TABLE OF DETAILS

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491.05	Residential Street Section Design
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492.03	Residential Street Section Design
492.04	Residential Street Section Design
492.05	Residential Street Section Design

RESIDENTIAL 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 three alternatives may be used to determine the soil support value (SSV).

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 - Assigned SSV from Soil Classification of the Pit County Soil Survey Map

The soil types may be determined by using the "Soil Survey of Pitt County, North Carolina" prepared by the United States Department of Agriculture, Soil Conservation Service, issued in November, 1974. A copy is available for use in the Engineering Department offices. To use this publication, locate the proposed street areas on the soil maps in the back of the publication and determine the soil types along the proposed street right-of-way. Then use Table 6, Pages 50-53 of the publication, to determine the AASHTO classifications of the soil types.

Soil support values (SSV) shall be assigned to these classifications using Std. detail No. 491.01, Table A. Soil support values from this table were derived from Std. detail No. 491.01, Table B and conservative estimates of the assigned soil types. The entire street shall be designed using the lowest SSV obtained along any portion of the street.

NOTE: Method B is generally much more conservative than Method A and will usually require a thicker pavement section.

METHOD C: 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 either Method A or B, 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:

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

$$G = (1 + 1)^{n}$$

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 details No. 492.01, 02, 03, 04 (for the City of Greenville, use Std. detail No. 492.03; 15-year design life). From these figures, derive a structural number (SN) for the pavement section. For collector streets, add 1.0 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.

CONSTRUCTION CONSIDERATION

Subgrade Preparation

1. If Method A or C was used to obtain the SSV in Step 1 of the DESIGN PROCEDURES, 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 C was used, the upper 18 inches of soil below the pavement section must be compacted. At least one in-place density test must be performed per 100 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.

2. No 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 with a rubber-tired proof roller (loaded dump truck) and have a minimum gross weight of at least 20,000 pounds under the observation of a representative of the Engineering Department. Proof rolling must be done within ten days prior to placement of the asphalt. The proof roller and operator shall be furnished by the developer. All areas of the subgrade 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 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 15-year design life of the street, the street may be paved without making repairs to the subgrade.

Pavement Structures

1. No pavement section shall be placed in a one course paving operation without prior approval of the city engineer.

2. All required testing shall be performed by an approved independent testing laboratory, in accordance with NCDOT Standards & Specs. All materials should be placed in accordance with NCDOT Standards & Specs.

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.

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RESIDENTIAL PAVEMENT DESIGN NOTES

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EXAMPLE: DEVELOPMENT CONSISTING OF 100 LOTS IN R-9 ZONING CLASSIFICATION. NO CBR TEST AVAILABLE - SOIL TYPE A-3 FROM PITT COUNTY SOIL SURVEY. ASSUME NORMAL TRUCK LOADING. DESIGN FOR FULL DEVELOPMENT AND 15-YEAR DESIGN LIFE.

SOLUTION:

STEP 1 - Determine the Soil Support Value (SSV) since a CBR is not available and therefore the formula SSV = 5.32 (log CBR) -1.52 cannot be used, go to Std. detail No. 491.01 to get a SSV.

SSV = 3.5

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

Std. detail No. 491.02 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. 491.03 assuming fully developed subdivision which implies 0.5% annual increase in traffic.

$$\overline{ADT} = \frac{820 + (1.05 \times 820)}{2} = 840 \text{ trip/day}$$

STEP 3 - Determine $\overline{N}$

Use Std. Detail No. 491.04 or the equation on Std. detail No. 491.04 to get a $\overline{N}$ of approximately 14.

STEP 4 - Determine the Structural No. (SN)

Go to Std. detail No. 492.02 with a SSV of 3.5 and a $\overline{N}$ of 14 SN = 2.02

STEP 5 - Determine Pavement Section

Go to Std. detail No. 491.05 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 < 2.02	DESIGN INSUFFICIENT	
(b)	Trial 2 -	6" CABC	6 x 0.14 =	0.84
		3" S9.5B	3 x 0.44 =	1.32
				2.16
		2.16 > 2.08	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 > 2.02	DESIGN OK	

SUFFICIENT NUMBER OF LABORATORY CBR'S (CALIFORNIA BEARING RATIO) TO COVER THE RANGE OF SOIL CONDITIONS ENCOUNTERED WITHIN THE AREA TO BE PAVED SHALL BE MADE.

