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A DESIGN GUIDE FOR SUBDIVISION PAVEMENTS IN VIRGINIA

by

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Highway Research Engineer

Virginia Highway Research Council
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INTRODUCTION

The design method for subdivision roads 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.

This 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 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 or 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 15 and 16.

THE EVALUATION OF VARIABLES

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 the 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.

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. 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 should be made. Soils with moisture contents 10 percent above the optimum will need special treatment or 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.

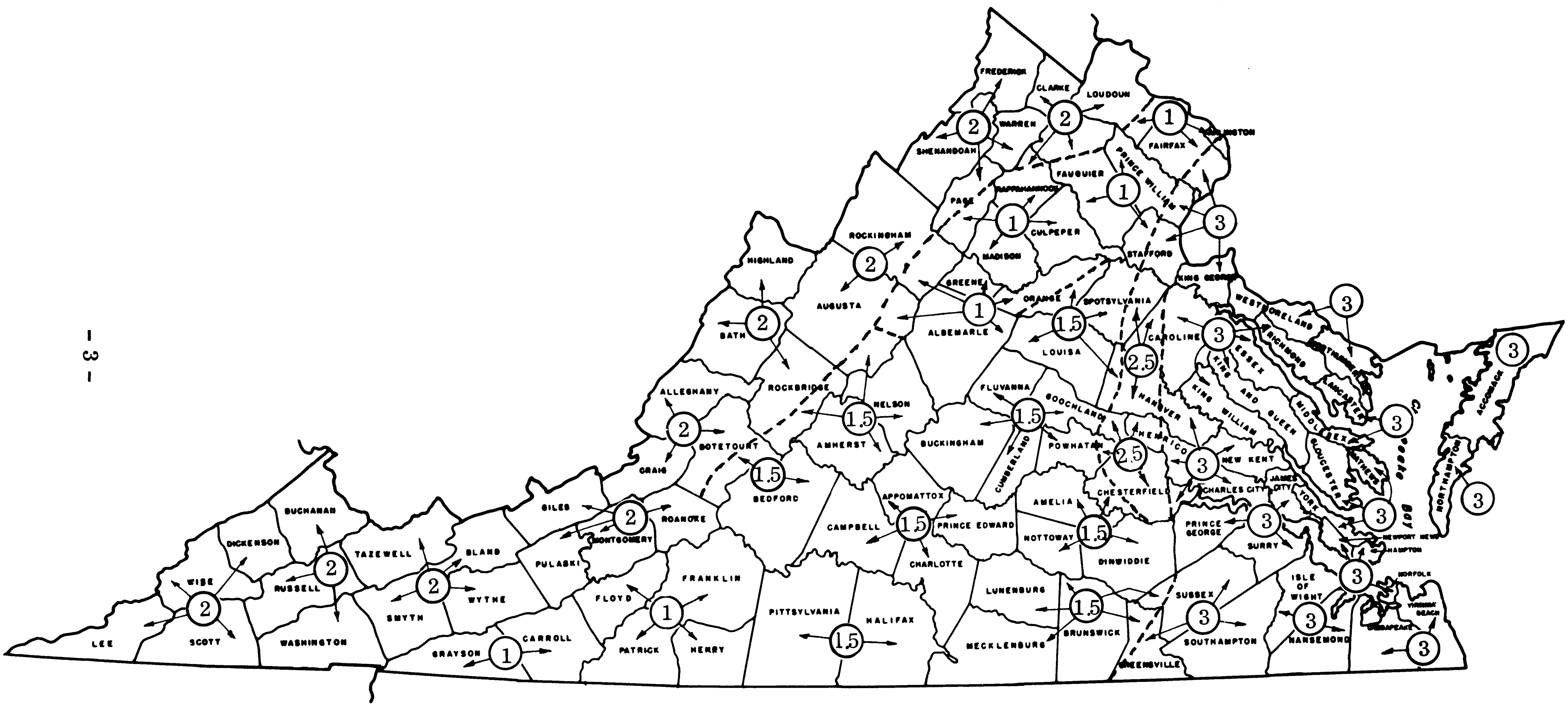

Figure 1. Soil resilience factors (R. F.) for subdivision roads.

