3 STREET DESIGN

(Rev 3/09/15)

3.1 INTRODUCTION

The following section has been established to assist developers and engineers with the design of streets (private and public) within the jurisdiction of the Town of Wake Forest. The methods, procedures, design factors, formulas, graphs, and tables presented in this division are intended to establish minimal guidelines for residential and commercial pavement design. The Town of Wake Forest believes that the following design criteria are sufficient to ensure the welfare and safety of the general public and to protect the economic investment of the citizens of our Town.

Alternative design methods may be considered by the Engineer/Designer on a case-by-case basis, however, there should not be extensive variations from the criteria and procedures within this division without the expressed approval of the Director of Engineering.

3.1.1 TOWN OF WAKE FOREST TOWN'S ENGINEER

The Town of Wake Forest Engineering staff shall be responsible for interpretation and implementation of the pavement design criteria for the Town of Wake Forest. Approval from other applicable agencies may be required.

3.1.2 TOWN OF WAKE FOREST PAVEMENT POLICY

It is the policy of the Town of Wake Forest that all developed land within the Town Limits have adequate streets and parking lots. The Town may accept roadway systems for maintenance if the system provides pavement sections that have been accepted for maintenance by the Town Board of Commissioners and have been designed and constructed in accordance with the provisions of the Town and this division.

3.1.3 ACKNOWLEDGEMENTS

This section was prepared by Appian Consulting Engineers, P.A. of Rocky Mount, North Carolina, in cooperation with the Town of Wake Forest, North Carolina. However, the content of this division is largely derived from the AASHTO Guide for Design of Pavement Structures [AASHTO, 1986] and the Asphalt Pavement Design System [Taylor, 1993]. These manuals were particularly important because of their format, quality, completeness, and because they represented accepted criteria applied in the area of the Town of Wake Forest.

3.2 STREET DESIGN

All streets within the jurisdiction of the Town of Wake Forest shall meet all the requirements of this manual and the Town Unified Development Ordinance. Designers are to refer to Section 6 of the Unified Development Ordinance for requirements related to pavement width, curb and gutter, etc.

3.2.1 PAVEMENT DESIGN

A. All pavement thickness shall generally be confirmed by a geotechnical report. However, if a developer wishes, he may design cul-de-sac and local streets using a subgrade CBR one standard deviation to the left of the average of all CBR's determined by geotechnical reports thus far. If, in the opinion of the Town's representative, soils appear weaker or have inherent problems such as a high mica content, the services of a geotechnical engineer shall be required in any case for the design of pavements.

B. Pavement must be designed in accordance with the procedures in Section 3.3, Pavement Design Methods.

3.2.2 VERTICAL ALIGNMENT

A. Grades

1. Unless necessitated by exceptional topography and subject to the approval of the Town's Engineer, street grades shall not exceed eight (8%) percent unless approved by the Town's Engineer. Streets to be maintained by the North Carolina Department of Transportation shall not exceed seven (7%) percent. In all cases, street grades shall not be less than one (1%) percent.

2. Grades approaching intersections shall not exceed five (5%) percent for a distance of at least one hundred (100) feet from the centerline of the intersection.

3. Street grades shall be established wherever practicable in such a manner as to avoid excessive grading, the promiscuous removal of ground cover and tree growth, and general leveling of the topography.

4. **Commercial and Industrial driveways or entrance roads tying to a public roadway facility accessible to emergency fire apparatus**: Approach grades shall not exceed 8% or as otherwise allowed or permitted by the Fire Marshall. See NC Fire Code Sections D102 and D103 of Appendix D, Fire Apparatus Access Road. K values shall be as directed by either the Town's Engineer or Fire Marshall but at a minimum shall be sufficient to prevent front or rear bumper drag.

B. Vertical Curves

All changes in street grade shall be connected by a vertical curve having a length of at least 100 feet, or the equivalent in feet, rounded upward to even multiples of 50, of the value of K (given in Table 3.1) times the absolute value of arithmetic difference of the two grades in percent, whichever is greater.

Table 3.1 Minimum K Values

Street Type	K	
	Sag	*Crest*
Major Thoroughfare	140	240
Minor Thoroughfare	100	150
Residential Collector	28	28
Local Street & Cul-de-sac	18	18
Frontage Road	18	18

C. Superelevation: Superelevation shall only be utilized on major thoroughfares except when widening NCDOT streets. Superelevation for shoulder sections shall not exceed 0.08 feet/foot of width. For curb and gutter sections, superelevation shall not be less than 0.02 feet/foot of width or more than 0.06 feet/foot of width.

D. Grading

Grading and filling shall be undertaken to ensure that:

1. The street is centered in the right-of-way.

2. Adequate shoulders and space for future sidewalks are provided.

3. Allowance is made for roadside ditches, curbs and gutters, and storm sewers for street drainage.

4. Cut slopes shall not exceed a ratio of 2:1
5. Fill slopes shall not exceed a ratio of 2:1
6. Ditch front slopes do not exceed a ratio of 4:1 for shoulder sections.
7. See Standard Detail 9.01A.

3.2.3 HORIZONTAL ALIGNMENT

A. Curves

1. Where a street centerline deflection of five (5) or more degrees occurs a curve shall be introduced having a radius of curvature of not less than the following:

Table 3.2 Minimum Horizontal Curve Radii

Type of Street	Minimum Radius
Major Thoroughfare	850
Minor Thoroughfare	500
Residential Collector	300
Local Street	200
Cul-de-Sac	150
Frontage Road	150

2. A tangent of not less than one hundred (100) feet shall be provided between reverse horizontal curves on all streets.

3.2.4 INSTALLATION OF UTILITIES, STORM DRAINAGE, STREET LIGHTS AND STREET TREES

After grading of street right-of-way is completed and approved and before any base is applied, underground work to be installed such as water mains, sewerage mains and taps shall be installed by the developer and approved by the Administrator and Utilities Director.

3.2.5 DRAINAGE

A. Inlet design and spacing to be designed in accordance with Section 2.

B. Streets shall be designed so as not to permit storm runoff to cross intersections. Storm drainage structures should be used to avoid storm runoff crossing intersections. Directional arrows must be shown on plans to reflect surface drainage flow. This is particularly important around curb returns.

C. Under no circumstances will penetration of the back of the curb and gutter be permitted (i.e. "cutdowns" for drainage or small pipes) for drainage.

D. On strip paved streets, the absolute minimum shall consist of shoulders graded to allow water to run off the street and collect in such a manner that it will not return in the subsurface to the base of the street. When soil conditions permit and the property owner desires, roadside drainage may consist of water ponding off the strip paved street until it is absorbed in the ground if, in the opinion of the Town's Engineer, said ponding will not adversely affect the life of the street.

3.2.6 STREET SECTIONS

A. Shoulder Sections/Roadside Ditches

1. Width for shoulder/swale section where appropriate is shown on Detail 9.01A. No on-street parking would be permissible for this cross section. This design would only be appropriate for low-density development.

2. The absolute minimum drainage required on strip-paved streets shall consist of shoulders graded to allow water to run off the street and collect in such a manner that it will not return in the subsurface to the base of the street. When soil conditions permit and the property owner desires, roadside drainage may consist of water ponding off the strip paved street until it is absorbed in the ground, if, in the opinion of the Town's Engineer, said ponding will not adversely affect the life of the street.

