CHAPTER 6 ROADWAY

6.1 INTRODUCTION

6.1.1 APPLICABILITY

This chapter contains minimum criteria to be met on all streets and parking lots designed and constructed in the City, both by private land developers and by the City.

6.1.2 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 and may be authorized by the Public Works Director where the proposed variance in minimum requirements will result in a level of safety, service, and quality equal to or greater than that intended by the application of the minimum requirements.

6.1.3 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 will be allowed subject to the review and approval of the Public Works Director.

6.1.4 CITY CAPITAL IMPROVEMENT PROJECTS

It is recognized that the minimum requirements contained in these STANDARDS AND SPECIFICATIONS are not necessarily sufficient for plans, specifications, and contract administration purposes for City administered street capital improvement projects. Accordingly, the Public Works Director is authorized to develop and/or approve such additional requirements and procedures necessary for bidding, awarding and administering for such projects, provided said additional requirements and procedures are substantially consistent with these STANDARDS AND SPECIFICATIONS and applicable provisions of other City ordinances and resolutions.

6.2 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" as published by the American Association of State Highway and Transportation Officials (Latest Edition).

6.2.1 REPORTS

6.2.1.1 Submittal Format

All reports shall be bound in an 8-1/2" x 11" folder 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 Northglenn's review of this study is only for general conformance with submittal requirements, current design criteria, and standard engineering principles and practices."

6.2.1.2. **Traffic Analysis Report**

All subdivision, Planned Unit Development (PUD) and commercial developments or redevelopments may require a traffic analysis report giving information and details as may be required by the Public Works Director and as specified in Chapter 8 of these STANDARDS AND SPECIFICATIONS.

6.2.1.3. **Pavement Design Report**

All roadway construction in the City of Northglenn shall require a pavement design report. The report content shall be in accordance with Chapter 6 of these STANDARDS AND SPECIFICATIONS.

6.2.1.4. **Pavement Evaluation Report**

After installation of the concrete pavement or bituminous surface course except for the final two inches (2") on residential streets, the developer may be required to furnish the Public Works Director with a copy of a report prepared by a Professional Engineer registered in the State of Colorado utilizing non-destructive deflection testing to access and predict the performance of the pavement. This testing may be required if evidence exists that the pavement section may not meet the design specifications. The Professional Engineer shall have a past history and knowledge in performing these tests. Qualifications of Professional Engineers shall be submitted to the Public Works Director for approval before the start of work.

The pavement evaluation shall be performed in accordance with good engineering practices. The report shall generally embody the following testing and pavement evaluation techniques:

a. Environmental Study (Frost Cycle, Drainage, etc.).

b. Pavement Surface Elevation.

c. Soil Borings in Areas of High Deflections.

d. Pavement Deflection Analysis.

The report shall evaluate the existing condition of the base and binder course by performance of deflection tests at one-hundred-foot (100') spacing per traffic lane. Spacing will be staggered in each lane. The report shall determine whether or not the pavement section will meet a 20-year pavement life or greater.

If the pavement section is not projected to meet a life expectancy of 20 years or more, the report shall propose asphalt overlays in excess of the existing pavement section to bring the new pavement section to a 20-year life expectancy. The Public Works Director will evaluate the results of the report and inform the developer of the acceptable solution mentioned in the report.
6.2.2 LOCAL STREET

6.2.2.1. **Local**

The City of Northglenn determines the classification of its city streets. For new development and redevelopment, a local street is a general term denoting a roadway designed or operating with the following characteristics:

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. Less than 2,500 vehicles per day.

c. Limited Continuity.

d. Safety. Designed for the safety of pedestrians and bicyclists and the ease of access to adjacent parcels of land.

e. 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 applicant’s engineer and the City’s Transportation Engineer.


g. Function. Local streets provide direct access to adjacent property. Traffic carried by local streets should have an origin or a destination with the neighborhood. Local streets are utilized in single family residential areas. Utility line easements should be available.

h. Right-of-Way. Sixty feet (60’) with detached walk. Attached walks to be used only with written permission from the Public Works Director.

i. Number of Moving Lanes. Two.

j. Access Conditions. In accordance with Chapter 8 of these STANDARDS AND SPECIFICATIONS.

k. Planning Characteristics. Local streets should not intersect major arterial streets.

l. Type of Curb and Gutter. Six inch (6”) vertical with detached walk. Four inch (4”) combination curb, gutter and walk, with attached walk only with written permission from the Public Works Director.

m. Sidewalk Width. Five foot (5’) minimum, attached or detached from curb.

n. Cul-de-sacs. In accordance with Chapter 6 of these STANDARDS AND SPECIFICATIONS.
o. Street Widths. Thirty (30’) minimum paved width plus two (2) two and a half foot (2.5’) curb and gutter pans.

6.2.3 COLLECTOR STREET

6.2.3.1 Collector

The City of Northglenn determines the classification of its city streets. For new development and redevelopment, a collector is a general term denoting a roadway designed or operating with the following characteristics:

a. Posted Speed Limit. Between 25 and 35 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 12,000 vehicles per day.

c. Continuous. For less than two (2) miles.

d. Safety. Designed to handle traffic volumes loading from and onto local, other collector, and arterial roadways.

e. 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.

f. Driveways. No back-out drives permitted.

g. Function. Collector streets collect and distribute traffic between arterial and local streets and serve as main connectors within communities, linking one neighborhood with another. Traffic carried by collector streets should have an origin or a destination within the community. Utility easements should be available.

h. Right-of-Way Width. Seventy-feet (70’) minimum, eighty-foot (80’) average.

i. Number of Moving Lanes. Two (2).

j. Access Conditions. In accordance with Chapter 8 of these STANDARDS AND SPECIFICATIONS.

k. Planning Characteristics. 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.

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

m. Sidewalk Width. Five feet (5’) minimum. Detached from curb.
n. Street Widths. Thirty seven foot (37’) to forty nine foot (49’) paved with two (2) two and a half foot (2.5’) gutter pans.

