TABLE OF DETAILS

PAVEMENT DESIGN

The following tables, graphs, and procedures have been developed by the City Engineering Department to assist developers and engineers with the design of streets within subdivisions. The following procedures are based on information provided by the North Carolina Department of Transportation, North Carolina State University Civil Engineering Department, and the Soil Conservation Service.

DESIGN PROCEDURES

STEP I. Determining the Soil Support Value (SSV)

Either of the following two alternatives may be used to determine the soil support value (SSV). $SSV = 5.32(\log CBR) - 1.52$

The lowest obtained CBR value (regardless of penetration depth) shall be used for the design.

METHOD A - Measure CBR of Soils and Calculate SSV

This is the best method to determine the actual characteristic of the subgrade base material and will require a certified laboratory CBR (California Bearing Ratio) test by an approved soil laboratory. The CBR test should be performed in accordance with AASHTO designation T193 (latest edition) with the exception that if the required soil compaction density to be used during construction is known, only one specimen needs to be tested at the required density for each soil type.

A sufficient number of CBR tests shall be made to ensure coverage in the range of soil conditions encountered in the area to be paved.

The following minimum testing is required:

(1) Soil Borings - Perform soil borings with a maximum spacing of 250 linear feet and with at least four borings in each separate street area and with at least one boring in each soil type area identified in the soil survey map of Pitt County. Each boring shall extend at least two feet below the finished subgrade elevation.

(2) CBR Tests - A CBR test shall be performed on each soil type which will be within two feet of the finished subgrade elevation. If off-site soils are used as fill, CBR tests shall also be performed on each soil type which will occur in the upper two feet below pavement subgrade.

METHOD B: Measure CBR of Soils to be Used to Fill and Calculate SSV

If the SSV of the soil types at the pavement subgrade level, as determined by Method A, result in an uneconomical pavement section, the developer has the option of undercutting the existing soils to a depth of at least 18 inches below finished pavement subgrade elevations and backfilling with better soils. The SSV is then determined by performing a CBR test on each soil type used for backfilling and by calculating the SSV from the measured CBR values. The subgrade soils must be prepared as outlined in the “Construction Considerations” section of this manual.

STEP II. **Derive the Design AVERAGE DAILY TRAFFIC (ADT)**

An average daily traffic (ADT) shall be determined according to Std. detail No. 491.02 for residential streets. A design average daily traffic ($\overline{ADT}$) shall be calculated according to the following formula:

$$\overline{ADT} = \frac{ADT + (G \times ADT)}{2}$$

$G = (1 + i)^n$

i = fractional rate of yearly increase

n = design life of pavement (See Std. detail No. 491.03)

STEP III. **Determine N (See Std. detail No. 491.04)**

STEP IV. **Determine the STRUCTURAL NUMBER (SN)**

Go to Std detail No. 492.01 (20-year design life). From these figures, derive a structural number (SN) for the pavement section. For collector streets, add 0.75 to the structural number; for minor thoroughfares, add 1.5 to the structural number; and for major thoroughfares, add 2.0 to the structural number.

STEP V. **Determine Pavement Section**

Design the pavement according to Std. detail No. 491.05 such that the structural number obtained using Std. detail No. 491.05 will be equal to or greater than the structural number derived in Step IV. To use Std. detail No. 491.05, multiply the thickness (in inches) of the various components of the pavement section (Base Course, Binder Course, and Surface Course) by the corresponding structural coefficient and total the results. The total must be equal to or greater than the structural number derived in Step IV. This will be the minimum pavement design allowable for the particular street in question. Pavement section of turn lanes shall match pavement section of through lanes for all streets.

CONSTRUCTION CONSIDERATION

Subgrade Preparation

1. The soils below the pavement subgrade must be compacted during construction to a density equal to or greater than the density at which the CBR test was performed. If Method A was used, the upper 12 inches of soil below the pavement section must be compacted. If Method B was used, the upper 18 inches of soil below the pavement section must be compacted and at least one in-place density test must be performed per 200 linear feet of street in accordance with AASHTO designation T191, T204, T205, or T238 (latest edition) by an approved soils laboratory. The test results shall be submitted to and approved by the Engineering Department before the street is paved. Required densities shall be in accordance with the appropriate NCDOT Standards.