3. In all subdivisions where there is no curb and gutter, side ditches, which require protection for erosion caused by excessive velocity shall be concrete paved. Riprap may be accepted upon approval of Town of Wake Forest Engineering staff.

B. Curb and Gutter

1. All curb and gutter shall be constructed according to Standard Detail 9.02 of the Town of Wake Forest Manual of Specifications.

2. The standard 30" curb and gutter section is the preferred type to be used. The 30" concrete valley gutter type may also be used on local and cul-de-sac streets only. Shapes of other curb may be used provided a 6" height is maintained and subject to the approval of the Town's Engineer after review on an individual basis.

3. If the street is to be maintained by the Town of Wake Forest, the Public Works Director shall be consulted for approval of the gutter type. Approval will be subject to the terrain factors in the area under study as they relate to potential maintenance problems.

4. Curb Cuts and Curb ramps: See also, 3.2.7.A, below for curb cuts and curb ramp requirements.

3.2.7 SIDEWALKS

Sidewalk material, width and locations shall be in accordance to the Section 6 of the Town's Unified Development Ordinance.

A. Curb Cuts and Curb Ramps: Curb cuts and curb ramps, commonly used to provide accessibility for persons with disabilities, shall be provided at all intersections where curb and gutter is provided and where sidewalks and/or greenway trails intersect streets subject to the following conditions:

1. Where sidewalk is not required, the curb return shall be depressed to the specified dimensions for the future connection of curb ramps.

2. Sidewalk construction shall meet the applicable provisions of the latest editions of ANSI A117.1, the NC State Building Code, and the 2010 Standards for State and Local Government Facilities: Title II.

3. See Standard Details 9.13 and 9.15 for other requirements pertaining to curb ramp construction.

B. Construction Methods for Brick Sidewalks

1. **Subgrade Preparation**: The subgrade for sidewalks shall be shaped to the proper cross-section and thoroughly compacted by rolling or tamping. Tree roots shall be removed to a depth of 12-inches below subgrade for the full width of the walk. All soft and spongy material shall be removed and replaced with suitable material that shall be compacted in layers not exceeding 6-inches in thickness.

2. **Base**: A 5-inch thick base of stone screenings or sand, well compacted and properly graded to provide drainage according to the standard sidewalk slope, shall be installed. Where the sidewalk is crossed by a driveway, the base shall be increased to 6-inches.
3. **Sidewalk Width & Material**: Except when repairing a non-conforming brick sidewalk, a 5-foot wide sidewalk of paving brick (conforming to ASTM C902) shall be laid to grade with a smooth uniform surface with a slope of ¼-inch per foot toward the street.
4. **Filling Voids**: The voids between the brick shall be filled with a mixture of sand and cement broomed into the voids. The sand-cement ratio shall be 1/3 cement and 2/3 sand well mixed before brooming into the voids. After the voids are well filled, the brick surface shall be cleaned of all excess sand and cement.

3.2.8 MATERIALS TESTING

A. Asphalt, Concrete and Subgrade Testing: Refer to Section 3.4, Subgrade Preparation & Testing.

3.3 PAVEMENT DESIGN METHODS

The purpose of this section is to provide a guide for the design of pavement structures for the Town of Wake Forest.

3.3.1 TERMINOLOGY

To fully understand the methods of pavement design that will be outlined in the following sections it is necessary to establish standard terminology. It is noted that many considerations are required to assure that a pavement structure is reliable. For example, material requirements, construction requirements, and quality control will significantly influence the ability of the pavement structure to perform according to design expectations.

A. Standard Definitions

1. **Average Daily Traffic (*ADT*):** The average daily traffic using the pavement section at full development.
2. **California Bearing Ratio (*CBR*):** The CBR is the penetration resistance of a soil relative to standard crushed rock.
3. **Design Average Daily Traffic ($\overline{ADT}$):** The average daily traffic over the design life of the pavement.
4. **Pavement Design Life:** All pavement structures for the Town of Wake Forest shall be designed with a 25-year design life.
5. **Soil Support Value (*SSV*):** This value reflects the structural strength of a particular type of soil.
6. **Structural Number (*SN*):** The structural number is an abstract number that reflects the structural strength of the pavement required for soil support and traffic loads.
7. **Traffic Growth Factor (*G*):** This number, typically between 0.00 and 0.07, allows the designer to assume an annual percentage growth rate in the traffic volume and is used to determine the design average daily traffic.
8. **Trip Factor:** The number of vehicles that can be assumed for a particular type of land use. This information is derived from a table of traffic generators of

which some of the factors can be modified by the engineer to best model the exact circumstance of the design.

9. **Truck Factor ($\overline{N}$):** This quantity adjusts the design average daily traffic ($\overline{ADT}$) to account for the percentage of single frame and multiple frame trucks expected along a particular pavement section.

3.3.2 STANDARD SUBDIVISION PAVEMENT DESIGN

Shown below are minimum thicknesses of base and surface course to be used for typical residential subdivision design. Pavement design for any other developments, or design for residential subdivisions which differs from the table below, will be reviewed by the

Town's Engineer on an individual basis according to the Detailed Pavement Design Procedure in Section 3.3.3.

A. Standard Subdivision Pavement Design Table: A design shall be chosen from Group 1 or Group 2 in Table 3.3 below depending on sub-grade soil type.

Table 3.3 Minimum Pavement Sections

GROUP 1 – GOOD TO EXCELLENT		
Sub-Grade Soil Types	**Base Course***	**Pavement Surface**
A-1-a, A-1-b, A-3	7" STBC, Type A or C or 6" CABC	2" S9.5B
A-2-4, A-2-5, A-3-6	9" STBC, Type A or C or 8" ABC	2" S9.5B
A-2-7	8" CABC or STBC, Type B	BST, 2" S9.5B
	6" CABC or STBC, Type B	2" S9.5B
	3" BCBC, Type B25.0B	2" S9.5B
	3-1/2" BCBC, Type B25.0B	2" S9.5B
		5" Plain Concrete
GROUP 2 – POOR TO FAIR		
Sub-Grade Soil Types	**Base Course***	**Pavement Surface**
A-4, A-5, A-6, A-7-5,	9" STBC, Type A or C or 8" CABC	2" S9.5B
A-7-6	8" CABC or STBC, Type B	2" S9.5B
	10" CABC or STBC, Type B	BST, 1 1/2" S9.5B
	4" BCBC, Type B25.0B	2" S9.5B
	3" BCBC, Type B25.0B	2" S9.5B or 6" Plain Concrete

** No base course shall be placed on muck, pine clay, vegetable matter or other unsuitable material.*

CABC: Aggregate Base Course
STBC: Soil Type Base Course
BST: Bituminous Surface Treatment
SF9.5A: Sand Asphalt, Type SF9.5A
S9.5B: Bituminous Concrete Surface Course, Type S9.5B
BCBC: Bituminous Concrete Base Course, Type B25.0B

B. Other base courses such as various cement-treated materials may be used in lieu of those shown above. These materials shall be of sufficient thickness to provide equivalent strength. However, any design other than those shown above must be approved prior to use. The total thickness of the pavement structure shall in no case be less than 5".