CERTIFICATION AND A REPORT OF SAID TESTS SHALL BE SUBMITTED TO THE CITY ENGINEERING DEPARTMENT BY AN APPROVED SOILS LABORATORY.

IN LIEU OF, THE DESIGNER SHALL SUBMIT TO THE CITY ENGINEERING DEPARTMENT A LIST OF THE SOIL TYPES ENCOUNTERED WITHIN THE AREA TO BE PAVED ACCORDING TO THE PITT COUNTY SOIL SURVEY AS PUBLISHED BY THE SOIL CONSERVATION SERVICE.

A COPY OF THE SOIL SURVEY MAP WITH THE BOUNDARIES OF THE SUBDIVISION AND AREAS TO BE PAVED, SUBSCRIBED THEREON, SHALL ALSO BE SUBMITTED.

FROM THIS INFORMATION, THE SOIL SUPPORT VALUE ACCORDING TO TABLE b SHALL BE ASSIGNED.

TABLE A

AASHTO SOIL CLASSIFICATION	ASSIGNED SOIL SUPPORT VALUE (SSV)
A-1-a	4.2 *
A-1-b	4.2 *
A-3	3.5
A-2-4	4.2 *
A-2-5	4.2 *
A-2-6	3.4
A-2-7	3.4
A-4	1.0
A-5	1.0
A-6	1.0
A-7-5	1.0
A-7-6	1.0

* SUGGESTED MAXIMUM SSV BY N.C.D.O.T. WITHOUT CBR TEST ALTHOUGH AASHTO SOIL CLASSIFICATION INDICATES HIGHER.

TABLE B

CALIFORNIA BEARING RATIO (CBR)

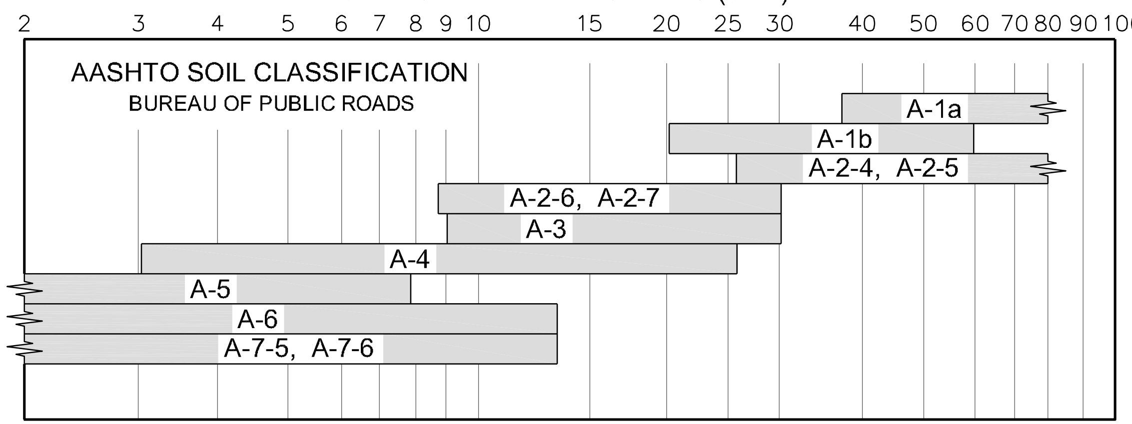

TABLE A IS A VERY CONSERVATIVE DERIVATION OF TABLE B. THE LOWEST CBR FOR EACH SOIL TYPE WAS USED TO CALCULATE THE ASSOCIATED SSV.

TRIP GENERATION

THE FOLLOWING SHALL BE USED TO DETERMINE THE “AVERAGE DAILY TRAFFIC” (ADT) WITHIN NEW RESIDENTIAL DEVELOPMENTS. THE DESIGN LIFE FOR ALL PAVEMENTS SHALL BE A MINIMUM OF 15-YEARS. 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 FACTORS ON AN INDIVIDUAL BASIS BY THE CITY ENGINEERING DEPARTMENT, USING THE TRIP GENERATION INTENSITY FACTORS AND SUPPLEMENTS THEREOF PUBLISHED BY THE ARIZONA DEPARTMENT OF TRANSPORTATION 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.

