TABLE OF CONTENTS

CHAPTER 6

ROADWAY

CHAPTER 6
ROADWAY

6.00.00 GENERAL PROVISIONS

6.01.00 APPLICABILITY

This chapter contains minimum criteria to be met on all streets and public alleys designed and constructed in the CITY, both by the DEVELOPER and by the CITY.

6.02.00 VARIANCES

Where any particular minimum requirements contained in this chapter can be shown to be inappropriate when applied to an “out-of-the-ordinary” situation, variances to said minimum requirements will be considered according to the provisions in Chapter 1 of these STANDARDS AND SPECIFICATIONS.

6.03.00 PRIVATE STREET SYSTEMS AND PARKING LOTS

Private street systems and parking lots shall be subject to all minimum requirements of these STANDARDS AND SPECIFICATIONS except that variances, as provided for in Chapter 1, will be considered subject to the review and approval of the CITY ENGINEER.

6.10.00 ROADWAY DESIGN AND TECHNICAL CRITERIA

This section sets forth the minimum design and technical criteria and specifications to be used in the preparation of all roadway plans. Within this chapter, "AASHTO "Green Book" refers to "A Policy on Geometric Design of Highways and Streets" (latest edition) as published by the American Association of State Highway and Transportation Officials.

Design criteria are summarized below in Table 6.10.00. Refer to Sections 6.12.00 through 6.14.00 for requirements for each street classification. Roadway widths presented in this section are minimums. Additional widths shall be provided for bicycle lanes, transit lanes, etc. when required by the Traffic Engineer.

TABLE 6.10.00
Roadway Design Criteria

Design Element	Major Arterial	Minor Arterial	Major Collector	Minor Collector	Local Detached	Local Attached
Cross Section	See Typical Section Details R1-R3					
Right-of-Way Minimum	130'/155'	130'	104'	90'	59'	53'
Paved Section Minimum (excluding curb & gutter)	60'/82'	60'	44'	30'	30'	30'
Sidewalk Width Minimum	8'/10'[1]	8'/10'[1]	5'	5'	5'	5'
Curb & Gutter Type	6" Barrier	6" Barrier	6" Barrier	6" Barrier	6" Barrier	6" Mountable
Number of Travel Lanes	4 to 6	2 to 4	2 to 4	2	2	2
Travel Lane Width Minimum	10.5'	10.5'	10.5'	10.5'	10'	10'
Bike Lane Minimum	4'	4'	4'	4'	NA	NA
Street Light Spacing Per Side of Roadway[2]	250'	250'	250'	250'	250'	250'
Traffic Volume	30,000	12,000	7,000	7,000	2,500	2,500
Parking Allowed	No	No	No	Select	Yes	Yes
Direct Residential Access	No	No	No	Select	Yes	Yes
Normal Cross Slope	2%	2%	2%	2%	2%	2%
Maximum Superelevation[3]	4%	4%	4%	NA	NA	NA
Minimum Curve Radius	See Table 6.16.01					
Minimum Tangent Between Horizontal Curves	100'	100'	50'	50'	NA	NA
Maximum Street Grade	See Table 6.17.00					
Minimum Street Grade	0.75%	0.75%	0.75%	0.75%	0.75%	0.75%
Maximum Grade at Intersection	See Figure 6.17.01					
Design Speed (Min/Max)	45/50	40/50	35/50	30/35	30	30
Posted Speed (Min/Max)	40/45	35/45	30/45	25/30	25	25
K-Values Crest	See Table 6.17.00					
K-Values Sag	See Table 6.17.00					
Right and Left Turn Lanes	Required at all access points to Arterial roadways. May be required at access points to Collectors as determined at time of development. Minimum dimensions: 100' storage, 100' taper. Arterial/Arterial intersection 200' storage, 100' taper. Storage shall accommodate the 95%ile of future traffic volume. See Table 6.22.02 for taper ratio.					

Notes:

[1] Eight feet typical; ten feet when multi-use path is required.

[2] See the Street Lighting chapter of these STANDARDS AND SPECIFICATIONS for specific requirements.

[3] See Section 6.19.02 for additional information.

6.11.00 REPORTS

6.11.01 Submittal Format

All reports shall be submitted in PDF or similar format to the CITY's online permit system and shall include the seal and signature of the Professional Engineer registered in the State of Colorado who is responsible for the report contents. In addition, all reports shall include the following statement:

"We acknowledge that the City of Westminster's review of this study is only for general conformance with submittal requirements, current design criteria, and standard engineering principles and practices. We are also aware of the provisions of Section 11-6-5(B)3 of the Westminster Municipal Code."

6.11.02 Traffic Analysis Report

All developments, including but not limited to subdivision, Planned Unit Development (PUD), and commercial developments shall require a traffic analysis report giving information and details as may be required by the CITY ENGINEER and as specified in Chapter 8 of these STANDARDS AND SPECIFICATIONS.

6.11.03 Pavement Design Report

All roadway construction in the City of Westminster shall require a pavement design report. The report content shall be in accordance with Section 6.30.00 of these STANDARDS AND SPECIFICATIONS.

6.12.00 LOCAL STREET

6.12.01 Local

Local streets provide direct access to adjacent property. Traffic carried by local streets should have an origin or a destination within the neighborhood and should accommodate all mode types. Local streets are utilized in single family residential areas. Local streets should not intersect major arterial streets.

(A) **Posted Speed Limit.** 25 miles per hour. Posted or prima facia speeds for the various street classifications are normally five (5) to ten (10) miles per hour less than the design speed of that street.

(B) **Traffic Volumes.** Less than 2,500 vehicles per day.

(C) **Traffic Control.** Stop signs, yield signs, or right-of-way rules for uncontrolled intersections. Traffic requirements in other than residential areas may require special design consideration by the DEVELOPER and TRAFFIC ENGINEER.

(D) **Right-of-Way.** Fifty three feet (53') with attached walk. Fifty-nine feet (59') with detached walk.

(E) **Number of Travel Lanes.** Two.

(F) **Access Conditions.** In accordance with Chapter 8 of these STANDARDS AND SPECIFICATIONS.

(G) **Type of Curb and Gutter.** Six inch (6") mountable combination curb, gutter and walk, with attached walk; or six inch (6") vertical with detached walk.

(H) **Sidewalk Width.** Five foot (5') minimum, attached or detached from curb.

(I) **Cul-De-Sacs.** In accordance with Section 6.21.00 of these STANDARDS AND SPECIFICATIONS.

(J) **Street Widths.**

1. Thirty foot (30') paved width (minimum) plus two (2) two foot (2') gutter pans.

6.12.02 TMUND Local Streets

Traditional Multi-Use Neighborhood Development (TMUND) local street sections, as shown in the standard drawings, may be used only in TMUND developments when approved by the CITY ENGINEER.

6.13.00 COLLECTOR STREET

6.13.01 Minor Collector

Collector streets collect and distribute traffic between arterial and local streets and serve as main connectors within communities, linking one neighborhood with another, and should accommodate all mode types. Traffic carried by collector streets should have an origin or a destination within the community. Collector streets should have continuity throughout a neighborhood but need not extend beyond the neighborhood. Intersections with collectors, major collectors, and arterial streets should be at least one quarter (1/4) mile apart.

(A) **Posted Speed Limit.** Between 25 and 30 miles per hour. Posted or prima facia speeds for the various street classifications are normally five (5) to ten (10) miles per hour less than the design speed of that street.

(B) **Traffic Volumes.** Generally less than 7000 vehicles per day.

(C) **Traffic Control.** Regulation of traffic accomplished through the use of stop signs and channelization. Traffic signals normally use only at intersections with major collectors and arterial streets.

(D) **Driveways.** No back-out drives permitted.

(E) **Right-of-Way Width.** Ninety-feet (90') minimum.

(F) **Number of Travel Lanes.** Two (2).

(G) **Access Conditions.** In accordance with Chapter 8 of these STANDARDS AND SPECIFICATIONS.

(H) **Type of Curb and Gutter.** Six (6) inch vertical.

(I) **Sidewalk Width.** Five feet (5') minimum. Detached from curb.

(J) **Street Widths.** Thirty-foot (30') paved (minimum) with two (2) two-foot (2') gutter pans.

6.13.02 Major Collector

Major collector streets permit relatively unimpeded traffic movement and are intended for use on those routes where two (2) moving lanes are required but where a larger classified street is not warranted. Utilized in industrial, commercial, multi-family and single family residential areas. Major collector streets should be employed where traffic demands are high, and should accommodate all mode types.

(A) **Posted Speed Limit.** Between 30 and 45 miles per hour. Posted or prima facie speeds for the various street classifications are normally five (5) to ten (10) miles per hour less than the design speed of that street.

(B) **Traffic Volumes.** Generally greater than 7000 vehicles per day and less than 12,000 vehicles per day, when the land which the collector serves is fully developed.

(C) **Traffic Control.** Regulation of traffic accomplished by signing and channelization. Traffic signals will normally be located only at intersections with streets of higher classification. Parking prohibited.

(D) **Driveways.** No back-out drives permitted.

(E) **Right-of-Way Width.** one hundred four feet (104').

(F) **Number of Travel Lanes.** Four (4).

(G) **Access Conditions.** In accordance with Chapter 8 of these STANDARDS AND SPECIFICATIONS.

(H) **Type of Curb and Gutter.** Six (6) inch vertical.

(I) **Sidewalk Width.** Five feet (5') wide minimum. Detached from curb.

(J) **Street Widths.** Forty-four feet (44') paved (minimum) plus two (2) two-foot (2') gutter pans.

6.13.03 TMUND Collector Streets

Traditional Multi-Use Neighborhood Development (TMUND) collector street sections, as shown in the standard drawings, may be used only in TMUND developments when approved by the CITY ENGINEER.

6.14.00 ARTERIAL STREET

6.14.01 Minor Arterial

Arterial routes permit relatively unimpeded traffic movement and are intended for use on these routes where four (4) moving lanes and one (1) left turn lane are required but where a major arterial cross section would not be warranted. Parking is not allowed and all mode types should be accommodated.

Arterials should be spaced from one half (1/2) to one (1) mile apart and should, where possible, be continuous. Arterials should act as boundaries between neighborhood areas. Arterial cross section should be employed where traffic demands are high. Detached sidewalk and/or multi-use trail required. Separate major land uses.

(A) **Posted Speed Limit.** Between 35 and 45 miles per hour. Posted or prima facie speeds for the various street classifications are normally five (5) to ten (10) miles per hour less than the design speed of that street.

(B) **Traffic Volumes.** Twelve thousand (12,000) vehicles per day expected minimum traffic volume when the land which the arterial serves is fully developed.

(C) **Access.** In accordance with Chapter 8 of these STANDARDS AND SPECIFICATIONS.

(D) **Traffic Control.** Regulation of traffic accomplished by signs and channelization. Traffic signals will normally be located only at intersections with streets of high classification. Parking shall be prohibited.

(E) **Right-of-Way Width.** One hundred and thirty feet (130') minimum.

(F) **Number of Travel Lanes.** Four (4).

(G) **Type of Curb and Gutter.** Six (6) inch vertical.

(H) **Sidewalk Width.** Eight-foot (8') minimum, or ten-foot (10’) multi-use path, detached from curb, or as required by the CITY ENGINEER.

(I) **Street Widths.** Sixty feet (60’) paved (minimum) and two (2) two-foot (2') gutter pans plus deceleration lanes at intersections.

6.14.02 Major Arterial (4-Lane)

Major arterial streets permit rapid and relatively unimpeded traffic movement throughout the City of Westminster, connecting major lane use element, as well as communities with one another. No parking is allowed and all mode types should be accommodated. Sidewalks and/or multi-use trails are required.

Major arterial streets should be spaced approximately one (1) mile apart and should traverse the entire City of Westminster. Major arterial streets should not bisect neighborhoods but should act as boundaries between them.

(A) **Posted Speed Limit.** 40 to 45 miles per hour. Posted or prima facie speeds for the various street classifications are normally five (5) to ten (10) miles per hour less than the design speed of that street.

(B) **Traffic Volumes.** Nineteen thousand (19,000) vehicles per day expected minimum traffic volume when the land which the arterial serves is fully developed.

(C) **Access.** In accordance with Chapter 8 of these STANDARDS AND SPECIFICATIONS.

(D) **Traffic Control.** Movement of traffic will be controlled by signals and channelization. Parking shall be prohibited. Roadways should have a raised median strip between them.

(E) **Right-of-Way Width.** One-hundred-thirty feet (130') minimum.

(F) **Number of Travel Lanes.** Four (4).

(G) **Type of Curb and Gutter.** Six (6) inch vertical with two foot (2') pan on outside of traveled way; six (6) inch vertical with one foot (1') pan on medians.

(H) **Sidewalk Width.** Eight-foot (8') minimum, or ten-foot (10') multi-use path, detached from curb, or as required by the CITY ENGINEER.

(I) **Street Widths.** Sixty feet (60') paved (minimum), two (2) two-foot (2') gutter pans plus necessary left-turn and deceleration lanes at intersections.

6.14.03 Major Arterial (6-Lane)

Major arterial streets permit rapid and relatively unimpeded traffic movement throughout the City of Westminster, connecting major land use elements, as well as communities with one another. Parking is not allowed and all mode types should be accommodated. Sidewalks and/or multi-use trails are required.

Major arterial streets should be spaced approximately one (1) mile apart and should traverse the entire City of Westminster. Major arterial streets should not bisect neighborhoods but should act as boundaries between them.

(A) **Posted Speed Limit.** 40 to 45 miles per hour. Posted or prima facie speeds for the various street classifications are normally five (5) to ten (10) miles per hour less than the design speed of that street.

(B) **Traffic Volumes.** Thirty thousand (30,000) vehicles per day expected minimum traffic volume when the land which the arterial serves is fully developed.

(C) **Access.** In accordance with Chapter 8 of these STANDARDS AND SPECIFICATIONS.

(D) **Traffic Control.** Movement of traffic will be controlled by signals and channelization. Parking shall be prohibited. Roadways should have a 4 foot (4') minimum raised median strip between them.

(E) **Right-of-Way Width.** One hundred fifty-five foot (155') minimum.

(F) **Number of Travel Lanes.** Six (6).

(G) **Type of Curb and Gutter.** Six (6) inch vertical with two foot (2') pan on outside of traveled way; six (6) inch vertical with one foot (1') pan on median.

(H) **Sidewalk Width.** Eight-foot (8') minimum, or ten-foot (10') multi-use path, detached from curb, or as required by the CITY ENGINEER.

(I) **Street Widths.** Eighty-two (82') paved (minimum), two (2) two-foot (2') gutter pans and necessary left-turn lanes and deceleration lanes at intersections.

6.15.00 DRAINAGE

The minor and major storm drainage systems shall be designed in accordance with the CRITERIA. The safe and efficient movement of traffic is the primary function of roadways. The storm drainage function of roadways (such as allowable gutter capacity and street overtopping) shall be designed to the limits set forth in the drainage criteria.

6.15.01 Crosspans

Crosspans shall be constructed in accordance with the detail drawing. Crosspans are not permitted perpendicular to collector or arterial roadways, nor are they allowed on roadways with storm sewer systems. Crosspans may be used parallel to collectors or arterial roadways to convey storm runoff across residential roadways. The use of crosspans elsewhere, or the use of any crosspan on roadways where the vertical grade exceeds four-and-one-half percent (4.5%) will be considered only after all alternatives have been exhausted.

6.15.02 Inlets

Inlets shall be located to intercept the curb flow at the point curb flow capacity is exceeded by storm runoff. Refer to the CRITERIA for curb capacity. Inlets shall also be installed to intercept cross-pavement flows at points of transition in superelevation. Due to the presence of handicap ramps, inlets shall not be allowed in the curb return but shall be located outside the tangent points of the curb returns. Gutter transition sections abutting inlets shall not be within the curb return.

6.15.03 Sidewalk Chases

Storm water from concentrated points of discharge shall not be allowed to flow over sidewalks but shall drain to the roadway or storm inlet by use of chase sections. Sidewalk chase sections shall not be located within a curb cut or driveway. Sidewalk chase sections shall be constructed when requested by the CITY ENGINEER and in accordance with the detail drawing.

6.16.00 HORIZONTAL ALIGNMENT

6.16.01 Horizontal Curves

The minimum horizontal curves for roadway alignment shall be in accordance with Table 6.16.01 below.

TABLE 6.16.01
Horizontal Curves

Design Speed (MPH)	Minimum Curve Radius (feet)*
20	107
25	198
30	333
35	510
40	762
45	1039
50**	926
55**	1190

* AASHTO Table 3-13b - for low speed urban street - normal crown.
** Requires Superelevation per AASHTO Table 3-8 - 0.04 ft/ft maximum.

6.16.02 Curb Return Radius

Minimum return radius shall be as shown in Table 6.16.02 below.

TABLE 6.16.02
Curb Return Radii
(Measured Along Flowline)

Through Street	Intersecting Streets: Arterial	Collector	Local Service
Arterial	*	30 Feet	25 Feet
Collector	30 Feet	25 Feet	20 Feet
Local Service	25 Feet	20 Feet	15 Feet

* Special design required and will be reviewed by the CITY ENGINEER. Corner may need to incorporate turn lanes and islands, and turning template simulations will be required.

6.16.03 Design Speed

Horizontal alignment design speed shall be consistent with the requirement for vertical alignment design speed. If no superelevation is required and normal crown section exists, the horizontal curve data as shown in Table 6.16.01 shall be used.

6.16.04 Spiral Curves

Spiral curves shall be used only on arterial roadways within the City of Westminster and only upon written approval of the CITY ENGINEER.

6.16.05 Small Deflection Angles

For small deflection angles, curves should be sufficiently long to avoid the appearance of a kink. Curves should be at least five hundred (500) feet long for a central angle of five degrees (5^o), and the minimum length should be increased one hundred feet (100') for each one-degree (1^o) decrease in the central angle. Horizontal curves should not be used when the central angle is fifty-nine minutes (59') or less. This criteria applies to arterial roadway design only and latest AASHTO criteria will control.

6.16.06 Compound Curves

A compound curve on arterials should be avoided, particularly where a simple curve can be obtained and is reasonably feasible. Where topography makes their use necessary, the radius of the flatter curve should not be more than fifty percent (50%) greater than the radius of the sharper curve. When this is not feasible, an intermediate curve or spiral should be used to provide the necessary transitions. Spiral curves are only to be used upon written approval of the CITY ENGINEER.

6.16.07 Reversing Curves

True reversing curves should not be used. In cases of reversing curves, a sufficient tangent should be maintained to avoid overlapping of the required superelevation runoff and tangent

runout. The following is the minimum tangent lengths that shall be used for each roadway classification (if the curves have superelevation, the required transition lengths will control):

(A) Local -- not applicable.