3.3.3 DETAILED PAVEMENT DESIGN PROCEDURE

A. Pavement Design Life

All pavement structures for the Town of Wake Forest shall be designed with a pavement design life of 25 years.

B. Determine the Design Average Daily Traffic ($\overline{ADT}$)

1. From Table 3.4, locate the best description of the land use for which the proposed pavement section will serve and determine the total number of trips per day per unit. Multiply the trips per day per unit by the total number of units using the street at full development. This total number of trips per day is the average daily traffic (*ADT*) at full development.

Table 3.4 Trips per Day According to Land Use (for pavement design only)

Description of Land Use	Trips/ Day/ Unit	Unit
Residential		
• Apartments	6.29	DU
• Condominiums	5.69	DU
• Mobile Homes	4.77	DU
• PUD	6.96	DU
• Retirement Home	3.3	DU
• Single Family Homes	9.53	DU
Lodging		
• Hotel	8.93	Room
• Motel	5.63	Room
• Nursing Home	2.0	Bed
Retail		
• New Car Sales	38.72	1,000 gsf
• Convenience Store (24 hr)	758.79	1,000 gsf
• Restaurant (Quality)	92.55	1,000 gsf
• Restaurant (High-Turnover)	158.37	1,000 gsf
• Restaurant (w/Drive Thru)	623.19	1,000 gsf
• Restaurant (w/o Drive Thru)	778.18	1,000 gsf
• Building & Lumber Store	28.80	1,000 gsf
• Special Retail Center	37.97	1,000 gsf
• Discount Store	70.56	1,000 gsf
• Hardware/Paint Store	58.23	1,000gsf
• Garden Center	44.51	1,000 gsf
• Furniture Store	4.67	1,000 gsf
• Shopping Center (0 to 50,000 sf)	115.8	1,000 gsf

• Shopping Center (50,000 to 100,000 sf)	79.1	1,000 gsf
• Shopping Center (100,000 to 200,000 sf)	60.4	1,000 gsf
• Shopping Center (200,000 to 300,000 sf)	49.9	1,000 gsf
• Shopping Center (300,000 to 400,000 sf)	40.4	1,000 gsf
• Shopping Center (400,000 to 500,000 sf)	47.6	1,000 gsf
• Shopping Center (500,000 to 1,000,000 sf)	34.5	1,000 gsf
• Shopping Center (Greater than 1,000,000 sf)	26.5	1,000 gsf
• Supermarket	172.02	1,000 gsf
Industrial		
• Light Industrial	5.26	1,000 gsf
• Industrial Park	5.44	1,000 gsf
• Manufacturing	3.05	1,000 gsf
• Mini Warehouse	2.45	1,000 gsf
• Warehousing	3.77	1,000 gsf
Port and Terminal		
• Aviation Airport	1.98	Av. Flts/day
• Truck Terminal	62.48	Acre
Recreational		
• Golf course	8.18	Acre
• Athletic/ Fitness/ Gym	10	1,000 gsf
• Racquet Club	17.14	1,000 gsf
Institutional		
• Elementary School	10.72	1,000 gsf
• High School	10.90	1,000 gsf
• Community College	1.6	Student
• University	2.4	Student
• Library	39.75	1,000 gsf
• Church	13.28	1000 gsf
• Day Care Center	58.33	1,000 gsf
Office		
• General Office	15.00	1,000 gsf
• Corp. Headquarters Bldg.	6.27	1,000 gsf
• Medical Office Building	25.91	1,000 gsf
• Office Park	8.50	1,000 gsf
• Research Center	5.93	1,000 gsf
• Business Park	10.89	1,000 gsf
Medical		
• Hospital	15.25	1,000 gsf

Services		
• Bank (Walk-In)	190.44	1,000 gsf
• Bank (Drive-In)	201.56	1,000 gsf

GSF = Gross Square Feet; D.U. = Dwelling Unit
Note: Trip Rate based on a daily average calculated over one week.
Source: Institute of Transportation Engineers. *Trip Generation*, (latest edition should apply)

2. The next step in determining the design average daily traffic is to determine the traffic growth factor (*G*). This number, typically between 0.00 and 0.07, allows the designer to assume an annual percentage growth rate in the traffic volume. If significant future development is expected to occur along the proposed corridor, then future potential traffic should be accounted for and can be accommodated for by using a percentage increase in traffic volume. If there is no significant future development expected due to saturation or because there are no other possible inlets or outlets, the percent of growth should be close to zero (0). The traffic growth factor shall be obtained from Equation 3.1.

$$G = (1+i)^n \qquad \textbf{(Equation 3.1)}$$

Where,

G = Traffic growth factor

i = fractional rate of yearly increase, from Table 3.5

n = Design Life of Pavement, years

Table 3.5 Traffic Growth Rate

Facility Description	Estimated Yearly Increase
Dead End Street	0.01
Connector Street	0.02
Subdivision Street	
Fully Developed	0.005
50% Developed	0.04
Industrial Service Road	
Undeveloped	0.06
50% Developed	0.04

Source: "Manual of Specifications," City of Rocky Mount, NC, 1991.

3. The Design Average Daily Traffic ($\overline{ADT}$) shall then be calculated according to the following formula:

$$\overline{ADT} = \frac{ADT + (G \times ADT)}{2} \qquad \textbf{(Equation 3.2)}$$

Where,

$\overline{ADT}$ = Average Daily Traffic (trips/ day)

G = Traffic growth factor, as described above

C. Determine the Truck Factor: The truck factor adjusts the design average daily traffic ($\overline{ADT}$) to account for the percentage of single frame and multiple frame trucks expected along a particular pavement section. Single frame trucks refer to those trucks with dual wheels on the rear axle, such as delivery trucks. Multiple frame trucks refer to tractor-trailers, semi-trailers, and garbage trucks (which have very high loadings per tire compared to most vehicles). If the designer does not have information to estimate these percentages, 4% single frame trucks ($x = 0.04$) and 1% multiple frame trucks ($y = 0.01$) may be used. Table 3.6 lists equivalent truck factors for various design average daily traffic quantities at these percentages.

$$\overline{N} = \overline{ADT}\,(0.25x + 0.60y) \qquad \textbf{(Equation 3.3)}$$

Where,

$\overline{N}$ = Truck Factor

x = Percentage Single frame trucks

y = Percentage Multiple frame trucks

Table 3.6 Equivalent $\overline{N}$ and $\overline{ADT}$ *

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

*Tabulated values assume 4% single frame and 1% multiple frame traffic.
Source: "Manual of Specifications," City of Rocky Mount, NC, 1991.

D. Determine the Soil Support Value (*SSV*)

1. All pavement thicknesses shall generally be confirmed by a geotechnical report. However, if a developer wishes, he may design cul-de-sac and local streets using a subgrade CBR one standard deviation to the left of the average of all the CBR's determined by geotechnical reports thus far. If, in the opinion of the Town's representative, soils appear weaker or have inherent problems such as high mica content, the services of a geotechnical engineer shall be required in any case for the design of pavements.