ZONE CLASSIFICATION		TRIPS/DAY/DWELLING
R-6	MULTIFAMILY	6.7
R-9	HIGH DENSITY SINGLE FAMILY	8.2
A-3	MEDIUM DENSITY SINGLE FAMILY	10.0
A-2-4	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
CONNECTOR 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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TABULATED VALUES ASSUMES 1% OF TRAFFIC IS COMPOSED OF TRUCK-TRACTOR SEMI-TRAILER (TTST) AND 4% SINGLE-AXLE DUAL-TIRE VEHICLES. 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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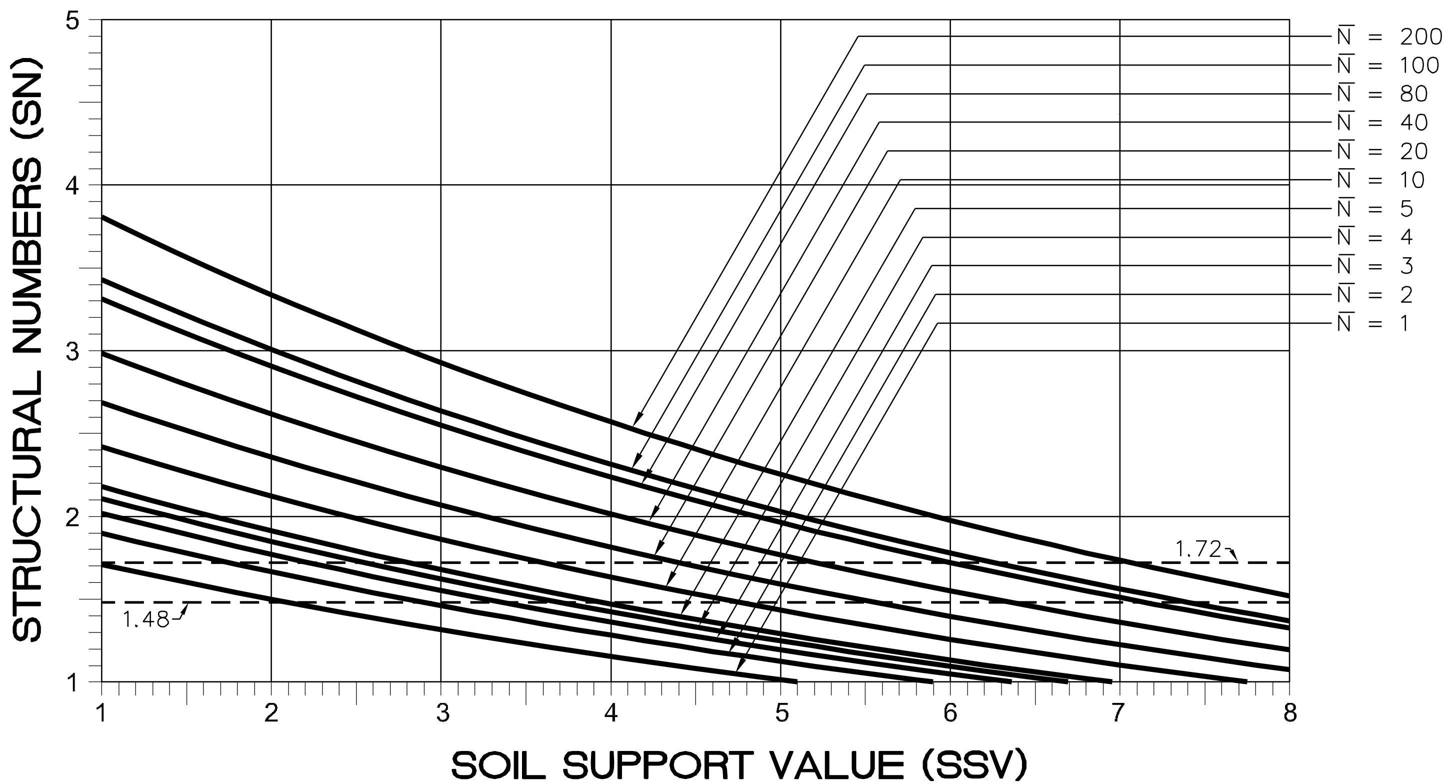
NO SN BELOW 1.72 FOR POOR TO FAIR SUBGRADE SOILS NOR 1.48 FOR GOOD TO EXCELLENT SUBGRADE SOILS SHOULD BE USED.

