CHAPTER 7 CONCRETE

7.1. INTRODUCTION

7.1.1 GENERAL

This specification enumerates the requirements for the materials, storage, transportation, measuring, mixing, placing and curing of Portland cement concrete. This specification applies to all Portland cement concrete used in sidewalks, driveways, approaches, patches, manholes, inlets and other structures constructed in the City of Northglenn. Specifications for Portland cement concrete pavement are in Chapter 6 of these STANDARDS AND SPECIFICATIONS. Engineering plans, licenses, permits, inspection, warranty and acceptance shall be as detailed in these STANDARDS AND SPECIFICATIONS for the applicable type of construction involved. Permits shall be obtained before work begins. The contractor shall contact the Public Works Department twenty-four (24) hours in advance of concrete placement when the form work is ready to receive the concrete. Where required, compaction test results shall verify the adequacy of all ground upon which concrete is to be placed.

7.1.2 DESIGN STANDARDS

Design criteria for the various elements using concrete are specified in other chapters of this document. Design specifications for sidewalks, curb and gutter, driveways, inlets, sidewalk and concrete paved streets are in Chapter 6 - Roadway. Design specifications for concrete pipe, manholes, inlets and other drainage and wastewater concrete structures are in Chapter 3 - Water System, Chapter 4 - Sanitary Sewer and Chapter 5 - Storm Sewer. Design specification relative to traffic signals and traffic control items is in Chapter 8 - Traffic Control.

7.2. PLACING CONCRETE

7.2.1 PREPARATION

Before depositing concrete, debris shall be removed from the space to be occupied by the concrete and the forms. Concrete shall not be placed until all forms and reinforcing steel have been inspected and approved by the Public Works Director. The soil receiving the concrete shall be moist, but not wet, and shall not contain frost or frozen material. Specifications for subgrade preparation are in Chapter 6 – Roadway.

7.2.2 TIMING

Concrete which has developed initial set or does not have workable consistency shall not be used. Concrete shall be continuously mixed or agitated from the time the water is added until the time of use, and shall be completely discharged from the truck mixer or truck agitator within one-and-one-half (1-1/2) hours after it comes in contact with the mixing water or with the aggregates. Retempered concrete will not be allowed.

7.2.3 CONCRETE TEMPERATURE
At the time of concrete placement, the mix temperature shall be between fifty degrees Fahrenheit (50°F) and 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-and-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.

7.2.4 HANDLING

Concrete shall be handled from the mixer to the place of final deposit as rapidly as possible by methods which prevent separation or loss of ingredient. The concrete shall be deposited in the forms as nearly as practicable in its final position to avoid rehandling. Concrete shall be deposited in continuous layers, the thickness of which generally shall not exceed twelve inches (12’). Concrete shall be placed in one continuous operation, except where keyed construction joints are shown on the plans or as approved by the Public Works Director. Delays in excess of thirty (30) minutes may require removal and replacement of that pour, as determined by the Public Works Director.

Concrete shall be placed in a manner that will avoid segregation and shall not be dropped freely more than five feet (5’). If segregation occurs, the Public Works Director may require the concrete to be removed and replaced at the contractor's expense. Necessary hand spreading shall be done with shovels and not with rakes.

Concrete shall be thoroughly compacted or vibrated. All concrete shall be compacted by internal vibration using mechanical vibrating equipment, except that concrete in floor slabs, sidewalks, or curb and gutter, not poured against form linings, shall be either tamped or vibrated. Care shall be taken in vibrating the concrete to vibrate only long enough to bring a continuous film of mortar to the surface. Vibration shall stop before any segregation of the concrete occurs. Mechanical vibrators shall be an approved type as specified in ACI Publication 309, Chapter 5 (Latest Edition). Vibrators shall not be used to move or spread the concrete. Any evidence of lack of consolidation or over consolidation will be regarded as sufficient reason to require the removal of the section involved and its replacement with new concrete at the contractor's expense. The contractor shall be responsible for any defects in the quality and appearance of the completed work. A backup vibrator must be onsite.

7.2.5 WORKABILITY

The consistency of concrete shall be kept uniform for each class of work and shall be checked by means of a slump tests. The workability of the concrete will be varied as directed by the Public Works Director. At all times, concrete shall have a consistency such that it can be worked into corners and angles of the forms and around joints, dowels and tie bars by the construction methods which are being used without excessive spading, segregation or undue accumulation of water or laitance on the surface. If, through accident, intention or error in mixing, any concrete that fails to conform to the proportions of the approved mix design, such concrete shall not be incorporated in the work but shall be discarded off the project site as waste material at the contractor's expense. NO WATER MAY BE ADDED AT THE JOB SITE WITHOUT
PERMISSION OF THE PUBLIC WORKS DIRECTOR or his representative. If approval is obtained and water is added at the job site, slump tests shall be run and test cylinders cast following the addition of the water. Any expense incurred in excess of ordinary tests will be borne by the contractor.

