CHAPTER 7

PAVEMENT DESIGN AND TECHNICAL CRITERIA

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INDEX

CHAPTER 7 - PAVEMENT DESIGN AND TECHNICAL CRITERIA

7.1 GENERAL

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

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

Option 1: 7.1.2.1 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.

Option 2: 7.1.2.2 The final pavement design may be completed and submitted after County 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 County. If option 2 is used, the Applicant may obtain pavement construction permits only after the final construction plans which include the pavement design are approved by the County. If option 2 is used, the application for pavement design approval must be in accordance with Chapter 2, Section 2.3.2.

7.1.2.3 If a street is to be built in phases (i.e., the center two lanes are built first, then at some later date more lanes are added), a new pavement design investigation and report for the additional lanes will be required if it has been at least two years since the original design was made.

7.1.3 **Preliminary Pavement Design Reports**
For all County land development approvals that involve a S.I.A. for roadway construction, upon the request by the County Engineer, 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 EDLA of Table 7.2. This preliminary pavement design serves as a justification of the roadway improvement costs included in the S.I.A.

A preliminary pavement design may be submitted with final construction plans for Applicants using submittal option 2 in Section 7.1.2. Table 7.1 provides a checklist for subgrade investigation and pavement design.

TABLE 7.1
SUBGRADE INVESTIGATION AND PAVEMENT DESIGN CHECK LIST

SOIL CONSULTANT DEVELOPMENT FILING JOB NO. STREET DATE	OK		REVIEWED BY REJECTED
	YES	NO	COMMENT
1. VICINITY MAP			
2. DRAWING WITH LOCATION OF BORINGS			
3. DRAWING WITH ESTIMATED EXTENT OF SOIL TYPES AND EDLA			
4. DRAWING WITH PAVEMENT ALTERNATIVES			
5. ATTERBERG LIMITS & % PASSING NO. 200 SIEVES			
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 ± 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 pressure 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 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 PROBLEMS			
14. IF THE DENVER/COLORADO/SWELL-CONSOLIDATION TEST SHOWS OVER 2.00% SWELL, PROPOSED MITIGATIVE MEASURES ACCEPTABLE TO COUNTY ENGINEER			

7.2 SUBGRADE INVESTIGATION

7.2.1 Field Investigation

The field investigation shall consist of borings or other suitable methods of sampling subgrade soils to a 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 County Engineer. Every fifth hole shall be 10 feet deep or as otherwise specified by the County Engineer. Samples shall be taken after grading is completed and the subgrade is rough cut or as otherwise specified by the County Engineer.

7.2.2 Classification Testing

Subgrade samples shall be tested to determine Liquid Limit, Plastic Limit, Plasticity Index, Atterberg Limits and the percentage passing the U.S. Standard No. 200 sieve as specified by the County Engineer. Samples of sands 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.

7.2.3 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. Groupings 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 Section 7.2.2.

7.2.4 Subgrade Support Testing

Individual subgrade or composite samples shall be tested to determine the subgrade support value using either CBR 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 7.4. Tests shall be conducted in accordance with the procedures. (Sections 7.2.4.1 or 7.2.4.2.)

7.2.4.1 **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 9.2 of these Roadway 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 results shall be reported.

7.2.4.2 **R-Value Tests** - Hveem Stabilimeter 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.

7.2.4.3 **Swell Test** - A Denver/Colorado/Swell-Consolidation Test (Appendix E) shall be required in all pavement design reports.

If the swell (at an overburden pressure of 100-150 psf, at specified compaction per CDOT and at optimum moisture content) is 2.0% or greater, the pavement design report must provide mitigative measures to minimize the destructive swell potential. Since the pavement is not placed on the soils until after the soil has been scarified, moisture treated, and compacted to optimum, the "% swell" shall be measured from the point after the overburden pressure is applied, to the point after water is added. In other words, after the overburden pressure is applied and consolidation has occurred, the "% swell" = 0.0%, then add water and measure the swell. 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 County Engineer 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-walk if attached or monolithic walk).