2. The designer may choose one of three methods to determine the soil support value (*SSV*).

a. Measure the CBR of Soils and Calculate the *SSV*

b. Measure the CBR of Soils to be Used as Fill and Calculate the *SSV*

c. Assign a *SSV* from the Soil Classification of the County Soil Map

3. Measure the CBR of Soils and Calculate the *SSV*

a. This is the most accurate method to determine the actual characteristic of the subgrade base material because it is based on an actual laboratory CBR (California Bearing Ratio) test that has been approved by a 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.

b. Certification and report of tests performed by an approved soils laboratory shall be submitted to the Town of Wake Forest Engineering Department.

c. Although the following minimum testing is required, a sufficient number of CBR tests shall be made to determine the consistency of the soil conditions in the area to be paved.

i. Soil Borings – Perform soil borings with a maximum spacing of 250 linear feet and with at least four (4) borings in each separate street area and with at least one (1) boring in each soil type area identified in the soil survey map of Wake County, if available. Each boring shall extend at least two (2) feet below the finished subgrade elevation. The Engineer may require more depth as the conditions warrant.

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

d. The CBR value shall then be substituted in Equation 3.4 to obtain the soil support value (*SSV*).

$$SSV = 5.32\,(\log CBR) - 1.52 \qquad \textbf{(Equation 3.4)}$$

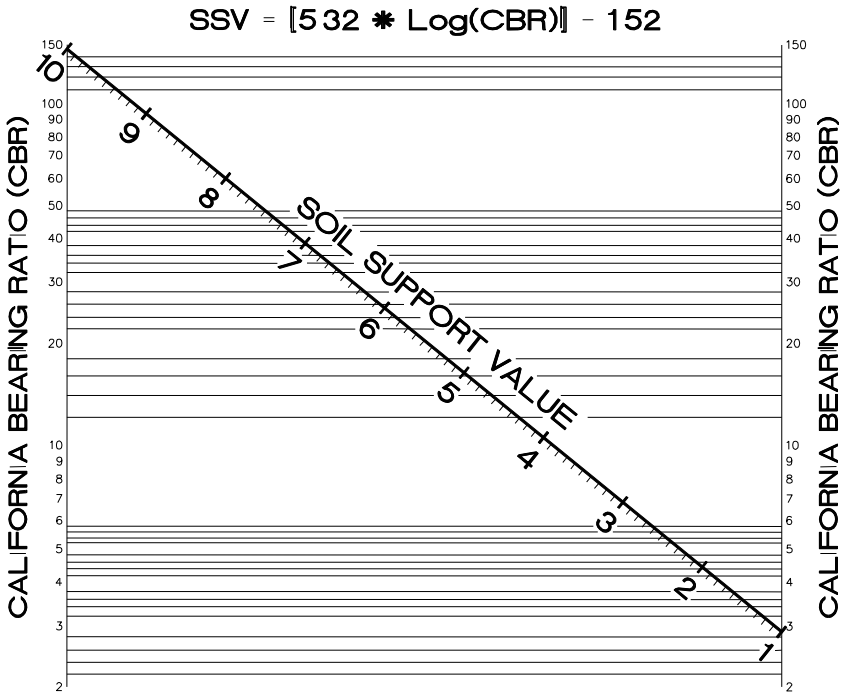
Where,

SSV = Soil Support Value

CBR = California Bearing Ratio (as determined by laboratory report or Figure 3.1)

e. Figure 3.1 can also be use to quickly determine the CBR for the soil in study.

Figure 3.1 Soil Support Values (SSV) per CBR



Source: "Manual of Specifications," [City of Rocky Mount, 1991].

4. **Measure the CBR of Soils to be used as Fill and Calculate the *SSV***

   a. If the characteristics of the existing soils in the area to be paved result in an uneconomical pavement section based on the two preceding methods, the developer may opt to undercut the existing soils to a depth of at least 18 inches below the finished pavement subgrade elevations and backfill with better material. The *SSV* for the proposed pavement section is then determined by performing a CBR test on each soil type used for backfilling (performed in accordance with AASHTO designation T193, latest edition).

   b. The CBR value determined by laboratory testing shall then be substituted in Equation 3.4 to obtain the soil support value (*SSV*).

5. **Assign a *SSV* from Soil Classification of the County Soil Map**

   a. The soil types may be determined by using, if available, the "Soil Survey of Wake County, North Carolina" prepared by the United States Department of Agriculture, Soil Conservation Service. This method is usually more conservative than designs based on actual laboratory data as described in Section 3.3.3.D.3 and will generally require a thicker pavement section.

   b. Locate the project on the soil maps and determine the soil types in the areas to be paved. A copy of the soil survey map with the boundaries of the property and areas to be paved shall be submitted to the Town of Wake Forest Engineering Department.

   c. From the Engineering Index Properties Table determine the AASHTO Classification of the soil types. From this information, use Table 3.7 and/or

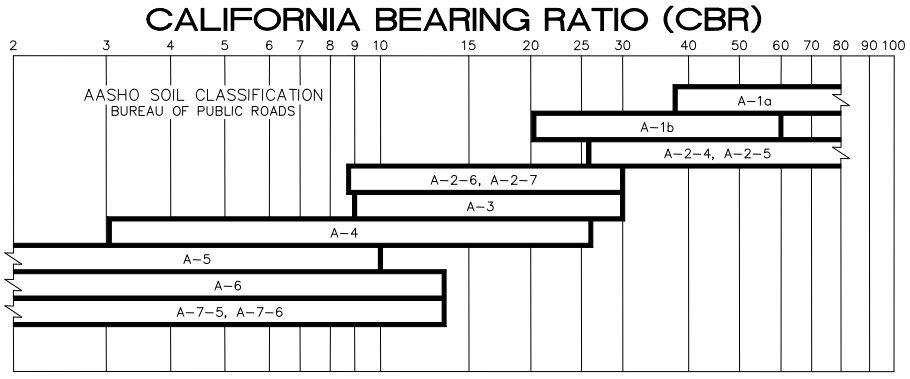
Figure 3.2 to assign the most appropriate soil support value (*SSV*). The entire paved area shall be designed using the lowest *SSV* obtained along any portion of the paved area. The CBR value determined from Figure 3.2 shall then be substituted in Equation 3.4 to obtain the soil support value (*SSV*).

Table 3.7 Assigned Soil Support Values (SSV)

AASHTO Soil Classification	Assigned *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 NCDOT without CBR Test, although AASHTO Soil Classification indicates higher value.
Source: "Manual of Specifications," City of Rocky Mount, NC, 1991

Figure 3.2 CBR Values per Soil Classification



Source: AASHTO Bureau of Public Roads.

