STREET DESIGN

SELECTED LINKS TO SECTIONS WITHIN THIS DOCUMENT

SECTION 1
INTRODUCTION – STREETS

(Last revised 6/28/10)

The following division has been established to assist developers and engineers with the design of streets (private and public) within the jurisdiction of the Town of Clayton. 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 Clayton 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 Town Engineer.

1.1 TOWN OF CLAYTON TOWN ENGINEER

The Town Engineer shall be responsible for interpretation and implementation of the pavement design criteria for the Town of Clayton. Approval from other applicable agencies may be required.

1.2 TOWN OF CLAYTON PAVEMENT POLICY

It is the policy of the Town of Clayton that all developed land within the Town Limits has adequate streets and parking lots. The Town may accept roadway systems for maintenance if they have been designed and constructed in accordance with the provisions of this specification or as otherwise instructed in writing by the Town Engineer.

1.3 ACKNOWLEDGEMENTS

This division has been prepared by Appian Consulting Engineers, P.A. of Rocky Mount, North Carolina, in cooperation with the Town of Clayton, North Carolina. However, the content of this

division is partially derived from the *AASHTO Guide for Design of Pavement Structures* [AASHTO, 1993] and the *Asphalt Pavement Design System* [Taylor, 1993]. The AASHTO method looks at total volume of traffic over the life span of the pavement. The AASHTO method also allows for acceptance of pavement deterioration as an economic decision. When correctly used, especially in conjunction with a good model of traffic numbers and wheel loads, the method provides reasonable results. These manuals were particularly important because of their format, quality, completeness, and because they represent generally accepted criteria.

SECTION 2
STREET/SUBDIVISION DESIGN

The purpose of this division is to define the policy of the Town of Clayton with respect to the design, construction, and maintenance of public streets within the Town.

All streets within the Town of Clayton shall meet all the requirements of the Town of Clayton Manual of Specifications, Standards and Design, latest revision.

The following shall be considered the *minimum* standards of design for streets within the Town of Clayton.

2.1 SUBDIVISION STREETS

Table 2.01
Required Improvements

Public Improvement	Required
Traffic Control Devices (signage and pavement markings)	X
Underground Drainage	X
BMP's	X
Curb and Gutter and Paving	X
Public Water and Hydrants	X
Public Sewer	X
Paved Streets	X
Sidewalks	Both sides[a]
Street lights	X
Street trees	In accordance with Town of Clayton UDC for street trees
Underground Power	Not required but recommended

[a]See Sidewalk Requirements, paragraph 2.6.1, Sidewalks General

In every new subdivision or development, the street system shall conform to the Town of Clayton's Comprehensive Transportation Plan. In areas where the Comprehensive Transportation Plan does not apply, streets shall be designed and located in proper relation to existing and proposed streets, topography, natural features, tree growth, public convenience, public safety, and the proposed use of land to be served by such streets. All proposed streets shall provide for the appropriate protection of principal streets in surrounding areas and provide reasonable access for surrounding acreage tracts.

The developer shall be responsible for the cost and installation of the residential, residential collector, collector, frontage road, commercial streets and/or thoroughfare improvements (see paragraph 2.3.8, *Thoroughfares*) in accordance with the street design standards. Paving shall be installed from roadways through and adjoining the development in accordance with the Town's Manual of Specifications, Standards and Design (or the NCDOT standards if applicable). The developer shall also provide additional pavements surfaces/lane widening for turning lanes in accordance with the Town's Manual.

Right-of-way and pavement widths shall comply with **Standard Detail 401.01**, *Typical Street Cross Section (Geometric Properties)*.

2.1.1 Street Classifications/Definitions

1. **Alley**: A public vehicular way providing service access along rear or side property lines of lots which are also served by one of the other listed street types.

2. **Collector Streets**: A street whose principal function is to carry traffic between residential collectors, residential streets, cul-de-sacs and major and minor thoroughfares but may also provide direct access to abutting properties. It is designed to carry more than 3,500 but less than 6,000 trips per day. Typical, a collector is able to serve directly or indirectly, between 350 and 600 dwelling units.

3. **Commercial Stree**t: A multi-lane street connecting to major or minor thoroughfares designed to accommodate large volumes of traffic (in excess of 6,000 trips per day) at moderate speeds while also providing, as a major part of its function, direct access to nonresidential or mixed use high trip generating land uses.

4. **Cul-De-Sac** (residential or commercial): A short, street having one end open to traffic and the other permanently terminated by a vehicular turnaround. See **Standard Detail 401.02**

5. **Frontage Road**: A street, parallel and adjacent to a major or minor thoroughfare, which provides access to abutting properties, protection from through traffic, and control of access to the major or minor thoroughfare.

6. **Minor Thoroughfare**: A street designed primarily to collect and distribute traffic between the local street network and major thoroughfares as shown on the Town's Transportation Plan. This street type generally consists of more than one travel lane in each direction. A minor thoroughfare shall be designated where the anticipated average daily volume range exceeds 6,000 trips per day. Residences should not front on a minor thoroughfare.

7. **Major Thoroughfare:** A street serving the principal network for high volumes of traffic or high speed traffic as shown on the Town's Transportation Plan. This street type consists of at least two travel lanes in each direction. A major thoroughfare shall be designated where the anticipated average daily volume exceeds 10,000 vehicles per day. Residences shall not front on a major thoroughfare.

8. **Residential Street**: A street whose principal function is to provide access to adjacent properties.

9. **Residential Collector Street**: A street which serves as a connector street between residential streets, cul-de-sacs, and major and minor thoroughfares. Residential collector streets typically collect traffic from 100 to 400 dwelling units.

2.1.2 Widening of Existing Streets

Widening of streets in existing neighborhoods will be considered on a case-by-case basis, taking into consideration the effects on the neighborhood, traffic, and parking requirements.

2.1.3 Standard Street Cross Sections and Pavement Design Criteria

Pavement sections/thicknesses shall conform to the minimum cross-sectional widths and thicknesses shown on **Standard Detail 401.01**.

Geotechnical Investigation Required:

1. All new streets or street improvements shall conform to the minimum pavement sections shown on **Standard Detail 401.01.** The section shall be confirmed as to adequacy by a Geotechnical Investigation taking into consideration the projected volume and type of traffic for the new sections under consideration. See *Section 3, Pavement Design*.

2. If the subgrade soils appear to be weak or have inherent problems, such as a high mica content or a seasonal high or perched groundwater condition, the Geotechnical Engineer shall confirm and/or alter the minimum section as required to account for the influence of these factors. Improvements may include, but are not necessarily limited to, subsurface drainage (parallel or lateral), subgrade stabilization with a Geotextile fabric, lime or cement, increased pavement thickness, etc.

3. **Pavement Design Life:** Pavement must be designed in accordance with the procedures in Section 3, *Pavement Design*. The minimum pavement design life for streets within the jurisdiction of the Town of Clayton shall be 20 years but may be increased at the discretion of the Town Engineer. The thickness shall be determined by either the average in-situ or soaked laboratory CBR value for the street or roadway section. However, the minimum asphalt pavement section thickness shall be no less than that shown on **Standard Detail 401.01 for** the applicable classification.

All design modifications are subject to approval by the Town Engineer.

2.2 VERTICAL ALIGNMENT

2.2.1 Grades

Street grades shall not exceed 10% percent unless approved by the Town Engineer. In all cases, street grades shall not be less than 0.5% percent. However, in no case may streets be constructed with grades that, in the professional opinion of the Town Engineer, create a substantial danger to the public safety or cause any substantial degradation to either the street or drainage system.

Grades approaching intersections shall not exceed 5% percent for a distance of at least 100 feet from the centerline of the intersection.

2.2.2 Vertical Curves

All changes in street grade shall be connected by vertical curves. The following formula shall be used for determining the length of vertical curve required to provide minimum sight distance:

$L = KA$

L = Length of vertical curve in feet

K = Rate of vertical curvature in feet per percent of A (Table 2.02)

A = Algebraic difference in grades in percent

Table 2.02 Minimum K Values		
Street Type	K	
	Sag	**Crest**
Major Thoroughfare	100	140
Minor Thoroughfare	40	30
Collectors, Commercial	30	30
Residential, Frontage	30	30
Cul-de-sac, Alley	20	20

2.2.3 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.

2.2.4 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, curb and gutter, and storm sewers for street drainage.

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

2.3 HORIZONTAL ALIGNMENT

2.3.1 Street Layout

1. The street layout of any development should be in conformity with the Town's Transportation Plan and all other applicable adopted plans and policies of the town. Public streets shall be constructed to the boundary lines of the development submitted for approval when required to provide for efficient circulation of traffic within the community.

2. Each side of a collector street, commercial street, or residential street shall, within every 1,500 foot length of the street, be intersected by at least one connective street. The 1,500 foot length shall be measured from the origination point, if established, of the collector, commercial, or residential street.

3. A waiver may be granted by the Town Council for developments that do not meet the above layout or creates a violation of this layout if:

a. Existing surrounding development prevents extending a street to any adjoining developments to meet this regulation.
b. The adjoining existing street pattern or a planned "stub" street provides for an appropriate intersecting street beyond the 1,500-foot point that would provide equivalent benefits as an intersecting street within 1,500 feet.
c. Severe topography or other physical features warrant making a connection of an intersecting street at another location either inside or outside the development to provide equivalent benefits as an intersecting street within a distance of 1,500 feet, and this other alternate specific location is provided for at the time the development making the request for an alternate location is approved.

4. Existing adjoining public streets, public platted streets, and publicly planned streets shall be continued and extended as public streets as part of the development. Streets that are not to be extended, as determined by the Town Council, shall be terminated in a permanent cul-de-sac.

5. Where a proposed development will extend a public street that is already stubbed out to the property line, such extension as a public street shall be required.

6. Wherever there exists a dedicated or platted half street adjacent to the parcel to be developed, the other half shall be platted and, where required, constructed.

7. Where a through street or a series of streets establishes a connection between 2 public streets and the connection is greater than 1,200 feet in length, or the connection may encourage through traffic not generated by the development, the street shall be a public street, except in instances where the Town Council determines that requiring such connection to be a public street will serve no purpose, due to the existing or proposed street pattern, traffic flow or traffic volumes.