6.2.4 ARTERIAL STREET

6.2.4.1 Arterial

The City of Northglenn determines the classification of its city streets. For new development and redevelopment, an arterial street is a general term denoting a roadway designated or operating with the following characteristics:

a. Posted Speed Limit. Between 40 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 and up 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. Continuity. Several miles, generally connecting with inter-city routes.

e. 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 should be prohibited.

f. Function. 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. No parking is allowed.

g. Right-of-Way Width. One hundred feet (100’) minimum.

h. Number of Moving Lanes. Four (4) minimum.

i. Planning Characteristics. 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 and right-of-way acquisition costs are prohibitive. Detached sidewalk required. Separate major land uses.

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

k. Sidewalk Width. Eight-foot (8’) minimum, detached from curb or as required by the Public Works Director.
1. Street Widths. Four (4) twelve-foot (12') travel lanes, one (1) sixteen-foot (16') left-turn lane/striped or curbed median, and two (2) two and a half foot (2.5') gutter pans plus acceleration/deceleration lanes at intersections. Variation from these dimensions must be approved by the Public Works Director.

6.2.5 DRAINAGE

The minor and major storm drainage systems shall be designed in accordance with the Urban Drainage and Flood Control District’s Criteria Manual (UDFCD) (Latest Edition). Because 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.

6.2.5.1. Crosspans

Crosspans shall be constructed in accordance with the detail drawing in the Appendix. Crosspans are not permitted across collector or arterial roadways, nor are they allowed on roadways with storm sewer systems. Double crosspans may be used parallel to collectors or arterial roadways to convey storm runoff across residential roadways. The use of double 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.

6.2.5.2. Inlets

Inlets shall be located to intercept the curb flow at the point curb flow capacity is exceeded by storm runoff. Refer to the UDFCD Criteria Manual (Latest Edition) 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.

6.2.5.3. 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. Hydraulic design shall be in accordance with the UDFCD Criteria Manual (Latest Edition). Sidewalk chase sections shall be constructed in accordance with the detail drawing in the Appendix.

6.2.5.4. Temporary Erosion Control

Temporary erosion control is required along and at the ends of all roadways that are not completed due to project phasing, subdivision boundaries, etc., in accordance with Chapter 2 of these STANDARDS AND SPECIFICATIONS.
6.2.6 GEOMETRIC DESIGN

Geometric design elements, such as horizontal and vertical alignments and sight distances shall be in accordance with the “A Policy on Geometric Design of Highways and Streets” by the American Association of State Highway and Transportation Officials (Latest Edition). Geometric design elements must also consider the requirements of the local Fire District.

6.2.7 SIDEWALKS, CURB AND GUTTERS, RAMPS AND DRIVEWAYS

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

B. Sidewalks or bicycle paths shall be constructed on both sides of all roadways unless specifically deleted by action of City of Northglenn.

C. All sidewalks used in conjunction with vertical curb and gutter shall have a minimum width of five feet (5'). Variation from the 5’ minimum width must be approved by the Public Works Director.

D. Combination curb, gutter and walk are approved for use on local roadways only where right of way restrictions exist and must be approved by the Public Works Director. Vertical curb, gutter and detached walk shall be used on all other roadways.

E. State law requires that handicap 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)]. Handicap ramps shall be constructed in accordance with the detail drawings the Appendix. Handicap ramps may be shown at all curb returns or called out by a general note on the development plans, but must be shown (located) on all "T" intersections. Whenever referencing a handicap ramp, call out the specific detail drawing to construct that ramp. Handicap ramps are to be poured monolithic with the abutting curb and gutter. The ramp portion shall be constructed with “Truncated Domes/Detectable Warning Devices in accordance with the detail drawings in the Appendix.

F. Drainage structures shall not be placed in line with handicap ramps. Location of handicap ramps shall take precedence over location of the drainage structure.

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

H. 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.
I. Curb cuts and driveways shall be constructed in accordance with the detail drawings in the Appendix.

6.2.8 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 the Appendix.

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 is greater.

6.2.9 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. The need for deceleration lanes is established by the approved traffic study for the final plat or final development plan. Design criteria shall be in accordance with AASHTO "A Policy on Geometric Design of Highways and Streets”, (Latest Edition).

6.2.10 ACCELERATION LANES

At intersections, it is desirable to provide acceleration lanes for vehicles turning right onto the arterial from a cross street. The design elements of these acceleration lanes shall be in accordance with the Colorado Department of Transportation Roadway Design Manual, Latest Edition.

6.2.11 OFF-SITE DESIGN

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.

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 his improved section to the existing roadway. The following formula shall be applied to the taper of lane change necessary for this transition:

\[ L = \frac{WS^2}{60} \quad S \leq 40 \text{ MPH} \]

\[ L = WS \quad S > 45 \text{ MPH} \]
Where:

\[ L = \text{Length of Transition in Feet} \]
\[ W = \text{Width of Offset in Feet} \]
\[ S = \text{Speed Limit or 85th Percentile Speed} \]

The City of Northglenn Public Works Department should be contacted to establish unusual transition criteria. This contact is the responsibility of the applicant.

6.2.12 BARRICADES

Whenever roadways terminate due to project phasing, subdivision boundaries, etc., barricades are required. Design and construction shall comply with the requirements of the Manual of Uniform Traffic Control Devices, most recent edition. Details shall be shown on the construction drawings and installation shall be provided by the developer.

6.3. PAVEMENT DESIGN AND TECHNICAL CRITERIA

6.3.1 GENERAL

Recommended design methodologies for asphalt follow the Colorado Department of Transportation’s “Pavement Design Manual”, latest edition (the “Manual”).

For all City land development approvals that involve a Public Improvements Agreement for roadway construction, the applicant shall provide a subgrade investigation and pavement design report that recommends a typical pavement structural section based on the known site soil conditions and the approved traffic study or in accordance with the criteria set forth in Chapter 6 of these Standards and Specifications. This pavement design serves as a justification of the roadway structural requirements.