E. Determine the Structural Number (*SN*)

1. The structural number is an abstract number that reflects the structural strength of the pavement required for soil support and traffic loads. Obtain the structural number (*SN*) for the given soil support value (*SSV*) and truck factor ($\overline{N}$) from Figure 3.3 and/or Equation 3.5.

$$SN = \frac{2.41\ (\overline{N})^{0.151}}{(1.14)^{SSV}} \qquad \textbf{(Equation 3.5)}$$

Where,

SN = Structural Number required for the design pavement section

$\overline{N}$ = Truck Factor, see Section 3.3.3.C

SSV = Soil Support Value, see Section 3.3.3.D

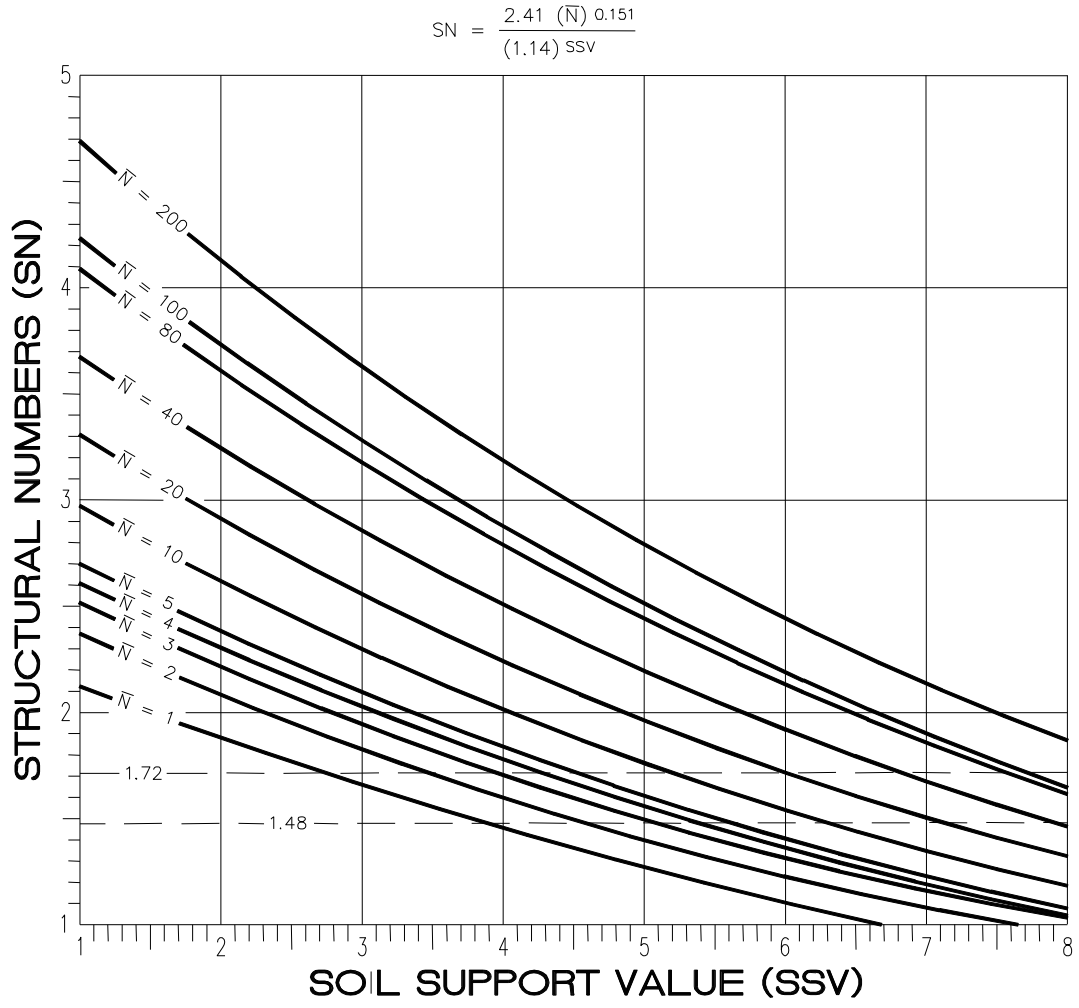
2. The designer should not use a *SN* below 1.72 for poor to fair subgrade soils nor below 1.48 for good to excellent subgrade soils

a. For collector streets, add 1.0 to the structural number.

b. For minor thoroughfares, add 1.5 to the structural number.

c. For major thoroughfares, add 2.0 to the structural number.

Figure 3.3 Structural Numbers for Pavement Sections



Source: "Manual of Specifications," [City of Rocky Mount, 1991].

F. Determine the Structural Coefficients: From Table 3.8, determine the structural coefficient for each layer in the design pavement section.

Table 3.8 Structural Coefficients for Pavement Design

Permanent Layer	Type of Material	Structural Coefficient per inch of Thickness
Surface Courses	Bituminous Concrete Type SF 9.5A; S 9.5X	0.44
	Bituminous Surface Treatment	0.20[a]
Binder Course	Bituminous Concrete Type I 19.0X	0.44
Base Courses	Coarse Aggregate Base Course (CABC)	0.14
	Bituminous Concrete Type B 25.0X	0.30
	Cement Treated ABC (CTABC)	0.23
Subgrade	Cement Stabilized Subgrade (Soil-Cement)	0.14[b]
	Lime Stabilized Subgrade (Soil-Lime)	0.13[b]

[a]Bituminous surface treatment. Do not multiply by thickness in calculations.
[b]For design purposes, do not exceed 1.0 for total depth of subgrade stabilized.

Source: "Paragraph 3.7, *Layer Coefficients*, NCDOT *2006 QMS Manual"*, *NCDOT April 2000 Interim Pavement Design Procedure*," updated November 2007.

1. Commentary on Subgrade Stabilization and Pavement Section Performance:

   a. Lime Stabilized Subgrade: Pozzolanic materials are siliceous substances that will react with lime in the presence of water. Clays are pozzolanic and react with lime to form cement. Lime (approximately 5%) is worked 7 to 8 inches into the subgrade in order to reduce the plasticity of the subgrade soil. However, lime cannot be used with sand.

   b. Cement Stabilized Subgrade: Cement is used with sand to form a Cement Stabilized Subgrade (soil cement). Thickness is generally 7 inches.

   c. Best Performing Pavement Section: By monitoring pavement sections under highway traffic, research has found that the best performing pavement section is comprised of asphalt, aggregate base (ABC) and a lime treated subbase (especially areas where clay-type soils are prevalent). This section performed better than full-depth asphalt pavement sections. [7] Subgrade strength is very important to the performance of asphalt pavements (as opposed to concrete pavements).

G. Select Pavement Thickness to Obtain Required Structural Number

1. Design the pavement section such that the structural number (*SN*) designed is equal to or greater than the number obtained in Section 3.3.3.E. This design may be done by trial and error. However, the minimum pavement section in the Town of Wake Forest shall be no less than that shown in Table 3.3.

2. Multiply an initial thickness (in inches) of the various components of the pavement section (base course, binder course, and surface course) by the corresponding structural coefficient and sum the results. The total number must be equal to or greater than the structural number obtained in Section 3.3.3.E.

3. The combination of layers and structural coefficients that sum greater than the required structural number is the *minimum* pavement design allowable for the particular area to be paved.

H. Minimum Asphalt And Aggregate Thickness

1. Minimum Asphalt Concrete Pavement Thickness: The minimum total asphalt concrete thickness shall not be less than 1 1/2 inches (minimum single lift thickness for S9.5B) for any public roadway.

2. Minimum Aggregate Base Course Thickness: The minimum aggregate base course thickness shall not be less than 6 inches for any public roadway.

I. Summary Sheet

The designer shall provide a summary sheet, either attached to or included in the Geotechnical report, similar in layout to the following example summary sheet. Pavement calculations shall be attached to the summary sheet.