$$SN = \frac{1.95\,(\overline{N})^{0.151}}{(1.14)^{SSV}}$$

5 YEAR DESIGN LIFE



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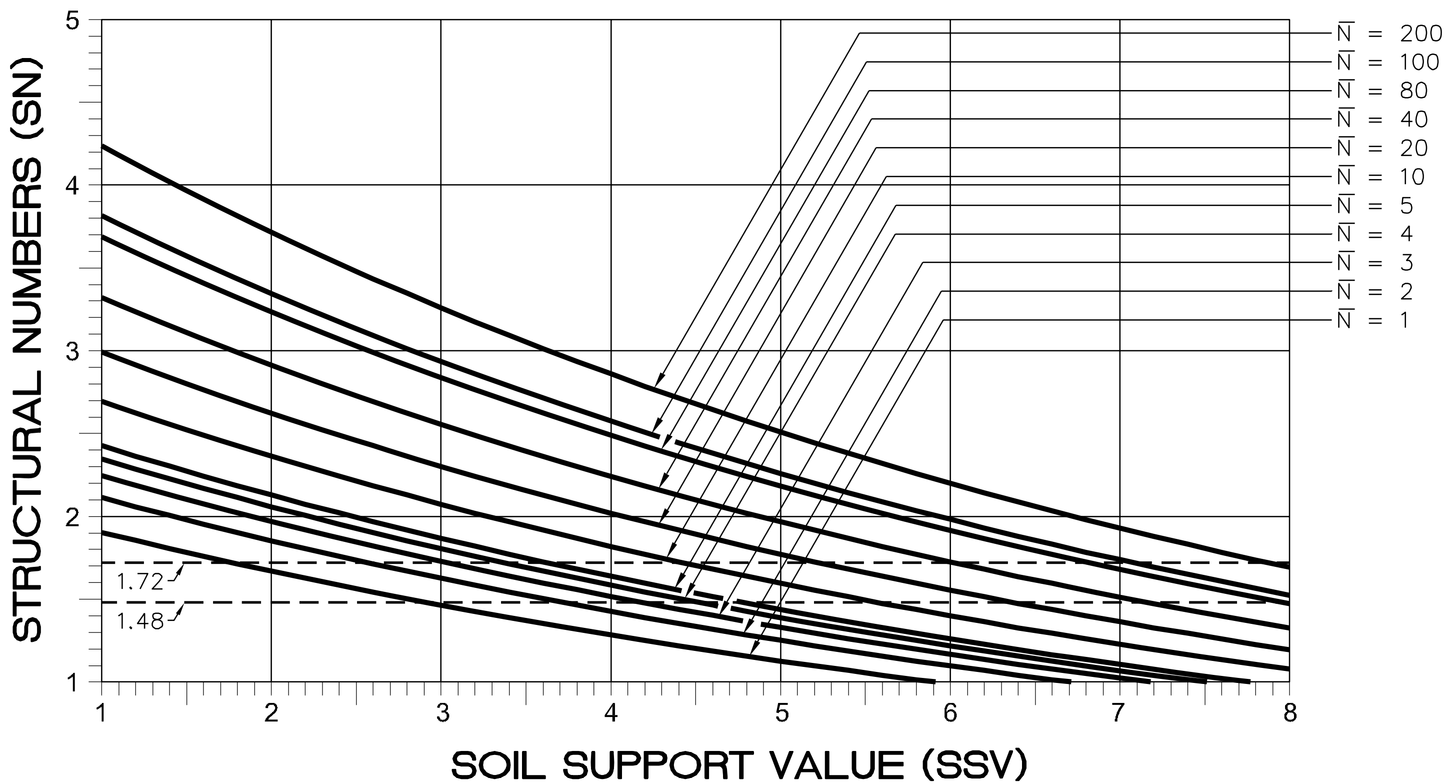
NO SN BELOW 1.72 FOR POOR TO FAIR SUBGRADE SOILS NOR 1.48 FOR GOOD TO EXCELLENT SUBGRADE SOILS SHOULD BE USED.