(B) Collector -- Fifty feet (50') minimum.

(C) Arterial -- One hundred feet (100') minimum.

6.16.08 Broken-Back Curves

A broken-back curve consists of two (2) curves in the same direction joined by a short tangent, of length less than one thousand five hundred feet (1500'). Broken-back curves are undesirable. If the length of intervening tangent is less than one thousand five hundred feet (1500'), a simple curve, a compound curve, or spiral transitions should be used to provide some degree of continuous superelevation. Spiral curves are only to be used upon written approval of the CITY ENGINEER.

6.16.09 Alignment at Bridges

Ending a curve on a bridge is undesirable and adds to the complication of design and construction. Likewise, curves beginning or ending near a bridge should be so placed that no part of the spiral or superelevation transitions extends onto the bridge. Compound curves on a bridge are equally undesirable. If curvature is unavoidable, every effort should be made to keep the bridge within the limits of the simple curve.

6.16.10 Coordination With Vertical Alignment

To avoid the possibility of introducing serious traffic hazards, coordination is required between horizontal and vertical alignment. Particular care must be exercised to maintain proper sight distance at all times. Sharp horizontal curves introduced at or near the top of pronounced crest or bottom of sag vertical curves should be avoided. Vertical curvature superimposed upon horizontal curves, or vice versa, generally results in a more pleasing facility.

6.17.00 VERTICAL ALIGNMENT

Vertical Alignment Control Table:

Design Controls for vertical alignment are shown on Table 6.17.00.

TABLE 6.17.00
Vertical Alignment Controls

Design Speed (MPH)*	Maximum Grade**	Minimum K Value Crest***	Minimum K Value Sag***	Minimum Vertical Curve Length (feet)
25	8%	12	26	50
30	8%	19	37	50
35	8%	29	49	50
40	7%	44	64	50
45	7%	61	79	50
50	7% Collector 6% Arterial	84	96	150
55	6%	114	115	165

* The design speed is a minimum of 5 miles per hour over the posted speed.

** The maximum grades indicated should only be used in extreme topographic conditions. The designer should strive to minimize the use of these grades for considerable lengths and on north-facing slopes.

*** K values exceeding 167 on curbed streets should be checked for drainage. Multiple inlets may be required within long sag vertical curves, and where the longitudinal slope is less than 0.4 percent.

6.17.01 Permissible Roadway Grade

The minimum allowable grade for roadways is three-quarter percent (0.75%). The minimum allowable grade for bubbles and cul-de-sacs within the bulb is one percent (1%). The maximum allowable grade for any roadway is shown in Table 6.17.00 above.

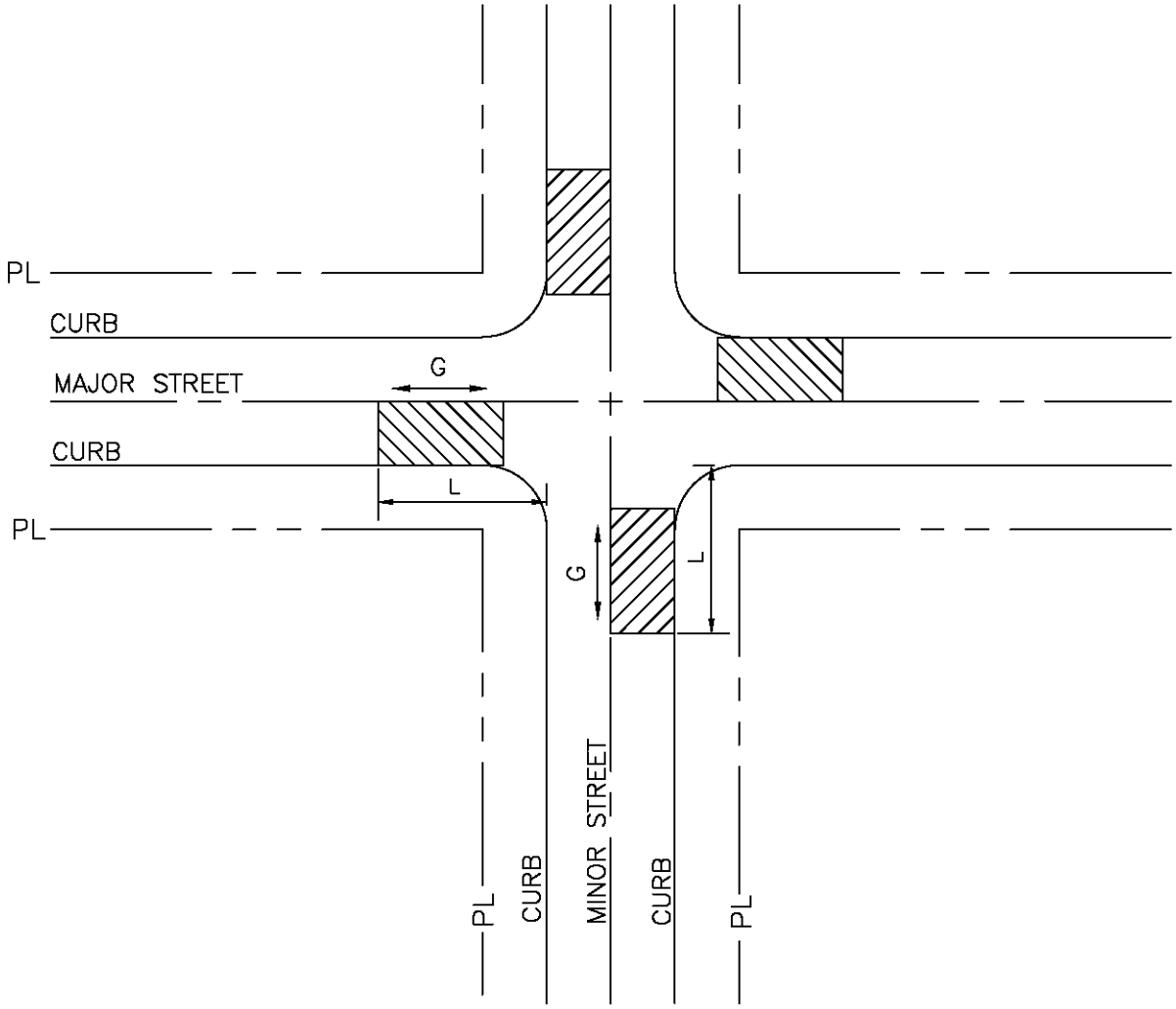
6.17.02 Permissible Intersection Grades (Public Rights-of-Way)

The maximum permissible grade at intersections shall be as shown in Figure 6.17.01. These grades are maximum instantaneous flowline grades for the stated distances (each side of the street) for the minor (intersecting) street.

The intersection grade of the major (through) street at the intersection may be dictated by design considerations for the street. However, if the major street intersection grade exceeds three percent (3%), the type of access and access control will be as directed by the CITY ENGINEER.

All private commercial driveways with curb return radii shall follow the standards set forth for a local street. The length of the maximum grade for the commercial driveway shall be a minimum of fifty feet (50') measured from the flowline intersection of the public roadway.

FIGURE 6.17.01
Maximum Permissible Intersection Grades



MINOR STREET / MAJOR STREET		LOCAL	MINOR COLLECTOR	MAJOR COLLECTOR	MINOR ARTERIAL	MAJOR ARTERIAL
LOCAL	L	95'	100'	100'	125'	125'
	G	4%	4%	4%	4%	4%
MINOR COLLECTOR	L	--	100'	120'	150'	150'
	G	--	4%	3%	3%	3%
MAJOR COLLECTOR	L	--	--	120'	150'	200'
	G	--	--	3%	3%	3%
MINOR ARTERIAL	L	--	--	--	200'	200'
	G	--	--	--	2%	2%
MAJOR ARTERIAL	L	--	--	--	--	200'
	G	--	--	--	--	2%

6.17.03 Changing Grades

The use of grade breaks in lieu of vertical curves is discouraged. However, if a grade break is necessary and the algebraic difference in grade does not exceed eight-tenths of a percent (0.008 ft./ft.) along the roadway, the grade break will be permitted. The maximum grade break allowed at the point of tangency at a curb return for local and collector roads shall be two percent (2%) and for arterial roadways a maximum of one percent (1%).

6.17.04 Vertical Curves

When the algebraic difference in grade (A) is at, or exceeds, eight-tenths of a percent, a vertical curve is to be used. Design criteria for vertical curves is found in Table 6.17.00 of this chapter. The minimum gradients into and out of a sag (sump) vertical curve is three-quarters of a percent (0.0075 ft./ft.). Minimum length of a vertical curve is shown in Table 6.17.00 of this chapter. All vertical curves shall be labeled in the profile with length of curve (L), K=L/A values, Vertical Point of Curvature (VPC), Vertical Point of Tangent (VPT), Vertical Point of Intersection (VPI), and stationing and elevation of these components. In addition, the low point or high point of the vertical curve shall be shown.

6.17.05 Intersections

In addition, the following criteria shall apply at intersections.

(A) The grade of the "through" street shall take precedence at intersections. At the intersections of roadways with the same classification, the more important roadway, as determined by the CITY ENGINEER, shall have this precedence. The design should warp side streets to match through streets with as short a transition as possible. Transition lengths shall be according to AASHTO criteria.

(B) The key criteria for determining the elevation of the curb return on the side street and the amount of warp needed on a side street transitioning to a through street are:

1. Permissible grade in the stop/start lane. See Section 6.17.02 of these STANDARDS AND SPECIFICATIONS.

2. Pavement cross slope at the PCR's on the side street and permissible warp in pavement cross slope (see Section 6.19.01(B)).

3. Normal vertical curve criteria.

4. Vertical controls within the curb return itself.

(C) The elevation at the PCR of the curb return on the through street is always set by the grade of the through street in conjunction with pavement cross slope.

(D) Carrying the crown at a side street into the through street is permitted only when drainage considerations warrant such a design.

(E) A more detailed review shall be performed for arterial-arterial intersections to maximize driveability. A few arterial intersections will have a uniform two percent (2%) cross-slope, the majority of them having one or more sides warped.

(F) Whenever possible, intersections shall be made at right angles or radial to a curve. No intersecting angle of less than seventy-five degrees (75^{o}) will be allowed.

6.17.06 Curb Returns

Minimum grade around curb returns for flow along the curb line shall be as follows:

Table 6.17.06
Curb Return Grades

Curb Return Radius (Feet)	Minimum Grade Around Curb Return
15 to 35	1.00%
40 and Greater	0.75%

6.17.07 Curb Return Profiles

Curb return profiles are required for radii equal to or greater than twenty five (25') within the public right-of-way. A mid-point elevation along the arc length of the curb return shall be shown in plan view for radii equal to or greater than twenty-five feet (25'). Curb return design shall be set in accordance with the following design procedure. General standards for flowline control and profiles with the curb returns shall be as follows:

(A) The point of tangency at each curb return shall be determined by the projected tangent grade beginning at the point of intersection (PI) of the flowlines.

(B) The arc length and external distances of the curb return shall be computed and indicated on the drawing.

(C) Show the projected flowline (or top of curb) grade for each roadway beyond the PCR.

(D) Design the flowline of the curb return such that a maximum cross slope between the mid-point of the curve and the PICR (external distance) does not exceed five percent (5%). Grade breaks at the PCRs shall not exceed two percent (2%) for local and collector streets and one percent (1%) for arterials. The flowline design of the curb return shall be accomplished within the return without affecting street grades beyond the PCR. Maximum vertical curves will equal the arc length of the curb return. The elevation and location of the high or low point within the return, if applicable, is to be called out in the profile.

6.17.08 Connection With Existing Roadways

(A) Connection with existing roadways shall be smooth transitions conforming to normal vertical curve criteria if the algebraic difference in grade between the existing and proposed grade exceeds eight-tenths (0.008 ft./ft.) of a percent. When a vertical curve is used to make this transition, it shall be fully accomplished prior to the connection

with the existing improvements and shall also comply with the grade requirements at intersection approaches.

(B) Existing grade shall be shown for at least three hundred feet (300') with field verified as-builts showing stations and elevations at twenty-five-foot (25') intervals. In the case of connection with an existing intersection, these as-builts are to be shown within a three-hundred-foot (300') radius of the intersection. This information will be included in the plan and profile that shows that proposed roadway. Limits and characteristics of the proposed improvement are the primary concern in the plan view. Such characteristics include horizontal alignment, off-site intersections, limits of the improvement, etc.

(C) Previously approved designs for the proposed improvement are not an acceptable means of establishing existing grades. However, they are to be referenced on the construction plan where they occur.

(D) The basis of the as-built elevations shall be the design elevations (both flowline or both top of curbs, etc.) when possible.

6.18.00 SIGHT DISTANCES

6.18.01 General

The major considerations in alignment design are safety, grade, profile, road area, design speed, sight distance, topography, drainage, and performance of heavy-duty vehicles. The road alignment should provide for safe and continuous operation at a uniform design speed. New road layout shall bear a logical relationship to existing or platted roads in adjacent properties. Design for sight distances shall be in accordance with the following:

Adequate intersection design necessitates the provision of safe ingress and egress from one street or driveway to the other, based in part on the ability of a driver to see oncoming vehicles or pedestrians. The following guidelines shall be used in the design of intersections, private driveways and public streets which intersect other traffic carrying facilities.

6.18.02 Sight Distance Triangle

At the intersection of two public streets or a private driveway and a public street, sight distance shall be evaluated across a “sight distance triangle” where obstructions are restricted according to the following criteria. Within the area of the triangle there must be no wall, fence, sign, foliage, berming or other structure which will obscure the driver’s view of traffic approaching that intersection. The structures or berms within the sight distance triangle can extend no higher than thirty inches (30”) above the curb elevation.. Exceptions to this requirement exist for public facilities such as fire hydrants, utility poles and traffic control devices. These facilities must be located to minimize visual obstruction.

The evaluation of sight distance shall be made on two different types of sight distance areas. The first is shown in Figure 6.18.01 for the intersection of two public streets or a public street and a private driveway. The sight distance triangle in this case is formed by the intersection of two lines plotted along the curb line of the intersecting streets using the specified lengths. The

diagonal connects the other ends of those lines. Where one or the other of the intersecting streets/driveways has no curb, the lines are plotted along the edge of the traveled way.

The second sight distance triangle is shown in Figure 6.18.02, and is formed by lines plotted along the flowlines or edge of traveled way of both streets and the diagonal lines d_1 and d_2 as shown. Distance d_1 is measured to vehicles approaching from the left and d_2 is measured to those approaching from the right. The sight lines (d_1 and d_2) have their origin at the stopped driver's eye, located fourteen and a half (14.5') behind the flowline of the street being entered.

Tables 6.18.01 through 6.18.04 show recommended sight distances d_1, and d_2 for passenger vehicles and semi-tractor trailer trucks for several different vehicle operating speeds and roadway configurations. The tables were developed according to the following general criteria:

1. Vehicles turning left or right can accelerate to the operating speed of the intersecting street without causing approaching vehicles to reduce speed by more 70% of their initial speed.

2. Vehicles turning left can clear the near half of the street without conflicting with vehicles approaching from the left.

3. The distance requirements are based on the driver's eye being 3.5 feet above the roadway and an object height of 4.35 feet. For semi-tractor trailers, a 7.6 foot driver's eye height and a 4.35 feet object height are assumed.

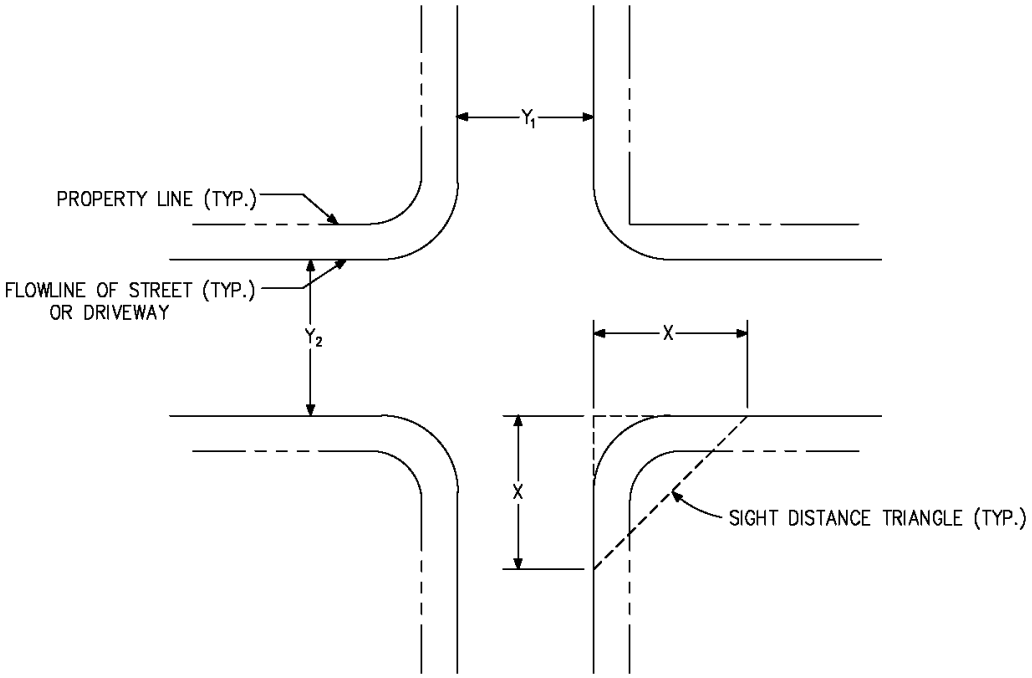
4. The operating speed on each approach is assumed to be (in the order of desirability):

