CHAPTER 5

PAVEMENT DESIGN AND TECHNICAL CRITERIA

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CHAPTER 5 - PAVEMENT DESIGN AND TECHNICAL CRITERIA

5.1 GENERAL

5.1.1 This Chapter provides the basic Criteria and Design Procedures for roadway pavements. Recommended design methodologies for asphalt and Portland cement concrete are addressed and essentially follow the Colorado Department of Highways methodology. Some standardization of criteria has been made in design procedures.

5.1.2 Pavement Design Report Submittal Options
There are two acceptable submittal options for pavement design geotechnical reports related to the final construction plans:

5.1.2.1 The final pavement design may be completed concurrent with the final construction plans, with the pavement section dimensions and pavement material and construction specifications included in the final construction plan submittal. All soil samples must be taken after overlot grading has been completed.

5.1.2.2 The final pavement design may be completed and submitted after Town approval of the associated street plan, profile and drainage final construction plans.

If option 1 is chosen, the applicant may obtain all necessary construction permits when the final construction plans are approved by the Town. If option 2 is used, the applicant may obtain pavement construction permits only after the final construction plans, which include the pavement design approved by the Town. If option 2 is used, the application for pavement design approval must be in accordance with this Chapter.

5.1.3 Preliminary Pavement Design Reports
For all Bennett Land Development approvals that involve a subdivision improvements agreement for

roadway construction, the applicant must provide, at minimum, a preliminary subgrade investigation and pavement design report that recommends typical pavement structural section based on the known site soil conditions and the valid Traffic Impact Study. The preliminary reports shall use the Equivalent (18 Kip) Daily Load Applications (EDLA) of Table 5.2. This preliminary pavement design serves as a justification of the roadway improvement costs included in the subdivision improvements agreement.

5.2 SUBGRADE INVESTIGATION

5.2.1 Field Investigation

The field investigation shall consist of borings or other suitable methods of sampling subgrade soils to depth of at least 5 feet below proposed subgrade elevation (10 feet below proposed subgrade on arterial roadways), at spacings of not more than 250 feet unless otherwise accepted by the Engineering Division. Every fifth hole shall be 10 feet deep. Samples shall be taken after grading is completed and the subgrade is rough cut.

TABLE 5.1

SUBGRADE INVESTIGATION AND PAVEMENT DESIGN CHECK LIST

SOIL CONSULTANT SUBDIVISION FILING JOB# STREET	OK		REVIEWED BY: REJECTED
DATE 1. VICINITY MAP	YES	NO	COMMENT
2. DRAWING WITH LOCATION OF BORING			
3. DRAWING WITH ESTIMATED EXTENT OF SOIL TYPES AND EDLA			
4. DRAWING WITH PAVEMENT ALTERNATIVES			
5. ATTERBERG LIMITS & % PASSING NO. 200 SIEVE			
6. CORRECT SOIL CLASSIFICATIONS			
7. COMPOSITE SAMPLES: CORRECTLY GROUPED AT 250' MAXIMUM INTERVALS			
8. FOR CBR TESTING -MOISTURE DENSITY CURVES -STRESS-STRAIN CURVES OF CBR'S SHOWN -SURCHARGE WEIGHTS (CORRECT UNIT WEIGHTS, INTENSITY OF LOADING EQUAL TO MASS OF PAVEMENT DESIGN ± 5LBS -PERCENTAGE OF SWELL ON STRESS-STRAIN CURVES -MOISTURE CONTENT&DRY DENSITY FOR EACH SAMPLE			
8b. FOR R-VALUE TESTING -DRY DENSITY & MOISTURE CONTENT FOR EACH SAMPLE -EXPANSION PRESSURE FOR EACH SAMPLE -EXUDATION PRESSURE-R VALUE CURVE			
9. DESIGN NOMOGRAPH SHOWN WITH CORRECT SOIL SUPPORT AND EDLA			
10. CORRECT DESIGN COEFFICIENT USED FOR ASPHALT, BASE COURSE, ETC.			
11. DESIGN CALCULATIONS SHOWN FOR ALL PHASES OF SOIL REPORT			
12. MINIMUM PAVEMENT SECTIONS MET FOR PROPER CLASSIFICATION			
13. SPECIAL PROBLEMS (EXPANSION, FROST HEAVE, GROUNDWATER) WITH DESIGN & CONSTRUCTION PROBLEM			
14. IF THE DENVER/COLORADO/ CONSOLIDATION SWELL TEST SHOWS OVER 2.00% SWELL PROPOSED MITIGATIVE MEASURES ACCEPTABLE TO TOWN ENGINEER			

5.2.2 Classification Testing

Each subgrade sample shall be tested to determine Liquid Limit, Plastic Limit, Plasticity Index, Atterberg Limits and the percentage passing the U.S. Standard No. 200 sieve. Samples of sand and gravels may require gradation analysis for classification determination. These data shall be determined using the following methods:

Liquid Limit - AASHTO T 89 (ASTM D 4318)
Plastic Limit - AASHTO T 90 (ASTM D 4318)
% Passing No. 200 - AASHTO T 11 (ASTM C 117)
Gradation - AASHTO T 27 (ASTM D 422)

The results of these tests shall be used to calculate the AASHTO Classification and Group Index using AASHTO M 145.

5.2.3 Soil Grouping

To facilitate subgrade support testing, soil samples collected in the field investigation can be combined to form soil groups. These groups shall be based upon the AASHTO Classification, Group Index and location within the area investigated. Grouping shall not consist of samples with different AASHTO Classifications (Note: there may be more than one group within a given classification). Composite samples can be manufactured by combining small portions of each subgrade sample contained within the group and mixing to provide a uniform composite sample of the soil group. Composite samples shall be subjected to Classification Testing as outlined in Item 5.2.2

5.2.4 Subgrade Support Testing

Individual subgrade or composite samples shall be tested to determine the subgrade support value using either CBR (California Bearing Ratio) or Hveem Stabilimeter (R-Value) testing. These

values shall be used in the design of pavement sections in accordance with the procedures outlined in Section 5.4. Tests shall be conducted in accordance with the procedures listed below in items 5.2.4.1 or 5.2.4.2.

5.2.4.1 CBR Tests - California Bearing Ratio Tests shall be conducted in accordance with AASHTO T 193 with the following modifications:

a. Note 4 of AASHTO T 193 shall not apply. A 3 point CBR evaluation is required.
b. The requirement for compaction shall be per Table 8.2 of these Standards.
c. Surcharge shall be calculated using a unit weight of 140 pcf for bituminous pavement and 135 pcf for untreated aggregate base course.
d. The design CBR value shall be determined from the CBR - Dry Density Curve and shall be the CBR value at 95 percent compaction.
e. In addition to the values requested in AASHTO T 193, Stress-Penetration curves for each sample, a CBR - Dry Density curve and Proctor Compaction Test result shall be reported.

5.2.4.2 R-Value Tests - Hveem Stabilizer tests shall be conducted in accordance with AASHTO T 190. The Design R-Value shall be at 300 psi exudation pressure. The reported data shall consist of:

a. Dry Density and moisture content for each sample.
b. Expansion pressure for each sample.
c. Exudation Pressure-corrected R-Value curve showing the 300 psi Design R-Value

5.2.4.3 Swell Test - A Colorado Swell Test (also referred to as the Denver Swell Test or Swell Consolidation Test)shall be required on all pavement design reports. See section 5.7 of this Chapter.

If the swell (at an overburden pressure of 150-200 psf, at 95% compaction, and at optimum moisture within 2%) is 2.0% or greater, the pavement design report must provide mitigative measures to minimize the destructive swell potential. Mitigation could be overexcavation and replacement with suitable non-expansive material to a depth sufficient to protect the pavement, lime treatment, french drains, or other procedures acceptable to the Public Works Department as recommended and supported by a geotechnical engineer. Moisture treatment, by itself, may not be an adequate mitigative measure. If expansive soil mitigation is made, the soil treatment shall extend to the back-of-curb (if detached walk or no walk), or to the back of the walk (if attached or monolithic walk).

5.3 PAVEMENT DESIGN CRITERIA

5.3.1 General

This section provides the parametric input data to be used for the design of pavements of various roadway classifications.

5.3.2 Equivalent (18 Kip) Daily Load Applications (EDLA)

The pavement design procedure in this Chapter provides for a 20 year service life of pavement, given that normal maintenance is provided to keep roadway surface in an acceptable condition. EDLA and Design Traffic Number (DTN) are considered equivalent units based on 20 year design criteria and an 18 kip axle loading. All Data and Design nomographs in this Chapter use EDLA units for pavement loading repetitions.

EDLA criteria for each Town of Bennett Roadway Classifications are given in Table 5.2.

TABLE 5.2
RECOMMENDED EQUIVALENT (18Kip) DAILY
LOAD APPLICATIONS (EDLA)

CLASSIFICATION	CLASS MODIFIER	EDLA VALUES [1]
Local	Residential	
	Serving<80 D.U.	5
	Others	10
	Commercial[2]	30
	Industrial[2]	100
Minor Collector	Residential	30
	Commercial[2]	50
	Industrial[2]	150
Major Collector[2]	Residential	100
	Commercial	100
	Industrial	150
Minor Arterial[2]	All	200
Major Arterial[2]	All	200

[1] Alternative EDLA values may be considered with justification provided by the Traffic Impact Study, proposed land uses, and traffic analysis that defines proportion of truck vehicles.