8. Where a proposed development utilizing private streets has an area of 20 or more acres, at least one public through street must be provided in a location determined by the Town Council to assure continuity of the public street system, except in instances where the Town Council determines that such public through street will serve no purpose due to the existing or proposed street pattern, traffic flow or traffic volume. The Town Council may also require additional public through streets for the provision of emergency services, such as police and fire protection, or to provide alternate circulation at congested or critical intersections.

2.3.2 Street Layout in Relation to Topography

Streets shall be designed to relate appropriately to the topography of a site. In particular, streets shall be designed to facilitate storm drainage. Layout shall be subject to the design requirements relating to maximum grades set forth in paragraph 2.2.1, Grades. Street grades shall conform as closely as practicable to the original topography.

2.3.3 Blocks

1. **Proposed Use:** Blocks shall be laid out with special consideration given to the type of land use proposed within the block.

2. **Length:** Blocks (streets providing multiple points of access, NOT cul-de-sacs) shall not exceed 1,500 feet in length nor shall they be less than 500 feet in length, as measured from centerline to centerline.

3. **Width**: Blocks shall have sufficient width to provide for two tiers of lots of appropriate depth except where otherwise required to separate residential development.

4. A pedestrian connection not less than 10 feet in width may be required near the center and entirely across any block in excess of 900 feet in length to provide adequate access to schools, shopping centers, churches, or transportation facilities.

5. A pedestrian connection through a cul-de-sac not less than 10 feet in width may be required when the cul-de-sac helps provide adequate access to schools, shopping centers, churches, or transportation facilities.

2.3.4 Cul-de-Sacs

Cul-de-sacs shall be used only when it is determined by the Town Council that extension of the street to an adjacent property is impractical or unnecessary. Alternative turnaround designs on residential streets serving 6 dwelling units or less may be considered on a case-by-case basis. Alternative designs must readily accommodate emergency vehicles and sanitation trucks. Medians may be permitted where the cul-de-sac radius is increased and it can be demonstrated that emergency vehicles and sanitation trucks can be accommodated. Unless specifically agreed upon with the town, landscaped medians are not to be maintained by the town, and a private maintenance agreement for the median shall be required to be approved by the Town Attorney.

The maximum length of cul-de-sacs shall be as follows:

1. No residential street cul-de-sac serving lots of 20,000 square feet or greater in size shall exceed 1,000 feet in length.

2. No residential street cul-de-sac serving lots less than 20,000 square feet in size shall exceed 700 feet in length.

3. No commercial street cul-de-sac shall exceed 400 feet in length.

The length of a cul-de-sac shall be measured from the centerline of its intersection with a road with multiple points of access to the centerline intersection of the vehicle turn around as shown in **Standard Detail 401.02.**

2.3.5 Curves

Where a street centerline deflection of 10 or more degrees occurs a curve shall be introduced having a radius of curvature of not less than the following:

Table 2.03 Minimum Horizontal Curve Radii	
Classification	**Minimum Radii**
Major Thoroughfare	600
Minor Thoroughfare, Commercial	300
Collector St., Residential Collector, Frontage Road	230
Residential	150
Cul-de-Sac, Alley	100

A tangent of not less than 100 feet shall be provided between reverse curves on all streets.

2.3.6 Intersections

Street intersections shall be designed in the following manner:

1. No more than two streets shall intersect at one point.

2. Streets shall intersect as nearly as possible at right angles, and no street shall intersect any other street at an angle of less than 80 degrees.

3. Street jogs with centerline offsets of less than 125 feet are prohibited.

4. Property lines at street intersections shall be rounded with a minimum radius of 20 feet.

5. Intersections with a minor thoroughfare shall be at least 600 feet apart.

6. Intersections with major thoroughfares shall be at least 1,000 feet apart.

7. All intersections shall have a 10 ft x 70 ft sight triangle on all stop approaches. See **Standard Detail 403.01**.

All proposed connections to NCDOT roads shall meet the applicable criteria of the NCDOT "Subdivision Roads Minimum Construction Standards," latest revision, and the "Policy on Street and Driveway Access to North Carolina Highways," latest revision.

2.3.7 Frontage Roads: In the case that a subdivision borders along an existing or proposed minor or major thoroughfare, no direct driveway access will be permitted to the thoroughfare. When subdividing residential properties adjacent to the thoroughfare, all lots should back onto the thoroughfare and shall be required to have frontage on another public road or approved private street. When subdividing commercially zoned property, the developer shall create a frontage road adjacent to the thoroughfare right-of-way or shall provide some other form of access, which does not entail direct driveway access onto a thoroughfare.

2.3.8 Thoroughfares: The developer shall be responsible for making improvements to the thoroughfare rights-of-way, as designated on the Town's Transportation Plan. The improvements to be installed are as follows: the thoroughfare subbase and surface paving material, thoroughfare grading, and the remaining standards of applicable minimum residential, residential collector, collector, or commercial streets. The

improvements shall be made to extend to the outer perimeter boundaries of development for any development where any of the following conditions occur:

1. The thoroughfare improvements would provide necessary access to the development or adjoining properties.

2. The improvements would be an extension of an already existing section of thoroughfare roadway.

3. The traffic from the development is predominantly from nonresidential activities and the development would otherwise gain access through a residential area.

2.4 DRAINAGE

Inlet design and spacing to be designed in accordance with the *Stormwater Design Manual,* paragraph 4.6, *Curb Inlet Design.*

Streets shall be designed such that storm runoff will not cross the approach of intersections Storm drainage structures should be used to avoid storm runoff crossing through street intersections. Directional arrows must be shown on plans to reflect the proposed surface drainage flow. This is particularly important around curb returns. Valley gutters shall not be used unless approved by the Town Engineer.

Unless otherwise permitted by the Town Engineer, pipe penetration or cutting down the back of the curb and gutter for drainage purposes will not be permitted.

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, the property owner desires, or when used as a BMP, 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 Engineer, said ponding will not weaken the subgrade of the street.

2.5 STREET SECTION TYPES

2.5.1 Strip Paved Streets (Shoulder Sections/Roadside Ditches)

Width for shoulder/swale section where appropriate is shown on **Standard Detail 401.01**. No on-street parking would be permissible for this cross section. This design would only be appropriate for low-density development.

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, the property owner desires, or when used as a BMP, 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 Engineer, said ponding will not adversely affect the life of the street.

In all subdivisions where there is no curb and gutter, side ditches, which require protection for erosion caused by excessive velocity, shall be lined with sod, approved temporary erosion control material to permit establishment of a non-erodible mat of grass or a permanent armor protection.

2.5.2 Curb and Gutter

All curb and gutter shall be constructed according to **Standard Detail 402.01** of the Town of Clayton Manual of Specifications. Allowable sections shall be the standard 30" vertical curb and gutter (preferred) and the 30" roll curb type.

2.6 SIDEWALKS AND DRIVEWAYS

2.6.1 Sidewalks – General

In order to enhance pedestrian safety and mobility, except as set forth below, sidewalks shall be required on both sides of all streets.

Sidewalks should generally link residential areas with employment, commercial and public areas and, where such a facility exists, should interconnect with Greenway/Bicycle Trails when possible.

Table 2.04 Sidewalks per Facility

Facility	Both Sides of Street[1]
Cul-de-sacs	Yes
Collector Streets	Yes
Commercial Streets	Yes
Major Thoroughfare	Yes
Minor Thoroughfare	Yes
Residential Street & Residential Collectors	Yes

1. Sidewalks are not required on the following:

    a. In residential developments with a minimum lot size of one acre or greater, except where an existing school, park, open space, trail or greenway lies within one quarter mile of the boundaries of the proposed subdivision, in which case a safe pedestrian connection between the subdivision and the off-site facility is required.

    b. Residential streets serving less than or equal to 10 dwelling units. Corner lots that have frontage on both a connective or loop street shall not be included in determining the number of dwell units served by the streets. Street stubs temporarily serving 10 lots or less shall provide sidewalk on both sides of the streets.

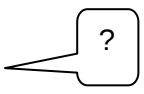
    c. Commercial street cul-de-sacs that are less than 150 feet in length.

2. Sidewalks shall be required on only one side of a frontage road.

3. Sidewalk access ramps, commonly referred to as wheelchair ramps for the physically handicapped, shall be provide at all intersections where curb and gutter is provided and where sidewalks and/or greenway trails intersect streets subject to the following conditions:

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

    b. Domes are not required on ramps in single-family residential developments.



c. Sidewalk construction shall meet the applicable ADA/ABA provisions.

4. Pedestrian crosswalks are required on any residential street at each intersection and at any midblock pedestrian or bicycle connections.

2.6.2 Other Sidewalk Requirements:

When required by the Town, a trail and/or greenway shall be installed in lieu of the sidewalk.

Multi-family and planned developments shall provide sidewalks for interior movement of pedestrians and for interior to connect to public sidewalk system.

The subdivider shall bear the expense of all sidewalk construction except as otherwise exempted by the Town Council

2.6.3 Brick Sidewalks

1. **Allowable Locations and Installation**: Installation and maintenance of brick sidewalks shall be permitted only:

   a. Where an existing sidewalk is brick and is being replaced or repaired; or

   b. In an area designated as an historic district; or

   c. Adjacent to an historic property; or

   d. Where proposed for an entire block and all property owners agree to brick installation; or

   e. Where a streetscape plan has been approved by Town specifying brick sidewalk. In such areas, brick sidewalk may be installed on a lot-by-lot basis.

2. **Construction Methods for Brick Sidewalks**

   a. **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 and approved borrow material (on-site or off-site). Borrow material shall be compacted in lifts not exceeding 8 inches in thickness.

   b. **Base**: Base to be 4-inch thick 3,000 psi concrete with a minimum of 1-inch thick stone screenings or sand. Concrete shall be 6-inches thick when crossing driveways.

   c. **Sidewalk Width and Grade**: Except when repairing a non-conforming brick sidewalk, the width shall be as specified by the Town Engineer and shall be laid to grade with a smooth uniform surface with a slope of ¼-inch per foot toward the street.

   d. **Material**: Brick shall conform to ASTM C902.

e. **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.

