FINAL REPORT

PAVEMENT DESIGN SYSTEM FOR MISSISSIPPI HIGHWAYS

By

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and

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Conducted by

Mississippi State Highway Department
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16. Abstract

Procedures are described for the design of flexible and rigid pavements that generally follow the AASHTO Interim Guide (1972, Rigid Design Revised 1981). A correlation is established between California Bearing Ratio (CBR) and Soil Support Value (SSV) for materials used in Mississippi. Design charts (nomographs) are presented that incorporate region factor, terminal serviceability, and other relatively constant values to form a system needing only two data inputs, namely: SSV/Modulus of Support and equivalent 18-kip single axle applications. Procedures are outlined for the determination of CBR, SSV, and Modulus of Support.

The flexible pavement design procedures have been adopted by the Department, while the rigid pavement procedures have not, largely due to the very small amount of such construction in recent years.

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Pavement design, flexible, rigid, soil support valve (SSV), California Bearing Ratio (CBR), nomograph, modulus of support

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Appreciation is expressed to the many people whose efforts contributed to this study. Acknowledgement is made to involved personnel of the Research and Development, Roadway Design, and Testing Divisions, as well as the involved personnel of the various district offices.

METRIC CONVERSION CHART

To convert U.S. units to metric units, the following conversion factors should be used:

Multiply U.S. Units	By	To Obtain Metric Units
mils	0.0254	millimeters (mm)
inches (in)	2.5400	centimeters (cm)
feet (ft)	0.3048	meters (m)
yards (yds)	0.9144	meters (m)
square inches (in^2)	6.4516	square centimeters (cm^2)
square feet (ft^2)	0.0929	square meters (m^2)
square yards (yd^2)	0.8361	square meters (m^2)
cubic inches (in^3)	16.3872	cubic centimeters (cm^3)
cubic feet (ft^3)	0.0283	cubic meters (m^3)
cubic feet (ft^3)	28.3162	liters (l)
cubic yards (yd^3)	0.7646	cubic meters (m^3)
gallons (gal)	3.7853	liters (l)
pounds (lbs)	0.4536	kilograms (kgs)
pounds (lbs)	453.592	grams (g)
ounces (oz)	28.3495	grams (g)
pounds per square inch (psi)	0.0703	kilograms per square centimeter (kgs/cm^2)
pounds per cubic foot (lbs/ft^3)	16.091	kilograms per cubic meter (kgs/m^3)
miles per hour (mph)	1.609	kilometers per hour (km/hr)
degrees Fahrenheit (°F) minus 32°	5/9	degrees Celsius (°C) °C = 5/9(°F-32°)
British thermal units (BTU)	252.0	calories (cal)

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INTRODUCTION

Background

In approximately January 1976, the Roadway Design Engineer of the Mississippi State Highway Department (MSHD) made a strong request to the Research and Development Division to determine the procedures and methods employed in the past and present for the design of pavement thickness in Mississippi. It was felt that, eventually, a major research effort might be required to look into our pavement design system with the final result being the possible implementation of a "Pavement Design Management System" for Mississippi.

It was determined that the design policy for evaluating pavement thicknesses in Mississippi consisted of design charts developed in 1963. These design charts were developed based on engineering judgement and experience that met the conditions and requirements at that time and not on any design analysis, per se. With this information as a background, both the Roadway Design Division and the Research and Development Division investigated the use of various design procedures, and it was the consensus that the design procedures developed from the AASHO Road Test appeared best suited for Mississippi.

This report summarizes the effort made in evaluating the AASHTO Flexible and Rigid Pavement Designs for Mississippi conditions and describes the methods necessary to utilize the designs.

DESIGN PROCEDURES FOR FLEXIBLE PAVEMENT

Background on Soil Support Value (SSV)

Based on work from the AASHO Road Test in Illinois, a correlation was established between what has been defined as the soil support value (SSV) and the California Bearing Ratio (CBR). This correlation was determined by testing two materials that were obtained from the Road Test site at that time. One of these materials was the subgrade material which was arbitrarily assigned an SSV of 3.0. The second material was a crushed stone base material which was arbitrarily assigned the SSV of 10. It was assumed that the relationship between SSV and CRB could be represented by a straight line on a semi-logarithmic plot through these two points. By assuming that this relationship was correct and by testing any subgrade material using the CBR test, it was possible to determine an SSV.

It was found within the Department that the procedure for estimating CBR varied from District to District. In order to standardize this procedure for each District, a recommended procedure for estimating CBR has been developed by the Testing Division and is summarized in the appendix.

SSV-CBR Correlation

The MSHD has established a correlation between SSV and CBR. This correlation was determined by extensive testing of two materials. One material was a subgrade soil that was obtained from the old AASHO Road Testing site in Illinois, and the other material was a crushed gravel obtained locally in Mississippi.

The Illinois soil was tested for CBR value at hammer blows of 10, 30, and 65 blows. The average CBR value and the dry density obtained for each set of blows are plotted in Figure 1. A best fit line was then drawn through these points such that when entering the curve with any density value, the corresponding CBR value could be obtained. It was noted that the specified density for subbase material similar to the AASHO Road Test site material was 98 percent. At this specified density, the standard density was determined to be 114.5 pounds per cubic foot (pcf). Thus, entering the curve on Figure 1 with this standard density of 114.5 pcf, a CBR value of 3 was obtained. This CBR value of 3 was equated to an SSV of 3 as used by AASHO. It is interesting to note in Figure 2 that the CBR value obtained during the AASHO Road Test at an SSV of 3 was very close to the CBR value of 3 obtained by Mississippi.

Likewise, samples of crushed gravel were also tested for CBR values using a vibratory load. It should be pointed out that the CBR test on the base material from the AASHO Road Test could not be reproduced as was the case for the subbase material. Base material for the Road Test is no longer available; thus, the Department used a local crushed gravel material to simulate the base material. The CBR values obtained for the various dry densities of this material have been plotted in Figure 3. The CBR values obtained varied from a low of 98 to a high of 124. There is difficulty in testing the base material at these high CBR values which creates a scattering of the results as shown. An average best fit line was drawn through these points from which the required CBR could be obtained. The specified density for crushed gravel material is 100 percent; and at this specified density, the standard density is 119.2 pcf. Entering the chart in Figure 3 with a density of 119.2 pcf, a CBR value of 100 was obtained. This CBR value of 100 was equated to an SSV of 8. However, it should be noted that for the AASHO Road Test, the upper CBR level was equated to an SSV of 10. The Department chose to equate this upper CBR value to an SSV of 8 for a number of reasons. First, as shown in Figure 2, the results of other states indicate that at a CBR of 100 the SSV varies in the range of 8 to 10. Also, Kentucky conducted an extensive study relating CBR to SSV and found the correlation at the higher CBR values to be most difficult. Based on results and experience with existing roads, Kentucky was able to back calculate and determine the CBR-SSV correlation using structural number computations. Kentucky found that for a CBR of 100, the corresponding value of soil support was 8.25 for their conditions.