[2] EDLA shall be calculated based on projected traffic uses. Minimum EDLA values are as prescribed in Table 5.2

5.3.3 Design Serviceability

The following criteria shall be used for all Town of Bennett roadways to be dedicated for public use:

TABLE 5.3
SERVICEABILITY INDEX

ROADWAY CLASSIFICATION	S1
ARTERIALS (minor major)	2.5
COLLECTORS	
Major	2.5
Minor Commercial/Industrial	2.5
Minor Residential	2.5
LOCAL	
Residential	2.0
Commercial/Industrial	2.5

5.3.4 Minimum Pavement Section

This paragraph provides the minimum acceptable pavement sections for public roadways in the Town of Bennett. These pavement thicknesses may be used for preliminary planning purposes or for estimating collateral requirements for subdivision Improvements agreements. Final pavement designs must be based on actual subgrade support tests results. Table 5.4 lists these minimum thicknesses for each roadway classification.

5.3.4.1 Additional Requirements for Warranty

TABLE 5.4

RECOMMENDED MINIMUM PAVEMENT SECTIONS

		COMPOSITE SECTION			
CLASSIFICATION	EDLA	ASPHALT (inches)	TREATED SUBGRADE OR BASE (inches)	FULL DEPTH ASPHALT (inches)	PORTLAND CEMENT CONCRETE (inches)
Local					
Residential	(Table 5.2)	4	6	6.0	6.0
Commercial	30	4	6	6.0	6.0
Industrial	100	4	6	6.0	6.0
Minor Collector					
Residential	30	4	6	6.0	6.0
Commercial	50	4	6	6.0	6.0
Industrial	150	4.5	6	6.5	6.0
Major Collector					
Residential	100	4	6	6.0	6.0
Commercial	100	4	6	6.0	6.0
Industrial	150	4.5	6	6.5	6.0
Minor Arterial	200	5	6	7.0	6.0
Major Arterial	200	5	6	8.0	6.0

5.3.5 Flexible Pavement Strength Coefficients
Table 5.5 contains the standard design coefficients for various pavement materials. Nonstandard Design Coefficients may be used only if approved in advance by the Engineering Division. In addition, design values must be verified by pre-design mix test data and supported by daily construction tests; or, redesign values will be required; i.e., such as, Add 1/2 to 1" to the in-place surface course of the final Asphalt Concrete.

TABLE 5.5
STRENGTH COEFFICIENTS

PAVEMENT STRUCTURE COMPONENT*	STRENGTH COEFFICIENTS	(LIMITING TEST CRITERIA)
CONVENTIONAL MATERIALS		
Plant Mix Seal Cost	0.25	
Hot Bituminous Pavement	0.40	(1500 lbs. Marshall or Rt 90+)
Exist Bituminous Pavement	0.30 0.24	(9-15 yr) (>15yr)
Aggregate Base Course	0.12	(CBR 80+ or R 78+)
Exist Aggregate Base Course	0.10	(CBR 50+ or R 69+)
Granular Sub-base Course	0.07	(CBR 15 or R 50+)
Treated Materials		
Cement Treated Aggregate Base	0.23	(7 day, 650-1000 psi)
Lime Treated Subgrade	0.14	(7day, 160 psi, PI.<6)

* The combination of one or more of the following courses placed on a subgrade to support the traffic load and distribute it to the roadbed.

a. Sub-base. The layer or layers of specified or selected material of designed thickness placed on a subgrade to support a base course, surface course or both.

b. Base course. The layer or layers of specified or selected material of designed thickness placed on a subbase or subgrade to support a surface course.

c. Surface Course. One or more layers of a pavement structure designed to accommodate the traffic load, the top layer of which resists skidding, traffic abrasion, and the disintegrating effects of climate. The top layer is sometimes called "Wearing Course".

5.3.6 Portland Cement Concrete Working Stress (f_t)

The working stress(f_t) to be used in the design shall be 75% of that provided by the third-point beam loading which shall have a minimum laboratory 28-day strength of 600 psi based on actual tests of materials to be used.

5.4 PAVEMENT DESIGN PROCEDURES

5.4.1 Flexible Pavements

The following procedure should be used in determining the Structural Number (SN) of the pavement being designed:

5.4.1.1 Determine roadway classification and corresponding EDLA (Table 5.2)

5.4.1.2 Determine the Serviceability Index (SI) of the roadway classification (Table 5.3)

5.4.1.3 Select the proper nomograph:

Table 5.6 Flexible Pavements with SI=2.0
Table 5.7 Flexible Pavements with SI=2.5

5.4.1.4 Using subgrade CBR or R-value test results and EDLA, determine the SN from the appropriate design nomograph.

5.4.1.5 Once the Structural Number (SN) has been determined, the design thicknesses of the pavement structure can be determined by the general equation:

$$SN = a_1D_1 + a_2D_2 + a_3D_3 + \ldots$$

where

a_1 = Hot Bituminous Pavement (HBP) strength coefficients

a_2, a_3, a_n = strength coefficients of additional pavement components

D_1 = thickness of Hot Bituminous Pavement (HBP) (inches)

D_2, D_3, D_n = thickness of additional pavement component sections

The strength coefficients for various components of the pavement structure are given in Table 5.5.

The component thickness must meet two conditions.

a. Total HBP thickness selected cannot be less than the minimum specified in Table 5.4 for the roadway classification.

b. The base course thickness selected cannot exceed 2.5 times the HBP thickness selected.

5.4.1.6 The design must reference any mitigation measures required when the subgrade contains swelling soils (swell potential >2.00% under 200 psf surcharge pressures at 95% standard compaction from a Colorado (Denver) Swell Test; moisture treatment is not an adequate mitigative procedure). Design reports recommending permeable layers such as untreated aggregate base course in the pavement system, must present the measures to be used to ensure adequate drainage of such layers, and to maintain segregation of the layers from the swelling soils. Also, see Section 8.3, Roadway Subgrade Preparation.

If expansive soil mitigation is made, the soil treatment shall extend to the back of-the-curb (if detached walk or no walk), or to the back-of-walk (if attached or monolithic walk).

5.4.1.7 Refer to Section 11.4.4.1 for additional requirements.

5.4.2 Rigid Pavement

The design of rigid pavements is a function of structural quality of the subgrade soil (R-value or CBR), traffic (EDLA), and the strength of the concrete (working stress). In comparison to the strength of the concrete slab, The structural contribution of underlying layers to the capacity of the pavement are relatively insignificant. Therefore, the use of thick bases or sub-bases under concrete pavement to achieve greater structural capacity is considered to be uneconomical and is not recommended.

