement treated aggregate and select materials types I and II are similarly considered.

Investigations have shown that the strength of the cement treated native soil or borrow materials (e.g., select materials type II and select borrow) varies depending upon their physical and chemical properties. For this reason, the thickness equivalencies of such materials are kept the same whether they are placed in the base or in the subbase.

In the case of a two-layer system, the thickness equivalencies of the material in the lower layer will be the same as that of the material in the base (given in Table 2) for a thickness of eight inches or less. If the thickness of this lower layer exceeds eight inches, the pavement should be considered as equivalent to a three-layer system with the lower half of the base having thickness equivalencies equal to those of the subbase.

For full-depth asphaltic concrete (consisting of a S-5 surface and the remainder a B-3 base) placed directly on the prepared subgrade, the tentative recommendations are that it should have a minimum total thickness of 6 inches and a thickness equivalency of 1.5. In case the subgrade soil is very weak or highly resilient (R.F. = 1 or 2) the subgrade should be stabilized.

TABLE 2

THICKNESS EQUIVALENCY VALUES FOR MATERIALS FOR SECONDARY AND SUBDIVISION ROADS

Location	Location Notation	Material	Material Notation	Thickness Equivalency Value
Surface	a_1	Bituminous (Asphaltic) Concrete (S-5)	A.C.	1.67
	a_1	Prime and Double Seal*	D.S.	0.84
	a_1	Full Depth Bituminous Concrete Over Raw Subgrade (Including Base B-3)	A.C. (raw sub)	1.60
Base	a_2	Bituminous Concrete (B-3)	A.C.	1.67
	a_2	Bituminous Concrete (B-1)	A.C.	1.50
	a_2	Full Depth Bituminous Concrete Over Raw Subgrade (Including S-5 Surface)	A.C. (raw sub)	1.60
	a_2	Untreated Aggregate	Agg.	1.00
	a_2	Cement Treated Aggregate	CTA	1.67
	a_2	Cement Treated Select Material Type II Min. CBR = 20	Sel. Mat. C.	1.50
	a_2	Sel. Mat., Type I & III, Non-Plastic Min. CBR = 30	Sel. Mat.	0.84
	a_2	Sel. Mat., Type II, Non-Plastic Min. CBR = 20	Sel. Mat.	0.60
	a_2	Soil Cement	S.C.	1.00
	a_2	Cem. Tr. Sel. Matl, Type II	Sel. Mat. C.	1.17
	a_2	Cem. Tr. Sel. Borrow	Sel. Bor. C.	1.00

* Use this value of a_1h_1 as shown in examples 1, 2, and 3 given on pages 11, 12, and 13.

TABLE 2

THICKNESS EQUIVALENCY VALUES FOR MATERIALS FOR SECONDARY AND SUBDIVISION ROADS (cont.)

Location	Location Notation	Material	Material Notation	Thickness Equivalency Value
Subbase	a_3	Untreated Aggregate	Agg.	0.60
	a_3	Cement Treated Aggregate	CTA	1.33
	a_3	Sel. Mat. Type I & III, Non-Plastic Min. CBR = 30	Sel. Mat.	0.50
	a_3	Sel. Mat. Type II, Non-Plastic Min. CBR = 20	Sel. Mat.	0.40
	a_3	Soil Cement	S.C.	1.00
	a_3	Soil Lime	S.L.	0.92
	a_3	Cem. Tr. Sel. Matl., Type II	Sel. Mat. C.	1.17
	a_3	Cem. Tr. Sel. Borrow	Sel. Bor. C.	1.00

D. Design Procedure

The design procedure is as follows:

1. Evaluation of Design CBR

The method of evaluation of the average CBR value of the project has been explained in the preceding pages.

The design CBR value is two-thirds of the average CBR value. The factor of two-thirds is adopted as a safety factor to compensate for the non-uniformity of soils encountered on projects, and also to compensate for the very low bearing CBR samples, which are not considered when computing the average CBR values of soils encountered on projects. Further, four days of soaking – as specified in the test method – does not necessarily give the minimum CBR strength of some soils. Thus. The two-thirds factor would compensate for all such variations.

The predicted CBR design values given in Appendix II (pages A-2 through A-6) can be used only with the approval of the District Materials Engineer located in the District Highway Engineer's Office. The district Materials Engineer will have the option of changing that predicted CBR values based on his knowledge of local soil conditions.

2. Evaluation of Resiliency Factor (R.F)

The predicted regional resiliency factors given in Appendix II (pages A-2 to A-6) and Figure 1 should be used.

3. Evaluation of Soil Support Value (SSV)

SSV = Design CBR x R.F. The evaluations of the design CBR and R.F. are given above.

The predicted SSV value as given in Appendix II (pages A-2 through A-6) and also in Figure 3 (page 8) can be used only when the District Materials Engineer has approved the design CBR value given in the Appendix.

4. Evaluation of Design Traffic (Design VPD)

The method of determining the traffic count has been noted in the preceding pages. This traffic count is the traffic in both directions. For two-lane facilities, the design traffic is equal to this traffic count. For four-lanes, the design traffic is equal to 80% of this traffic count.

