

# **CHAPTER 10: Roadway Design Standards and Construction Specifications**

**Revised November 20, 2006**

---

## **Section 100 - General Standards**

### **110 Purpose and Intent**

The intent and purpose of these regulations is to establish a uniform road development policy throughout Lake County. These standards and specifications should provide safe, attractive travel corridors, efficient traffic flow and efficient maintenance.

This manual sets forth policies, procedures, design standards and construction specifications for use by design engineers for road construction in Lake County. The standards are intended to set forth minimum requirements and should not preclude good engineering design and judgement. The minimum and maximum values listed in this manual should be used as limits and not as the general rule for design. This manual covers basic design issues. If a roadway requires additional or more complex design standards the Colorado Department of Transportation (CDOT) requirements and specifications shall be used.

### **120 Authority**

The State of Colorado, by statute, authorizes Lake County to administer its county road system. The County shall enforce design standards and construction specification, review plans and conduct inspections.

State highways passing through Lake County shall be designed and constructed to Colorado Department of Transportation requirements.

### **130 Application of Standards**

#### **130.1 New Construction**

All new private and public roadways constructed after the date of adoption of these regulations shall comply with these requirements. These standards are applicable to roadways build by the County as well as private developers.

Private roads in Lake County will not be maintained by the County.

#### **130.2 Upgrading of Existing Roads**

Existing roads may need to be upgraded to accommodate a proposed new development. The developer shall analyze projected traffic volumes as well as review the existing road widths, curves, intersections and surface drainage. The developer shall compare the projected traffic volumes with the design standards for each roadway classification listed in this manual. The developer shall then make a recommendation to the County on the improvements necessary to accommodate the additional traffic generated by the new development. The county shall decide if

the improvements are adequate. Upgrades will be designed and constructed to the minimum standards and specification listed in this manual.

## **140 Variances**

If site characteristics prohibit following the County Roadway Design Standards, an applicant may petition the county in writing for a variance from these standards. The county shall at its discretion and upon the demonstration of sufficient cause decide if the variance is acceptable as is, needs to be modified, or it is denied.

## **150 Required Permits**

Permits shall be required for all work within the right-of-way. Work shall include but is not limited to new road construction, upgrades to existing roads, road cuts for utilities or drainage work and driveway construction.

## **160 Submittal Requirements**

All submittals shall be neat, clean, professional and legible. Mechanical lettering is required on all plan sheets. Any submittal deemed unprofessional or illegible will be rejected by the County without review. Submittals shall include the following items:

1. Traffic Report: For the proposed roadway, an estimate of the traffic volume and access points shall be made.
2. Vicinity Map: A vicinity map with a minimum scale of 1"=2000' shall be submitted. The map shall include all arterial roads within 1 mile of the proposed roadway, and the township, range and section lines. The roadway project area shall be shaded or somehow appropriately delineated.
3. Site Plan: A site plan showing all proposed roadway, drainage, and utility construction within the right-of-way shall be submitted. The site plan shall be submitted on a single sheet.
4. Plan and Profile Drawings: Plan and profile drawings at a scale of not less than 1"=100' (horizontal) and 1"=10' (vertical) scale shall be submitted.
5. Cross Sections: Cross sections of the proposed roadway shall be provided to show that it will fit into the terrain. In addition to the typical cross-section, cross sections at 100-foot intervals and at critical locations shall be included.
6. Storm Drainage Report and Plans: A storm drainage report shall be submitted that demonstrates to the county that all the drainage requirements in Section 270 have been addressed. The report must state the storm event used to evaluate the drainage area and design the culverts and drainage swales. The

plan sheets shall delineate the drainage basin boundaries and show all relevant construction details.

7. Erosion control Plan: An erosion control plan which meets all the Lake County Soil Conservation Service requirements and specifications shall be submitted.

8. Pavement Design Report: A pavement design report meeting the design requirements outlined in Section 260 shall be submitted.

## **170 Definitions and Abbreviations**

*AASHTO* - American Association of State Highway and Transportation Officials

*CDOT* - Colorado Department of Transportation

*ASTM* - American Society for Testing and Materials

## **Section 200 - Design Standards**

### **210 General**

#### **211 Future Planning**

Prior to design, projections of future traffic demands on the proposed roadway shall be made. The estimate shall include both the proposed project as well as adjacent properties which will be served by the roadway. Undeveloped properties shall be assumed developed in accordance with the County

Master Plan. Roadways shall be designed to meet the needs projected for the design period. The design period extends 20 years after the date of construction.

#### **212 Roadway Classification**

Roadways shall be classed by either their functional use or anticipated traffic flow. If both methods apply, the roadway classification which requires the largest section shall be used for design.

##### **212.1 Based on Functional Use**

*Arterial Road:* A roadway to link cities, towns and other traffic generators (such as major resort areas). Arterials allow high speed travel with a minimum number of interferences from intersections. Generally, an arterial road will be a state roadway and therefore shall be designed to meet CDOT requirements and specification. Non-state arterial roads shall be designed to meet the requirement and specification listed in this manual.

<i>Collector Road:</i>	A roadway to link local roads with arterials. Collector roads allow continuous movement of traffic through neighborhoods and serve commercial and industrial areas. If a subdivision separates adjacent private land from an arterial road, <i>at least one road will be a collector.</i>
<i>Local Road:</i>	A roadway to provide access to areas zoned low and medium density residential districts.
<i>Primitive Road:</i>	A single-lane or two-lane roadway to provide access to undeveloped areas, ranches or recreational areas.
<i>Sub-primitive Road:</i>	An existing roadway with a width of less than 12 feet which is to provide access primarily to remote locations with few, if any, permanent residences.
<i>Cul-de-Sac:</i>	Cul-de-sacs are dead-end local or primitive roads. The overall length of a cul-de-sac from the intersection with another street or road to the radius point of the turn shall not exceed 1,000 feet. No cul-de-sacs will serve more than 12 lots. Adequate snow storage must be available at the end of the cul-de-sac. The radius of the cul-de-sac shall be 50 feet. The radius of right-of-way shall be 60 feet.
<i>One-Way Roads:</i>	One-way roads shall not be permitted.

## **212.2 Based on Anticipated Traffic Flow**

The projected Average Daily Traffic (ADT) volume for the development type shall be determined from the table below.

**Table 1**  
**Projected Average Daily Traffic**

<b>Type</b>	<b>Unit</b>	<b>ADT Per Unit</b>
Residential	Per dwelling unit	10.0
Condominium	Per dwelling unit	7.0
Mobile Home Park	Per mobile home	7.0
Hotel	Per room	10.5
Restaurant	Per 1000 s.f. gross	164.0
Commercial	Per 1000 s.f. gross	115.0
Office	Per 1000 s.f. gross	12.3
Campground	Per space	6.6
RV Park	Per space	6.6
Supermarket	Per 1000 s.f. gross	125.0

The roadway then shall be classified based on the projected ADT.

<b>Classification</b>	<b>ADT</b>
Arterial	Over 1500
Collector	1001-1500
Local	100-1000
Primitive	Less than 100

## **220 Geometric Design Elements**

### **221 Right Of Way**

The minimum right-of-way widths required for each roadway classification shall be as specified in Table 2. Rights-of-way shall be widened as necessary to include drainage improvements, cuts or fills, intersections, snow storage, bike paths and other road appurtenances.

### **222 Design and Travel Speeds**

Design and travel speeds for each roadway classification are listed in Table 2. The design speed is the speed for which a roadway is designed and is the maximum speed at which safe travel can be maintained. The travel speed of a roadway is the posted speed limit of a roadway. The design speed shall be at least equal to or greater than the maximum travel speed. The maximum travel speed for a roadway shall be selected by the design engineer after studying the roadway terrain and traffic volumes.

## **223 Number of Lanes**

The number of lanes for each roadway classification shall be as specified in Table 2. All roadways, except primitive roads shall have two lanes. Arterial roads may have four lanes. Primitive roads shall have either one or two lanes.

## **224 Lane and Shoulder Width**

The lane and shoulder width for each roadway classification is listed in Table 2. The land width for arterial, collector, and local roads shall be 12 feet.

## **225 Climbing Lanes**

A climbing lane may be required for roadways on long, steep terrains. The decision to require such a lane will be based on traffic volume, capacities, percent of trucks, grades, speeds and level of service. If the County deems that a climbing lane is necessary, the lane will be designed to the CDOT requirements and specifications

## **226 Side Slopes**

Cut and fill slopes shall be determined by a registered professional engineer experienced in geotechnical engineering or engineering geology. Slopes shall not exceed 3 feet horizontal to 1 foot vertical without a soils analysis by a registered professional engineer and a variance granted by Lake County. When cut or fill slopes intersect the original ground surface, the area shall be rounded to blend the new slope into the existing ground surface.

Retaining walls shall be designed to avoid long fill slope or extreme steep slopes.

Side slopes shall only be benched if deemed absolutely necessary for engineering reason, such as, to intercept drainage in long, steep cuts, to intercept loose material, or stabilize material for economical reasons.

**Table 2**  
**Roadway Design Elements**

<b>Design Element</b>	<b>Arterial Road</b>	<b>Collector Road</b>	<b>Local Road</b>	<b>Primitive Road</b>
Right-of-way (ft)	80	60	50	40
Design Emphasis (mph)	60	45	30	25
Travel Speed (mph)	35-55	30-45	20-30	15-25
Lanes	2-4	2	2	1-2
Lane Width (ft)	12	12	12	12 (1)
Shoulder Width (ft)	8	4	4	2
Maximum Grade (%)	6	6	7	10 (2)
Design Capacity (ADT)	>1500	1001-1500	100-1000	<100

- (1) One-lane roads shall have 12' lanes, two-lane roads 12' lanes. One lane roads are special review use only.
- (2) Refer to vertical alignment section.

## **230 Alignment**

### **231 Horizontal Alignment**

#### **231.1 Stopping Sight Distance**

Horizontal alignment must provide the minimum stopping distance for the design speed at all points along the roadway. Visibility at intersections, around curves and around roadside encroachments is included in this requirement.

The distance required for a driver traveling at the design speed to bring a vehicle to a complete stop after an object on the road becomes visible is the minimum stopping sight distance. Stopping sight distance is a sum of two distances: braking reaction distance (the time it takes for a driver to react after seeing an object and start braking) and braking distance (the time it takes to bring a vehicle to a stop). Stopping distances on upgrades are shorter and downgrades are longer. Stopping sight distances for variance speeds can be calculated with the following formula, or Table 2, whichever is greater.

$$D_s = 1.45 Vt + V^2 / 30 (f + g)$$

Where:

$D_s$  = stopping site distance

$V$  = Speed in mph

$t$  = reaction time (constant)

= 2.5 seconds

$f$  = coefficient of sliding friction

$g$  = grade, in percent

Coefficient of Friction

Design Speed (mph)	F*
30-40	.24
40-50	.22
50-60	.21
60-70	.20

\* Assume snow-packed conditions

### 231.2 Passing Sight Distance

Two-lane roads should provide adequate passing zones. The passing zone shall be designed based on the passing sight distance which is the minimum sight distance that is required for the driver of one vehicle to safely pass another without interfering with oncoming traffic. Minimum passing sight distances are provided in Table 3.