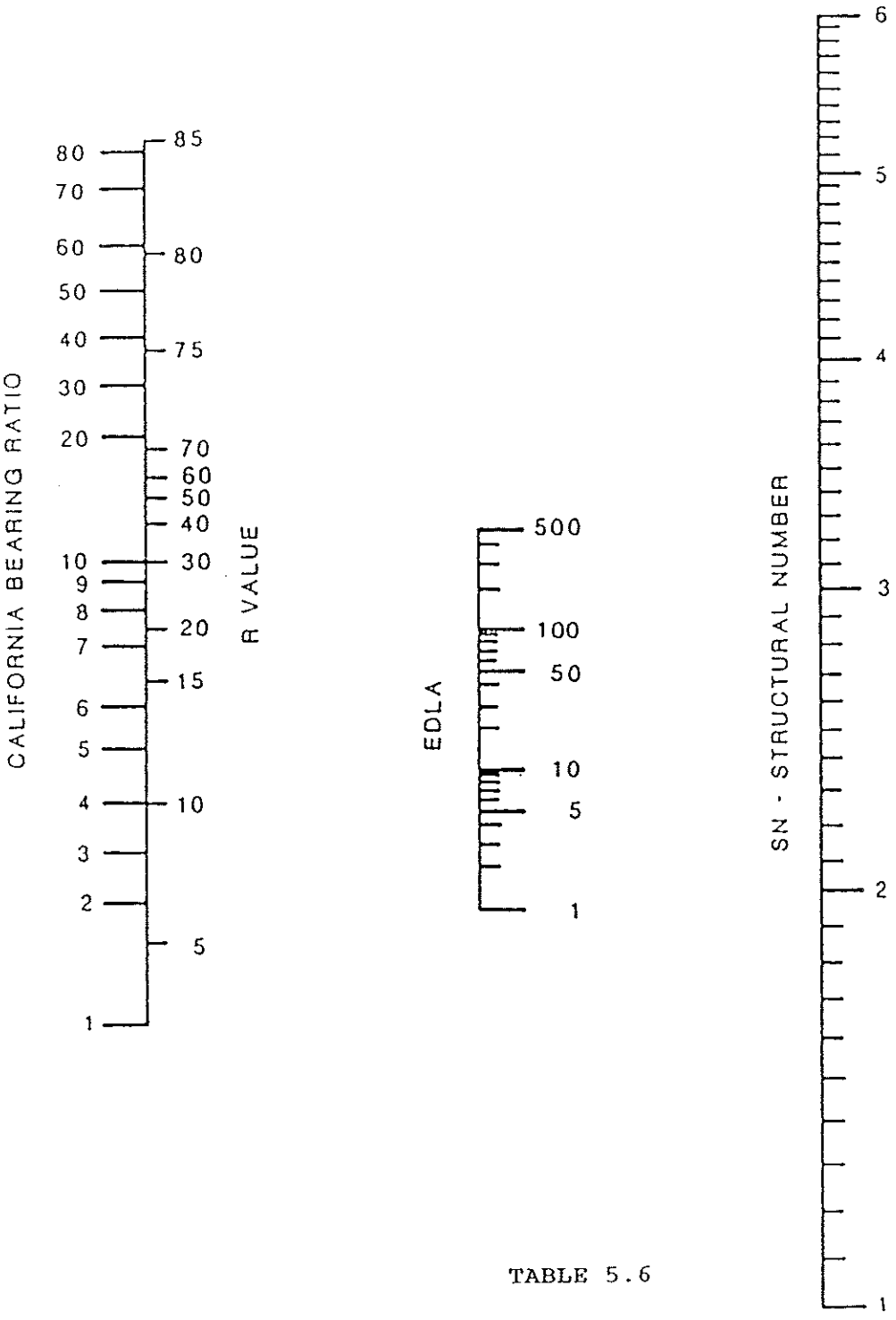


TABLE 5.6

NOMOGRAPH FOR FLEXIBLE PAVEMENT DESIGN WITH SI=2.0

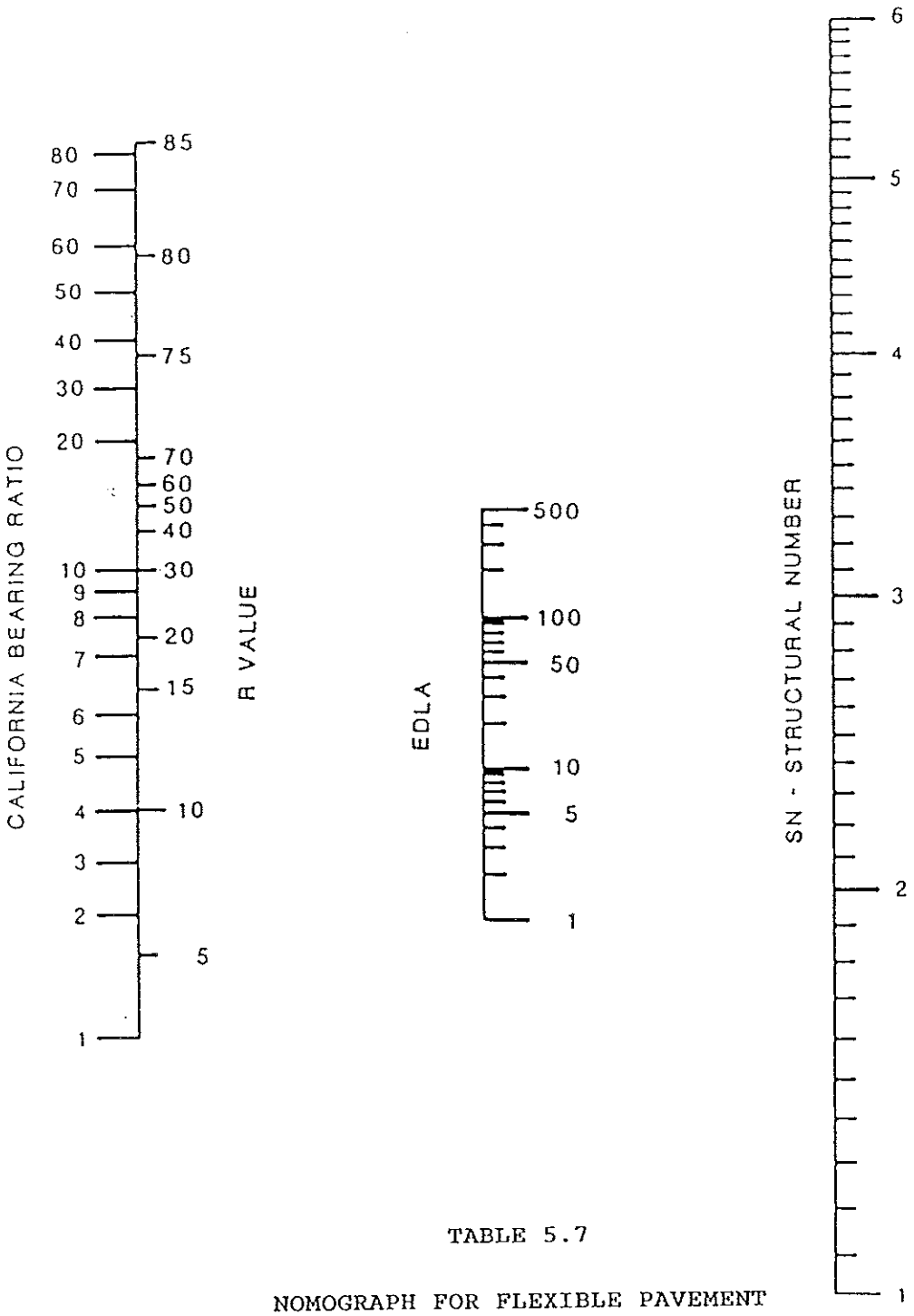


TABLE 5.7

NOMOGRAPH FOR FLEXIBLE PAVEMENT DESIGN WITTH SI=2.5

Use the following procedure to obtain required thickness:

5.4.2.1 Determine Roadway Classifications and corresponding EDLA (Table 5.2)

5.4.2.2 Determine Design Serviceability Index (SI) of the roadway (Table 5.3)

5.4.2.3 The working stress of the concrete (f, is to be obtained from laboratory test) for preliminary design, this value shall be assumed to be 450 psi until laboratory test have been completed.

5.4.2.4 Select the proper nomograph
Table 5.8 Rigid pavement with SI-2.0
Table 5.9 Rigid pavement with SI-2.5

5.4.2.5 Using EDLA and working stress data, locate point on the pivot line; connect this point the R-value or CBR value on the soil support scale to determine slab thickness.

5.4.2.6 Use slab thickness from step 5.4.2.5 or the minimum thickness from Table 5.4.

5.4.2.7 The design must reference any mitigation measures required when the subgrade contains swelling soils (swell potential >2.00% under 200 psf surcharge pressures at 95% standard compaction from Colorado (Denver) Swell Test; moisture treatment is not an adequate mitigative procedure). Design reports recommending permeable layers such as untreated aggregate base course in the pavement system, must present the measures to be used to ensure adequate drainage of such layers, and to maintain segregation of the layers from the swelling soils. Also see Section 8.3, Roadway Subgrade Preparation. If expansive soil mitigation is made, the soil treatment shall extend to the back-of-curb (if

detached walk or no walk), or to the back-of-walk (if attached or monolithic walk).

5.4.2.8 Refer to the Policy and Procedures Section of these Regulations for additional requirements.

5.5 MATERIAL SPECIFICATIONS

5.5.1 General

The Specifications presented in this section are performance oriented. The Town's objective in setting forth these Specifications is to achieve an acceptable quality of roadway structures. All sources for the mined or manufactured materials listed in paragraph 5.5.5 must be approved by the Town's Engineering Division as having met the appropriate materials performance specifications. This approval is a condition of using those materials sources for public improvement construction. For the purpose of these Standards, public improvement are all roadway improvements, sidewalks, curbs and gutter, appurtenant drainage basins or structures, storm severe and their access ways, other public works within Bennett right-of-way, and Town mandated stormwater detention structures built on private property and maintained by the property owner(s).

5.5.2 Procedure For Material Source Approval

A minimum of 14 calendar days before construction, a material supplier for any Bennett public improvements may supply written documentation and material test results from a competent materials testing laboratory that describes:

a. Material(s) being tested to meet Town of Bennett specifications.

b. The test procedures employed.

c. The supplier's manufacturing, mining or treating process by which the tested materials were created

d. The material test results.

e. A signed statement by the material supplier that the materials to be provided for public improvement in the Town of Bennett during the coming 365 day period.