For the Mississippi condition, a similar type computation was made for one of the interstate routes (I-55 in Grenada County) in which there has not been a failure of the deep strength asphalt pavement, and it has not required an overlay in the 15 years since being opened to traffic. The in-place structural number for this pavement was computed, as well as the total 18-kip loads for a 20-year period. It was determined from this analysis that if an SSV-CBR curve was produced setting the high CBR value of 100 equal to the SSV of 10, using such a curve for design would have resulted in a considerable reduction in structural number for the pavement compared to what is in place. Thus, it was found that if the CBR value of 100 was equated to an SSV of 8, the CBR-SSV curve produced, resulted in a closer approximation of the structural number actually used for this pavement. Hence, the performance experienced with this pavement under Mississippi traffic conditions indicates that an SSV of 8 for the high CBR test value appears most appropriate. Also, equating the high CBR to an SSV of 8 reduces the possibility of under-designing the pavement thickness and results in a slightly longer pavement life design.

The Department's correlation between SSV and CBR is given in Figure 4. The resulting equation for the straight line connection of this plot is

$$SSV = 3.289 \log_{10} CBR + 1.421$$

Flexible Pavement Design Chart

The AASHTO Design Chart for Flexible Pavement with a terminal Serviceability Index of 2.5 is being used for obtaining the required structural number for thickness design. A copy of this design chart is attached as Figure 5. The only modification to this chart was the elimination of the Regional Factor multiplier line. The Regional Factor for Mississippi has been determined to be a value of 2.0 (from AASHTO) and is assumed constant throughout the state. This constant value for Regional Factor was incorporated into the Structural Number Line.

Additional Testing and Research

In using the chart for the design of flexible pavement as indicated in Figure 5, there are certain material layer coefficients which have to be employed to compute the structural number (SN). The structure number is an abstract number expressing the structural strength of pavement required for a given combination of soil support value, total equivalent 18-kip single-axle loads, terminal Serviceability Index, and Regional Factor. The required SN must be converted to actual thickness of surface, base, and subbase by means of appropriate layer coefficients representing the relative strength of the material to be used for each layer. The layer coefficients currently used by the Department for asphaltic concrete surface course, crushed stone base course, and sandy gravel subbase course were those established at the AASHO Road Test. Value of coefficients for other materials were those developed on the basis of field experience, other road tests, and by application of layered elastic theory. All these layer coefficients are listed in the AASHTO INTERIM GUIDE FOR DESIGN OF PAVEMENT STRUCTURES and have been used by most other highway agencies. The layer coefficients currently in use by the MSHD are shown in Table 1.

Because of widely varying environments, traffic, and construction practices, the value of actual layer coefficients may vary from region to region or state to state. Additional testing and research to verify or modify the layer coefficient values was conducted by the Department of Civil Engineering of the University of Mississippi under contract to the MSHD. The final report for this study, entitled "Material Parameters for Pavement Design Using AASHTO Interim Guide" was published in December 1981. This study, performed by K. P. George, recommended layer coefficients as shown in Table 2. These coefficients are in general agreement with those currently used by the MSHD with the exception of the plant mix bituminous binder and base mixes. Shortly after these coefficients were recommended, the MSHD changed the grades of asphalt cement used in hot plant mixes. Instead of using AC-20 in surface and binder course mixes and AC-40 in base course mixes, it was decided to use AC-30 in all three courses. For this reason and also because the other recommended coefficients were in general agreement with currently used coefficients, the decision was made to continue using the ones now in use.

The design procedure is illustrated as follows:

The design traffic data for a proposed location is:

1979 ADT = 5210 Existing
1983 ADT = 5700 Current
1993 ADT = 9030 Design
DHV = 990
D = 55% of DHV
T = 11% of DHV
T(Total) = 32% of ADT
18k(Rigid) = 350/1000
18k(Flex) = 240/1000

The estimated CBR for this location is 6-10.
The design life = 10 years.

ADL (Average Daily Load) = Average ADT X D X T(Total) X 18k(Flex)
ADL = (5700 + 9030)/2 X 0.55 X 0.32 X 0.240 = 311
Draw a line on nomograph extending from 3.98 on SSV scale through 311 on traffic scale to the SN scale. SN required = 4.37. See Figure 6. The following pavement structure is selected:

6" Lime-Treated Design Soil @ 0.15 = 0.90
9" Granular Material (Cl.6, Gp.c) @ 0.10 = 0.90
4.5" Plant Mix Bituminous Base @ 0.34 = 1.53
1.5" Binder Course @ 0.44 = 0.66
1.0" Surface Course @ 0.44 = 0.44

SN Designed = 4.43

DESIGN PROCEDURE FOR RIGID PAVEMENT

Rigid Pavement Design Chart

The AASHTO Design Chart for Rigid Pavement is similar to that for flexible pavement as shown in Figure 7. The chart shown is for the design of CRCP and jointed pavements (either reinforced or non-reinforced). The design chart has been simplified from the AASHTO chart by taking into consideration certain constants for Mississippi conditions. These constants are as follow:

Terminal Serviceability Index = 2.5
Concrete Working Stress = (0.75)(flexural strength) =
(0.75)(650) = 488 psi
Modulus of Elasticity of Concrete = 4.5 X 10^6 psi

With these items constant, the charts were condensed to that shown in Figure 7. The values of flexural strength and modulus of elasticity of concrete are approximate values currently obtained for concrete pavement in Mississippi. Using these charts, the concrete pavement thickness can be determined. The design of the base material can be obtained using the set of curves plotted next to the chart. The curves shown at the upper portion are for various CBR values found for Mississippi soils. See the appendix for the MSHD recommended procedure for estimating CBR. These CBR values actually represent modulus of subgrade reaction values. These values can be equated to CBR by using a correlation chart developed by the Corps of Engineers. The base design curves in the lower portion are for cement stabilized material and asphalt and actually represent the modulus of elasticity of these materials. The rigid pavement design chart can also be worked in two different ways: (1) the case when the concrete thickness is known and the base thickness needs to be determined, and (2) the case when the base thickness is selected first and the concrete thickness must be determined. An example of this design for the case when the design is for the base is as follows: (1) Enter the chart for the total number of 18-kip single axle applications and draw a line between this point and the known value of the concrete thickness. (2) Read a value on the modulus of support line. (3) Enter the base material thickness design curves for this modulus of support and draw a horizontal line across to the correct subgrade material CBR curve. (4) Draw a vertical line downward and intersect the curve for the base material selected, and (5) extend this line horizontally across and read the base thickness required.