2.6.4 Driveways

1. Residential driveways shall have a minimum width of 10 feet and a maximum width of 24 feet and shall conform to **Standard Details 404.01**. Commercial driveways shall comply with **Standard Detail 404.02**; width to be approved by the Town Engineer.

2. **Access to Major or Minor Thoroughfares**: Whenever a subdivision borders on or contains an existing proposed major or minor thoroughfare, no direct driveway access may be approved from the lots within a subdivision onto the major or minor thoroughfare.

2.6.5 Pedestrian Easements or Walkways

Pedestrian easements or walkways may be provided through the interior of blocks. Pedestrian easements shall be at least 10 feet wide and shall be laid out along front, side or rear property lines.

2.6.6 Greenways & Bikeways

1. **Greenways**: When required, Greenways shall be provided with an easement as required but no less than 20 feet in width (cross country).

2. **Bikeways**: When required, the bikeways shall be designed in accordance with the Comprehensive Bicycle Plan and the NCDOT's *North Carolina Bicycle Facilities Planning and Design Guidelines*, latest revision.

2.7 STREET NAMES

Street names shall be subject to the approval of the Town Council. New names shall not duplicate or be similar to existing street names in Johnston County. Existing street names shall be projected where appropriate.

2.8 TRAFFIC IMPACT ANALYSIS

2.8.1 Applicability

(1) A traffic impact analysis may be required to be submitted in conjunction with an application for a planned development, preliminary plat, major site plan, or special use permit.

a. Unless exempted in (2.8.2) of this section, a traffic impact analysis shall be required for projects, which can be anticipated to generate at least 100 vehicle trips at peak hour from the latest edition of the Institute of Transportation Engineers (ITE) Trip Generation Manual.

***Commentary**: 100 peak hour vehicle trips equates to approximately 100 single-family units or 25,000 square feet of general commercial space.*

2.8.2 Exemptions: The following projects shall not be required to submit a traffic impact analysis:

(1) Developments approved prior to the effective date of § 155.708 (Traffic Impact Analysis) of the Town UDC that have maintained valid planned development master plans, preliminary plats, major site plans or special use permits.

(2) Redevelopment of any site on which the additional traffic at peak hour represents an increase of less than 100 trips from the previous development, where the redevelopment is initiated within 12 months of the completion of demolition of the previous project.

(3) Minor site plans.

2.8.3 Pre-application conference

(1) All applicants required to submit a traffic impact analysis shall schedule a pre-application conference with the Planning Director, in accordance with § 155.702(A) of the Town UDC.

(2) The Planning Director and the Town's consultant, if applicable, shall determine the type and scope of the study during the pre-application conference, which may also involve representatives from other agencies or departments.

2.8.4 Waiver authorized

(1) The Planning Director may waive the requirement to submit a traffic impact analysis. If the Director waives the requirement to submit a traffic impact analysis, the Director shall include the reason for the waiver in the Director's decision or recommendation on the application.

(2) An applicant who obtains a waiver under this section must mitigate adverse effects of the traffic generated from a proposed development.

(3) The traffic generated from a proposed development for which the requirement to submit a traffic impact was waived may not:
(a) In combination with existing traffic, exceed the desirable operating level established in (2.8.8) of this section; or
(b) Endanger the public safety.

2.8.5 Application requirements: A traffic impact analysis prepared by a professional engineer licensed in the State of North Carolina shall be submitted in accordance with § 155.702(C) of the Town UDC. The traffic impact analysis must conform to the requirements of this section and the applicable provisions of this design Manual. The traffic impact analysis report must describe the study methodology, the data used, and the study findings and provide recommendations based on the results.

2.8.6 Definition of impact area: The Director shall determine the geographic area to be included in a traffic impact analysis. Identification of the points of access and key streets and intersections to be affected by development of the subject parcel shall be required. Traffic recorder and turning movement assessment locations may also have to be

determined. The study area shall not extend beyond the point where the project traffic at build-out is less than 10% of the capacity of the roadway or intersection**.**

2.8.7 Consultants: The Planning Director may require that an independent consultant be hired by the Town to perform the required studies, or to review all or part of a study prepared by the applicant's consultant. The Planning Director is authorized to administer the contract for any such consultant.

(1) The Town shall determine the scope of services to be performed by the independent consultant and receive a cost estimate of such services.

(2) The applicant shall provide an amount equal to the cost estimate to the Town, which shall deposit the amount in an escrow or other special account set up for this purpose. Any funds not used shall be returned to the applicant in a timely manner, without interest. If the estimated or actual cost increases during the review from the Town's initial cost estimate, the applicant immediately shall provide an amount equal to the increased cost to the Town, which the town shall deposit in the escrow or special account. The final approval of any application requiring a traffic impact analysis by the Town shall be contingent upon the full payment of all consultant costs incurred for the analysis.

(3) The Town may require additional funds for independent review where a decision-making body expands the scope of the required review; the applicant substantially amends the application; additional meetings involving the consultant are requested by the applicant; or the consultant's appearance is requested at public or affected agency meetings beyond those anticipated in the original scope of services.

2.8.8 Desirable operating levels for certain streets: Traffic on a residential local or collector street is operating at a desirable level if it does not exceed the following levels:

Pavement Width	Vehicles Per Day (ADT)
Less than 30 feet	1,200
30 feet to less than 40 feet	1,800
40 feet or wider	4,000

Editors Note: *Check above numbers with NCDOT*

2.8.9 Action on application

(1) The Planning Director may deny an application if the results of a traffic impact analysis demonstrate that a proposed development may overburden the Town's street system.

(2) The Planning Director shall deny an application if the traffic impact analysis demonstrates that:
(a) The projected traffic generated by the project, combined with existing traffic, exceeds the desirable operating level established in (2.8.8) of this section in the traffic impact analysis study area; or
(b) The project endangers the public safety.

2.8.10 Application modification based on traffic analysis: An applicant may modify an application to minimize the traffic-related effects identified in a traffic impact analysis. Modifications may include:

(1) A reduction in the projected vehicle trips per day;

(2) The dedication of additional right-of-way;

(3) The rerouting of traffic and a proposed access and egress point;

(4) Participation in the funding of a traffic signal or intersection improvement; and

(5) Other modification determined to be necessary.

2.8.11 Appeal of Planning Director's action

(1) An applicant may appeal the Planning Director's denial to the Town Council.

(2) The Town Council may approve the traffic impact analysis if the Council determines that the:
   (a) Applicant has satisfactorily mitigated adverse traffic effects; or
   (b) Additional traffic from the project has an insignificant effect on the Town's streets.

2.8.12 Period of validity: Traffic impact analysis shall be valid for a specific site for no more than 10 years, so long as no significant modifications to the development approved for the site are made.

SECTION 3
PAVEMENT DESIGN

3.1 PAVEMENT DESIGN

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 ensure 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.

3.1.1 Standard Definitions

Average Daily Traffic (ADT): The average daily traffic using the pavement section at full development.

California Bearing Ratio (CBR): The CBR is the penetration resistance of a soil relative to standard crushed rock.

Design Average Daily Traffic ($\overline{ADT}$): The average daily traffic over the design life of the pavement.

ESAL (Equivalent Single Axle Load): Number of standard axle load (18,000 lbs) applications that cause the same damage as mixed traffic.

Pavement Design Life: All pavement structures for the Town of Clayton shall be designed with a pavement design life of 20 years.

Serviceability (used in determining the Truck Factor - Method 2)**:** Defined as the facility's ability to serve the type of traffic based on a specific total traffic volume and a minimum level of serviceability desired at the end of the performance period. The Serviceability index ranges from 0 (impassible road) to 5 (perfect road). The spreadsheets provided herein as standard Town of Clayton worksheets assume a terminal Serviceability of 2 (some cracks and deterioration at the end of the design life; a condition in which 85 of people state the facility is unacceptable).

Soil Support Value (SSV): This value reflects the structural strength of a particular type of soil.

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.

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.

Trip Factor: The number of vehicles that can be assumed for a particular type of land use. This information is derived from the ITE Trip Generation, latest edition/publication.

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

3.2 PAVEMENT DESIGN PROCEDURE

3.2.1 Pavement Design Life

All pavement structures for the Town of Clayton shall be designed with a pavement design life of 20 years.

3.2.2 Determine the Design Average Daily Traffic ($\overline{ADT}$):

From Table 3.01, 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. The figures below shall be the minimum; however, the latest edition of the Institute of Traffic Engineer's *Trip Generation* shall apply.

Table 3.01
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	115.8	1,000 gsf

Table 3.01
Trips per Day According to Land Use
(for pavement design only)

(0 to 50,000 sf)		
• 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		

Table 3.01
Trips per Day According to Land Use
(for pavement design only)

• 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 version.

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 "0."

The traffic growth factor shall be obtained from Equation 3.01.

$$G = (1+i)^n \qquad \text{[Equation 3.01]}$$

Where, G =Traffic growth factor
i =fractional rate of yearly increase, from Table 3.02
n =Design Life of Pavement, years

Table 3.02 Traffic Growth Rate for Pavement Design

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.

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

$$\overline{ADT} = \frac{ADT + (G \times ADT)}{2} \qquad \text{[Equation 3.02]}$$

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

G =Traffic growth factor, as described above

3.2.3 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 axle compared to most vehicles).

The Truck Factor ($\overline{N}$) is the most significant factor in the determination of the pavement cross-section. Therefore, it is important that the Engineer carefully considers the assumptions used in the determination of the Truck Factor.

Two methods of determining the Truck Factor are provided below; the percentage method and the AASHTO ESAL Calculator. The applicable method can be determined using the following table as a guide.