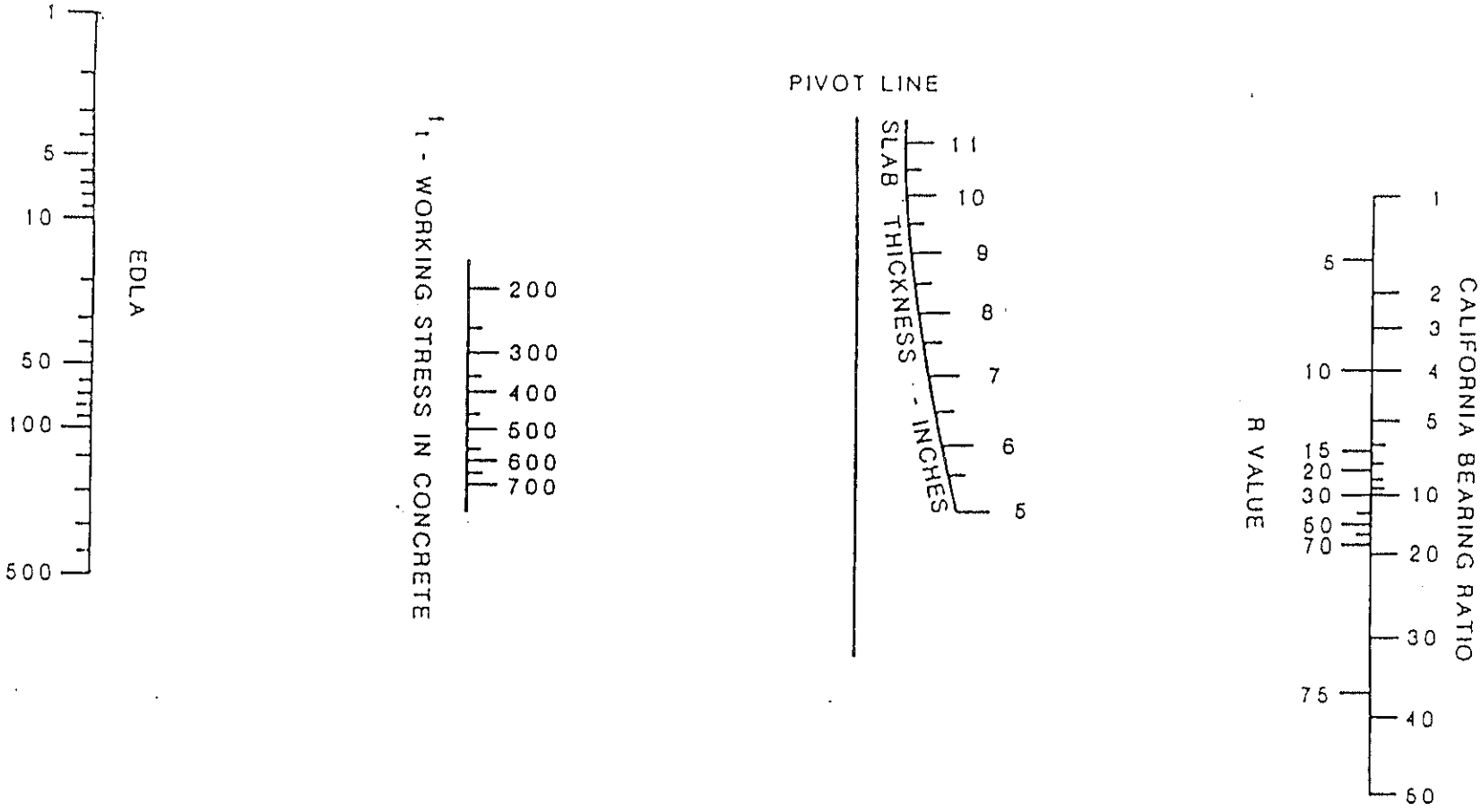
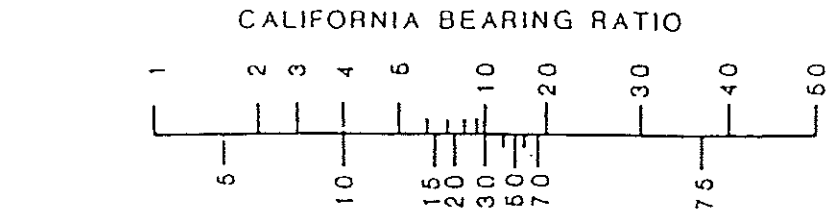
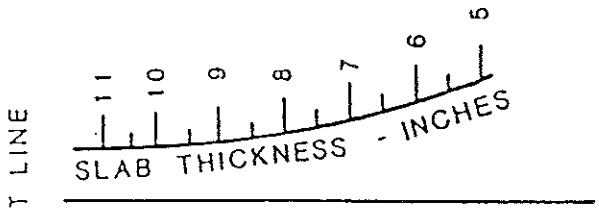


TABLE 5.8

NOMOGRAPH FOR RIGID PAVEMENT
DESIGN WITH SI=2.0





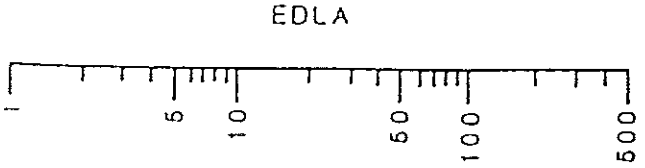


TABLE 5.9

NOMOGRAGH FOR RIGID PAVEMENT
DESIGN WITH SI=2.5

5.19

5.5.3 Violations of Approved Conditions

5.5.3.1 Random Testing
The Town Engineering Division may order random tests of materials used in public I improvements to verify compliance with material specifications. These tests are in addition to the requirements of Chapter 8.

5.5.3.2 Any and all materials used to construct Bennett public improvements that is not from a certified source, or that is from a certified source and fails one or more random materials test, may be subject to complete removal as a condition of Bennett acceptance of that public improvement. Additional tests will be required to confirm the existence and extent of the sub-standard material prior to the initiation of remedialaction. The extent of the materials to be removed will be at the discretion of Bennett's Town Engineer.

5.5.4 Use Of Materials Not Listed In Section 5.5.5
Materials in this section and provided with a set of specifications are those deemed by the Town to be the primary structural materials commonly or typically used in public improvements. Ancillary public improvement materials such as manufactured paints and coatings, bonding agents, sealer,gaskets, insulating materials, etc. should be in compliance with Colorado Department of Highways material specifications for the appropriate material employed. Alternative materials for construction may be proposed for use, except where expressly prohibited by the Subdivision Regulation. Decisions on acceptability of alternative materials will be made by the Town Engineer.

5.5.5 Materials Specifications

5.5.5.1 Hot Bituminous Pavement

This material shall consist of a mixture of aggregate, filler (if required) and asphalt cement. The aggregate mixture shall meet the grading requirements of the job mix formula. Test on the aggregates for cleanliness, abrasion loss and fractured faces shall meet the requirements shown below. The job mix formula shall establish a single percent passing each sieve size, an optimum percent of asphalt cement to be added to the aggregate and a recommended mix temperature when discharged at the plant.

TABLE 5.10
MATERIAL SPECIFICATIONS FOR
HOT BITUMINOUS PAVEMENT

SIEVE SIZE OR TEST PROCEDURE	PERCENT PASSING OR TEST REQUIREMENT	
	E MIX	EX MIX
3/4"	100	---
1/2"	---	100
#4	38-72	45-78
#8	25-58	30-60
#200	3-12	3-12
% Wear, AASHTO T-96	45. Max.	45, Max.
One Crushed face on +4	50, Min.	50, Min.
Index of retained Strength	75, Min.	75, Min.
ASTM D-4867 Lottman Test		

a. Aggregates shall not contain clay balls, organic matter, or other deleterious substances.
b. After the job mix formula is established, all mix furnished for the project shall conform to within the ranges of tolerances in Table 5.11

TABLE 5.11
MIX TOLERANCES

MAXIMUM SIZE	± 0 PERCENTAGE POINTS
PASSING NO. 8 AND LARGER	± 8 PERCENTAGE POINTS
NO. 8 TO NO. 100	± 6 PERCENTAGE POINTS
PASSING NO. 200	± 3 PERCENTAGE POINTS
ASPHALT CONTENT	±0.5 PERCENTAGE POINTS
DISCHARGED MIX TEMPERATURE	± 20°F

c. An Additive may be used to meet the requirements for index of Retained Strength, if necessary. Such additives may be hydrated lime, Type I Portland cement, or anti-stripping agents approved by the Colorado Department of Highways.
d. The asphalt cement used shall be grade AC-10

A mix design, including the job mix formula, shall be submitted for review and approval a minimum of seven (7) days prior to placing mix on the project. The mix design shall be performed using either the Marshall or Hveem Procedures as outlined in The Asphalt Institute's, "Mix Design Methods for Asphalt Concrete" (MS-2). Mix design parameters for each of the procedures are shown in Table 5.12.

TABLE 5.12
MIX DESIGN CRITERIA

TEST	MARSHALL (50 blows) AASHTO T 245	HVEEM AASHTO T 246
STRENGTH OR STABILITY	1,500 lb.	S 35 Min.
FLOW 0.01"	8-18	N/A
VMA, (E MIX)	14 Min.	14, Min.
VMA, (EX MIX)	15, Min.	15, Min.
AIR VOIDS, TOTAL MIX%	3-6	3-5

5.5.5.2 Portland Cement Concrete Pavement
This material shall consist of a mixture of course and fine aggregates, Portland cement, water and other materials or admixtures as required. Colorado Department of Highways Class "P" (no substitutes for "P" may be used)or "AX" mix shall be used. Other high-early strength concretes may be used where special conditions warrant, subject to written

approval by the Town Engineer.

a. Portland Cement shall comply with the Colorado Department of Highways requirements. The type of cement shall be Type II unless sulfate conditions dictate otherwise. Table 2.2.3 in Chapter 2.2 of ACI 201 indicates recommendations for sulfate resistance.

b. Fine aggregates shall meet Colorado Department of Highway Section 703.01 requirements and gradation as shown in Table 5.13.

c. Coarse Aggregates shall meet Colorado Department of Highways Section 703.02 requirements and gradation as shown in Table 5.14

d. Fly Ash shall comply with Colorado Department of Highways Section 701.02.

TABLE 5.13
FINE AGGREGATES FOR PORTLAND CEMENT CONCRETE

SIEVE SIZE OR TEST PROCEDURE	PERCENT PASSING OR TEST REQUIREMENT
3/8"	100
#4	95-100
#16	45-80
#50	10-3
#100	2-10
#200	3, Max.
FRIABLE PARTICLES, %	1.0, Max.
COAL & LIGNITE, %	1.0, Max.
DELETERIOUS MATERIAL (AASHTO T-11), %	3, Max.
SAND EQUIVALENT (AASHTO T176), %	80, Min.
FINENESS MODULES	2.50-3.50
SODIUM SULFATE SOUNDNESS, %	20.0, Max.

e. Water shall meet the requirements of Colorado Department of Highways Section 712.01.

f. Air entraining and chemical admixtures shall meet the requirements of Colorado Department of Highways Section 711.02 and 711.03. No additive manufactured with the purposeful addition of chloride shall be permitted.