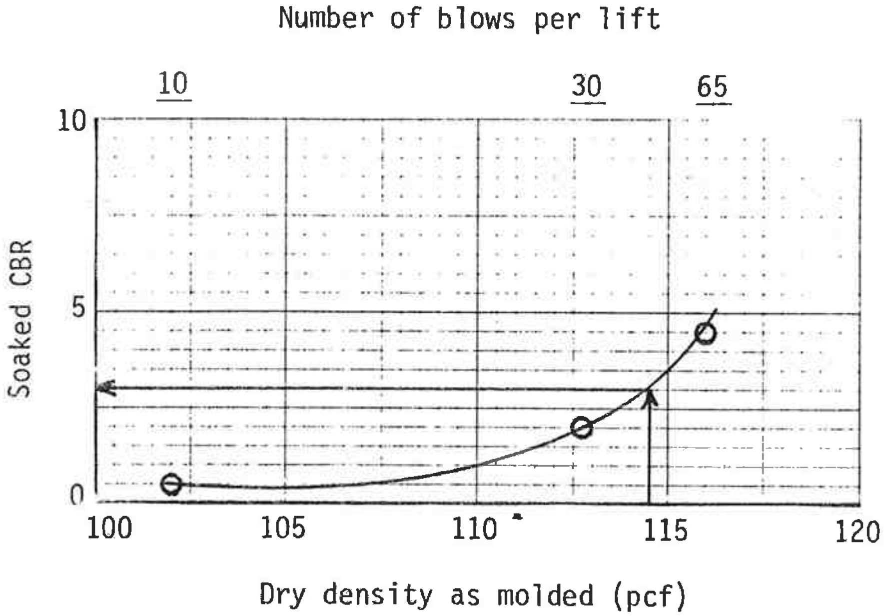
Additional Testing and Research

For the rigid pavement design, certain material values needed to be determined for Mississippi conditions. Two of these material values deal with concrete properties, these being the flexural strength and the modulus of elasticity. The flexural strength for concrete used in pavement in Mississippi is documented by tests and an average value can be readily obtained. The modulus of elasticity of concrete requires testing of concrete cylinders with strain gages attached; however, this is a simple testing procedure. More extensive testing is required to obtain the modulus of elasticity of cement stabilized base and asphalt base materials.

In the previously mentioned study by George, moduli of elasticity tests were conducted for concrete, cement stabilized base, and asphalt base materials. Moduli values for base materials agree with those suggested in the AASHTO Interim Guide (1972). A value of 3.0 X 10^6 psi was recommended for the concrete modulus of elasticity. It is worthwhile to point out that the value for the concrete modulus used in the design chart (Figure 7) is 4.5 X 10^6 psi; however, it has been noted by George and others that rigid pavement thickness is not overly sensitive to the concrete modulus. For the range of rigid pavement thicknesses encountered in Mississippi, the use of the lower value results in an increase in thickness of approximately 0.25 inch. Because of this small difference, no change was made in the design chart.

CONCLUSION

The flexible pavement design procedures described herein have been adopted by the MSHD. The rigid pavement design procedures have not yet been adopted, largely due to the very small amount of rigid pavement construction in our state in recent years.



Note: Specified Density for Subbase Material Similar to the AASHO Road Test Site Material = 98%.

Standard Density = 114.5 pcf.

Figure 1. CBR test values for Illinois soil (AASHO Road Test Material).

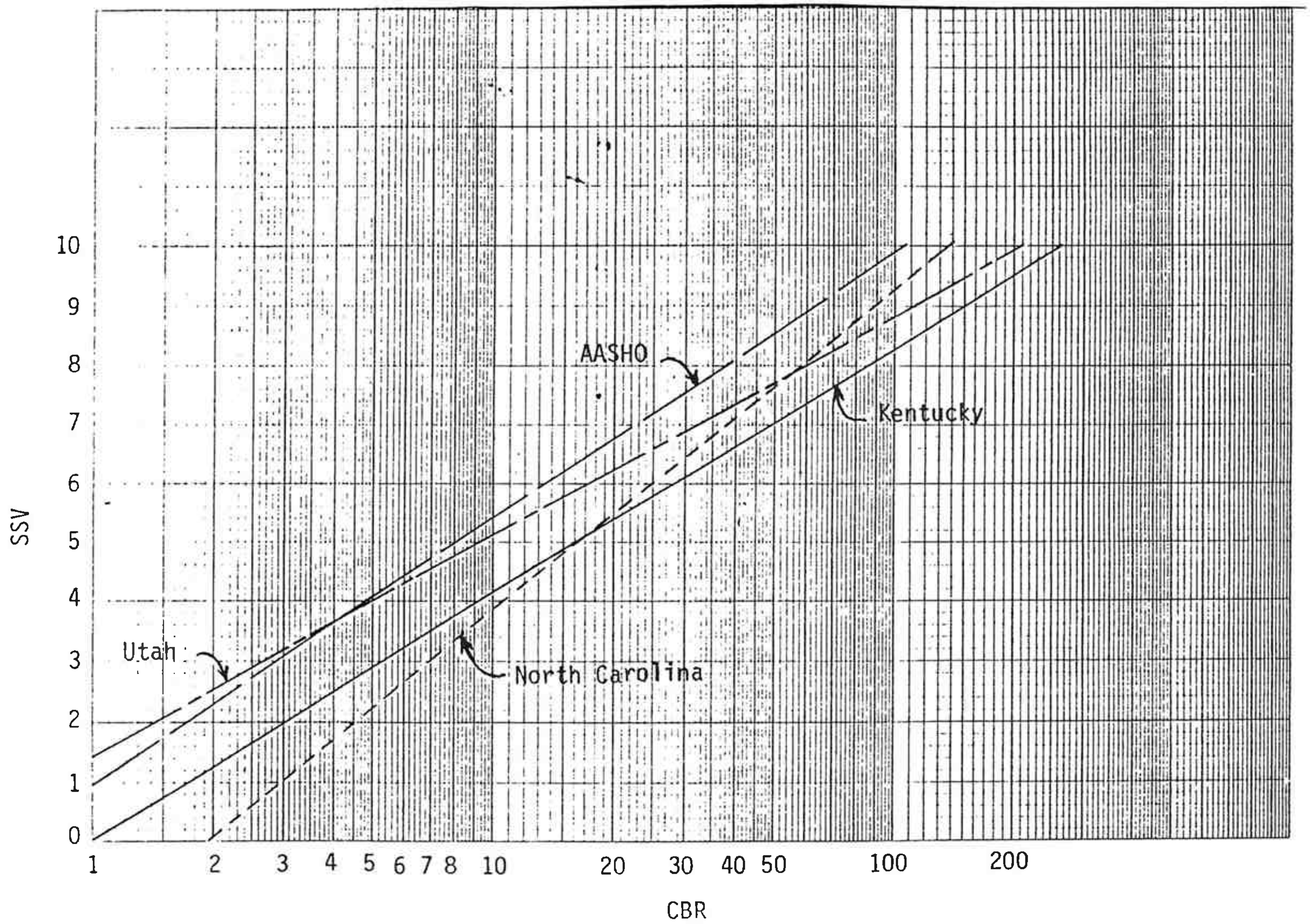
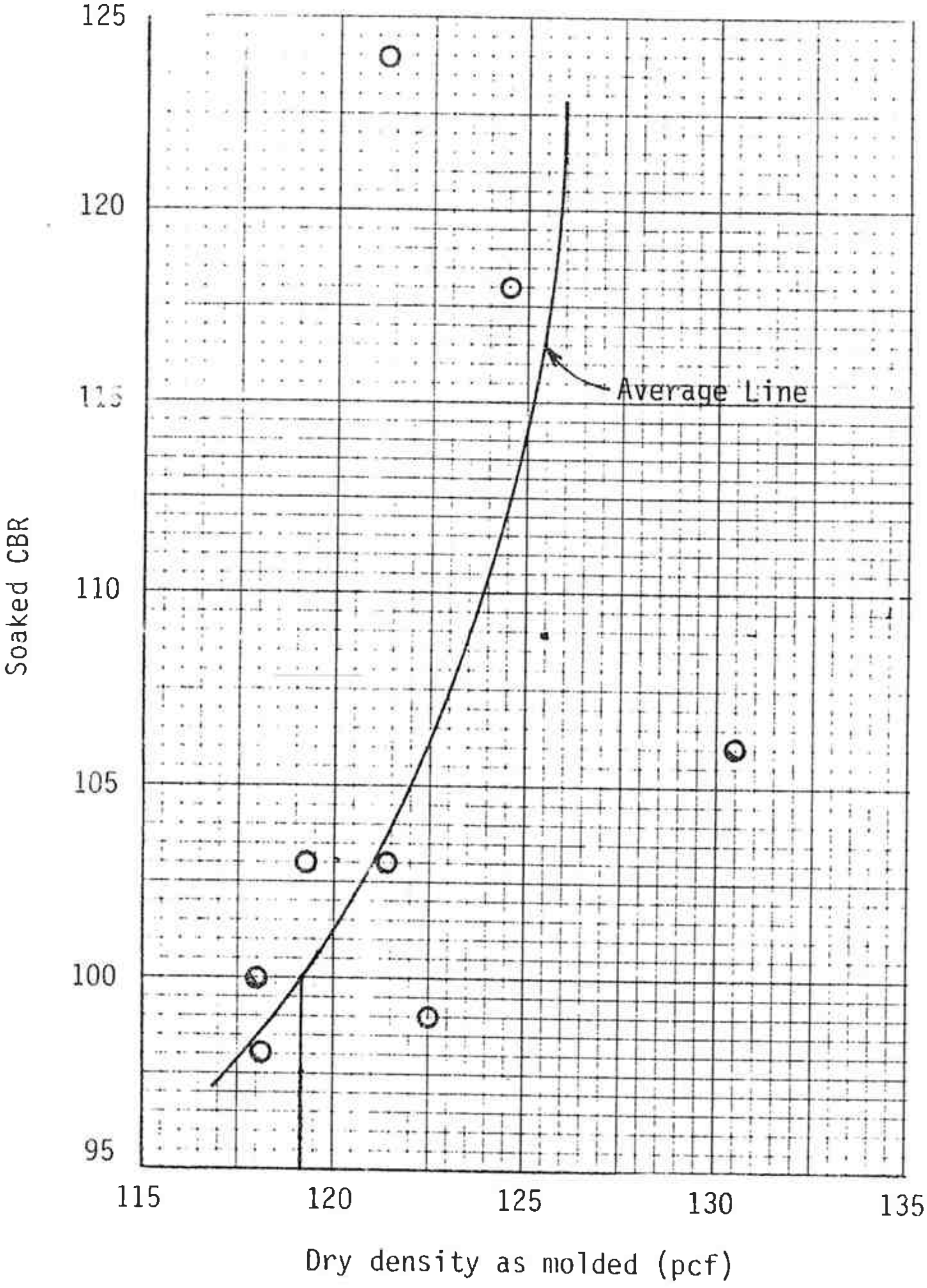