Figure 3.4 Summary Sheet

PAVEMENT DESIGN SUMMARY SHEET						
Street Name	**Avg CBR**	**Facility Classification (Local, Collector, etc.)**	**ADT Range**	**SN**	**Design Pavement Cross-section**	**Special needs (subdrain, fabric, etc.)**

The designer may group similar facilities by corresponding average CBR'/ADT's. However, realizing the variability in soil type and traffic (ADT and truck composition), the designer may need to provide a separate line for each street or section of street (identified by block).

3.3.4 EXAMPLE OF PAVEMENT DESIGN

Figure 3.5 Example of Pavement Design

Design a pavement section for a street accessed by a development consisting of 100 lots in a high density single family residential subdivision. No CBR test is available, however, soils are found to be type A-3 from the county Soil Survey. Assume normal truck loading. Follow the design procedures in this design manual.

Solution:

1. Determine the Design Average Daily Traffic ($\overline{ADT}$):
   - Using Table 3.4 for single family homes,

     $ADT = 9.53\ trips\ /\ day\ /\ dwelling \times 100\ dwellings = 953\ trips\ /\ day$
   - Using Table 3.5 for a subdivision street (fully developed) the estimated yearly increase is 0.5%., so i = 0.005, in Equation 3.1.
   - The Town requires that all pavement sections be designed for a 25 year design life, so n =25, in Equation 3.1. It follows that:

     $$G = (1+i)^n = (1+0.005)^{25} = 1.13$$
   - Using Equation 3.2:

     $$\overline{ADT} = \frac{ADT + (G \times ADT)}{2} = \frac{953 + (1.13 \times 953)}{2} = 1015\ trips\ /\ day$$
2. Using Equation 3.3, determine the Truck Factor, assuming 4% single frame trucks and 1% multiple frame trucks:

   $$\overline{N} = \overline{ADT}\ (0.25x + 0.60y) = 1015[(0.25)(.04) + (0.60)(0.01)] = 16.2\pm$$
3. Determine the *SSV*. Although a CBR is not available, the county soil survey classifies the soils in the area as type A-3. From Table 3.7, for A-3 soils, it is found that:

   $$SSV = 3.5$$
4. Determine the Structural Number (*SN*). Substituting the known values into Equation 3.5,

   $$SN = \frac{2.41\ (\overline{N})^{0.151}}{(1.14)^{SSV}} = \frac{2.41\ (16.2)^{0.151}}{(1.14)^{3.5}} = 2.32$$

   See paragraph 3.3.3.E.2 for minimum permitted Structural Number.
5. Determine Structural Coefficients. Choose an S9.5B asphalt layer over a CABC layer over the subgrade for the pavement section. From Table 3.8, S9.5B coefficient is 0.44 and CABC coefficient is 0.14.

   Note: The minimum pavement section allowed for a local street w/ A-3 subgrade, per Table 3.3, is 2 inches of S9.5B over 6 inches of CABC: SN = 1.72.
6. Select pavement thickness to obtain required structural number. Try different sections.
   - Try 6" CABC + 2" S9.5B: 6 x 0.14 = 0.84; 2 x 0.44 = 0.88; 1.72 < 2.32, Design *INSUFFICIENT*
   - Try 6" CABC + 3" S9.5B: 6 x 0.14 = 0.84; 3 x 0.44 = 1.32; 2.16 < 2.32, Design *INSUFFICIENT*
   - Try 8" CABC + 3" S9.5B: 8 x 0.14 = 1.12; 3 x 0.44 = 1.32; 2.44 > 2.32, Design *SUFFICIENT*

     See paragraph 3.3.3.H for minimum allowable layer thickness thicknesses.

The designer may choose the sufficient pavement section that is preferred. For the given situation, ***choose 3" S9.5B asphalt over 8" CABC over compacted subgrade as the design pavement section.***

3.4 SUBGRADE PREPARATION & TESTING

The purpose of this section is to provide a guide for the subgrade preparation of paved areas within the Town of Wake Forest.

3.4.1 SUBGRADE INSPECTION – CBR TESTING

A. If the soils at the site were tested to obtain the CBR and SSV as described in Section 3.3.3.D.3 and Section 3.3.3.D.4, the soils below the proposed pavement subgrade must be compacted during construction to a density equal to or greater than the density at which the CBR test was performed. Unless filling is involved, the upper twelve (12) inches of soil below the proposed pavement section must be compacted.

B. After the subgrade has been brought to grade, the design assumptions shall be confirmed by visual inspection and classification of the subgrade soils by the Geotechnical Engineer that performed the original investigation. In-situ CBR's do not have to be taken to verify the design pavement section unless the exposed subgrade is deemed by the Geotechnical Engineer to be at variance with original CBR's.

3.4.2 SUBGRADE INSPECTION – DENSITY TESTS

A. In the areas where the roadway has been filled (fill sections), the soil below the pavement section must have been placed in lifts, compacted, and verified by field density tests during fill placement to meet the minimum requirements outlined in Specification Section 02200, Earthwork. The test results shall be submitted to and approved by the Town's Engineer prior to placement of stone base.

B. Field density tests do not have to be performed in either cut sections or undercut areas. Proofrolling shall be performed on these areas. However, if the undercut area is considered to be extensive, as determined by the Town's Engineer, the Town's Engineer may require that density tests be performed in those areas during placement of borrow/fill.

C. The subgrade in cut sections must be compacted prior to proofrolling.

3.4.3 SUBGRADE INSPECTION – PROOFROLLING

A. No pavement shall be placed in the Town of Wake Forest without prior inspection and approval by the Town of Wake Forest Engineering Department. The inspection shall include, but not be limited to, proofrolling the prepared subgrade with a rubber-tired proof-roller (**fully loaded** dump truck) that has a minimum gross weight of at least 20,000 pounds (10 tons) under the observation of a representative of the Town. **No other method will be acceptable.** The developer shall bear the costs of proofrolling, which must be done within ten (10) days prior to placement of the asphalt. All areas of the subgrade shall be covered by the wheels of the proof-roller operating at walking speed (two or three miles per hour).

B. The earthen subgrade must pass a proof-roll prior to the placement of the stone base course or the concrete curb and gutter. The stone base course must in turn pass proofrolling prior to placement of asphalt on the stone base. A proofroll must be repeated on any previously inspected subgrade following a rain event. At a minimum, visual inspection of stone base course following a precipitation event is required.

C. Any areas that rut, or pump excessively under the wheels of the proof-roller, as determined by the Town's Engineer, shall be repaired by the developer before the street is paved. Those repaired areas, at the discretion of the Town's Engineer, may be required to be proofrolled prior to placement of stone or asphalt, as applicable.

Prior to placement of either stone base or asphalt, while exposed to weather, the Contractor shall exercise care and diligence in protecting and maintaining drainage of the subgrade in order to minimize the potential for subgrade deterioration.

D. Should the Contractor or Developer disagree with the representative of the Town about the need for repairs to the subgrade, the Contractor, developer or his project engineer may employ a Licensed Professional Geotechnical Engineer to perform such tests as may be required to confirm the adequacy of the prepared subgrade with the test results provided to the Town's Engineer for review and approval. If the Geotechnical Engineer certifies that the full width and length of the subgrade will provide adequate support for the design pavement section as prepared by the Contractor and the anticipated loading for the design life of the paved area, the area may be paved without making repairs to the subgrade. However the Town's Engineer reserves the right to request/require such additional tests as deemed necessary to satisfy himself/herself as to the adequacy of the subgrade.