**Table 3**  
**Stopping and Passing Sight Distance**

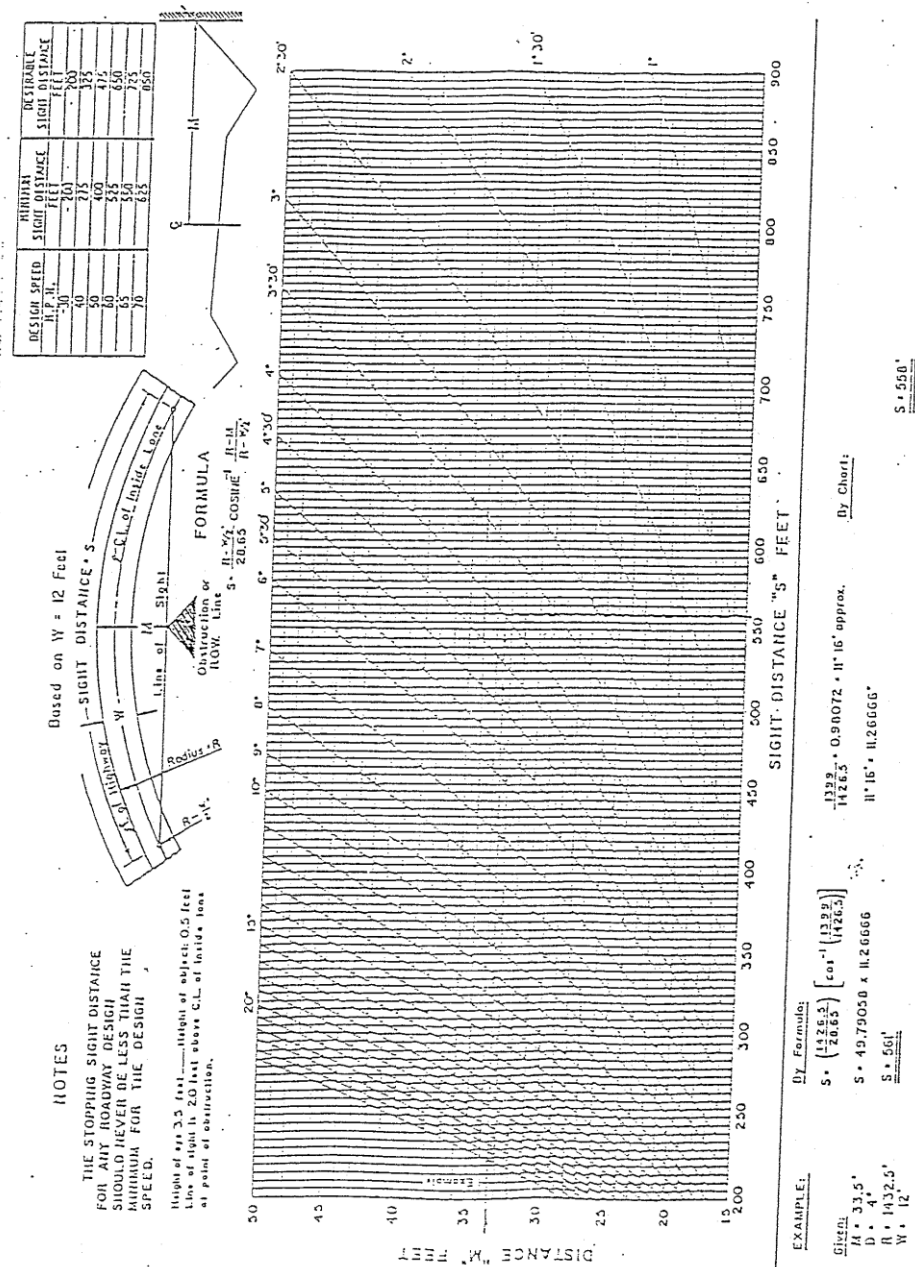
<b>Design Speed</b>	<b>Stopping Sight Distance</b>	<b>Passing Sight Distance</b>
15	100	500
20	150	700
25	200	900
30	250	1100
35	300	1300
40	400	1500
45	500	1650
50	600	1800
55	700	1950

### 231.3 Stopping Sight Distance on Horizontal Curves

Stopping sight distances on a horizontal curve should be obtained from Figure 1.



FIGURE 1  
Stopping Sight Distance on Horizontal Curves



Source: 1990 Roadway Design Manual, State of Colorado, Department of Highways, Division of Highways

## 231.4 Curvature

Table 4 provides the minimum centerline radius for specific design speeds. Sight distance factors are not taken into consideration, so if possible the minimum values should be exceeded.

Design speeds and curve radii should be kept consistent. If changes in the design speed are required, the design speed between successive curves shall not change by more than 10 mph. A low speed curve is prohibited at the end of a long tangent, where high approach speeds are anticipated. Compound curves should be avoided. Reverse curves without a tangent section between the end of curvature of the first curve and the beginning of curvature of the second curve shall only be allowed where design speeds are less than 25 mph. Reverse curves shall provide the minimum tangent length provided in Table 4.

**Table 4**  
**Minimum Radius**

Design Speed	Minimum Curvature Radius	Minimum Tangent Lengths
15	75	50
20	125	75
25	175	100
30	250	150
35	375	200
40	550	250
45	700	250
50	850	250
55	1200	250

### 231.5 Curve Widening

Roadway curves shall be widening on the inside radius in accordance with the following formula:

$$w = 1.5 \frac{V^2}{R}$$

Where:

V=mph

R = curve radius

### 231.6 Curb Returns

Curb return or pavement rounding shall be provided at the intersection of all roads and driveways. The following minimum radius shall be used:

**Table 5**  
**Curb Return Radius**

Road Class	Minimum Radius
Arterial Road	35
Collector Road	35
Local Road	25
Primitive Road	25

Additional right-of-way is required to provide a minimum clear distance of 15 feet between the curb or edge of pavement and the right-of-way limit.

## 232 Vertical Alignment

### 232.1 Minimum Grade

Minimum grade shall be 0.5 percent. Exceptions to the minimum grade may be permitted provided the pavement is adequately crowned to drain the surface laterally.

### 232.2 Maximum Grade

Maximum grade for arterial and collector roads shall be 6 percent. Local roads shall be 7 percent, and ten percent shall be the maximum for primitive roads.

**232.21 Exceptions:** Due to severe terrain conditions, exceptions to the maximum grade can be made for the following roadways.

*Arterial and collector:*

7% for a maximum distance of 500 feet

8% for a maximum distance of 200 feet

*Local roads:*

10% for a maximum distance of 500 feet

*Primitive Roads:*

12% for a maximum distance of 500 feet

Conditions for this exception are as follows:

1. The horizontal radius shall be greater than 1,500 feet.
2. Grades shall not exceed 6 percent within 500 feet of either end of the roadway section with a steep grade.
3. Curves with a radius of less than 600 feet shall not be within 500 feet of either end of the roadway section.
4. No intersections or access shall be allowed within the section.

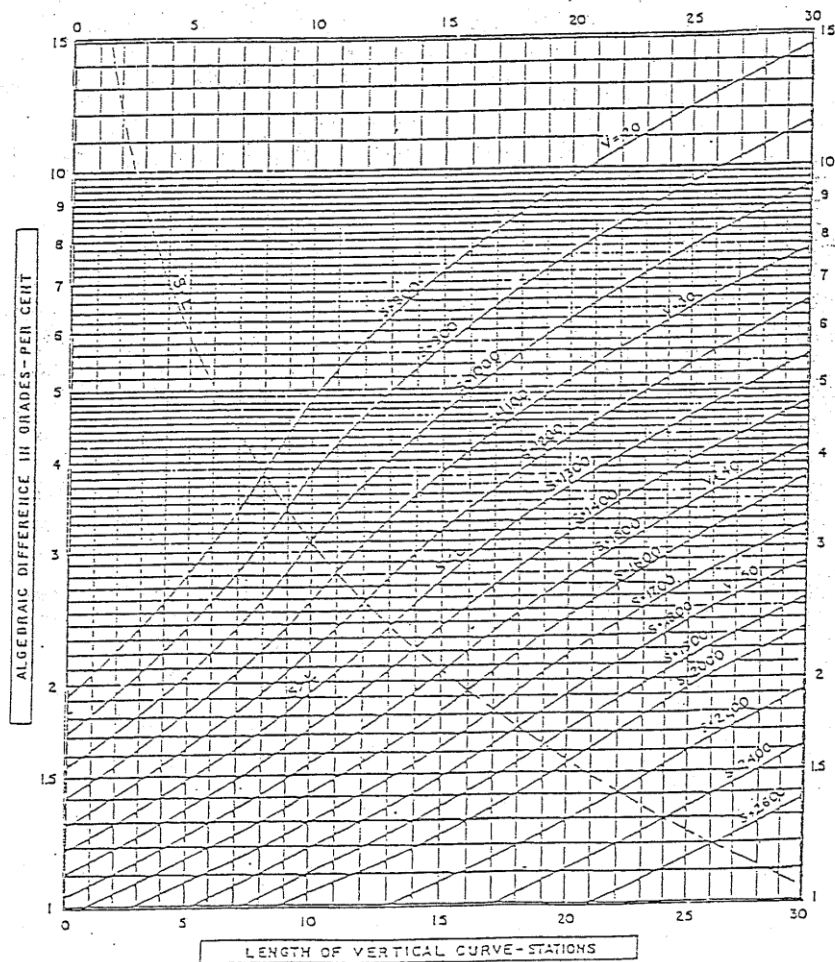
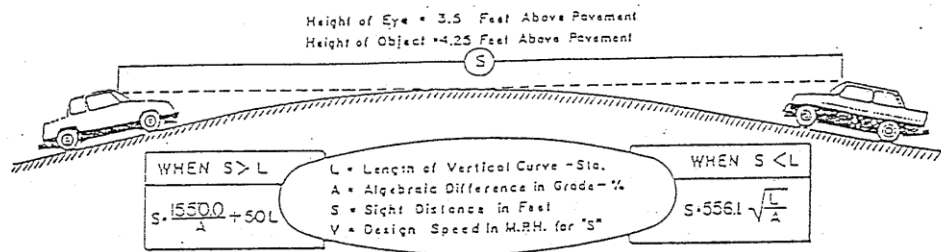
### **232.3 Vertical Curves**

These curves must be properly designed to provide adequate safety, stopping and passing sight distances, headlight distance, driver comfort and good drainage. The minimum length of a crest vertical curve is controlled by stopping sight distance. The minimum length for a sag and crest vertical curve is determined from the sag vertical curve or crest vertical curve components (Figures 2 and 3).

Long, flat, vertical curves are not allowed, since they may develop poor drainage. Vertical curves are not required if the algebraic difference in grade is less than 3.0 percent.

Superimposed vertical and horizontal curves must be properly designed so the superelevations do not cause pavement distortions. Sharp horizontal curves are not permitted at or near a pronounced summit or sag.

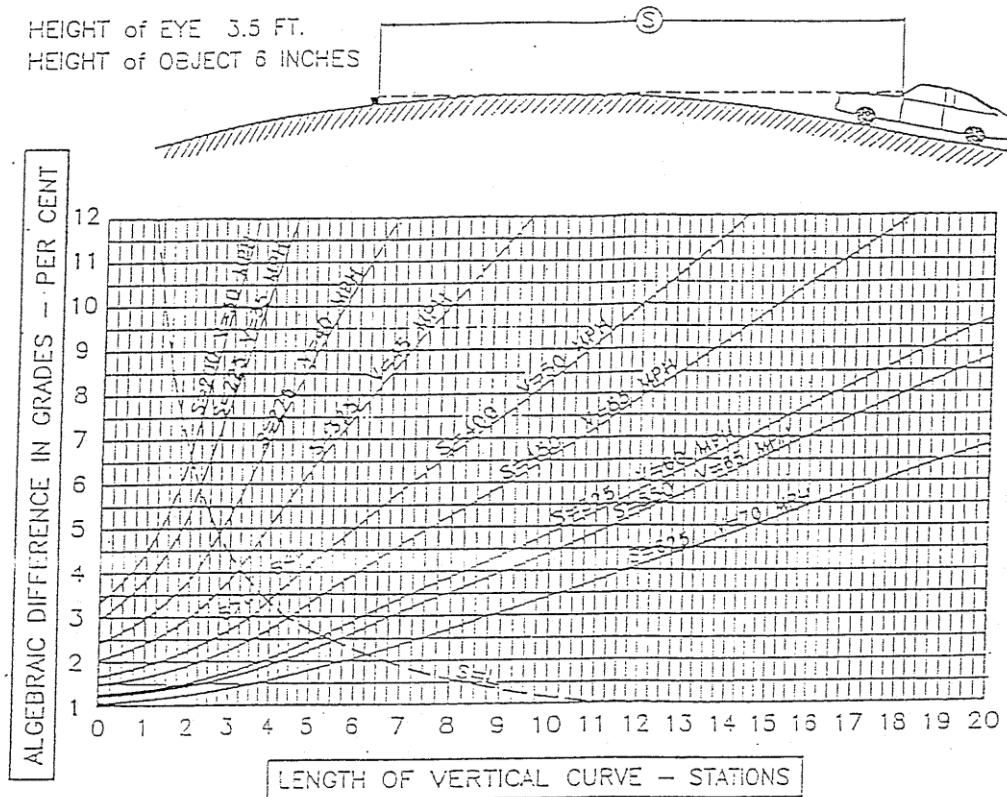
**FIGURE 2**  
Passing Sight Distance on Crest Vertical Curves



Source: 1990 Roadway Design Manual, State of Colorado, Department of Highways, Division of Highways

FIGURE 3  
Stopping Distance on Crest Vertical Curves

HEIGHT of EYE 3.5 FT.  
HEIGHT of OBJECT 6 INCHES



\* STOPPING SIGHT DISTANCES ARE MINIMUM VALUES  
FOR DESIGN SPEEDS SHOWN.

WHEN $S > L$	WHEN $S < L$
$S = \frac{664.5}{A} + 50L$	$S = 364.6 \sqrt{\frac{L}{A}}$
<p>L = Curve length — stations  A = Algebraic grade difference — %  S = Sight distance — ft.  V = Design speed — M.P.H. for "S"</p>	

Source: 1990 Roadway Design Manual, State of Colorado, Department of Highways, Division of Highways

## **232.4 Switchbacks**

A switchback is a curve with a delta greater than 120 degrees and radius less than 100 feet. Switchbacks are not permitted on arterial or collector roads and will only be permitted on other roadways after a special review by the County.

The minimum standards of a switchback shall be as follows:

1. Maximum speed 10 - 15 mph.
2. Maximum centerline grade must not exceed 4 percent within 25 feet on either side of the curve.
3. Minimum centerline radius is 50 feet.
4. Adequate snow storage must be provided.
5. Curve widening shall be required.

## **233 Intersections**

Intersections shall be designed to avoid steep profile grades and to insure adequate sight distance to the intersection. If possible, roads shall intersect at right angles. A maximum deviation from the right angle will be 30 degrees. Listed below are the required minimum sight distances and minimum distance between intersections.