Figure 2. Correlations between SSV and CBR from several sources.

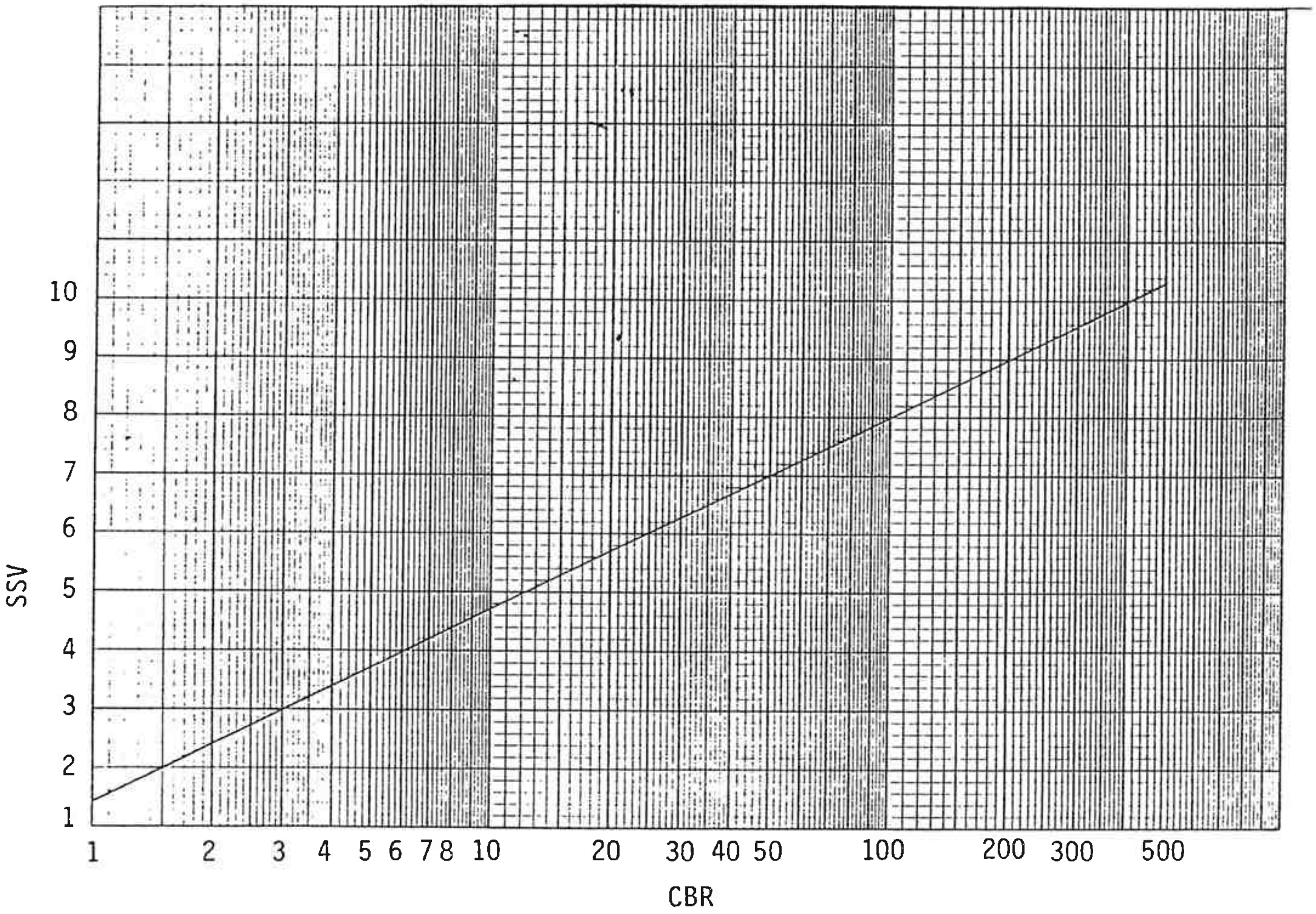


Standard
Density = 119.2 pcf.

