DESIGN GUIDE FOR SECONDARY ROAD PAVEMENTS IN VIRGINIA

by

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Virginia Highway Research Council
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INTRODUCTION

This design method for secondary roads is based on AASHO Road Test Results and Virginia's design experience. 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.

THE EVALUATION OF VARIABLES

(1) The Soil Support Value (SSV) is equal the design CBR* times the resiliency factor. "The Virginia Test Method of Determining CBR Values" (VTM-8) is to be used for evaluating the design CBR. In unusual circumstances where actual CBR data cannot be obtained, predicted design values as given in Appendix I (pages A-1 through A-5) may be used. If these predicted values are used, the SSV of the subgrade can be obtained from Figure 1 (page 2) or Appendix I.

The predicted regional resiliency factors are given in Figure 2 (page 3) and Appendix I. These factors are valid when the moisture content of the subgrade soil is at or below the plastic limit. For soils with moisture contents close to their liquid limits, the resiliency factors are much lower and the SSV should be a maximum of 2.

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* California Bearing Ratio

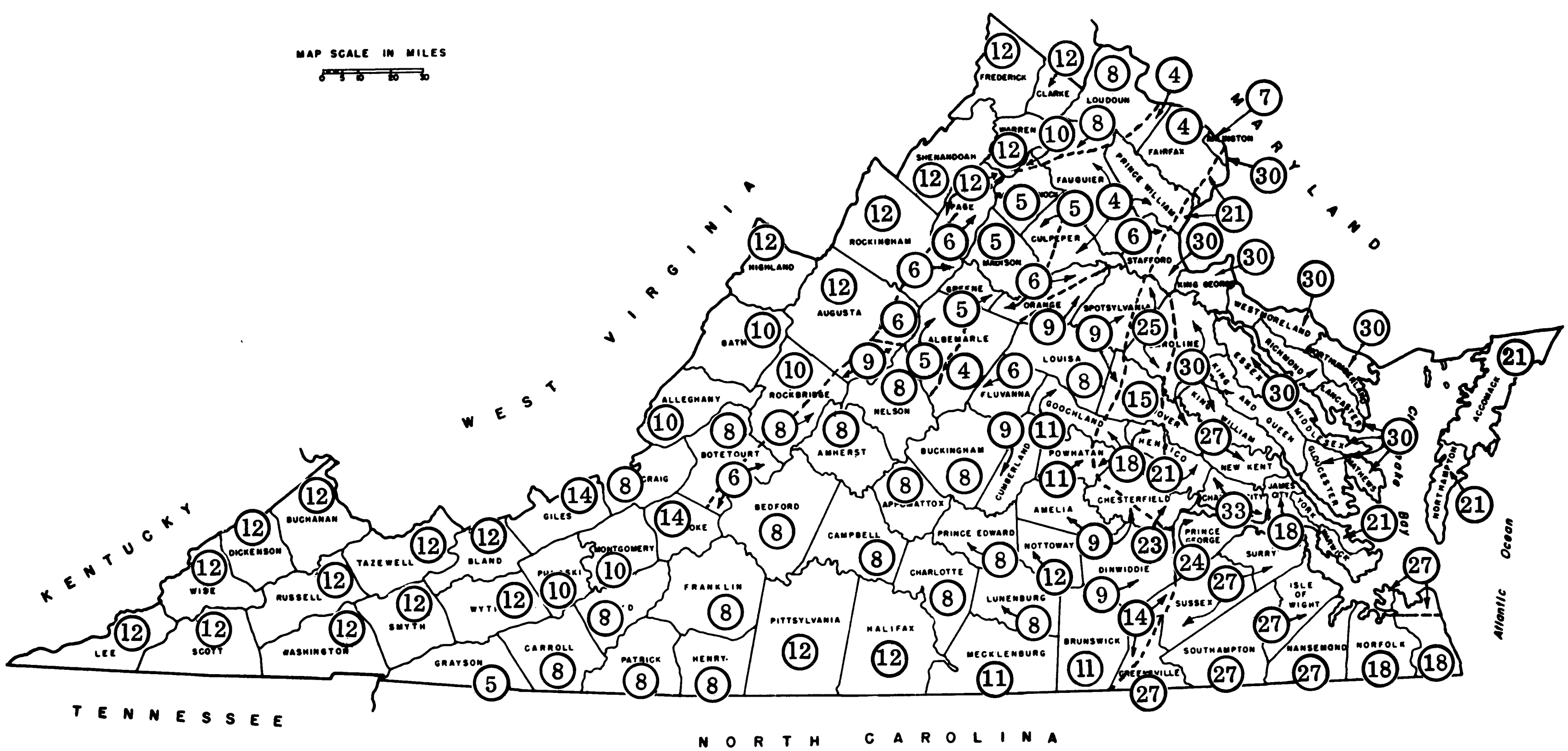


Figure 1. Predicted soil support values (SSV) for secondary roads.