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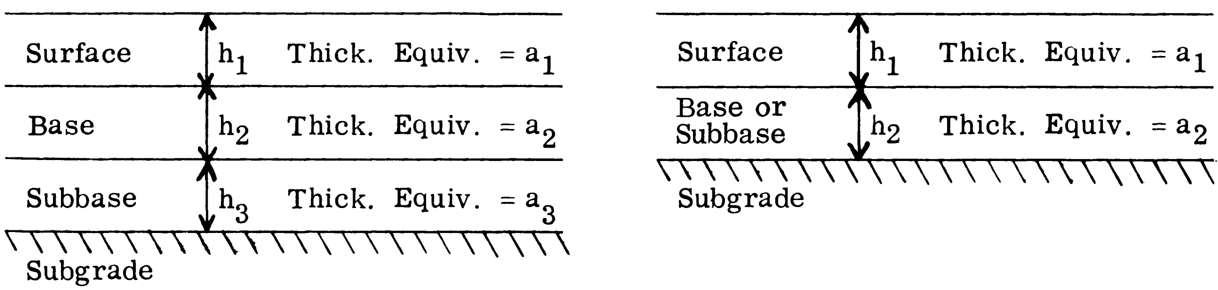
Traffic in Terms of Vehicles Per Day (vpd)

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.

DESIGN METHOD FOR FLEXIBLE PAVEMENTS

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.



(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.

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 a_1, a_2, and a_3 are the thickness equivalencies of the materials in the surface, base, and subbase layers, and h_1, h_2, and h_3 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 $h_3 = 0$.

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 the material and its location in the pavement.

The thickness equivalencies of the paving materials 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 an a value of 1.0 when used in the base course and an a value of 0.6 in the subbase course. Cement treated aggregate and select materials types I and III 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 an 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 SUBDIVISION ROADS

Location	Location Notation	Material	Material Notation	Thick. Equiv. Value
Surface	a_1	Asphaltic Concrete (S-5)	A.C.	1.67
	a_1	Prime and double seal*	D.S.	0.84*
	a_1	Full depth asphalt concrete	A.C. (Full dep.)	1.50
Base	a_2	Asphaltic Concrete (B-3 or B-1)	A.C.	1.67
	a_2	Untreated Aggregate	Agg.	1.00
	a_2	Cement treated Aggregate	CTA	1.67
	a_2	Sel. Mat., Type I & III	Sel. Mat.	0.84
	a_2	Soil Cement	S.C.	1.00
	a_2	Cem. Tr. Sel. Mat., Type II	Sel. Mat. C	1.17
	a_2	Cem. Tr. Sel. Borrow	Sel. Bor. C	1.00
Subbase	a_3	Untreated Aggregate	Agg.	0.60
	a_3	Cement treated Aggregate	CTA	1.33
	a_3	Sel. Mat., Type I & III	Sel. Mat.	0.50
	a_3	Soil Cement	S.C.	1.00
	a_3	Soil Lime	S. L.	0.92
	a_3	Cem. Tr. Sel. Mat., Type II	Sel. Bor. C	1.17
	a_3	Cem. Tr. Sel. Borrow	Sel. Bor. C	1.00

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

Design Procedure

The design procedure is as follows:

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 nonuniformity 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 these predicted CBR values based on his knowledge of local soil conditions.

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.

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.

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.