TABLE 5.14
COARSE AGGREGATES FOR PORTLAND CEMENT CONCRETE

SIEVE SIZE OR TEST PROCEDURE	PERCENT PASSING OR TEST REQUIREMENT
2"	100
1 1/2"	95-100
3/4"	35-70
3/8"	10-30
#4	0-5
#200	1.0, Max (1.5% if crusher fines)
% WEAR	45, Max.
CLAY LUMPS & FRIABLE PARTICLES, %	2.0, Max.
COAL & LIGNITES, %	0.5, Max.
SODIUM SULFATE SOUNDNESS, %	12, Max.

g. Curing materials shall be white pigmented liquid membrane forming curing compound and meet the requirements of AASHTO M 148.

h. Reinforcing steel shall meet the requirements of Colorado Department of Highways Section 709.01, grade 40 minimum.

i. Minimum compressive laboratory design strength shall be 3750 psi; minimum modules of rupture or flexural strength shall be 600 psi.

5.5.5.3 Aggregate Base Course Material
This material shall consist on hard,

durable particles or fragments of stone or gravel, crushed to required sizes, containing an appropriate quantity of sand or other finely-divided mineral matter which conform to requirements of AASHTO M 147, and to Section 703.03, CDOH Standard Specification. In addition, the material must have an R-value of 78 or greater or a CBR of 80+ and must be moisture stable. Moisture stability is determined by R-value testing which shows a drop of 12 points or less in R-value between exudation pressures of 300 psi and 100 psi.

Only aggregate from Bennetts' Engineering Division approved sources shall be used, unless otherwise approved in writing by the Engineering Division. Approval of sources will be at the discretion of the Engineering Division and submissions will, at a minimum, consist of supplying documented gradation, Atterberg limits and CBR/R-value testing on a annual basis. See Section 5.5.2.

Only one (1) type of crushed aggregate base course is acceptable in the Town of Bennett. The gradation specifications for this type of base course is listed below:

TABLE 5.15
AGGREGATE BASE COURSE MATERIAL

SIEVE DESIGNATION	PERCENT PASSING BY WEIGHT CLASS 6
3/4"	100
#4	30-65
#8	25-55
#200*	3-12**
LIQUID LIMIT (LL)	30 Max.

*ASTM (C117)

** For gravel shoulders, No. 200 should be 9-12

5.5.5.4 Cement Treated Aggregate Base Course

This material shall consist of a mixture of aggregate materials, Portland cement and water is outlined in Section 308 of the CDOH Standard Specifications (latest revisions). Acceptable aggregates include CDOH Classes 4,5,and 6. Other aggregates may be used, if previously approved by Engineer.

The materials to be used in construction shall be tested and a mix design submitted to the Engineer. As a minimum, the mix design report shall contain a description of material sources, gradations and Atterberg limits of aggregates, cement type, Proctor compaction curves and unconfined compressive strength results for each mix, strength versus cement content curves, a design mix and special construction procedures recommended. Testing shall be in accordance with appropriate AASHTO specifications.

To be approved, the mix shall have a 7 day compressive strength of at least 650 psi and no more than 1,000 psi. The minimum acceptable cement content shall be 5 percent by weight. Only mix designs approved by the Town Engineer Division shall be used. Approvals are required on a project basis, or an annual basis for suppliers, prior to issuing construction permits.

5.5.5.5 Lime Treated Subgrade

This material consists of a mixture of native or imported soils, hydrated or quick lime and water as outlined by ASTM Specification C977.

The materials to be used in construction shall be tested and a mix design submitted to the Town Engineer for approval. As a minimum, the mix design report shall contain a description of material sources, gradation (or-200) and

Attenberg limits of native soils, Attenberg limits and 7 day unconfined compressive test results for each mix, strength versus lime content curves, a design mix and special construction procedures recommended. Testing shall be in accordance with appropriate AASHTO methods.

To be approved, the mix shall have a minimum 7 day compressive strength of 160 psi. In addition, the Plasticity Index of the treated soil shall not exceed 6. The minimum acceptable hydrated lime content shall be 4 percent by weight.

Only mix designs approved by the Engineering Division shall be used. Approvals are required on a project basis prior to issuing construction permits. Minimum in-place thickness for this materials shall be eight (8) inches.

5.6 SUBGRADE INVESTIGATION AND PAVEMENT DESIGN REPORT

The report shall be prepared by or under the supervision of and signed by a Professional Engineer registered in the State of Colorado and shall include the following information:

A. Vicinity map to locate the investigated area.

B. Scaled drawings showing the location of borings.

C. Scaled drawings showing the estimated extent of subgrade soil types and EDLA for each street.

D. Pavement design alternatives for each street on a scaled drawing.

E. Tabular listing of sample designation, sample depth, Group Number, Liquid Limit, Plasticity Index, percent passing the No. 200 sieve, AASHTO Classification, Group Index and soil description.

F. CBR or R-value test results of each soil type used in the design.

G. Pavement design nomographs properly drawn to show Soil Support-EDLA-SN.

H. Design Calculations

I. A discussion regarding potential subgrade soil problems including, but not limited to:

1. heave or settlement prone soils,
2. frost susceptible soil,
3. ground water,
4. drainage considerations (surface and subsurface),
5. cold weather construction (if appropriate), and
6. other factors or properties which could affect the design or the performance of the pavement system.

J. Recommendations to relieve or mitigate the impact of problems discussed in item (I) above.

5.7 DENVER/COLORADO/SWELL-CONSOLIDATION TEST

A. Test Objectives

To determine the magnitude of swell/consolidation of soil sample under a given surcharge load with 1-dimensional consolidometer (DENVER MACHINE).

B. References

ASTM D-2435-80, Part 1

C. Equipment

1. Trimming equipment
2. Calipers, sensitive to 0.001 inch
3. Balance, sensitive to 0.1 grams
4. Oven, set a 110 ± 5 degree C
5. Moisture dishes
6. Consolidometer ring 1.94 inch diameter by 1.00 inch depth
7. Porous stones
8. Loading device
9. Dial indicator, sensitive to 0.001 inch
10. Weights

D. Procedure

1. Sample preparation

   a. Use undisturbed sample from California tube, or approved hand drive thin-wall sampler. Trim to fit the sample ring. (NOTE: California Samples should not need trimming.) Place the sample in the ring and trim the bottom of the sample flush with the ring.

   b. Determine and record the sample weight, height, and diameter.

   c. Obtain trimmings of sample for moisture content evaluation.

2. Testing

   a. Assemble by placing the ring sample with top and bottom porous stones in the consolidometer dish. Place the top loading cap on top of the porous stone, and place the consolidometer dish into the loading device.

   b. Once the sample is placed in the consolidometer, adjust the dial to read 0 (zero) or a round number (i.e. 200). Record this dial reading.

   c. Apply the specified surcharge load. If nosurcharge load is specified, use 200 psf.

   d. Record dialreading hourly until the readings remain constant, or a minimum of 4 hours.

   e. Add water to the consolidometer.

   f. Record dial reading periodically until sample movement stabilizes, and a minimum of 24 hours.

   g. Add additional loads to bring the sample to its original height. The following load increments are suggested 500, 1000, 3000, 6000, 10,000, 15,000, and 20,000 psf. As a minimum, load the sample to 6000 psf. Record dial readings constant, or a minimum of 2 to 4 hours, before

additional load increment application.

h. At completion of all load increments, dismantle the consolidometer and obtain a final sample moisture content.

E. Calculations

1. Obtain final dial reading for each load increment (correct for machine deflection by adding the deflection when sample swell, and subtracting when sample consolidates).

2. Calculate percent swell (+) or consolidation(-) as follows:

$$\text{Percent Swell} = \frac{\text{Corrected Final Dial Reading}}{\text{Initial Sample Height}} \times 1000$$

3. Prepare plot of swell % - Consolidation % versus log of pressure curve: include sample number, location, natural dry density, natural moisture, soil description.

4. Atterberg Limits - ASTM D-4318-83

5. Specific gravity - ASTM D-854-83
One test for every other gradation test sample of Zone A and Zone B fill(item 4), and for each compaction test (Item 1).

6. Swell-Consolidation - Attachment 1
One test for each 20,000 cubic yards of Zone A fill placed. Test to be made adjacent to in place soil density test (Item 2) and each Atterberg Limit test (Item 5) for correlation.

7. Classification-ASTM D-2487-83/ASTM D-2488-75
Classify each sample of the above tests (Items 1 through 7) using data from those tests and visual methods.

8. Sodium Soundness-ASTM C-88
One test on sample of drainage soils from each different source of material and one test for each 10,000 cubic yards placed.

9. Abrasion-ASTM C-131
One test on sample of drainage soils from each different source of materials and one test for each 10,000 cubic yards placed.

10. Abrasion-ASTM C-535
One test on sample of riprap from each source of material and one test for each 10,000 cubic yards placed.

11. Freeze-Thaw-AASHTO-T103 Procedure
One test on sample or riprap from each source of materials and one test for each 10,000 cubic yards placed.