$$SN = \frac{2.17\,(\overline{N})^{0.151}}{(1.14)^{SSV}}$$

10 YEAR DESIGN LIFE



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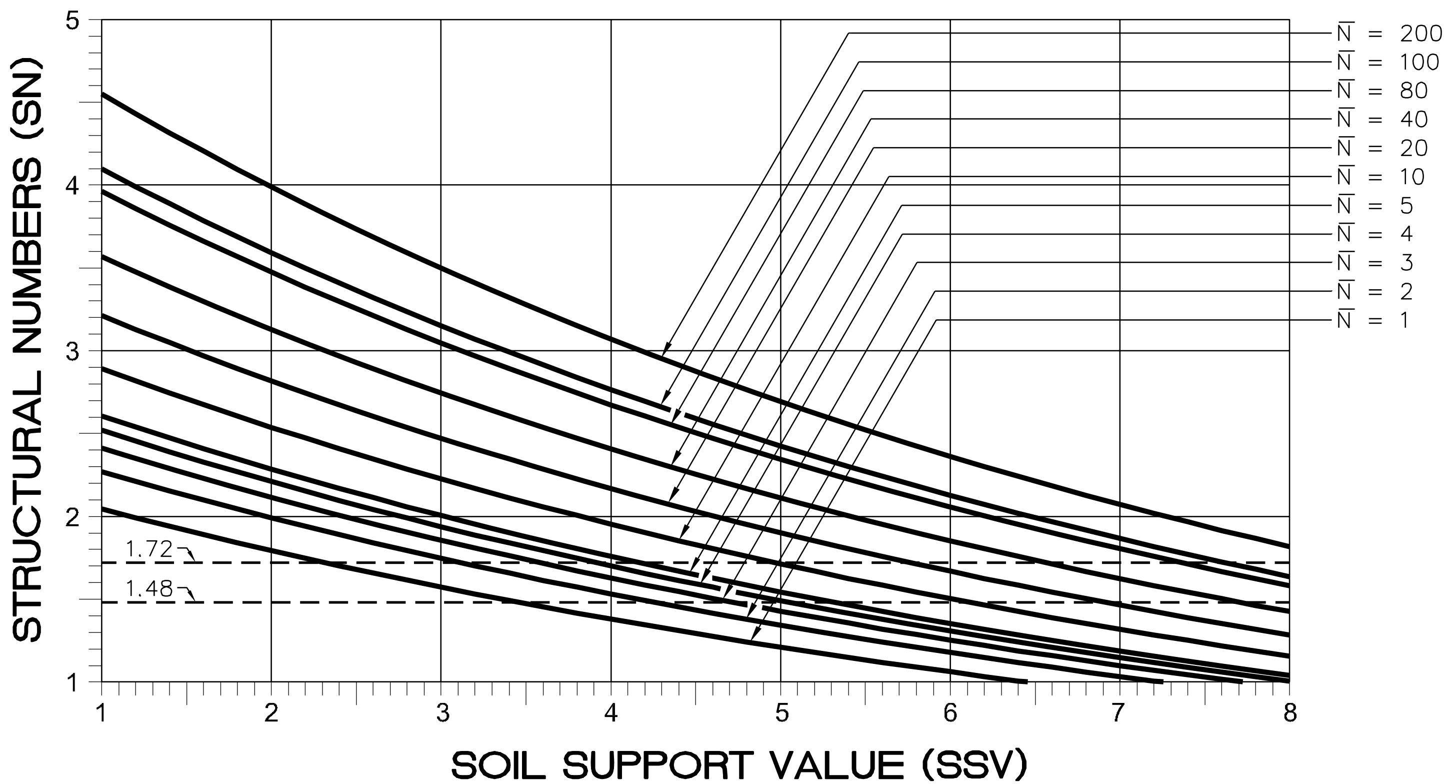
NO SN BELOW 1.72 FOR POOR TO FAIR SUBGRADE SOILS NOR 1.48 FOR GOOD TO EXCELLENT SUBGRADE SOILS SHOULD BE USED.