2. No stone base, curb and gutter, or asphalt pavement shall be placed without prior inspection by the Engineering Department. The inspection shall include, but not be limited to proof rolling the prepared subgrade and/or stone base with a rubber-tired proof roller (loaded dump truck) with a minimum gross weight of at least 50,000 pounds under the observation of a representative of the Engineering Department. Proof rolling must be done within ten days prior to placement of the stone, curb, or asphalt. Proof rolls shall become invalid if rainfall over 0.5" occurs on exposed soil or stone subgrade. If rainfall over 0.25" occurs on exposed soil subgrade, the subgrade shall be evaluated by the Engineering Department for determination of the requirement for an additional proofroll. Rainfall data shall be determined from an on site rain gauge or the Multi-sensor Precipitation estimates available on the North Carolina State University website at https://legacy.climate.ncsu.edu/dot. The proof roller and operator shall be furnished by the developer. All areas of the subgrade and/or stone base shall be covered by the wheels of the proof roller operating at walking speed (two to three miles per hour). Any areas which rut or pump excessively under the wheels of the proof roller shall be repaired by the developer and reinspected before the street is paved. If the developer disagrees with the Engineering Department about the need for repairs to the subgrade, the developer may hire a registered professional engineer to perform CBR tests on the prepared subgrade. If the registered professional engineer certifies that the subgrade will provide adequate support for design pavement section and the anticipated traffic loading for the 20-year design life of the street, the street may be paved without making repairs to the subgrade.

3. Stone subgrade testing shall be performed by an approved independent testing laboratory in accordance with appropriate NCDOT standards, to include but not limited to the NCDOT Standard Specifications for Roads & Structures (latest edition) and/or NCDOT Materials and Tests Unit Manuals. Minimum testing shall include stone thickness verification, stone densities, and crown verification. Minimum stone densities shall be in accordance with Table 2 in Section 4 of the NCDOT Nuclear Density Testing Manual.

Pavement Structures

1. All materials should be placed in accordance with the appropriate NCDOT standards, to include but not limited to the NCDOT Standard Specifications for Roads & Structures (latest edition) and the NCDOT Asphalt Quality Management System (latest edition). As an exception, the maximum lift thickness of S9.5B asphalt shall be 2.0".

2. All required pavement structure testing shall be performed by an approved independent testing laboratory, in accordance with the appropriate NCDOT standards, to include but not limited to the NCDOT Standard Specifications for Roads & Structures (latest edition), the NCDOT Asphalt Quality Management System (latest edition), and/or NCDOT Materials and Tests Unit Manuals.

3. Asphalt density testing shall be in accordance with the NCDOT Asphalt Quality Management System (latest edition). All density tests/samples shall meet or exceed the minimum density requirements as listed in Table 610-7. No consideration shall be given for acceptance of asphalt with a compaction percentage less than that listed in the table.

4. Cores for asphalt thickness verification shall be required. A minimum of one core shall be required on each street. Streets in excess of 500 linear feet shall have a minimum of one core taken for every 500' in length or portion thereof. For example, a street that is 900 linear feet in length would require a minimum of two cores, and a street that is 1,100 linear feet in length would require a minimum of three cores. Random core locations for each street shall be determined as specified in Section 10.3.6 of the NCDOT Asphalt Quality Management System - "Determining Random Sample Locations." Core samples on streets that require multiple samples shall alternate travel lanes. The average thickness of all core samples of a given design thickness shall meet or exceed the design pavement thickness. No individual core shall have a thickness less than $\frac{1}{4}$" below the design pavement thickness.

5. Existing asphalt shall be saw cut at all tie in points. Joint shall be crack sealed upon completion of paving operations.

MAINTENANCE

The developer is responsible for maintenance and repairs of streets until such time as the City accepts responsibility for permanent maintenance. Upon completion of all improvements, the developer may submit a letter to the city engineer, accompanied by a metes and bounds survey map of the streets to be accepted, requesting that the City accept said streets. The City Council may at that time accept responsibility of said streets.