Optimun
Moisture = 9%.

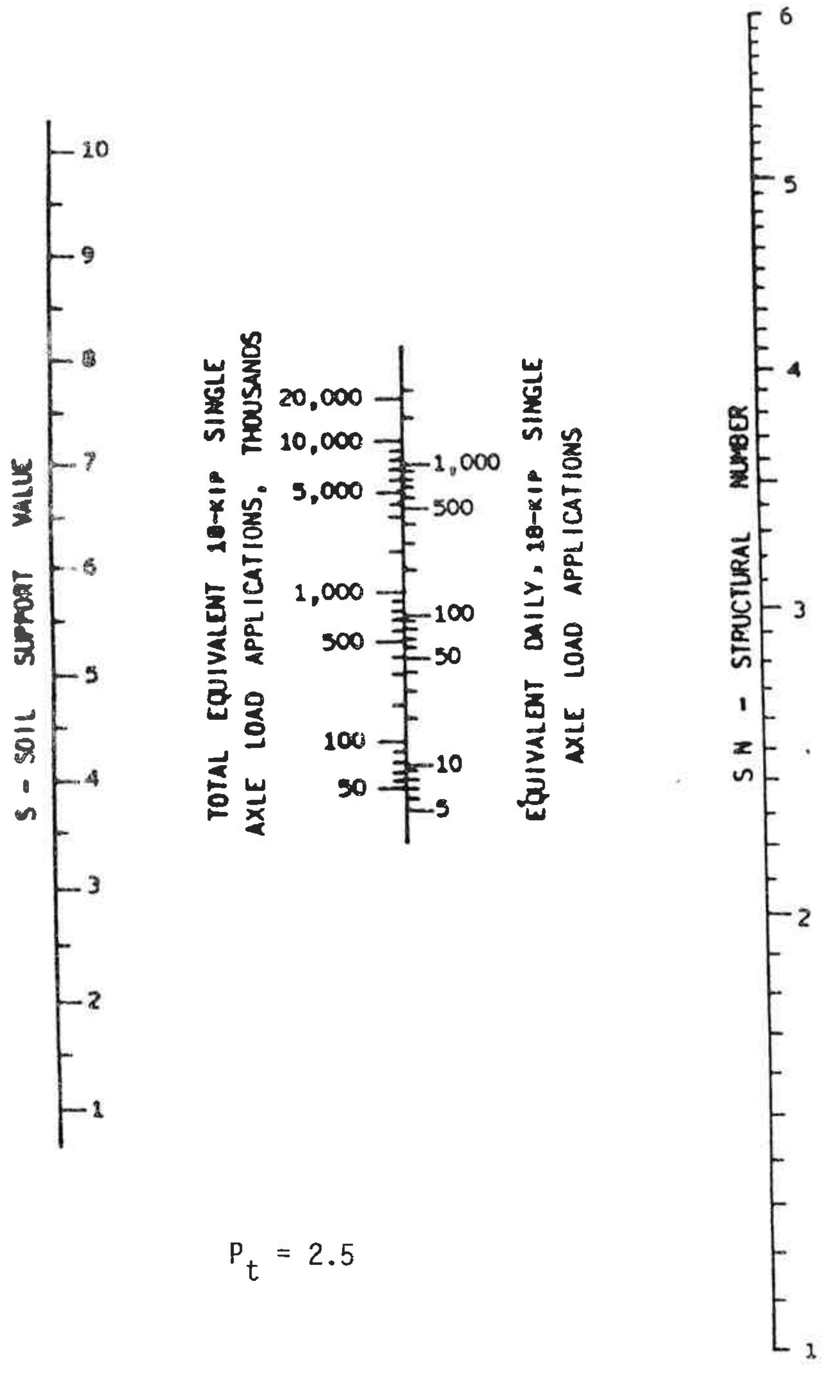
Specified Density
for Crushed Gravel
Material = 100%.

Figure 3. CBR values for crushed gravel.



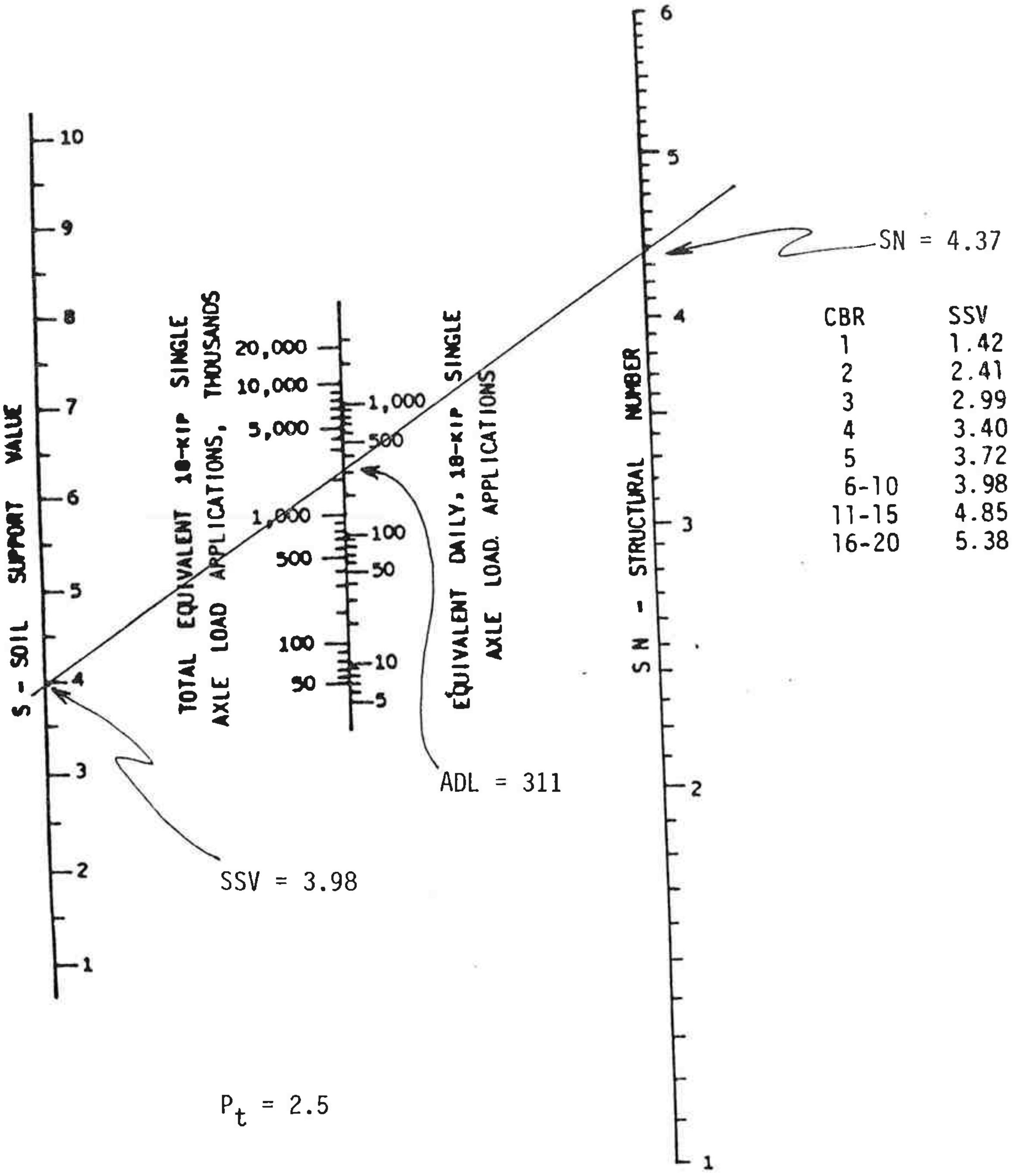
$SSV = 3.289 \log_{10}CBR + 1.421$ (Mississippi)