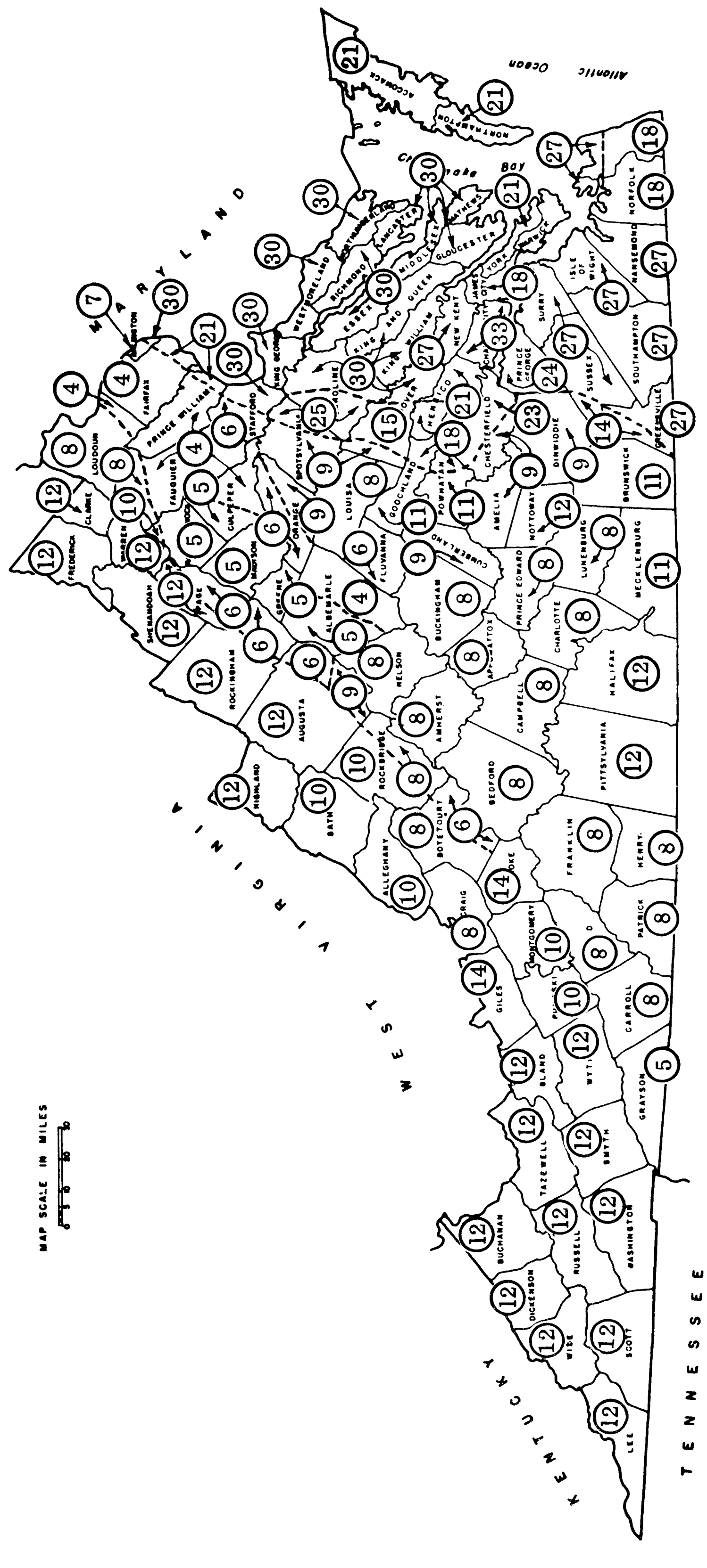


Figure 3. Predicted soil support values (SSV) for subdivision roads.

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 or heavier) to be not greater than 5.0% 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 design 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.

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.

Choice of Materials and Their Thicknesses

After the value of 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 is illustrated 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.