7.2.6 **WEATHER RESTRICTIONS**

7.2.6.1. **Hot Weather:**

Except by written authorization, concrete will not be placed if the temperature of the plastic concrete cannot be maintained at ninety degrees Fahrenheit (90°F) or lower. The placement of concrete in hot weather shall comply with ACI 305 (Latest Edition).

7.2.6.2. **Cold Weather:**

During extreme weather conditions, placing of concrete will be permitted only when the temperature of the concrete placed in the forms will not be less than fifty degrees Fahrenheit (50°F), nor more than ninety degrees Fahrenheit (90°F). To maintain this temperature range, the contractor shall provide acceptable heating apparatus for heating the aggregates and the water. Concrete slabs shall not be placed, regardless of temperature conditions, if the supporting ground is frozen or contains frost. Use of salt or other additives to prevent concrete from freezing will not be allowed. Concrete which has been frozen shall be completely removed and replaced as directed by and to the satisfaction of the Public Works Director.

Concrete may be placed when the air temperature in the shade is at least forty degrees Fahrenheit (40°F) and rising. No concrete shall be placed, regardless of the present temperature, when the weather forecast promises freezing weather before final set of the concrete unless special means of heating and protection are used. Protection against freezing is the contractor's responsibility regardless of the weather forecast or climatic conditions at the time of placing. During cold weather conditions, concrete less than seventy-two (72) hours old shall be protected as follows:

**Table 7.1 - Concrete placement Temperature Protection Requirements**

<table>
<thead>
<tr>
<th>Forecast Low Temperature (per National Weather Service)</th>
<th>Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between 40 and 32 Degrees</td>
<td>One layer of plastic or burlap</td>
</tr>
<tr>
<td>Between 31 and 25 Degrees</td>
<td>One layer of plastic and one layer of burlap, or two layers of burlap</td>
</tr>
<tr>
<td>Below 25 Degrees</td>
<td>Six inches (6&quot;) of hay or straw and two layers of plastic or burlap in addition to regular curing method, or equivalent commercial insulating material in addition to regular curing method</td>
</tr>
</tbody>
</table>
These coverings must remain in place until the concrete is at least five (5) days old. When straw is required on concrete and the concrete is cured with only curing compound, the fresh concrete shall be covered with a layer of burlap or plastic before application of straw. Heated enclosures may be utilized in lieu of protection requirements cited above. If used, such enclosures shall be maintained for seven (7) days.

7.2.7 JOINTING

7.2.7.1. Expansion Joints:

Expansion joint material shall be provided at the following locations and shall be in place prior to the placing of concrete:

a. Between new concrete and existing masonry buildings
b. As shown on the drawings
c. As directed by the Public Works Director

7.2.7.2. Contraction Joints:

Transverse joints shall be placed at maximum intervals of ten feet (10') to control random cracking. Joints shall be formed, sawed or tooled to a minimum depth of one-third (1/3) of the total thickness, but no less than 1.5 inches. Contraction joints shall be placed as follows:

a. Not more than ten feet (10') nor less than six feet (6') apart in curb and gutter and combination curb-walk.
b. Not more than the walk width in non-monolithic concrete sidewalk.
c. At least two joints equally spaced at not greater than ten-foot (10') intervals as applicable in driveways.
d. As approved and shown on the plans for special concrete structures.

7.2.8 FINISHING AND CURING

In addition to the curing techniques unique to hot and cold weather placement, adequate attention shall be given to finishing and curing the fresh concrete. Exposed faces of curbs and sidewalks shall be finished to true line and grade, as shown on the plans. The surface shall be floated to a smooth, but not slippery finish. The addition of surface water to assist in the finishing process is prohibited. Sidewalk and curb shall be broomed or combed and edged, unless otherwise indicated by the Public Works Director. After completion of brooming and before concrete has taken its initial set, all edges in contact with the forms shall be tooled with an edger having a three-eighths-inch (3/8") radius. No dusting or topping of the surface or sprinkling with water to facilitate finishing will be permitted.
Immediately following the removal of the forms, all fins and irregular projections shall be removed from all surfaces except from those which are not to be exposed or are not to be waterproofed. On all surfaces cavities produced by form ties, honeycomb spots, broken corners or edges and other defects shall either be thoroughly cleaned, moistened with water and carefully pointed and trued with a mortar consisting of cement and fine aggregate or removed and replaced at the direction of the Public Works Director. The surface shall be left sound, smooth, even and uniform in color. Mortar used in pointing shall not be more than thirty (30) minutes old. All construction and expansion joints in the completed work shall be left carefully tooled and free of all mortar and concrete. The joint filler shall be left exposed for its full length with clean and true edges.