7.3 PAVEMENT DESIGN CRITERIA

7.3.1 General

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

7.3.2 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 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 Teller County roadway classification are given in Table 7.2.

TABLE 7 .2
RECOMMENDED EQUIVALENT (18 Kip) DAILY LOAD APPLICATIONS (EDLA)

CLASSIFICATION	CLASS MODIFIER	EDLA VALUES[1]
Local	Residential Serving <80 D.U. All Others Commercial[2] Industrial[2]	 5 10 30 100
Entry	Residential	10
Collector	Residential Commercial[2] Industrial[2]	30 50 150
Minor Arterial[2]	All	200
Major Arterial[2]	All	200
Entry Street		10 EDLA MINIMUM (EDLA may be required to be 30 if number of DU's served is over 100)

Notes:
[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 7.2.

7.3.3 Design Serviceability

The following criteria shall be used for all roadways subject to these Roadway Standards:

TABLE 7.3
SERVICEABILITY INDEX

ROADWAY CLASSIFICATION	SI
Arterials (minor, major)	2.5
COLLECTORS	
Commercial/Industrial	2.5
Residential	2.5
LOCAL	
Residential	2.0
Commercial/Industrial	2.5

7.3.4 Minimum Pavement Section

This section provides the minimum acceptable pavement sections for public roadways in Teller County. These pavement thicknesses may be used for preliminary planning purposes or for estimating collateral requirements for S.I.A. Final pavement designs must be based on actual subgrade support test results. Table 7.4 lists these minimum thicknesses for each roadway classification.

7.3.4.1 **Additional Requirements for Warranty** - Refer to Section 15.4.2.1 for additional requirements.

TABLE 7.4
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)	3	6	5.0	5.0
Commercial	30	3	6	5.0	6.0
Industrial	100	4	6	6.0	6.0
Collector					
Residential	30	3	6	5.0	6.0
Commercial	50	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

7.3.5 Flexible Pavement Strength Coefficients

Table 7.5 contains the standard design coefficients for various pavement materials. Nonstandard design coefficients may be used only if approved in advance by the County Engineer. In addition, design values must be verified by predesign mix test data and supported by daily construction tests; or, redesign values will be required; i.e., such as - Add ½ to 1" to the in-place surface course of final asphalt concrete.

TABLE 7.5
STRENGTH COEFFICIENTS

PAVEMENT STRUCTURE COMPONENT*	STRENGTH COEFFICIENTS	(LIMITING TEST CRITERIA)
CONVENTIONAL MATERIALS		
Plant Mix Seal Coat	.25	
Hot Bituminous Pavement	.40	(1500 lbs. Marshall or Rt 90+)
Exist Bituminous Pavement	.30 .24	(9-15 yr) (>15 yr)
Aggregate Base Course	.12	(CBR 80+ or R 78+)
Exist Aggregate Base Course	.10	(CBR 50+ or R 69+)
Granular Subbase Course	.07	(CBR 15 or R 50+)
TREATED MATERIALS		
Cement Treated Aggregate Base	.23	(7 day, 640-1000 psi)
Lime Treated Subgrade	.14	(7 day, 160 psi, Pl.<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) Subbase. 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 a 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."

7.3.6 **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 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.

7.4 PAVEMENT DESIGN PROCEDURE

7.4.1 Flexible Pavements

The following procedure should be used in determining the SN of the pavement being designed:

7.4.1.1 Determine roadway classification and corresponding EDLA (Table 7.2)

7.4.1.2 Determine the Serviceability Index (SI) of the roadway classification (Table 7.3)

7.4.1.3 Select the proper nomograph:

Table 7.6 Flexible Pavements with SI=2.0
Table 7.7 Flexible Pavements with SI=2.5

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

7.4.1.5 Once the 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 = HBP strength coefficients

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

D_1 = 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 7.5.

The component thickness selected must meet two conditions.

a. Total HBP thickness selected cannot be less than the minimum specified in Table 7.4 for the roadway classification.