Table 3.02a
Method Design Guide

Project Type	Suggested Method for Determining Truck Factor ($\overline{N}$)
Single-Family Residential S/D's up to 150 lots	Method 1 - Percentage Method[a] or Method 2 - AASHTO ESAL Calculator
Single-Family Residential S/D's greater than 150 lots	Method 2 - AASHTO ESAL Calculator
Collector Streets & Local Thoroughfares	Method 2 - AASHTO ESAL Calculator
Any project or site where truck type and volumes can reasonably be determined and a more precise factor is desired; either to the low or high side (i.e. industrial parks, commercial parks, etc.)	Method 2 - AASHTO ESAL Calculator

[a]The smaller the single-family subdivision, the less significance the Percentage Method tends to have on resulting pavement section. On the other hand, for larger developments, the Percentage Method tends to result in a heavier pavement section.

Method 1: Truck Factor by Percentage Method

The designer may determine the Truck Factor ($\overline{N}$) by Equation 3.03 using these percentages of 4% for single frame trucks (x =0.04) and 1% for multiple frame trucks (y =0.01). Table 3.03 lists equivalent truck factors for various design average daily traffic quantities at these percentages.

$$\overline{N} = \overline{ADT}\,(0.25x + 0.60y) \qquad \text{[Equation 3.03]}$$

Where, $\overline{N}$ =Truck Factor

x = Percentage Single frame trucks

y = Percentage Multiple frame trucks

Table 3.03 Equivalent $\overline{N}$ and $\overline{\overline{ADT}}$ *

$\overline{\overline{ADT}}$	$\overline{N}$
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.

3.2.4 Determine the Soil Support Value (*SSV*)

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

3.2.4.1 Measure the CBR of soils and calculate the *SSV*
3.2.4.2 Measure the CBR of Soils to be used as fill and calculate the *SSV*
3.2.4.3 Assign a *SSV* from the Soil Classification of the County Soil Map

3.2.4.1 Measure the CBR of soils and calculate the *SSV*

The California Bearing Ratio (CBR) is the current accepted method of determining the characteristics of the subgrade base material. The CBR test should be performed in accordance with AASHTO designation T193, *The California Bearing Ratio* (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.

Certification and report of tests performed by an approved soils laboratory shall be submitted to the Town of Clayton Town Engineer.

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

- Soil Borings: Perform soil borings with a maximum spacing of 500 linear feet and with at least 3 borings in each separate street and with at least one boring in each soil type area identified in the soil survey map of the applicable county. Each boring shall extend at least 2 feet below the proposed finished subgrade elevation. The Town may require more depth as conditions warrant.

- CBR Tests: A CBR test shall be performed on each soil type that will be within 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 2 feet below pavement subgrade.

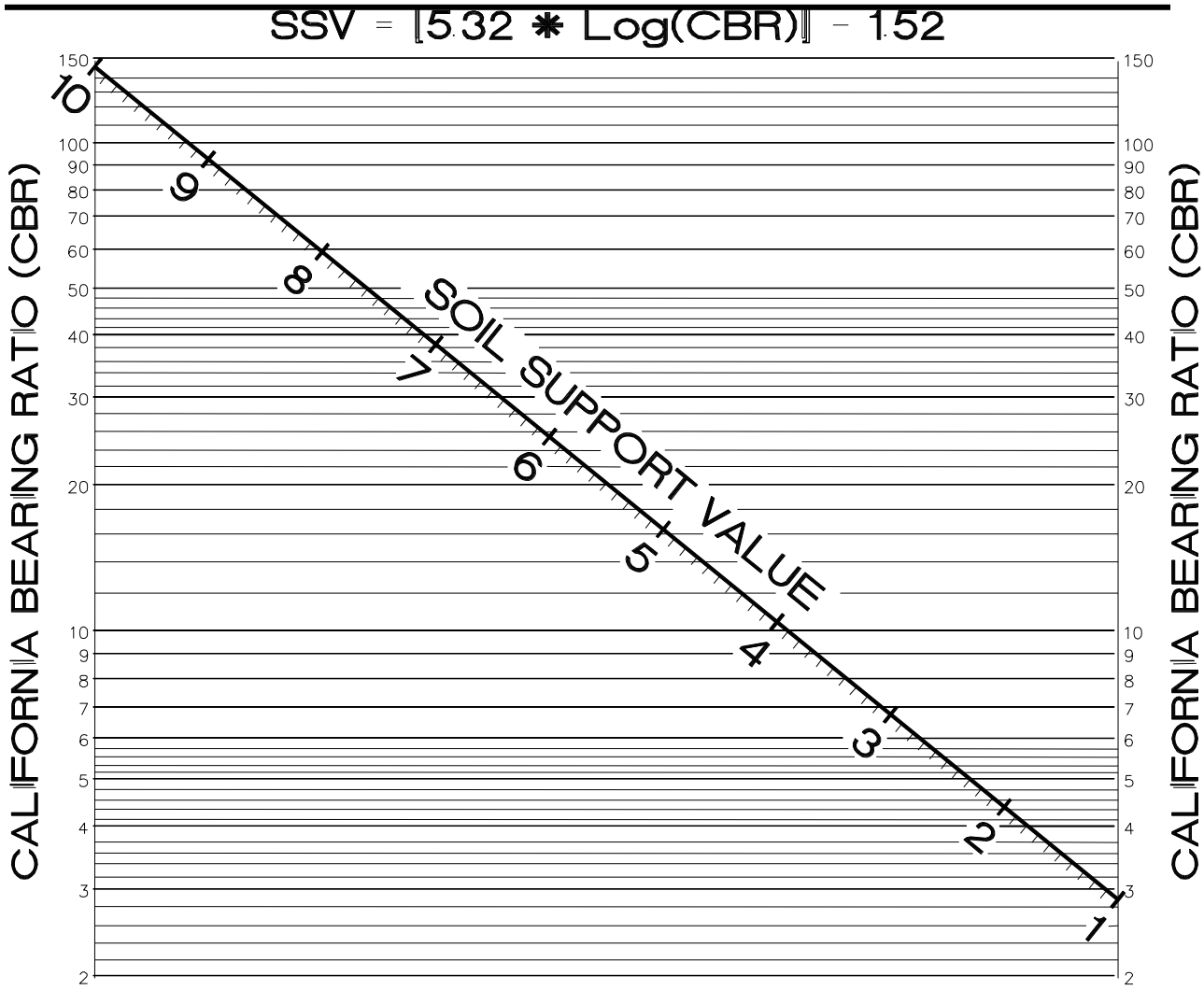
The average CBR value for the section under study shall then be substituted in Equation 3.04 to obtain the soil support value (SSV).

$$SSV = 5.32\,(\log CBR) - 1.52 \qquad \text{[Equation 3.04]}$$

Where, SSV =Soil Support Value
CBR =California Bearing Ratio (as determined by laboratory report or Figure 3.02)

Figure 3.02 can also be use to quickly determine the CBR for the soil in study.

Figure 3.02 Soil Support Values (SSV) per CBR



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

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

If the characteristics of the existing soils in the area to be paved result in an uneconomical pavement section based on the preceding method, the designer may opt to undercut the existing soils to a depth of at least 24 inches below the finished pavement subgrade elevations and backfill with select 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, *The California Bearing Ratio,* latest edition).

The CBR value determined by laboratory testing shall then be substituted in Equation 3.04 to obtain the soil support value (*SSV*).

3.2.4.3 Assign a *SSV* from Soil Classification of the County Soil Map

The soil types may be determined by using, if available, the applicable Soil Survey map prepared by the United States Department of Agriculture (USDA) – Natural Resources Conservation Services. This method is usually more conservative than designs based on actual laboratory data as described in Section 3.2.4.1 and will generally require a thicker pavement section. Consequently, this method is seldom applied or used.

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 Clayton Town Engineer.

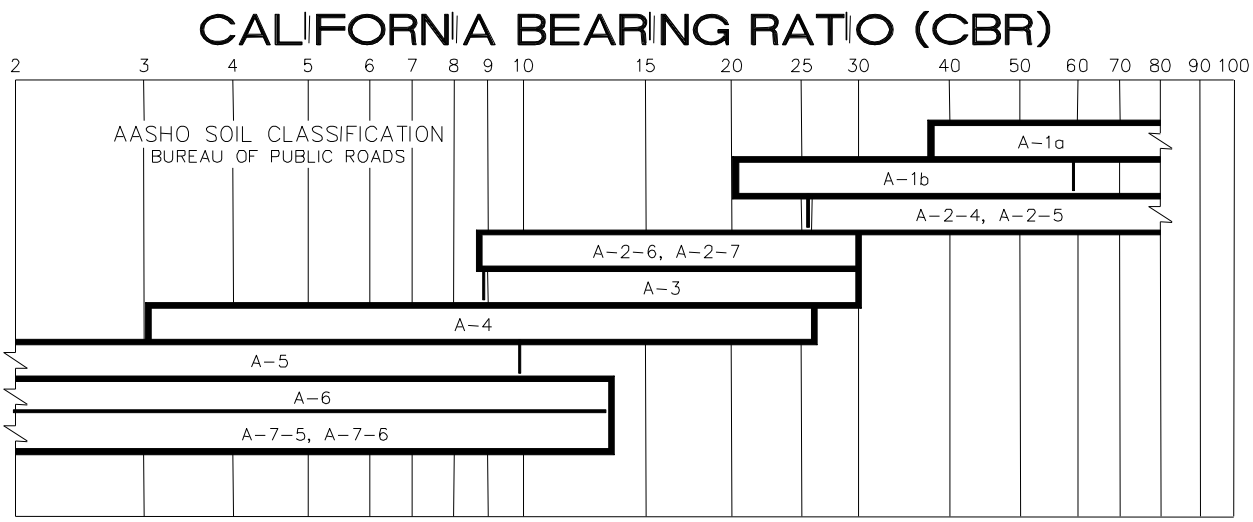
From the Engineering Index Properties Table, determine the AASHTO Classification of the soil types. From this information, use Table 3.04 and/or Figure 3.03 to assign the most appropriate soil support value (*SSV*). The entire paved area shall be designed using the *lowest SSV* obtained along any portion of the paved area. The CBR value determined from Figure 3.03 shall then be substituted in Equation 3.04 to obtain the soil support value (*SSV*).

Table 3.04 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 3.03 CBR Values per Soil Classification



Source: AASHTO Bureau of Public Roads.