Figure 4. MSHD correlation between SSV and CBR.



CBR	SSV
1	1.42
2	2.41
3	2.99
4	3.40
5	3.72
6-10	3.98
11-15	4.85
16-20	5.38

Figure 5. MSHD design chart for flexible pavements.



SN = 4.37

ADL = 311

SSV = 3.98

CBR	SSV
1	1.42
2	2.41
3	2.99
4	3.40
5	3.72
6-10	3.98
11-15	4.85
16-20	5.38

$P_t = 2.5$

Figure 6. Sample problem solution.

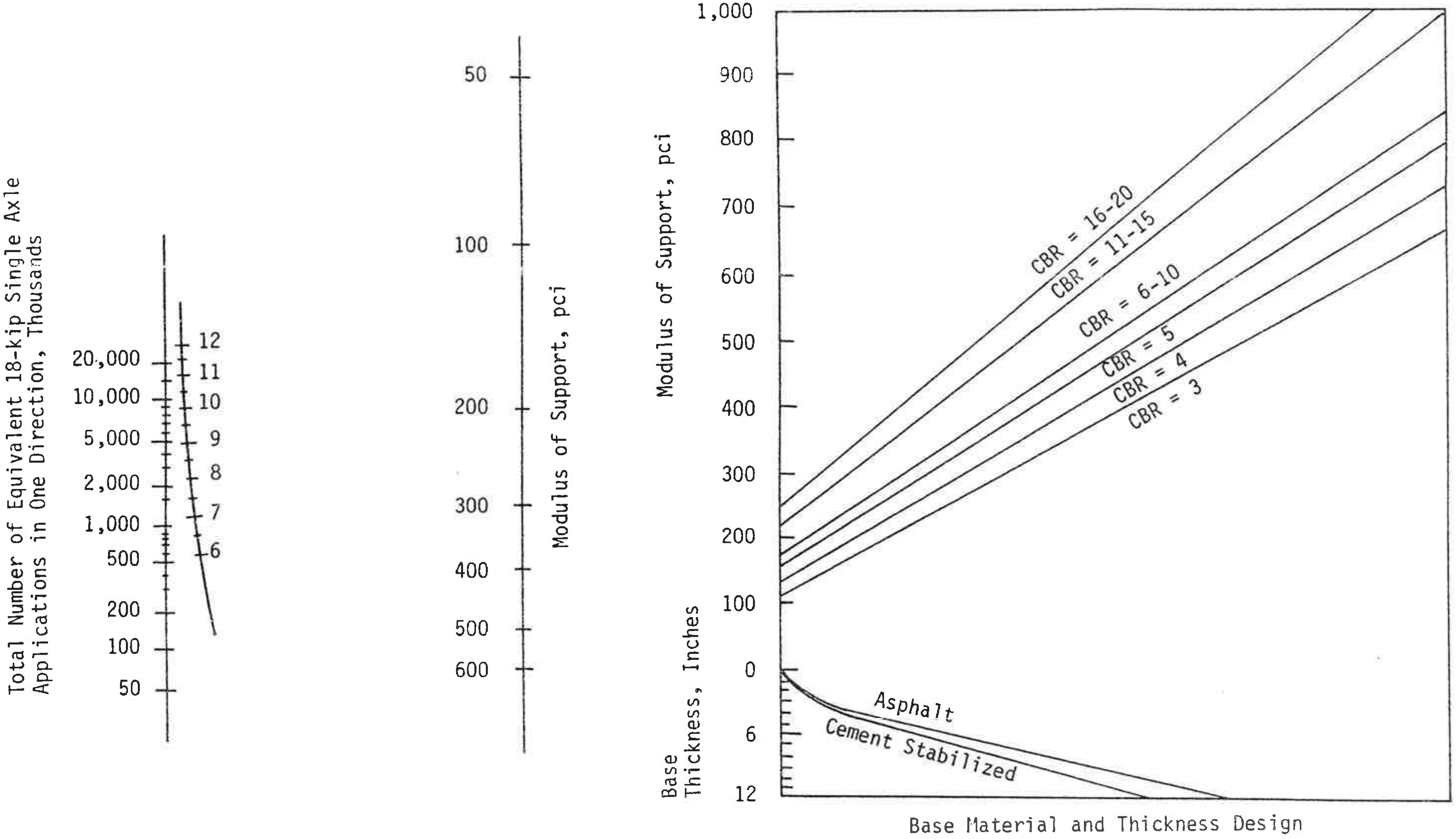


Figure 7. Pavement and base design for ALL types of rigid pavement (continuous, jointed, plain and reinforced) and either asphalt or cement stabilized base.

Table 1. Layer coefficients currently used by the MSHD.

	COMPONENT	COEFFICIENT PER INCH
1.	Surface Course	
	Hot Bituminous Pavement, Surface and Binder Courses	0.44
	Double Bituminous Surface Treatment	0.00
2.	Base Course	
	Plant Mix Bituminous Base Course	0.34
	Cement Treated Granular Material (Class 1 or 2, Group D)	0.23
	Cement Treated Granular Material (Class 3 - 6, Group D)	0.20
	Cement Treated Granular Material (Class 9, Group D)	0.17
	Granular Base Course (Class 1 or 2, Group A)	0.10
	Crushed Stone	0.14
	Sand Asphalt Base Course	0.25
3.	Subbase Course	
	Granular Subbase Course (Class 1 or 2, Group C)	0.12
	Granular Subbase Course (Class 3 or 4, Group C)	0.11
	Granular Subbase Course (Class 5 or 6, Group C)	0.10
	Granular Subbase Course (Class 9, Group C)	0.09
	Cement Treated Granular Material (Class 9, Group D)	0.20
4.	Design Soil Treatment	
	Lime Treated Course	0.15
	Lime-Cement Treated Course	0.15
	Cement Treated Course	0.15 - 0.20

Table 2. Layer coefficients recommended by K. P. George.