**Table 6**  
**Distances Between Intersections**

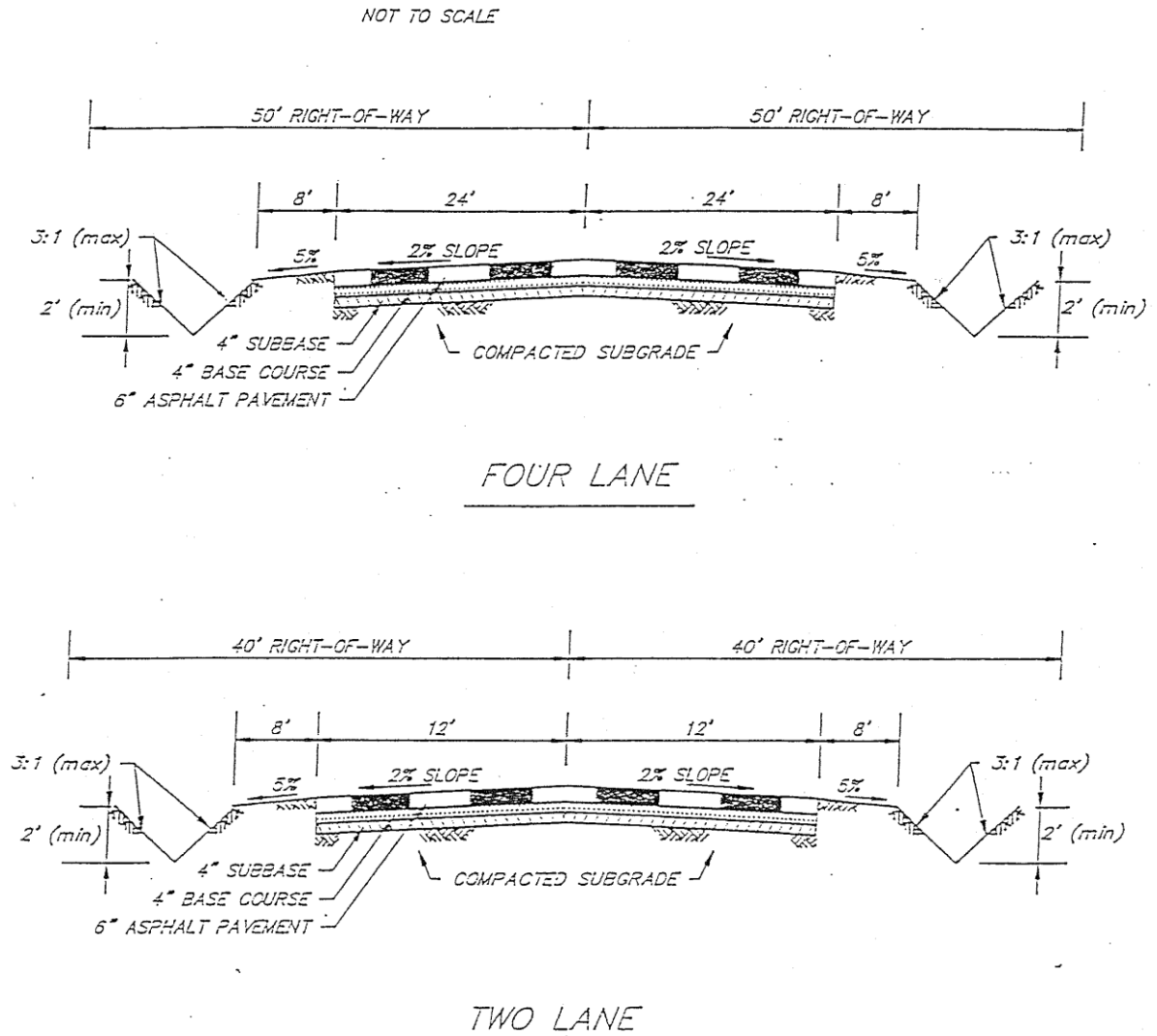
Road Classification	Minimum Sight Distance at Intersections	Minimum Distance Between Intersections
Arterial Roads	500 ft	1000 ft
Collector Roads	400 ft	750 ft
Local Roads	300 ft	500 ft
Primitive Roads	200 ft	200 ft

## **240 Typical Cross Sections**

Typical cross sections for each roadway classification are shown in Figures 4 through 8.

Lane widths may be modified if it can be demonstrated to the County that significant adverse environmental impacts can be avoided. All roadways will be crowned. Undivided paved roads in tangent alignment shall have the high point of the crown centered on the pavement and the pavement uniformly sloped at 2 percent toward the edges. Gravel roads may have a 3 percent crown slope. Unpaved roads in mountainous terrains may be sloped toward the cut side of the road on a 3 percent slope to limit surface erosions. For divided roadways on tangent alignment, each travel way shall have a uniform cross slope with the high point at the edge nearest the median.

FIGURE 4  
Arterial Road

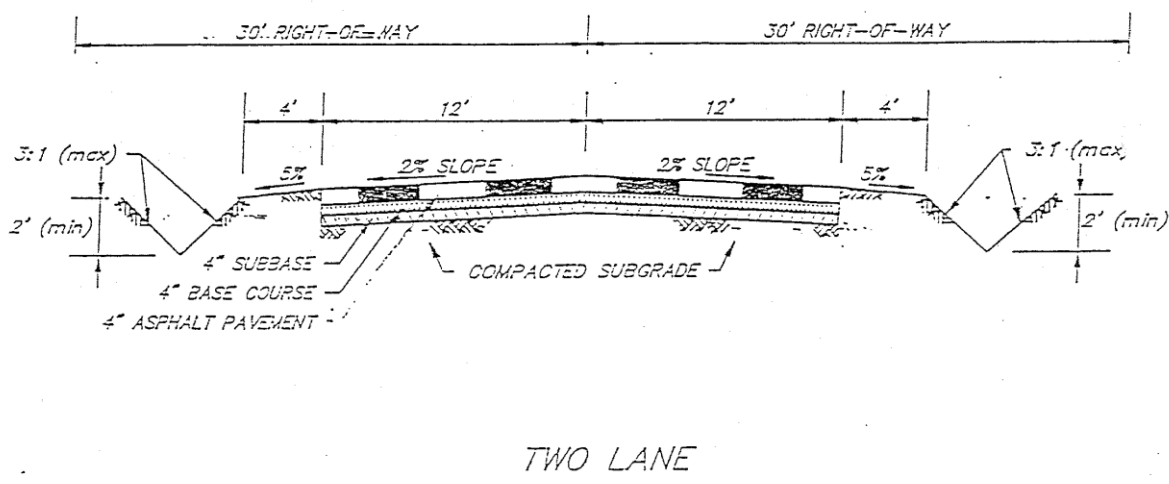


NOTE: THESE DETAILS SHOW MINIMUM DIMENSIONS.  
ACTUAL ROADWAY THICKNESS SHALL BE  
DETERMINED AS OUTLINED IN SECTION 250.



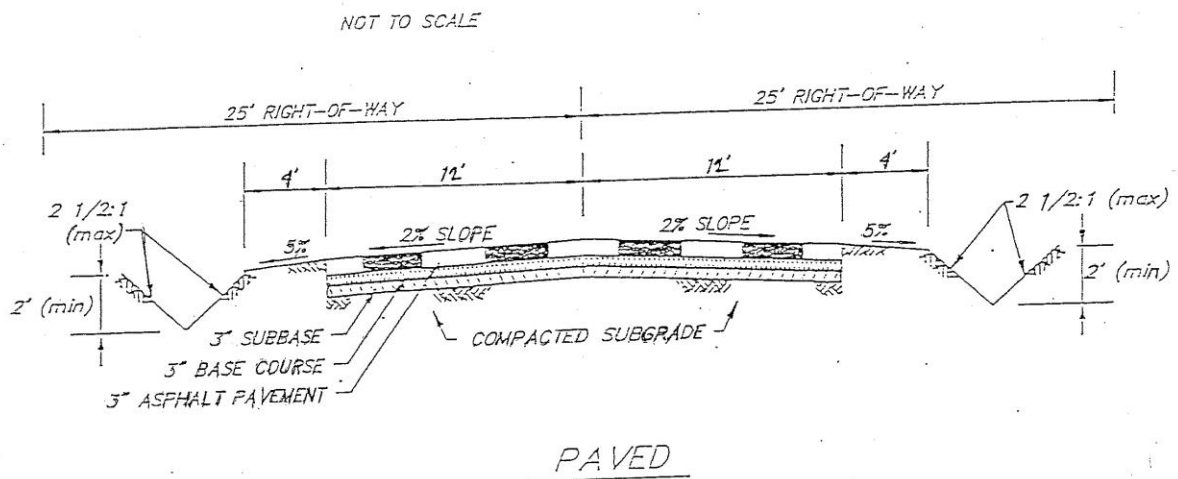
FIGURE 5  
Collector Road

NOT TO SCALE



NOTE: THIS DETAIL SHOWS MINIMUM DIMENSIONS.  
ACTUAL ROADWAY THICKNESS SHALL BE  
DETERMINED AS OUTLINED IN SECTION 260.