ENGINEERING DEPARTMENT
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PAVEMENT DESIGN NOTES

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EXAMPLE PAVEMENT DESIGN

EXAMPLE: DEVELOPMENT CONSISTING OF 100 LOTS IN R-9 ZONING CLASSIFICATION. CBR TEST RESULTS INDICATE A CBR VALUE 10. ASSUME NORMAL TRUCK LOADING. DESIGN FOR FULL DEVELOPMENT AND 20-YEAR DESIGN LIFE.

SOLUTION:

STEP 1 - Determine the Soil Support Value (SSV) using the formula SSV = 5.32 (log CBR) -1.52.

$$SSV = 5.32(\log 10) - 1.52 = 3.8$$

STEP 2 - Derive the Design Average Daily Traffic ($\overline{ADT}$).

Std. detail No. 491.01 implies a trip/day/dwelling factor of 8.2 for an R-9 zone classification, therefore:

8.2 x 100 lots = 820 trips/day = ADT

Using the equation $\overline{ADT} = \frac{ADT + (G \times ADT)}{2}$ in conjunction with Std. detail No. 491.02 assuming fully developed subdivision which implies 0.5% annual increase in traffic.

$$\overline{ADT} = \frac{820 + (1.11 \times 820)}{2} = 865 \text{ trip/day}$$

STEP 3 - Determine $\overline{N}$

Use Std. Detail No. 491.03 or the equation on Std. detail No. 491.03 to get a $\overline{N}$ of approximately 14.

STEP 4 - Determine the Structural No. (SN)

Go to Std. detail No. 492.01 with a SSV of 3.8 and a $\overline{N}$ of 14 SN = 2.18

STEP 5 - Determine Pavement Section

Go to Std. detail No. 491.04 and try different sections

(a) Trial 1 -

6" CABC	6 x 0.14	=	0.84
2.5" S9.5B	2.5 x 0.44	=	1.10
			1.94

1.94 < 2.18 DESIGN INSUFFICIENT

(b) Trial 2 -

7" CABC	7 x 0.14	=	0.98
3" S9.5B	3 x 0.44	=	1.32
			2.30

2.30 > 2.18 DESIGN OK

(c) Trial 3 -

4" CABC	4 x 0.14	=	0.56
2.5" Binder I.19.0B	2.5 x 0.44	=	1.10
1.5" S9.5B	1.5 x 0.44	=	0.66
			2.32

2.32 > 2.18 DESIGN OK

TRIP GENERATION

THE FOLLOWING SHALL BE USED TO DETERMINE THE “AVERAGE DAILY TRAFFIC” (ADT) WITHIN NEW RESIDENTIAL DEVELOPMENTS. THE FOLLOWING FACTOR SHALL BE USED ON A PER LOT BASIS, PER DWELLING UNIT BASIS, PER USE BASIS, OR CALCULATED ON THE MAXIMUM DENSITY, WHICHEVER WILL GENERATE THE GREATEST NUMBER OF TRIPS. FACTORS FOR AREAS ZONED OTHER THAN RESIDENTIAL SHALL BE ASSIGNED ON AN INDIVIDUAL BASIS BY THE CITY ENGINEERING DEPARTMENT, USING THE TRIP GENERATION INTENSITY FACTORS AND SUPPLEMENTS THEREOF PUBLISHED BY THE ITE TRIP GENERATION MANUAL AS A REFERENCE MANUAL.

ONCE THE ADT HAS BEEN CALCULATED, THE “DESIGN AVERAGE DAILY TRAFFIC” ($\overline{ADT}$) CAN BE CALCULATED BY USING FORMULA (2) BELOW IN CONJUNCTION WITH TABLE 10-4. THE DESIGN LIFE FOR ALL PAVEMENTS SHALL BE A MINIMUM OF 20-YEARS.