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

7.4.1.6 The design must reference any mitigation measures required when the subgrade contains swelling soils (swell potential >2.00% under 100-150 psf surcharge pressures at 95% standard compaction from a Denver/Colorado/Swell-Consolidation 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. (See Section 9.3, 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).

7.4.1.7 If the entity responsible for paving the road so chooses, a one-year warranty period may be employed, instead of the normal two (2) year warranty period, by using the following procedure: (See Section 15.3.5.4.)

Pavement design report shall state that, at initial construction, the contractor shall pave one-half inch (½") less than the asphalt thickness arrived at in Section 7.4.1.5. above. Then at the end of the one-year warranty period (and after all punch list repairs have been made), the Developer shall either escrow sufficient money for the County to pave a one-inch (1") CX overlay within the next five (5) years, or the Developer may pave a one-inch (1") CX overlay himself (example: If Section 7.4.1.5. says the pavement section should be 5.5" full-depth asphalt, the report shall instruct the contractor to pave 5.0" at initial construction, leaving the finish asphalt ½" below the lip of the gutter. Then after one year (and after all warranty repairs have been made), the Developer may either escrow the money, or do a 1.0" CX overlay, prior to the County accepting the streets for full-term maintenance). Refer to Section 15.4.2.1. and 15.4.2.2. for additional requirements.

7.4.2 **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 contributions of underlying layers to the capacity of the pavement are relatively insignificant. Therefore, the use of thick bases or subbases under concrete pavement to achieve greater structural capacity is considered to be uneconomical and is not recommended.

Use the following procedure to obtain required thickness:

7.4.2.1 Determine roadway classification and corresponding EDLA (Table 7.2).

7.4.2.2 Determine design SI of the roadway (Table 7.3).

7.4.2.3 The working stress of the concrete (f_t is to be obtained from laboratory tests). For preliminary design, this value shall be assumed to be 450 psi until laboratory tests have been completed.

7.4.2.4 Select the proper nomograph.

Table 7.8 Rigid Pavement with SI = 2.0
Table 7.9 Rigid Pavement with SI = 2.5

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

7.4.2.6 Use slab thickness from Section 7.4.2.5 or the minimum thickness from Table 7.4 whichever is greater.

7.4.2.7 The design must reference any mitigation measures required when the subgrade contains swelling soils (swell potential >2.00% under 100-150 psf surcharge pressures at 95% standard compaction from Denver/Colorado/Swell-Consolidation Test [see Appendix E]; 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. (See Section 9.3, 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).