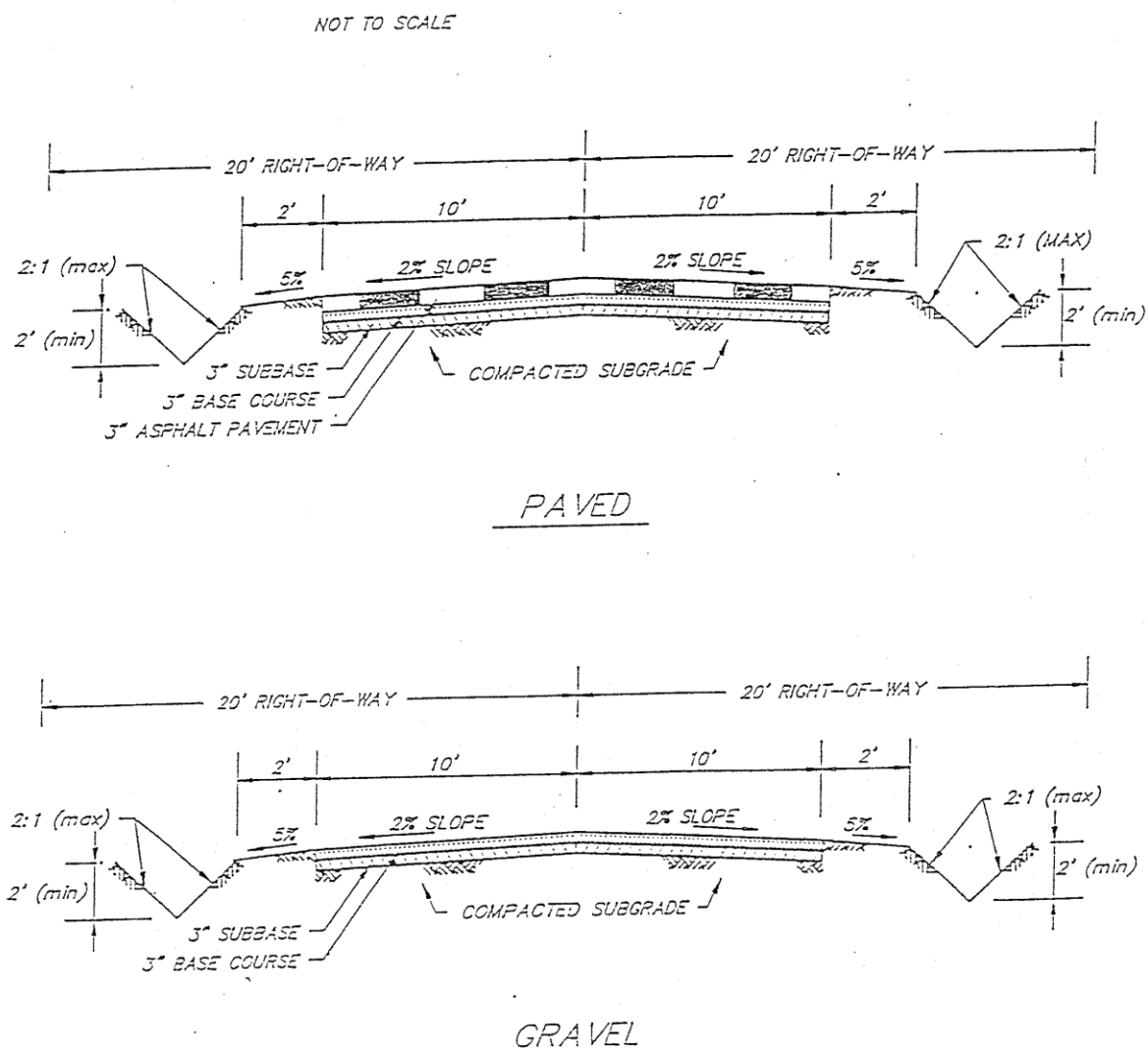
FIGURE 6  
Local Road



NOTE: THESE DETAILS SHOW MINIMUM DIMENSIONS.  
ACTUAL ROADWAY THICKNESS SHALL BE  
DETERMINED AS OUTLINED IN SECTION 260

This page was amended November 20, 2006

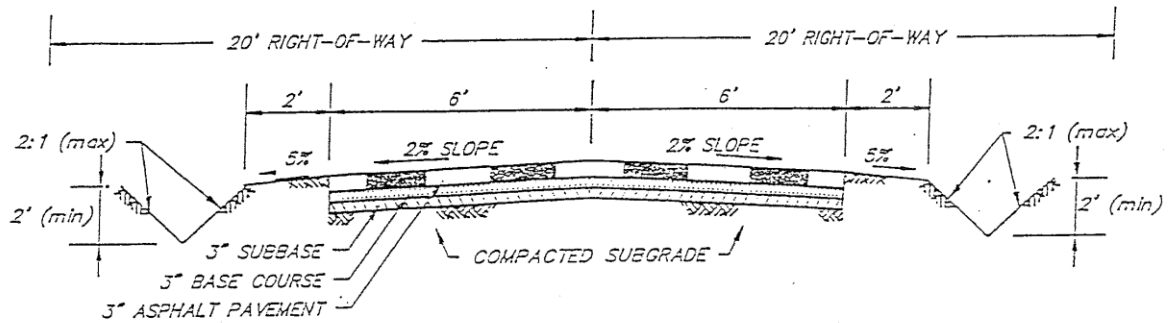
**FIGURE 7**  
Two Lane Primitive Road



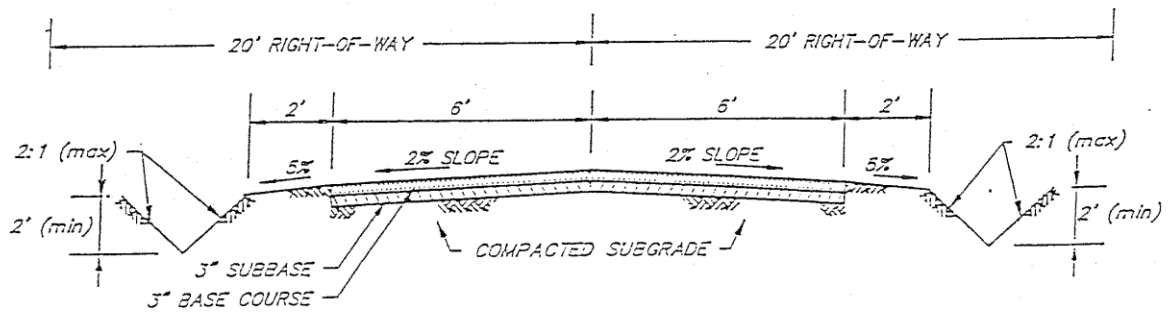
NOTE: THESE DETAILS SHOW MINIMUM DIMENSIONS.  
ACTUAL ROADWAY THICKNESS SHALL BE  
DETERMINED AS OUTLINED IN SECTION 250.

FIGURE 8  
One Lane Primitive Road

NOT TO SCALE



PAVED



GRAVEL

NOTE: THESE DETAILS SHOW MINIMUM DIMENSIONS.  
ACTUAL ROADWAY THICKNESS SHALL BE  
DETERMINED AS OUTLINED IN SECTION 250.

The superelevation for arterial and collector road curves at a specific design speed shall be determined from Table 7.

Degree of Curve	20 MPH e	L	30 MPH e	L	40 MPH e	L	50 MPH L	60 MPH e	L		
1	NC	0	NC	0	NC	0	RC	0	.029	175	
2	NC	0	RC	0	.021	125	.038	150	.051	175	
3	NC	0	.025	100	.038	125	.053	150	.068	180	
4	RC	50	.031	100	.047	125	.063	150	.078	210	
5	.021	50	.038	100	.055	125	.071	170	Dmax	=4°4	
6	.025	50	.043	100	.062	130	.077	180			
7	.028	50	.048	100	.067	140	.080	190			
8	.031	50	.053	100	.071	150	Dmax	7°30'			
9	.035	50	.056	100	.075	160					
10	.037	60	.060	100	.078	160					
12	.043	60	.065	120	.080	170					
14	.047	70	.070	130	Dmax = 12°15'						
16	.051	70	.074	130							
18	.054	80	.077	140							
20	.057	90	.079	140							
22	.060	90	.080	140							
24	.062	100	Dmax = 22°45'								
28	.067	100	Dmax = 22°45'								
32	.070	110									
36	.074	110									
40	.076	120									
44	.078	120									
48	.079	120									
52	.080	120									
	Dmax = 22°45'										

D = Degree of Curve and  $D = 5730/R$

e = Rate of Superelevation

L = Minimum length of runoff

Source: A Policy on Geometric Design of Highways and Streets, 1984; pp 187-190

- A) Transition - Minimum 60-80 percent of the superelevation runoff is to be on the tangent.

## 250 Miscellaneous Design Elements

## **251 Pedestrian And Bicycle Facilities**

Roadways near certain areas, such as dense residential development near a school or a "main street" through a commercial development, may be required to provide pedestrian sidewalks or bike paths. The County will determine if the current or anticipated number of pedestrians or bicycles is sufficient to interfere with traffic and warrant the construction of these facilities. If required, sidewalks and bike paths shall be designed as shown in Figures 9 and 10.

## **252 Guardrails**

Guardrails are an important part of roadway safety and design. Guardrails shall only be installed if they reduce the severity of potential accidents. If it is economically feasible to remove the obstruction, it should be done since guardrails are considered hazards. Guardrails are installed near steep embankment and roadside hazards, such as bridge ends, trees and open ditches. All guardrails shall be designed to conform with AASHTO and CDOT requirements and specifications.

## **253 Traffic Control Devices**

All signs, striping, markers, delineators, signals, and other traffic control devices shall conform to the requirements of the "Manual on Uniform Traffic Control Devices" published by the U.S. Department of Transportation Federal Highway Administration. Non-standard signs or other traffic control devices shall be approved by the County. The developer shall pay for all required signs (speed limit, stop, road name) and other traffic control devices in new developments.

FIGURE 9  
Bike Path

NOT TO SCALE

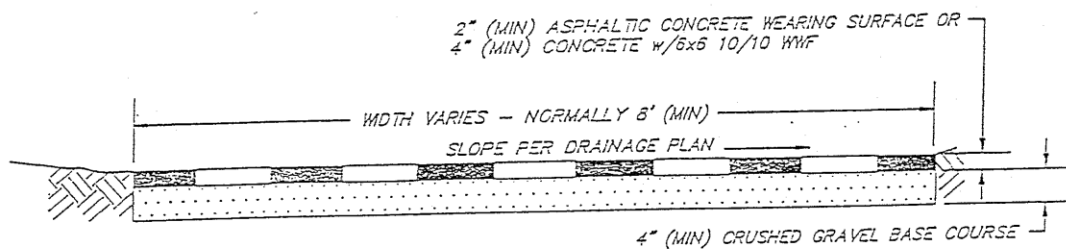
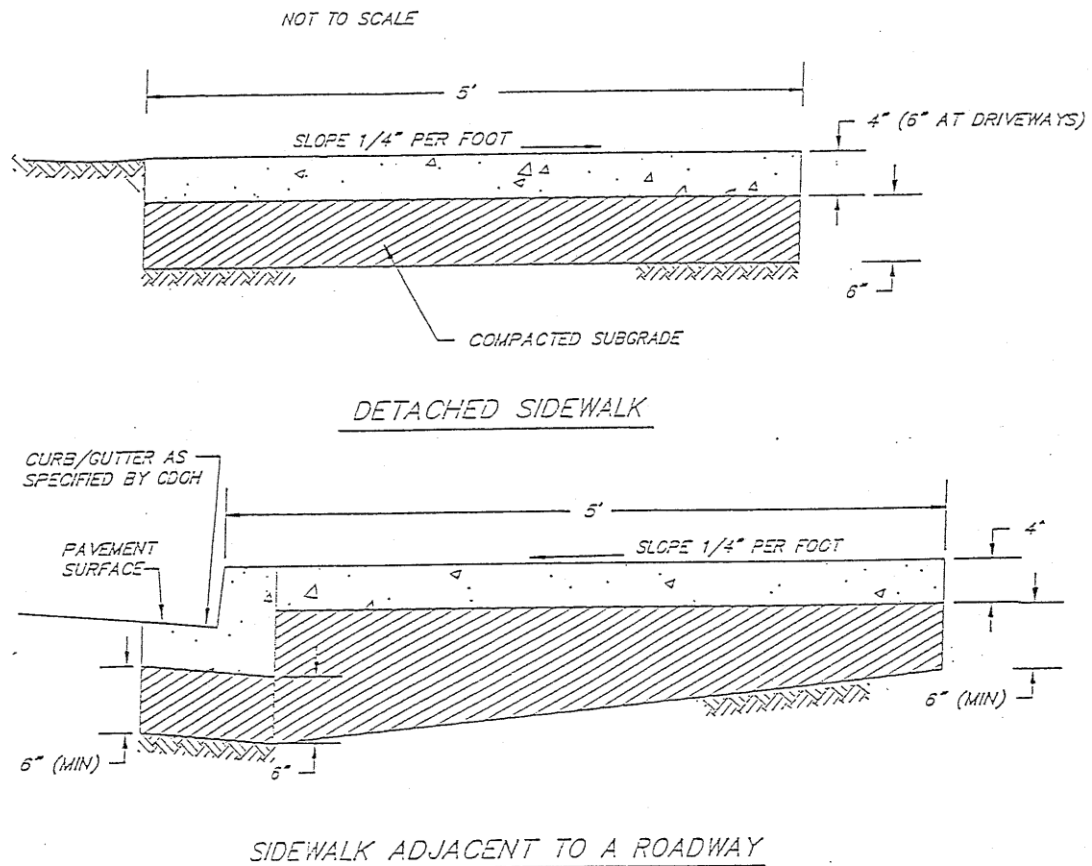


FIGURE 10  
Sidewalk Standards



NOTES

1. Sidewalk shall be constructed in 10 to 120 foot monolithic sections.
2. Expansion joints shall be provided every 100 to 120 feet and between new sidewalk and existing structures such as existing concrete slabs, poles, fire hydrants, and buildings.
3. Expansion joints shall extend for the depth and width of concrete. Expansion joint material must be set vertical and with the top edge flush with the finished surface of the concrete. Expansion joint to be a minimum of 1/2" wide.
4. Contraction joints shall be provided every 5 to 10 feet.
5. Contraction joints shall have a maximum width of 1/4" and depth equal to one-third of the height of the concrete. Expansion joints shall be either formed with a template or sawcut. Sawcut shall begin as soon as concrete is hardened sufficiently to allow sawing without excessive raveling and before uncontrolled cracking occurs.



## 254 Driveways

In order to connect a driveway or parking area to a public roadway, a property owner, developer, contractor or other individual must first obtain a permit from the County. Modification or regrading of an existing driveway will also require a permit.

A driveway is an accessway for vehicles from a public or private roadway to either an individual residence or to a parking area serving multiple residences, commercial business, recreational, institutional, or industrial land uses, or a combination of land uses. A driveway which serves more than four individual residences shall be classified, designed and constructed as a roadway.

Driveway entrances shall be designed to have a minimum sight distance of at least 200 feet for local or primitive roads and 400 feet on collector roads. Driveways shall not be located on arterial roads. Parcels of land or lots which have frontage on more than one road shall access the road with the lowest traffic density.

Driveway openings shall be separated by at least 50 feet, as measured from curve return to curve return. Increased spacing may be required for safety reasons. A shared driveway shall be designed if the minimum spacing cannot be met. Driveways shall not be located within 50 feet of an intersection or curb return.