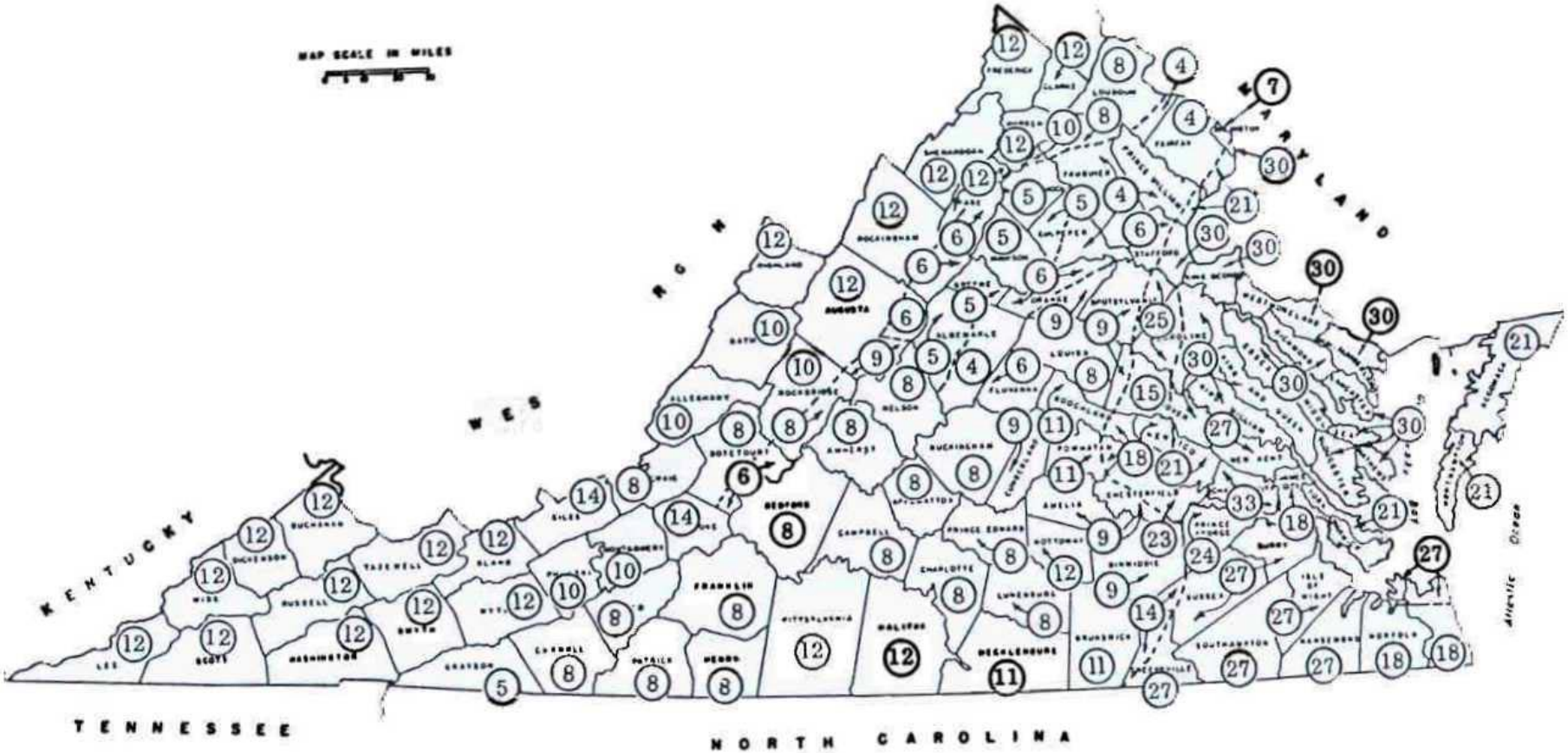


Figure 3
Predicted Soil Support Values (SSV) for Subdivision Roads.

The nomograph (Figure 4, page 10) considers design traffic in both directions. The fact that only half the design traffic uses the design lane has been taken into account in the development of the thickness index (D). For this reason, the nomograph should be entered at the design traffic count.

The nomograph assumes heavy commercial trucks (2 axles and 6 tires of heavier) to be greater than 50% of the total VPD. When it is anticipated that the traffic will include a higher percentage of these heavy trucks the equivalent design VPD will be calculated as follows. Equivalent design VPD = the deign VPD =20 times the number of excess heavy commercial trucks over 5.0 percent of the traffic. The nomograph will then be entered at the equivalent design VPD instead of at the design VPD.

5. Evaluation of Thickness Index (D)

Enter the nomograph (Figure 4, page 10) at the soil support value (SSV) and design traffic (design VPD) value and determine the thickness index (D).

The nomograph specifies a minimum D of 6.8 and a maximum D of 20. If the D value obtained from the nomograph is greater than 20, stage construction with D = 20 in the first stage may be provided.

6. Choice of Materials and Their Thicknesses

After the value D is obtained, the material in each layer of the pavement and the thickness of each layer as shown in Figure 2 (page 4) can be determined by the following equation:

$$D = a_1h_1 + a_2h_2 + a_3h_3 \qquad \text{(see Figure 2, page 4)}$$

This illustration by three examples, given on pages 11, 12, and 13, using the data given below. These examples are intended to clarify the design procedure and not necessarily the pavement design selection.