    A. The 85th percentile speed;

    B. The speed limit, if based on a traffic engineering study;

    C. The design speed in the case of a new facility.

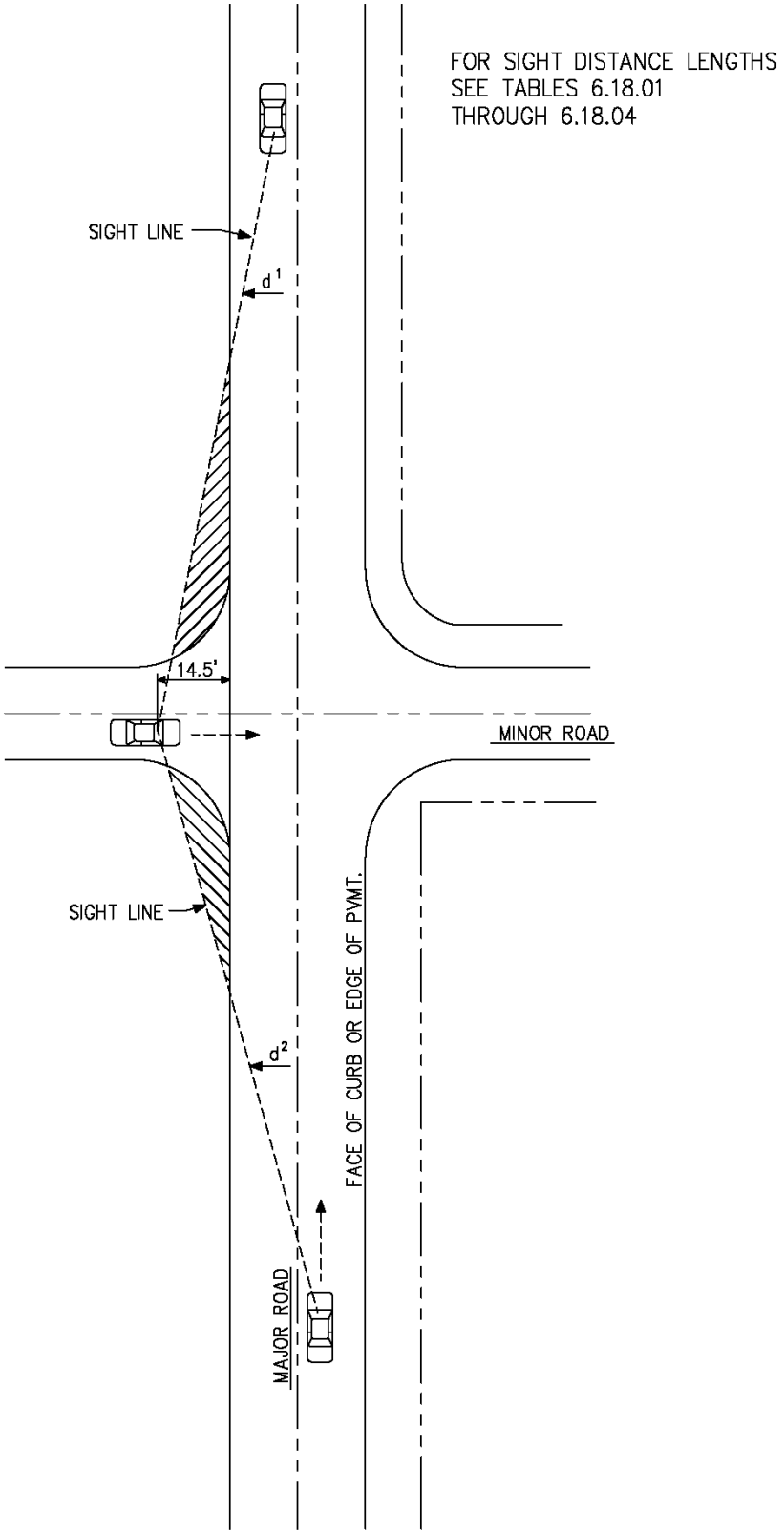
FIGURE 6.18.01
Intersection Sight Lines Case 1



NOTE: IF $Y_1 \neq Y_2$ USE THE LARGER OF THE TWO TO DETERMINE THE "LEG LENGTH" OF THE SIGHT DISTANCE TRIANGLE

FLOWLINE TO FLOWLINE (Y)	LEG LENGTH (X)
≤ 36 FT.	35 FT.
≤ 44 FT.	45 FT.
>= 45 FT.	55 FT.

FIGURE 6.18.02
Intersection Sight Lines Case 2



When the criteria for sight distance cannot be met, the CITY may prohibit certain turns by exiting vehicles to provide safe operating conditions. These standards apply to accesses on State Highways and CITY streets.

TABLE 6.18.01

Sight Distance d^1 and d^2 (feet) for Passenger Cars Turning Left from Private Accesses or Public Streets onto Public Streets

Speed (mph)	Sight Distances d^1 and d^2 (feet)		
	Onto Two-Lane Street	Onto Four-Lane Street	Onto Six-Lane Street
20	225	235	250
25	280	295	315
30	335	355	375
35	390	415	440
40	445	470	500
45	500	530	565
50	555	590	625
55	610	650	690
60	665	710	750

TABLE 6.18.02

Sight Distance (feet) for Passenger Cars Turning Right or Crossing from Private Accesses or Public Streets onto Public Streets

Speed (mph)	Sight Distances (feet)			
	Right Turn (d^1)	Crossing Two-Lane Street (d^1 & d^2)	Crossing Four-Lane Street (d^1 & d^2)	Crossing Six-Lane Street (d^1 & d^2)
20	195	195	225	250
25	240	240	280	315
30	290	290	335	375
35	335	335	390	440
40	385	385	445	500
45	430	430	500	565
50	480	480	555	625
55	530	530	610	690
60	575	575	665	750

TABLE 6.18.03

Sight Distance d^1 and d^2 (feet) for Semi-Trailers Turning Left from Private Accesses or Public Streets onto Public Streets

Speed (mph)	Sight Distances d^1 and d^2 (feet)		
	Onto Two-Lane Street	Onto Four-Lane Street	Onto Six-Lane Street
20	340	360	380
25	425	450	475
30	510	540	570
35	595	630	665
40	680	720	760
45	765	810	855
50	845	900	950
55	930	990	1,045
60	1,015	1,080	1,140

TABLE 6.18.04

Sight Distance (feet) for Semi-Trailers Turning Right or Crossing from Private Accesses or Public Streets onto Public Streets

Speed (mph)	Sight Distances (feet)			
	Right Turn (d^1)	Crossing Two-Lane Street (d^1 & d^2)	Crossing Four-Lane Street (d^1 & d^2)	Crossing Six-Lane Street (d^1 & d^2)
20	310	310	350	395
25	390	390	440	490
30	465	465	525	590
35	540	540	615	685
40	620	620	700	785
45	695	695	790	880
50	775	775	875	980
55	850	850	965	1,075
60	930	930	1,050	1,175

The sight distance shown in Tables 6.18.05 and 6.18.06 are required for vehicles turning left from a public street to allow them a clear view of oncoming vehicles and complete the maneuver safely.

TABLE 6.18.05

Sight distance (ft.) for Passenger Cars Entering Private Accesses or Public Streets by Left Turns from a Public Street

Speed (mph)	Sight Distance in Feet [1]		
	2-Lane	4-Lane	6-Lane
20	165	180	195
25	205	225	240
30	245	265	290
35	285	310	335
40	325	355	385
45	365	400	430
50	405	445	480
55	445	485	530
60	490	530	575

[1] Measured from the point where a left turning vehicle stops to a vehicle approaching in the outside lane.

TABLE 6.18.06

Sight distance (ft.) for Semi-Trailers Entering Private Accesses or Public Streets by Left Turns from a Public Street

Speed (mph)	Sight Distance in Feet [1]		
	2-Lane	4-Lane	6-Lane
20	225	245	265
25	280	305	330
30	335	365	395
35	390	425	460
40	445	485	525
45	500	545	590
50	555	605	655
55	610	665	720
60	665	725	785

[1] Measured from the point where a left turning vehicle stops to a vehicle approaching in the outside lane.

The sight distances in Tables 6.18.01 and 6.18.04 apply when highway grades are zero to 3.0% (either up or down). When grades are steeper than 3.0%, adjustments must be made to compensate for the different distances required to reach the speed of highway traffic. Adjustment factors are provided in Table 6.18.07.

TABLE 6.18.07

Factors for the Effect of Grade on Sight Distance

Grade	Downgrade Factor [1]	Upgrade Factor [2]
0 - 3%	1.0	1.0
3.1 - 5%	0.7	1.3
5.1 - 8%	0.6	1.5

[1] When the highway in the section to be used for acceleration after leaving the access descends, sight distance in the direction of approaching descending highway traffic should be reduced by these factors.

[2] When the highway in the section to be used for acceleration after leaving the access ascends, then sight distance in the direction of approaching ascending should be increased by these factors.

6.19.00 ROADWAY CROWN

6.19.01 Cross Slope

Except at intersections or where superelevation is required, roadways shall be level from top of curb to top of curb (or flowline to flowline) and shall have a minimum two percent (2%) crown. Within one-hundred-fifty feet (150') of an intersection, the maximum elevation difference between flowlines shall be dictated by the allowable intersection grade and the actual distance between flowlines.

(A) Parabolic or curved crowns are not allowed. In no case shall the pavement cross slope at warped intersections exceed the grade of the through street.

(B) The rate of change in pavement cross slope when warping side streets at intersections shall not exceed one percent (1%) every twenty-five feet (25') horizontally on a local roadway, one percent (1%) every thirty-seven-and-one-half feet (37.5') horizontally on a collector roadway, or one percent (1%) every fifty-six-and-one-half feet (56.5') horizontally on arterial roadway.

(C) In the case of conflict caused by requirements of the CRITERIA, the drainage requirements shall govern.

6.19.02 Superelevation

Superelevation is required for curves on all arterial roadways and selected collector roadways. Horizontal curve radius on superelevation shall be in accordance with the recommendations of the AASHTO "A Policy on Geometric Design of Highways and Streets", latest edition (Green Book).

Superelevation shall not be used on local or other roadway classifications with a design speed of 40 miles per hour or less. The following procedure is an outline for the correct application of superelevation on roadways within the City of Westminster.

(A) Definitions Regarding Superelevation:

Superelevation Runoff. That length of roadway needed to accomplish the change in cross slope from a section with the adverse crown removed (flat) to the fully superelevated section, or vice versa.

Transition Points. Beginning or ending of tangent run-out, superelevation runoff, or full superelevation.

Tangent Run-Out. That length of roadway needed to accomplish the change in cross slope from a normal (2 percent) crown section to a section with the adverse crown removed (flat), or vice versa.

(B) General:

One of the most important factors to consider in highway safety is the centrifugal force generated when a vehicle traverses a curve. Centrifugal force increases as the velocity of the vehicle and/or the degree of curvature increases. In order to overcome the effects of centrifugal force, curves should be superelevated. It is impossible to balance centrifugal force by superelevation alone because for any given curve radius a certain superelevation rate is exactly correct for only one driving speed. At all other speeds there will be a side thrust either outward or inward, relative to the curve center, which must be offset by side friction.

(C) Standards for Superelevation:

AASHTO's Green Book, Table 3-8 on superelevation gives the required rates of superelevation for the various degree of curvature. Maximum superelevation rate of 0.04 foot per foot are commonly used on major streets.

(D) Urban Street Conditions:

Every effort should be made to maintain standard rates of superelevation. However, in urban areas street intersections, established street grades, curbs, and drainage conditions may require a reduction in the rate of superelevation or different rates for each half of the road bed. In warping areas for drainage, adverse superelevations should be avoided.

6.20.00 SIDEWALKS, CURB AND GUTTERS, RAMPS, AND DRIVEWAYS

(A) Roadway typical sections shall be as specified by these STANDARDS AND SPECIFICATIONS.

(B) Sidewalks are the portion of a street, whether paved or unpaved, between the edge of a roadway and adjacent property lines for the use of pedestrians. Sidewalks and/or shared use paths shall be constructed on both sides of all roadways and conform to ADA requirements.

(C) All sidewalks used in conjunction with vertical curb and gutter shall have a minimum width of five feet (5').

(D) State and federal law requires that accessible curb ramps be installed at all intersections and at certain mid-block locations for all new construction of curb and sidewalk [CRS 43-2-107(2) and federal Accessibility Guidelines for Public Rights-of-Way (PROWAG)]. Accessible curb ramps shall be constructed in accordance with the detail drawings in these STANDARDS AND SPECIFICATIONS. Accessible curb ramps shall be shown at all curb returns. Whenever referencing an accessible curb ramp, call out the specific detail drawing to construct that ramp. Accessible curb ramps shall be poured monolithic with the abutting curb and gutter. The ramp portion shall be constructed with cast-in-place truncated dome panels according to Section 6.75.00 of these STANDARDS AND SPECIFICATIONS.

(E) Drainage structures shall not be placed in line with accessible curb ramps. Location of accessible curb ramps shall take precedence over location of drainage structures.

(F) Medians shall be included when required by the street classification. Medians shall be paved with concrete median cover or landscaped. At intersection approaches, the median shall not be landscaped and shall be paved with concrete median cover for the distance needed to meet sight distance requirements for all allowed movements at the intersection.

(G) Concrete median cover shall meet the dimension, pattern and color requirements in the detail drawings.

(H) Curb cuts should not be used for commercial/industrial or high volume residential driveways. In general, when the number of parking spaces services by the driveway exceeds ten (10), radius returns should be used.

(I) Where curb cuts are allowed based on traffic considerations, concentrated storm water runoff must not be discharged across the sidewalk. These flows must be directed to a sidewalk chase section. If this is not possible due to grading restraints, radius returns and a crosspan shall be used.

(J) Curb cuts and driveways shall be constructed in accordance with the detail drawings in these STANDARDS AND SPECIFICATIONS.

6.21.00 CUL-DE-SACS

The following criteria shall be used for cul-de-sac horizontal geometry.

(A) The minimum property line radius shall be fifty feet (50').

(B) The minimum flowline radius shall be forty feet (40'). See the detail drawing in this section.

(C) The maximum length of the cul-de-sac as measured along and between the radius point and the right-of-way line on the abutting street shall be five hundred feet (500') or a maximum of fifteen (15) residential dwelling units, whichever results in a shorter street. Refer to Chapter 3 and Chapter 4 of these STANDARDS AND SPECIFICATIONS for additional utility requirements that affect maximum cul-de-sac lengths.

(D) Vertical alignment shall be in accordance with Section 6.17.00 of these STANDARDS AND SPECIFICATIONS.

6.22.00 DECELERATION LANES

The design of the arterial street system depends upon the proper control of access to developments. The location and design of access points must minimize traffic hazards and interference to through traffic movements. To ensure proper control, the following standards for deceleration lanes have been established. Deceleration lanes are required if the volume of turning vehicles is 100 vehicles or more in the peak hour, as established by the approved traffic study.

(A) Requests for exemption from the requirements for a deceleration lane shall be based upon a traffic engineering study that presents trip-generation data for the proposed development in terms of impacts upon through traffic flows. Such requests shall be reviewed by the TRAFFIC ENGINEER and may be approved, except that such an approval cannot be granted if through traffic would be impeded more than three percent (3%) of the total time, more than five percent (5%) of the time during peak traffic flow periods, or if other unique circumstances warrant special design considerations.

(B) Deceleration lanes may be required along segments of collector streets if the proposed development constitutes a potential for creating a traffic hazard or unnecessarily impedes through traffic movements.

(C) Deceleration lanes shall have a minimum paved width of eleven feet (11') unless otherwise approved at a lesser width by the CITY ENGINEER.

(D) The vehicle storage length of the deceleration lane shall be based upon the peak hour turning volume for the development as follows:

TABLE 6.22.01
Deceleration Lanes

Peak Hour Volume	Minimum Length
35-50	40 Feet
51-60	50 Feet
61-100	100 Feet
101-200	175 Feet
201-300	250 Feet

(E) The lead-in taper length plus additional deceleration length for the deceleration lane shall be based upon the posted speed limit along the street.

TABLE 6.22.02
Deceleration Tapers

Speed Limit	Deceleration Length	Taper Ratio*
30 MPH & Under	160 Feet	8:1
35 MPH	250 Feet	12:1
40 MPH	370 Feet	12:1
45 MPH	425 Feet	15:1
50 MPH	500 Feet	15:1

* Taper length equals taper ratio times lane width.

(F) Deceleration lanes shall be provided for all exclusive right-turn access points (i.e., right-in/right-out driveways).

(G) The deceleration lane and the associated signage and pavement marking shall be installed as per the requirements established by the TRAFFIC ENGINEER prior to the issuance of any Certificate of Occupancy within the development.

6.23.00 TRANSIT AND BUS PULL-OUT LANES

Streets shall accommodate transit users.

If recommended by the Regional Transportation District or required by the CITY, bus pull-out lanes shall be designed and constructed by the adjacent subdivider.

(A) The design of the pull-out lanes shall be governed by dimensions shown in the current detail drawings from the Regional Transportation District; and shall be reviewed and approved according to procedures set forth in these design standards.

(B) The pavement design report shall consider the requirements of the pull-out lane separately from the adjacent roadway.

(C) Bus pull-outs shall be constructed with no less than fifty feet (50') between an intersection curb return curve (PC) and the beginning of the lead-in taper.

6.24.00 OFF-SITE DESIGN

(A) The design grade, and existing ground at that design grade, of all roadways that dead end due to project phasing, subdivision boundaries, etc., shall be continued in the same plan and profile as the proposed design for at least three hundred feet (300') or to its intersection with an arterial roadway.

(B) If the off-site roadway adjacent to the proposed development is not fully improved, the developer is responsible for the design and construction of a transition for the safe conveyance of traffic from the improved section to the existing roadway. The following formula shall be applied to the taper of lane change necessary for this transition:

$L = WS^2/60$

Where:

L = Length of Transition in Feed
W = Width of Offset in Feet
S = Speed Limit or 85th Percentile Speed

(C) The CITY ENGINEER should be contacted to establish unusual transition criteria. This contact is the responsibility of the applicant.

6.30.00 PAVEMENT DESIGN AND TECHNICAL CRITERIA

6.31.00 GENERAL

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

For all CITY roadway construction, the applicant shall provide a subgrade investigation and pavement design report that recommends typical pavement structural section based on the known site soil conditions and the valid traffic study. This pavement design serves as a justification of the roadway improvements agreement in addition to determining roadway structural requirements.

6.32.00 SUBGRADE INVESTIGATION

All subgrade investigation shall be in accordance with these STANDARDS AND SPECIFICATIONS, and more specifically:

(A) The field investigation shall consist of borings or other suitable methods of sampling subgrade soils to a depth of at least three feet (3') below proposed subgrade elevation at spacings of not more than two hundred fifty feet (250') unless otherwise accepted by the CITY ENGINEER. Samples shall be taken after grading is completed and the subgrade is rough cut.

(B) The treatment of expansive soils shall be in accordance with these STANDARDS AND SPECIFICATIONS unless approved otherwise, in writing, by the CITY ENGINEER.

(C) The “Subgrade Resilient Modulus”(Mg) shall be correlated the Resistance Value (R-value) using the formulas in these STANDARDS AND SPECIFICATIONS. If the Plasticity Index (PI) of the subgrade is more than 15 or the R-value of the soil is less than 10, then the subgrade shall be stabilized with one of the methods outlined in these STANDARDS AND SPECIFICATIONS.