CLASSIFICATION	TRIPS/DAY/DWELLING
MULTIFAMILY	6.7
HIGH DENSITY SINGLE FAMILY	8.2
MEDIUM DENSITY SINGLE FAMILY	10.0
LOW DENSITY SINGLE FAMILY	9.5

(2) $$\overline{ADT} = \frac{ADT + (G \times ADT)}{2}$$

Where: $\overline{ADT}$ = THE "DESIGN AVERAGE DAILY TRAFFIC” OR THE AVERAGE DAILY TRAFFIC OVER THE DESIGN LIFE OF THE PAVEMENT.

ADT = THE AVERAGE DAILY TRAFFIC AT FULL DEVELOPMENT = (TOTAL NUMBER OF DWELLINGS USING THE STREET AT FULL DEVELOPMENT) x (THE TRIPS/DAY/DWELLING FOR THE ZONE CLASSIFICATION OF THE DWELLING)

G = GROWTH FACTOR (SEE STD. DETAIL NO. 491.03)

TRAFFIC GROWTH

FACILITY DESCRIPTION	ESTIMATED YEARLY INCREASE	GROWTH FACTOR, G			
		20 YRS.	15 YRS.	10 YRS.	5 YRS.
DEAD END STREET	1%	1.22	1.16	1.10	1.05
COLLECTOR STREET	2%	1.49	1.35	1.22	1.11
SUBDIVISION STREET					
(a) FULLY DEVELOPED	0.5%	1.11	1.08	1.05	1.03
(b) 50% DEVELOPED	4%	2.19	1.80	1.48	1.22
PRINCIPAL COUNTY ROAD	3%	1.81	1.56	1.34	1.16
OTHER COUNTY ROADS	2%	1.49	1.35	1.22	1.11
INDUSTRIAL SERVICE ROAD					
(a) UNDEVELOPED	6%	3.21	2.40	1.79	1.34
(b) 50% DEVELOPED	4%	2.19	1.80	1.48	1.22

THE ABOVE ARE TYPICAL VALUES. THE ACTUAL TRAFFIC GROWTH RATE FOR A PARTICULAR FACILITY MAY VARY SUBSTANTIALLY FROM THOSE ABOVE. IF THE DESIGNER HAS BETTER INFORMATION AVAILABLE, HE MAY CALCULATE AN APPROPRIATE GROWTH FACTOR USING THE FOLLOWING EQUATION (1)

(1) $G = (I + i)^n$

where i = FRACTIONAL RATE OF YEARLY INCREASE

n = DESIGN LIFE OF PAVEMENT

(2) $\overline{ADT} = \frac{ADT + (G \times ADT)}{2}$

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STREET SECTION DESIGN

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TABULATED VALUES ASSUMES 1% OF TRAFFIC IS COMPOSED OF TRUCK-TRACTOR SEMI-TRAILER (TTST) AND 4% SINGLE-AXLE DUAL-TIRE VEHICLES. FOR THESE VALUES USE THE FOLLOWING FORMULA

$\overline{N} = \overline{ADT}\ (0.016)$

WHEN THE DESIGNER HAS A BETTER ESTIMATE OF THE ACTUAL TRAFFIC HE SHOULD USE THE FORMULA

$$\overline{N} = \overline{ADT}\ \left(0.25\frac{X}{100} + 0.60\frac{Y}{100}\right)$$

WHERE X = PERCENT DUALS AND Y = PERCENT TTST USING THE PAVEMENT.

$\overline{N}$ IS A FUNCTION OF THE NUMBER OF TRUCKS.

EQUIVALENT $\overline{N}$ AND $\overline{ADT}$

$\overline{N}$	$\overline{ADT}$
200	12,500
100	6,250
80	5,000
40	2,500
30	1,875
25	1,562
20	1,250
15	937
10	625
5	312
4	250
3	187
2	125
1	63

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STRUCTURAL COEFFICIENTS

PAVEMENT LAYER	TYPE OF MATERIAL	STRUCTURAL COEFFICIENT PER INCH OF THICKNESS
SURFACE COURSES	SAND ASPHALT	0.40
	BITUMINOUS CONCRETE S9.5X	0.44
	BITUMINOUS SURFACE TREATMENT	0.20 *
BINDER COURSE	BITUMINOUS CONCRETE I19.0X	0.44
BASE COURSES	SOIL TYPE BASE COURSE	0.10
	COURSE AGGREGATE BASE COURSE	0.14
	BITUMINOUS CONCRETE B25.0X	0.30
	SAND ASPHALT	0.30

* USE AS SHOWN. DO NOT MULTIPLY BY THICKNESS.