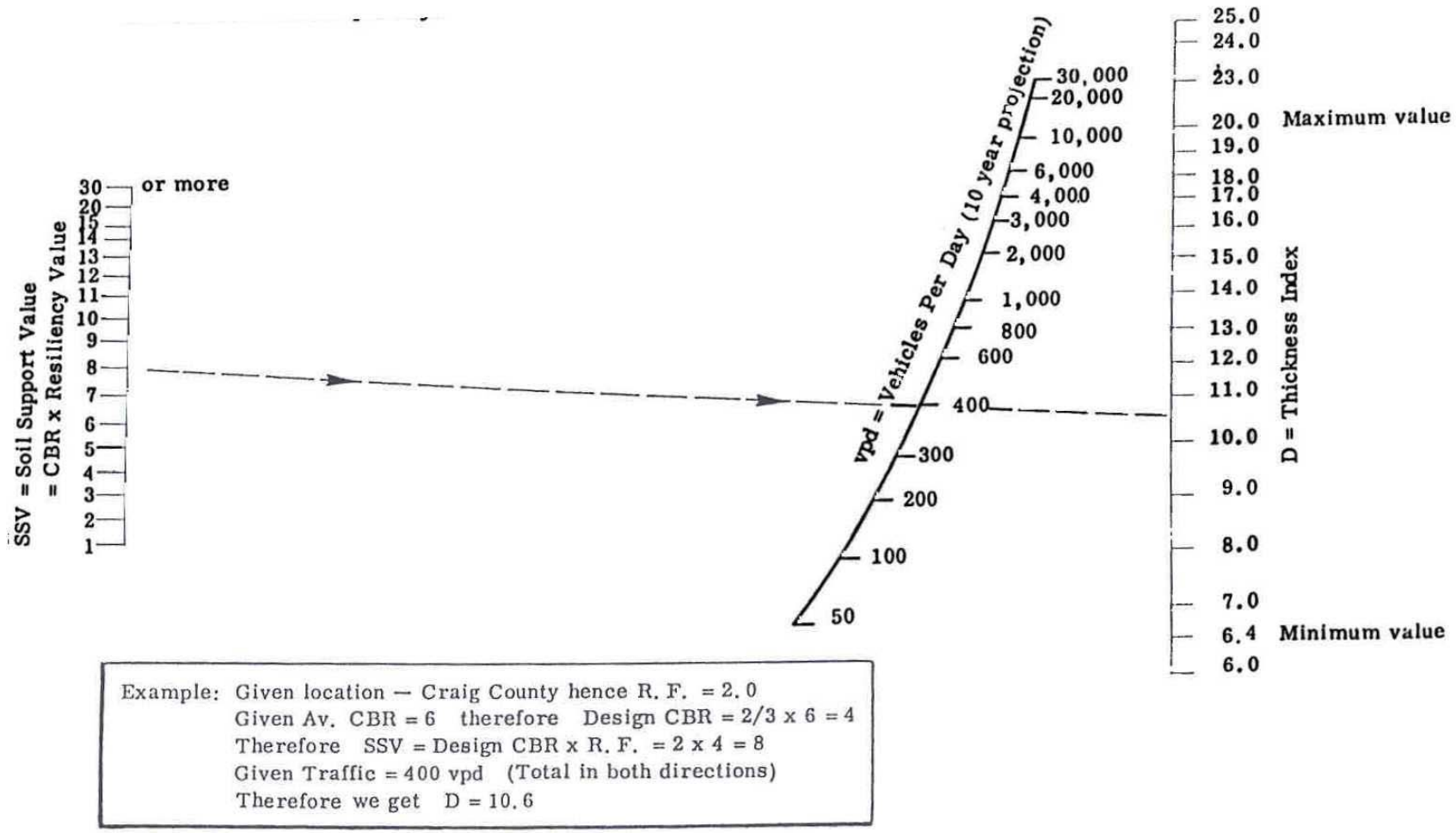
Example No. 1 – For sandy and sandy clay soils of the coastal plain and where the VPD = 150, 300 and 800.

Example No. 2 – For micaceous soils of micaceous clay silts and where the VPD = 350, 900, and 4,000.

Example No. 3 – For clayey soils with no mica content and where VPD = 200, 500, and 3,000.

The above mentioned pavement design standards are for flexible pavements only. These are minimum requirements, and where a county has established pavement designs, which have a greater thickness index, the county's pavement designs shall supercede this design procedure.

Note: 1) vpd = vehicles per day in both directions
2) The thickness index (D) is calculated, based on traffic in one direction.
3) For design D greater than 20, stage construction with D = 20 in the first stage may be provided.
4) The minimum value of D = 6.4 could be reduced for service roads and for subdivision roads with less than 50 vehicles per day.



Also see pages 11, 12 and 13.

Figure 4
Nomograph correlating the soil support value (SSV), traffic (vpd),
and the thickness index (D) (based on AASHO Equation) for subdivision roads.

Example No. 1: Data Collected: 1) Average CBR = 15; 2) Sandy and Sandy Clay soils of coastal plains; 3) Three pavement designs for traffic of 150, 300 and 800 vpd are required with six choices in each case.

Evaluation: From Appendix II or Figure 2 the resiliency factor (R.F.) of the soil = 3.0; hence, SSV = Design CBR x R.F. = (2/3 x 15) x 3 = 30. From nomograpn (Figure 3) - (a) D = 6.4 for 150 vpd; (b) D = 8 for 300 vpd; and (c) D = 12 for 800 vpd.