6.33.00 PAVEMENT DESIGN CRITERIA

6.33.01 General

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

6.33.02 Equivalent (18 Kip) Single Axle Load Applications (ESAL)

The pavement design procedure in this section provides for a 20-year service life of pavement, given that normal maintenance is provided to keep roadway surface in an acceptable condition. ESAL and Design Traffic Number (DTN) are considered equivalent units based on 20-year design criteria and an 18 Kip axle loading. All data and design nomographs in this chapter use ESAL units for pavement loading repetitions. Minimum ESAL criteria for each roadway classification are given in Table 6.33.02 and are to be used when a traffic study indicates lesser ESAL values.

TABLE 6.33.02
Minimum Equivalent (18 Kip) Single Axle Load Applications (ESAL)

Classification	Class Modifier	ESAL Values
Cul-de-Sac	Serving < 10 D.U.	14,600
Local	Serving < 80 D.U.	36,000
Minor Collector	Residential	219,000
	Commercial	365,000
Major Collector`	All	730,000
Minor Arterial	All	1,460,000
Major Arterial	All	1,460,000

(1) ESAL for major arterial roadways shall be set on a case-by-case basis; 1,460,000 is the recommended minimum for planning purposes.

6.33.03 Design Serviceability Loss (APSI)

The following criteria shall be used for all CITY roadways to be dedicated for public use: ASI is based on an initial serviceability index of 4.5 and is the value to use in the CDOT procedure.

TABLE 6.33.03
Serviceability Index and Loss

Roadway Classification	SI	ASI
Arterials (Minor, Major)	2.5	2.0
Collectors:		
Major	2.5	2.0
Minor Commercial	2.5	2.0
Minor Residential	2.5	2.0
Local and Private Parking Lots	2.0	2.5

6.33.04 Reliability

Reliability is the probability that the pavement system will perform its intended function over its design life (or time) and under the conditions (or environment) encountered during operation.

TABLE 6.33.04
Reliability (Risk)

Functional Classification	Reliability
Principal Arterials	95
Minor Arterials	95
Collectors	90
Local	80

6.33.05 Minimum Pavement Section

This paragraph provides the minimum acceptable pavement sections for public roadways in the CITY. The pavement thickness may be used for preliminary planning purposes. Final pavement designs shall be based on actual subgrade support test results. Table 6.33.05 lists the minimum thickness for each roadway classification.

TABLE 6.33.05
Minimum Pavement Sections

Classification	Composite (3) Section Asphalt Inches	Treated Subgrade	Full Depth (2) Asphalt (Inches)
Cul-de-Sac (1)	--	--	6.0
Local	4	8	5.0
Minor Collector			
(A) Residential	4	8	7.0
(B) Commercial	4	8	7.0
Major Collector	4	8	7.0
Minor Collector	5	8	7.0
Major Arterial	6	8	9.0

(1) All cul-de-sacs shall be the minimum full depth shown or the full depth determined by the subgrade support tests, whichever is greater.

(2) "Full Depth Asphalt" is required in all RIGHT-OF-WAY.

(3) Composite sections will only be allowed on private streets and private parking lots.

6.33.06 Flexible Pavement Strength Coefficients

Table 6.33.06 contains the standard design coefficients for various pavement materials. Non-standard design coefficients may be used only if approved in advance by the CITY ENGINEER. In addition, design values shall be verified by predesign mix test data and supported by daily construction tests or redesign values shall be required; i.e., such as add one-half inch (1/2") to one inch (1") to the in-place surface course of final asphalt concrete.

TABLE 6.33.06
Strength Coefficients

Pavement Structure Component*	Structural Layer Coefficients	(Limiting Test Criteria)
Conventional Materials:		
Hot Bituminous Pavement	0.44	
Exist Bituminous Pavement	0.30	(9-15 yr)
	0.24	(> 15 yr)
Aggregate Base Course	0.14	(R≥83)
Aggregate Base Course	0.12	(77≤R-value<83)
Aggregate Base Course	0.11	(69≤R-value<77)
Aggregate Base Course	0.10	(R-value <69
Treated Materials:		
Cement-Treated Aggregate Base	Refer to the Pavement Design Report accepted by the CITY	
Lime-Treated Subgrade	Refer to the Pavement Design Report accepted by the CITY	

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

(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."

6.34.00 PAVEMENT DESIGN PROCEDURE

6.34.01 Flexible Pavements

(A) The following procedure should be used in determining the structural number (SN) of the pavement being designed.

1. Determine roadway classification and corresponding ESAL (Traffic Study or Table 6.33.02 whichever is greater).

2. Determine the serviceability loss (ASI) of the roadway classification (Table 6.33.03).

3. M_R value of subgrade as determined by soils report from laboratory and/or correlation equation below:

   Convert Hveem "R" to Soil Support

   $S_1 = [(\text{"R"} - 5)/11.29] + 3$

   To Convert S_1 to M_R

   $$M_R = 10^{[S_1 + 18.72]/6.24}$$

4. Structural Layer Coefficients (Table 6.33.06)

5. Overall deviation, So, which is 0.44 for flexible pavement.

6. Reliability, R, (see Table 6.33.04)

7. Use nomograph (Table 6.34.01) or use the AASHTO pavement design software,DARWin™ to obtain the Structural Number (SN).

8. Once the structural number (SN) has been determined, the design thicknesses of the pavement structure can be determined by the general equation:

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

Where:

a_1 = Hot Bituminous Pavement (HBP) strength coefficients

D_1 - Thickness of Hot Bituminous Pavement (HBP) (inches)

D_2, D_3, D_n - Thickness of Additional Pavement Component Sections (inches)

a_2, a_3, a_n - Strength coefficient for the corresponding pavement structure *

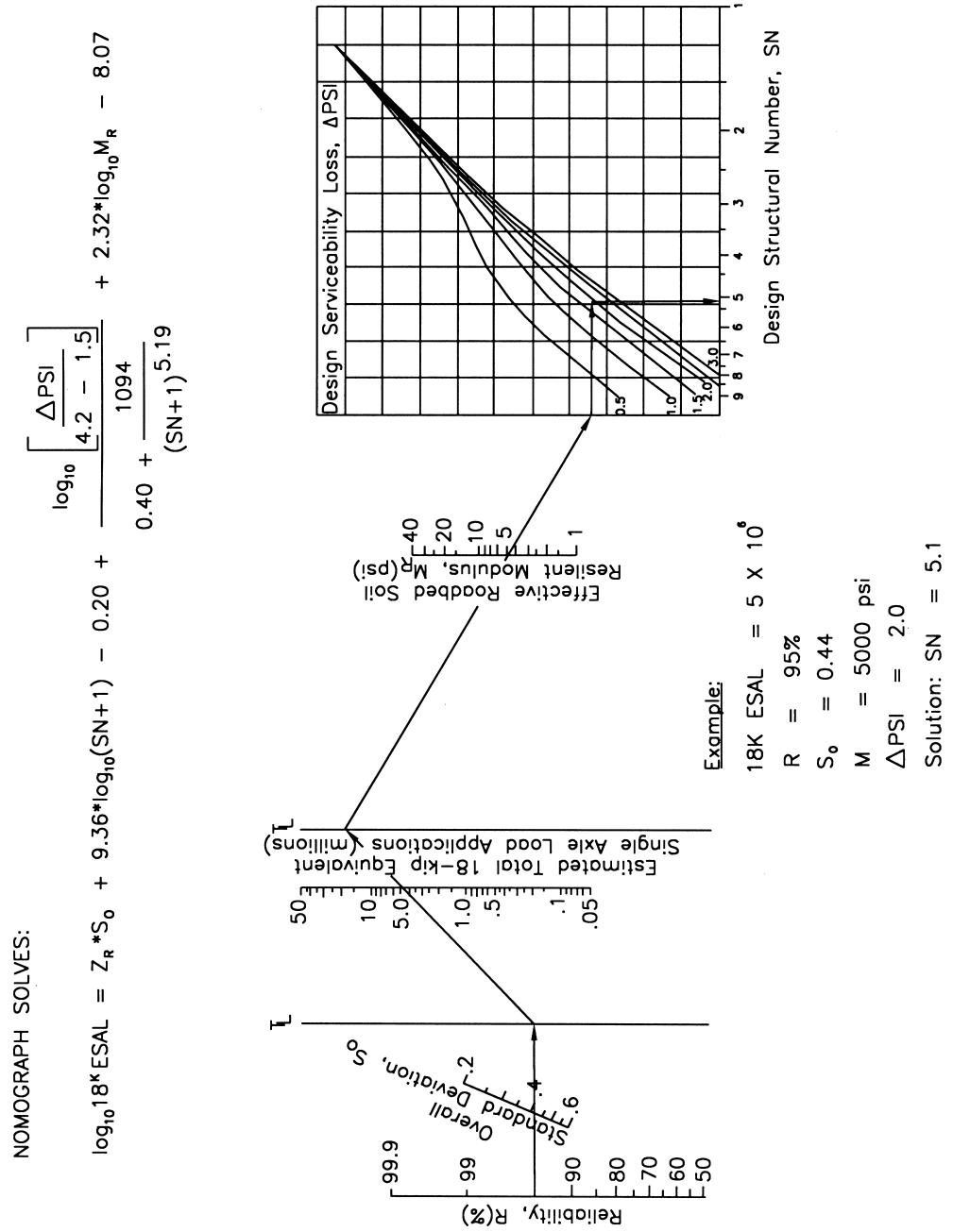
- The Strength coefficients for various components of the pavement structure are given in Table 6.33.06. The component thickness selected must meet two conditions:

a. Total HBP thickness selected cannot be less than the minimum specified in Table 6.33.05 for the roadway classification

b. The base course thickness cannot exceed 2.5 times the HBP thickness selected. If a base course section is allowed, in writing, by the CITY ENGINEER.

TABLE 6.34.01

Flexible Pavement Design



6.34.02 Rigid Pavement

If rigid pavement is allowed by the CITY ENGINEER, the procedures provided by the CITY shall be followed.

6.35.00 SUBGRADE INVESTIGATION AND PAVEMENT DESIGN REPORT

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

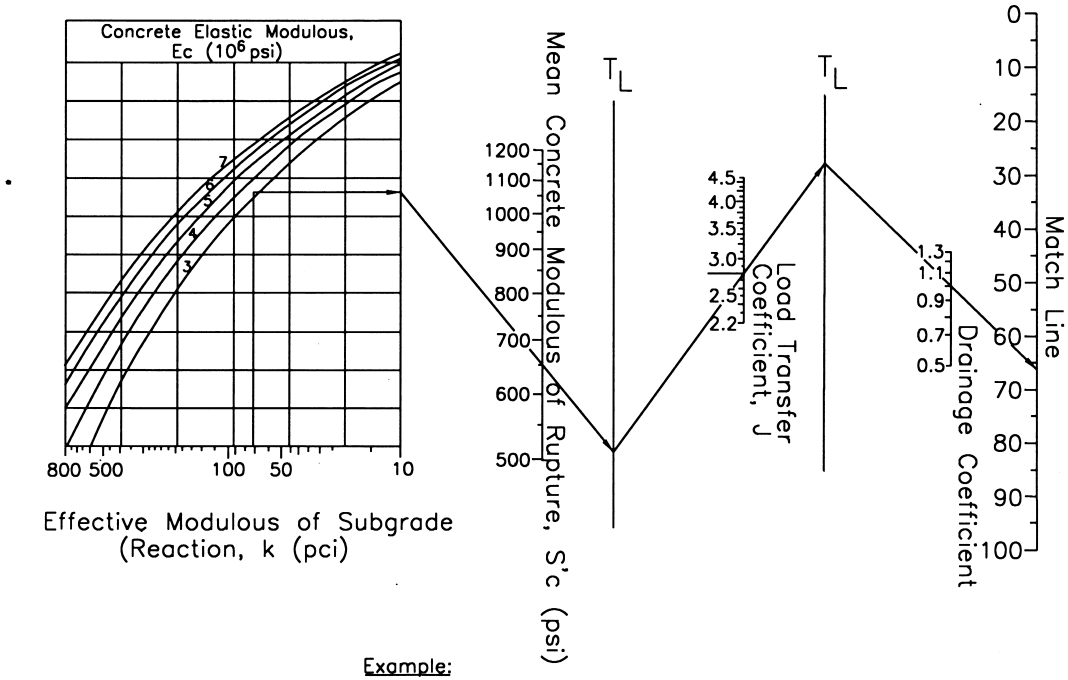
(A) Vicinity map to locate the investigated area.

(B) Scaled drawings showing the location of borings.

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

NOMOGRAPH SOLVES:

$$\log_{10} 18^{K}\,ESAL = Z_R * S_o + 7.35*\log_{10}(D+1) - 0.06 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.5 - 1.5}\right]}{1 + \frac{1.624*10^{7}}{(D+1)^{8.46}}} + (4.22-0.32p_t)*\log_{10}\left[\frac{S'c*Cd\left[D^{0.75}-1.132\right]}{215.63*J\left[D^{0.75}-\frac{18.42}{(Ec/k)^{0.25}}\right]}\right]$$



Example:

k = 72 pci
Ec = 3.4x10 psi
S'c = 650 psi
J = 2.8
Cd =1.0

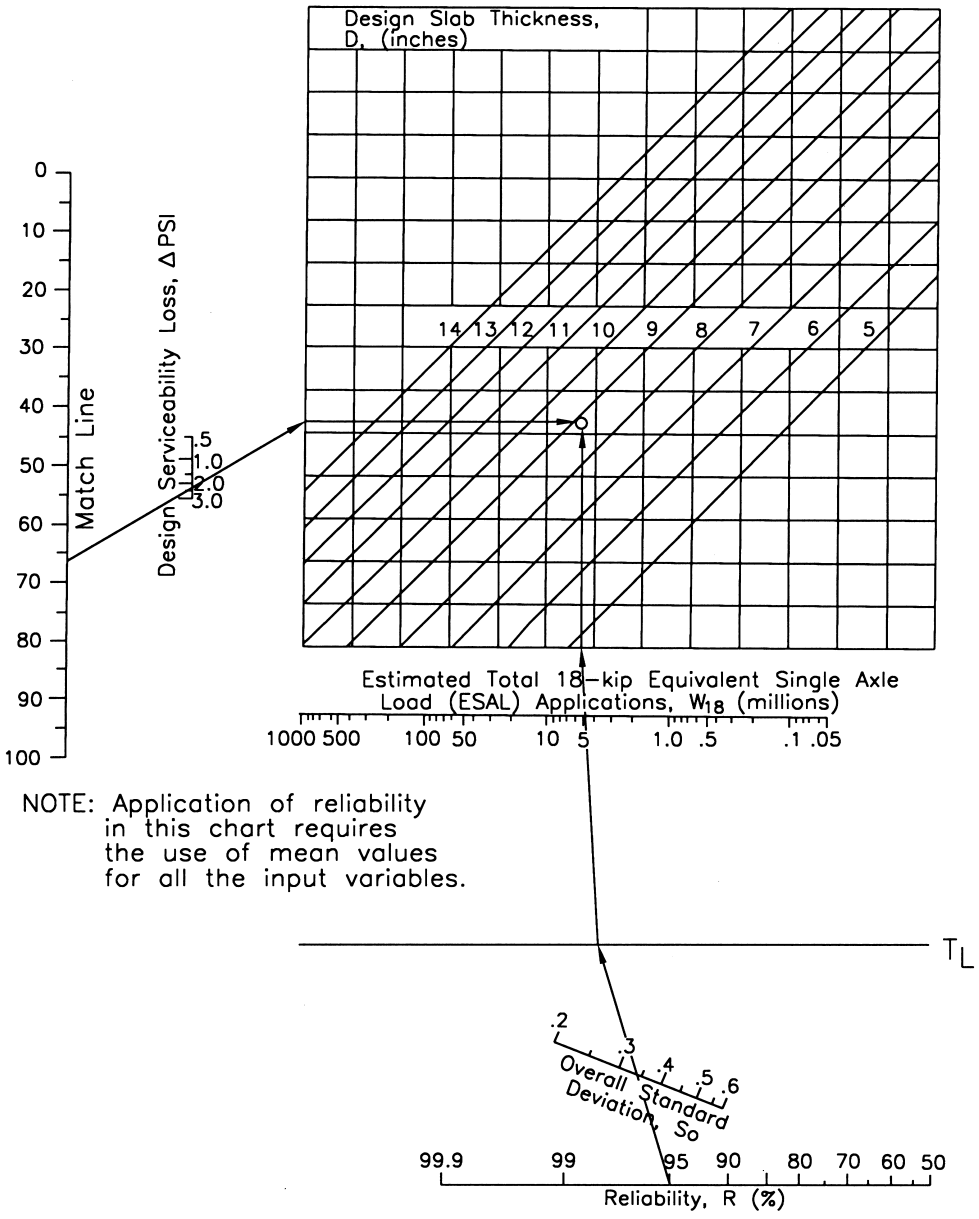
So =0.34
ΔPSI = 4.0−2.5=2.0
18K ESAL = 5.1 X 10^6
Solution: D=9.0 inches (nearest half−inch, from segment 2)

Design chart for rigid pavement based on using mean values for each input variable(Segment 1)

TABLE 6.34.02
Rigid Pavement 1of 2

TABLE 6.34.02

Rigid Pavement 2 of 2



Design chart for rigid pavements based on using mean values for each input variable (Segment 2).

(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 (R-value) test results of each soil type used in the design.

(G) Pavement design nomographs properly drawn to show soil support -- ESAL - SN.

(H) Design calculations.

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

1. Heave or settlement-prone soil.

2. Frost-susceptible soils.

3. Ground water.

4. Drainage considerations (surface and subsurface).

5. Cold-weather construction (if appropriate).

6. Other factors or properties which could affect the design or performance of the pavement system.

(J) Recommendations to alleviate or mitigate the problems discussed in Items 1 through 6 above.

6.40.00 CONSTRUCTION SPECIFICATIONS

6.41.00 GENERAL

The purpose of this section is to set forth the criteria to be used in the construction of all streets and appurtenances within the CITY.

6.42.00 COMPACTION IN UTILITY TRENCHES

Before new street construction will be permitted, all utility trenches within the street right-of-way (including service lines) shall be compacted to ninety-five percent (95%) of maximum standard density, as determined by ASTM D 698 or as specified in the approved soils report. This compaction shall extend to the street right-of-way lines as a minimum. Water settlement of trenches shall not be permitted. All water and sewer services, including water and sewer main stub-outs, shall be installed prior to street construction except that curb and gutter and sidewalk shall be installed prior to water service line installation, unless otherwise directed by the CITY ENGINEER.