6.3.2 SUBGRADE INVESTIGATION

All subgrade investigations shall be in accordance with the procedures outlined in the “Manual” with the more specific criteria as follows:

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 the proposed subgrade elevation at spacings of not more than two hundred and fifty feet (250’) unless otherwise accepted by the Public Works Director. Samples shall be taken after grading is completed and the subgrade is rough cut.

The treatment of expansive soils shall be in accordance with Chapter 2 of the “Manual” unless approved otherwise, in writing, by the Public Works Director.

The “Subgrade Resilient Modulus” (MR) shall be correlated to the Resistance Value (R-value) using the formulas in the “Manual”. 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 the “Manual”.

6-9
6.3.3 PAVEMENT DESIGN CRITERIA

6.3.3.1 Minimum Pavement Section

This paragraph provides the minimum acceptable pavement sections for public roadways in the City of Northglenn. These pavement thicknesses may be used for preliminary planning purposes. Final pavement designs must be based on actual subgrade support test results. Table 6.1 lists these minimum thicknesses for each roadway classification.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Composite Section (2)</th>
<th>Full Depth</th>
<th>Portland Cement (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Asphalt</td>
<td>Aggregate Base Course</td>
<td>Asphalt</td>
</tr>
<tr>
<td>Cul-de-sac (3)</td>
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<td>6.0</td>
<td></td>
</tr>
<tr>
<td>Local</td>
<td>8.0</td>
<td>6.0</td>
<td></td>
</tr>
<tr>
<td>Major Collector</td>
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<td>8.0</td>
<td></td>
</tr>
<tr>
<td>Arterial</td>
<td>9.0</td>
<td>9.0</td>
<td></td>
</tr>
</tbody>
</table>

(1) Concrete streets are only allowed with specific written approval of the Public Works Director.

(2) “Full Depth Asphalt” is required on all “Public Streets”. Composite sections will only be allowed when specifically approved by the Public Works Director.

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

6.3.4 PAVEMENT DESIGN PROCEDURE

6.3.4.1 Flexible Pavements

Flexible Pavement shall be designed per the “Manual” to meet the required structural number (SN).

6.3.4.2 Rigid Pavement

If rigid pavement is allowed by the Public Works Director, the procedures in the “Manual” should be followed.

6.3.4.3 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 ESAL for each street.

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

e. Tabular listing of sample designation, sample depth, group number, liquid limit, plasticity index, percent passing the No. 200 sieve, AASHTO classification, group index, and soil description.

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

g. Pavement design nomographs properly drawn to show soil support -- ESAL - SN. A computer printout may be used if the DARWin™ program is used.

h. Design calculations.

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

j. Swell or settlement-prone soil.

k. Frost-susceptible soils.

l. Ground water.

m. Drainage considerations (surface and subsurface).

n. Cold-weather construction (if appropriate).

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

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

6.4. STREET CONSTRUCTION STANDARDS

6.4.1 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 of Northglenn.

6.4.2 COMPACTION IN UTILITY TRENCHES

Before 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 at one percent (1%) (plus or minus) optimum moisture, as determined by ASTM D 698-78 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.

6.4.3 EXCAVATION AND EMBANKMENT

6.4.3.1. 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 the CDOT Standard Specifications for Road and Bridge Construction (Latest Edition) and in conformity with the lines, grades, quantities and the typical cross-section shown on the plans or as directed by the Public Works Director.

6.4.3.2. Salvage

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 Public Works Director. The contractor shall be required to replace any materials lost from improper storage methods or damaged by negligence.

6.4.3.3. Disposal

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 Public Works Director may require the contractor to furnish written permission from the property owner on whose property the materials will be placed.

6.4.3.4. 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 material 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 Public Works Director 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 Public Works Director.

6.4.4 SUBGRADE PREPARATION AND GRADING

6.4.4.1. 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, Trenching, Backfilling and Compaction.

6.4.4.2. **Subgrade Stabilization**

Embankment and subgrade soils shall be compacted to ninety-five percent (95%) of maximum standard density at plus or minus two percent (+2%) optimum moisture or as recommended in the approved soils report. Maximum density shall be determined by ASTM D 698-78. 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 Public Works Director 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 Public Works Director. No paving, subbase or base shall be placed on soft, spongy or frozen unstable subgrade which is considered unsuitable by the Public Works Director.

The contractor, when requested by the Public Works Director, shall furnish the necessary equipment to proof roll, even though density tests may indicate compliance. Heavy construction equipment or loaded trucks acceptable to the City 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.

6.4.4.3. **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 solid nor more than one inch (1”) above or six inches (6") below in rock.

6.4.5 **SUBBASE CONSTRUCTION**

6.4.5.1. **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.
6.4.5.2. **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 (+2%) of optimum moisture as determined by ASTM D 698-78. 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.

6.4.5.3. **Subbase Surface Tolerance**

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

6.4.6 **BASE CONSTRUCTION**

6.4.6.1. **General**

The intent of this section is to specify methods to be used for the construction, overlaying, sealcoating and pavement rejuvenating of streets, parking lots, walks, drainageways and other miscellaneous work requiring the use of aggregates. The work covered shall include general requirements that are applicable to aggregate base course, bituminous base and pavements of the plant-mix type, bituminous prime coat, bituminous 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 Public Works Director.

6.4.6.2. **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 Colorado Department of Transportation’s Standard Specifications for Road and Bridge Construction (Latest Edition) and the approved pavement design. The composite base course material shall be free from vegetation and lumps or balls of clay.

6.4.6.3. **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 698-78. 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.

6.4.6.4. **Base Surface Tolerance**

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

6.4.7 **BITUMINOUS CONSTRUCTION**

6.4.7.1. **Hot Bituminous Pavement**

All pavements shall be hot bituminous pavement of the plant mix type unless otherwise approved in writing by the Public Works Director. Construction shall be in accordance with the Colorado Department of Transportation’s Standard Specifications for Road and Bridge Construction, (Latest edition).

When tack coats, seal coats, rejuvenating agents or the heating and scarifying process are specified on the approved construction plans or required by the Public Works Director, all materials and construction shall be in accordance with the CDOT Standard Specifications for Road and Bridge Construction (Latest Edition).