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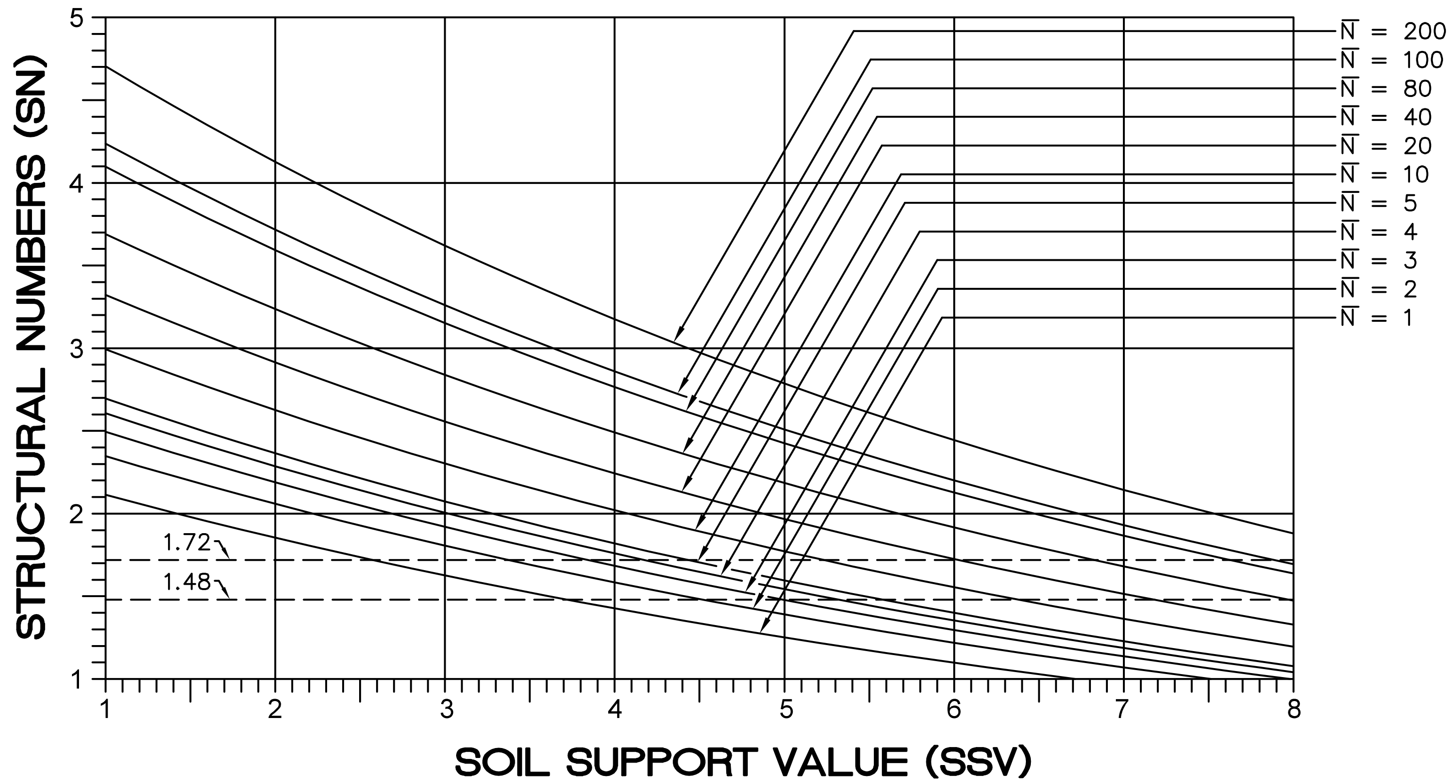
Detail # **491.04**