Location	Material Notation	Choice 1		Choice 2		Choice 3		Choice 4		Choice 5		Choice 6	
		h	h x a	h	h x a	h	h x a	h	h x a	h	h x a	h	h x a
(a) For 150 vpd, SSV = 30 and D = 6.4													
Surface - a_1	A.C.	1	1.00x1.67=1.67	1	1.00x1.67=1.67	-		-		-		-	
Surface - a_1	D.S.	-		-			0.84	-		-			0.84
Surface - a_1	S.S.	-		-		-			0.42		0.42	-	
Base – a_2	Agg.	5	5.00x1.00=5.00	1		-		6	6.00x1.00=6.00	-		-	
Base – a_2	Sel. Mat.	-		6	6.00x0.84=5.04	7	7.00x0.84=5.88	-		-		-	
Base – a_2	Sel. Bor. C.	-		-		-		-		6	6.00x1.00=6.00	6	6.00x1.00=6.00
	D		6.67		6.71		6.72		6.42		6.42		6.84
(b) For 300 vpd. SSV = 30 and D = 8													
Surface - a_1	A.C.	1.25	1.25x1.67=2.09	1.25	1.25x1.67=2.09	-		1.25	1.25x1.67=2.09	-		-	
Surface - a_1	D.S.	-			0.84		0.84	-			0.84		0.84
Base – a_2	Agg.	6	6.00x1.00=6.00	7	7.00x1.00=7.00	5	5.00x1.00-5.00	-		-		-	
Base – a_2	Sel. Mat.	-		-		-		7	7.00x0.84=5.88	-		8	8.00x0.84=6.72
Base – a_2	Sel. Bor. C.	-		-		-		-		7	7.00x1.00=7.00	-	
Subbase – a_3	S.C.	-		-		-		-		-		-	
Subbase – a_3	Sel. Mat.	-		-		4	4.00x0.5=2.00	-		-		-	
	D		8.09		7.84		7.84		7.97		7.84		7.56
(c) For 800 vpd. SSV = 30 and D = 12													
Surface - a_1	A.C. Full Dep.	8	8.00x1.5=12.00	-		-		-		-		-	
Surface - a_1	A.C.	-		3.5	3.5x1.67=5.85	2.5	2.5x1.67=4.18	4	4.00x1.67=6.68	1.25	1.25x1.67=2.09	1.5	1.5x1.67=2.51
Base – a_2	Agg.	-		6	6.00x1.00=6.00	8	8.00x1.00-800	-		4	4.00x1.00=4.00	3	3.00x1.00=3.00
Base – a_2	Sel. Mat.	-		-		-		6	6.00x0.84=5.04	-		-	
Base – a_3	Sel. Bor. C.	-		-		-		-		-		6	6.00x1.00=6.00
Subbase – a_3	S.C.	-		-		-		-		6	6.00x1.00=6.00	-	
	D		12.00		11.85		12.18		11.72		12.09		11.51

* A.C. Full Dep. = asphalt concrete full depth; A.C. = asphalt concrete; D.S. = double seal; S.S. = single seal; Agg. = untreated aggregate; Sel. Mat. = select material Type I or III; Sel. Bor. C = select borrow (Minimum CBR = 20) cement treated; S.C. = soil cement.

Example No. 2: Data Collected: 1) Average CBR = 10.5; 2) Miccaceous soils or micaceous clay silts of Piedmont area; 3) Three pavement designs for traffic of 350, 900 and 4,000 vpd are required with six choices in each case.

Evaluation: From Appendix I or Figure 2 the resiliency factor (R.F.) of the soil = 1.0; hence, SSV = Design CBR x R.F. = (2/3 x 10..5) x 1 = 7. From nomograpn (Figure 3) - (a) D = 10.0 for 350 vpd; (b) D = 14.0 for 900 vpd; and (c) D = 18 for 4,000 vpd.

Location	Material Notation	Choice 1		Choice 2		Choice 3		Choice 4		Choice 5		Choice 6	
		h	h x a	h	h x a	h	h x a	h	h x a	h	h x a	h	h x a
(a) For 150 vpd, SSV = 30 and D - 6.4													
Surface - a_1	A.C.	1.5	1.5x1.67=2.51	1.5	1.5x1.67=2.51	-		-		-		-	
Surface - a_1	A.C. Full Dep	-		-		-		-		7	7.00x1.5=10.50	-	
Surface - a_1	D.S.	-		-			.084		0.84	-			.084
Base – a_2	Agg.	8	8.00x1.00=8.00	6	6.00x1.00=6.00	4	4.00x1.00=4.00	4	4.00x1.00=4.00	-		3	3.00x1.00=3.00
Subbase – a_3	S.C.	-		-		6	6.00x1.00=6.00	-		-		-	
Subbase – a_3	S.L.	-		-		-		6	6.00x0.92=5.52	-		-	
Subbase – a_3	CTA	-		-		-		-		-		-	
Subbase – a_3	Sel. Mat. C.	-		-		-		-		-		6	6.00x1.17=7.02
Subbase – a_3	Sel. Mat.	-		4	4.00x0.5=2.00	-		-		-		-	
	D		10.51		10.51		10.84		10.36		10.50		10.86
(b) For 900 vpd. SSV = 7.0 and D = 14.0													
Surface - a_1	A.C.	4	4.00x1.67=6.68	4	4.00x1.67=6.68	2.5	2.5x1.67=4.18	2.5	2.5x1.67=4.18	-		2.5	2.5x1.67=4.18
Surface - a_1	A.C. Full Dep	-		-		-		-		9	9.00x1.5=13.50	-	
Base – a_2	Agg.	8	8.00x1.00=8.00	6	6.00x1.00=6.00	4	4.00x1.00=4.00	4	4.00x1.00=4.00	-		3	3.00x1.00=3.00
Subbase – a_3	S.C.	-		-		6	6.00x1.00=6.00	-		-		-	
Subbase – a_3	S.L.	-		-		-		6	6.00x0.92=5.52	-		-	
Subbase – a_3	CTA	-		-		-		-		-		-	
Subbase – a_3	Sel. Mat. C	-		-		-		-		-		6	6.00x1.17=7.02
Subbase – a_3	Sel. Mat.	-		4	4.00x0.5=2.00	-		-		-		-	
	D		14.68		14.68		14.18		13.70		13.50		14.20
(c) For 4,000 vpd. SSV = 7.0 and D = 18.8													
Surface - a_1	A.C. Full Dep	12.5	12.5x1.5=18.75	-		-		-		-		-	
Surface - a_1	A.C.	-		5.5	5.5x1.67=9.18	5	5.00x1.67=8.35	5.5	5.5x1.67=9.19	4	4.00x1.67=6.68	4.5	4.5x1.67=7.52
Base – a_2	CTA	-		6.0	6.00x1.67=10.02	-		-		-		-	
Base – a_2	Agg.	-		-		4	4.00x1.00=4.00	4	4.00x1.00=4.00	4	4.00x1.00=4.00	4	4.00x1.00=4.00
Subbase – a_3	S.C.	-		-		6	6.00x1.00=6.00	-		-		-	
Subbase – a_3	S.L.	-		-		-		6	6.00x0.92=5.52	-		-	
Subbase – a_3	CTA	-		-		-		-		6	6.00x1.33=7.98	-	
Subbase – a_3	Sel. Mat. C	-		-		-		-		-		6	6.00x1.17=7.02
	D		18.75		19.20		18.35		18.71		18.66		18.54