6.4.7.2. **Grinding**

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 a bituminous overlay. After grinding, the surface shall have a grooved or ridged finish, uniform and resistant to raveling or traffic displacement. This textured surface shall have grooves of one-quarter inch (1/4”) plus or minus one-eighth inch (+1/8).

Wedge cut grinding shall consist of grinding the existing pavement surface a minimum of four feet (4’) wide at the existing concrete gutter. The edge of the gutter end of the finished wedge cut shall be one-and-one-half inches (1-1/2”) below the edge of the existing concrete gutter. The centerline of the street edge of the wedge cut will be cut one-eighth inch (1/8”). The depth of cut shall be determined by measuring to the top of the ridges by placing a five-foot (5’) straight edge perpendicular to the grooving pattern. Full-width grinding shall consist of grinding the existing pavement surface from edge of gutter to edge of gutter to a minimum depth of two inches (2”) unless otherwise directed by the Public Works Director.

In grinding around utility castings, the contractor may choose to remove the entire existing bituminous pavement around the castings where grinding is not completed and replace it with bituminous surface course placed and compacted in three-inch (3”) lifts. The contractor shall vertically cut the limits of the area to be patched, mechanically compact the existing base course, and prime the bottom and vertical edges before
backfilling. The contractor shall remove the cuttings immediately behind the grind machine by belt loader, end loader, power sweeper and/or by hand. The removed material shall be disposed of as approved by the Public Works Director.

The grinding machine shall be a power-operated, self-propelled machine having a cutting drum with lacing patterns that will attain a grooved surface and produce grinding chips of less than one inch (1") in size. The grinding machine shall be equipped with a pressurized watering system for dust control. The equipment shall be a type that has successfully performed similar work.

The cleaning equipment shall be a type which will efficiently remove all loosened material and load into trucks for hauling and spreading. Because of the nature of the streets to be ground and the traffic restrictions, a belt loader followed by a power sweeper and manual sweeper is the most desirable method. Flushing into the City's storm sewer system as a means of clean-up will not be allowed.

6.4.8 PORTLAND CEMENT CONCRETE PAVEMENT

6.4.8.1. General

Furnishing all tools, transportation, labor, equipment, accessories, services and material, and in performing all operations in constructing a single course of air-entrained Portland cement concrete pavement constructed on a prepared subgrade shall be in accordance with the CDOT Standard Specifications for Road and Bridge Construction (Latest Edition). Portland Cement Concrete Pavements will only be allowed if approved in writing by the Public Works Director.

6.4.8.2. Curing

Finishing and consolidation shall be performed per CDOT specifications. Immediately after the finishing operations have been completed and as soon as marring of the concrete will not occur, the entire surface of the newly-placed concrete shall be covered and cured in accordance with the following methods. In all cases in which curing requires the use of water, the curing shall have prior right to all water supply or supplies. Failure to provide sufficient cover material or lack of water to adequately take care of both curing and other requirements shall be cause for immediate suspension of concreting operations. The concrete shall not be left exposed for more than one-half (1/2) hour between stages of curing or during the curing period.

6.4.8.2.1 Impervious Membrane Method:

The entire surface of the pavement shall be sprayed uniformly with an accepted white pigmented curing compound immediately after the finishing of the surface and before the set of the concrete has taken place. Curing compound shall be applied under pressure at the rate of one (1) gallon to not more than one hundred-and-fifty (150) square feet by mechanical sprayers. The spraying equipment shall be the fully-atomizing type equipped with a tank agitator. At the time of use, the compound shall be in a thoroughly mixed condition with the pigment uniformly dispersed.
throughout the vehicle. During application, the compound shall be stirred continuously by effective mechanical means. Hand-spraying of odd widths or shapes and concrete surfaces exposed by the removal of forms will be permitted. Curing compounds shall not be applied to the inside faces of joints yet to be sealed.

Membrane-curing compounds shall be wax base Protex DW3 or equal and meet the requirements of AASHTO M 148, Type 2, latest edition. Should the film become damaged from any cause within the required curing period, the damaged portions shall be repaired immediately with additional compound. Upon removal of side forms, the side of the slabs exposed shall be protected immediately to provide a curing treatment equal to that provided for the surface.

6.4.8.2.2  **Wet Burlap Curing:**

After completion of the finishing operations, the surface of the concrete shall be entirely covered with burlap mats. The mats used shall be in such length or width that as laid they will extend at least twice the thickness of the concrete beyond the edges of the slab or structure. They shall be placed so the entire structure and all edges of the concrete, when forms are removed, are completely covered. This covering shall be placed as soon as the concrete has set sufficiently to prevent marring of the surface. After being placed, the mats shall be thoroughly saturated with water by spraying with a mist spray. The burlap shall be placed and weighted down so it remains in contact with the surface covered, and covering shall be maintained fully wetted and in position for seven (7) days after the concrete has been placed. If it becomes necessary to remove the burlap for any reason, the concrete shall not be exposed for a period of more than one-half (1/2) hour. This method of curing shall not be used when the outside air temperature is below thirty-two degrees Fahrenheit (32°F) unless heated enclosures are provided.

6.4.8.2.3  **Plastic Sheet Curing:**

As soon after the completion of the finishing operation as the concrete has set sufficiently to prevent marring of the surface, the top surface and sides shall be entirely covered with plastic sheet materials. The plastic sheet as prepared for use shall have dimensions such that each unit as laid will extend beyond the edges of the concrete at least twice the thickness of the concrete. The units as used shall be lapped at least twelve inches (12") and the laps of plastic sheet shall be secured in such a manner that they do not open or separate. The plastic shall be placed and weighted so it remains in contact with the surface covered during the entire curing period of seven (7) days.

6.4.8.2.4  **Waterproof Paper Curing:**
The procedures used for plastic sheet curing shall be used when waterproof paper is used in curing concrete.

6.4.8.2.5  **Insulation Pad:**

Insulation pads or other thermal devices may be used to protect concrete in cold weather.