7.4.2.8 Refer to Section 15.4.2.1. and 15.4.2.2. for additional requirements.

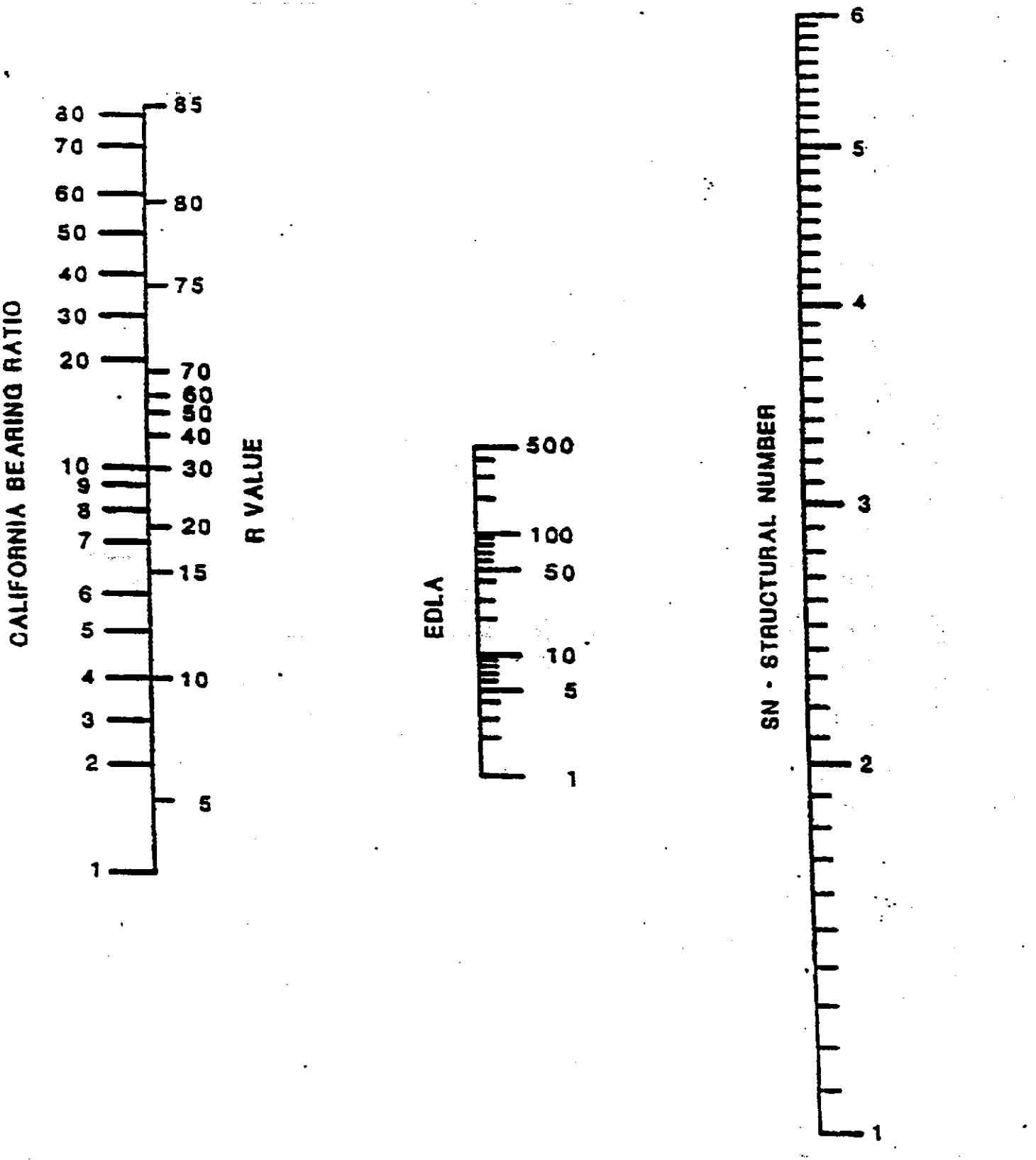


TABLE 7.6

NOMOGRAPH FOR FLEXIBLE PAVEMENT
DESIGN WITH SI=2.0