$$SN = \frac{2.33\,(\overline{N})^{0.151}}{(1.14)^{SSV}}$$

15 YEAR DESIGN LIFE



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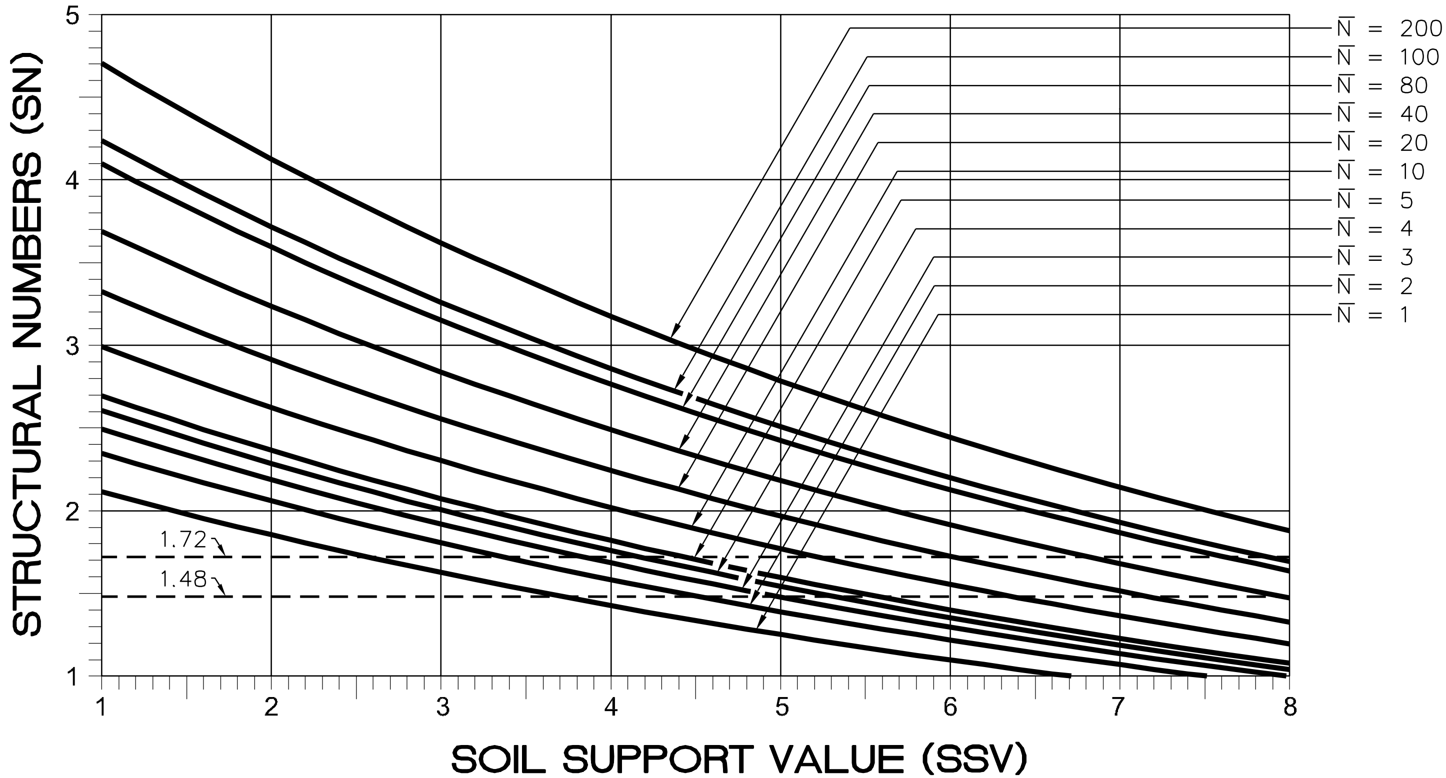
NO SN BELOW 1.72 FOR POOR TO FAIR SUBGRADE SOILS NOR 1.48 FOR GOOD TO EXCELLENT SUBGRADE SOILS SHOULD BE USED.

