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 Transportation methodology. Some standardization of criteria has been made in design procedures.

5.1.2 Pavement Design Report Submittal Options - There are two (2) acceptable submittal options for pavement design geotechnical reports related to the final construction plans:

5.1.2.1 Option 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 Option 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 five (5) feet below proposed subgrade elevation (10 feet below proposed subgrade on arterial roadways), with maximum spacings of two hundred and fifty (250) feet unless otherwise accepted by the Town Engineer. Every fifth (5^{th}) hole shall be ten (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: _____ DATE: _____		OK		REVIEWED BY: _____ REJECTED:
		YES	NO	COMMENT
1.	VICINITY MAP			
2.	DRAWING WITH LOCATION OF BORING			
3.	DRAWING WITH ESTIMATED EXTENT OF SOIL TYPES & EDLA			
4.	DRAWING WITH PAVEMENT ALTERNATIVES			
5.	ATTERBERG LIMITS AND % 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 CBRS SHOWN ▪ SURCHARGE WEIGHTS (CORRECT UNIT WEIGHTS, INTENISTY OF LOADING EQUAL TO MASS OF PAVEMENT DESIGN +/- 5 LBS) ▪ 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 PRESSUE FOR EACH SAMPLE ▪ EXUDATION PRESSURE R-VALUE CURVE			
9.	DESIGN NOMOGRAPH SHOWN WITH CORRECT SOIL SUPPORT & EDLA			
10.	CORRECT DESIGN COEFFICIENT USED FOR ASPHALT, BASE COURSE, ETC.			
11.	DESIGN CALCUALTIONS 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 SHOWNS 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:

A. Liquid Limit - AASHTO T 89 (ASTM D 4318)
B. Plastic Limit - AASHTO T 90 (ASTM D 4318)
C. % Passing No. 200 - AASHTO T 11 (ASTM C 117)
D. 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 percent compaction, and at optimum moisture within 2 percent) is 2 percent or greater, the pavement design report must provide mitigative measures to minimize the destructive swell potential. Mitigation could be over-excavation 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 (18 Kip) DAILY LOAD APPLICATIONS (EDLA)

Classification	Class Modifier	EDLA Values (1)
Local	Residential	
	• Serving <80 DU	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 project 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	
Classification	SI
Arterials (minor major)	2.5
Collectors	
• Major	2.5
• Minor Commercial / Industrial	2.5
• Major 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 • Commercial • Industrial	Table 5.2 30 100	4 4 4	6 6 6	6.0 6.0 6.0	6.0 6.0 6.0
Minor Collector • Residential • Commercial • Industrial	30 50 150	4 4 4.5	6 6 6	6.0 6.0 6.5	6.0 6.0 6.0
Major Collector • Residential • Commercial • Industrial	100 100 150	4 4 4.5	6 6 6	6.0 6.0 6.5	6.0 6.0 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 Town Engineer. 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 Coat	0.25	
Hot Bituminous Pavement	0.40	(1500 lbs. Marshall or Rt 90+)
Exist Bituminous Pavement	0.30 0.24	(9-15 yr) (>15 yr)
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	(7 day, 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

The working stress to be used in the design shall be 75 percent 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:

$$SN = a_1 D_1 + a_2 D_2 + a_3 D_3 + \ldots$$

Where:
A_1 =Hot Bituminous Pavement (HBP) strength coefficients

A_2 A_3 A_4= strength coefficients of additional pavement components

D1 = thickness of Hot Bituminous Pavement (HBP) (inches)

D_2, D_3, D_4 = 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 percent under 200 psf surcharge pressures at 95 percent 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-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 PAVMENT DESIGN WITH SI=2.0