6.4.8.2.6  **Other:**

Other acceptable curing methods may be used upon review and acceptance by the Public Works Director.

6.4.8.3.  **Curing in Cold Weather**

When the air temperatures may be expected to fall below thirty-five degrees Fahrenheit (35°F), the contractor's written, detailed proposal for protecting the concrete must be accepted by the Public Works Director before commencement of the paving operation. A sufficient supply of straw, hay, grass or other suitable material shall be provided along the work. The methods and materials used shall be such that a minimum temperature of forty degree Fahrenheit (40°F) will be maintained at the surface of pavement. Acceptance of the contractor's proposed method shall not relieve the contractor of the responsibility for the quality and strength of the concrete placed during cold weather. Any concrete damaged by frost action shall be removed and replaced at the contractor's expense.

During paving operations, day or night, when the air temperature reaches thirty-five degrees Fahrenheit (35°F) and is falling, placement of concrete shall cease and the previously-approved protection method shall be initiated. All concrete placed within the previous seventy-two (72) hours shall be protected for a minimum of five (5) days after initial placement of the concrete.

Admixtures for curing or temperature control may be used only when permitted by the Public Works Director.

6.4.8.4.  **Clean-Up**

When concrete operations have been completed, the contractor shall be responsible for the clean-up and removal of all leftover or waste materials resulting from any of his activities. All curbs shall be properly backfilled and the adjacent ground left in an acceptably neat and presentable condition.

6.4.8.5.  **Protection Against Rain:**

In order that the concrete may be properly protected against the effects of rain before the concrete is sufficiently hardened, the contractor shall be required to have materials available at all times for the protection of the edges and surface of the unhardened concrete. Such protective materials shall consist of standard metal forms or wood plank having a nominal thickness of not less than two inches (2") and a nominal width of not
less than the thickness of the pavement at its edge for the protection of the pavement edges and covering material such as burlap or cotton mats, curing paper, or plastic sheeting material for the protection of the surface of the pavement. When rain appears imminent or when requested by the Public Works Director, all paving operations shall stop, forms shall be placed against the sides of pavement and protective covering shall be placed over the surface of unhardened concrete.

6.4.8.6. **Opening to Traffic**

Opening to traffic, including the contractor's vehicles, shall not be permitted until the flexural strength of the concrete, as indicated by the modules of rupture of beams tested in conformity with the latest ASTM Standard Method of Test for "Flexural Strength of Concrete Using Simple Beam With Third-Point Loading." Designation C-78 is at least five hundred (500) pounds per square inch or the compressive strength of six-inch by 12-inch (6" x 12") cylinders, tested in conformity with the latest ASTM Standard Method of Test for "Compressive Strength of Molded Concrete Cylinders." Designation C-39 is at least three thousand (3000) pounds per square inch. These tests shall be performed when the concrete is seven (7) days old unless otherwise requested by the contractor. If permanent shoulders are not in place, a six-foot (6') wide temporary earth shoulder shall be placed against the outside pavement edges before traffic is allowed on the pavement. Opening to traffic shall not constitute a final acceptance of the pavement.

6.4.8.7. **Defects**

The City will allow either flexural or compressive Quality Control Testing at the Contractors expense. The Contractor shall be responsible for process control testing of all elements of the project. Before final inspection and acceptance, tolerances and smoothness shall be tested by means of surface-testing machine or a straightedge applied to each separate lane of pavement. All surface variations of one-eighth inch (1/8") or more in ten feet (10') shall be ground off. Brush-hammering shall not be permitted. Sections of pavement containing depressions with a depth in excess of one-eighth inch (1/8") in ten feet (10') shall be removed and replaced at the contractor's expense. Such removed sections shall not be less than full-lane width and full distance between joints in length. Slabs containing excessive cracking, fractures, spalling or other defects shall be removed and replaced as above, when directed by the Public Works Director.

6.4.9 **APPURTEAN CONCRETE STRUCTURES**

6.4.9.1. **Curb and Gutter Section**

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

6.4.9.2. **Sidewalks**

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.

6.4.9.3. **Crosspans and Curb Return Fillets**

Crosspans and curb return fillets shall be constructed eight inches (8") thick with six by six/ten/ten (6x6/10-10) wire mesh. Typical crossspan sections are shown on the detail drawings in the Appendix. Where unusual conditions prevail, additional reinforcing steel and special joints may be required by the Public Works Director.

6.4.9.4. **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 in the Appendix. Spacing will be as shown on the approved plans or as approved by the City Traffic Engineer.

6.4.9.5. **Curb Ramps**

Curb ramps for the handicapped shall be installed at locations designated by the Public Works Director or his designee and at all intersections unless approved otherwise by the Public Works Director. Curb ramps will be constructed as shown on the detail drawings in the Appendix.

6.4.9.6. **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. The contractor shall not remove stakes until three (3) working days after placement of concrete unless approved by the Public Works Director.

6.4.9.7. **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.

6.4.9.8. **Connections with Existing Concrete Curb, Gutter, 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.

6.4.10 **UTILITY POTHOLE REPAIR**
6.4.10.1. General

Contractor shall be required to restore all utility potholes in a timely fashion as determined by the Public Works Director or designee. Potholes located in pavement sections must be backfilled with approved Controlled Low Strength Material (refer to section 9.3.4). Potholes located in concrete pavement sections require replacement of entire concrete panel section. Potholes located in asphalt pavement sections require replacement of a minimum of 2 foot by 2 foot section. Refer to section 6.3.3 for pavement depth requirements.

6.5. BRIDGES AND MAJOR DRAINAGE STRUCTURES

6.5.1 GENERAL

All culvert pipe, box culverts, and bridges which will ultimately be maintained by the City of Northglenn shall conform to the following:


C. Colorado Department of Transportation’s "Bridge Manual," Volumes I and II

D. All structures shall be designed to an HS-20 loading.

E. All box culverts and bridges shall have the year of construction permanently indentured on the downstream headwall face in legible numbers. The numbers shall be three inches (3”) high by one-and-one-half inches (1-1/2”) deep in the headwall face.