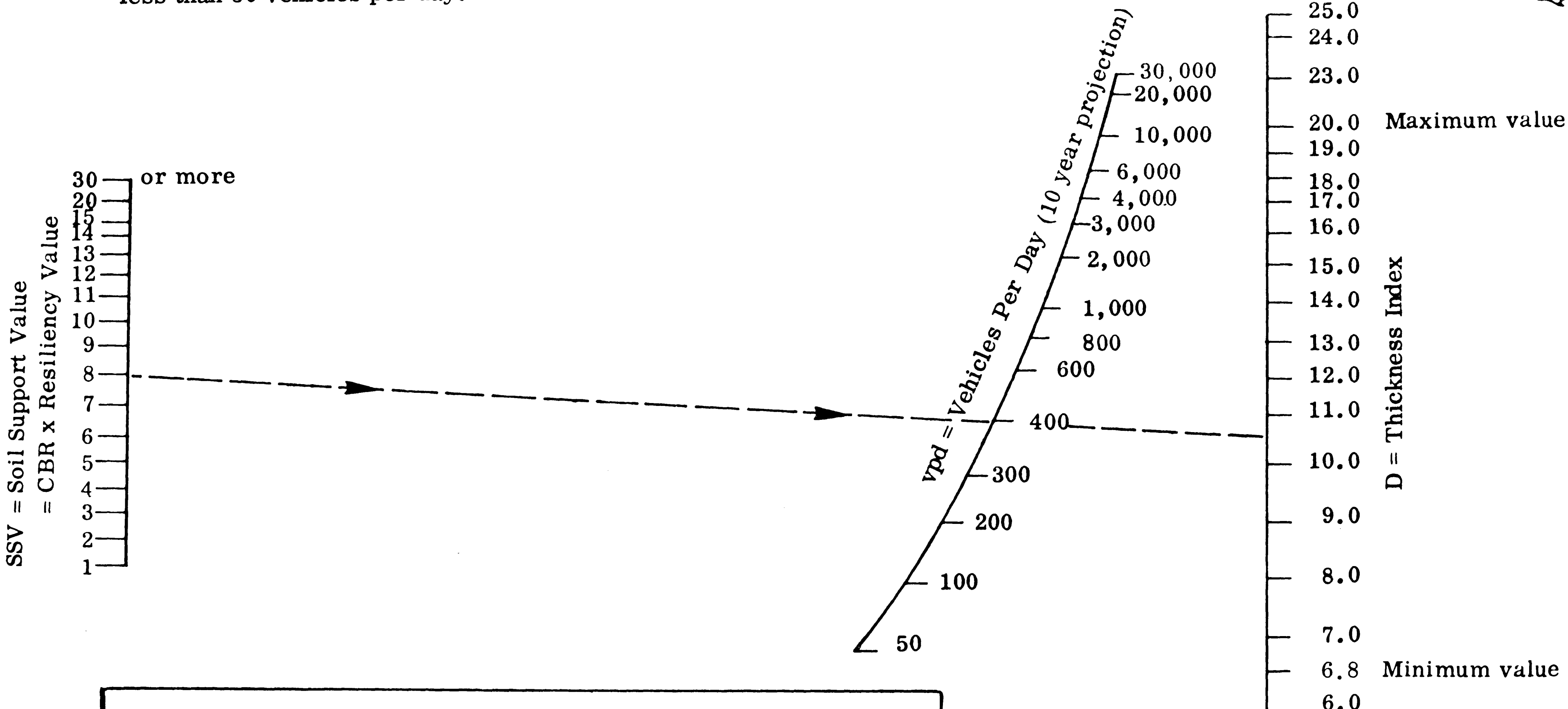
Example No. 1 — For sandy and sandy clay soils of the coastal plain and where the vpd = 150, 300, and 800.

Example No. 2 — For micaceous soils or 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 supersede 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 = 6.8 could be reduced for service roads and for **subdivision roads** with less than 50 vehicles per day.



Example: Given location — Craig County hence R. F. = 2.0
Given Av. CBR = 6 therefore Design CBR = 2/3 x 6 = 4
Therefore SSV = Design CBR x R. F. = 2 x 4 = 8
Given Design Traffic = 400 vpd (Total in both directions)
Therefore we get D = 10.6

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: <u>Data Collected</u>: 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 four to six choices in each case.

<u>Evaluation</u> : From Appendix II or Figure 1 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 nomograph (Figure 4) — (a) D = 6.4 for 150 vpd; (b) D = 8 for 300 vpd; and (c) D = 12 for 800 vpd.

(a) For 150 vpd, SSV = 30 and D = 6.4

Location	Material Notation*	Choice 1 h	Choice 1 hxa	Choice 2 h	Choice 2 hxa	Choice 3 h	Choice 3 hxa	Choice 4 h	Choice 4 hxa
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
Base -a_2	Agg.	5	5.00x1.00=5.00	1		-		-	
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
	D		6.67		6.71		6.72		6.84

(b) For 300 vpd, SSV = 30 and D = 8

Location	Material Notation*	Choice 1 h	Choice 1 hxa	Choice 2 h	Choice 2 hxa	Choice 3 h	Choice 3 hxa	Choice 4 h	Choice 4 hxa	h	hxa	h	hxa
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

Location	Material Notation*	Choice 1 h	Choice 1 hxa	Choice 2 h	Choice 2 hxa	Choice 3 h	Choice 3 hxa	Choice 4 h	Choice 4 hxa	h	hxa	h	hxa
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=8.00	-		4	4.00x1.00=4.00	3	3.00x1.00=3.00
Base -a_2	Sel.Mat.	-		-		-		6	6.00x0.84=5.04	-		-	
Subbase-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; 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.