* A.C. Full Dep. = asphalt concrete full depth; A.C. = asphalt concrete; CTA = cement treated aggregate; Agg. = untreated aggregate; SC = soil cement; S.L. = soil lime; Sel. Mat. C. = select material, Type II; Sel. Mat. = select material Types I and iII..

Example No. 3: Data Collected: 1) Average CBR = 9; 2) Clayey soils with no mica content of Valley & Ridge; 3) Three pavement designs for traffic of 200, 500 and 3000 vpd are required with six choices in each case.

Evaluation: From Appendix I or Figure 2 the resiliency factor (R.F.) of the soil = 2.0; hence, SSV = Design CBR x R.F. = (2/3 x 9) x 2 = 12. From nomograpn (Figure 3) - (a) D = 7.4 for 200 vpd; (b) D = 11 for 500 vpd; and (c) D = 16.8 for 3,000 vpd.

Location	Material Notation	Choice 1		Choice 2		Choice 3		Choice 4		Choice 5		Choice 6	
		h	h x a	h	h x a	h	h x a	h	h x a	h	h x a	h	h x a
(a) For 200 vpd, SSV = 12 and D – 7.4													
Surface – a_1	A.C.	1.5	1.5x1.67=2.51	-		-		-		-		-	
Surface – a_1	D.S.	-			.084		0.84	-		-		-	
Surface – a_1	S.S.	-		-		-			0.42		0.42		.042
Base – a_2	Agg.	5	5.00x1.00=5.00	6	6.00x1.00=6.00	-		7	7.00x1.00=7.00	-		4	4.00x1.00=4.00
Base – a_2	Sel. Mat.	-		-		8	8.00x0.84=6.72	-		8	8.00x0.84=6.72	-	
Subbase – a_3	Sel. Mat.	-		-		-		-		-		6	6.00x0.5=3.00
	D		7.50		6.84		7.56		7.42		7.04		7.42
(b) For 500 vpd. SSV = 12 and D = 11.0													
Surface - a_1	A.C.	1.5	1.5x1.67=2.51	-		-		-		-		-	
Surface - a_1	A.C. Full Dep	-		7	7.00x1.5=10.50	-		-		-		-	
Surface - a_1	D.S.	-		-			0.84		0.84		0.84		0.84
Base – a_2	Agg.	6	6.00x1.00=6.00	-		4	4.00x1.00=4.00	4	4.00x1.00=4.00	3	3.00x1.00=3.00	-	
Base – a_2	Sel. Mat.	-		-		-		-		-		4	4.00.0.84=3.36
Subbase – a_3	S.C.	-		-		6	6.00x1.00=6.00	-		-		-	
Subbase – a_3	S.L.	-		-		-		6	6.00x0.92=5.52	-		-	
Subbase – a_3	CTA	-		-		-		-		6	6.00x1.33=7.98	-	
Subbase – a_3	Sel. Mat. C	-		-		-		-		-		6	6.00x1.17=7.02
Subbase – a_3	Sel. Mat.	4	4.00x0.5=2.00	-		-		-		-		-	
	D		10.51		10.50		10.84		10.36		11.82		11.22
(c) For 3,000 vpd. SSV = 12 and D = 16.8													
Surface - a_1	A.C.	6	6.00x1.67=10.02	4	4.00x1.67=6.68	5	5.00x1.67=8.35	4	4.00x1.67=6.68	4	4.00x1.67=6.68	4	4.00x1.67=6.68
Base – a_2	Agg.	6	6.00x1.00=6.00	4	4.00x1.00=4.00	3	3.00x1.00=3.00	3	3.00x1.00=3.00	6	6.00x1.00=6.00	-	
Base – a_2	Sel. Mat.	-		-		-		-		-		4	4.00x0.84=3.36
Base – a_2	S.C.	-		6	6.00x1.00=6.00	-		-		-		-	
Subbase – a_3	S.L.	-		-		6	6.00x0.92=5.52	-		-		-	
Subbase – a_3	CTA	-		-		-		6	6.00x1.33=7.98	-		-	
Subbase – a_3	Sel. Mat. C	-		-		-		-		-		6	6.00x1.17=7.02
Subbase – a_3	Sel. Mat.	-		-		-		-		8	8.00x0.5=4.00	-	
	D		16.02		16.68		16.87		17.66		16.68		17.06

* A.C. Full Dep. = asphalt concrete full depth; D.S. = double seal; S.S. = single seal; Agg. = untreated aggregate; Sel. Mat. = select material Type I and III; S.C. = soil cement; S.L. = soil lime; CTA = cement treated aggregate; Sel. Mat. C = cement treated select material Type II.