5.8 TRANSPORTATION IMPACT ANALYSIS (TRAFFIC STUDIES)

5.8.1 Introduction

The importance of comprehensive and coordinated transportation planning is critical to the Town in order to provide a balanced transportation system. The application of sound design principles for new streets, preserving street capacities in existing areas, ensuring smooth traffic flow, accommodating all transpiration modes, and increased safety are goals the Town must attain. In order for the Town to evaluate the impacts of development proposals on the Towns transportation system, a professionally prepared Transportation Impact Analysis (TIA) may be required for all development proposals. This Chapter provides the guidelines for preparation of a Transportation Impact Analysis. In addition, the Towns Transportation Master Plan should be referenced for more detailed information.

5.8.2 Procedure

The following steps outline the procedure the Town requires for the preparation and submittal of a TIA:

* Pre-Design Meeting
* Determination of Base Assumptions
* Submittal
* Town Comments and Recommendations

5.8.2.1 Scoping

At the pre-design meeting, the Developer and Town shall determine if a TIA will be required and to initiate the determination of the base assumptions and pedestrian destinations to be utilized in the analysis. This meeting shall include a member of the Developers team (preferably the Transportation Consultant) and the Town's Designated Representative.

A TIA requirement may be waived if the average daily trip generation of the proposed project is less than 200 trips or by special variance approved by the Town. If this condition is satisfied and the Town's Designated Representative does not have other concerns with the transportation aspects of the proposed project, a memo shall be prepared by the Traffic Consultant Engineer showing the trip generation of the project and concluding that no transportation impacts are anticipated as a result of the proposed project.

At the pre-design meeting the Developer will provide information regarding:

* Project Description including type of land use (single family, fast food, etc.) and size(number of dwelling units, square footage, etc.)

* Preliminary project site plan showing all proposed access locations and proposed land uses.

* Anticipated project completion date and project phasing.

The Towns Designated Representative will review the applicants project information and provide feedback as to any anticipated concerns regarding transportation issues such as access locations, types, potential impacts on adjacent neighborhoods, and initial identification of study area. This initial scooping meeting will assist the Town and the Developer in determining the base assumptions and pedestrian analysis to be utilized in the TIA.

5.8.2.2 Determination of Base Assumptions

After the initial meeting is held, the Town Engineer will complete the TIA-Base Assumptions form. This form, included as Attachment "A", outlines the base parameters and assumptions to be utilized by the Consultant Engineer in the preparation of the TIA.

The Base Assumption Form will specify for the Developer what the Town will require in regards to the following:

* Study Area Boundaries
* Years for Study
* Growth Rates
* Study Intersections
* Time Periods for Study
* Trip Generation Rates
* Trip Adjustment Factors
* Overall Trip Distribution
* Mode Split Assumptions

* Commited Roadway Improvements
* Other Relevant TIAs
* Areas Requiring Special Study

5.8.2.3 Pedestrian Analysis

After the pre-design meeting is held, the Towns Engineer will complete the Pedestrian Analysis Worksheet, included as Attachment "B", which identifies original and destination pairs which should be utilized for analysis of the pedestrian level of service measurements for directness, continuity, street crossings, visual interest, visual amenities, and security. Based upon the project's land use classification, consideration should be given to the noted destinations that are located within one-quarter mile of the project site. Analysis of destinations which are farther than one-quarter mile may be necessary given particular site circumstances, such as residential site located within a school walking area boundary.

5.8.2.4 Submittal

Two copies of the TIA should be delivered to the Engineering Division, to be submitted as part of the required submittal information. Revisions to the TIA shall be provided as required by the Town, if considered necessary to complete the TIA or where changes to the site's access necessitate additional revisions to the Study.

5.8.2.5 Towns Comments and Recommendations

The Engineer will evaluate the TIA. After this evaluation, comments regarding the TIA will be forwarded to the Town Planning Department. All Town comments regarding the Project will be provided to the Developer through the Planning Department. After the evaluation, subsequent analysis may be requested of the Developer regarding specific transportation issues.

5.8.3 Transportation Impact Analysis

The extent of this TIA is to determine the potential impacts of the proposed development upon the transportation systems. Each TIA should address the following areas:

* Project Description
* Existing Conditions
* Future Background Traffic Projections
* Project Traffic
* Total Traffic Projections
* Site Circulation and Design Evaluation
* Transportation Impact Considerations
* Mitigation Measures
* Neighborhood Transportation Impact Considerations
* Conclusions

5.8.3.1 Project Description

A description of the proposed project will be prepared and include the type of land use and size of proposed project (number of dwelling units or building square footage). Any proposed phasing will be discussed and the anticipated completion date established. A figure depicting the proposed site plan will also be included and the proposed vehicular access locations will be described. This section will also include a description of how pedestrian and bicycle traffic will be accommodated within the proposed site plan. This will include a discussion of types of sidewalks (attached/detached), pathways, and connections to location and perimeter destinations. Additionally, this will include a discussion of traffic calming methodologies included within the design of the project.

5.8.3.2 Existing Conditions

The TIA will establish the existing transportation system conditions. The assessment of existing conditions will include: a description of the surrounding roadway network, bicycle facilities,

pedestrian facilities, and transit service; an evaluation of the peak hour level of service at the study intersections, determination of the bicycle and pedestrian level of service, and an evaluation of the existing transit level of service. The level of service for pedestrian facilities, bicycle facilities, and transit will be determined based upon the standards set forth in the Attachment C.

5.8.3.3 Description of Existing Transportation System
The description of the roadway network will include:

* Number of Travel Lanes
* Presence or not of pedestrian and bicycle facilities
* Posted Speed Limit
* Adjacent Land Uses

Traffic data at the roadway network and study intersections should be obtained through counts and the Engineering Division. Any recent (within the last two years) average daily traffic data which is available for the roadway network should be shown on a figure. Peak hour traffic data at the study intersections should be no older than six months, and if new counts are necessary this is the responsibility of the Developer. All traffic count data should be included in an appendix to the TIA.

The existing transit facilities within one-quarter mile of the project should be described. This description should include: location of existing transit routes, hours of service, weekday frequency of service, and location of transit stops.

The description of the existing bicycle and pedestrian facilities should include any facilities directly adjacent to the project

site and within one-quarter mile. Analysis of pedestrian destinations which are farther than one-quarter mile may be necessary given particular site circumstances, such as a residential site and the schools serving the development. If there are bicycle facilities, the type of facility (bike route, bike lane, bikepath) should be described and it should be mentioned if the facility is substandard and does not meet these Regulations.

Special attention should be given to the bicycle and pedestrian connections to specific uses such as: schools, parks, transit stops, employment centers, commercial areas, shopping and adjacent land uses.

5.8.3.4 Existing Levels of Service

The existing levels of service (LOS) of the transportation system adjacent to the project site should be determined. The existing LOS will be determined for the following: vehicular (at the study intersections), pedestrian facilities, bicycle facilities, and transit. The peak hour vehicular LOS at the study intersections will be determined based upon the procedures set forth in the latest addition of the HIGHWAY CAPACITY MANUAL. The LOS for pedestrian, bicycle and transit facilities should be determined by the Consultant Engineer based upon the standards set forth in the attachment C.

All level of service worksheets should be included in the Appendices to the TIA report.

5.8.4 Future Background Traffic Projections

The future traffic background projections should be determined for each of the study years identified earlier as part of the base assumptions. The future background projections should account for the following:

* Transportation System Improvements
* Cumulative Projects
* Overall Traffic Growth

A description of any planned transportation system improvements should be provided. This should include such improvements as: signalization, intersection improvements, roadway widening, bicycle/pedestrian projects, and transit capital and operating/service improvements.

The future background traffic projections should include any individual development projects which are within the study area and would impact the study intersections. Any larger projects outside the study area which would impact the study intersections. Each of the cumulative projects should be listed in the TIA and include location, size, and proposed land use.

The overall growth in traffic within the study area should also be accounted for when determining future background traffic projections. The growth factors which should be applied to the existing traffic will be provided by the Town.

The resulting future peak hour traffic projections at the study intersection should be depicted on a figure.

5.8.5 Project Traffic

The potential transportation impacts of the proposed development project will be determined based upon the following three steps process:

* Determination of Trip Generation
* Determination of Trip Distribution
* Assignment of Project Traffic

5.8.5.1 Trip Generation

The trip generation of the proposed project will be determined and provided in tabular form. The trip generation needs to be determined for total build out conditions and

for any development phases. The Trip Generation table should indicate the average daily trips and peak hour trips. This section of the TIA should also include a description of the mode split data which was assumed for the trip generation estimates.

The development of trip generation estimates for the project should be based upon data from the latest edition of the Institute of Transportation Engineers' Trip Generation Manual. However, other data sources or trip generation rate studies may be utilized if the manual does not contain data for the proposed project or additional data is available which better reflects the trip generation characteristics of the project. The use of other trip generation rate sources must be discussed with the Town in the pre-design meeting.

Adjustments to the standard trip generation of the proposed project may be made to account for internal site trips, passby trips or other unique characteristics of the proposed project. The allowance for these reductions will be discussed with the Town and in most cases should follow the guidelines set forth in documents such as the ITE Trip Generation Manual referenced above. The adjusted trip generation for the proposed project should be provided in tabular form.

5.8.5.2 Trip Distribution

The trip distribution for the proposed project will be identified in the TIA. The distribution pattern will be based upon:

* The project's location within the Town
* Standard gravity model
* Existing Traffic volume data
* Project marketing data
* Engineering judgment

5.8.5.3 Trip Assignment

The project traffic will be assigned to the roadway system according to the trip distribution established above. The resulting project site generated traffic will be depicted on figures for buildout conditions and any project phases. These figures will include daily and peak hour traffic volume information.