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.

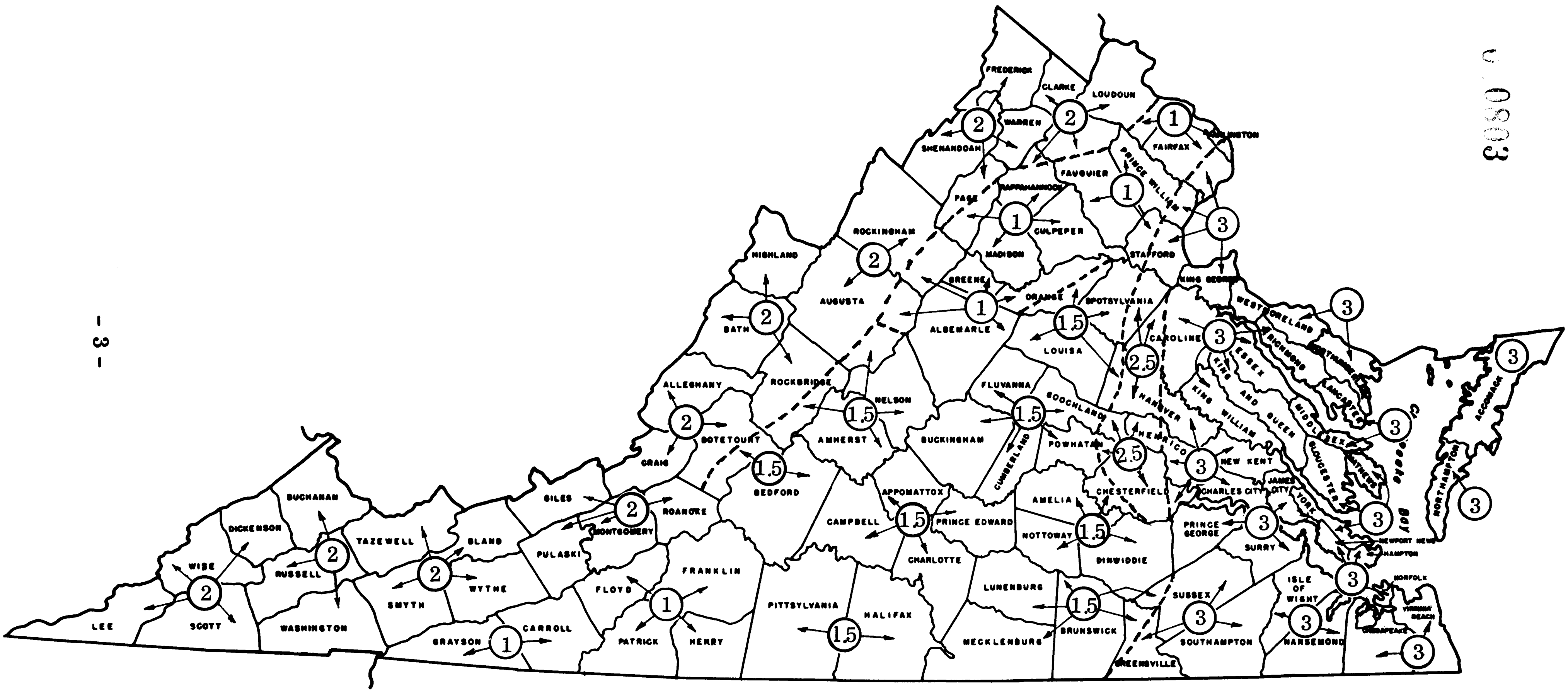


Figure 2. Soil resilience factors (R. F.) for secondary roads.

(2) The Thickness Equivalencies of Paving Materials are given in Table 1, below. The materials and construction specifications should be in accordance with the current Virginia Department of Highways Road and Bridge Specifications or appropriate supplemental specifications.