E. All construction and testing of materials shall be in accordance with the Town of Wake Forest Manual of Specifications.

3.5 STREET INSPECTIONS & TESTING

3.5.1 MINIMUM INSPECTON CRITERIA

A. Minimum Inspections: The following shall be the minimum inspections required by the Town:

1. **Proofroll Curb & Gutter:** No base course under curb and gutter except as required by the geotechnical report.

   Concrete samples must be taken for slump and strength.

   The initial test (from first ready mix truck) is to be taken after the second yard is dispatched from the mixer and is to consist of the following:

   a. One slump test

   b. Pull, prepare and store 3 cylinders on-site for 24 hours.

   c. Temperature

   Subsequent tests: after the above tests are pulled from the initial truck, every 5th truck thereafter is to be tested in the same manner as noted above.

2. **Proof roll street subgrade:** If stone is used to help stabilize subgrade, the poof roll must be at subgrade elevation. See Section 3.4.2 and 3.4.3 above for proof rolling procedure.

3. **Crossfall on subgrade** from crown to curb shall be checked with a string line prior to placement of base course.

4. **Base course** shall be proof rolled just prior to placement of asphalt. Crossfall on base course, from crown to curb, shall be checked with a string line prior to placement of asphalt. Quarter points in particular shall be checked. Cracked curb is to be removed prior to paving.

5. **Paving lifts**: If the proposed asphalt layer depth exceeds the maximum single lift thickness shown in Table 3.9 below, asphalt must be placed in **two lifts;** the first lift having a thickness of not less than the minimum single lift depth shown in Table 3.9 below. Maximum layer depth, shown in Table 3.9 shall not be exceeded. Asphalt cores must be taken to confirm thickness and compaction. See Section 3.5.2, Testing, below.

Table 3.9 Recommended Pavement Thickness Chart

Mix Type	*Minimum Single Lift Depth (inches)*	*Maximum Single Lift (inches)*	*Maximum Layer Depth (inches)*
SF 9.5A	1	2	3
S 9.5X[a]	1.5	2	3
S 12.5X[a]	2	2	4
I 19.0X[a]	2.5	4	4
B 25.0X[a]	3[b]	5.5	No Restrictions
B 37.5C[a]	4.5	6	No Restrictions
ABC[c]	4	10[d]	No Restrictions

Source: NCDOT 2006 HMA/QMS Manual.

[a] X= Level of Service.
[b] For **B 25.0X** placed on stabilized subgrade, minimum lift thickness is 4.0 inches.
[c]Construct the base so that the thickness of the base is within a tolerance of plus or minus ½ inch of the base thickness required by the plans.
[d]Where the required compacted thickness is more than 10 inches, spread the base material in 2 or more approximately equal layers. Compact the base material to a minimum thickness of approximately 4 inches for any one layer.

6. **Temperature** (Ambient Air and Mix): See temperature requirements for asphalt in Section 610-4 and in Table 610-5 of NCDOT *Standard Specifications for Roads & Structures*, latest edition, Placement Temperatures for Asphalt. For concrete, see Section 02400 – Curb & Gutter, Sidewalks, & Driveways, paragraph 3.4.9 B, Cold Weather Concreting.
7. **Sidewalk** forms and subgrade shall be checked prior to pouring. Slump and strength tests shall be required. See Section 3.5.2, Testing, below.
8. All **driveway** forms must be checked prior to pouring. If a ditch and shoulder section is used, culvert inverts must be checked.
9. **Driveway culverts** must be installed to ensure positive and uniform ditch flow line grade between publicly maintained structures/culverts.
10. **Grade and Alignment**: The Town shall not be responsible for ensuring proper grade and alignment.

B. CO Inspections

Before a Certificate of Occupancy will be granted, the following shall be the minimum inspections required by the Town:

1. Broken Curb & Gutter along frontage
2. Broken Sidewalk where applicable
3. Broken driveway aprons
4. Sewer cleanout set per City of Raleigh standards
5. Water meter box set per City of Raleigh standards
6. Grade right-of-way per Standard Detail 9.01A.
7. All temporary Erosion Control Measures have been removed
8. Adequate ground cover has been established per approval by the Town of Wake Forest Engineering Department

C. Geotechnical Engineering Inspection Services:

1. The services of a Geotechnical Engineer shall be required in all cases where unusual soil conditions have been found during construction such as high water table or springs, soft or yielding soils, unsuitable soils, or
2. A developer may elect to use the services of a consulting Geotechnical Engineer to perform all inspections of streets. In this case, the Geotechnical Engineer shall be required to guarantee that the street shall perform as required.
3. See also paragraphs 3.4.2 and 3.4.3, as applicable.

D. Inspection Fee: All inspections, which fail, are subject to a re-inspection fee.

E. Inspection Procedure: Warranty, maintenance during warranty period, inspection procedure, repairs, utility cuts, etc. are covered under Section 3.6, Warranty & Acceptance.

3.5.2 TESTING

A. Concrete Testing:

1. The initial test (from first ready mix truck) is to be taken after the second yard is dispatched from the mixer and is to consist of the following:
   a. One slump test
   b. Pull, prepare and store 3 cylinders on-site for 24 hours. Do not store at locations subject to vibration. Deliver to lab for a 7-day and 28-day break test.
   c. Temperature
2. **Subsequent tests**: after the above tests are pulled from the initial truck, every 5th truck thereafter is to be tested in the same manner as noted above. The Inspector may require two additional tests per truck if he/she feels the condition of the concrete has changed.
3. **Slump Test Limitations**

Table 3.10 Slump Test Limitations

APPLICATION	ALLOWABLE SLUMP	REFERENCE
Hand poured Curb and Gutter	2" to 3 ½"	02400, 3.4.12
Machine formed Curb and Gutter	0-2"	02400, 3.1.2.E
Other Applications	as specified by Town's Engineer	02400, 3.4.12

B. Asphalt Testing

1. **Compaction**: Testing for asphalt density is to follow NCDOT "Standard Specifications for Roads and Structures," Section 609-7, "Field Compaction Quality Control," latest revision.
2. **Thickness**: The minimum frequency of coring for thickness testing shall be on the basis of test sections consisting of not more than 1500 linear feet of lay down width, exclusive of intersections and irregular areas. The test sample is to be a 6-inch diameter cored sample. The sample is to be numbered and logged for identification purposes.
3. **Contractor's Quality Control System**: Follow NCDOT "Standard Specifications for Roads and Structures," Section 609-4 "Contractor's Quality Control System Personnel Requirements" and 609-5. "Contractor's Quality Control System Field Laboratory Requirements," latest revisions.

4. **Mixture and Job Mix Formula Adjustments**: Follow NCDOT "Standard Specifications for Roads and Structures," Section 609-6, "Plant Mix Quality Control," latest revision.

5. **General**: All other applicable sections of Section 609 of the NCDOT "Standard Specifications for Road and Structures" shall apply relating to Quality Control Plan, mix design, control limits, corrective action, equipment and measurement.

6. **Testing Cost**: Project owner is responsible for cost of testing.