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

<u>Evaluation</u> : From Appendix II or Figure 1 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 nomograph (Figure 4) — (a) D = 10.0 for 350 vpd; (b) D = 14.0 for 900 vpd; and (c) D = 18.8 for 4,000 vpd

(a) For 350 vpd, SSV = 7.0 and D = 10.0

Location	Material Notation*	Choice 1 h	Choice 1 hxa	Choice 2 h	Choice 2 hxa	Choice 3 h	Choice 3 hxa	Choice 4 h	Choice 4 hxa	Choice 5 h	Choice 5 hxa	Choice 6 h	Choice 6 hxa
Surface-a_1	A.C.	1.5	1.5x1.67 =2.51	1.5	1.5x1.67 =2.51	-		-		-		-	
Surface-a_1	A.C.FullDep.	-		-		-		-		7	7.00x1.5=10.50	-	
Surface-a_1	D.S.	-		-		-	0.84	-	0.84				0.84
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

Location	Material Notation*	Choice 1 h	Choice 1 hxa	Choice 2 h	Choice 2 hxa	Choice 3 h	Choice 3 hxa	Choice 4 h	Choice 4 hxa	Choice 5 h	Choice 5 hxa	Choice 6 h	Choice 6 hxa
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.FullDep.	-				-		-		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

Location	Material Notation*	Choice 1 h	Choice 1 hxa	Choice 2 h	Choice 2 hxa	Choice 3 h	Choice 3 hxa	Choice 4 h	Choice 4 hxa	Choice 5 h	Choice 5 hxa	Choice 6 h	Choice 6 hxa
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	4.0	4.00x1.67=6.68	4.5	4.5x1.67 =7.52
Base -a_2	CTA	-		6.0	6.0x1.67 =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; S.C. = soil cement; S.L. = soil lime; Sel. Mat. C = cement treated select material, Type II; Sel. Mat. = select material Types I and III.

Example No. 3: <u>Data Collected</u>: 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 required with three to six choices in each case.

<u>Evaluation</u> : From Appendix II or Figure 1 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 nomograph (Figure 4) — (a) D = 7.4 for 200 vpd; (b) D = 11 for 500 vpd; and (c) D = 16.8 for 3000 vpd.

(a) For 200 vpd, SSV = 12 and D = 7.4

Location	Material Notation*	Choice 1		Choice 2		Choice 3		Choice 4		Choice 5		Choice 6	
		h	hxa	h	hxa	h	hxa	h	hxa	h	hxa	h	hxa
Surface-a_1	A.C.	1.5	1.5x1.67 =2.50	-		-							
Surface-a_1	D.S.	-			0.84		0.84						
Base -a_2	Agg.	5	5.00x1.00=5.00	6	6.00x1.00=6.00	-							
Base -a_2	Sel.Mat.	-		-		8	8.00x0.84=6.72						
Subbase-a_3	Sel.Mat.	-		-		-							
D			7.50		6.84		7.56						

(b) For 500 vpd, SSV = 12 and D = 11.0

Location	Material Notation*	Choice 1		Choice 2		Choice 3		Choice 4		Choice 5		Choice 6	
		h	hxa	h	hxa	h	hxa	h	hxa	h	hxa	h	hxa
Surface-a_1	A.C.	1.5	1.5x1.67 =2.51	-		-		-		-		-	
Surface-a_1	A.C.FullDep.			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			3	4.00x1.00=4.00	4	4.00x1.00=4.00	3	3.00x1.00=3.00	-	
Base -a_2	Sel.Mat.	-		-		-		-		-		4	4.00x0.84=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	4.00.0.5 =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

Location	Material Notation*	Choice 1		Choice 2		Choice 3		Choice 4		Choice 5		Choice 6	
		h	hxa	h	hxa	h	hxa	h	hxa	h	hxa	h	hxa
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
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.	-		-		-		-		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; Agg. = untreated aggregate; Sel. Mat. = select material types I and III; S.C. = soil cement; S.L. = soil lime; CTA = cement treated aggregate; Sel. Mat. C = cement treated select material Type II.

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. This 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°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 II 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.

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 to 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.

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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 (b) A-2, A-4, A-5, A-6 and A-7 soils with sand content 60 or more percent	3.0
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 (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	1.5
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	Augusta	2	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	Culpeper — E. of Rtes. 229 and 15S	1.0	4	4
	W. of Rtes. 229 and 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 and 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 and E. Rte. 522	1.0	6	6
	N. of Rte. 20 and W. Rte. 522	1.0	5	5
	S. of Rte. 20 and E. Rte. 522	1.5	6	9
	S. of Rte. 20 and 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 and Rte. 609	1.5	7	11
	E. Rte. 522 and 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, and South Rivers	2.0	5	10
	E. James, Maury, and 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	Southampton	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