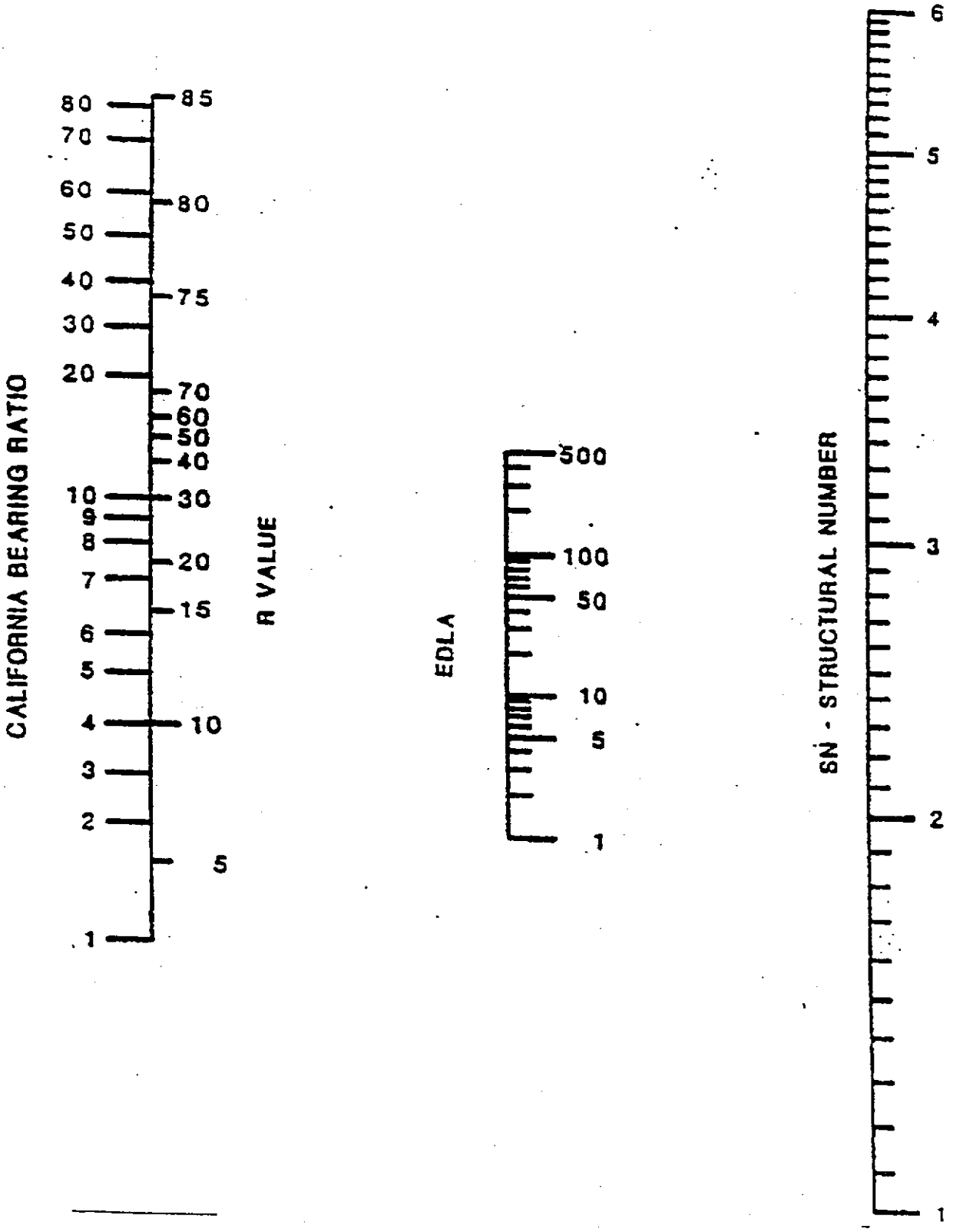
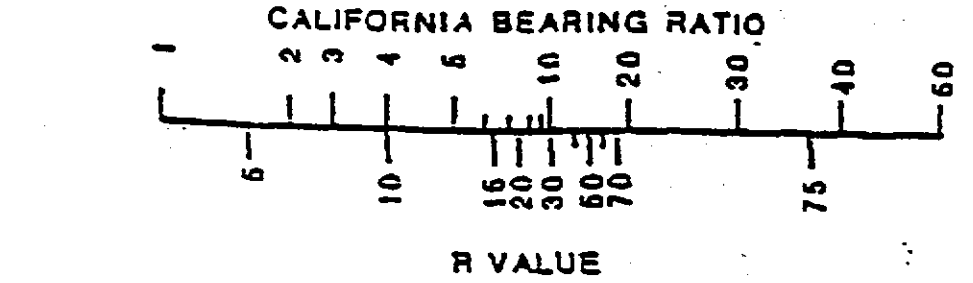
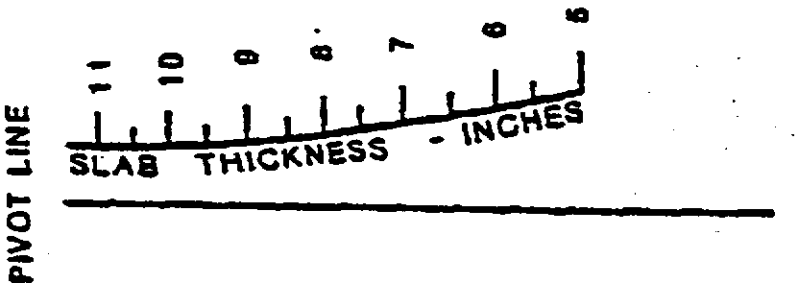
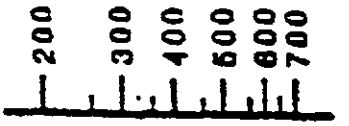