E. Design Considerations

After the required thickness index of the pavement has been determined, the choice of materials and the thicknesses of the layers are determined by the pavement designer. These decisions are usually based on dollar value, structural adequacy, and pavement serviceability.

Based on design and construction experience, the following are recommended:

1. Subgrade, subgrade treatment, or subbase

   a. The preparation of the subgrade should be in accordance with the current Virginia Department of Highways' Road and Bridge Specifications.

   b. Local materials that normally would be considered unsatisfactory for use in construction (like micaceous, A-3 type, or swelling soils) may be acceptable when stabilized with a stabilizing agent such as cement or lime. Ibis practice is highly desirable when feasible.

      Lime or cement stabilized subgrades provide a rigid foundation that is a good investment when the traffic is likely to increase considerably.

   c. Lime treatment of high moisture content soil can be done in lieu of undercutting when appropriate. In such cases this lime treated layer is not to be considered as part of the pavement structure.

   d. When cement stabilized subgrade is recommended, approximately 10 percent by volume should be used. When lime is the stabilizing agent, approximately 5 percent by weight should be used. In all cases, however, representative samples of the soil should be submitted for test.

      If soil stabilization (cement or lime) is used, verification of the quantity of stabilization actually used will be required through the Highway District Materials Engineer.

   e. When stabilized subgrades or subbases are overlain by asphaltic concrete, cracks in these courses reflect through the asphalt mix. To prevent this type of reflection crack an untreated aggregate layer (minimum of 3-inches thick-) laid between the stabilized layer and the asphaltic concrete may be provided.

f. Soil stabilization should be completed before the temperature drops below 40 0 F. For best results, soil stabilization should be immediately covered with an untreated aggregate base course.

2. Base Course

a. Aggregate base courses are of two types and various sizes as shown below:

Type I - Aggregate base material (crushed material only). Aggregate size nos. 20, 21, 21-A, or 22.

Type II - Aggregate base material (crushed or uncrushed material). Aggregate size nos. 21, 21-A, or 22.

When aggregate base material Type I is specified, the coarser grading aggregates nos. 20, 21, or 21-A are preferable.

When aggregate base material Type 11 is specified, aggregate size nos. 21, or 21-A should be selected when a commercial material is provided.

b. When it is intended to stabilize a local material with cement, approximately 8 percent by volume should be used. When lime is the stabilizing agent, approximately 4 percent by weight should be used. In all cases, however, representative samples of the material should be submitted for test to determine the correct percentage of stabilizing agent.

c. Bituminous concrete base courses shall be either Type B-1 or B-3. The minimum layer thickness of the course is 3 inches.

3. Surface course

An equivalent thickness of bituminous concrete in lieu of a prime and double seal would be a prime with cover material and 100 pounds per square yard (one inch thick) bituminous concrete, Type S-4 or S-5.

4. Alternate type designs

Alternate type designs may be set up where practical to provide reasonable competition. This practice might attract more bids with resultant economies in construction costs.

IV. DESIGN METHOD FOR PORTLAND CEMENT CONCRETE PAVEMENT

Table 3 gives the concrete slab and base thickness for various categories of design traffic in terms of vehicles per day.

Where it is anticipated that the traffic will include a higher than normal percentage of heavy commercial trucks (2 axles 6 tires and heavier) - above 5 percent - a six-inch depth of base material stabilized with 4 percent cement by weight will replace the base thickness provided in Table 3. In case of very weak or highly resilient soil, the soil in place should be stabilized for a depth of 6 inches with 10 percent cement by volume.

The concrete shall be Class A-3 paving concrete according to the current Virginia Department of Highways' Road and Bridge Specifications or appropriate supplemental specifications. The concrete pavement shall be plain portland cement concrete with maximum transverse joint spacings of 20 feet.

TABLE 3

SLAB AND BASE THICKNESSES FOR DIFFERENT TRAFFIC CATEGORIES

Design Traffic (vpd)	Slab Thickness	Base Thickness
Up to 400	5”	--
401 – 750	6”	--
751 – 3,000	7”	4”*
Over 3,000	8”	6”*

* 6-inch soil cement could be substituted for 4-inch or 6-inch base material.

ACKNOWLEDGMENTS

This Design Guide is the end result of the design method developed by N. K. Vaswani. In preparing this guide a subcommittee consisting of J. P. Bassett, K. H. McGhee and N. K. Vaswani was established. Messrs. Bassett and McGhee worked many hours and with great care to verify, constantly evaluate, and improve each statement made in this guide. It reflects their enormous work and experience.

The study was conducted under the general supervision of Jack H. Dillard, state highway research engineer, and was financed from state research funds.

ADDENDUM

DESIGN GUIDE FOR SUBDIVISION ROAD PAVEMENTS IN.VIRGINIA

May 1982

(This addendum supplements the "Design Guide for Subdivision Pavements in Virginia", October 1973, VHTRC 73-R21, and supersedes the earlier addendum on "Minimum and Maximum Thickness of Layers.")