6.43.00 EXCAVATION AND EMBANKMENT

6.43.01 General

The intent of this section is to specify methods and standards to be used in the construction of embankments or excavations for CITY streets or for other purposes, as indicated on the approved drawings or contract documents. The work will include excavation, embankment, grading; compacting; clearing and grubbing; removal of topsoil, trees, stumps, or other vegetation; removal and/or resetting of minor obstructions; subgrade preparations; and any other work incidental for the construction of excavations and embankments. All workmanship and materials shall be in accordance with the requirements of these STANDARDS AND SPECIFICATIONS and in conformity with the lines, grades, quantities, and the typical cross-section shown on the plans or as directed by the CITY ENGINEER.

6.43.02 Clearing and Grubbing

Work shall consist of clearing, grubbing, removing and disposing of all vegetation and debris within the limits of the project, and such other areas as may be indicated on the approved plans or required by the work except such objects as are designated to remain or are to be removed in accordance with other sections of these STANDARDS AND SPECIFICATIONS. All surface objects and trees, stumps, roots, and other protruding obstructions not designated to remain shall be cleared and/or grubbed as required except non-perishable solid objects which shall be a minimum of two feet (2') below subgrade.

Except in areas to be excavated, stump holes and other holes from which obstructions are removed shall be backfilled with suitable material and compacted in accordance with these STANDARDS AND SPECIFICATIONS. Materials and debris shall be disposed of in a manner acceptable to the CITY ENGINEER. Burning shall not be permitted.

The CONTRACTOR shall make all necessary arrangements for obtaining suitable disposal locations. If disposal will be at other than established dump sites, the CITY ENGINEER shall require the CONTRACTOR to furnish written permission from the property owner on whose property the materials and debris will be placed. Branches on trees or shrubs shall be removed as directed. Branches of trees extending over the road bed shall be trimmed to give a clear height of twenty feet (20') above the road bed surface. All trimming shall be done by skilled workmen and in accordance with good tree surgery practices.

6.43.03 Removal of Existing Structures

(A) The CONTRACTOR shall raze, remove, and dispose of all foundations, signs, structures, fences, old pavements, abandoned pipe lines, traffic signal materials, and other obstructions which are within the project limits except for utilities and for those items which other provisions have been made for removal. Traffic signals and related materials will include all attachment hardware and other incidental materials such as, but not limited to, mast arms and span wire. Concrete adhering to sign posts shall be removed, and pedestals and bases shall be removed to two feet (2’) below the surrounding ground or subgrade.

Where portions of structures are to be removed, the remaining portions shall be prepared to fit new construction. The work shall be done in accordance with plan details and in such a manner that materials to be left in place will be protected from damage. All damage to portions of structures which are to remain in place shall be repaired by the CONTRACTOR at their expense. Reinforcing steel, projecting from the remaining structure, shall be cleaned and aligned to provide bond with new extension. Dowels shall be securely grouted with approved grout. All other removals are subject to review process by the CITY.

(B) Bridges, culverts, and other drainage structures in use by traffic shall not be removed until satisfactory arrangements have been made to accommodate traffic. Unless otherwise directed, the substructures of existing structures shall be removed to one foot (1') below natural stream bottom or ground surface. Where such portions of existing structures lie wholly or in part within the limits of a new structure, it shall be removed as necessary to accommodate the construction of the proposed structure. Steel, precast concrete, and wood bridges shall be carefully dismantled without unnecessary damage. Steel members to be salvaged shall be match-marked with waterproof paint.

(C) Unless otherwise provided, all pipe shall be carefully removed and cleaned. Every precaution shall be taken to avoid breaking or damaging the pipe. Pipes to be relaid shall be removed and stored, when necessary, so that there will be no loss or damage before relaying. When removing manholes, catch basins, and inlets, any live sewer connected to these items shall be properly reconnected and satisfactory bypass service shall be maintained during such operation.

(D) Concrete or asphalt concrete that is to remain shall be cut in a straight, true line with a vertical face. The CONTRACTOR shall be responsible for the cost of removal and replacement of all overbreak. Sawing shall be done carefully, and all damages to concrete or asphalt to remain in place, which are caused by the CONTRACTOR's operations, shall be repaired by the CONTRACTOR at their expense. The minimum depth of saw cuts in concrete shall be two inches (2"). If the removed portion falls within five feet (5') of an existing joint or edge, the concrete shall be removed to that joint or edge.

6.43.04 <u>Salvage</u>

All salvageable material shown on the plans shall be removed without unnecessary damage in sections or pieces which may be readily transported and shall be stored by the CONTRACTOR in locations approved by the CITY ENGINEER. The CONTRACTOR shall be required to replace any materials lost from improper storage methods or damaged by negligence.

6.43.05 <u>Disposal</u>

The CONTRACTOR shall make all necessary arrangements for obtaining suitable disposal locations, and the cost involved shall be included in the work. If disposal will be at other than established dump sites, the CITY ENGINEER may require the CONTRACTOR to furnish written permission from the property owner on whose property the materials will be placed.

6.43.06 Excavation and Embankment

Excavation of whatever substances that are encountered within the limits of the project shall be performed to the lines and grades indicated on approved plans. All excavated areas shall be graded in a manner that will permit adequate drainage. Whenever practicable, all suitable material removed from the excavations shall be used in the formation of embankments, for backfilling, and for other approved purposes. Where material encountered within the limits of the work is considered unsuitable, such material shall be excavated below the grade shown on the approved drawings or as directed by the CITY ENGINEER and replaced with suitable material. All unsuitable excavated materials and any surplus or excavated material which is not required for embankments shall be disposed of by the CONTRACTOR.

Before any embankment is placed, clearing, tree removal, sod and topsoil removal over the entire area shall be performed in accordance with these STANDARDS AND SPECIFICATIONS. The base of fill areas shall be scarified to a depth of not less than six inches (6") prior to placement of embankment material. Each layer shall be wetted or aerated, if necessary. No embankment material shall be placed upon organic, spongy, or frozen material or other material unsuitable for the placement thereof in the opinion of the CITY ENGINEER. When an embankment is to be placed on slopes, it shall be continuously benched in horizontal layers to key to the existing slopes.

The construction of embankments by deposition, placing, and compacting materials of acceptable quality above the natural ground or other surface shall be in accordance with the lines, grades, and cross-sections shown on the approved plans and/or as required by the CITY ENGINEER. Each lift of the embankment material shall not exceed eight inches (8") in loose depth. The CONTRACTOR shall thoroughly mix the different materials to secure a uniform moisture content and to insure uniform density and proper compaction. Each layer shall be thoroughly compacted by roller or vibratory equipment which is suitable for the type of embankment material to 95% of maximum dry density unless otherwise prescribed in an approved geotechnical report recommendation, or directed by the CITY ENGINEER.

Class I structural backfill shall be used on all bridges, box culverts, or where otherwise specified. All other backfill shall be developed on site.

6.43.07 Select Borrow Material

In the event the material found on site is unsatisfactory for constructing subgrade, embankments, or filling excavations, the CONTRACTOR shall provide material from off-site. The selected borrow material shall be a well-graded mixture of sound mineral aggregate particles containing sufficient quality bonding material to secure a firm stable foundation when placed and compacted on the roadway. The R-value of the borrow shall be equal to or greater than the design R-value required for the street. The R-value of the borrow shall be provided to the CITY ENGINEER prior to placing borrow. If tests reveal that material being placed is not of suitable quality and structural value, the CONTRACTOR shall provide other material as approved by the CITY ENGINEER.

6.44.00 SUBGRADE PREPARATION AND GRADING

6.44.01 General

The work covered by this section concerns the furnishing of all labor, equipment, supplies, and materials needed to perform preparation of subgrade within the public RIGHT-OF-WAY. The bottom of the excavation for the pavement, or top of the fill, will be known as the pavement subgrade and shall conform to the lines, grades, and cross-sections shown on the approved plans. Prior to the street being excavated, all service cuts shall be checked to see if the backfill meets density requirements. If deficient, they shall be recompacted and brought up to the density as specified in Chapter 9 of these STANDARDS AND SPECIFICATIONS.

6.44.02 Subgrade Stabilization

Embankment and subgrade soils shall be compacted to ninety-five percent (95%) of maximum standard density at plus or minus two percent ($\pm$2%) optimum moisture or as recommended in the approved soils report. Maximum density shall be determined by ASTM D 698. Soft and yielding material and other portions of the subgrade which will not compact when rolled or tamped shall be removed as directed by the CITY ENGINEER and replaced with suitable material.

Subgrade surfaces below excavated areas such as cut areas and undisturbed areas shall require additional preparation. Said subgrade shall be scarified to a minimum depth of twelve inches (12"), wetted or aerated as needed, and compacted until the required density is obtained, unless otherwise approved by the CITY ENGINEER. No paving, subbase, or base shall be placed on soft, spongy, or frozen unstable subgrade which is considered unsuitable by the CITY INSPECTOR.

The CONTRACTOR shall furnish the necessary equipment to proof roll, even though density tests may indicate compliance. Minimum 5000 gallon loaded water truck or other trucks approved by the CITY INSPECTOR shall be driven over the finished subgrade and deflections noted. Soft and yielding material and portions of the subgrade which show deflection shall be scarified and re-rolled or shall be removed and replaced with subgrade course material and then placed and compacted as specified herein. Subgrade shall not be approved for base course construction or paving until it is uniformly stable and unyielding.

6.44.03 Chemically Treated Subgrade

When recommended by the approved soils report and/or pavement design, the surface of the road bed shall be bladed to the established lines, grades, and cross-sections as shown on the approved plans. The prepared road bed shall be scarified to the depth and width required for the subgrade stabilization. The material thus obtained shall be pulverized. Application, mixing, and finishing shall be in accordance with CDOT Standard Specifications for Road and Bridge Construction (latest revision), Section 307. Lime shall conform to the requirements of ASTM C 977 and rate of slaking test for moderate reactivity per ASTM C 110 and shall be the product of a high-calcium limestone as defined in by ASTM C 51.

6.44.04 Mechanically Treated Subgrade

Means of mechanically treating subgrade, including but not limited to geogrid, will be considered based on review of a geotechnical design report.

6.44.05 Subgrade Surface Tolerance

The excavation and embankments for the street, intersections, and driveways shall be finished to a reasonably smooth and uniform surface. Variations from the subgrade shall not be more than one-half inch (1/2") in soil nor more than one inch (1") above or six inches (6") below in rock.

6.45.00 SUBBASE CONSTRUCTION

6.45.01 General

The subbase shall consist of a foundation course composed of granular material constructed on the prepared subgrade in accordance with these STANDARDS AND SPECIFICATIONS and in reasonable conformity to the lines and grades and typical cross-sections as shown on the approved plans.

6.45.02 Placement and Compaction

Each layer of subbase material shall be placed in layers not to exceed six inches (6") in compacted depth. Each layer shall be wetted or aerated, if necessary, and compacted to ninety-five percent (95%) maximum density at plus or minus two percent ($\pm$2%) of optimum moisture as determined by ASTM D 698. No subbase material shall be placed upon a soft, spongy, or frozen subgrade or other subgrade, the stability of which is unsuitable for the placement thereof.

6.45.03 Subbase Surface Tolerance

The prepared surface of the subbase shall not vary from the approved grade by more than a half inch (1/2").

6.46.00 BASE CONSTRUCTION

6.46.01 General

The intent of this section is to specify methods to be used for the construction of private roads and private parking lots requiring the use of aggregates. The work covered shall include general requirements that are applicable to aggregate base course, asphalt base, and pavements of the plant-mix type, prime coat, tack coat, rejuvenating applications, and asphalt concrete overly. All workmanship and material shall be in accordance with requirements of these STANDARDS AND SPECIFICATIONS and in conformity with the lines, grades, depths, quantity requirements, and the typical cross-section shown on the approved plans or as directed by the CITY ENGINEER.

6.46.02 Base Course

This item shall consist of a foundation course composed of crushed gravel or crushed stone and filler, constructed on the prepared subgrade or subbase course. Construction shall be in accordance with the requirements of the CDOT's Standard Specifications for Road and Bridge Construction, Section 304 and the approved pavement design. The composite base course material shall be free from vegetation and lumps or balls of clay.

6.46.03 Placement and Compaction

The base course material shall be deposited and spread in a uniform layer without segregation of size to a compacted depth not to exceed six inches (6"). The material shall be compacted to a minimum ninety-five percent (95%) density as determined by ASTM D 698. No base course material shall be placed upon a soft, spongy, or frozen subgrade or subbase with an unsuitable stability. Base material shall not be placed on a dry or dusty foundation where the existing condition would cause rapid dissipation of moisture from the base material and hinder or preclude its proper compaction. Such dry foundations shall have water applied and shall be reworked and recompacted.

Rolling shall be continuous until the base material has been compacted thoroughly in accordance with these STANDARDS AND SPECIFICATIONS. Water shall be uniformly applied as needed during compaction to obtain optimum moisture content and to aid in consolidation. The surface of each layer shall be maintained during the compaction operations in such a manner that a uniform texture is produced and the aggregates are firmly placed.

6.46.04 Base Surface Tolerance

The prepared surface of the base shall not vary from the approved grade by more than one-half inch (1/2").

6.47.00 HOT MIX ASPHALT CONSTRUCTION

6.47.01 Hot Mix Asphalt Pavement

All pavement shall be hot mix asphalt pavement of the plant mix type unless otherwise approved in writing by the CITY ENGINEER. Construction shall be in accordance with Chapter 6 of these STANDARDS AND SPECIFICATIONS.

6.47.02 Tack Coat

When tack coat is specified on the approved plans or required by the CITY ENGINEER, all construction shall be in accordance with the requirements of Chapter 6 of these STANDARDS AND SPECIFICATIONS.

6.47.03 Grinding

(A) Grinding shall consist of milling, grinding, or cold planing the existing pavement surface to establish a new surface profile and cross section in preparation for an asphalt

overlay. It shall consist of furnishing all equipment, supervision, labor, and necessary items for removal and disposal of pavements and pavement markings as illustrated in the plans or as directed. It shall also include salvaging and hauling away all planed material, and sawing and cutting to facilitate controlled breaking and removal of concrete and asphalt pavement to a neat line.

(B) The CONTRACTOR shall supply all equipment necessary to perform the work, including but not limited to: A planer with sufficient power, traction, and stability shall be required to maintain an accurate depth of cut. The propulsion and guidance system of the planer shall be maintained in such condition that the planer may be operated to straight and true lines without excessive lateral deviation. Operation with broken or missing teeth will not be allowed. Worn teeth shall be replaced if the planer does not produce a uniform surface. The planer shall be capable of picking up the removed asphalt cement concrete pavement in a single operation. A self-loading conveyer shall be an integral part of the planer. Windrows will not be allowed. A sufficient number of brooms shall be used immediately after planing to remove all planed material remaining on the roadway. All equipment and machinery shall be kept in good working order, free of leaks and properly muffled.

(C) Prior to beginning planing operations, the CONTRACTOR shall submit a planing plan for approval by the CITY ENGINEER. This plan shall include as a minimum:

- The number and types of planers to be used.
- The width and location of each planing pass.
- The number and types of brooms to be used, and their locations with respect to the planers. The CONTRACTOR shall have at least one back-up broom on the project at all times in case one of the operating brooms breaks down.
- Traffic control plan.
- Pedestrian access plan including how vertical face of milled edges at crosswalks will be addressed.
- Considerations for how material will be prevented from entering drainage inlets, by covering or other means, during milling and paving operations.

(D) When planing adjacent to new asphalt pavement, the planer shall cut a minimum of 3 inches laterally into the new asphalt pavement. The asphalt pavement shall be broken or chipped away to match the plane depth. The planed surface shall be no rougher (in inches/mile) than the original surface.

(E) When planing operations and the CONTRACTOR’s phasing cause rough or uneven surface conditions for traffic, appropriate signage shall be placed, including but not limited to: Bump, Grooved Pavement, Uneven Lanes, and Shoulder Drop Off signs.

(F) Traffic crossing vertical faces at the edges of milled pavement will not be allowed. Longitudinal milled faces shall be tapered to not less than a 3:1 slope. Transverse vertical faces shall be tapered to not less than a 25:1 slope. The use of temporary asphalt wedges with a papered joint for transverse tapers is allowed.

6.47.04 <u>Infrared Patching</u>

(A) When specified by the CITY ENGINEER, the roadway surface shall be repaired by the infrared method. The repairs shall include the cleaning of the area, infrared heating, adding specified asphalt material, raking to grade and compacting with approved compaction equipment. All work shall be done in accordance with these STANDARDS AND SPECIFICATIONS and as directed by the CITY ENGINEER.

(B) The CONTRACTOR performing this work must be fully qualified and properly equipped to complete this work expeditiously and in a satisfactory manner.

(C) The CONTRACTOR shall furnish equipment meeting the following: The unit can either be truck or trailer mounted. Each unit shall have the following equipment:

i. Heated storage unit.

ii. Reflective chamber that is fully vented and painted with a highly reflective paint.

iii. Equipped with all CDOT safety devices.

(D) All infrared asphalt repair material must contain 50% crushed fines and 50% natural sand fines with an asphalt content of no less than 6.5%. Variations of these requirements can be accepted on a pavement design report submitted to and approved by the CITY ENGINEER. All material must be stored and obtained from a suitable infrared heated storage unit required to keep asphalt at near constant temperature throughout the day. Under no circumstances is any asphalt mix to be used that is at a temperature less than 200 °F.

(E) The work shall be performed in the following general manner:

i. Areas to be repaired shall be swept clean to remove all lose and foreign material.

ii. An approved infrared heater not to exceed fifteen thousand British Thermal Units (15,000 BTUs) per square foot per hour shall be positioned over the area to be repaired for a period of time required to soften the existing pavement to a depth of two to three inches (2” to 3”). If a depth of more than three inches (3”) is required, multiple heatings and removals will be required.

iii. Oxidation of the pavement, caused by excessive heat as determined by the CITY INSPECTOR, shall be avoided. In the event of oxidation, the

CONTRACTOR shall remove the unsuitable material and replace with approved asphalt material.

iv. The soft material shall be removed a minimum of six inches (6”) from the heated edge to ensure no cold joint will exist. It is not acceptable to remove the entire heated area. A straight edge shall be cut with a rake for cosmetic appearance, with corners at ninety degrees (90°). Approved asphalt stated above shall be added to the heated surface and shall be raked to a workable condition and compacted in maximum three inch (3”) lifts.

v. After the paving mixture has been admixed and raked to grade, compaction shall be obtained by use of a steel wheeled vibratory roller of at least two tons to establish uniform density to ninety-four percent plus-minus two percent (94% ±2%) theoretical maximum density. The finished patch shall be level with no depression retaining water on any of its surface.