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

6.6. CONSTRUCTION TRAFFIC CONTROL

6.6.1 GENERAL

Traffic control devices shall be maintained in a safe operating condition at all times. The contractor shall provide for approval by the Public Works Director or his designee, a traffic control plan, and shall comply with Chapter 8 of these STANDARDS AND SPECIFICATIONS. If the Public Works Director 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.

6.6.2 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 Manual on Uniform Traffic Control Devices, 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 Public Works Director.

C. Unless otherwise authorized by the Public Works Director, 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.

E. Facilities satisfactory to the Public Works Director shall be provided for pedestrian crossing at corners, pedestrian crossovers, and public transportation stops.

6.6.3 VEHICULAR TRAFFIC

Construction work zone traffic shall be controlled by signs, barricades, detours, etc., which are designed and installed in accordance with the Manual on Uniform Traffic Control Devices, most recent edition, and applicable City of Northglenn traffic standards. Traffic control plan shall be submitted and approved by the Public Works Director or his designee prior to start of any construction.

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 without approval from the Construction Engineer.

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-builds, construction plan drawings or other detailed map.

The Manual on Uniform Traffic Control Devices shall be the basis upon which the construction 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.
Directional access on roadways may be restricted [minimum travel lane width in construction area is ten feet (10')], but proper controls including flagging must be indicated. Removal of on-street parking should be considered and noted where applicable.

6.7. MATERIAL SPECIFICATIONS

6.7.1 SUBBASE

Subbase material, if allowed, shall be composed of granular material consisting, essentially, of sand, gravel, rock, slag, disintegrated granite or a combination of such materials. The coarse portions of the material shall be sound fragments of the crushed or uncrushed materials enumerated above. Supplied material shall be a well-graded mixture containing sufficient soil mortar, crushed dust or other proper quality binding material which, when placed and compacted in the roadway structure, will result in a firm, stable foundation. Material composed of uniform size particles or which contains pockets of excessively fine or excessively coarse material, will not be acceptable for use.

This material need not be crushed but shall be graded within the following limits:

Table 6.2 - Classification Table for Subbase

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>% Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1/2 Inch Screen</td>
<td>100</td>
</tr>
<tr>
<td>2-Inch Screen</td>
<td>95-100</td>
</tr>
<tr>
<td>#4 Mesh Sieve</td>
<td>30-60</td>
</tr>
<tr>
<td>#200 Mesh Sieve</td>
<td>5-15</td>
</tr>
</tbody>
</table>

Note: Liquid Limit -- 35 Maximum  
Plasticity Index -- 6 Maximum

6.7.2 BASE

Base material, if allowed, 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 Colorado Department of Transportation’s "Standard Specifications for Road and Bridge Construction," Section 703. Gradation shall be Class 6 (3/4-inch maximum) in accordance with the following gradation:

Table 6.3 - Classification Table for Aggregate Base Course

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>% Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4 Inch Screen</td>
<td>100</td>
</tr>
<tr>
<td>#4 Mesh Sieve</td>
<td>30-65</td>
</tr>
</tbody>
</table>
6.7.3 BITUMINOUS MATERIALS AND PAVEMENTS

6.7.3.1. **Prime Coat**

Materials shall be in accordance with the requirements of the Colorado Department of Transportation’s "Standard Specifications for Road and Bridge Construction."

6.7.3.2. **Hot Bituminous Pavement**

All pavements shall be hot bituminous pavement of the plant mix type unless otherwise approved in writing by the Public Works Director. Materials shall be in accordance with the Colorado Department of Transportation’s "Standard Specifications for Road and Bridge Construction”, Sections 702 and 703, and the following exceptions and/or requirements:

a. The asphalt cement shall be Superpave Performance Graded Binders and shall conform to the requirements listed in table 702-2 of the Colorado Department of Transportation’s “Standards and Specifications for Road and Bridge Construction” (Taken from AASHTO Provisional Standard MP1) and the following:

1) 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.

2) 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.

b. The top layer of asphalt shall be a stone matrix asphalt (SMA) or hot bituminous pavement (HBP) Grading SX. The lower layers may consist of HBP Grading SG or HBP Grading S. SMA mixes will only be required as determined by the Public Works Director. The minimum layer thickness shall be 1.5 inches and each layer should be a minimum of two times the maximum aggregate size.

c. Hot bituminous pavements shall not contain any recycled or reclaimed asphalt pavements (RAP) in the mix.

6.7.3.3. **Tack Coat**
When is specified on the approved plans or required by the Public Works Director, all materials shall be in accordance with the requirements of the Colorado Department of Transportation’s Standard Specifications for Road and Bridge Construction. Bituminous material shall be SS-1h emulsion.

6.7.3.4. Seal Coat

When seal coat is required, all materials shall be in accordance with the requirements of the Colorado Department of Transportation’s Standard Specifications for Road and Bridge Construction. The type of bituminous material, cover aggregate and rates of application will be as shown on the approved construction plans.

6.7.3.5. Rejuvenating Agent

When a rejuvenating agent is specified on the approved construction plans or required by the Public Works Director, all materials shall be in accordance with the requirements of the Colorado Department of Transportation’s Standard Specifications for Road and Bridge Construction. The rejuvenating agent shall be as shown on the approved construction plans or as specified by the Public Works Director.

6.7.3.6. Appurtenant Structures Concrete

Concrete used in the construction of curb, gutter, sidewalk, drive cuts and other appurtenant roadway concrete structures shall be in accordance with Chapter 6 of these STANDARDS AND SPECIFICATIONS.

6.7.3.7. Structure Backfill Material

Structure backfill shall comply with Colorado Department of Transportation’s specifications for Class I material. Flowfill may be required in lieu of Class 1 backfill as determined by the Public Works Director.

6.7.4 PORTLAND CEMENT CONCRETE PAVEMENT -- MATERIALS

6.7.4.1. General

Concrete materials, including fine aggregates, course aggregates, Portland cement, forms, reinforcing steel, water, joints, metal supports, expansion tubes, curing materials, admixtures and bonding agents shall comply with the Colorado Department of Transportation’s Standard Specifications for Road and Bridge Construction (Latest Edition.). Fly ash shall not be used unless prior approval is given by the Public Works Director.