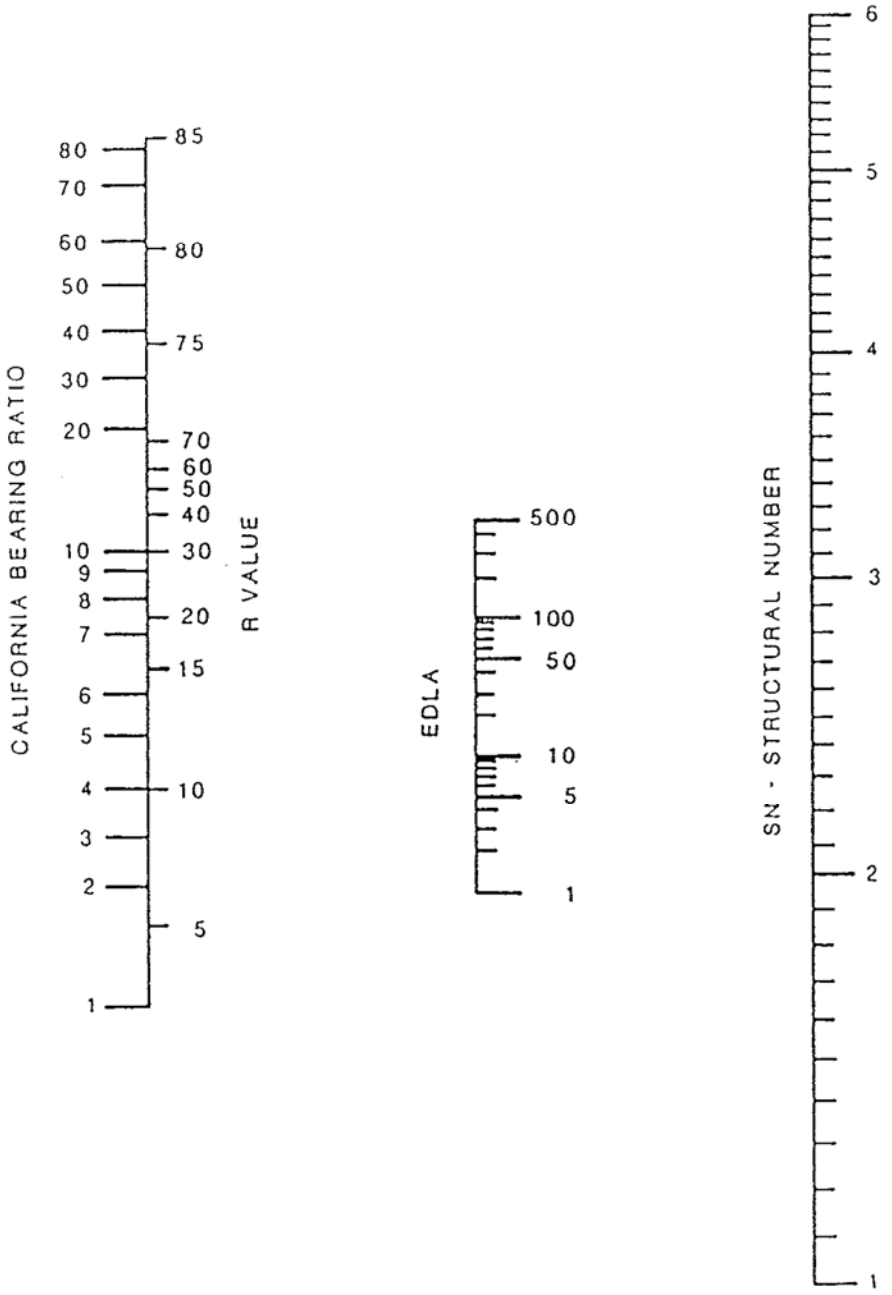