Fresh concrete shall be adequately protected from weather damage and mechanical injury during the curing periods. The selected curing process shall be started as soon as it can be done without injury to the concrete surface. The use of a membrane-curing compound is recommended. The following curing procedures may be used subject to the approval of the Public Works Director.

7.2.8.1. **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 that 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 so placed and weighted down so it remains in contact with the surface covered, and the 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.

7.2.8.2. **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 such dimensions 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 secure such that they do not open up or separate. The plastic shall be placed and weighted so it remains in contact with the surface covered, curing the entire curing period of seven (7) days.

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

**7.2.8.4. Liquid Curing Membrane:**

Immediately after the surface water has disappeared from the concrete surface, the liquid membrane curing compound (white pigmented) shall be sprayed under pressure to the concrete surface at a rate not less than one (1) gallon per one-hundred-fifty (150) square feet with a spray nozzle or nozzles, so it covers the entire pavement with a uniform water-impermeable film. If the forms are removed within seven (7) days, the exposed sides and edges shall be sprayed in the above-described manner or the backfill completed immediately.

**7.2.8.5. Insulation Pad:**

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

Wax base and resin base solutions shall not be used if linseed oil protection is to be applied to the concrete surface. If linseed oil protection is to be utilized, the method of curing shall be either linseed oil base curing compound, wet burlap, plastic sheet or waterproof paper curing.

**7.2.9 TESTING OF CONCRETE**

The requirements of this section shall apply to testing services for all concrete curb and gutter, sidewalk, slope paving, retaining walls, structures and for all miscellaneous concrete testing. Testing for concrete pavement shall be in accordance with Chapter 6 of these STANDARDS AND SPECIFICATIONS.

The contractor shall furnish the concrete necessary for casting test cylinders. See Table 7.2 for the cylinders test requirements.

**Table 7.2 - 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>
</tbody>
</table>
### Air Content
1 per set of cylinders and as often as needed for quality control

### Yield and Cement Factor
1 per set of cylinders and as often as needed for quality control

### Compressive Strength
1 set of four (4) cylinders per 50 cubic yards or major fraction thereof on each day pavement is placed, with two (2) cylinders to be field-cured and 1 additional set shall be made if the contractor intends to open early for traffic

### Thickness
1 per 1250 linear feet each traffic lane on freshly finished concrete and as often as needed for quality control

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 shall be paid for by the Contractor/Developer.

#### 7.2.10 REPAIRS

After stripping of the forms, if any concrete is found to be not formed as shown on the drawings or is out of alignment or level or shows a defective surface, it shall be considered as not conforming with the intent of these STANDARDS AND SPECIFICATIONS and shall be removed and replaced by the contractor at his expense unless the Public Works Director gives written permission to patch the defective area. In this case, patching shall be done as described in the following paragraphs. Defects that require replacement or repair are those that contain honeycomb, damage due to stripping of forms, loose pieces of concrete, bolt holes, tie-rod holes, uneven or excessive ridges at form joints and bulges due to movement of the forms and other deficiencies identified in the acceptance and warranty inspection. Ridges and bulges shall be removed by grinding. Honeycombed and other defective concrete that does not affect the integrity of the structure shall be chipped out and the vacated areas shall be filled in a manner acceptable to the Public Works Director. The repaired area shall be patched with a non-shrink, non-metallic grout with a minimum compressive strength of five thousand (5000) psi in twenty-eight (28) days. All repair areas treated with an epoxy bonding agent shall have the approval of the Public Works Director before the repair filling is placed.

Bolt holes, tie-rod holes and minor imperfections as approved by the Public Works Director shall be filled with dry-patching mortar composed of one (1) part Portland cement to two (2) parts of regular concrete sand (volume measurement) and only enough water so that after the ingredients are mixed thoroughly the mortar will stick together on being molded. Mortar repairs shall be placed in layers and thoroughly compacted by suitable tools. Care shall be taken in filling rod and bolt holes so that the entire depth of the hole is completely filled with compacted mortar. The mortar mix proportions described above are approximate.
An approved mix shall be prepared by a commercial testing laboratory to ensure that grout has a twenty-eight (28) day compressive strength equal to that of the area on which it is placed. All costs for mix design and testing shall be paid by the contractor. Those areas with excessive deficiencies as determined by the Public Works Director shall be removed and replaced at the contractor's expense. Where repairs are made in existing sidewalks, all edges of the old sidewalk allowed to remain shall be saw-cut to a minimum depth of two inches (2”). No rough edges will be permitted where new construction joins the old section. Unless directed by the Public Works Director, no section less than five feet (5’) in length shall be placed or left in place. Where new sidewalk construction abuts existing sidewalks, the work shall be accomplished so that there is no abrupt change in grade between the old section and the new work.