TABLE 7.7

NOMOGRAPH FOR FLEXIBLE PAVEMENT DESIGN WITH SI=2.5







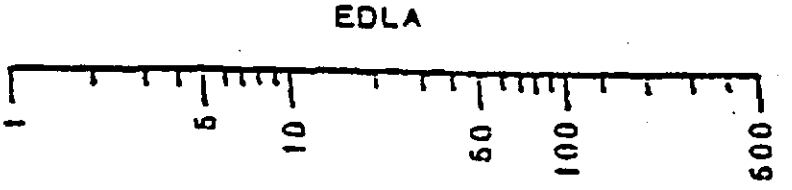
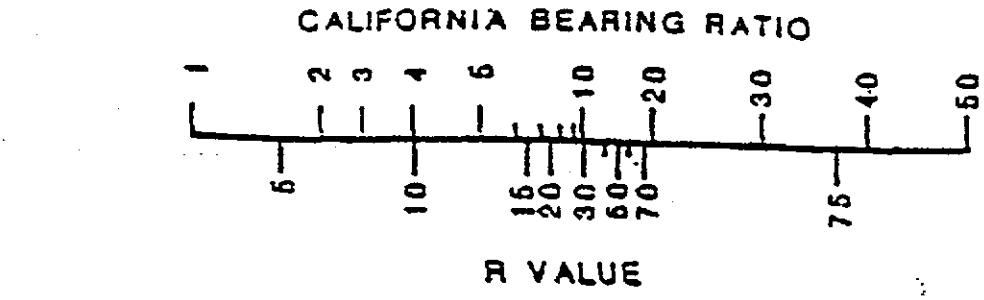
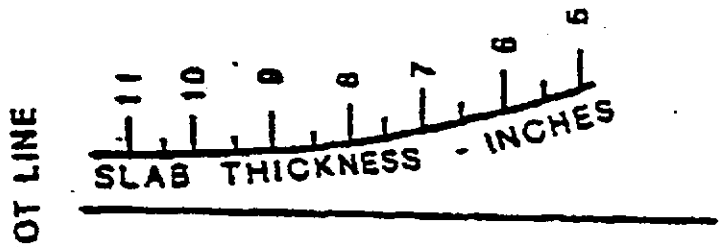
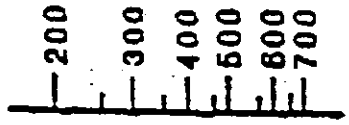


TABLE 7.8
NOMOGRAPH FOR RIGID PAVEMENT
DESIGN WITH SI=2.0







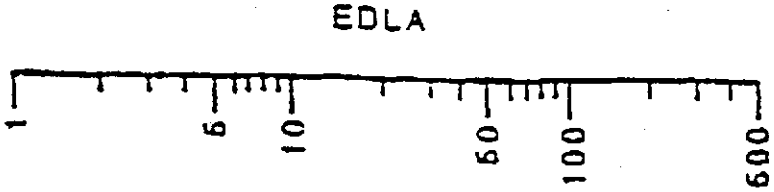


TABLE 7.9

NOMOGRAPH FOR RIGID PAVEMENT DESIGN WITH Si=2.5

7.5 MATERIAL SPECIFICATIONS

7.5.1 General

The specifications presented in this section are performance oriented. The County's objective in setting forth these Specifications is to achieve an acceptable quality of roadway structures. All mined or manufactured materials listed in Section 7.5.5 must be approved by the County Engineer as having met the appropriate materials performance specifications. This approval is a condition of using those material sources for public improvement construction. For the purpose of these Roadway Standards, public improvements are all roadway improvements, sidewalks, curbs and gutters, appurtenant drainage basins or structures, storm sewer and their access ways, other public works within Teller County ROW, and County mandated stormwater detention structures built on private property and maintained by the property owner(s).