3.5.3 SETUP PERIOD

A. Unless otherwise waived by the Town's Engineer, for all new areas to be paved, the developer shall be required to wait at least six (6) months before the final lift of asphalt is placed. This setup period includes the winter months through February.

B. Existing streets that are to be rebuilt or reconstructed will not be required to meet this setup period and may be paved when the specifications in this manual are met and approved.

3.5.4 MAINTENANCE

For warranty, maintenance during warranty period, inspection procedure, repairs, utility cuts, etc. see Section 3.6, Warranty & Acceptance.

3.5.5 WARRANTY

Warranty, maintenance during warranty period, inspection procedure, repairs, utility cuts, etc. are covered under Section 3.6, Warranty & Acceptance.

3.6 WARRANTY & ACCEPTANCE

3.6.1 GENERAL REQUIREMENTS

A. Prior to commencing construction, all approvals including plan approval and all permits and encroachments shall be obtained. Site grading **only** may be performed upon issuance of a grading permit from the Town of Wake Forest. All other construction must await the issuance of all remaining permits. A preconstruction conference must also be held prior to commencing **any** construction.

B. The developer is responsible for the maintenance and repair of streets for twelve (12) months after acceptance by the Town for warranty. At the end of twelve (12) months the Town of Wake Forest will accept permanent responsibility. If a significant failure occurs requiring extensive maintenance during the first year of service, the Town's Engineer shall suspend the twelve-(12) month warranty until the failure is repaired to an acceptable condition.

C. The developer is responsible for the maintenance and repair of all paved areas other than streets.

D. No contractor shall permit mud or construction debris to accumulate in any paved street which is maintained or is proposed to be maintained by the Town of Wake Forest.

E. The final lift of asphalt cannot be laid before 25% of the lots in a subdivision have been developed, but shall be laid before 75% of the lots in a subdivision have been developed.

3.6.2 INSPECTIONS

A. Upon completion of construction, the developer shall request a final inspection. Upon completion of all punch list items, the provision of a set of acceptable record drawings, and the submission of engineer's certifications, a one-year warranty period shall commence.

B. During the one-year warranty period the developer shall promptly repair any latent defects which occur. At the end of the one-year warranty period, the developer shall request a warranty inspection. Upon successful completion of all warranty items the developer shall be released from maintenance responsibilities for the warranted construction.

C. All inspections must be scheduled the day prior to when needed. Inspections will be performed in the order received. Every effort will be made to accommodate the time of request; however, this cannot be guaranteed.

D. All inspections, which fail, are subject to a re-inspection fee.

3.6.3 MAINTENANCE

A. Existing Streets: The Town will assume all maintenance responsibility on all existing paved streets. If an individual owner wishes to pipe an existing roadside ditch and/or install curb and gutter in front of their property, the Town's Engineer shall make a determination whether it is favorable to do so. The Town will at its option install these improvements. If the Town installs these improvements it shall require the owner to pay the full cost of the materials. The Town will cover labor and equipment cost.

B. Existing Strip Paved Streets: The Town shall maintain existing strip-paved streets in the following manner:

1. Streets that have an adequate base and inadequate roadside drainage system shall be resurfaced as required. This maintenance shall be at the sole cost and expense of the Town.

2. Streets that have an inadequate base, but an adequate roadside drainage system shall have the inadequate base replaced and shall be resurfaced as required. If in the judgment of the Town's Engineer, more than one-half of the street surface needs its base replaced, the Town's Engineer may recommend that the street be rebuilt with curb, gutter, and paving to standard Town of Wake Forest specifications. The Board of Commissioners will make the final determination as to whether the street is to be rebuilt with curb and gutter.

3. Streets that have inadequate base and/or inadequate roadside drainage will be resurfaced and drained as required. If, in the judgment of the Town's Engineer, one-half of the street surface needs its base replaced or if adequate roadside drainage cannot be obtained without extensive work, the Town's Engineer may recommend that the street be rebuilt with curb, butter and paving to standard Town specifications.

4. If a new roadside ditch is required and its invert elevation is more than 30" below the elevation of the edge of the finished asphalt surface, the resident may:

a. Elect to have the ditch remain open, or

b. Elect to have the ditch piped with the total cost of the piping and appurtenances being assessed against the property in a manner consistent with other street improvement assessments, or

c. Elect to have curb and gutter and pavement widening installed in accordance with existing assessment policies.

The Board of Commissioners will make the final determination for which option best meets the interest of the Town and parties involved.

5. Streets that intersect streets that have been petitioned for curb and gutter that also need curb and gutter to adequately drain into the street to be improved shall:

a. Have curb and gutter installed upon recommendation of the Town's Engineer and upon approval of the Board of Commissioners.

C. Existing Curb & Gutter Streets: All existing public streets that have curb, gutter and paving shall be maintained as required at the sole cost and expense of the Town unless they are on the NCDOT system.

D. Existing Dirt Streets

1. All dirt streets are to be improved at the expense of the abutting property owners or developer. These improvements can be caused by petition, Board of Commissioners order or as a requirement to obtain subdivision approval. Once approved, the Town will thereafter maintain the street at its sole cost and expense.

2. Existing dirt streets accepted by the Town prior to adoption of this policy shall be maintained as a dirt street at the sole expense of the Town.

3.6.4 UTILITY CUTS

A permit will be required for any utility company wishing to excavate or place utilities in the Town right-of-way. Pavement cuts in streets made by the utility company or the Town shall be repaired in either the following ways:

A. No. 57 stone shall be placed and vibrated on top of pipe to within 8-inches of the pavement surface after which 6-inches of B25.0B asphalt base and 2-inches of S9.5B asphalt is placed. All edges shall be over-excavated by 12-inches on each side of the cut and a 2-inch depth of S9.5B asphalt and 6-inches of B25.0B shall be placed in the remaining cut area. All pavement joints shall be tacked and sealed with an approved sealer. See Standard Detail 9.06.

B. Alternatively, the Contractor may backfill the cut with flowable fill concrete to within a minimum of 2 inches of the pavement surface (or match existing asphalt depth if greater than 2 inches in thickness) and top with a minimum of 2 inches of S 9.5B asphalt (or match existing thickness if greater than 2 inches). Excavatable flowable fill shall have a compressive strength of no less than 30 psi and no more than 100 psi. See Specification Section 02210, *Trenching, Backfilling, and Compaction of Utilities*, paragraph 2.1.5 for more information relating to flowable fill concrete.

C. Electric service shall not be installed until the street section is graded at final and approved.

3.6.5 USE OF EASEMENTS – HARD IMPROVEMENTS

All public easements including sewer, water, storm sewer and electric are to remain clear of obstructions. No buildings, fences, trees, shrubs or other obstructions shall be placed in any easement. However, fences may be allowed transversely but not longitudinally across utility easement with an approved encroachment permit. Fences across utility easements shall be required to provide a 12 foot vehicular gate. Driveways, walkways, asphalt and parking lots may be permitted in easements; however, the Town reserves the right to remove such asphalt, concrete, base course and sod as necessary to access its

facility in the case of emergency. Pavement or concrete will be replaced with a patch. Sod will be replaced with fescue or rye seeding. The Town will not be responsible for replacing a property owner's sod after repairing a utility line.