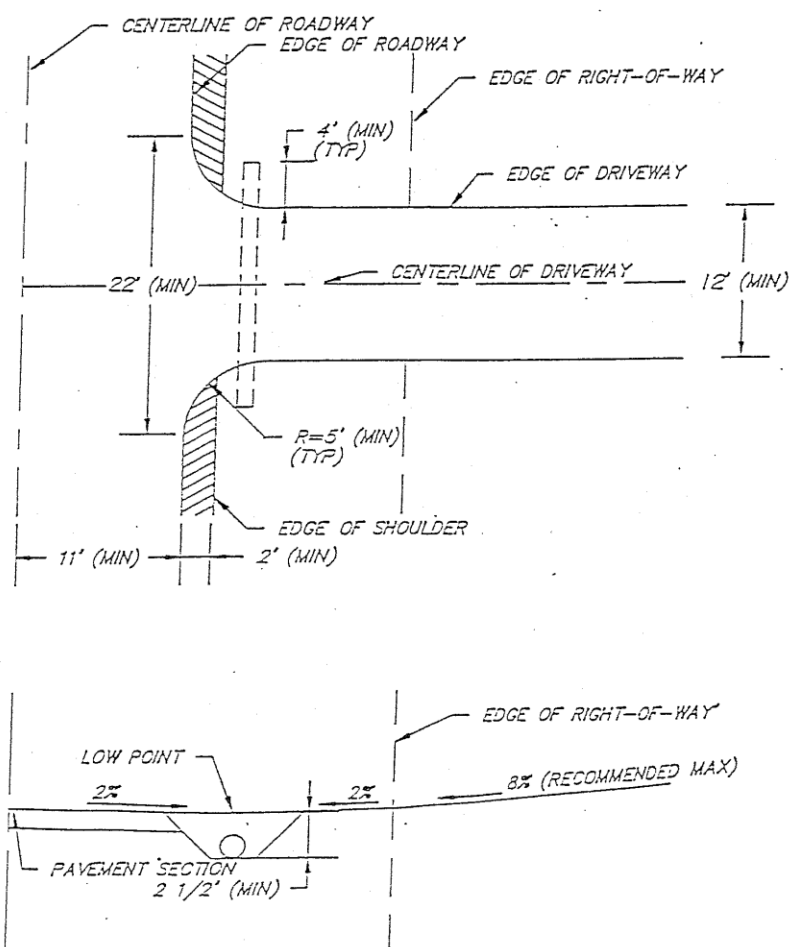
As shown in Figure 11, driveways shall have the following widths:

**Table 8  
Driveway Design  
Elements**

Type of Service	Widths		Flare Radius		Total Width (Including Flares)		Minimum CL Radius (ft)
	(Min)	(Max)	(Min)	(Max)	(Min)	(Max)	
Commercial	20	30	5	10	30	55	100
Residential Single Family/ Duplex serving 2 units or less	12	15	5	5	22	25	50
Residential Single Family/ Duplex serving more than 2 units	12	20	5	10	22	40	100
Multi- Family	20	35	5	10	30	55	100

**FIGURE 11**  
Driveway Design Standards

NOT TO SCALE



Driveways shall have a maximum grade of 8 percent. In areas with difficult terrain, a written request for a variance from this requirement may be made for single family residences and duplexes. In order to be granted a variance, additional fire protection which meets the requirements of Section 1003 of the Uniform Fire Code shall be installed in the residences. One example of additional fire protection is an approved automatic sprinkler system.

Driveways connecting to roadways with an ADT greater than 500 or driveways longer than 300 feet in length shall be designed with a vehicle turn around. The driveway shall have either a cul-de-sac with a minimum radius of 50 feet or a hammer head turn-around that will allow emergency vehicles to turn around. Driveways shall be flared to 20 feet at the location where the cul-de-sac or hammer head begins. See Figure 12 for an example of a hammer head turn-around.

Driveways longer than 400 feet must have turnouts which allows emergency vehicles to pass each other. The turnouts shall be designed and installed every 400 feet.

All driveways shall be designed to allow adequate drainage and prevent erosion. Culverts at least 24 inches in diameter shall be installed to handle roadside drainage.

## **255 Bridges**

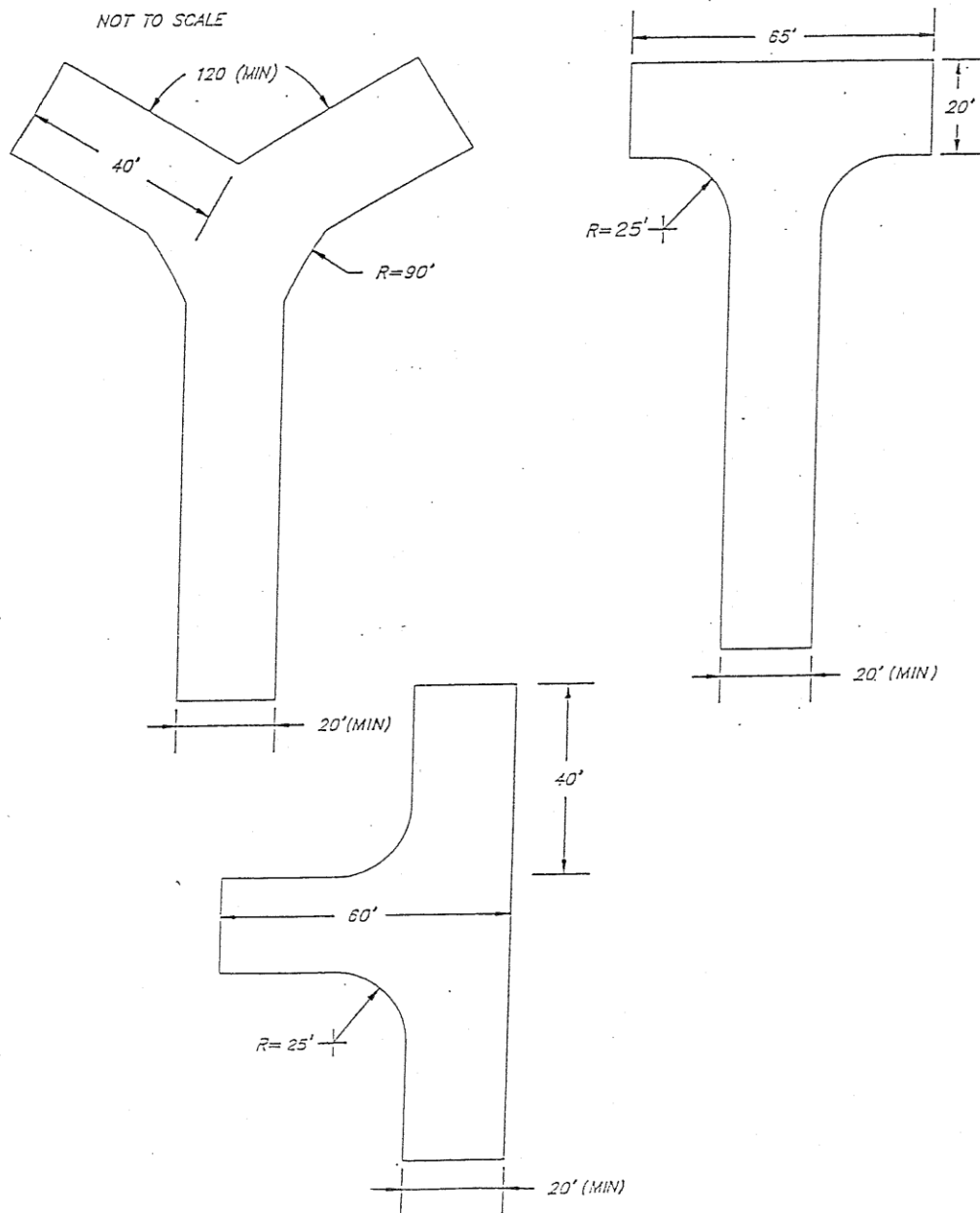
All bridges shall be designed to conform to the Colorado Department of Transportation (CDOT) requirements and specifications. Bridge designs shall be prepared by a registered professional structural engineer. Bridge deck widths shall accommodate the full width of the approaching roads and shoulders. All bridges shall be designed to accommodate an AASHTO (American Association of State Highway Officials) H-20 live load carrying capacity.

Bridges shall be designed to meet the 100-year storm frequency as defined by FEMA. A minimum of 1 foot of free board shall be required.

## **256 Vertical Clearance**

The minimum vertical clearance from the finished grade of a roadway or driveway to any structure or utility line within the roadway right-of-way shall be 18 feet.

**FIGURE 12**  
Hammerhead Designs for Emergency Vehicle Turnaround



## 260 Structural Design

Roadways shall be designed with sufficient strength to accommodate an AASHO H-20 live load.

## 261 Structural Sections

Structural sections of each roadway shall be prepared by a registered professional engineer.

Soils along the roadway shall be sampled at a maximum interval of 250 feet and a minimum depth of 3 feet. Composite soil samples may be used provided that laboratory testing indicates that the soil characteristics are similar enough to allow grouping. The following laboratory tests will be required on the soil samples.

- a. CBR-AASHTOT193
  1. Required supercharge weight not more than 2.5 pounds higher than the weight of final base and pavement.
  2. Asphalt 140 lbs/ft<sup>3</sup>  
Base Gravel 133 lbs/ft<sup>3</sup>
- b. Use AASHTO T193 for computations of CBR
- c. Sieve Analysis - AASHTO T11 and T27
- d. Atterberg Limits - AASHTO T89 and T90
- e. Soil Classification -AASHTO M145

The subgrade compaction requirements shall be made based on the soil sample results. Below are the minimum requirements based on the soil classification.

AASHTOM145 Soil Classification	Minimum Compaction	Minimum Depth
A-1, A-2, A-3, A-4 Non-cohesive soils, PI<6	95% AASHTO T1 80	6 inches
A-4, A-5, A-6 Cohesive soils, PI>6	95% AASHTO T99	1 foot

Organic soils shall be removed.

## 262 Surfacing Requirements

All newly constructed or upgraded roadways shall be asphalt or other paving materials acceptable to the county. Primitive roadways shall be excluded from this requirement and may be constructed of native materials mined from the roadbed.

This page amended November 20, 2006

## 263 Pavement Design Procedures

1. Determine the road classification, zoning and Design Traffic Number.

**Table 9**  
**Design Traffic Number (DTN)**

Road Classification	Residential	Commercial
Arterial	200	200
Collector	30	100
Local	5	30
Primitive	5	N/A

2. Determine Serviceability Index

Serviceability Index:

Arterial Road	2.5
Commercial Zoning	2.5
Residential Zoning	2.5

3. Using CBR, determine the structural number (SN).
4. Using the strength coefficient from the table below, determine the thickness of the various pavement elements by the following formula:

where  $A_1, A_2$  = strength coefficients  
 $D_1, D_2$  = thickness of pavement layer (inches)

**Table 10**  
**Strength Coefficient**

<b>Component</b>	<b>Strength Coefficient</b>
Hot Bituminous Pavement	0.40
Road Mix Bituminous Pavement	0.20
Existing Bituminous Pavement	0.30
Plant Mix Bituminous Base	0.30
Aggregate Base Course	0.12
Emulsified Asphalt Treated Base	0.15

Regional Factor - 2.25

5. Make sure the thickness determined above meets the following minimum pavement section requirements.

**Table 11**  
**Minimum Pavement Sections**

<b>Road Class</b>	<b>Gravel</b>	
Arterial Road	N/A	6" Asphalt 4" Base Course 4" Subbase
Collector Road	N/A	4" Asphalt 4" Base Course 4" Subbase
Local Road	4" Base Course 4" Subbase	3" Asphalt 3" Base Course 3" Subbase
Primitive Road**	3" Base Course 3" Subbase	3" Asphalt 3" Base Course 3" Subbase

- \* Full depth asphalt or concrete designs will be considered and may be used with approval of the County.

\*\* Primitive roads may be constructed of native materials mined from the roadbed.

6. Prepare a Pavement Design Report which will include at a minimum, the following information:
  - A. Design nomograph showing the line connecting CBR-DTN-SN
  - B. Map showing location of each different pavement section and the existing soil types
  - C. Design calculations for each pavement section
  - D. Discussion of any unusual design or construction problems or requirements

## **270 Drainage**

Good drainage is one of the most important factors in roadway design, since it can minimize maintenance costs and preserve the appearance. The protection of public and private roads and property is the primary objective of drainage design.

## **271 Storm Water Runoff Estimates**

Storm water runoff estimates shall be determined by the methods discussed in "Procedures for Determining Peak Flows in Colorado" and "Urban Hydrology for Small Watersheds" (Technical Release 55) published by the Soil Conservation Service, U.S. Department of Agriculture. The most current revision shall be used. The rational method can be used for drainage areas less than 10 acres provided rainfall intensity curves are developed for the area. Other methods may be used if approved by the County.

Roadways shall be designed so they will remain open to vehicle and pedestrian traffic in the following storm events.

**Road Classification**

<b>Road Classification</b>	<b>Storm Event</b>
Arterial	100 year
Collector	50 year
Local	25 year
Primitive	10 year

## **272 Culverts**

All natural draw or water courses, either continuous or intermittent, shall be culverted beneath roadways. Culverts will also be located at each natural draw or water course to prevent excessive accumulation of flow in roadside ditches or along the toe of the slope. Natural water flowing in



roadside ditches shall be diverted away from the roadway as quickly as possible. In no instance will the water remain in the ditch for a distance greater than 800 feet or a flow of 5 cubic feet per second. Natural draws and water courses shall be cleared of debris for a distance of 100 feet upstream from a culvert inlet.

Unless objectionable ponding or backwater curves develop, inlet inverts shall be slightly elevated above the normal flow line in steep or natural draws to avoid clogging with debris.

#### Culverts

shall be designed to be self cleaning. Headwalls, rip-rap or other means of protection are required at inlets and outlets where erosion might occur. If an inlet structure is not provided, culverts shall have flared ends on both the inlets and outlets. Under no condition will the outlet discharge on unprotected fills, unstable material or at adverse angles to streams or open channels. If necessary, velocity dissipaters shall be installed at outlets.

The velocity, slope, length, size and bedding of culverts shall be calculated using acceptable design charts or formulas. Culverts shall be designed for the full design storm event for each road classification.

The minimum diameter of pipes beneath a roadway shall be 24 inches. The minimum rise for arch pipes shall be 18 inches. See Figures 13, 14 and 15.