6.48.00 PORTLAND CEMENT CONCRETE PAVEMENT

Portland Cement Concrete Pavement is not allowed in RIGHT-OF-WAY. Concrete pavement may be allowed in private alleys, but if public utilities are to be under the private alley then the concrete pavement must conform with the pavement design report and be approved in writing by the CITY ENGINEER.

6.49.00 APPURTENANT CONCRETE STRUCTURES

6.49.01 Curb and Gutter Section

The section to be constructed shall be as identified on the approved plans or as shown on the detail drawings.

6.49.02 Sidewalks and Trails

Sidewalks shall be six inches (6") thick and detached or six inches (6") thick and attached and constructed to the dimensions shown on the approved construction plans. All areas of sidewalk that will be crossed by driveways will be constructed with six-inch (6") thick concrete in residential areas and eight-inch (8") thick concrete in commercial areas.

6.49.03 Crosspans and Curb Return Fillets

Crosspans and curb return fillets shall be constructed eight inches (8") thick with fiber mesh reinforced concrete. Typical crosspan sections are shown on the detail drawings. Where unusual conditions prevail, additional reinforcing steel and special joints may be required by the CITY ENGINEER.

6.49.04 Curb Cuts and Driveways

Curb cuts shall be provided at all driveway locations and at additional locations, as shown on the approved plans. Construction of curb cuts shall be as shown on the detail drawings and

meet Americans With Disabilities Act requirements. Spacing will be as shown on the approved plans or as approved by the TRAFFIC ENGINEER.

6.49.05 Curb Ramps

Curb ramps for accessibility shall be installed at locations designated by the TRAFFIC ENGINEER. Curb ramps will be constructed as shown on the detail drawings.

6.49.06 Detectable Warning Tiles

(A) The CONTRACTOR will not be allowed to install cast-in-place detectable warning tiles until all submittals have been reviewed and approved by the CITY ENGINEER. Cast-in-place tile shall be installed per manufacturer's instructions. Protect the cast-in-place tiles against damage during the construction period to comply with cast-in-place tiles manufacturer's specifications.

(B) The CONTRACTOR shall provide all tools, equipment and services required for satisfactory installation per manufacturer's instructions. Equipment which may be required include typical mason's tools, a four-foot (4') long level with electronic slope readout, twenty-five (25) pound weights, vibrator and rubber mallet with two-inch by four-inch by ten-inch (2" x 4" x 10") wood tamping plate, and a device for cutting the cast-in-place tile.

(C) The CONTRACTOR shall engage an experienced installer certified in writing by the cast-in-place tile manufacturer, who has successfully completed Tactile Warning Surface installations similar in material, design, and extent to that indicated by the detail and/or construction drawings.

(D) The physical characteristics of the concrete shall be consistent with these STANDARDS AND SPECIFICATIONS while maintaining a slump range of four to seven inches (4" – 7") to permit solid placement of the cast-in-place tile. An overly wet mix will cause the cast-in-place tile to float. Under these conditions suitable weights such as two (2) concrete blocks or sandbags weighing approximately twenty-five (25) pounds shall be placed on each cast-in-place tile.

(E) The concrete shall be poured and finished, true and smooth to the required dimensions and slope prior to the cast-in-place tile placement.

(F) To the maximum extent possible, the cast-in-place tiles shall be oriented such that the rows of in-line truncated domes are parallel with the direction of the ramp. When multiple cast-in-place tiles regardless of size are used, the truncated domes shall be aligned between the tactile warning surface tiles and throughout the entire tactile warning surface installation.

(G) Cast-in-place tiles shall be tamped or vibrated into the fresh concrete to ensure that there are no voids or air pockets, and the field level of the cast-in-place tile is flush to

the adjacent concrete surface or as the detail drawings indicate to permit proper water drainage and eliminate tripping hazards between adjacent finishes.

(H) Cutting and setting of cast-in-place tiles shall be cut into the size and configuration indicated on the detail drawings using a sixty (60) tooth carbide blade on a table saw or equivalent cutting device. Minimize any cantilever effect (to the maximum extent practicable) when cutting between successive embedment ribs as concrete will tend to flow up and over the cast-in-place tiles. The top of the body of the cast-in-place tiles shall be fully seated and flush with the adjacent concrete substrate. For specific instructions for cutting and setting refer to Tactile Warning Surface manufacturer's written instructions.

(I) During and after the cast-in-place tiles installation and the concrete curing stage, there shall be no walking, leaning or external forces placed on the cast-in-place tiles to rock the cast-in-place tile, causing a void between the underside of the cast-in-place tile and the concrete.

(J) Remove Protective Plastic Sheeting from cast-in-place tile within twenty-four (24) hours of installation of the cast-in-place tile. Particularly under hot weather conditions (80 degrees or higher), plastic sheeting will adhere strongly to Tactile Warning Surface Tile when not removed quickly resulting in difficult removal.

(K) If requested by the CITY ENGINEER, clean cast-in-place tiles not more than four (4) days prior to date scheduled for inspection intended to establish date of substantial completion in each area of project. Clean cast-in-place tile by method specified by Tactile Warning Surface Products manufacturer.

6.49.07 Construction Stakes

The CONTRACTOR's surveyor shall provide all stakes required for curbs, gutters, walks, and structures and shall furnish all necessary information relating to lines and grades. The CONTRACTOR shall be held responsible for the reasonable preservation of all such stakes.

6.49.08 Backfilling

When side forms are removed, the space adjoining the concrete shall be backfilled in a timely manner with suitable material properly compacted and brought flush with the surface of the concrete and adjoining ground surface. In embankments, the backfill shall be level with the top of the concrete for at least two feet (2') and then sloped to the property line. Maximum slope shall be four to one (4:1). Where detached walks occur, the space between the curb and walk shall be backfilled on a straight line from the top of walk to the top of curb.

6.49.09 Connections with Existing Concrete Curb, Gutter, Inlets, Sidewalk and Drives

Where new construction abuts existing, the work shall be accomplished so that no abrupt change in grade between the old and new work results. New concrete construction shall be

mechanically connected to existing concrete features by means of dowels or other approved method.

6.50.00 BRIDGES AND MAJOR DRAINAGE STRUCTURES

6.50.01 General

(A) All culvert pipe, box culverts, and bridges which will ultimately be maintained by the CITY shall conform to the following:

1. AASHTO "Standard Specifications for Highway Bridges," latest edition, and applicable interims.

2. CDOT's "Standard Specifications for Road and Bridge Construction," latest edition.

3. CDOT's "Bridge Manual," Volumes I and II.

(B) All structures shall be designed to an HL-93 loading.

(C) All box culvert and bridge designs shall be stamped by a Professional Engineer registered in the State of Colorado who is competent to perform such designs.

6.51.00 CRUSHER FINES TRAILS

6.51.01 General

This work consists of construction of trails or shared use paths surfaced with crusher fines. Crusher fines materials shall be according to the requirements contained in these STANDARDS AND SPECIFICATIONS.

6.51.02 Equipment

(A) Equipment shall be capable of performing the work as described in this specification. Equipment that is inadequate to obtain the results specified shall be replaced or supplemented as required to meet the requirements of this specification. Any equipment that is used in an improper manner may be cause for rejection of the work if in the opinion of the CITY ENGINEER the work fails to meet the requirements of this specification.

(B) Equipment used for compaction shall be the rolling type, vibratory type, or combination of both types, and shall be of sufficient capacity to meet the compaction requirements herein.

6.51.03 Layout of Work

(A) The CONTRACTOR shall stake or otherwise delineate the proposed alignment of the path according to the drawings. Obtain approval of the CITY INSPECTOR prior to proceeding with excavation and subgrade preparation.

(B) Cut/fill bench for the crusher fines as shown on the drawings.

(C) Cut existing grade to a minimum of seven inches (7") deep or as shown on the drawings within limits of paving. Wet and roll subgrade to obtain a firm, uniform, compacted subgrade. Keep cut sides vertical and true to line horizontally with a uniform width.

(D) Make sure proper drainage is available to ensure no standing water on the surface or adjacent to crusher fines.

6.51.04 Weed Control

(A) Apply Casoron 4G granular weed and grass killer or approved equal to prepared subgrade per manufacturer's recommendations.

(B) Apply Casoron 4G granular weed and grass killer at a rate of two hundred fifty to three hundred (250 – 300) pounds per acre. Apply approved equal at manufacturers recommended rate.

(C) Herbicides or other chemicals shall be applied using well-maintained equipment by individuals working for the CONTRACTOR who are properly licensed by any State and/or Federal Agency having jurisdiction over such applications. It shall be the responsibility of the CONTRACTOR to be knowledgeable of any and all current laws and regulations pertaining to herbicide and other chemical applications, and to notify the CITY ENGINEER immediately if any request for herbicide or chemical applications by the CITY ENGINEER is inappropriate as they pertain to these laws and regulations.

(D) Herbicides or other chemicals shall not be applied during periods when wind or other physical conditions cause the herbicides or chemicals to be transported a distance of more than five feet (5') from the immediate area where they are being placed. It shall be the responsibility of the CONTRACTOR to stop the work immediately and notify the CITY ENGINEER if any weather or other physical condition exists, which would make the application of herbicides or other chemicals inappropriate.

(E) All herbicides or other chemicals used shall be applied at a rate and strength, and by the method recommended by the manufacturer of the product being used.

6.51.05 Placement and Compaction

(A) The CONTRACTOR is responsible for controlling placement of the material; no additional compensation will be made for material placement in excess of the specified thickness or width.

(B) Do not install crusher fines material during rain or snow. Do not install crusher fines on sub-grade that has standing water.

(C) If the required compacted depth of the crusher fines exceeds six inches (6"), place course in two or more layers of approximately equal thickness. The minimum thickness of any one layer shall be four inches (4").

(D) Add water to plus-minus two percent (±2%) wet of optimum moisture content. Use roller or mechanical hand tamper for compaction. Compact to ninety-five percent (95%) Standard Proctor Density (ASTM D698) to a uniform thickness.

(E) Use plate compactor on edges and hard to get areas.

(F) Loose material shall not be present on final surface.

(G) Top of path shall be flush with adjacent grade. Remove any excess gravel on edges. Ensure that there are no low spots, high spots, or standing water on or adjacent to path.

6.51.06 Surface Finishing

(A) Use a smooth steel wheel roller for the final rolling of top surface of Crusher Fines. Water surface and evenly spread loose stones before final rolling. Make minimum of two complete passes over area to embed stones. Correct soft spots developed during rolling.

(B) Compacted surface shall be smooth and free from waves and other irregularities. Unsatisfactory portions of surfacing shall be torn up, reworked, re-laid, and rerolled at no additional expense to the project.

6.51.07 Inspection

(A) Finished surface shall be uniform and solid, with no evidence of chipping or cracking.

(B) Compacted paving material shall be firm to the full depth of pavement with no soft areas.

(C) Loose material shall not be present on the surface.

(D) No ruts shall be visible on the surface of the pavement.

(E) Pavement sections that do not meet this specification, shall be repaired or replaced at the CONTRACTOR's expense.

6.51.08 Repairs

(A) Excavate damaged area to depth of crusher fines paving material and square off sidewalls.

(B) If area is dry, moisten damaged portion lightly and scarify.

(C) Apply crusher fines to excavated area to finished grade.

(D) Compact with an eight-inch to ten-inch (8” to 10”) hand tamp or one thousand pound (1000 lb.) roller.

(E) Repaired surface shall be smooth and free from waves and other irregularities. Unsatisfactory portions of surfacing shall be torn up, reworked, re-laid, and rerolled at no additional expense to the project.

6.60.00 CONSTRUCTION TRAFFIC CONTROL

6.60.01 General

Traffic control devices shall be maintained in a safe operating condition and in compliance with current MUTCD standards at all times. The CONTRACTOR shall provide for approval by the Traffic Engineer, a traffic control plan, and shall comply with Chapter 8 of these STANDARDS AND SPECIFICATIONS. If the CITY ENGINEER finds the construction area to be inadequately barricaded, he has the authority to stop work and direct that corrective measures be taken prior to proceeding with work.

6.60.02 Pedestrian Traffic

Every precaution shall be taken to ensure that construction work does not interfere with the movement of pedestrian traffic, which shall be maintained on the sidewalk at all times. Flagmen shall be provided for guidance as necessary.

(A) Where an excavation interrupts the continuity of the sidewalk, the CONTRACTOR shall provide suitable bridge or deck facilities to be supplemented by the use of such proper devices and measures as prescribed in the MUTCD, most recent edition, for the safe and uninterrupted movement of pedestrian traffic. The edges or ends of the pedestrian bridge or decking shall be beveled or chamfered to a thin edge to prevent tripping.

(B) Temporary diversion walkways shall be hard surfaced and electric lighting shall be provided and kept continuously burning during hours of darkness, when required by the CITY ENGINEER.

(C) Unless otherwise authorized by the CITY ENGINEER, pedestrians shall not be channeled to walk on the traveled portion of the roadway.

(D) Under certain conditions, it may be necessary to divert pedestrians to the sidewalk on the opposite side of the street. Such crossings shall only be made at intersections or marked pedestrian crossovers. Detectable barricades meeting accessibility requirements shall be provided.

(E) Facilities satisfactory to the CITY ENGINEER shall be provided for pedestrian crossing at corners, pedestrian crossovers, and public transportation stops. Closures which affect transit stops or transit routes must be coordinated with the City Engineer and RTD prior to closures.

(F) Pedestrian detour routes during construction shall be ADA accessible.

6.60.03 <u>Vehicular Traffic</u>

(A) Construction work zone traffic shall be controlled by signs, barricades, detours, etc., which are designed and installed in accordance with the MUTCD, most recent edition, and applicable STANDARDS AND SPECIFICATIONS. Traffic control plan shall be submitted and approved by the CITY ENGINEER prior to start of any construction.

(B) During construction of new facilities, traffic control should strive to keep the motorist from entering the facility. The primary means to accomplish this is by use of temporary barricades, located in advance of the point where new construction joins existing, and by appropriate signing. New construction shall not be opened to traffic and, thus, the construction traffic control removed without the approval of the CITY INSPECTOR and the TRAFFIC ENGINEER.

(C) In general terms, a construction traffic control plan must be drawn on a map. For minor projects or local roadways, a neat sketch of the roadways and the proposed control devices will suffice. For major projects or major roadways, the traffic control plan should be superimposed on as-builts, construction plan drawings, or other detailed map.

(D) The MUTCD shall be the basis upon which the TRAFFIC CONTROL PLAN is designed in concern with proper, prudent, and safe engineering practice. All necessary signing, striping, coning, barricading, flagging, etc. shall be shown on the plan.

(E) Minimum travel lane width in construction areas shall be ten feet (10’). Turning movements on roadways may be restricted, but proper controls including flagging must be indicated. Removal of on-street parking should be considered and noted where applicable.

(F) The approved PERMIT lane closure restriction times will govern when lane closures are allowed.

6.60.04 <u>Bicycle Traffic</u>

(A) Bicycles shall be considered in the development of a TRAFFIC CONTROL PLAN. If work causes the closure of a bicycle lane, the MHT shall include bicycle lane closure

signage.

(B) If a bicycle path or multi-use path is closed, appropriate bicycle detour signage shall be provided. Detours shall be along facilities appropriate for bicycle traffic.

6.70.00 MATERIAL SPECIFICATIONS

6.71.00 BASE

The use of base is allowed in private streets and private parking lots only. Base shall consist of a foundation course composed of crushed gravel or crushed stone and filler constructed on the prepared subgrade or subbase course. Materials and construction shall be in accordance with the requirements of the CDOT's "Standard Specifications for Road and Bridge Construction." Gradation shall be Class 6 (3/4-inch maximum) in accordance with the following gradation:

TABLE 6.71.00
CLASSIFICATION TABLE FOR AGGREGATE BASE COURSE

Sieve Designation	Percent by Weight Passing Square Mesh Sieve Class 6
3/4 Inch	100
No. 4	30 - 65
No. 8	25 - 55
No. 200	3 - 12

Liquid Limit -- 30 Maximum
Plasticity Index -- 6 Maximum
R-Value Minimum -- 78

6.72.00 HOT MIX ASPHALT PAVEMENT

6.72.01 Description

(A) General

This work shall consist of providing an Asphalt Paving Mixture (APM) to be placed as shown on the plans, or as directed by the CITY ENGINEER. The CONTRACTOR shall be responsible for Process Control (PC) of the APM; including the design, and control of the quality of the material incorporated into the project. The CITY ENGINEER will be responsible for Owners Acceptance (OA); including testing, to assure the quality of the material incorporated into the project meet design parameters. The following specifications include general requirements applicable to all types of plant mixed asphalt pavements. The work shall meet the requirements within the contract documents and in conformity with the lines, grades, thickness, and design cross sections as shown on the plans or established by the CITY ENGINEER.

This specification is to maximize the service life of APM. It is also the intent of this document to provide construction requirements in accordance with these specifications

to the standard of practice. This item shall include all labor, equipment, and materials to produce, place, and compact asphalt pavement.

(B) Definition of Terms

Wherever the following abbreviations are used in the specifications or other contract documents, the intent and meaning will be interpreted as shown below:

AASHTO: American Association of State Highway & Transportation Officials

ASTM: American Society for Testing & Materials

APM: Asphalt Paving Mixture

RAP: Reclaimed Asphalt Pavement

SMA: Stone Matrix Asphalt (at locations required by the CITY ENGINEER)

(C) Process Control

At least 10 business days prior to placing any mixture on the project, the CONTRACTOR shall submit a mix design for acceptance.

The CONTRACTOR shall assume full responsibility for controlling all operations and processes to meet the Specifications. The CONTRACTOR shall perform all tests necessary for process control purposes and maintain a log of all process control testing. Owners Acceptance (OA) and/or Process Control (PC) test results will be evaluated to determine acceptability.

6.72.02 Materials

(A) General

Asphalt mixtures may consist of aggregate, filler, anti-strip agent, Recycled Asphalt Pavement (RAP) and asphalt binder.

The top layer of asphalt shall be stone matrix asphalt (SMA) or hot mix asphalt pavement (HMA) Grading SX. The lower layers may consist of HMA Grading SG or HMA Grading S. SMA mixes will only be required as determined by the CITY ENGINEER. The minimum layer thickness shall be 2 inches and each layer should be a minimum of 2 times the aggregate size.