(3) The Traffic in Terms of Vehicles per Day (vpd) is available from district traffic engineers. For two-lane facilities provide for the total traffic. For four-lane use 80 percent of the total traffic.

TABLE 1

THICKNESS EQUIVALENCY VALUES FOR MATERIALS USED IN SECONDARY 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	Prime and single seal*	S.S.	0.42*
	a_1	Full depth asphalt concrete	A.C. (Full depth)	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. Mat. 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 7, 8 and 9.

THE DESIGN METHOD FOR FLEXIBLE PAVEMENTS

Design Procedure

The design procedure is as follows: The design nomograph is given in Figure 3 (page 6). From the nomograph, with a given SSV and vpd in both directions the thickness index (D) can be determined as shown by the example.

The nomograph specifies a minimum D of 6.4 and a maximum D of 20. The minimum D value could be reduced for service roads and for secondary roads with less than 50 vehicles per day. If the D value obtained from the nomograph is is greater than 20, stage construction with D = 20 in the first stage may be provided.

After the value of D is obtained, the material in each layer of the pavement and the thickness of each layer can be determined by the following equation:

$$D = a_1h_1 + a_2h_2 + a_3h_3 \qquad \text{(see Figure 4, page 10.)}$$

Use of the equation is illustrated in three examples, given on pages 7, 8 and 9 using the data given below.

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

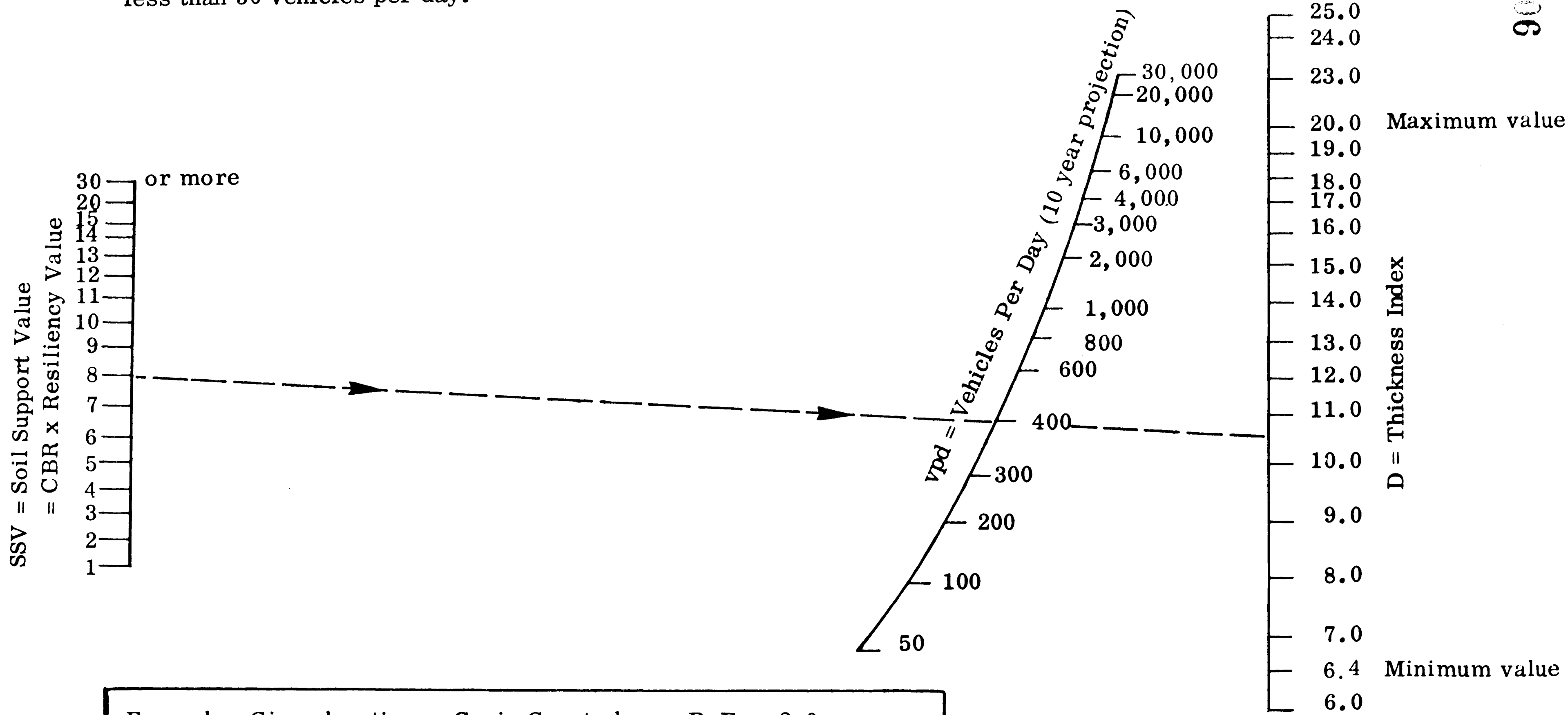
Example No. 2 — for micaceous soils or micaceous clay silts and where the vpd = 350, 900, and 4,000.