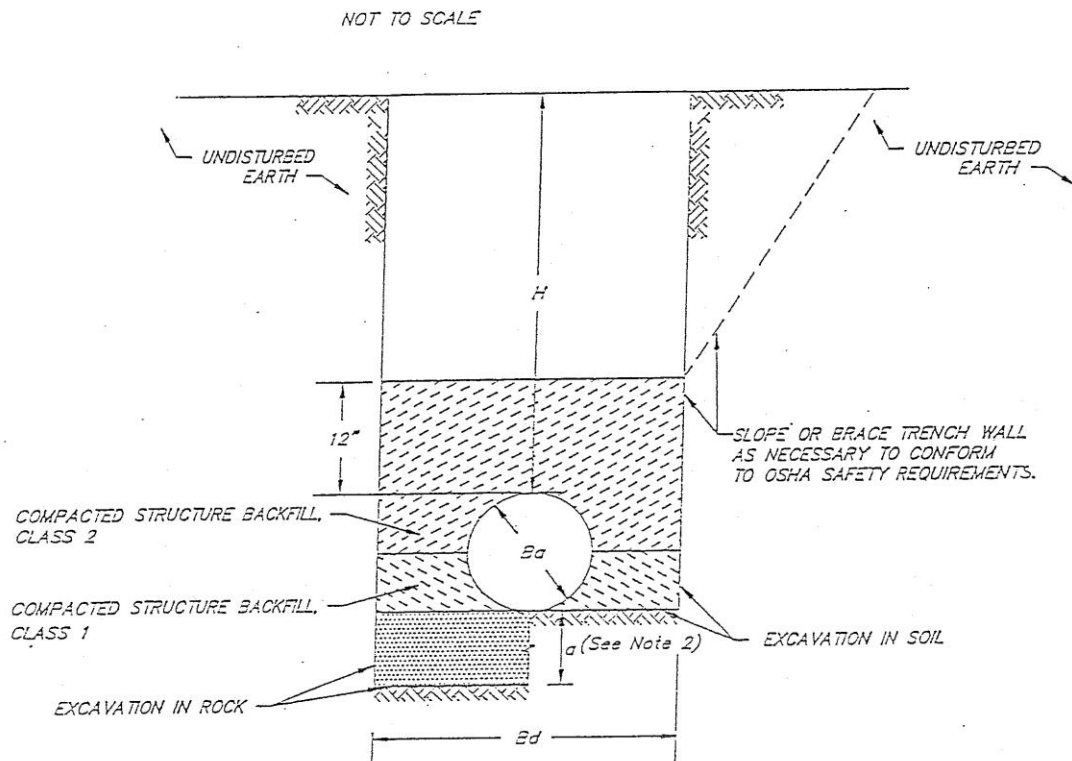
Corrugated steel pipe, HDPE pipe, reinforced concrete pipe or reinforced concrete boxes are acceptable materials for culvert construction. Aluminum and other pipe materials are not acceptable. Steel pipes shall be asphalt coated or paved when corrosive soils or other conditions exist that may attack the steel.

A battery of pipes shall have a clear space of  $\frac{1}{2}$  the pipe diameter (1 foot minimum, 4 foot maximum) between pipes.

The minimum slope on corrugated metal and concrete pipes shall be two and one percent, respectively.

Clean out access shall be placed at a maximum spacing of 200 feet in pipes up to 24 inches and 400 feet for pipes larger than 24 inches. Clean out access shall also be provided at each angle point and at each change in

**FIGURE 13**  
Flexible Pipe Installation

**LEGEND**

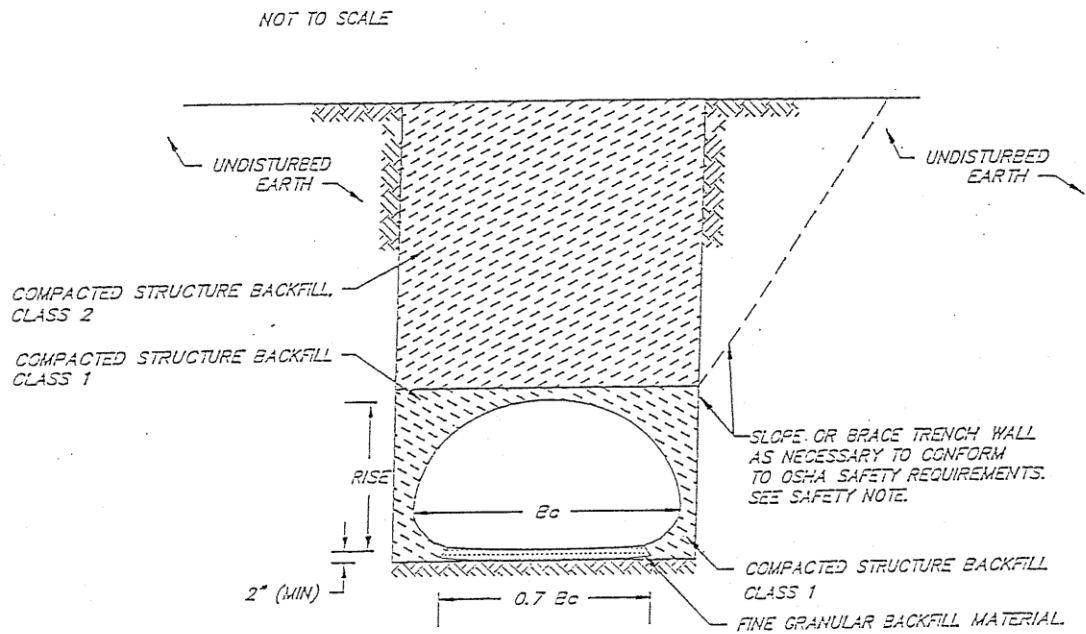
$H$  = Height of fill over top of pipe  
 $Ea$  = Inside diameter of pipe  
 $Ed$  = trench width  
 $Ea + 3'$   
 $a$  = Loose granular bedding, as follows:

I.D. of PIPE	$a$ IN SOIL	$a$ IN ROCK
6"-27"	3"	12"
30"-60"	4"	12"
66" or >	6"	12"

**NOTES**

1. Trenches over 5 feet deep shall be either shored or the trench walls sloped to meet OSHA safety requirements.
2. Bedding material for SOIL shall be Class 2 Structure Backfill.  
Bedding material for ROCK shall be Class 1 Structure Backfill.

FIGURE 14  
Arch Pipe Installation



#### SAFETY NOTE

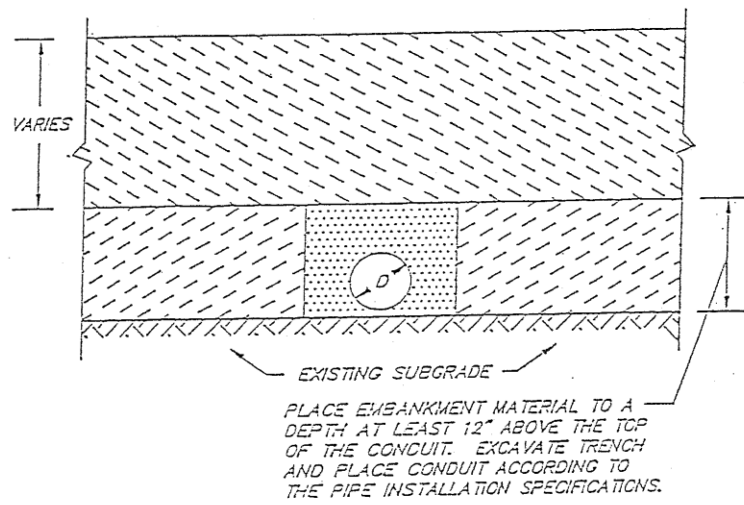
Trenches over 5 feet deep shall be either shored or the trench walls sloped to meet OSHA safety requirements.

#### BACKFILLING PROCEDURE

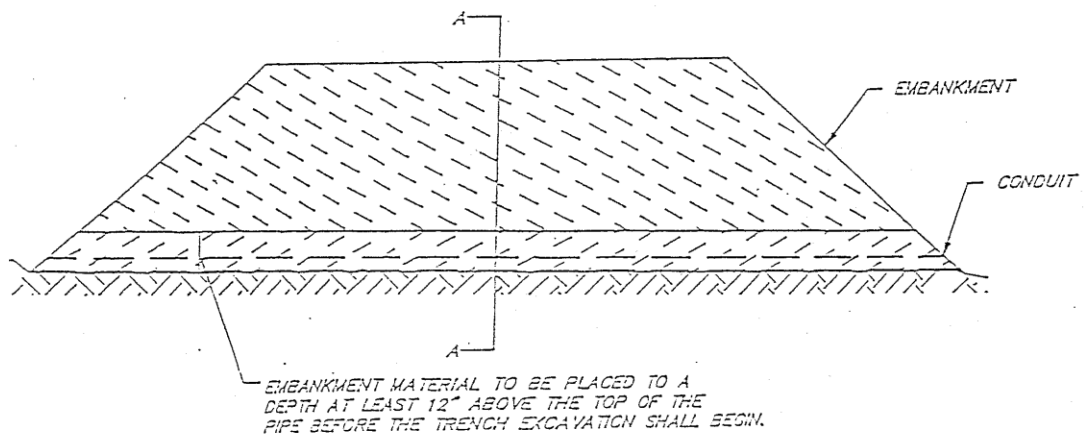
1. Cover entire arch with an envelope of backfill material to avoid arch from "pecking up" during backfilling.
2. Place fill on arch by distributing material around and over the structure in uniform layers, tamping thoroughly. Place fill material from top of arch.
3. Backfill on both sides of the pipe shall be brought up evenly to avoid the arch from shifting.

**FIGURE 15**  
Conduit Placed Through an Embankment

NOT TO SCALE



SECTION A-A



## 273 Open Channel and Swales

The size, shape, slope and lining material of all open channels and swales must be designed using Manning's equation or another acceptable design formula. For triangular swales with 3 horizontal to 1 vertical side slopes, the following modified Manning equation can be used.

$$Q = 0.56 (z/n) s^{1/2} d^{8/3}$$

where Q = flow (cfs)  
z = top width divided by depth  
n = Manning's  
coefficient s = slope  
d = depth of  
flow

Flow velocities in a grass-lined ("n" value equal to 0.050) channel shall not exceed 4 feet per second (fps). If the channel cannot be modified to adequately decrease the flow, a gravel or rip-rap channel must be specified. See Figure 16 for the design charts to size rip-rap.

## 280 Utilities

All utilities, except major power transmission lines, transformers, switching and terminal boxes, meter cabinets and other facilities necessarily appurtenant to such utilities, shall be placed beneath the ground. If excessive hardship would result from placing the utilities underground, a written request of exemption shall be submitted to the County.

### 281 Permits

Before the installation of any utilities within the county right-of-way or major flood way, a permit shall be obtained. The permit shall be issued after the installation procedures are approved by the utility company and County.

### 282 Underground Utilities

Underground utilities shall be placed according to the utility company's recommendations or with a minimum of 18 inches of cover between the top of the utility and the bottom of the pavement section, whichever is greater. All utilities structures, such as manholes, will be capable of supporting heavy equipment and vehicle traffic. All structures will be flush with the pavement surface.

Manhole covers and rings shall be cast in a concrete collar extending a minimum of 12 inches from the sidewall of the ring and cover and a minimum of six inches in thickness. The collar shall be reinforced with a rebar mat of #4 (grade 60) rebar (conforming to ASTM Standard A615) 6" on center each way.

In connection with all upgrading of any existing development, utility pedestals or cabinets within any public or private right-of-way are to be no more than five (5) feet from the edge of that right-of-way. For all new development, utility pedestals or cabinets are prohibited from being located within any public or private right-of-way.

**FIGURE 16**  
**Riprap Design**

RIPRAP REQUIREMENTS FOR CHANNEL LININGS \*\*

$V S^{0.17} / (S_s - 1)^{0.55}$ (ft <sup>1/2</sup> /sec)	Rock Type
1.4 to 3.2	VL
3.3 to 3.9	L
4.0 to 4.5	M
4.6 to 5.5	H
5.6 to 6.4	VH

where:

V = Mean channel velocity in feet per second

S = Channel slope in feet per second

S<sub>s</sub> = Specific gravity of rock (Minimum S<sub>s</sub>=2.50)

\* Use S<sub>s</sub> = 2.5 unless the source of rock and its densities are known at the time of design.

\*\* Table valid only for Froude number of 0.8 or less and side slopes no steeper than 2h:1v.

CLASSIFICATION AND GRADATION OF ORDINARY RIPRAP

Riprap Designation	% Smaller Than Given Size By Weight	Intermediate Rock Dimension (Inches)	d <sub>50</sub> * (Inches)
Type VL	70-100	12	6**
	50-70	9	
	35-50	6	
	2-10	2	
Type L	70-100	15	9**
	50-70	12	
	35-50	9	
	2-10	3	
Type M	70-100	21	12
	50-70	18	
	35-50	12	
	2-10	4	
Type H	100	30	18
	50-70	24	
	35-50	18	
	2-10	5	
Type VH	100	42	24
	50-70	33	
	35-50	24	
	2-10	9	

\*d<sub>50</sub> = Mean particle size

\*\* Bury types VL and L with native top soil and revegetate to protect from vandalism.