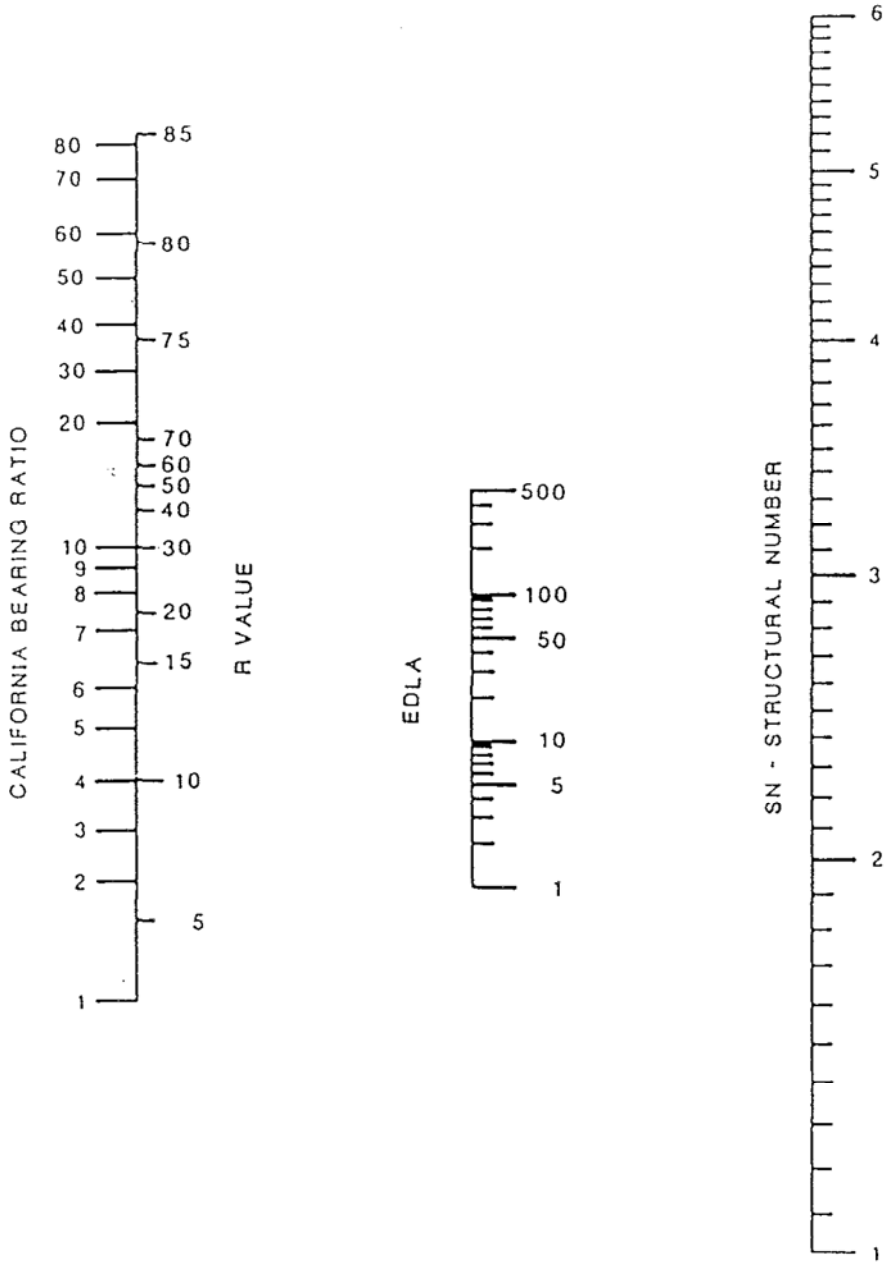