NO.	COMPONENT	COEFFICIENT PER INCH
1	Plant-Mix Asphalt Surface with AC-20	0.44
2	Plant-Mix Asphalt Base with AC-40	0.38
3	Plant-Mix Asphalt Binder with AC-20	0.35
4	Soil-Cement Base (7-day Compressive STrength no less than 600 psi)	0.24
5	Soil-lime Subbase (CBR no less than 20)	0.20

APPENDIX A

RECOMMENDED PROCEDURE FOR ESTIMATING CBR

1. Determine AASHTO Soil Classification. Combination soils should be considered as the worst condition. For instance, an A-2-6 soil must be considered as an A-6 soil when using Tables A-1 and A-2.

2. Determine Unified Soil Classification.

3. Determine Atterberg Limits and Volume Change.

4. Determine the Group Index.

5. Determine Gradation.

6. Determine Standard Density for A-3 Soils.

7. Estimate the CBR. Enter Table A-1 or Table A-2, as applicable, with the AASHTO soil class and select the CBR corresponding to the controlling data.

TABLE A-1
METHOD OF ESTIMATING CBR FOR A-4, A-6, AND A-7 SOILS

AASHTO Soil Class	UNIFIED Soil Class(es)	LIQUID Limit	PLASTICITY Index	VOLUME Change	GROUP Index	ESTIMATED CBR
A-7	CH	41 Min.	11 Min.	125	-	1
				100-125	-	2
	CH, MH			75-99	-	3
				63-74	-	4
	CH, MH, CL			≦62	-	5
A-6	CL or ML-CL	40 Max.	11 Min.	35-55	-	5
				26-34	-	6
				17-25	-	7
				-	10	8
				-	9	9
	SC, SMu, or SM-SC	40 Max.	11 Min.	-	8	10
				-	7	11
				-	6	12
				-	5	14
				-	<5	15
A-4	CL	40 Max.	10 Max.	≧17	-	7
				<17	-	8
	ML or ML-CL	40 Max.	10 Max.	>16	-	8
				9-16	-	9
				0-8	-	10
	ML	>25	NP	-	-	12
		≦25		-	-	13
	SC, SM or SM-SC	40 Max.	7-10	-	-	15
			4-6	-	-	16
			3	-	-	17
			2	-	-	18
			1	-	-	19
	SMd	40 Max.	NP	-	-	20

Controlling Data:

A-7 Soils - Volume Change
A-6 Soils - Volume Change & Group Index
A-4 Soils - Liquid Limit, Plasticity Index, and Volume Change

TABLE A-2

METHOD OF ESTIMATING CBR FOR A-2 AND A-3 SOILS

AASHTO Soil Class	UNIFIED Soil Class(es)	PLASTICITY Index	PERCENT PASSING No. 40 Sieve	STANDARD Density	ESTIMATED CBR
A-3	"S" Soils AND "G" Soils	NP	-	≦ 116	11-15
			-	117-119	16-20
			-	> 119	20+
A-2	"S" Soils	7-12	-	-	24
		1-6	-	-	26
		NP	95-100	-	26
		NP	85-94	-	28
		NP	< 85	-	30
	"G" Soils	15	-	-	45
		14	-	-	46
		13	-	-	47
		12	-	-	48
		11	-	-	49
		10	-	-	50
		9	-	-	51
		8	-	-	52
		7	-	-	53
		6	-	-	54
		5	-	-	55
		4	-	-	56
		3	-	-	57
		2	-	-	58
		1	-	-	59
		NP	-	-	60

Controlling Data:

A-3 Soils - Standard Density

A-2 Soils - Plasticity Index and/or Percent Passing No. 40 Sieve

Table A-3. Soil Classification System

The Unified Soil Classification
(Including Identification and Description)

Major Divisions			Symbols	Typical Names
Coarse-grained Soils Fifty percent or more is larger than #200 sieve size.	Gravels More than 50 percent of coarse fraction is larger than #4 sieve size. (Coarse fraction is that part retained on the #200 sieve.)	Clean Gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines. Wide range in grain sizes and substantial amounts of all intermediate particle sizes.
			GP	Poorly-graded gravels, gravel-sand mixtures little or no fines. Predominately one size or a range of sizes with some intermediate sizes missing.
		Gravel with Fines (Appreciable amount of fines)	GMd	Silty gravels, gravel-sand-silt mixtures. Non-plastic fines or fines with low plasticity. LL 28 or less and PI 6 or less.
			GMu	Silty gravels, gravel-sand-silt mixtures. Non-plastic fines or fines with low plasticity. LL greater than 28.
			GM	Silty gravels, gravel-sand-silt mixtures. Non-plastic fines or fines with low plasticity. LL 28 or less and PI greater than 6.
			GC	Clayey gravels, gravel-and-clay mixtures. Plastic fines.
	Sands Fifty percent or more of coarse fraction is smaller than #4 sieve size.	Clean Sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines. Wide range in grain size and substantial amounts of all intermediate particle sizes.
			SP	Poorly-graded sands, gravelly sands, little or no fines. Predominantly one size or a range of sizes with some intermediate sizes missing.
		Sands with Fines (Appreciable amount of fines)	SMd	Silty sands, sand-silt mixtures. Non-plastic fines or fines with low plasticity. LL 28 or less and PI 6 or less.
			SMu	Silty sands, sand-silt mixtures. Non-plastic fines or fines with low plasticity. LL greater than 28.
			SM	Silty sands, sand-silt mixtures. Non-plastic fines or fines with low plasticity. LL 28 or less and PI greater than 6.
			SC	Clayey sands, sand-clay mixtures. plastic fines.
Fine-grained Soils More than 50 percent of material is smaller than #200 sieve size.	Silt & Clays	Liquid Limit 50 or less	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
			OL	Organic silts and organic silty clays of low plasticity.
	Silt & Clays	Liquid Limit greater than 50	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
			CH	Inorganic clays of high plasticity, fat clays.
			OH	Organic clays of medium to high plasticity, organic silts.
Highly Organic Soils			PT	Peat and other highly organic soils.

Table A-4. Design table using No. 200 sieve and liquid limit.