Example No. 3 — for clayey soils with no mica content and where vpd = 200, 500, and 3,000.

These examples are intended to clarify and explain the design procedure and not necessarily the pavement design selection.

Other combinations of pavement layers may be used. Pavement designs should fit local conditions.

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 secondary 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 Traffic = 400 vpd (Total in both directions)
Therefore we get D = 10.6

Also see pages 7, 8 and 9.

Figure 3. Nomograph correlating the soil support value (SSV), traffic (vpd), and the thickness index (D) (based on AASHO Equation) for secondary 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 nomograph (Figure 3) - (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		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	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

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.	1.25	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		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. 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; 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: <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 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 nomograph (Figure 3) - (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		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	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		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.	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		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. 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 Depth = 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 six choices in each case.

<u>Evaluation</u> : 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 nomograph (Figure 3) - (a) D = 7.4 for 200 vpd; (b) D = 11 for 500 vpd; and (c) D = 16.8 for 3,000 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	-		-		-	
Surface-a_1	S.S.	-		-		-			0.42		0.42		0.42
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

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

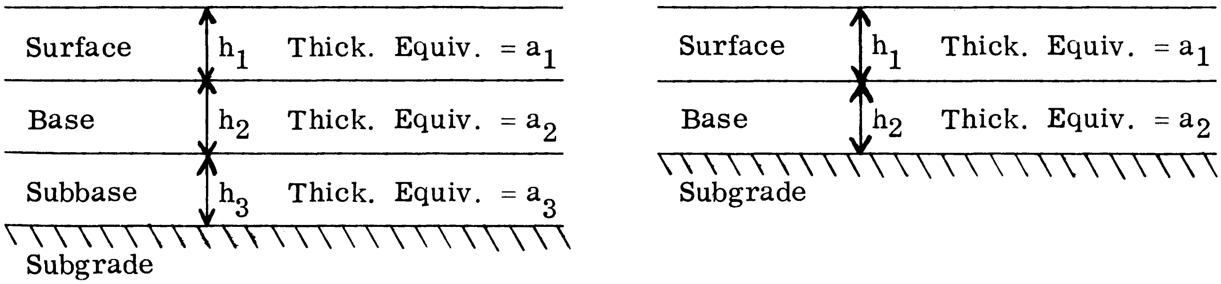
(c) For 3,000 vpd, SSV = 12 and D = 16.8

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; S.S. = single 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.

Discussion of the Design Method

The flexible pavements of secondary roads in Virginia usually consist of two or three layers of different materials of varying depth over the subgrade, as shown in Figure 4 below.



(a) Three-layer System (b) Two-layer System

Figure 4. Secondary road flexible pavement sections.

CBR Values

For each project sufficient CBR tests should be run to determine the true support 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.

The design CBR value of the project is two-thirds of the average value. The factor of two-thirds provides a safety factor to compensate for the nonuniformity of the 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.

Resiliency Factor (R. F.)

The subgrade soils for secondary roads have been divided into five classifications based on their resiliency properties. The resiliency factors are given in Table 2. Please note that the higher the resiliency, the lower the resiliency factor. The degree of resiliency of a soil could be obtained if its soil classification is known as shown in Appendix II, page A-6.

TABLE 2

RESILIENCY FACTORS FOR SOILS

Degree of Resiliency	R. F.
Highly resilient soils	1.0
Medium resilient soils	1.5
Medium low resilient soils	2.0
Low resilient soils	2.5
Very low resilient soils	3.0

Traffic

The design nomograph (Figure 3, page 6) has a vpd curve which shows the total traffic in both directions, since this is normally the way the total traffic volume is obtained on secondary roads. If the data available are for traffic in one direction (e.g., on a one-way street), this value should be doubled for use of this nomograph.