3.2.5 Determine the 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. Using Figure 3.04 and/or Equation 3.05, obtain the structural number (SN) for the given soil support value (SSV) and truck factor ($\overline{N}$) [(Method 1 or Method 2, as applicable].

$$SN = \frac{2.41\ (\overline{N})^{0.151}}{(1.14)^{SSV}} \qquad \text{[Equation 3.05]}$$

Where, SN =Structural Number required for the design pavement section
$\overline{N}$ =Truck Factor, see Section 3.2.3
SSV =Soil Support Value, see Section 3.2.4

Minimum Permitted Structural Number

Subgrade Soils	Minimum SN	Min Pavement Section
All Soil Types	2.22	2 1/2" asphalt/8" ABC

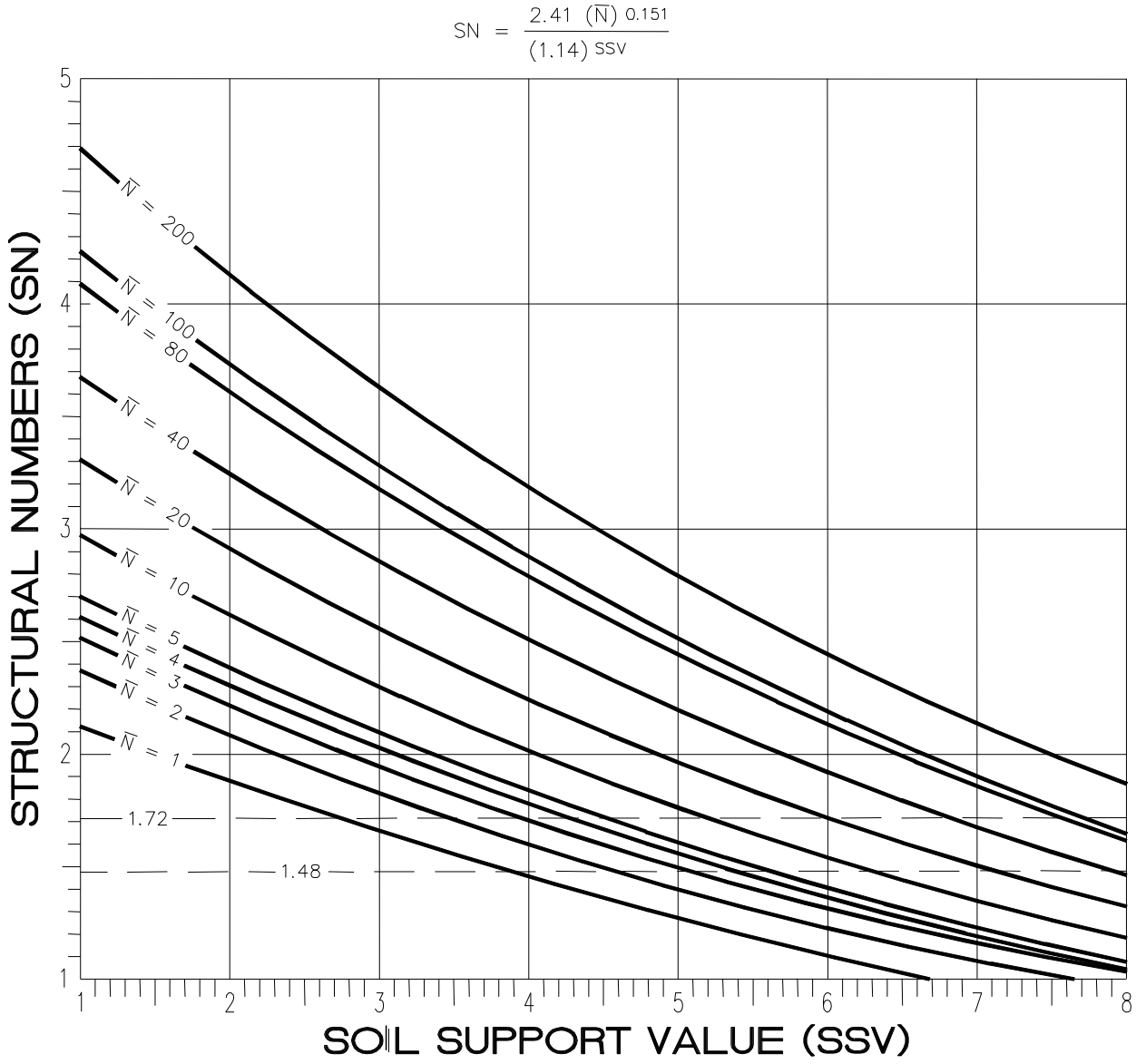
See also paragraph 3.2.7, below and **Standard Detail 401.01**.

Method 1 – If the Percentage Method (Method 1) is used in determining the Truck Factor, the following increases shall be employed in determining the Structural Number (SN).

Required Increase In Structural Number based on Facility Type (Truck Factor computed by Method 1)[a]		
Facility	**ADT (trips per day)**	**To be added to Structural Number[a]**
Collector Streets	3,500 to 6,000	1.0
Minor Thoroughfare	Greater than 6,000	1.5
Major Thoroughfare	Greater than 10,000	2.0

[a] If the AASHTO 1993 ESAL Calculator is used in determining the Truck Factor (Method 2), the above increases are not applicable.

Figure 3.04 Structural Numbers for Pavement Sections



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

3.2.6 Determine the Structural Coefficients

From Table 3.05, determine the structural coefficient for each layer in the design pavement section.

Table 3.05 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 (ABC)	0.14
	Bituminous Concrete Type B 25.0X	0.30
	Cement Treated ABC (CTABC)	0.23
	Crushed Marl	0.10[b]
Subgrade	Cement Stabilized Subgrade (Soil-Cement)	0.14[c]
	Lime Stabilized Subgrade (Soil-Lime)	0.13[c]

[a] Bituminous surface treatment. Do not multiply by thickness in calculations.

[b] NCDOT will not permit use of crushed marl on DOT roads.

[c] For design purposes, do not exceed 1.0 for total depth of subgrade stabilized.

Source: "Paragraph 3.4, *Layer Coefficients*, NCDOT *2002 Asphalt Technology, Construction, Quality Control & Quality Assurance Training manual*."

Commentary on Subgrade Stabilization and Pavement Section Performance:

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.

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

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).

3.2.7 Select Pavement Thickness to Obtain Required Structural Number

Design the pavement section such that the structural number (SN) designed is equal to or greater than the number obtained in Section 3.2.5. This design may be done by trial and error. However, the minimum pavement section in the Town of Clayton shall conform to **Standard Detail 401.01** (also see paragraph 2.1.3, *Standard Street Cross-sections and Pavement Design Criteria* for other requirements pertaining to pavement section thickness). Multiply an initial thickness (in inches) of the various components of the pavement section (surface course, base course, binder course, etc.) 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 3.2.5.

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.

Minimum Asphalt Concrete Pavement Thickness: The minimum total asphalt concrete thickness shall not be less than 2 1/2 inches for any public roadway.

Minimum Aggregate Base Course Thickness: The minimum aggregate base course thickness shall not be less than 8 inches for any public roadway.

3.2.8 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.

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 EXAMPLE OF PAVEMENT DESIGN – METHOD 1 (Truck Factor by Percentage)

Design a pavement section for a local 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 3.01 for single family homes (high density),
     $ADT = 9.5\ trips/day/dwelling \times 100\ dwellings = 950\ trips/day$
   - Using Table 3.02 for a subdivision street (fully developed) the estimated yearly increase is 0.5%; so i = 0.005, in Equation 3.01.
   - Assuming a pavement sections is to be designed for a 20 year design life, let n = 20, in Equation 3.01. It follows that:
     $G = (1+i)^n = (1+0.005)^{20} = 1.10$
     - Using Equation 3.02:
       $$\overline{ADT} = \frac{ADT + (G \times ADT)}{2} = \frac{950 + (1.10 \times 950)}{2} = 998\ trips/day$$

2. Determine the Truck Factor, assuming 4% single frame trucks and 1% multiple frame trucks:
   $\overline{N} = \overline{ADT}\ (0.25x + 0.60y) = 998\ [(0.25)(.04) + (0.60)(0.01)] = 16 \pm$

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 3.04, for A-3 soils, it is found that:
   $SSV = 3.5$

4. Determine the Structural Number (SN). Substituting the known values into Equation 3.05,
   $$SN = \frac{2.41\ (\overline{N})^{0.151}}{(1.14)^{SSV}} = \frac{2.41\ (16)^{0.151}}{(1.14)^{3.5}} = 2.32$$
   2.32 > min SN of 2.22, SN okay!
   (ref. paragraph 3.2.5)

5. Determine Structural Coefficients. Choose an S 9.5B asphalt layer over an ABC layer over the subgrade for the pavement section. From Table 3.05, SF 9.5B coefficient is 0.44 and ABC coefficient is 0.14.

   The minimum pavement section allowed for a local street per **Standard Detail 401.01** is 2 ½" of SF 9.5B and 8" of ABC, SN = 2.22.

6. Select pavement thickness to obtain required structural number. Try several different sections:
   - Try 8" ABC 8 x 0.14 = 1.12
     2.5" S 9.5B 2.5 x 0.44 = 1.10
     2.22 < 2.32, Design *INSUFFICIENT* ☹
   - Try 8" ABC 8 x 0.14 = 1.12
     3" S 9.5B 3 x 0.44 = 1.32
     2.44 > 2.32, Design *SUFFICIENT* ☺

     NOTE: Refer to Table 5.01 for min/max allowable pavement thickness
   - Try 10" ABC 10 x 0.14 = 1.40
     2.5" S 9.5B 2.5 x 0.44 = 1.10
     2.50 > 2.32, Design *SUFFICIENT* ☺

The designer may choose the sufficient pavement section that is preferred. For the given situation, ***choose 3" S 9.5B asphalt over 8" ABC over compacted subgrade as the design pavement section.***

Flexible Pavement Design Using METHOD 2 to Determine Truck Factor ($\overline{N}$)
(AASHTO 1993 ESAL Calculator for Flexible Pavements)

Getting a good handle on a reasonable estimate of the percentage of truck volume and truck type on any given facility can be challenging for most designers. In the absence of such data, the natural tendency is to default to the percentage values provided under Method 1. However, Method 2 enables the designer to reasonably evaluate both truck type and volume in manner that can easily be understood and often defended. Method 2 is the method of choice and can be employed in all cases.