Source: Urban Storm Drainage Criteria Manual Volume 2, Urban Drainage and Flood Control District, Wright-McLaughlin Engineers, Denver, CO, March, 1969.

**FIGURE 17**  
Paved Roadway-Utility Patchwork Detail

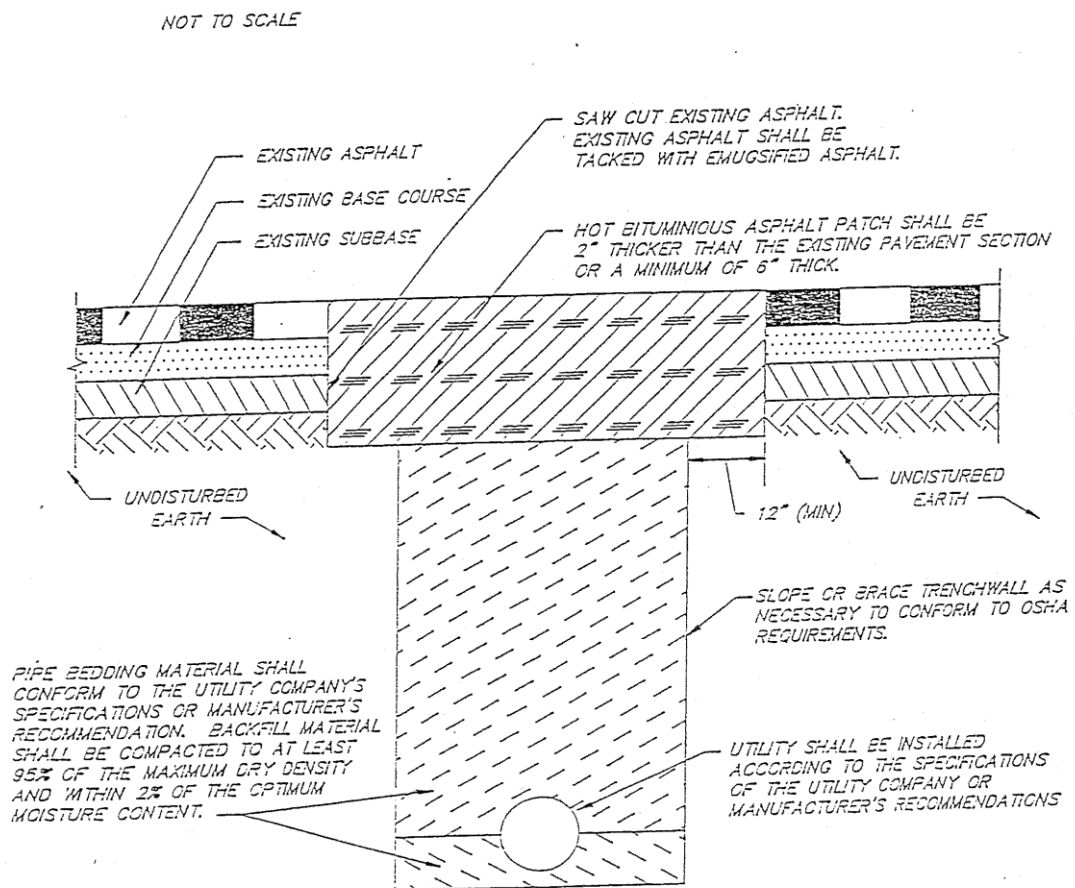
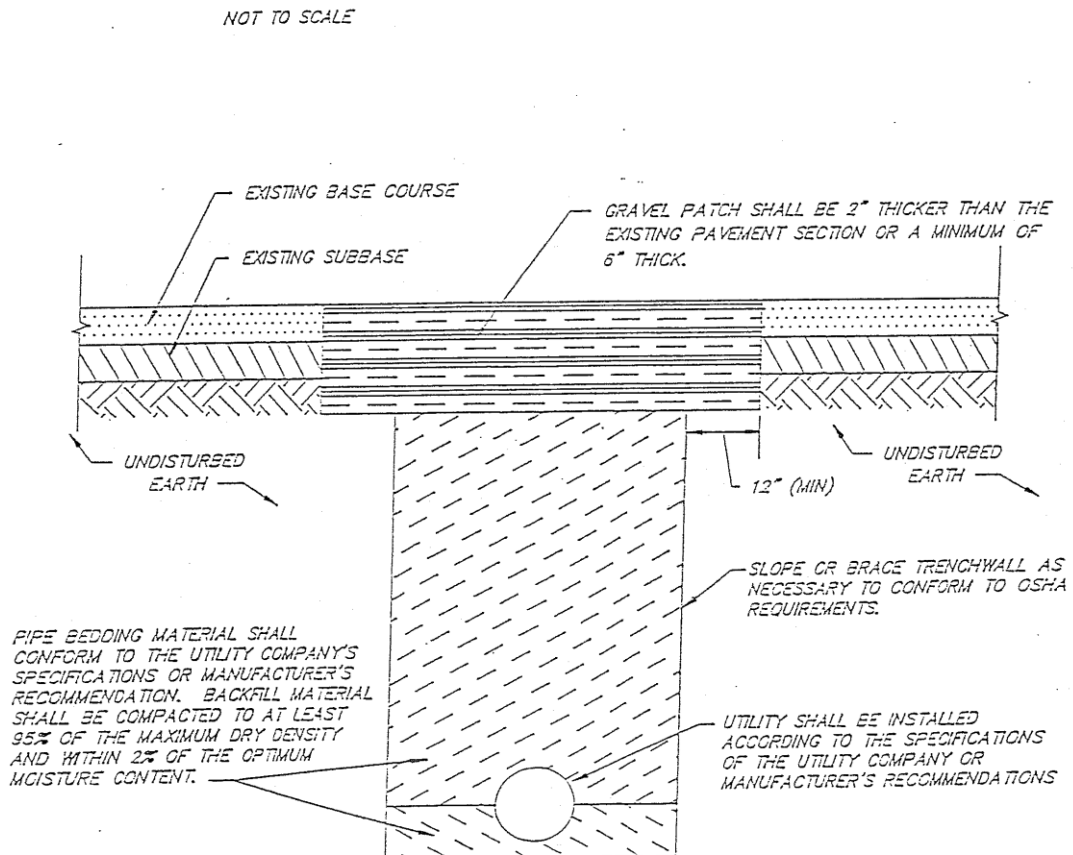


FIGURE 18  
Gravel Roadway-Utility Patchwork Detail





## **283 Above Ground Utilities**

Above ground utilities shall be located in a safe location where they will not cause unnecessary obstruction to pedestrian, bicycle or vehicle traffic or drainage to the utility. No utility pole shall be allowed within 10 feet of the outer edge of a traffic land shoulder.

All roadways and driveways shall have a minimum unobstructed vertical clearance of 18 feet.

## **290 Landscaping**

All roadways shall be designed in a manner which will minimize disturbance of existing vegetation and soil cover. Adequate provisions shall be made for revegetation and for soil stabilization during and after development of the site. An Erosion Control Plan meeting the Lake County Soil Conservation Service specifications shall be submitted to and approved by Lake County prior to the commence of construction.

During construction, the contractor shall prevent erosion of soil on the site and adjacent properties resulting from their activities. Erosion control measures shall be initiated prior to the commencement of clearing, grading, excavation or other operation that will disturb the natural protection. Temporary erosion control measures shall include the installation of silt fences, hay bales, and check dams.

Areas in which the ground cover has been disturbed during road construction shall be revegetated equal to or better than the preconstruction conditions. The revegetation shall occur during the first planting season following the construction. Prior to planting, the landscaping plan must be approved by the County. Native materials shall be used when possible. The contractor responsible for the road construction shall post a performance bond guaranteeing the vegetation for at least a full growing season following planting.

All cut and fill areas shall be designed, engineered and landscaped to control erosion as well as provide stability for the entire mass. Natural drainage patterns shall be preserved and protected from increased water flows that could alter such patterns or subject existing channels and adjacent areas to increased erosion.

## **Section 300 - Road Construction Specifications**

### **310 General**

### **311 Purpose and Intent**

The purpose and intent of these specifications is to set forth the minimum roadway construction specifications for all roads in Lake County. After roadways have been designed, good engineering judgement shall be used to determine if these specification are adequate or if additional specification need to be developed.

If a material or condition is not specified in this manual, designers shall refer to the CDOT specifications.

### **312 General Construction Guidelines**

The contractor or developer shall contact all utility companies 72 hours prior to the commence of construction to locate their utilities. Utilities must be located prior to any excavation. Contractors shall take precautions to protect all utilities during construction.

Gravel roads shall be constructed of aggregate base course on top of a prepared subgrade. Structure rim elevations shall be set at an elevation 5 inches below the finished surface of the roadway.

Asphaltic concrete pavement shall be placed over a prepared aggregate base course and subgrade. All construction shall be performed in accordance with the latest edition of the "Standard Specifications for Road and Bridge Construction" published by the Colorado Department of Transportation except as modified by these requirements.

### **313 Inspection and Warranty**

No roadway construction shall be allowed until the construction plans and specifications are approved by Lake County and a permit is issued. During construction, the permit as well as one set of the approved plans and specifications shall be on

Construction inspections shall be done at intervals deemed appropriate by the County. At a minimum, inspections shall be done at the following stages of construction:

1. Completion of Clear and Grub
2. Completion of Subgrade
3. Completion of Aggregate Base Course
4. Completion of Asphalt Paving
5. Completion of Drainage Improvements
6. Completion of Traffic Control Devices

Inspections by the County do not alleviate the contractor from his obligation.

A warranty period shall extend for a period of one year after the construction has been completed and accepted by the County. The contractor shall post a bond for 10 percent of the construction cost during the warranty period.

### **314 Cleanup and Restoration**

After the completion of construction, all pavements, curbs, gutters, utilities, fences, irrigation ditches, yards, lawns and other structures or surfaces shall be restored to a condition equal to or better than before work began. Restoration shall be to the satisfaction of the County.

### **315 Permits**

A permit shall be required for all work within a public right-of-way or a right-of-way easement through private land. All required construction permits shall be obtained from the County before construction commences.

### **316 Environmental Controls**

#### **Dust Control**

Acceptable measures, such as the application of water, shall be made to control dust during construction.

#### **Erosion Control**

An erosion control plan which meets the Lake County Soil Conservation Service requirements shall be submitted to and approved by the County prior to construction commencement. The plan, which includes both temporary and permanent controls, shall be followed during construction.

Temporary measures shall include at a minimum the installation of silt fence or hay bales at the downstream limit of grading. See Figures 19 and 20 for an example of acceptable silt fence and hay bale installation. No site surface water shall be allowed to run onsite for a distance greater than 500 feet. Hay bales shall be installed at the discharge point of all onsite drainage and as necessary to protect existing culverts and inlets from siltation. Check dams may need to be installed in natural drainage channels.

Permanent measures shall include seeding and installation of erosion control blankets.

### **320 Construction Work Within Public Ways**

Construction work within public ways shall be constructed in accordance with specifications sections 200 through 700 of the "Standard Specifications for Road and Bridge Construction" as prepared by the State Department of Highways Division of Highways State of Colorado dated 1991.

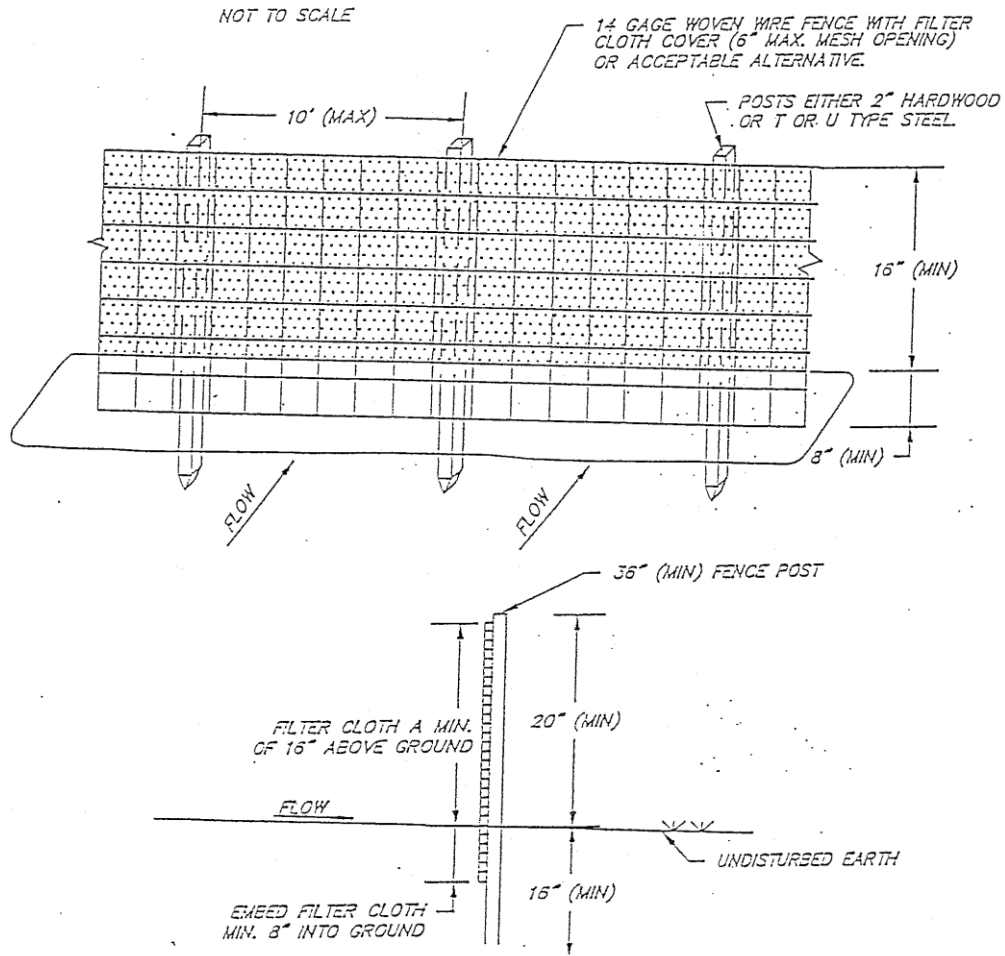
Specifications are on file and may be obtained at the address of the Engineer at the cost of reproductions.