I. MINIMUM AND MAXIMUM THICKNESS OF LAYERS

The minimum and maximum thicknesses of layers may be related to practical considerations. Items such as the maximum obtainable density of aggregates and asphaltic concrete, the stability of bituminous concrete (S-5) mixes, the preparation of the subgrade by providing subbase or a stabilized soil layer, and the weaknesses of thin layers of fairly rigid materials like bituminous concrete, and stabilized soil layers should be considered.

The following minimum and maximum limits are recommended.

A. Minimum thickness of the aggregate layer used as the base in a one or two layer system --- 5 inches.

B. Minimum thickness of the aggregate layer used as the subbase --- 4 inches.

C. Minimum thickness of the bituminous concrete base (B-3) layer used on the top of subbase --- 3 inches.

D. Minimum thickness of the bituminous concrete surface (S-5) layer used on top of bituminous concrete base (B-3) or binder (1-2) --- 1 inch.

E. Minimum thickness of the bituminous concrete surface (S-5) layer used on top of aggregate material (treated or untreated) --- 2 inches.

F. Minimum thickness of the stabilized soil layer (cement, lime, etc.) --- 6 inches.

G. For stage construction, the minimum thickness of the bituminous concrete surface (S-5) --- 2 1/2 inches, the lower lift being 1 1/2 inches.

H. Maximum thickness of bituminous concrete surface (S-5) --- 3 inches.

I. Maximum thickness of aggregate layer used over soil cement or cement treated aggregate --- 6 inches.

J. Minimum thickness of cement treated aggregate placed directly on untreated subgrade soil --- 6 inches.

II. FURTHER DESIGN CONSIDERATIONS

The following are intended as clarification of miscellaneous design considerations.

A. If 3 inches or more of bituminous concrete base Type B-3 are used, the underlying aggregate material is considered as subbase.

B. In the case of a two-layer system, the thickness equivalencies of the material in the lower layer will be that of the material in the base for a lower layer thickness of eight (8) inches or less. If the thickness of the lower layer exceeds eight (8) inches, the pavement shall be considered as equivalent to a three-layer system with that portion of the base exceeding eight (8) inches in thickness having thickness equivalencies equal to those of the subbase.

C. In the case of more than three (3) layers, the thickness equivalencies of layers four (4) and subsequent layers shall be those for subbase layers.

D. For full-depth asphaltic concrete placed directly on untreated subgrade soil, the pavement shall have a minimum total thickness of six (6) inches and a thickness equivalency of 1.6. In case the subgrade soil is very weak or highly resilient (R.F. = 1 or 2) the subgrade shall be lime or cement treated. If such treatment is not possible the thickness equivalency of full-depth asphaltic concrete shall be reduced to 1.5.

APPENDIX I

EVALUATION OF SOIL RESILIENCY FACTORS

In this evaluation, soil classifications based on AASHO Designation M-145-66, sand content (retained #200) and mica content* have been adopted.

To determine the soil resiliency factor, proceed from the top to the bottom of the table and obtain the correct resiliency factor by the process of elimination.

SOIL TYPE			RESILIENCY FACTOR
	Soils Without Mica Content		
Very low resilient soils –	(a)	A-1 and A-3 soils	3.0
	(b)	A-2, A-4, A-5, A-6 and A-7 soils with sand content 60 or more percent	
Low resilient soils -		A-2, A-4, A-5, A-6 and A-7 soils with sand content more than 40 and less than 60 percent	2.5
Medium low resilient soils -		A-2, A-4, A-5, A-6 and A-7 soils with sand content 40 percent or less.	2.0
	Soils With Mica Content		
Medium low resilient soils -	(a)	A-7-5 soil	1.5
	(b)	A-4 soil with low (including traces) mica content* and with an average group index (G.I.) below 5.	
	(c)	A-2, A-5, A-6 and A-7-6 soils with low (including traces) mica content	
High resilient soils -		Soils which do not come within the category of "medium low resilient soils" and also contain mica.	1.0

* Determination of the mica content is to be done by visual observations. The borderline cases of low or high mica content will be decided by the District Materials Engineer of the Virginia Highway Department.

APPENDIX II

CLASSIFICATION BASED ON RESILIENCY AND CBR VALUES OF SOILS

Code	County or Town		Predicted Resiliency Factor	Predicted Design CBR Values	Predicted Soil Support Value (SSV) = (Res. Factor x Predicted CBR)
00	Arlington-	W. of Rte. 95	1.0	7	7
		E. of Rte. 95	3.0	10	30
01	Accomack		3.0	7	21
02	Albemarle -	E. of Rte. 29	1.0	4	4
		W. of Rte. 29	1.0	5	5
03	Alleghany		2.0	5	10
04	Amelia		1.5	6	9
05	Amherst		1.5	5	8
06	Appomattox		1.5	5	8
07	Agusta		2.0	6	12
08	Bath		2.0	5	10
09	Bedford		1.5	5	8
10	Bland		2.0	6	12
11	Botetourt -	A bulge in the eastern rock, half way up to Eagle Rock.	1.5	4	6
		Remainder of county.	2.0	4	8
12	Brunswick		1.5	7	11
13	Buchanan		2.0	6	12
14	Buckingham		1.5	5	8
15	Campbell		1.5	5	8
16	Caroline -	W. of Rte. 2	2.5	10	25
		E. of Rte. 2	3.0	10	30
17	Carroll		1.0	8	8
18	Charles City		3.0	11	33

APPENDIX II (continued)