5.8.6 Total Traffic Projections

The total traffic projections will be determined for existing conditions and for each of the study years identified earlier in the base assumptions. For existing conditions the project related traffic will be added to the existing peak hour traffic. The resulting total traffic projections for existing conditions will be depicted on a figure. For each of the study years, the total traffic projections will included the future background traffic plus the project generated traffic. The future total traffic projections will be depicted on figures for each study year. Based upon the total traffic projections and the Roadway Design Criteria of these Regulations, provide roadway functional classification recommendations. For example, a roadway projected to carry between 3,500 and 5,000 vehicles per day would be recommended as a collector without parking where as if the projected traffic was less than 1,000 vehicles per day, it would be recommended as a local street with parking.

5.8.7 Site Design and Circulation Evaluation

The projects site design should be analyzed to determine if the proposed circulation system serves pedestrians, bicyclist, transit users, and vehicles. The site design should be evaluated to determine if facilities for vehicles, pedestrians, bicycles and transit meet these Regulations.

The projects site design should be evaluated to determine if traffic flows are adequately designed. The on-site traffic flows should be evaluated to minimize areas where motorists would tend to speed,

minimize potential conflict areas between vehicles and pedestrians/bicyclist, and to determine if circulation patterns are designed to avoid unnecessary traffic congestion and conflict points.

5.8.8 Transportation Impact Considerations

The TIA will determine if the project will create any significant impacts at the study intersections and surrounding the project site. In order to determine this, the peak hour levels of service at each of the study intersections will be evaluated for each of the following scenarios:

* Future Background Traffic Conditions for each Study Year.
* Total Existing Traffic Conditions.
* Future Total Traffic Conditions for each Study Year.

The level of service analysis for each of the traffic scenarios and study years need to include mode split assumptions. The level of service findings should be shown in the TIA in tabular form.

5.8.8.1 Minimum Acceptable Levels of Service

Minimum acceptable levels of service for all intersections in the Town shall be LOS D.

5.8.9 Significant Impacts

This section applies primarily to vehicular related impacts associated with the proposed project. A project is defined as significantly impacting a study intersection when one of the following conditions are satisfied:

5.8.9.1 For Signalized Intersections

- When the added project traffic causes an intersection to fail the minimum acceptable level of service standard; or
- When the background traffic conditions

- (without project traffic) causes an
- intersection to fail the minimum acceptable level of service standards; and when the project traffic causes more than a 2 percent increase in the intersection delay.

5.8.9.2 For Unsignalized Intersections

- When backstacking to adjecent intersections would create impeded traffic flows and/or excessive congestion; or
- When added project traffic is determined to create potential safety problems.

For Local Residential Streets

Projected Average Daily Traffic with Project (Total ADT)	Project Related Increase in ADT
up to 2,000	12% or more of Total ADT
2,000 or more	10% or more of Total ADT

5.8.10 Mitigation Measures

When a project's vehicular impacts are determined to not meet the minimum acceptable level of service standard, the TIA include feasible measures which would mitigate the project's impacts. The mitigation measures are intended to be in addition to the required improvements necessary to meet these Regulations. The goal of the mitigation measure(s) should be to minimize the demand for trips by single occupant vehicles and to increase the use of alternative modes. Therefore, the following mitigation categories are listed in order of priority:

* Transportation Demand Management Measures
* Transit Capacity and Access Improvements
* Traffic Signal Operation Improvements

* Street Widening and Other Physical Improvements
* Street Restriping and parking Regulations

The Intersection LOS should be recalculated to reflect the effectiveness of the proposed mitigation measures and show that the project related impacts have been reduced to an acceptable LOS for all transportation modes. The LOS findings should be shown in tabular form.

5.8.10.1 Transportation Demand Management (TDM) Measure

TDM measures are designed to facilitate the use of alternative transportation modes in an effort to decrease demand on the roadway system by single occupant vehicles. Examples of TDM measures include the following:

* Vehicle trip reduction incentives and services offered by employers to encourage employees to utilize alternative modes of travel such as carpooling, vanpooling, bicycling, walking, telecommuting, etc.
* Financial support for the capital and/or operating costs of enhanced transit or vanpool service to the project.
* Site trip cap and/or parking cap including trip monitoring agreements.

A Detailed description of the proposed TDM measures and implementation plan must be included in the TIA for any project seeking TDM – Related trip reductions. If the TDM program is acceptable to the Town, the Developer will be allowed to reduce total project vehicle trips by an amount commensurate with applicable trip reduction policies.

5.8.10.2 Transit Capacity and Access Improvements

Suggested elements of a transit program should include:

* Contributions of equipment or funds to increase the capacity of existing transit systems;
* Transit shuttles provided by applicant (e.g. bus, taxicab, van, etc.)
* Contributions toward transit station or centers

5.8.10.3 Traffic Signal Operational Improvements

Traffic Signal Operational Improvements would include upgrading the signal to include additional signal phases and or signalization of an unsignalized intersection. Signalization of project access drives would not be considered as a mitigation measure. Signal improvements and/or installations must be approved by the Town.

5.8.10.4 Street Widening or Other Physical Improvements

Mitigation measures which include street widening and other physical improvements must be demonstrated to be physically feasible and must meet minimum standards in these Regulations for both on and off site improvements.

5.8.10.5 Street Restriping and Parking Regulations

Proposed striping and parking regulation mitigation must be approved by the Town. Generally, street restriping is not a preferred mitigation measure because it often requires parking regulations which may cause secondary impacts in certain commercial and residential areas. Therefore, any parking impacts should be clearly identified and proposed for mitigation by extent feasible.

5.8.11 Neighborhood Transportation Impact Considerations

The TIA should include a focused analysis of the potential project related impacts on adjacent residential areas. The need for this Study will be identified as part of the Base Assumptions. If it is determined that a neighborhood transportation impact review is required the following procedure should be used:

* Examine the existing transportation conditions within the neighborhood. This should follow the same procedure as set forth earlier for the transportation impact considerations. Daily and peak hour traffic volumes should be collected for the local streets to be included in the analysis.

* Determine project generated traffic for all modes within the neighborhood and show a figure.
* Determine total traffic projections for the local streets. This should follow the same procedures as described earlier, including other projects and areawide growth if applicable.
* Determine if the proposed project would create significant impacts to the residential streets using the conditions stated earlier.
* If necessary, develop measures including but not limited to traffic calming techniques, to mitigates any significant impacts.

The neighborhood TIA should also discuss how pedestrians and bicyclist would access the proposed project to/from the adjacent neighborhood(s), and the need for special facilities to enhance direct pedestrian and bicycle connectivity.

5.8.12 Conclusions

The findings of the TIA should be provided in summary format, including the identification of any areas of significant impacts and recommended improvements/mitigation measures to achieve the LOS standards for all modes.

Project Information				
Project Name				
Project Location				
TIS Assumptions				
Study Area Boundaries	North:		South:	
	East:		West:	
Study Years				
Future Traffic Growth Rate				
Study Intersections	1.All Access Drives		2.	
	3.		4.	
	5.		6.	
	7.		8.	
Time Period For Study	AM	PM	Sat Noon	
Trip Generation Rates				
Trip Adjustment Factors	Pass by:		Captive Market:	
Overall Trip Distribution	North	South	East	West
Mode Split Assumptions				
Committed Roadway Improvements				
Other Traffic Studies				
Areas Requiring Special Study				

	TRANSPORTATION IMPACT STUDY BASE ASSUMPTIONS	Issued: _____ Revised: _____
	Town of Bennett	Drawing No. 5.1 ATTACHMENT A

Pedestrian Destinations
(within ¼ mile of project site)

Origin (Project Site)	Rec.	Res.	Inst.	Ofc/Bus.	Com.	Ind.	Other (Specify)
Recreation							
Residential							
Institution (school, church, civic)							
Office/ Business							
Commercial							
Industrial							
Other (Specify)							

Based upon the project's land use classification, the pedestrian Level of Service analysis for directness, continuity, street crossings, visual interest/amenity, and security should consider the applicable destinations which are located within one quarter mile of the project site.

PEDESTRIAN ANALYSIS WORKSHEET

Town of Bennett

Issued: ________

Revised: ________

Drawing No. 5-2
ATTACHMENT B

Maps showing activity areas, pedestrian districts, transit corridors, bike facilities, various vehicular LOS areas, etc.

	TRANSPORTATION IMPACT ANALYSIS WORKSHEET	Issued: _____ Revised: _____
	Town of Bennett	Drawing No. 5.3 ATTACHMENT C

5.9 STREETSCAPE DESIGN CRITERIA

5.9.1 General This chapter provides a framework for the Developers in which to design streetscaping within the Towns right-of-ways and public areas. This criteria is not intended to direct the Developer in development of private landscaping within site plans or other on site development, however, the same water conservation methodologies used for public ways should be considered in the design of irrigation and landscaping on private property. The Developer should refer to Chapter 12 for additional plantscape design criteria.

5.9.2 Intent The intent of this design criteria is to beautify the Town and its many common areas through the planting of trees, shrubs and other plantings and the appropriate use of hardscape while practicing water conservation through drip irrigation and drought resistant plants.

The Town is committed to the reduction of water consumption in landscape irrigation and encourages the application of Xeriscape design and maintenance principles. This includes the required use of drip irrigation and the use of drought resistant and native plants.