### **321 Clear and Grub**

All large rocks, trees, stumps, brush, debris, structures and unsuitable material shall be removed to a depth of twelve inches below the roadway section. Unsuitable material is any material containing vegetation or organic matter, water, muck, industrial waste or other undesirable materials. Tree stumps shall be removed to a depth of eighteen inches below the subgrade surface. All trees not designated for removal shall be carefully protected during the construction operations.

The contractor shall dispose of all unsuitable material offsite. Excavated material that has been approved by the County, such as topsoil or earthfill, shall be used as far as practical, in the formation of embankments, backfilling or other purposes

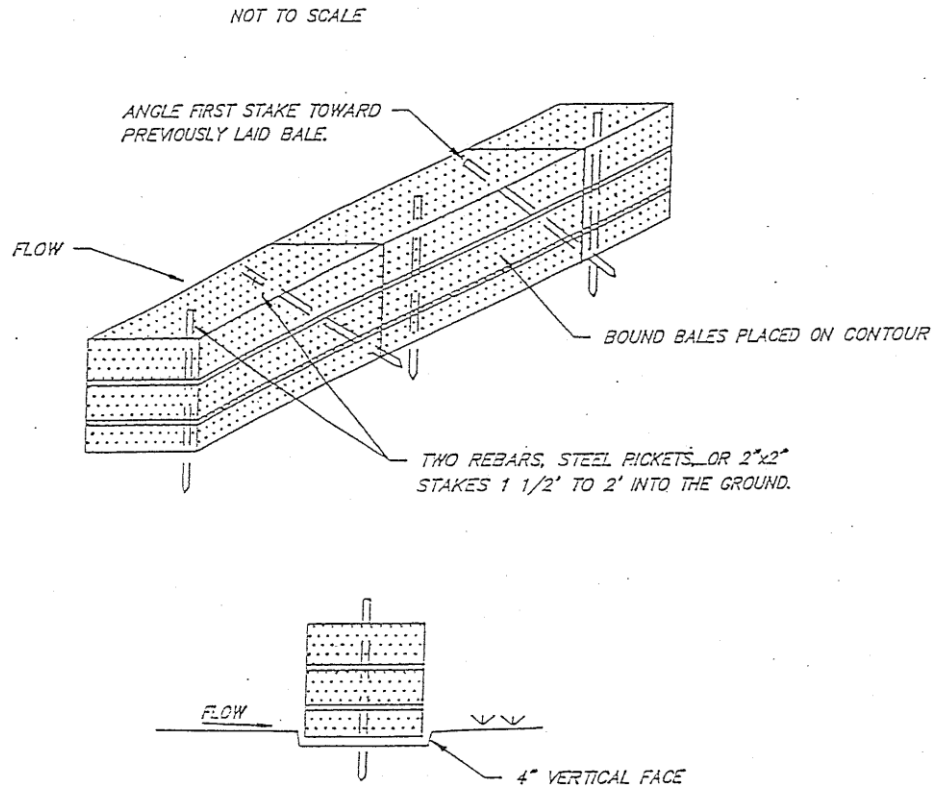
FIGURE 19  
Silt Fence Installation



NOTES

1. Silt fencing shall be continuously maintained during site construction activities.
2. Silt fence to remain in place until vegetation is fully established on upgradient areas.
3. Woven wire fence shall be fastened securely to fence posts with wire ties or staples. Filter cloth shall be fastened securely to woven wire fence with ties spaced every 24" at top and mid section.
4. When two sections of filter cloth adjoin each other they shall be overlapped by 6" or folded.
5. A pre-assembled S.C.S. approved silt fence may be installed as an alternative. The fence shall be installed in accordance with the manufacturer's specifications.

FIGURE 20  
Hay Bale Installation



NOTES

1. Bales shall be placed at the toe of a slope or on the contour and in a row with ends tightly abutting the adjacent bales.
2. Bales shall be securely anchored in place by either two stakes or rebars driven through the bale. The first stake in each bale shall be driven toward the previously laid bale at an angle to force the bales together.
3. Bales to remain in place until vegetation is fully established on upgradient areas.
4. Hay bales shall be continuously maintained during site construction activities.
5. Bales shall be removed when they have served their usefulness so as not to block or impede storm flow or drainage.

### 322 Structural Embankment Construction

All fill and embankment areas shall be constructed with suitable material. Suitable earthfill material consists of non-organic clays and silts, gravel, sands, and mixtures thereof with maximum particle size of six inches. Bedrock that breaks down to specified soil types and sizes during excavation, hauling, and placement may be considered as a suitable material, if inspected and approved by the County. Onsite soils may be used if acceptable to the County. All fill and embankment material shall be approved by the County before use.

Fill material shall be placed in uniform layers not exceeding eight inches of loose thickness. Fill material shall be compacted to 95 percent of the maximum density as determined by the appropriate compaction method, specified in Section 260. The moisture content shall be within two percent of the optimum.

Each layer shall be placed in a manner that will assure uniform compaction throughout the lift. A new lift shall not be placed until the compaction and moisture requirements are achieved on the preceding lift.

Rocks and cobbles less than six inches in maximum particle size found in the fill material shall be intermixed with soils so that no voids remain in the fill.

### 323 Subgrade Construction

Subgrade shall be defined as the 12 inches of material immediately below the roadway aggregate base course. Subgrade material shall be free of all organic, frozen or other deleterious material. Prior to placing any aggregate base course, the subgrade shall be shaped, graded and compacted to the crown, lines, grades and cross sections as shown on the plan.

The subgrade shall be prepared or modified as necessary to meet the following compaction and moisture requirements. Preparation shall include wetting, drying or removal. Compacted subgrade material shall be within 2 percent of the optimum moisture content.

<b>AASHTOM145 Soil Classification</b>	<b>Minimum Compaction</b>	<b>Minimum Depth</b>
A-1, A-2, A-3, A-4 Non-cohesive soils, PI<6	95% AASHTO T1 80	6 inches
A-4, A-5, A-6 Cohesive soils, PI>6	95% AASHTO T99	1 foot

Organic soils shall be removed.

The subgrade shall be proof rolled to detect any soft, wet, yielding soils or other unstable materials. Any unsatisfactory areas shall be identified, undercut, and repaired prior to the placement of the aggregate base course.

### **324 Aggregate Base Course**

Aggregate base course shall consist of the subbase and base course of a pavement section. The gradation requirements for the subbase shall meet CDOT Class 4. The gradation requirement for the base course shall meet CDOT Class 6. The following test reports shall be available for the aggregate base course materials.

1. Sieve Analysis - ASTM C136
2. Wear Abrasion - ASTM C131
3. Liquid Limit-AASHTO T89, T90
4. Moisture Density Curves - ASTM D-698, C-1557

The fill material for each layer of the aggregate base course shall be wetted, dried or mixed as necessary until it is uniform throughout. The material shall be free of organic and frozen matter, and lumps or balls of clay. Aggregate base course layers shall be placed in uniform layers not exceeding eight inches of loose thickness. Each layer shall be compacted to 95 percent of the maximum density as determined by the appropriate compacted test method. The moisture content shall be within 2 percent of the optimum.

The subbase and base course shall be constructed to the crown, lines, grades and typical sections as shown on the approved plans. The thickness of the material shall not vary more than 1/4 inch from the typical section. Variation above or below a 10-foot straight edge shall not exceed 1/2 inch.

The completed base course layers shall be proof rolled and any area showing unsatisfactory deflection shall be removed and replaced.

### **325 Asphalt Paving**

The materials and construction procedures associated with asphalt paving shall comply with the requirements of the most current revision of the "Standard Specifications for Road and Bridge Construction" published by the CDOT except as modified herein.

The following test reports shall be available for the asphalt:

1. Aggregate: AASHTO T96
2. Tar: AASHTO M52 Grade RTC B-5, MI 18
3. Liquid Asphalt: AASHTO M81, M82; ASTM D-2026
4. Emulsified Asphalt: AASHTO M140
5. Compaction: AASHTO T230
6. Stability and Flow: AASHTO T245, ASTM D-1559
7. Job Mix Formula

Asphaltic concrete shall not be placed on a wet surface or when the temperature is below 40°F. Vehicle traffic will not be allowed to travel on the asphalt until it has cooled and hardened.

The aggregate material shall be crushed stone, crushed gravel, natural gravel or crushed slag with not more than 45 percent wear (AASHTO T96). The gradation shall comply with CDOT Type C, CX, E or EX.

The asphaltic cement material shall meet AASHTO M226, Penetration Grade 85-100. The tack coat shall be Asphalt AASHTO M140.

The frames on all structures shall be adjusted to grade prior to placing asphalt paving. The final asphalt surface shall be 1/4 inch above all structures and gutters sloped away from the pavement. The asphalt surface shall be flush with gutters, sloping towards the pavement.

Asphalt pavement surface shall be constructed to the crown, lines, grade and typical sections shown in the approved plans. The thickness of the asphalt shall not be 1/4 inch thinner than the design section. Variation above or below a 10-foot testing straight edge shall not exceed 1/4 inch.

The asphalt pavement shall be compacted to a minimum of 95 percent of maximum density as determined by ASTM D-1559 (Marshall Density Test).

### **326    Revegetation**

All areas disturbed during the roadway construction shall be revegetated during the first growing season. The revegetated area shall be equal to or better than the preconstruction conditions. A minimum of 4 inches of topsoil, either stripped from the project area or obtained from an acceptable source, shall be placed over the area to be revegetated.

Disturbed areas shall be seeded and mulched at a minimum rate of 75 lbs/acre with a grass mixture native to the area. Mulch shall be natural straw, free of noxious weeds. Fertilizer 15-5-5 shall be applied at a rate of 400 lbs/acre.

Revegetated areas shall be irrigated as necessary to establish an acceptable stand of grass. All revegetation shall be guaranteed by the contractor with a performance bond for two growing seasons.

### **327    Trench Excavation**

Trenches shall be excavated so the pipes can be placed at the lines and grades indicated in the plans, without dips or humps. The trench for a pipe that is to be installed in a fill or embankment shall be excavated after the fill is placed at least 12 inches over the top of the conduit.

All trench excavation areas shall comply with all OSHA safety requirements, such as sheeting and shoring.



Backfill within the pipe zone, which extends from six inches below the pipe to one foot above the conduit, shall be as specified by the owner of the conduit or manufacturer's requirements.

Backfill above the pipe zone shall be with selected material excavated from the site. The material must be free of debris, organic matter or stones larger than six inches in largest dimension. Rocks shall be placed to prevent voids.

The backfill material shall be compacted to 95 percent of the maximum dry density as determined by ASTM D-698. The moisture content shall be within 2 percent of the optimum.

### **328 Culverts**

All culverts shall be a minimum of 24 inches in diameter. The minimum rise for arch pipes shall be 18 inches. Pipe, bedding material and installation procedures shall comply with CDOT requirements.

Structural backfill material shall be used within the pipe zone. Figures 15 and 16 illustrates the basic requirements associated with the installation of flexible and arch pipes. Figure 17 illustrates the requirements for installing a conduit that passes through fill or an embankment.

Class 1 structural backfill shall meet CDOT requirements which state that the material shall meet the following gradation requirements:

Sieve Size	% by Weight Passing Square Mesh Sieves
2 inch	100
No 4	30-100
No. 50	10-60
No. 200	5-20

The liquid limit of the material shall not exceed 35 and the plasticity index shall not exceed 6 as determined with AASHTO T89 and T90 respectively.

Class 2 structural backfill shall be suitable onsite materials. To be suitable, the material shall be free of frozen lumps, wood, or other organic material. If the onsite material is not acceptable to the County, the Contractor shall furnish Class 1 structural backfill material in place of the Class 2.

Flared metal end sections with the following specifications shall be provided for all culverts not embedded in a concrete headwall. The end sections shall be provided with a rolled reinforced edge.

1. 24-inch pipe - 16 gauge galvanized sheet metal
2. 24-inch and larger - 12 gauge galvanized sheet metal