(B) Aggregate

The Aggregate shall be of uniform quality, composed of clean, hard, durable particles of crushed stone, crushed gravel. The material shall not contain clay balls, vegetable matter, rounded aggregate, or other deleterious substances, and shall meet the following requirements:

TABLE 6.72.01
Aggregate Properties

Aggregate Test Property	Coarse: Retained on #4	Fine: Passing the #4
Fine Aggregate Angularity, CP-L 5113 Method A or AASHTO T 304 (Does not apply to RAP aggregate)		45% min.
Two Fractured Faces, ASTM D 5821 SG Mixtures Top and Middle Lifts Bottom Lifts SMA Mixtures	 90% min. 80% min. 70% min. 100% required	
Flat and Elongated (Ratio 5:1) % AASHTO M 283	10% max.	
Sand Equivalent. AASHTO T 176		45% min.
Micro Deval (for combined samples) AASHTO T 327	18% max. for design 20% max. for production	
LA Abrasion, AASHTO T 96 SMA Mixtures	 30% max.	

TABLE 6.72.02
Dense Graded Mixture Gradation
(AASHTO T 11 & T 27)

	SX (1/2" nominal) Top and Bottom Lifts, Patching	S (3/4" nominal) Lower Lifts	SG (1" nominal) Lower Lifts
Sieve Size	Percent Passing		
1.5"			100
1"		100	90-100
3/4"	100	90-100	
1/2"	90-100		
#8	28-58	23-49	19-45
#200*	2-8	2-7	1-7

* Shall include 1% by total weight if lime is used as the anti-strip agent.

TABLE 6.72.03
SMA Mixture Gradation
(AASHTO T 11 & T 27)

	1/2”	3/4”
Sieve Size	Percent Passing	
1”		100
3/4”	100	90-100
1/2”	90-100	50-88
3/8”	50-80	25-60
#4	20-35	20-28
#8	16-24	16-24
#30	12-18	12-18
#200	8-11	8-11

(C) Reclaimed Asphalt Pavement (RAP)

Allowable percentages of RAP in APM are shown in Table 6.72.04.

TABLE 6.72.04
RAP Allowed in APM Mixtures

Mix Grading	Max. % RAP allowed
SX (1/2”)	25%
S (3/4”)	25%
SG (1”)	35%
SMA (1/2” & 3/4”)	Not Allowed

(i) Quality of RAP

RAP may be used where allowed and shall be of uniform quality and gradation with a maximum size no greater than the nominal aggregate size of the mix. RAP shall not contain clay balls, vegetable matter, or other deleterious substances.

Asphalt mixtures containing RAP shall meet the same gradation and physical requirements as in Table 6.72.01.

Verification testing on RAP for asphalt content and gradation will be performed at the frequencies listed on Table 6.72.06, below. The CONTRACTOR shall provide testing results on RAP mixtures daily for properties listed in this specification.

The aggregate obtained from the processed RAP shall be based on the required gradation limits for the mixture being used. The aggregate and binder obtained from the processed RAP shall meet the tolerances provided in Table 6.72.05.

TABLE 6.72.05
RAP Binder & Aggregate Uniformity Tolerances

Element	Standard Deviation
Binder Content	0.5
% Passing 3/4”	4.0
% Passing 1/2”	4.0
% Passing 3/8”	4.0
% Passing #4	4.0
% Passing #8	4.0
% Passing #30	3.0
% Passing #200	1.5

(ii) Process Control (PC) Plan for RAP

A PC plan detailing how the RAP will be processed and controlled shall be developed and followed by the asphalt producer/CONTRACTOR and shall address the following:

A plan that explains the contractor’s processing techniques for crushing, screening, rejecting, and stockpile operation.

RAP shall be tested as shown in Table 6.72.06.

TABLE 6.72.06
Test Frequency of Processed RAP

Test	Minimum testing frequency (minimum 3 tests)
Asphalt Binder Content (AASHTO T 164)	1/1,000 tons
Gradation (AASHTO T 30)	1/1,000 tons

Process control charts shall be maintained for binder content and each screen when RAP material is added to the stockpile. Separate control charts for each RAP stockpile shall be maintained. These charts shall be displayed and shall be provided upon request.

(D) Mineral Filler

Mineral filler for use with Stone Matrix Asphalt (SMA) pavement may consist of limestone dust or any other material filler that will meet the requirements of this subsection and have a maximum Plasticity Index (AASHTO T 90) of less than or equal to 4.0 %.

The CONTRACTOR shall submit hydrometer analysis (AASHTO T 88) for the gradation of mineral filler used in the SMA mixture.

(E) Performance Graded Asphalt Binders

The CONTRACTOR shall provide to the CITY INSPECTOR an acceptable submittal of each applicable asphalt binder grade from the supplier. Should testing or certificate show nonconformance with the specifications, the asphalt binder may be rejected. When production begins, the CONTRACTOR shall, upon request, provide to the CITY ENGINEER a one quart can of each specified asphalt binder for analysis. Additionally, the CONTRACTOR shall provide the refinery test results that pertain to the asphalt binders used during production.

(F) Asphalt Binder

Asphalt binder shall meet the requirements of the Performance-Graded Binders (PG) as presented in Table 6.72.07 and consult www.LTTPbind.com when special circumstances arise.

On arterial streets the grade of asphalt cement for the top layer shall be PG 76-28 (Polymer Modified). The bottom layers may be PG 64-22. On all other street classifications, the grade of asphalt cement for the top layer shall be PG 64-28 (Polymer Modified). The bottom layers may be PG 64-22.

TABLE 6.72.07
Properties of Performance Graded Binders

Property of Binder Grade	PG 58-28	PG 64-22	PG 76-28
Flash Point Temperature, °C, AASHTO T 48	230 min.	230 min.	230 min.
Viscosity at 135 °C, Pas, ASTM D 4402	3 max.	3 max.	3 max.
Dynamic Shear, Temperature °C, where C/Sin ō @ 10 rad/sec. ≥ 1.00 Kpa, AASHTO TP 5	58 °C	64 °C	76 °C
Rolling Thin Film Oven Residue Properties, AASHTO T 240			
Mass Loss, %, AASHTO T 240	1.00 max.	1.00 max.	1.00 max.
Dynamic Shear, Temperature °C, where G/Sin ō @ 10 rad/sec. ≥ 2.20 Kpa, AASHTO TP 5	58 °C	64 °C	76 °C
Elastic Recovery1, 25 °C, % Min.	N/A	N/A	50 min.
Pressure Aging Vessel Residue Properties, Aging Temperature 100 °C, AASHTO R 28			
Dynamic Shear, Temperature °C, where G/Sin ō @ 10 rad/sec. ≤ 5,000 Kpa, AASHTO TP 5	19 °C	25 °C	28 °C
Creep Stiffness, @ 60 sec. Test Temperature in °C, AASHTO TP 1	-18 °C	-12 °C	-18 °C
S, Mpa, AASHTO TP 1	300 max.	300 max.	300 max.
m-value, AASHTO TP 1	0.300 min.	0.300 min.	0.300 min.

(G) Anti-Strip Additives

Anti-Strip shall be added into the APM. Anti-Strip agents shall be lime (added to the aggregates), and shall be submitted for approval by the CITY ENGINEER.

The minimum value for Tensile Strength Ratio (TSR) shall be 80% for the mix design and 70% during production.

(H) Hydrated Lime

The hydrated lime for APM shall conform to the requirements of AASHTO M 303, Type I. In addition, the particle size requirements shall conform to AASHTO M 303 when tested in accordance with CP-L 4209 Physical Testing of Quicklime, Hydrated Lime, and Limestone. Hydrated Lime shall be added at the rate of 1% by dry weight of the aggregate and shall be included in the amount of material passing the No. 200 sieve.

6.72.03 Mix Design and Production Requirements

(A) General

There shall be no substitutions of materials allowed during production. All substitutions will require checkpoint verification. If the checkpoint differs from the Job Mix Formula (JMF), a new mix design will be required. Upon request of the CITY ENGINEER, the binder grade may be changed by one available binder grade level without requiring a new mix design.

The mix design shall include the criteria concerning mix design method, traffic level, binder type, mixture grading, and percent of RAP allowed.

Grading SG (1-inch nominal aggregate) shall only be designed using the 150mm molds. Hveem Stability is not required for Grading SG mixtures. Grading ST, SX, and S shall be designed using 100mm molds.

(B) Mixture Design Submittals

The CONTRACTOR shall submit all mix designs and laboratory data to the CITY INSPECTOR for approval.

Designs shall be developed and performed in a materials laboratory that meets the requirements set forth by AASHTO Materials Reference Laboratory (AMRL) for all testing procedures. The design shall be stamped and signed by a Professional Engineer licensed in the State of Colorado. In addition, the CONTRACTOR shall submit, as part of the mixture design, laboratory data documents to verify the following:

- Gradation, specific gravity, source and description of individual aggregates and the final blend.
- Aggregate physical properties.
- Source and Grade of the Performance Graded Binder.
- Proposed Design Job Mix: aggregate and additive blending, final gradation, optimum binder content.

- Mixing and compaction temperatures used.
- Mixture properties shall be determined with a minimum of four binder contents.

The CITY ENGINEER reserves the right to verify the asphalt supplier's mix design for each APM design utilizing materials produced and stockpiled. The asphalt supplier shall provide, at no cost, a sufficient quantity of each aggregate, mineral filler, RAP, and additive for the required laboratory tests, as well as all Certificates of Conformance/ Compliance at any time on any material used. The Asphalt Supplier shall provide copies of quality control testing results during the production of APM used within three business day from the sampling date.

(C) Mixture Design Method

A Job Mix Formula (JMF) design shall be submitted for each mixture required for review by the CITY ENGINEER. The JMF design shall be determined using AASHTO T-312 for the Method of Mixture Design.

Mixture design and field control testing of dense graded asphalt mixes shall meet the requirements of Table 6.72.08.

Mixture design and field control testing of SMA shall meet the requirements of Table 6.72.09.

TABLE 6.72.08
Mixture Properties for Dense Graded Asphalt Mixtures

Property	Traffic Level (ESALs)	
	<100,000	≥100,000 to 3 million
Design Gyrations, N_{design}	50	75
Air Voids (V_a) % at N_{design} (AASHTO T 132)	3.0 – 4.0	3.0 – 4.0
Hveem Stability (AASHTO T 246) (Grading ST, SX & S only)	28 min.	28 min.
Voids Filled with Asphalt (V_a), MS-2	70-80	65-80
Dry Tensile Strength, psi (AASHTO T 283)	30 min.	30 min.
Voids in Mineral Aggregates (VMA) % (AASHTO PP-19)	Table 6.72.10	

TABLE 6.72.09
Mixture Properties for SMA

Property	Test Method	Value
Lab Compaction (Gyrations) N_{design}	AASHTO T 312	75
Air Voids (V_a) % at N_{design}	AASHTO T 312	3.0 – 4.0
Accelerated Moisture Susceptibility, Tensile Strength Ratio, (Lottman)	AASHTO T 283, Method B	80 min.
Dry Split Tensile Strength. psi	AASHTO T 283, Method B	30 min.
Grade of Asphalt Binder	N/A	PG 76-28
Voids in the Mineral Aggregate (VMA) %, minimum	AASHTO PP19	17
Drain Down at Production Temperature	AASHTO T 305	0.3 max.

TABLE 6.72.10
Minimum Voids in Mineral Aggregate (VMA)
Dense Graded & SMA Mixes

Nominal Maximum Particle Size	Minimum VMA (%)		
	3.0% V_a	3.5% V_a	4.0% V_a
1/2" (SX)	14.5	14.6	14.7
3/4" (S)	13.5	13.6	13.7
1" (SG)	12.5	12.6	12.7
SMA – 1/2"	17.0	17.0	17.0
SMA – 3/4"	17.0	17.0	17.0

(D) Change in Source or Grade

Should a change in the source of any material used in the production of APM (aggregate, mineral filler, lime, or performance graded asphalt binder) occur, a one-point verification test (at optimum binder content) of the mix must be performed to verify that the applicable criteria shown on Table 20.3A-1 (dense graded APM), Table 20.3A-2 (SMA), and Table 20.3A-3 (VMA), is still met. If this testing shows noncompliance, the CONTRACTOR shall establish a new job mix design and obtain approval by the CITY ENGINEER before the new APM is used.

(E) Mix Production Verification

Production verification shall occur prior to the start of the project. Volumetric properties of the mix shall be verified by LabCAT Level C certified Technicians. If the mix was produced for another project within the last 90 days, data from that project can be submitted for verification. Volumetric properties for mix verification testing shall be

within the tolerances in Table 6.72.14. The mix verification test reports shall be submitted to the CITY ENGINEER prior to mix placement.

Verification testing for binder content, gradation and physical properties shall be performed at the frequencies listed in Table 6.72.15.

(F) Pre-Paving Meeting

The CITY ENGINEER may require a pre-paving meeting of all parties that are directly involved in the project. Traffic control, transport, sequence of paving and construction plans may be reviewed and discussed.

6.72.04 Production

(A) Preparation of Aggregates

Heating and drying of the aggregates shall be accomplished without damaging the aggregate. An Anti-Strip additive shall be added to achieve uniform coating of the aggregate, in accordance with Section 6.72.02(G) Anti-Strip Additives.

(B) Mixing

The dried aggregates and asphalt binder shall be combined in the mixer in the quantities required to meet the design job mix formula. The materials shall be mixed until the aggregate is uniformly coated, and the asphalt binder is uniformly distributed throughout the aggregate. Baghouse fines may be fed back to the mixing plant in a continuous manner to maintain uniformity in the mixture at the discretion of the producer.

Discharge temperatures are shown in Table 6.72.11.

TABLE 6.72.11
Mixture Discharge Temperatures

Binder Grade	Minimum Discharge Temperature	Maximum Discharge Temperature
PG 58-28	275 °F	305 °F
PG 64-22	290 °F	320 °F
PG 76-28	320 °F	330 °F

To protect the properties of the binder, APM shall be produced at the lowest temperature within the specified range that produces a workable mix and provides for uniform coating of aggregates, and that allows the CONTRACTOR to achieve the required compaction.

(C) Transportation

Colorado Statutes require that each truck shall be covered. This will also help protect the mix during transport from contamination and weathering. The CITY ENGINEER may reject any uncovered APM which demonstrates it has been impacted by contamination and/or weather.

6.72.05 **Prime and Tack Coat**

(A) Prime Coat

Materials shall be in accordance with the requirements of the CDOT's "Standard Specifications for Road and Bridge Construction."

(B) Tack Coat

Prior to placement of APM, a tack coat shall be applied to all existing concrete and asphalt surfaces.

The tack coat shall meet the CDOT "Standard Specifications for Road and Bridge Construction" for emulsified asphalt, consisting of CSS-1h or SS-1h and conform to AASHTO M208 or M140.

The tack coat shall be applied at a rate of 0.1 to 0.3 gallons per square yard. The surface receiving the tack coat shall be dry and clean, and dust, debris, and foreign matter shall be removed. Tack coat shall be applied uniformly. The CONTRACTOR shall allow the tack coat to cure (dehydrate) prior to the placement of APM. If the tack becomes contaminated during construction, it shall be cleaned, and if necessary, additional tack coat shall be reapplied and allowed to cure before paving resumes.

TABLE 6.72.12
Tack Coat Application Rates

Pavement Condition	Application Rate (gal/yd^2)		
	Residual	Undiluted	Diluted (1:1)
New Asphalt	0.03 – 0.04	0.05 – 0.07	0.10 – 0.13
Oxidized Asphalt	0.04 – 0.06	0.07 – 0.10	0.13 – 0.20
Milled Surface (Asphalt)	0.06 – 0.08	0.10 – 0.13	0.20 – 0.30
Milled Surface (PCC)	0.06 – 0.08	0.10 – 0.13	0.20 – 0.30
Portland Cement Concrete	0.04 – 0.06	0.07- 0.10	0.13 – 0.20

6.72.06 **Equipment**

(A) Transport Equipment

Trucks used for transporting APM shall be free of debris, and should be treated with approved release agents. Petroleum distillates such as kerosene or fuel oil will not be permitted as a release agent. The CITY ENGINEER may reject any APM which demonstrates it has been contaminated from a petroleum distillate release agent.

(B) Material Transfer

Placement of SMA shall require the use of a Material Transfer Vehicle (MTV) or Material Transfer Device (MTD). The MTV shall be a self-propelled unit with on board storage of material. An MTD is a non-self-propelled unit. Both MTV and MTD are capable of receiving material from trucks or from the ground, transferring the material from the unit to a paver hopper insert via a conveyor system.

(C) APM Pavers

Self-propelled pavers shall be capable of placing the APM to the desired width, thickness and a satisfactory mat texture.

Pavers shall be equipped with automatic screed controls, the sensors may be contact or non-contact type devices. The controls shall be capable of maintaining the screed at the specified transverse slope within ±0.1%.

6.72.07 Placement

(A) General

APM shall be placed on properly constructed surfaces that are free from debris, frost, snow, or ice. APM shall be placed in accordance with the temperature limitations of Table 6.72.13. In-place density for APM shall be 94% of maximum theoretical specific gravity (Rice - AASHTO T 209). The allowable variance shall be ± 2%. Test results shall be reported to the nearest whole number.

(B) Temperature

Surface temperatures shall be used to determine placement of APM. Ambient temperatures and other weather conditions shall be considered prior to placement.

TABLE 6.72.13
Minimum Surface Temperatures for Placement of APM

Compacted Layer Thickness (in.)	Minimum Surface Temperature (°F)	
	Top Layer	Layers Below the Top Layer
<1-1/2	60	50
1-1/2 - <3	50	40
3 or more	45	35

If the CONTRACTOR modifies the placement and compaction processes when ambient temperatures are below minimum surface temperatures in Table 6.72.13, they shall demonstrate to the CITY ENGINEER the required in-place density has been achieved. APM cooling software such as PaveCool, or MultiCool can be used to determine placement and compaction times available.

(C) SMA Placement

The CONTRACTOR shall establish and document a roller pattern for the SMA being placed. The roller pattern shall include, but is not limited to the following:

- Number, size, and type of rollers
- Amplitude, frequency, and speed of rollers
- Temperature of mixture being compacted during each process (break down, intermediate and finish)
- Number of roller passes for each phase

The in-place density shall be determined during placement of the first 1,000 feet with a minimum of 95% of Theoretical Maximum Density (Rice). The allowable variance shall be ± 2%. Test results shall be reported to the nearest whole number.

SMA mixture shall be placed with the assistance of a MTV or MTD. The CONTRACTOR should minimize flushing and drain down during the transport and placement of SMA. If more than 50 square feet of flushed area is observed, the CONTRACTOR shall provide a remedy to address the flushing and/or drain down.