Code	County or Town	Predicted Resiliency Factor	Predicted Design CBR Values	Predicted Soil Support Value (SSV) = (Res. Factor x Predicted CBR)
19	Charlotte	1.5	5	8
131	Chesapeake	3.0	6	18
20	Chesterfield - S.W. Mosley and Colonial Heights	1.5	6	9
	Remainder of county	2.5	9	23
21	Clarke	2.0	6	12
22	Craig	2.0	4	8
23	Culpepper - E. of Rtes. 229 &15S	1.0	4	4
	W. of Rtes. 229 & 15S	1.0	5	5
24	Cumberland	1.5	6	9
25	Dickenson	2.0	6	12
26	Dinwiddie	1.5	6	9
28	Essex	3.0	10	30
29	Fairfax - E. of Rte. 95	3.0	7	21
	W. of Rte. 95	1.0	4	4
30	Fauquier - N. of Rte. 211	2.0	4	8
	S. of Rte. 211	1.0	4	4
31	Floyd	1	8	8
32	Fluvanna	1.5	4	6
33	Franklin	1.0	8	8
34	Frederick	2.0	6	12
35	Giles	2.0	7	14
36	Gloucester	3.0	10	30
37	Goochland - W. Rte. 522	1.5	7	11
	E. Rte. 522	2.5	7	18
38	Grayson	1.0	5	5
39	Greene	1.0	5	5
40	Greensville - E. Rte. 95	3.0	9	27
	W. Rte. 95	1.5	9	14

APPENDIX II (continued)

Code	County or Town		Predicted Resiliency Factor	Predicted Design CBR Values	Predicted Soil Support Value (SSV) = (Res. Factor x Predicted CBR)
41	Halifax		1.5	8	12
114	Hampton		3.0	9	27
42	Hanover -	E. Rte. 95	3.0	10	30
		W. Rte. 95 & E. Rte. 715	2.5	6	15
		W. Rte. 715	1.5	6	9
43	Henrico -	W. Rte. 95	2.5	7	18
		E. Rte. 95	3.0	7	21
44	Henry		1.0	8	8
45	Highland		2.0	6	12
46	Isle of Wight		3.0	9	27
47	James City		3.0	6	18
48	King George		3.0	10	30
49	King and Queen		3.0	10	30
50	King William		3.0	10	30
51	Lancaster		3.0	10	30
52	Lee		2.0	6	12
53	Loudoun -	W. Rte. 15	2.0	4	8
		E. Rte. 15	1.0	4	4
54	Louisa		1.5	5	7.5
55	Lunenberg		1.5	5	8
56	Madison		1.0	5	5
57	Mathews		3.0	10	30
58	Mecklenburg		1.5	7	11
59	Middlesex		3.0	10	30
60	Montgomery		2.0	5	10
61	Nansemond		3.0	9	27
62	Nelson		1.5	5	8
63	New Kent		3.0	9	27
121	Newport News		3.0	9	27

APPENDIX II (continued)

Code	County or Town		Predicted Resiliency Factor	Predicted Design CBR Values	Predicted Soil Support Value (SSV) = (Res. Factor x Predicted CBR)
122	Norfolk		3.0	9	27
65	Northampton		3.0	7	21
66	Northumberland		3.0	10	30
67	Nottoway		1.5	8	12
68	Orange -	N. of Rte. 20 & E. Rte. 522	1.0	6	6
		N. of Rt. 20 & W. Rte. 522	1.0	5	5
		S. of Rte. 20 & E. Rte. 522	1.5	6	9
		S. of Rte. 20 & W. Rte. 522	1.5	5	8
69	Page -	W. Alma	2.0	6	12
		E. Alma	1.0	6	6
70	Patrick		1	8	8
71	Pittsylvania		1.5	8	12
72	Powhatan -	W. Rte. 522 & Rte. 609	1.5	7	11
		E. Rte. 522 & Rte. 609 Rte. 609	2.5	7	18
73	Prince Edward		1.5	5	8
74	Prince George		3.0	8	24
76	Prince William –	W. Rte. 95	1.0	4	4
		E. Rte. 95	3.0	7	21
77	Pulaski		2.0	5	10
78	Rappahannock -	N. Flint Hill	2.0	5	10
		S. Flint Hill	1.0	5	5
79	Richmond		3.0	10	30
80	Roanoke		2.0	7	14
81	Rockbridge -	W. James, Maury & South Rivers	2.0	5	10
		E. James, Maury & South Rivers	1.5	5	8

APPENDIX II (continued)

Code	County or Town	Predicted Resiliency Factor	Predicted Design CBR Values	Predicted Soil Support Value (SSV) = (Res. Factor x Predicted CBR)
82	Rockingham - W. Rte. 81	2.0	6	12
	E. Rte. 81	1.0	6	6
83	Russell	2.0	6	12
84	Scott	2.0	6	12
85	Shenandoah	2.0	6	12
86	Smyth	2.0	6	12
87	Souhampton	3.0	9	27
88	Spotsylvania - W. Rte. 95	1.5	6	9
	E. Rte. 95	2.5	10	25
89	Stafford - W. Rte. 95	1.0	6	6
	E. Rte. 95	3.0	10	30
90	Surry	3.0	9	27
91	Sussex - W. Rte. 95	1.5	9	14
	E. Rte. 95	3.0	9	27
92	Tazewell	2.0	6	12
134	Virginia Beach – N. Rte. 44	3.0	9	27
	S. Rte. 44	3.0	6	18
93	Warren	2.0	6	12
95	Washington	2.0	6	12
96	Westmoreland	3.0	10	30
97	Wise	2.0	6	12
98	Wythe	2.0	6	12
99	York	3.0	7	21