TABLE 5.7

NOMOGRAPH FOR FLEXIBLE PAVEMENT DESIGN WITH 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 percent under 200 psf surcharge pressures at 95 percent 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 Engineer 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 ROW, 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 material 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

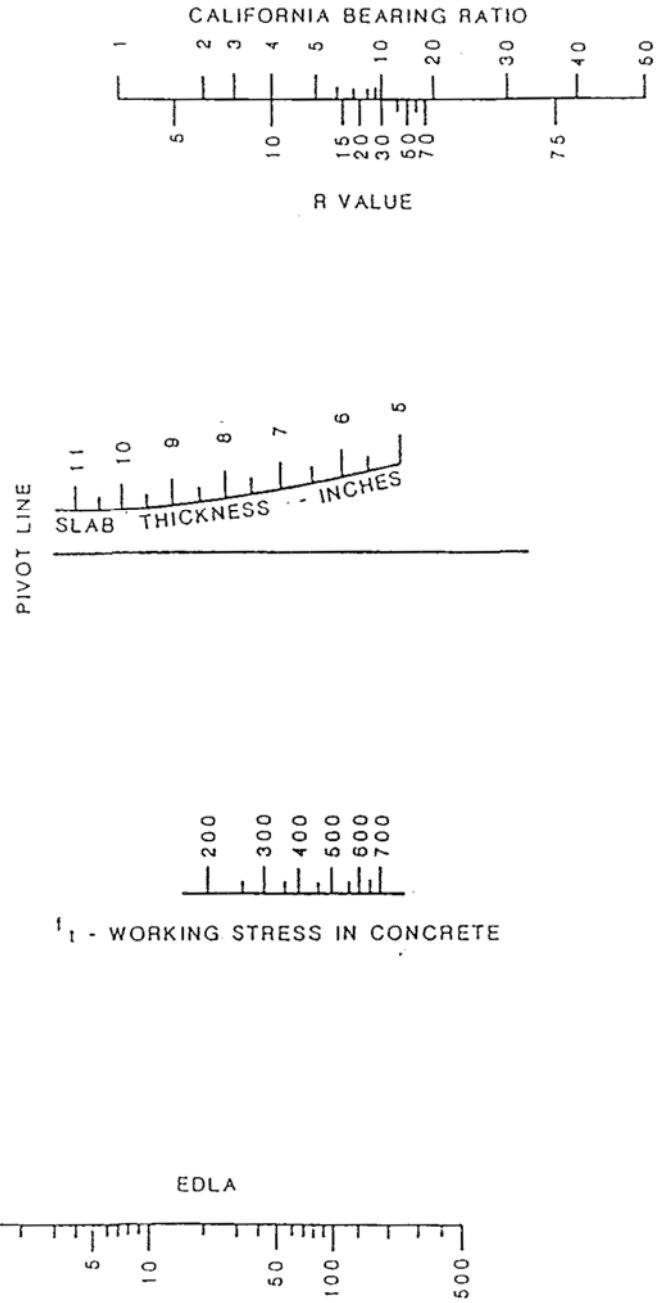
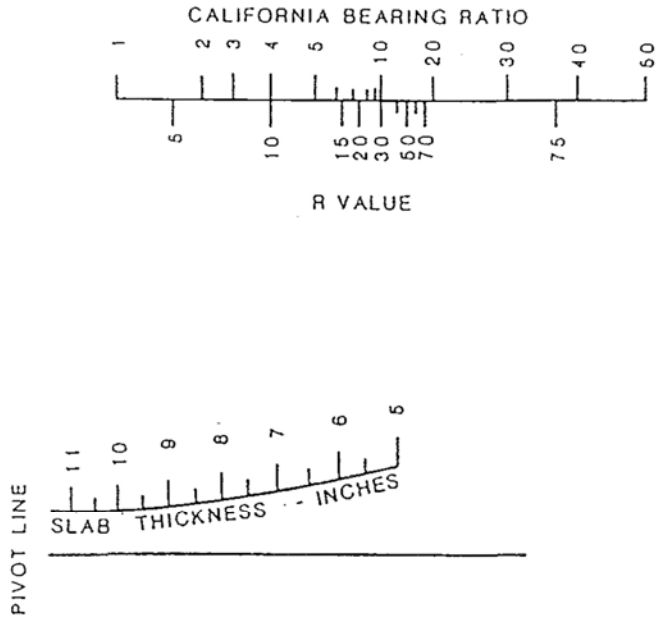


TABLE 5.9

NOMOGRAPH FOR RIGID PAVEMENT DESIGN WITH SI=2.5



5.5.3 Violations of Approved Conditions

5.5.3.1 Random Testing

The Town Engineer may order random tests of materials used in public 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 remedial action. 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 Transportation 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 SPCEIFICATIONS 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 TOLERENCES	
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 Transportation.

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 LBS.	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 Transportation 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 Transportation 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 Transportation Section 703.01 requirements and gradation as shown in Table 5.13.

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

D. Fly Ash shall comply with Colorado Department of Transportation 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 AND LIGNITE, %	1.0, MAX.
DELETERIOUS MATERIAL (AASHTO T-11), %	3, MAX.
SAND EQUIVALENT (AASHTO T 176), %	80, MIN.
FINENESS MODULES	2.50 – 3.50
SODIUM SULFATE SOUNDNESS, %	20.0, MAX.

E. Water shall meet the requirements of Colorado Department of Transportation Section 712.01.

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

TABLE 5.14 COURSE 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 AND FRIABLE PARTICLES, %	2.0, MAX.
COAL AND 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 Transportation 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, CDOT 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 Bennett's' Town Engineer approved sources shall be used, unless otherwise approved in writing by the Engineering Division. Approval of sources will be at the discretion of the Town Engineer and submissions will, at a minimum, consist of supplying documented gradation, Atterberg limits and CBR/R-value testing on an annual basis. See Section 5.5.2.

Only 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 shoulder, 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 CDOT Standard Specifications (latest revisions). Acceptable aggregates include CDOT Classes 4,5, and 6. Other aggregates may be used, if previously approved by Town 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 Town Engineer shall be used. Approvals are required on a project basis prior to issuing construction permits. Minimum in-place thickness for this material shall be 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 or a round number (i.e. 200). Record this dial reading.

   c. Apply the specified surcharge load. If no surcharge load is specified, use 200 psf.

   d. Record dial reading 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 percentage - Consolidation percentage 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-TI03 Procedure
One test on sample or riprap from each source of materials and one test for each 10,000 cubic yards placed.