7.5.2 Procedure For Material Source Approval

On or before April 1st of each year, or a minimum of 14 calendar days before construction, a material supplier for any Teller County 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 Teller County 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 improvements in Teller County during the coming 365 day period.

7.5.3 Violations Of Approval Conditions

7.5.3.1 Random Testing

The County Engineer may order random tests of materials used in County public improvements to verify compliance with material specifications. These tests are in addition to the requirements of Chapter 9.

7.5.3.2 Any and all material used to construct Teller County public improvements that is not from a certified source, or that is from a certified source and fails one or more random material tests, may be subject to complete removal as a condition of County 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 material to be removed will be at the discretion of the County Engineer.

7.5.4 Use Of Materials Not Listed In Section 7.5.5

Materials in this section and provided with a set of specifications are those deemed by the County 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, sealers, gaskets, insulating materials, etc. should be in compliance with CDOT material specifications for the appropriate material employed. Alternative materials for construction may be proposed for use, except where expressly prohibited by the Land Use Regulations. Decisions on acceptability of alternative materials will be made by the County Engineer.

7.5.5 Material Specifications

7.5.5.1 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. Tests on the aggregates for cleanliness, abrasion loss and fractured faces shall meet the requirements shown in Table 7.10. 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 7.10
MATERIAL SPECIFICATIONS FOR
HOT BITUMINOUS PAVEMENT

SIEVE SIZE OR TEST PRESSURE	PERCENT PASSING OR TEST REQUIREMENTS	
	C MIX	CX MIX
3/4"	100	
½"	70-95	100
3/8"	60-88	74-95
#4	44-72*	50-78*
#8	30-58	32-60
#30	12-34	12-34
#200	3-9	3-9
% Wear, AASHTO T-96	35, Max.	35, Max.
2 Fractures faces on + No. 4	70% Min.	70% Min.
Index of Retained Strength ASTM D-4867 Lottman Test	75, Min.	75, Min.
Atterberg Limits	NP	NP

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 range of tolerances in Table 7.11
c. The natural sand content shall not exceed 20 percent of the weight of the total aggregate blend.

TABLE 7.11
MIX TOLERANCES

Maximum Size	0%
Passing the 3/8" and Larger Sieves	± 6%
Passing the No. 4 and No. 8 Sieves	± 5%
Passing the No. 3 Sieve	± 4%
Passing the No. 200 Sieve	± 2%
Bitumen Content	± .3%
Discharged Mix Temperature	± 20°F

d. An additive may be used to meet the requirement for index of retained strength, if necessary. Such additives may be hydrated lime, Type I Portland cement, or anti-stripping agents approved by the CDOT.

e. 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 any project. If the mix design has been approved, a copy of the approval is required at the time of permit request application for any project. The mix design shall be performed using the Marshall Procedures as outlined in The Asphalt Institute's, "Mix Design Methods for Asphalt Concrete" (MS-2). Mix design parameters for the procedures are shown in Table 7.12.

TABLE 7.12
MIX DESIGN CRITERIA

TEST	LOCAL STREET	COLLECTOR	ARTERIAL
Marshall Blows Required (AASHTO T 235)	35	50	75
Air Voids, Percent (± 0.5)	4	4	4
Flow, 0.01"	8-18	8-16	8-14
Voids filled with asphalt (V.F.A.) (%)	70-80	65-78	65-75
Stability, lbs. Minimum	1500	1700	2000
Percent Voids in Mineral Aggregate (VMA)	See Table 7.12A		