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

20 YEAR DESIGN LIFE



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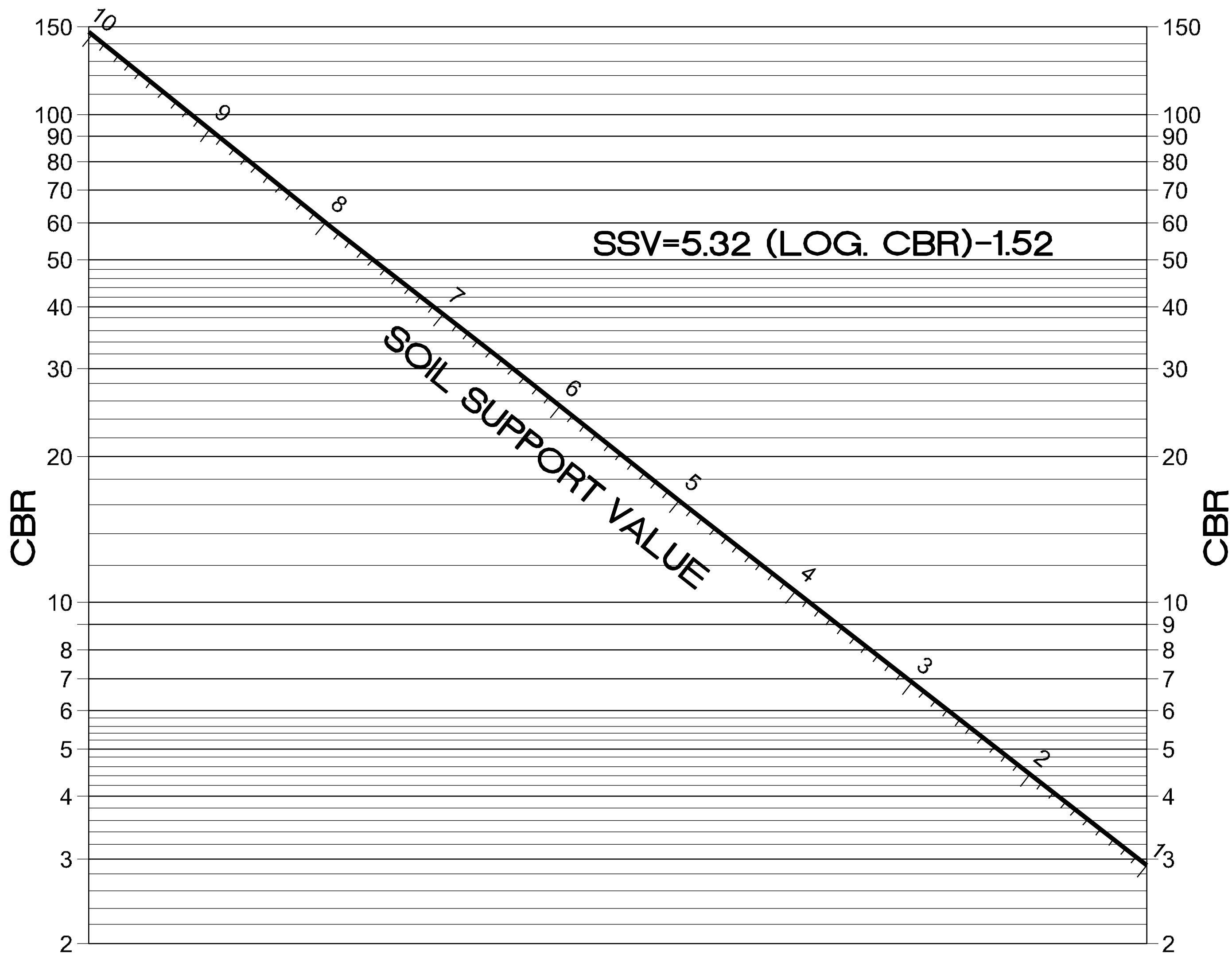

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