6.7.4.2. Test Specimens

The contractor shall furnish the concrete necessary for casting test cylinders. See Table 6.1 for the cylinders test requirements.
### Table 6.4 - Concrete Cylinder Test Requirements

<table>
<thead>
<tr>
<th>Type of Test</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gradation (aggregate)</td>
<td>1 per 2500 sq. yard or fraction thereof for each size aggregate</td>
</tr>
<tr>
<td>Moisture Content, fine aggregate</td>
<td>1 per day or as often as needed for quality control</td>
</tr>
<tr>
<td>Moisture Content, coarse aggregate</td>
<td>1 per day minimum where moisture content is +0.5 percent from SSD condition</td>
</tr>
<tr>
<td>Slump</td>
<td>1 per set of cylinders and as often as needed for quality control</td>
</tr>
<tr>
<td>Air Content</td>
<td>1 per set of cylinders and as often as needed for quality control</td>
</tr>
<tr>
<td>Yield and Cement Factor</td>
<td>1 per set of cylinders and as often as needed for quality control</td>
</tr>
<tr>
<td>Compressive Strength</td>
<td>1 set of four (4) cylinders per 5000 sq. yards or major fraction thereof on each day pavement is placed, with two (2) cylinders to be field-cured. One additional set shall be made if the contractor intends to open early for traffic</td>
</tr>
<tr>
<td>Thickness</td>
<td>1 per 1250 linear feet each traffic lane on freshly finished concrete and as often as needed for quality control</td>
</tr>
</tbody>
</table>

The degree and frequencies of all concrete testing beyond normal specified frequencies, if necessary to assure quality control, shall be determined by the Public Works Director at the time of concrete construction. All concrete testing necessary beyond normal specified frequencies to assure quality control shall be paid for by the contractor.

### 6.7.5 PORTLAND CEMENT CONCRETE PAVEMENT -- EQUIPMENT

#### 6.7.5.1. General

All equipment necessary for the proper preparation of the subgrade, placing, finishing and curing of the concrete pavement shall be on the project in good working condition and shall have been inspected by the Public Works Director or designed before the contractor will be permitted to begin paving operations. Throughout construction, the contractor shall maintain sufficient, adequate equipment to assure the proper execution of the work.

#### 6.7.5.2. Roller
Final subgrade compaction shall be by means of a self-propelled roller having a weight on the rear wheels of the roller of not less than two-hundred-and-fifty (250) pounds per inch of tread. Vibratory rollers may be used with the permission of the Public Works Director. The use of rubber-tired rollers is encouraged.

6.7.5.3. **Subgrade Planer**

The subgrade planer shall have an adjustable cutting edge which shall be set to leave the subgrade at the elevation necessary to produce pavement of the thickness shown on the plans. Each end of the planer shall be supported on the forms by means of two rollers with sufficient spacing to maintain stability. The planer shall be of sufficient weight to maintain contact with the forms during planing operations. Wheels or rollers on previously-placed concrete shall be rubber-faced and shall be adjusted so that bearing on concrete shall not be less than three inches (3”) from the edge of a pavement.

6.7.5.4. **Forms**

Side forms shall be made of metal except on curves of less than an one-hundred-foot (100’) radius where wooden forms may be used. Forms shall have base width of not less than eight inches (8”) for all forms more than eight inches (8”) in height. All side forms less than eight inches (8”) in height shall have a base width of not less than six inches (6”). The minimum length of each section of form used shall be ten feet (10’). Each section of form shall be straight and free from bends or warps.

The maximum deviation of the top surface of any section shall not exceed one-eighth inch (1/8”). The inside face shall not deviate more than one-fourth inch (1/4”) from a straight line. The method of connection between sections shall be such that the joint thus formed shall be free from movement in any direction. Forms shall be of such cross-section and strength and so secured as to resist the pressure of the concrete when placed and the impact and vibration of any equipment which they support without springing or settlement.

Each ten-foot (10’) length of form shall have at least three (3) form braces and pin sockets which shall be spaced at intervals of not more than five feet (5’), having the end brace and socket not less than six inches (6”) from the end of the form.

Forms that are not required to support a mechanical finishing machine, subgrade planer or other similar heavy equipment may, upon approval of the Public Works Director, be made of wood. They shall have sufficient stiffness and be so staked to remain vertical and true to lines and grade during the placing and finishing of the concrete. Straight wood forms shall have a thickness of not less than one-and-one-half inches (1-1/2”). Wood forms used at intersection radius points may be one-fourth inch (1/4”) thick. All wood forms shall be dressed on the side supporting the concrete and on their upper edge.

Curb forms, if used, shall be made of steel, except where returns of small radius or other special sections make the use of steel forms impractical. Back forms for curbs shall be rigidly attached to the side forms for the pavement slab using all the fastening provided by the manufacturer of the forms. Slip forms or curb mules may be used.
6.7.5.5.  **Vibrators**

Vibratory units shall be capable of frequencies of not less than ten thousand (10,000) vibrations per minute in air and shall produce vibration in vertical and horizontal planes and ensure a downward vibration of intensity as great as in other directions to provide thorough vibration through the full depth of the concrete. The unit shall be adjustable to approximately the cross-section of the finished surface. Vibration shall not be used as a means to cause concrete to flow or run into position in lieu of placing and shall not be prolonged to the point where segregation occurs.

6.7.5.6.  **Finishing Equipment**

A screed or template shall be used to roughly strike off the first layer of concrete to permit placing of required reinforcement in the specified position.

The contractor shall furnish an approved mechanical finishing machine of the screeding and troweling type. It shall be designed and operated both to strike off and to consolidate. The finishing machine shall be of adequate strength to withstand severe use and shall be fully and accurately adjustable to make the pavement conform to the required cross-section shown on the plans. If it is necessary to operate one or both sets of wheels on previously-placed concrete, they shall be rubber-faced and shall be adjusted so that bearing on concrete will not be less than three inches (3") from the edge of the pavement.