5.9.3 Requirements

A. Local Streets For all residential local streets the adjacent homeowner shall be responsible for planting and maintaining the right of way behind the walk. The homeowner shall install plantings and irrigation within the guidelines for these Regulations.

B. Local Streets-Commercial For all local Commercial local streets, the adjacent property owner shall be responsible for designing, planting and maintaining the right-of-way behind the curb. This design shall include the sidewalk as required by these Regulations. The property owners shall install plantings and irrigation (if necessary) within the guidelines

of these Regulations. All non-hardscape areas within the right-of-way shall be seeded, planted or covered within the guidelines of this Chapter. All on sight landscaping shall be designed in accordance with the Town Planning Department Guidelines.

C. Arterials, Collectors, and Entry Streets
For all arterials, collectors and entry streets within the Town including medians, the Developer shall be responsible for plans and construction of Streetscape within the Project. The plans shall be submitted as an integral part of the Plans as defined in the Policy and Procedure Section of these Regulations. The cost of such improvements shall be included in the Opinion of Costs for Public Improvements as required in the pertaining chapter of these Regulations. The HOA, District or Town as determined by the Town, may require the maintenance of these improvements. All non-hardscape within the Right-of-Way shall be seeded, planted or covered within the design criteria of this section.

D. Medians All medians shall be constructed as shown on Drawings No.'s 26, 27 and 28 within the appendix section of these Regulations.

1. All medians or sections of medians that are less than 4' wide must be completed in a hardscape, including stamped concrete, brick flagstone or exposed aggregate concrete. No landscaping will be allowed within the medians that are narrower than 4'. If a median is between 4' and 10', it shall be at the Towns discretion whether the median is hardscaped or irrigated and landscaped.

2. All medians or sections of medians over 4' are allowed to use drought resistant plantings as shown in this chapter. However, only drip irrigation systems will

be allowed. No pop up sprinklers will be allowed in medians to minimize wastewater that occurs with pop up sprinklers.

E. Tree Lawn On arterials, all sidewalks shall be set back from the curb a minimum of 5'. Pop up sprinklers may be approved in tree lawns over 8' in width.

5.9.4 Plantings

5.9.5 Street Trees

Design for street trees should respond to the uses on the street. The following factors are guidelines for determining how and when trees should be used within the streescaping areas.

1. Trees should have the same characteristics on both sides of the street. If mixing species, alternate them in a regular pattern.

2. Plant only one species where a area is to be unified. Avoid random changes in species.

3. Select trees that will fit when they are mature. Narrow areas suggest a narrow tree and open areas suggest a wide one.

4. Where tree lawns do not exist, tree grates or pavers are recommended to protect tree roots and pedestrians. Ground covers may considered for use in low traffic areas.

5. Use tree grates where pedestrian traffic is high.

6. Trees may be grouped in areas upon approval of the Town.

All existing trees must be protected during construction. The Towns Parks Department must approve any existing trees being removed from the right-of-way prior to removal.

5.9.6 Location

The Developer shall consider the mature trees shape and size during the design and before planting so that the tree has room to grow. Where signs, lights, overhead or underground utilities, utility poles and fire hydrants would limit mature tree size, adjustment in species or location should be considered to minimize excessive pruning. The following items are suggestions or guidelines in the design of trees:

1. Plant trees with regular spacing in straight rows to create a continous street edge. Adjust spacing only slightly for driveways and lights. On the arterials, the plant trees may be varied for visual appeal.

2. Locate trees in a straight line midway between curb and detached walk even where the width of the tree lawn varies.

3. Plant trees 35 to 45 ft. apart on center for most species. The spacing shall be related to species and age of trees.

4. When replacing trees in an existing row, select new trees of similar characteristics of those being replaced, including form, scale, texture, and color.

The following items are requirements to be followed in the design of trees and their locations:

1. Trees shall not be planted closer than 30 feet from the curb face at intersections and street corners within the sight distance triangle.

2. Within the Sight Distance Triangle, no non-plant materials over 32" or plant materials over 6" high are permitted.

3. Maintain the minimum sight distance triangle and corner triangle distances for safe view of on-coming traffic and pedestrians.

4. Trees must not interfere with the visibility of traffic control devices especially at intersections.

5. Trees should be located a minimum of 42" from the face of the curb.

6. For commercial areas, the minimum distance from streetlights is 20'.

7. Trees shall be designed to ensure the driver visibility of all regulatory signs.

8. Create a clear walking zone between trees and fences or buildings. In the downtown area this shall be a minimum of 10'.

9. No trees shall be planted within 5' of a utility.

5.9.7 Tree Size

Trees should be large enough when planted to add substantial shade and to reach a height appropriate to the surrounding vicinity.

1. Street trees in grates should be a 3" caliper, minimum with high branching where pedestrians will be passing under the tree canopy. This high branching shall be a minimum of 8' high. This size is recommended so that adequate branching height is achievable without severe pruning.

2. Trees planted in tree lawn should be 2" caliper, minimum.

3. The branching height of a tree on the traffic side of the street shall be no less than 13'-6" above the street.

4. The branching height of a mature tree on the pedestrian side of the street should be no less than 8' above the sidewalk.

5. Small varieties of thornless and fruitless trees may be used only in median areas or traffic islands where lower branching habits will not interfere with pedestrians, vehicles or driver visibility.

6. Smaller trees shall be used where power lines overhead would not allow a large street tree to reach maturity without severe pruning.

5.9.8 Tree Selection

All trees should fit the microclimate, soils, sun, moisture, budget and maintenance environment in which they are planted. This is a major concern in areas with high levels of pollution, salt, snow storage or automobile or pedestrian damage. Trees selected for urban streets should be able to endure pollution, compacted soils, minimal water and low maintenance.

1. Trees near walks should be thornless and fruitless to minimize maintenance and to reduce pedestrian hazards. They must be strong wooded, resistant to most diseases and insects, single trunked, with upright growth and a medium to long life expectancy. Branches should resist breaking.

2. Trees and irrigation techniques that require minimal water are necessary. Drip irrigation must be installed for street trees in all commercial streets. Irrigation must be designed to provide the appropriate amount of water to each tree with minimal waste. Easily adjustable, automatic irrigation systems are recommended.

3. Along commercial streets, trees should selected that will minimize the obstruction of

views to retail signs. Use trees with the appropriate forms and character. Utilize tree spacing that supports this concept.

5.9.9 Ground Covers

Ground covers provide seasonal color and serve as a buffer between people and cars. Groundcover plantings provide functional and aesthetic benefits, however maintenance is extremely important.

Plantings other than trees in the streetscape may include turf, ground covers or shrubs. In commercial streetscapes with a large area between the sidewalk and the street or low pedestrian volume, a tree lawn of grass may be most appropriate. This area helps soften the street environment along the street edge. Certain ground covers are recommended because they require moderate to low amounts of water and have been proven successful in the region.

Specific site conditions must be fully understood prior to plant selection. Local microclimates and soils are key factors that determine which plans will thrive. Where possible, low water requiring selected. Trees and shrubs will require less water and will thrive better if placed in planting beds rather than turf beds.

1. Tree lawn should be at least 8' wide to accommodate irrigation system and to provide adequate room for healthy tree root systems. Turf should be provided where the average width of the tree lawn is 8' or more. In medians, turf should be limited to median areas greater than 10'.

2. For tree lawn areas less than 8' wide, turf is difficult to irrigate efficiently and ground cover such as shrubs, etc. should be considered. In median areas, any width less than 4' shall be hardscaped.

3. Tree lawns should be planted with sod or low ground covers (below 6" in mature height) in residential areas and in commercial areas where pedestrian traffic does not warranty hardscape.

4. Very narrow tree lawns or those in high traffic areas may be paved with brick, flagstone or concrete pavers and/or colored or scored concrete. All tree lawn areas designated by the Town as high commercial or downtown shall be hardscaped.

5. Tree lawns may not be elevated.

6. Medians shall be elevated as shown in drawing No. 28.

5.9.10 Recommended TurfGrasses

Turf should be planted on prepared soil from seed or sod. Seeding allows a greater turf selection but requires approximately six months and regular maintenance to become established. Newly seeded areas require protection from pedestrians and must be kept moist until seeds germinate. All irrigated turf areas require organic soil amendments at the rate of at least 3 cubic yards per 1,000 square feet.

Alternatives to bluegrass are required. They are as follows:

1. Mixed Fine Fescue, Rye Grass and Bluegrass
This mix works in sun and shade, suits a number of climate and soil conditions and provides improved shade, disease, and moisture stress tolerance over pure bluegrass.

2. Tall Fescue-Turf Type
Deep green color, shade and salt tolerant, and drought resistant because of its deep root system. Include at least 3 improved varieties of turf type tall fescue in the blend.

5.9.11 Recommended Ground Covers (other than turf)
Where ground covers are used, the intent should be to create a consistent carpet of plant material similar to the affect achieved by turf. Mixed uses of species that create a planting display are not desirable except at corners of entry streets or in medians. Ground covers provide more seasonal variety, require less water and , once established, usually require lower maintenance than most turf species. For ground covers to be successful, they must create a tight, dense planting.

Ground covers are not as dependable as turf when required to grow with poor soil preperation and maintenance and should only be planted in areas that will receive minimal foot traffic. They require adequate water and weeding until established.

The species listed are preferred for their dependability, low maintenance and drought resistance.

5.9.12 Refer to the pertaining parts of Section 12 in these Regulations.