However, it should be noted that the thickness index (D) curve is calculated based on one direction traffic only, and hence gives the thickness index of the pavement in each traffic lane.

The nomograph assumes heavy commercial trucks (2 axles and 6 tires or heavier) to be not greater than 5.0 percent of the total vpd. When it is anticipated that the traffic will include a higher percentage of these heavy trucks the equivalent total traffic will be calculated as follows: equivalent total traffic = the total traffic + 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 total traffic instead of the total traffic.

The Thickness Equivalency

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

The strength equivalencies of the paving materials are given in Table 1. As new materials are introduced, their thickness equivalencies have to be evaluated.

The thickness equivalency of a given material placed in the base is higher than when it is placed in the subbase. Thus untreated stone has an $a = 1.0$ when it is used in the base course and an $a = 0.6$ when used in the subbase course. Asphalt concrete has an a = 1.67 in the surface course, but when placed in full depth over the subgrade its base and surface course have an a = 1.5. Cement treated aggregate and select materials types I and III are similarly considered.

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

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 thickness in inches of the surface, base, and subbase layers, respectively.

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

Design Considerations

After the required thickness index of the pavement has been determined, the choice of material and the thickness of the layer 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) Use of Local Materials: Every effort should be made to locate and utilize local materials. Sources of local materials that may have been considered unsatisfactory for use in construction (like micaceous, A-3 type, or swelling soils) may be entirely acceptable when stabilized with a stabilizing agent such as cement or lime. Subgrades so stabilized provide a rigid foundation.

(2) Subgrade, Subgrade Treatment or Subbase: (a) A rigid foundation is a good investment where the traffic is likely to increase considerably. For example, a rigid foundation (e.g., 6 inches of soil cement or soil lime) with 3 to 4 inches of untreated aggregate is capable of carrying a very heavy volume of traffic. (b) 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. (c) When cement stabilized subgrade is

recommended, approximately 10 percent by volume should be used; however, in all cases representative samples of the soil should be submitted to the laboratory for testing. (d) Stabilized subgrades (particularly those stabilized with cement) should be immediately covered with untreated aggregate to eliminate or reduce moisture and thermal cracking or deterioration with a resultant lower strength of the stabilized material. This could normally be handled by a firm specification; (e) Cement or lime stabilization should be completed before temperatures drop below 40°F. (f) Marshy soils, or sandy soils with high subgrade moisture content, or subgrades with water springs or A-3 type soils should be stabilized with a suitable agent, and if the subgrade strength is still considered to be weak in proportion to the expected amount of traffic, cement stabilized material may be provided over the stabilized subgrade.

(3) 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.

(4) Surface Course: Types of bituminous material and rates of application of bituminous material and cover material should be as specified in "Location and Design Division — Instructional and Information Memorandum, LD-71 (R)46.2," dated November 24, 1971.

When a double seal is specified, the first seal should have number 68 aggregate for cover material. The second seal should have number 78 aggregate for cover material.

Surface courses should be used when the traffic exceeds 50 vpd.

(5) Full Depth Bituminous Concrete: Designs using bituminous concrete for base and surface may be used on a prepared subgrade (properly compacted) where economics dictate its use.

A minimum depth (base and surface) of 6 inches should be used.

The base should be composed of B-1 or B-3 and the surface composed of S-4 or S-5.

The minimum layer thickness of base should be 3 inches and that of the surface course $1\frac{1}{2}$ inches.

(6) Minimum Designs (Less than 50 vpd): The base should consist of a minimum depth of 6 inches of aggregate base material, Types I or II in size nos. 20, 21, 21A or 22. This depth will give a thickness index of 6, which is acceptable for secondary roads with less than 50 vpd. As an alternative, in areas containing borderline local materials, but not meeting the specifications for Types I or II base materials, the base may consist of a minimum depth of 6 inches of select borrow with a minimum CBR value of 20. The select borrow base should be stabilized with 8 to 10 percent cement by volume, or approximately 40 pounds per square yard. The cement stabilized select borrow should be surfaced with a curing agent and double seal. This is a minimum recommended design and is not to be used when the road will not be surface treated.

(7) 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 inches of soil cement could be substituted for 4 inches or 6 inches of base material.

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APPENDIX I

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 I (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 I (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 I (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 I (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

APPENDIX II

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.