Method 2 was derived from the 1993 AASHTO Guide for Design of Pavement Structures. The Equivalency Factors given in the example spreadsheet (page 42) will vary with the assumed Structural Number (shown at bottom left corner of the spreadsheet). In the example spreadsheet, the Equivalency Factors for the given Vehicle Description are based on an assumed Structural Number *(SN)* of 2. At the end of this section, spreadsheets have been provided for the designer showing Equivalency Factors corresponding to *SN's of* 2, 3, and 4. However, it should be noted that the Truck Factor ($\overline{N}$) will not vary significantly with a Structural Number of 2 yielding a slightly higher Truck Factor than that of either a 3 or a 4. The "assumed" SN values in the spreadsheets relate as follows:

Assumed Structural Number	Facility
2	Local Residential Streets
3	Residential Collector Streets
4	Thoroughfares

Minimum Permitted Structural Number (Method 2 in Small Developments**):** When Method 2 is used in small developments; the resulting Structural Number *(SN)* cannot be less than the minimum permitted Structural Number (see paragraph 3.2.5, *Determine the Structural Number*).

Early Build Out: Method 2 allows the designer to compensate for higher truck volumes and load types that occur during the first few years of subdivision build out. These numbers, and the corresponding number of years this increase in truck loading can be anticipated, can be plugged into the spreadsheet.

Multiple Lanes: If a facility has multiple lanes in one direction, the following table may be used as a guide in determining the distribution factor (D_L):

Number of Lanes in Each Direction	Percent of 18-kip ESAL in Design Lane
1	100
2	80-100
3	60-80
4	50-75

[a]AASHTO Guide for Design of Pavement Structures

Two Optional Lines of Input: The designer has the option to input variables for vehicles not shown in the spreadsheet (e.g. fire apparatus). That data can be input in the "User Defined" rows. However, such data, in particular the equivalency factors, will need to be based on data derived from either AASHTO or other approved source.

3.4 EXAMPLE OF PAVEMENT DESIGN – METHOD 2 (Truck Factor by AASHTO ESAL Calculator)

Design a pavement section for a local 2-lane street accessed by a development consisting of 150 lots in a single-family residential subdivision. There is no possible expansion of the subdivision. An average CBR for the section under consideration is 4.0. Assume a SN of 2.0 (Local Residential Street). Truck loading is estimated to be as follows:

- 3% of the total volume is pickups or vans
- 4 School buses per day (in and out = 8 trips per day)
- 3 package delivery trucks per day (in and out = 6 trips per day)
- 4 garbage trucks, twice per week (in and out = 8 trips per day)
- 3 concrete trucks, one day twice per year (in and out = 6 trips per day) [assumes new construction at ex homes]
- 5 dump trucks, loaded, 3 days per week, 4 times per year (in and out = 10 trips per day) [assumes yard grading, periodic construction, leaf collection, landscaping type construction during life of street]
- 1 moving van (tractor trailer) twice per year (in and out = 2 trips per day)
- 2 building material trucks during start up of S/D every day, every week for 3 years (in and out = 4 trips per day)

Follow the design procedures in this design manual.

Solution:

1. Determine the Design Average Daily Traffic ($\overline{ADT}$):
   - Using Table 3.01 for single family homes,
     $ADT = 9.53\,trips/day/dwelling \times 150\ dwellings = 1430\ trips/day$
   - Using Table 3.02 for a subdivision street (fully developed) the estimated yearly increase is 0.005%, so i = 0.005, in Equation 3.01.
   - Assuming a pavement sections is to be designed for a 20 year design life, let n = 20, in Equation 3.01. It follows that:
     $G = (1+i)^n = (1+0.005)^{20} = 1.10$
   - Using Equation 3.02:
     $$\overline{ADT} = \frac{ADT + (G \times ADT)}{2} = \frac{1430 + (1.10 \times 1430)}{2} = 1502\ trips/day$$
   - Of the 1502 trips per day, we can estimate the pickup truck volume to be: 0.03 x 1502 = 45.
   - The total truck ADT is 80. Therefore, the remaining ADT for passenger cars and other vehicles = 1502-80 = 1422 (Note: The cumulative total of all vehicles should equal 1502).
2. From Figure 3.01 (next page), the Truck Factor = $\overline{N} = 45$
3. Determine the SSV from a CBR of 4.0. Using Equation 3.04, it is found that:
   $SSV = 1.68$
4. Determine the Structural Number (SN). Substituting the known values into Equation 3.05,
   $$SN = \frac{2.41\ (\overline{N})^{0.151}}{(1.14)^{SSV}} = \frac{2.41\ (45)^{0.151}}{(1.14)^{1.68}} = 3.44$$
5. Determine Structural Coefficients. Choose an S 9.5B asphalt layer over an ABC layer over the subgrade for the pavement section. From Table 3.05, S 9.5B coefficient is 0.44 and ABC coefficient is 0.14.
6. Select pavement thickness to obtain required structural number. Try several different sections:
   - Try 8" ABC — 8 x 0.14= 1.12
     4.5" S 9.5B — 4.5 x 0.44= 1.98
     3.10 < 3.44, Design *INSUFFICIENT* ☹
   - Try 10" ABC — 10 x 0.14= 1.40
     2.5" Binder (I.19.0B) — 2.5 x 0.44 = 1.10
     2" S 9.5B — 2 x 0.44= 0.88
     3.38 < 3.44, Design *INSUFFICIENT* ☹

     NOTE: Refer to Table 5.01 for min/max allowable pavement thickness. See also **Standard Detail 401.01** for minimum section thickness.
   - Try 12" ABC — 12 x 0.14= 1.68
     2.5" Binder (I.19.0B) — 2.5 x 0.44= 1.10
     2" S 9.5B — 2 x 0.44 = 0.88
     3.66 > 3.44, Design is *SUFFICIENT* ☺

The designer may choose the sufficient pavement section that is preferred. For the given situation, choose ***2" S 9.5B, 2.5" I.19.0B over 12" ABC over compacted subgrade as the design pavement section.***

Figure 3.01

AASHTO 1993 ESAL Calculator for Flexible Pavements

Vehicle Description	Traffic Volume: Quantity in the Design Lane	Traffic Volume: Days per week	Traffic Volume: Weeks per Year	Analysis Period (years)	Axle Load and Type: Axle 1 (kips)		Axle 2 (kips)		Axle 3 (kips)		Gross Weight (lbs)	Equivalency Factors: Axle 1	Axle 2	Axle 3	Total ESAL's over Analysis Period	ESAL's per day (*N* = Truck Factor)
Passenger Car	1422	7	52	20	2	S	2	S			4,000	0.0002	0.0002	0	4141	0.5672
Pick-up truck or van	45	7	52	20	2	S	4	S			6,000	0.0002	0.003	0	1048	0.1436
Recreational vehicle					4	S	4	S			8,000	0.003	0.003	0	0	0.0000
School Bus	8	5	40	20	6	S	14	S			20,000	0.012	0.338	0	11200	1.5342
TARC bus					8	S	14	S			22,000	0.035	0.338	0	0	0.0000
Greyhound MC-12 bus					13.4	S	18.4	S	6	S	37,800	0.2897	1.118	0.012	0	0.0000
Package delivery truck	6	5	52	20	4	S	14	S			18,000	0.003	0.338	0	10639	1.4574
Beverage delivery truck					6	S	12	S	12	S	30,000	0.012	0.177	0.177	0	0.0000
Garbage/dumpster truck	2	2	52	20	20	S	35	T			55,000	1.59	1.225	0	11710	1.6042
Concrete truck (full)	3	1	2	20	20	S	48	R			68,000	1.59	0.992	0	310	0.0424
Dump truck (full)	10	3	4	20	20	S	48	R			68,000	1.59	0.992	0	6197	0.8489
Semi-tractor (no trailer)					8	S	2	T			10,000	0.035	0	0	0	0.0000
Semi-tractor trailer (empty)					8	S	8	T	6	T	22,000	0.035	0.003	0.001	0	0.0000
Semit-tractor trailer	2	1	15	20	12	S	34	T	34	T	80,000	0.177	1.07	1.07	1390	0.1904
Bldg Material Trucks	4	5	52	3	8	S	32	S			40,000	0.035	13.5	0	42229	38.5655
User Defined															0	0.0000
Vehicle type H10					4	S	16	S			20,000	0.003	0.598	0	0	0.0000
Vehicle type H15					6	S	24	S			30,000	0.012	3.62	0	0	0.0000
Vehicle type H20					8	S	32	S			40,000	0.035	13.5	0	0	0.0000
Vehicle type 3					16	S	34	T			50,000	0.598	1.07	0	0	0.0000
Vehicle type HS15					6	S	24	S	24	S	54,000	0.012	3.62	3.62	0	0.0000
Vehicle type HS20					8	S	32	S	32	S	72,000	0.035	13.5	13.5	0	0.0000
Vehicle type 3S2					10	S	31	T	31	T	72,000	0.085	0.723	0.723	0	0.0000
	1502															

Terminal Serviceability, p_t	2
Assumed Structural Number, SN	2
Traffic Growth Rater, %/yr	0

Summary:			
Total AASHTO ESAL's		88,865	44.954
	Superpave	ESAL Class 1	
Traffic Category			

Project: **Test 1** Location: **Bedford Falls**

Job No.: **ACE 07-105** Date

Appian Consulting Engineers, PA
Ref: AASHTO Guide for Design of Pavement Structure
Last Rev: 12/18/07

NOTES:
1. Value of $\overline{N}$ = Truck Factor. $\overline{N}$ is then used in formula to determine *SN*.
2. One ESAL = 18 kips

This form to be used as an alternate method to determine the truck factor (N) for large residential developments (>150 SF lots) or site/facilities with unique truck counts (high or low).