*NO SN BELOW 2.0 SHOULD BE USED.

$$SN = \frac{2.41\,(\bar{N})^{0.151}}{(1.14)^{SSV}}$$

20 YEAR DESIGN LIFE



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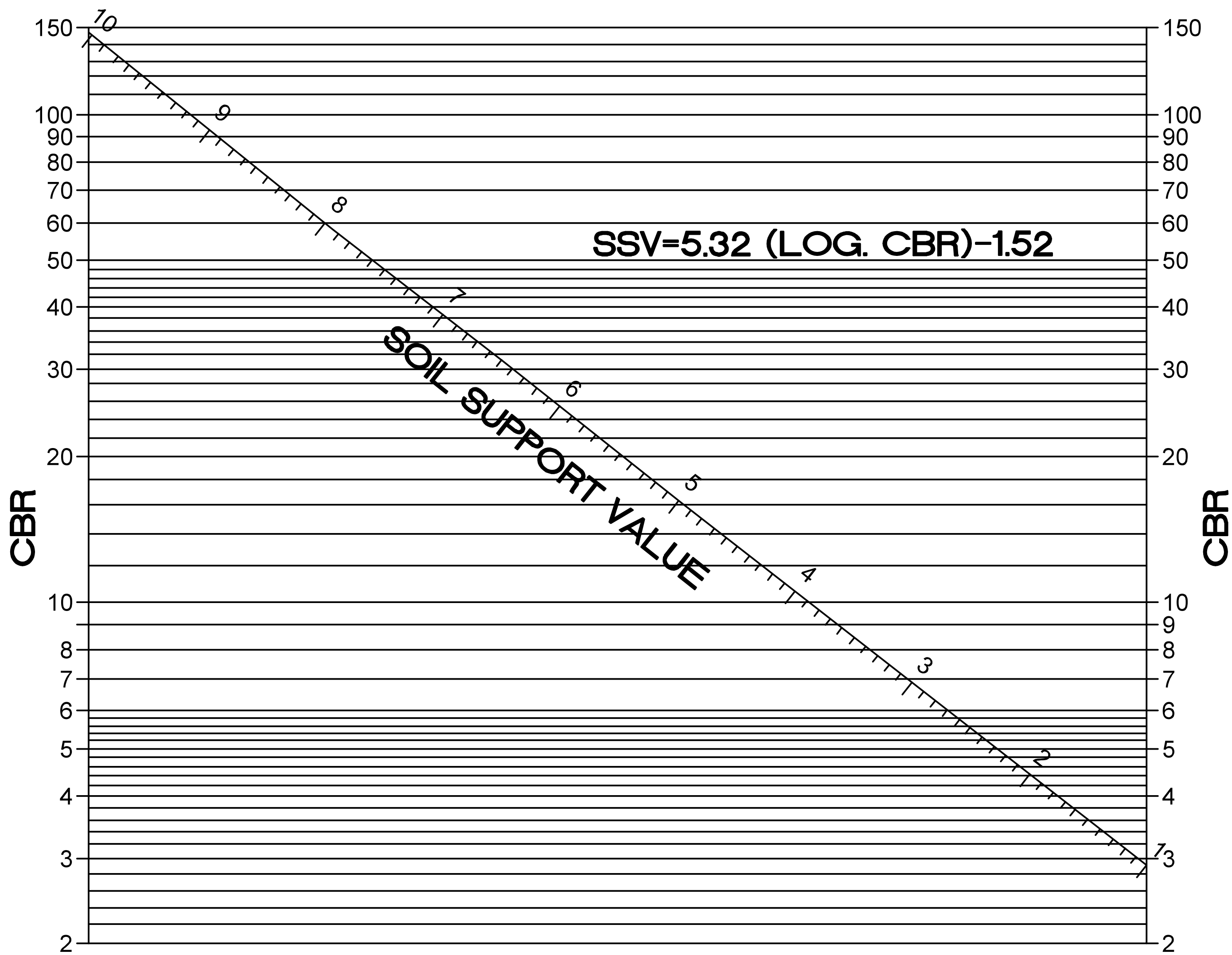

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