Such additional hand equipment -- including but not limited to wooden floats, straightedges, bridges, edgers, etc. required for proper finishing -- shall be furnished by the contractor.

6.7.5.7.  **Concrete Saw**

When sawing joints, the contractor shall provide sawing equipment adequate in number of units and power to complete the sawing with a water-cooled diamond-edge saw blade or an abrasive wheel to the required dimensions and at the required rate. The contractor shall provide at least one stand-by saw in good working order and meeting the same requirements as stated above. An ample supply of saw blades shall be maintained at the site of the work at all times during sawing operations. The contractor shall provide adequate artificial lighting facilities for night sawing. All of this equipment shall be on the job both before and continuously during concrete placement.

6.7.6  **PORTLAND CEMENT CONCRETE PAVING -- MIXING**

6.7.6.1.  **General Mixing**

Concrete may be mixed in a central mix plant, or in truck mixers. The mixer shall be of an approved type and capacity. Mixing time shall be measured from the time all materials, except water, are placed in the drum.

The time elapsing from the time water is added to the mix (or cement comes in contact with aggregate) until the concrete is deposited in place at the site of the work shall not
exceed forty-five (45) minutes when the concrete is hauled in non-agitating trucks nor ninety (90) minutes when hauled in truck mixers or agitating trucks. The contractor may use approved mixes utilizing admixtures which conform to AASHTO M 194, latest edition, Types A, B, and D. The use of AASHTO M 194 admixtures Types C and E may be used only when specifically provided for in the contract or upon written permission from the Public Works Director.

6.7.6.2. Stationary Mixing

When mixing or in a central mixing plant, the mixing time shall not be less than fifty (50) seconds nor more than ninety (90) seconds. Four (4) seconds shall be added to the specified mixing time if timing starts the instant the skip reaches its maximum raised position. Mixing time ends when the discharge chute opens. Transfer time in multiple drum mixers is included in mixing time. The contents of an individual mixer drum shall be removed before a succeeding batch is emptied therein.

The volume of concrete mixed per batch may exceed the mixer's nominal capacity in cubic feet, as shown on the manufacturer's standard rating plate on the mixer, up to ten percent (10%) provided concrete test data for strength, segregation, and uniform consistency are satisfactory and provided spillage of concrete does not occur.

The batch shall be charged into the drum such that a portion of the mixing water shall enter in advance of the cement and aggregates. The flow of water shall be uniform and all water shall be in the drum by the end of the first fifteen (15) seconds of the mixing period. The throat of the drum shall be kept free of accumulations that may restrict the free flow of materials into the drum.

The timing device on stationary mixers shall be equipped with a bell or other suitable warning device adjusted to give a clearly audible signal each time the lock is released. In case of failure of the timing device, the contractor will be permitted to operate while it is being repaired, provided he furnishes an approved timepiece equipped with minute and second hands. If the timing device is not placed in good working order within twenty-four (24) hours, further use of the mixer will be prohibited until repairs are made.

6.7.6.3. Ready-Mixed Concrete

The use of ready-mixed concrete in no way relieves the contractor or developer of the responsibility for proportion, mix, delivery or placement of concrete. All concrete must conform to all requirements of these STANDARDS AND SPECIFICATIONS and ASTM C-94 and AASHTO M 157.

The City shall have free access to the mixing plant at all times. The organization supplying the concrete shall have sufficient plant and transportation facilities to assure continuous delivery of the concrete at the required rate. (The contractor will collect delivery or batch, tickets from the driver for all concrete used on the project and deliver them to the Public Works Director.) Batch tickets shall provide the following information:

a. Weight and type of cement
b. Weights of fine and coarse aggregates  
c. Volume (in gallons) of water, including surface water on aggregates  
d. Quantity (cubic yards) per batch  
e. Times of batching and discharging of concrete  
f. Name of batch plant  
g. Name of contractor  
h. Type of mixture (mix designation code)  
i. Name and amount of admixture  
j. Date and truck number  

6.7.6.4. **Mixing Proportions of Concrete Materials**

Proportioning shall conform to the requirements set forth in for the Colorado Department of Transportation’s Standard Specifications for Road and Bridge Construction (Latest Edition).

6.7.6.5. **Limitations of Mixing**

Concrete shall be mixed, placed and finished only when the natural light is sufficient unless an adequate and approved artificial lighting system is provided. Unless authorized in writing by the Public Works Director, mixing and concreting operations shall be discontinued when a descending air temperature in the shade and away from artificial heat reaches forty degrees Fahrenheit (40°F) and not resumed until an ascending air temperature in the shade and away from artificial heat reaches thirty-five degrees Fahrenheit (35°F).

When concreting is authorized during cold weather, the aggregates may be heated by either steam or dry heat prior to being placed in the mixer. The apparatus used shall heat the mass uniformly and shall be arranged to preclude the possible occurrence of overheated areas which might injure the materials. Unless otherwise authorized by the Public Works Director, the temperature of the mixed concrete shall not be less than fifty degrees Fahrenheit (50°F) and not more than eighty degrees Fahrenheit (80°F) at the time of placing it in the forms.

If the air temperature is thirty-five degrees Fahrenheit (35°F) or less at the time of placing concrete, it will be required that the water and/or the aggregate be heated to not less than seventy degree Fahrenheit (70°F) nor more than one-hundred-fifty degrees Fahrenheit (150°F). Concrete shall not be placed on frozen subgrade nor shall frozen aggregates be used in the concrete. In concreting operations during the summer months, maximum temperature of the mixed concrete shall not exceed ninety degrees Fahrenheit (90°F).

In cold weather, aggregates and water may be heated as part of the batching operation but they shall not be heated beyond a temperature of one-hundred-fifty degrees
Fahrenheit (150°F). Aggregates shall not be heated directly by gas or oil flame or on sheet metal over direct flame. Materials containing frost or lumps of frozen material shall not be used in the mix and their presence in the concrete shall be cause for rejection of that batch.