SECTION 4
SUBGRADE PREPARATION AND TESTING

The purpose of this division is to provide a guide for the subgrade preparation of paved areas within the Town of Clayton.

4.1 SUBGRADE INSPECTION – CONFIRM CBR TESTS

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.

4.2 SUBGRADE INSPECTION – DENSITY TESTS

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 section 02200, *Earthwork*. The test results shall be submitted to and approved by the Town Engineer prior to placement of stone base.

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 Engineer, the Town Engineer may require that density tests be performed in those areas during placement of borrow/fill.

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

4.3 SUBGRADE INSPECTION – PROOFROLLING

No pavement shall be placed in the Town of Clayton without prior inspection and approval by the Town Engineer. The inspection shall include, but not be limited to proof-rolling the prepared subgrade with a rubber-tired proof-roller (**fully loaded** dump truck) that has a minimum gross weight of at least 30,000 pounds (15 tons) under the observation of a representative of the Town. No other proofrolling method will be acceptable. The developer shall bear the costs of proof-rolling, which must be done within 10 days prior to placement of the stone and/or 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).

The earthen subgrade must pass a "zero-tolerance" 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.

Any areas that rut or pump excessively under the wheels of the proof-roller, as determined by the Town Engineer, shall be repaired by the Contractor before the street is stoned or paved. Those repaired areas, at the discretion of the Town 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.

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 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 Engineer reserves the right to request/require such additional tests as deemed necessary to satisfy himself/herself as to the adequacy of the subgrade.

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

SECTION 5
STREET INSPECTIONS

5.1 INSPECTIONS

5.1.1 Minimum Inspection Requirements:

The following shall be the minimum inspections required by the Town:

a. **Proofroll Curb & Gutter**
b. **Proofroll Street Subgrade:** See paragraph 4.3 above for proof rolling procedure. If stone is used to help stabilize subgrade, the proof roll must be at subgrade elevation.
c. **Cross-fall on Subgrade**: Cross-fall on subgrade, from crown to curb, shall be checked with a string line prior to placement of base course.
d. **Base Course**: The base course shall be proofrolled just prior to placement of asphalt. Cross-fall 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.
e. **Curb & Gutter Concrete Sampling**: Concrete samples must be taken for slump and strength (as specified in 02400, *Curb & Gutter, Driveways & Sidewalks*). See paragraph 5.2, TESTING, below.
f. **Paving Lifts**: If the proposed depth of asphalt exceeds the maximum layer depth shown in Table 5.01 below, the asphalt must be placed in **two lifts;** the first lift having a thickness of not less than minimum single lift depth shown in Table 5.01 below. Asphalt cores must be taken to confirm thickness and compaction. See paragraph 5.2, TESTING below.

Table 5.01 Recommended Thickness Chart

Mix Type	Minimum Single Lift Depth (inches)	Maximum Single Lift (inches)	Maximum Layer Total Depths (inches)
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

[a] X=Level of Service
[b] For B 25.0X placed on stabilized subgrade, minimum lift thickness is 4.0 inches.
Source: NCDOT 2006 HMA/QMS Manual.
[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.

g. **Temperature** (Ambient Air and Mix): See temperature requirements for asphalt in 02740 – *Base Coarse and Paving*, paragraph 3.6.3, I, *Placement Limitations*. For concrete, see 02400 – *Curb & Gutter, Driveways & Sidewalks,* paragraph 3.1.6 B and C, *Cold Weather Curing and Hot Weather Curing, respectively*.

h. **Forms:** Curb & Gutter, Sidewalk, and Driveway forms and subgrade shall be checked prior to pouring. Slump and strength tests shall be required.
i. **Driveway Culvert Grades**: Driveway culverts must be installed to ensure positive and uniform ditch flow line grade between publicly maintained structures/culverts.
j. **Street Grade and Alignment**: The Town is not responsible for ensuring proper grade and alignment of streets.

5.1.2 Geotechnical Engineering Inspection Services:

The services of a Geotechnical Engineer shall be required in all cases where unusual soil conditions have been found during construction such as high groundwater elevation, springs, soft or yielding soils, unsuitable soils (e.g. expansive soils).

5.1.3 Inspection Fee

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

5.1.4 Inspection Procedure

Warranty, maintenance during warranty period, inspection procedure, repairs, utility cuts, etc. are covered under Section 6, *Street Policy*.

5.2 TESTING

5.2.1 Concrete Testing:

Initial Test: 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 three 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

Subsequent tests: After the above tests are pulled from the initial truck, every fifth 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.

Slump Test Limitations:

APPLICATION	ALLOWABLE SLUMP
Hand poured Curb and Gutter	2” to 3 ½”
Machine formed Curb and Gutter	0-2”
Other Applications	as specified by Town Engineer

5.2.2 Asphalt Testing:

Compaction: Testing for asphalt density is to follow NCDOT *Standard Specifications for Roads and Structures*, Section 609-5D, “Field Compaction Quality Control,” latest revision.

Thickness and Testing Frequency: The minimum frequency of coring for thickness testing shall be based on test sections consisting of not more than 300 linear feet of lay down length, exclusive of intersections and irregular areas. Every third cored sample shall be taken at street quarter points. The test sample is to be a 6-inch cored sample. The sample is to be numbered and logged for identification purposes. If it is found that the thickness of the asphalt is less than that required, a maintenance fee may be accepted in lieu of rejection. If less than 75% of the required thickness is present, the project must be rejected until the proper thickness is achieved.

Contractor's Quality Control System: Follow NCDOT "Standard Specifications for Roads and Structures," Section 609-5. "Contractor's Quality Control System," latest revision

Mixture and Job Mix Formula Adjustments: Follow NCDOT *Standard Specifications for Roads and Structures*, Section 609-4, "Field Verification of Mixture and Job Mix Formula Adjustments," latest revision.

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.

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

5.3 SETUP PERIOD

A setup period is not permitted. The full depth of asphalt must be placed in conformity to the NCDOT Standard Specifications for Roads and Structures, latest edition and in accordance with the NCDOT Superpave Hot Mix Asphalt Quality Management System, latest edition.

5.4 MAINTENANCE

For warranty, maintenance during warranty period, inspection procedure, repairs, utility cuts, etc. see *Street Policy*, Section 6.

5.5 WARRANTY

Warranty, maintenance during warranty period, inspection procedure, repairs, utility cuts, etc. are covered under Street Policy, Section 6.

SECTION 6
STREET POLICY

6.1 GENERAL REQUIREMENTS:

1. 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 Sedimentation and Erosion Control permit from the State. All other construction must await the issuance of all remaining permits.

2. Prior to the issuance of a certificate of occupancy for any dwelling, an Engineer's certification must be received by the Town, addressed to NCDENR, for both water and sewer extensions. Additionally, as-built drawings must be in hand and the gravity sewer lines confirmed to be within the permitted tolerances.

3. The developer is responsible for the maintenance and repair of streets for 12 months after acceptance by the Town for warranty. At the end of 12 months, the Town of Clayton will accept permanent responsibility. If a significant failure occurs, requiring extensive maintenance at any time during the warranty period, the Town's Engineer shall suspend the 12-month warranty until the failure is repaired to an acceptable condition.

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

5. No Contractor shall permit mud or construction debris to accumulate in any paved street that is maintained or is proposed to be maintained by the Town of Clayton.

6.2 INSPECTIONS

1. 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, the submission of Engineering's certifications, and acceptance by Town Council, a 12-month warranty period shall commence.

2. During the 12-month warranty period the developer shall repair any latent defects that occur. Prior to the end of the 12-month 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.

3. 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.

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

6.3 MAINTENANCE

6.3.1 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. If the Town allows these improvements, it shall require the owner to bear the full cost.

6.4 NEW STREETS

All streets constructed as part of a new subdivision or other development shall be constructed at the sole expense of the developer.

6.4.1 Warranty/Repairs Performance Guarantee

Upon completion of construction of new streets, the developer shall request a final inspection. Upon completion of all punch list items, the developer shall submit to the Town Engineer a set of acceptable record drawings. Upon approval of these materials by Town Council, a 12-month warranty period shall commence.

During the 12-month warranty period, the developer shall repair any latent defects that occur. At the end of the 12-month warranty period, the developer shall request an end of warranty inspection. Upon successful completion of all warranty items, the developer shall be released from maintenance responsibilities for the warranted construction.

Warranty repairs to the following common problems shall be as follows:

1. Trench failures in pavement shall be repaired in accordance paragraph 6.5 Utility Cuts, below.

2. The Town Engineer may require a 1-inch overlay over any segment of street in which there are trench failures. A trench failure shall be defined as a depression of ½ inch or greater at the deepest point over a trench width. The extent of resurfacing shall be as determined by the Town Engineer.

3. Structural cracks in sidewalk and/or curb and gutter shall be repaired by removing and re-pouring such sections as necessary. Cracked or defective curb is to be removed prior to paving.

4. Pavement, sidewalk, or curb and gutter failures caused by latent subsurface problems shall be repaired in accordance with the recommendations of an approved Geotechnical Engineer.

5. All storm sewer systems, ditches, sanitary sewers, and streets shall be free of debris, dirt or silt.

6. All water, sewer, storm sewer, drainage, and street appurtenances shall be in perfect condition and properly exposed (particularly water meters and sewer cleanouts).

7. All other defects shall be corrected in accordance with the recommendations of the Town Engineer or his/her representative.

If a developer fails to complete warranty items, future projects of the developer will not be reviewed by the Town until such defects have been corrected. In addition, the Town may take additional legal action against the developer.

6.4.2 Performance Guarantee

Following installation of erosion controls, the developer may proceed with installation of all required improvements in accordance with the approved construction drawings and the requirements of the Manual of Specifications, Standards and Design, latest revision. In lieu of installation of such improvements, the subdivider shall provide sufficient guarantee that such improvements will be installed in accordance with section 155.607 of the UDC.

6.5 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 of the following ways:

1. Repair in accordance with **Standard Detail C01.03**, or

2. Backfill cut with flowable fill concrete to within 2 inches of the pavement surface and top with 2 inches of S 9.5B asphalt. Excavatable flowable fill shall have a compressive strength of no less than 30 psi and no more than 100 psi. See Part 2-*Products*, 02275, *Trenching, Backfilling, and Compaction of Utilities* for more information relating to flowable fill concrete.