<table>
<tr><td colspan="8">Unified Soil Classification System (Corps of Engineers)</td></tr>
<tr><td colspan="8">Percent Passing No. 200 Sieve</td></tr>
<tr><td colspan="6">0 50
Coarse-Grained Soils
$\frac{(\%\text{Plus } \#200) - (\%\text{Plus } \#4)}{\%\text{ Plus } \#200} \text{ X } 100$</td><td colspan="2">51 100
Fine-Grained & Organic Soils</td></tr>
<tr><td colspan="3">0 49
"G" Soils</td><td colspan="3">50 100
"S" Soils</td><td>"L" Soils</td><td>"H" Soils</td></tr>
<tr><td colspan="6">Percent Passing No. 200 Sieve</td><td colspan="2">Liquid Limit</td></tr>
<tr><td>0 4</td><td>5 12</td><td>13 50</td><td>0 4</td><td>5 12</td><td>13 50</td><td>0 50</td><td>51 100</td></tr>
<tr><td>GW
GP</td><td>GW-GM
GP-GM
GW-GC
GP-GC</td><td>GM(1)
GC
GM-GC</td><td>SW
SP</td><td>SW-SM
SP-SM
SW-SC
SP-SC</td><td>SM(1)
SC
SM-SC</td><td>ML
CL
OL
ML-CL</td><td>MH
CH
OH
MH-CH</td></tr>
</table>

Note: (1) GM and SM soils to be sub-classified with a suffix:
"d" if the LL is 28 or less and the PI is 6 or less;
"u" if the LL is more than 28.

(2) Gradations are on a mass basis.

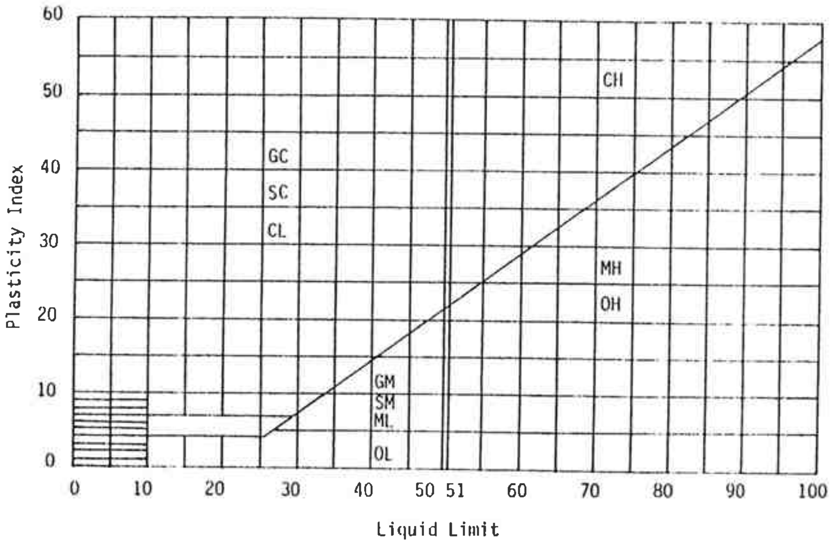


Figure A-1. Design chart utilizing plasticity index and liquid limit.

On Figure A-1, plot LL and PI; select classification as shown. A soil falling in the small box, or on the diagonal line, is a border line, or combined classification soil.

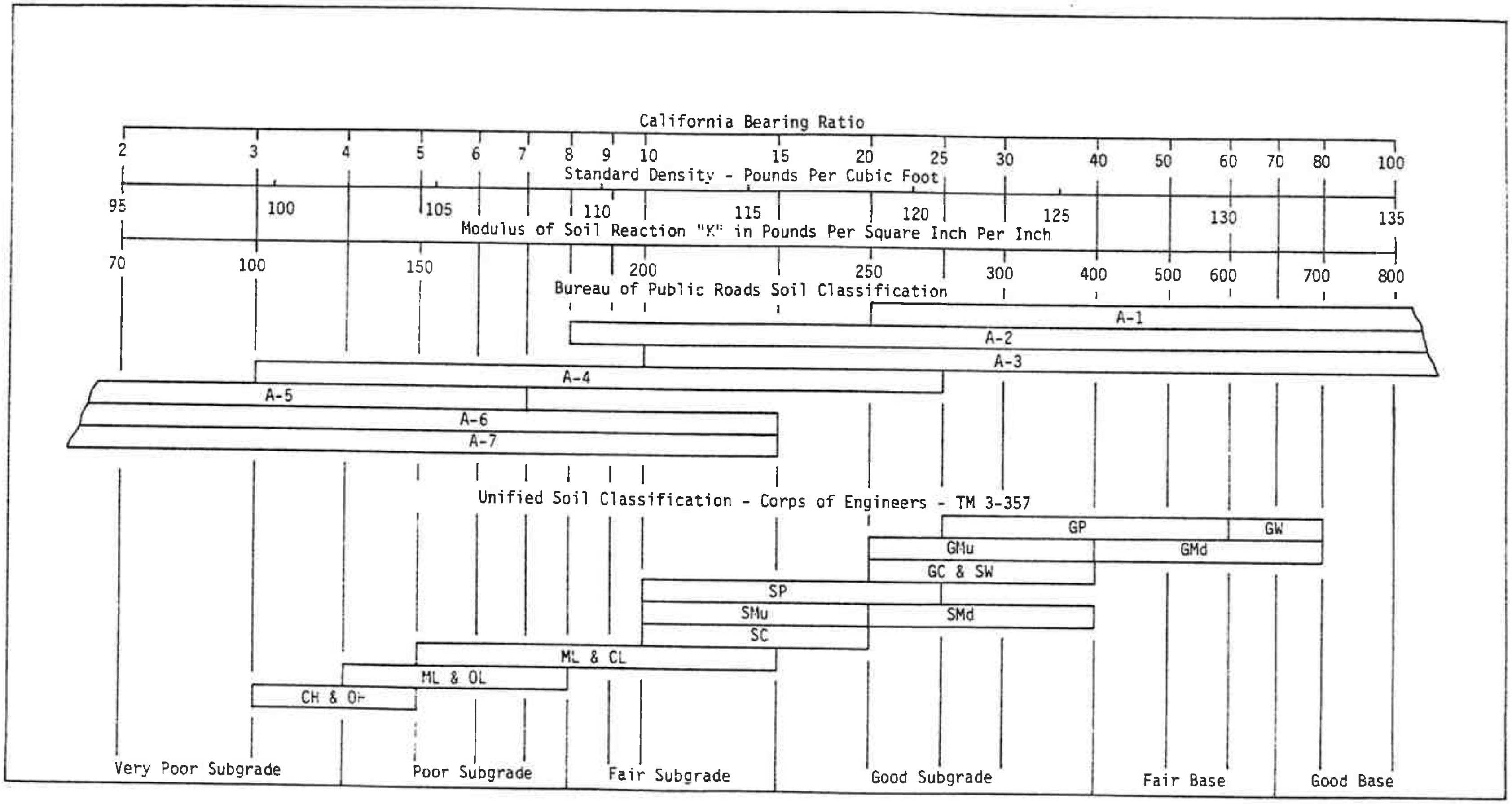


Figure A-2. Interrelations between soil classifications.