7.3. MATERIAL SPECIFICATIONS

7.3.1 CONCRETE MIX DESIGN

Concrete shall be classed according to the Colorado Department of Transportation’s Standard Specifications for Road and Bridge Construction (Latest Edition.).

7.3.2 CONCRETE MATERIALS

Concrete shall be composed of Portland cement and aggregate and water and shall be reinforced with steel bars, steel strands or steel-wire fabric where required. All concrete and steel components shall conform to the requirements of the Colorado Department’s of Transportation’s Standard Specifications for Road and Bridge Construction (Latest Edition). No admixture other than air-entraining agents shall be used without written permission of the Public Works Director.

7.3.3 CURING MATERIALS

Curing materials shall conform to the applicable section of the AASHTO standards (Latest Edition). Straw used for curing shall consist of threshed straw of oats, barley, wheat or rye. Clean field or marsh hay may be substituted when approved by the Public Works Director. Old dry straw or hay which breaks readily in the spreading process will not be permitted.

7.3.4 FORM WORK

Whenever necessary, forms shall be used to confine the concrete and shape it to the required lines. Forms shall have sufficient strength to withstand, without deformation, the pressure resulting from placement and vibration of the concrete. Forms shall be constructed so that the finished concrete will conform to the shapes, lines, grades and dimensions indicated on the approved plans. Any form which is not clean and has not had the surface prepared with a commercial form oil that will effectively prevent bonding and that will stain or soften concrete surfaces shall not be used. Plywood forms, plastic coated plywood forms or steel forms shall be used for all surfaces requiring forming which are exposed to view, whether inside or outside any structure. Surfaces against backfilled earth, interior surfaces, of covered channels or other places permanently obscured from view may be formed with forms having substandard surfaces.
Forms shall not be disturbed until the concrete has hardened sufficiently to permit their removal without damaging the concrete or until the forms are not required to protect the concrete from mechanical damage. Minimum time before removal of forms after placing concrete shall be one (1) day for footings and two (2) days for all other concrete except curbs, gutters, and sidewalks.

7.3.5 JOINTING MATERIAL

Joint materials, according to type, will conform to the applicable AASHTO specifications (Latest Edition).

7.3.6 BATCHING AND MIXING

7.3.6.1. General

All concrete shall be thoroughly mixed in a batch mixer of an approved type and capacity for a period of not less than two (2) minutes after all the materials, including the water, have been placed in the drum. During the period of mixing, the drum shall be operated at the speed specified by the manufacturer of the equipment. The entire contents of the mixer shall be discharged before recharge, and the mixer shall be cleaned frequently. The concrete shall be mixed only in such quantities that are required for immediate use. No retempering of concrete will be permitted. Hand-mixed concrete will not be permitted except by written approval of the Public Works Director and then in only very small quantities or in case of an emergency.

7.3.6.2. Proportioning the Mix

Proportioning the dry constituents of all concrete mixtures shall be accomplished by weighing. The supplier shall provide adequate and accurate scales for this work. There shall be no variance permitted in the minimum cement factor (sacks per cubic yard) as specified for the classes of concrete. The total quantity of mixing water per sack of cement, including free water in the aggregate, shall not exceed the minimum specified herein. The supplier shall be responsible for developing the proper proportions of aggregates, cement, and water that will conform to the various requirements of these STANDARDS AND SPECIFICATIONS.

7.3.6.3. 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 shall conform to all requirements of these STANDARDS AND SPECIFICATIONS and applicable ASTM standards (Latest Edition).

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 shall collect delivery or batch tickets from the driver for all concrete used on the project and deliver
them to the Public Works Director or his designee. Batch tickets shall provide the following information:

a. Supplier’s name and date  
b. Truck number  
c. Project number and location  
d. Concrete class designation  
e. Cubic yards batched  
f. Time batched  
g. DOH mix design number  
h. Type, brand, and amount of cement and fly ash  
i. Brand and amount of any admixture  
j. Weights of fine and coarse aggregates  
k. Moisture content of fine and coarse aggregates  
l. Gallons of batch water (including ice)  
m. Gallons of water added by truck operator.

Provide the following titles with blank space to record information:

1) Discharge time  
2) Water-cement ratio  
3) Air content