6.6 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. 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 by seeding, or at the Town's option, sod. The Town will not be responsible for replacing a property owner's sod after repairing a utility line.

SECTION 7
BIBLIOGRAPHY

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4. Haung, Yang H., *Pavement Analysis and Design*, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1993.

5. Holtz, Robert D. and William Kovacs, *An Introduction to Geotechnical Engineering*, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1981.

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7. Transportation Research Board, National Cooperative Highway research Program (NCHRP).

8. NCDOT, *SuperPave Hot Mix Asphalt Quality Management System*, 2005 Asphalt Technology, Construction, Quality Control & Quality Assurance Training Manual.

9. NCDOT *Standard Specifications for Roads and Structures*, 2006

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Figure 3.01

AASHTO 1993 ESAL Calculator for Flexible Pavements

Vehicle Description	Traffic Volume			Analysis Period (years)	Axle Load and Type						Gross Weight (lbs)	Equivalency Factors			Total ESAL's over Analysis Period	ESAL's per day (*N* = Truck Factor)
	Quantity in the Design Lane	Days per week	Weeks per Year		Axle 1 (kips)		Axle 2 (kips)		Axle 3 (kips)			Axle 1	Axle 2	Axle 3		
Passenger Car					2	S	2	S			4,000	0.0002	0.0002	0		
Pick-up truck or van					2	S	4	S			6,000	0.0002	0.003	0		
Recreational vehicle					4	S	4	S			8,000	0.003	0.003	0		
School Bus					6	S	14	S			20,000	0.012	0.338	0		
TARC bus					8	S	14	S			22,000	0.035	0.338	0		
Greyhound MC-12 bus					13.4	S	18.4	S	6	S	37,800	0.2897	1.118	0.012		
Package delivery truck					4	S	14	S			18,000	0.003	0.338	0		
Beverage delivery truck					6	S	12	S	12	S	30,000	0.012	0.177	0.177		
Garbage/dumpster truck					20	S	35	T			55,000	1.59	1.225	0		
Concrete truck (full)					20	S	48	R			68,000	1.59	0.992	0		
Dump truck (full)					20	S	48	R			68,000	1.59	0.992	0		
Semi-tractor (no trailer)					8	S	2	T			10,000	0.035	0	0		
Semi-tractor trailer (empty)					8	S	8	T	6	T	22,000	0.035	0.003	0.001		
Semit-tractor trailer					12	S	34	T	34	T	80,000	0.177	1.07	1.07		
User Defined																
User Defined																
Vehicle type H10					4	S	16	S			20,000	0.003	0.598	0		
Vehicle type H15					6	S	24	S			30,000	0.012	3.62	0		
Vehicle type H20					8	S	32	S			40,000	0.035	13.5	0		
Vehicle type 3					16	S	34	T			50,000	0.598	1.07	0		
Vehicle type HS15					6	S	24	S	24	S	54,000	0.012	3.62	3.62		
Vehicle type HS20					8	S	32	S	32	S	72,000	0.035	13.5	13.5		
Vehicle type 3S2					10	S	31	T	31	T	72,000	0.085	0.723	0.723		

Terminal Serviceability, r_t	2
Assumed Structural Number, SN	2
Traffic Growth Rater, %/yr	0

Summary:			
Total AASHTO ESAL's			
	Superpave	ESAL Class 1	
Traffic Category			

Project: _____ Location: _____

Job No.: _____ Date _____

Appian Consulting Engineers, PA

Ref: AASHTO Guide for Design of Pavement Structure

Last Rev: 12/18/07

NOTES:

1. Value of $\overline{N}$ = Truck Factor. $\overline{N}$ is then used in formula to determine *SN*.
2. One ESAL = 18 kips

This form to be used as an alternate method to determine the truck factor (N) for large residential developments (>150 SF lots) or site/facilities with unique truck counts (high or low).

Figure 3.01

AASHTO 1993 ESAL Calculator for Flexible Pavements

Vehicle Description	Traffic Volume			Analysis Period (years)	Axle Load and Type						Gross Weight (lbs)	Equivalency Factors			Total ESAL's over Analysis Period	ESAL's per day (*N* = Truck Factor)
	Quantity in the Design Lane	Days per week	Weeks per Year		Axle 1 (kips)		Axle 2 (kips)		Axle 3 (kips)			Axle 1	Axle 2	Axle 3		
Passenger Car					2	S	2	S			4,000	0.0002	0.0002	0		
Pick-up truck or van					2	S	4	S			6,000	0.0002	0.002	0		
Recreational vehicle					4	S	4	S			8,000	0.002	0.002	0		
School Bus					6	S	14	S			20,000	0.011	0.354	0		
TARC bus					8	S	14	S			22,000	0.036	0.354	0		
Greyhound MC-12 bus					13.4	S	18.4	S	6	S	37,800	0.3045	1.112	0.011		
Package delivery truck					4	S	14	S			18,000	0.002	0.354	0		
Beverage delivery truck					6	S	12	S	12	S	30,000	0.011	0.189	0.189		
Garbage/dumpster truck					20	S	35	T			55,000	1.56	1.23	0		
Concrete truck (full)					20	S	48	R			68,000	1.56	1.015	0		
Dump truck (full)					20	S	48	R			68,000	1.56	1.015	0		
Semi-tractor (no trailer)					8	S	2	T			10,000	0.036	0	0		
Semi-tractor trailer (empty)					8	S	8	T	6	T	22,000	0.036	0.003	0.001		
Semit-tractor trailer					12	S	34	T	34	T	80,000	0.189	1.08	1.08		
User Defined																
User Defined																
Vehicle type H10					4	S	16	S			20,000	0.002	0.613	0		
Vehicle type H15					6	S	24	S			30,000	0.011	3.43	0		
Vehicle type H20					8	S	32	S			40,000	0.036	12.4	0		
Vehicle type 3					16	S	34	T			50,000	0.613	1.08	0		
Vehicle type HS15					6	S	24	S	24	S	54,000	0.011	3.43	3.43		
Vehicle type HS20					8	S	32	S	32	S	72,000	0.036	12.4	12.4		
Vehicle type 3S2					10	S	31	T	31	T	72,000	0.09	0.7445	0.7445		

Terminal Serviceability, r_t	2
Assumed Structural Number, SN	3
Traffic Growth Rater, %/yr	0

Summary:	Total AASHTO ESAL's		
	Superpave	ESAL Class 1	
	Traffic Category		

Project: _____ Location: _____

Job No.: _____ Date _____

NOTES:

1. Value of $\bar{N}$ = Truck Factor. $\bar{N}$ is then used in formula to determine *SN*.
2. One ESAL = 18 kips

Appian Consulting Engineers, PA

Ref: AASHTO Guide for Design of Pavement Structure

Last Rev: 12/18/07

This form to be used as an alternate method to determine the truck factor (N) for large residential developments (>150 SF lots) or site/facilities with unique truck counts (high or low).

Figure 3.01

AASHTO 1993 ESAL Calculator for Flexible Pavements

Vehicle Description	Traffic Volume			Analysis Period (years)	Axle Load and Type						Gross Weight (lbs)	Equivalency Factors			Total ESAL's over Analysis Period	ESAL's per day ($\bar{N}$ = Truck Factor)
	Quantity in the Design Lane	Days per week	Weeks per Year		Axle 1 (kips)		Axle 2 (kips)		Axle 3 (kips)			Axle 1	Axle 2	Axle 3		
Passenger Car					2	S	2	S			4,000	0.0002	0.0002	0		
Pick-up truck or van					2	S	4	S			6,000	0.0002	0.002	0		
Recreational vehicle					4	S	4	S			8,000	0.002	0.002	0		
School Bus					6	S	14	S			20,000	0.01	0.35	0		
TARC bus					8	S	14	S			22,000	0.033	0.35	0		
Greyhound MC-12 bus					13.4	S	18.4	S	6	S	37,800	0.2999	1.11	0.01		
Package delivery truck					4	S	14	S			18,000	0.002	0.35	0		
Beverage delivery truck					6	S	12	S	12	S	30,000	0.01	0.183	0.183		
Garbage/dumpster truck					20	S	35	T			55,000	1.55	1.23	0		
Concrete truck (full)					20	S	48	R			68,000	1.55	1.014	0		
Dump truck (full)					20	S	48	R			68,000	1.55	1.014	0		
Semi-tractor (no trailer)					8	S	2	T			10,000	0.033	0	0		
Semi-tractor trailer (empty)					8	S	8	T	6	T	22,000	0.033	0.003	0.001		
Semit-tractor trailer					12	S	34	T	34	T	80,000	0.183	1.08	1.08		
User Defined																
User Defined																
Vehicle type H10					4	S	16	S			20,000	0.002	0.612	0		
Vehicle type H15					6	S	24	S			30,000	0.01	3.33	0		
Vehicle type H20					8	S	32	S			40,000	0.033	11.5	0		
Vehicle type 3					16	S	34	T			50,000	0.612	1.08	0		
Vehicle type HS15					6	S	24	S	24	S	54,000	0.01	3.33	3.33		
Vehicle type HS20					8	S	32	S	32	S	72,000	0.033	11.5	11.5		
Vehicle type 3S2					10	S	31	T	31	T	72,000	0.085	0.7425	0.7425		

Terminal Serviceability, r_t	2
Assumed Structural Number, SN	4
Traffic Growth Rater, %/yr	0

Summary:			
	Total AASHTO ESAL's		
	Superpave	ESAL Class 1	
	Traffic Category		

Project: _____ Location: _____

Job No.: _____ Date _____

NOTES:

1. Value of $\bar{N}$ = Truck Factor. $\bar{N}$ is then used in formula to determine *SN*.
2. One ESAL = 18 kips

Appian Consulting Engineers, PA

Ref: AASHTO Guide for Design of Pavement Structure

Last Rev: 12/18/07

This form to be used as an alternate method to determine the truck factor (N) for large residential developments (>150 SF lots) or site/facilities with unique truck counts (high or low).