In place density may be determined by nuclear gauge measurements in accordance with ASTM D 2950 and AASHTO T 230, or based on cores in accordance with AASHTO T 166, Method B. When cores are used, the CONTRACTOR shall provide all labor and equipment for the coring and repair of the holes.

When the material being placed is on a structure (bridge deck), nuclear gauge measurements shall be used.

6.72.08 Longitudinal Joints

The CONTRACTOR shall submit a joint plan and pavement marking plan showing the location of and the methods to establish the paving control lines. The plan shall be approved by the CITY ENGINEER. The CONTRACTOR shall use a method to delineate longitudinal joints during paving.

Longitudinal joints in all pavement layers shall offset the joint in the layer immediately below by a minimum of six inches. The joint in any pavement layer shall not fall in wheel paths. Joints in the top layer of new pavement shall be located on lane lines unless otherwise shown on the plans. Longitudinal joints shall be minimized with wide paving pulls. Joints shall be parallel to the flow of traffic and shall not cross any centerline, lane line, or edge line.

All paving shall be placed parallel to the roadway centerline and as straight as possible. All joints shall receive a coat of tack prior to placement of adjacent paving.

6.72.09 Transverse Joints

The CONTRACTOR shall submit a joint plan. The plan shall be approved by the CITY ENGINEER. The CONTRACTOR shall use an approved plan to delineate transverse joints during paving. Transverse

joints shall be formed by cutting back on the previous run to expose the full depth of the course. Tack coat material shall be applied to contact surfaces of all joints before additional mixture is placed against the previously compacted material.

The surface tolerance at the transverse joint shall be verified by the CONTRACTOR with a 10 foot straight edge. If the surface tolerance exceeds 3/16” across the joint, measured in at least three locations, the CONTRACTOR shall make corrections to the joint before proceeding.

6.72.10 Segregation

Visually segregated areas shall be corrected before the initial compaction process is applied. Segregated areas may be determined visually or by other acceptable means. The CONTRACTOR shall correct segregated areas to the satisfaction of the CITY ENGINEER.

6.72.11 Compaction

Equipment used for compaction of the APM will be at the discretion of the CONTRACTOR. The number, weight, and type of rollers furnished shall be sufficient to obtain the required density and surface texture.

When the mixture contains unmodified asphalt binder (PG 58-28 or PG 64-22), and the surface temperature falls below 180°F, further compactive effort shall not be applied unless the CONTRACTOR can demonstrate that there is no damage to the finished mat.

If the mixture contains modified asphalt binder (PG 76-28) and the surface temperature falls below 230°F, further compactive effort shall not be applied unless the CONTRACTOR can demonstrate that there is no damage to the finished mat.

Use of rollers with the vibrator on will not be permitted on bridge decks.

In-place density for APM shall be 94% of maximum theoretical specific gravity (Rice - AASHTO T 209). The allowable variance shall be ± 2%. Test results shall be reported to the nearest whole number. Rice values will be based on a three production day's average. The CONTRACTOR shall provide the producer's Rice value, which shall be used for production until the actual day's Rice value is determined by the testing firm of record for the project.

In place density for SMA shall be determined during placement of the first 1,000 feet with a minimum of 95% of theoretical maximum specific gravity Rice - AASHTO T 209). The allowable variance shall be ± 2%. Test results shall be reported to the nearest whole number.

All joints shall be compacted to 92% of Rice, taken six inches offset from the joint, at a minimum of one every 1000 linear feet or fraction thereof. The allowable variance shall be ±2%. Test results shall be reported to the nearest whole number.

The CONTRACTOR shall core the pavement, as required by the CITY ENGINEER; in accordance with AASHTO T 230, Method B, or for field calibration of nuclear density equipment in accordance with the ASTM D 2950. At a minimum, cores for nuclear density equipment correlation shall be taken at the beginning of placement of each pavement layer or change of mixture materials or gradation. Cores may be used to verify compaction results.

Along forms, curbs, headers, walls, and all other places not accessible to the rollers, the mixture shall meet all project compaction specifications. Any mixture that is defective, shall be corrected to meet the project specifications at the expense of the CONTRACTOR.

6.72.12 Utility Adjustments

The CONTRACTOR shall adjust all manholes to 1/8" maximum below final grade and adjust to match the slope of the roadway in accordance with the detail drawings. Valve boxes and survey range boxes shall be adjusted to be flush to 1/8" below final grade and adjusted to match the slope of the roadway. Valve boxes shall be adjusted with each layer of paving.

Valve boxes and manholes are to be maintained fully accessible at all times for emergency and maintenance operations. The cost of adjusting valve boxes, manholes, and survey range boxes shall be included in the work, unless otherwise specified. The CONTRACTOR shall be responsible for any cost to provide access to the covered manholes or valve boxes at the discretion of the CITY ENGINEER.

Final adjustment of all utility access points shall be completed within seven days from the time the APM was placed.

6.72.13 Production Tolerances

(A) Wearing Course

Surface variation shall not exceed 3/16 inch in 10 feet for full lane width paving. For patching, the variation shall not exceed 3/8 inch in 10 feet. The final pavement surface shall not vary from the specified cross section by more than one inch at any point. Transverse measurements for variations shall exclude breaks in the crown sections. Corrections shall be made at the CONTRACTOR's expense.

The final surface pavement adjacent to curb and gutter shall be finished from 1/8-inch to 1/4-inches above the lip for catch curb and shall not extend above the lip for spill curb.

(B) Job Mix Formula

Tolerances for gradation are presented in Table 6.72.02 and Table 6.72.03. APM volumetric tolerances are presented in Table 6.72.14.

TABLE 6.72.14
Production Mix Tolerances

Property	Tolerance
Air Voids	± 1.2%
VMA	± 1.2%
Asphalt Binder Content	± 0.3%

6.72.14 Conformity with Plans and Specifications

(A) Materials

Materials shall be sampled by and tested by a LabCAT certified technician(s) in an AMRL accredited testing laboratory in accordance with Section 6.72.15.

Test results that have sampling or testing errors shall not be used.

(B) Pavement Thickness

A minimum of 90% of all the pavement thickness cores must equal or exceed the required thickness shown on plans or pavement design report.

If the pavement thickness deficiency is greater than 0.25 inches for individual cores, two additional cores will be taken by the CONTRACTOR 50 feet before and after each

deficient core. The three core results will be averaged to determine if the results meet the required thickness.

When individual core thickness deviates from the target thickness by more than 0.25 inch but not more than 0.50 inch, remedial action will be required. The CONTRACTOR shall present proposed remedial measures for consideration by the CITY ENGINEER. The CITY ENGINEER will review the proposal within 10 working days to accept or modify the remedial measures. The remedial measures will be performed by the CONTRACTOR at no additional cost to the CITY.

When individual core thickness deviates from the target thickness by more than 0.50 inch, corrective action shall be required. The deficient area will overlaid with no less than one inch thick lift to meet the design thickness. The CONTRACTOR will mill to match existing facilities prior to corrective overlay. The mixture proposed shall be approved by the CITY ENGINEER. Corrective action will be performed by the CONTRACTOR within 15 working days.

If the CITY ENGINEER does not want the top lift cored, they may require the CONTRACTOR to use non-destructive survey techniques to determine APM thickness.

6.72.15 Testing and Inspection

If any materials furnished or work performed fails to meet the specification requirements, such deficiencies shall be documented and reported to the CITY ENGINEER. Field reports shall be delivered to the CITY ENGINEER within three business days. Test results that cannot be completed within three days shall be provided to the CITY ENGINEER no later than one week after the sample was obtained.

Testing of APM shall be performed in accordance with Table 6.72.15. Laboratories shall be accredited by AASHTO Materials Reference Laboratory (AMRL) for the tests being performed. Technicians obtaining samples and conducting compaction tests must have a LabCAT Level A certification. Technicians conducting tests of asphalt content and gradation must have a LabCAT Level B certification. Technicians performing volumetric testing must have a LabCAT Level C certification. Inspectors on APM projects shall be LabCAT Inspector Certified (Level I).

TABLE 6.72.15
Minimum Materials Sampling and Testing
for Process Control and Owners Acceptance

Test	Standard	Minimum Frequency
Sampling	AASHTO T 168, ASTM D 979 & ASTM D 3665	1/1000 tons or fraction thereof (not less than one test per day)
Density	AASHTO T 166, T 238 & T 230	One test for each 250 linear feet per lane
Thickness (Core)	ASTM D3549	As required
Air Voids & VMA	AASHTO T 166 & PP19	1/1000 tons or fraction thereof (not less than one test per day)
Gradation	AASHTO T 27 & T 11	1/1000 tons or fraction thereof (not less than one test per day)
Hveem/Marshall Stability As Applicable	AASHTO T 245 & T 246	1/1000 tons or fraction thereof (not less than one test per day)
Binder Content	AASHTO T 164 or other methods agreed upon between the CITY and CONTRACTOR	1/1000 tons or fraction thereof (not less than one test per day)
Maximum Theoretical Specific Gravity (Rice)	AASHTO T 209	1/1000 tons or fraction thereof (not less than one test per day)
Lottman Stripping, TSR & Dry Density	AASHTO T 283	One per project per mix used

6.72.16 Crack Seal Required

Following construction of new streets and/or alleys as part of a PUBLIC IMPROVEMENTS AGREEMENT, the OWNER/DEVELOPER shall conduct crack seal operations at the direction of the CITY ENGINEER on the asphalt surface one year after initial construction. Cracks with a width greater than one-eighth inch (1/8") shall be sealed with crack sealing compound conforming to Section 408 of the CDOT specifications.

6.73.00 APPURTENANT STRUCTURES CONCRETE

Concrete used in the construction of curb, gutter, sidewalk, drive cuts, and other appurtenant roadway concrete structures, including concrete pavement if allowed by the CITY ENGINEER, shall be in accordance with Chapter 7 of these STANDARDS AND SPECIFICATIONS.

6.74.00 STRUCTURE BACKFILL MATERIAL

Structure backfill shall comply with CDOT's specifications for Class 1 material and meet the following requirements from laboratory sieves:

TABLE 6.74.00

Sieve Designation	Percent by Weight Passing Lab Sieve
2 Inch	100
No. 4	30 - 100
No. 50	10 - 60
No. 200	5 - 20

Flowable fill may be required or allowed in lieu of Class 1 backfill as determined by the CITY ENGINEER.

6.75.00 DETECTABLE WARNING TILES

6.75.01 General

(A) This section includes specifications for furnishing permanently embedded cast-in-place tactile / detectable warning surface tiles with an in-line truncated dome pattern embedded in all accessible curb ramps at the locations and to the dimensions shown on the detail and/or construction drawings, and as directed by the CITY ENGINEER.

(B) Provide cast-in-place tiles and accessories as produced by a single manufacturer with a minimum of five (5) years' experience in manufacturing Cast In Place Composite Shell Tactile Warning Surface Tiles.

6.75.02 Manufacturers

(A) Available manufacturers, subject to compliance with these STANDARDS AND SPECIFICATIONS include, but are not limited to, the following: ADA Solutions Inc. of Chelmsford, MA (Phone: 800-372-0519, Fax: 978-262-9125, Web Site: www.adatile.com , E: info@adatile.com), or approved equal.

(B) Requests for Approved Equal Status must be submitted and approved by the CITY ENGINEER.

6.75.03 Submittals

(A) Product Data: Submit manufacturer's literature describing products, installation procedures and maintenance instructions.

(B) Samples for Verification Purposes: Submit two (2) Tactile Warning Surface samples minimum eight inches by eight inches (8" x 8") of the kind proposed for use. Samples

shall be properly labeled and shall contain the following information: Name of Project, Submitted by, Date of Submittal, Manufacturer's Name, and Catalog Number.

(C) Shop Drawings: Submit Standard Manufacturer Shop Drawings showing all pertinent characteristics of the cast-in-place tile, including profile, sound on cane contact amplification feature and installation methods.

(D) Material Test Reports: Submit current test reports from qualified, accredited independent testing laboratory in accordance with ASTM guidelines and indicating that materials proposed for use are in compliance with specification requirements and meet the properties indicated. All test reports submitted shall be representative of the cast-in-place tile delivered to the installation site.

(E) Maintenance Instructions: Submit copies of manufacturer's specified maintenance practices for each type of Tactile Warning Surface Tile and accessory.

6.75.04 <u>Tile Requirements</u>

(A) Cast-in-place tiles must be compliant with ADAAG and PROWAG requirements.

(B) Cast-in-place tiles shall meet or exceed the following test criteria using the most current test methods:

1. Compressive Strength: 28,900 psi minimum, when tested in accordance with ASTM D695.

2. Flexural Strength: 29,300 psi minimum, when tested in accordance with ASTM D790.

3. Water Absorption: Not to exceed 0.10%, when tested in accordance with ASTM-D570.

4. Slip Resistance: 1.05 minimum wet and 1.18 dry static coefficient of friction when tested in accordance with ASTM C1028.

5. Flame Spread: 25 maximum, when tested in accordance with ASTM E84.

6. Salt and Spray Performance of Tactile Warning Surface: No deterioration or other defects after 200 hours of exposure, when tested in accordance with ASTM-B117.

7. Chemical Stain Resistance: No reaction to 1% hydrochloric acid, motor oil, calcium chloride, gum, soap solution, bleach, and antifreeze, when tested in accordance with ASTM D543.

8. Abrasion Resistance: 500 minimum, when tested in accordance with ASTM C501.

9. Accelerated Weathering of Tactile Warning Surface when tested by ASTM-G155 or ASTM G151 shall exhibit the following result: $\Delta E<5.0$ at 2,000 hours minimum exposure.

10. Tensile Strength: 11,600 psi minimum, when tested in accordance with ASTM D638.

11. AASHTO-H20 Load Bearing Test: No Damage at 16,000# loading.

12. Freeze/Thaw/Heat: No deterioration when tested in accordance with ASTM C 1026.

6.75.05 <u>Delivery, Storage and Handling</u>

Cast-in-place tiles shall be suitably packaged or crated to prevent damage in shipment or handling. Finished surfaces shall be protected by sturdy wrappings.

Store cast-in-place tiles in an area that is within an acceptable temperature range (40-90 degrees). Maintain Storage Facility in a clean dry condition to prevent contamination or damage to cast-in-place tiles.

6.75.06 <u>Guarantee</u>

Cast-in-place tiles shall be guaranteed in writing for a period of five (5) years from date of Contract's final completion. The guarantee includes manufacturing defects, breakage, and deformation.

6.75.07 <u>Tile Materials</u>

(A) Composition: Cast-in-place tiles shall be manufactured using a matte finish exterior grade homogeneous (uniform color throughout thickness of product) glass and carbon reinforced polyester based Sheet Molding Compound (SMC) composite material. Truncated domes must contain fiberglass reinforcement within the truncated dome for superior structural integrity and impact resistance. A matte finish will be required on the Tactile Warning Surface for superior slip resistance performance superior to that offered by a gloss finish. Use of Tactile Warning Surface Products employing coatings or featuring layers of material with differing composition, performance, or color properties is expressly prohibited under this Section.

(B) Color: Color shall be homogeneous throughout cast-in-place tile: Brick Red (R) per Federal Standard 595B Table IV, Color No. 20109.

(C) Domes: Square grid pattern of raised truncated domes of two-tenths inch (0.2") nominal height, base diameter of nine-tenths inch (0.9") and top diameter of forty-five hundredths inch (0.45"). The Federal Code of Regulations permits a truncated dome spacing range of one-point-six to two-point-four inches (1.6"-2.4"). For superior wheelchair, walker and shopping cart mobility, the preferred truncated dome spacing

shall have a center-to-center (horizontally and vertically) spacing of two-point-thirty-five inches (2.35”), measured between the most adjacent domes on square grid.

(D) Configuration: Cast-in-place tile sizes shall be as indicated on the detail and/or construction drawings. For superior load bearing capacity, cast-in-place tile shall feature internal embedment ribs at three inches (3”) on center maximum. The field area shall consist of a non-slip textured surface with a minimum static coefficient of friction of eight-tenths (0.80), wet and dry. At a minimum, cast-in-place tile thickness shall measure two-tenths (0.20”) (nominal).

(E) Truncated dome surface of cast-in-place tile shall be protected with factory installed plastic sheeting for cleanliness during the installation process. Basic installation guidelines shall be printed on the plastic sheeting in both English and Spanish for customer convenience.

(F) Dimensions: Cast-in-place tiles shall be held within the following length and width dimensions:

1. 1.67” Dome Spacing: 24”x36”, 24”x48” or 24”x60”

2. 2.35” Dome Spacing: 24”x36”, 24”x48” or 24”x60”

(G) Cleaning materials used on site shall have code acceptable low VOC solvent content and low flammability.

(H) The specifications of the concrete, sealants and related materials shall be in accordance with these STANDARDS AND SPECIFICATIONS and the guidelines set by their respective manufacturers.

6.76.00 CRUSHER FINES AGGREGATE

6.76.01 Submittals

(A) The CONTRACTOR shall submit certification from the supplier certifying the crusher fines, or approved equal, meets the requirements of these STANDARDS AND SPECIFICATIONS.

(B) The CONTRACTOR shall submit certified laboratory test certificates for all items required in this section.

(C) The CONTRACTOR shall submit samples and or shop drawings for the following:

1. Aggregate strength.

2. Aggregate color.

(D) The CONTRACTOR shall submit the manufacturer, Material Safety Data Sheet (MSDS), Name, Trade Name, trademark, and conformance to state law of all herbicides or other chemicals.

6.76.02 Herbicide

Herbicide shall be Casoron 4G granular weed and grass killer or approved equal.

6.76.03 Crusher Fines

(A) Aggregates: Crushed stone shall consist of inert materials that are hard, durable, with stone free from surface coatings and deleterious materials.

(B) R-value minimum of seventy (70) determined by ASTM D 2488 Methodology (R-value is a measure of wear resistance).

(C) Sand equivalent: An engineering measurement of the proportion of sand to silt and clay will stay at a range of 30-55, as determined by ASTM D 2419 methodology.

(D) Gradations: Gradation shall meet the gradation below or approved equal as approved by the CITY ENGINEER.

TABLE 6.76.01
Crusher Fines Gradation

Standard US Sieve Size	Percentage Passing by Weight
1/2 Inch	100
3/8 Inch	100
No. 4	65-80
No. 8	48-63
No. 16	40-49
No. 30	30-40
No. 50	20-27
No. 100	10-18
No. 200	10-12
Note: Material shall consist of bank or pit run material.	