TABLE 7.12A
MINIMUM VOIDS IN THE MINERAL AGGREGATE (VMA), PERCENT

NOMINAL MAXIMUM PARTICLE SIZE [1,2]			VMA, PERCENT	
			DESIGN AIR VOIDS, PERCENT[3]	
Type	in.		3.0	4.0
	No. 16		21.5	22.5
	No. 8		19.0	20.0
	No. 4		16.0	17.0
CX	3/8		14.0	15.0
C	½		13.0	14.0
	3/4		12.0	13.0
	1.0		11.0	12.0
G	1.5		10.0	11.0
	2.0		9.5	10.5
	2.5		9.0	10.0

1. Standard Specification for wire Cloth Sieves for Testing Purposes, ASTM Designation E11 (AASHTO Designation M92).
2. The nominal maximum particle size is one size larger than the first sieve to retain more than 10 percent.
3. Interpolate minimum voids in the mineral aggregate (VMA) for design air void values between those listed.

7.5.5.2 **Portland Cement Concrete Pavement**

This material shall consist of a mixture of coarse and fine aggregates, Portland cement, water and other materials or admixtures as required. CDOT Class "P" or "AX" mix may be used. (The only alternatives to ""P" or "AX" shall be according to Section 412.03 of CDOT Standard Specifications). Other high-early strength concretes may be used where special conditions warrant, subject to written approval by the County Engineer.

a. Portland cement shall comply with the CDOT 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 CDOT Section 703.01 requirements and gradation as shown in Table 7.13.

c. Coarse aggregates shall meet CDOT Section 703.02 requirements and gradation as shown in Table 7.14.

d. Fly Ash shall comply with CDOT Section 701.02.

TABLE 7.13
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 - 30
#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 Modulus	2.50 - 3.50
Sodium Sulfate Soundness, %	20.0, Max.

e. Water shall meet the requirements of CDOT Section 712.01.

f. Air entraining and chemical admixtures shall meet the requirements of CDOT Sections 711.02 and 711.03. No additive manufactured with the purposeful addition of chloride shall be permitted.

TABLE 7.14
COARSE AGGREGATES FOR
PORTLAND CEMENT CONCRETE

SIEVE SIZE OR TEST PROCEDURE	PERCENT PASSING OR TEST REQUIREMENT
2"	100
1 ½"	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 & Lignite, %	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 CDOT Section 709.01, grade 40 minimum.

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

7.5.5.3 **Aggregate Base Course Material**

This material shall consist of 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 the requirements of AASHTO M 147, and to Section 703.03, CDOT Standard Specifications. In addition, the material must have a 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 County Engineer approved sources shall be used, unless otherwise approved in writing by the County Engineer. Approval of sources will be at the discretion of the County 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 7.5.2.)

Only one (1) type of crushed aggregate base course is acceptable in Teller County. The gradation specifications for this type of base course is listed in Table 7.15:

TABLE 7.15
AGGREGATE BASE COURSE (ABC) MATERIALS

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, repairing gravel surfaces, or in cases where the BOCC allows gravel roads, No. 200 shall be 9 - 12, and No. 4 shall be 30 - 50.

NOTE: The specific gravity must be greater than 2.4 (at the source) for aggregate base course materials to be used as shoulders or on gravel roads.

7.5.5.4 **Cement Treated Aggregate Base Course**

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

The materials to be used in construction shall be tested and a mix design submitted to the County 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 1000 psi. The minimum acceptable cement content shall be 5 percent by weight. Only mix designs approved by the County Engineer shall be used. Approvals are required on a project basis, or an annual basis for suppliers, prior to issuing construction permits.

7.5.5.5 **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 C 977.

The materials to be used in construction shall be tested and a mix design submitted to the County Engineer for approval. As a minimum, the mix design report shall contain a description of material sources, gradation (or -200) and Atterberg limits of native soils, Atterberg 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 County 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 eight (8) inches.

7.6 SUBGRADE INVESTIGATION AND PAVEMENT DESIGN REPORT

The report shall be prepared by or under the supervision of and signed by an engineer 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 soils,
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 performance of the pavement system.

J. Recommendations to alleviate or mitigate the impact of problems discussed in Section 7.6.I.