

**CHAPTER 6 - BRIDGES AND MAJOR DRAINAGE STRUCTURES**

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## CHAPTER 6 BRIDGES AND MAJOR DRAINAGE STRUCTURES

### 6.1 GENERAL

The developer/owner/applicant shall be responsible to fund an independent review of the design construction plans and all necessary independent field inspections. The independent review and inspection contractor shall be specified by and shall contract with Arapahoe County and the developer/owner/applicant shall be responsible for all associated costs through Final Acceptance.

### 6.2 Pipe, Culvert and Bridge Criteria

**6.2.1** All culvert pipe, box culverts and bridges which will ultimately be maintained by Arapahoe County shall conform to:

- a. AASHTO (American Association of State Highway Transportation Officials), "LRFD Bridge Design Specifications, U.S.", latest edition and applicable interims.
- b. AASHTO, "LRFD Standard Specifications for Transportation Materials and Methods of Sampling and Testing", latest edition and applicable interims.
- c. CDOT (Colorado Department of Transportation), "Standard Specifications for Road and Bridge Construction", latest edition and Standard Special Provisions and Bridge Specific Project Special Provisions.
- d. CDOT, "Bridge Manual", latest edition and Bridge Technical Memorandums.
- e. CDOT, "Bridge Detail Manual", latest edition.
- f. CDOT, "Structural Worksheets", latest edition.
- g. CDOT, "Construction Manual", latest edition.
- h. CDOT, "Field Testing Manual", latest edition.

**6.2.2** Any structure over a 20 ft. span must be designed to an HL-93 vehicular live loading.

**6.2.3** All box culverts and bridges shall have the year of construction permanently indented on the downstream headwall face in legible numbers. The numbers shall be 3" high by 1½" deep in the headwall face.

**6.2.4** All box culverts and bridge designs shall be certified by a Colorado registered professional engineer who is competent to perform such designs.

**6.2.5** Culvert and bridge waterway opening designs shall conform to the parameters set forth in the Arapahoe County "Drainage Criteria Manual", latest edition.

### 6.3 CONCRETE STRUCTURE TESTING AND INSPECTIONS

This section delineates the testing, inspection and related documentation requirements for bridges, cast-in-place box culverts and concrete lined channels.

#### 6.3.1 Plan and Specifications Review

It is the owner/developer's responsibility to familiarize the materials testing firm with the plans and specifications approved by Arapahoe County prior to any construction.

**6.3.2 Structural and Inspection Requirements - General**

The contents of this paragraph are provided as a convenient reference only because they are anticipated to be the most frequently used provisions of the Colorado Department of Transportation Standard Specifications for Road and Bridge Construction. This section is not the complete requirements and criteria to be used for testing and inspection.

**6.3.2.1** The design structural engineer or his representative, familiar with assumptions inherent in the structural design, shall review the construction in sufficient detail to confirm that the construction is appropriate.

**6.3.2.1** Inspection of construction shall be provided, as frequently as necessary to confirm that the construction conforms to the plans and specifications, by qualified technical personnel experienced in the inspection of similar structures. A written log or report of all work shall be furnished to Arapahoe County at or prior to the request for probationary acceptance of the bridge or major drainage structure.

**6.3.3 Material Testing Requirements - General**

Testing of materials shall conform to the requirements of AASHTO “LRFD Bridge Design Specifications, U.S., Division II, Construction”, latest edition and applicable interims, CDOT, “Construction Manual”, latest edition, and CDOT, “Field Testing Manual”, latest edition.

**6.3.4 Foundation Testing and Inspection Requirements**

Unstable foundation material shall be removed to a minimum of 2 feet below the finish grade elevation and be replaced with a Class 2 structural backfill material. If there is no suitable Class 2 material available on site, Class 1 structural backfill shall be used, which meets the following gradation requirements:

**TABLE 6.1**

**CLASS 1 STRUCTURAL BACKFILL**

Sieve Size	Mass Percent Passing Square Mesh Sieves
2”	100
No. 4	30-100
No. 50	10-60
No. 200	5-20

In addition this material shall have a liquid limit not exceeding 35 and a plasticity index of not over six when determined in conformity with AASHTO T 89 and T 90 respectively.

Testing of the foundation will be done at random locations with a minimum depth requirement of one-foot (1’) and the minimum moisture and density for the foundation material as required by T 99 or T 180. If Class 2 structural backfill material is used, the minimum moisture shall not be lower than two (2) percentage points under optimum moisture at 95% compaction as determined by AASHTO T 180 modified, tested at random through the depth of the fill.

### **6.3.5 Inspection of Forms and False work**

- a.** The inside surfaces of forms shall be clean of all dirt, mortar and foreign material. Forms, which will later be removed, shall be thoroughly coated with approved form oil prior to use.
- b.** Forms shall be mortar tight and sufficiently rigid to prevent distortion due to the pressure of the concrete and other loads incidental to the concrete operations, including vibration.
- c.** Unless otherwise specified, forms for exposed surfaces shall be constructed with triangular fillets  $\frac{3}{4}$  in. x  $\frac{3}{4}$  in. at all exterior corners.
- d.** The contractor shall be responsible for designing and constructing false work, which provides the necessary rigidity, supports the loads imposed, and produces in the finished structure the lines and grades indicated on the plans.
- e.** False work shall not be removed until sufficient concrete compressive strengths have been achieved per the CDOT "Standard Specifications for Road and Bridge Construction", latest edition.

### **6.3.6 Inspection of Reinforcing Steel**

- a.** The material grade and size shall be as specified by the Registered Professional Engineer, licensed in the State of Colorado, on the certified construction drawings.
- b.** Placing and Fastening.
  - 1.** Reinforcing steel shall be clean and free of all foreign material before concrete is placed.
  - 2.** The minimum spacing center to center of parallel bars shall be  $2\frac{1}{2}$  times the diameter of the bar. However, the clear distance between the bars shall not be less than  $1\frac{1}{2}$  times the maximum size of the coarse aggregate or 1½ inches, whichever is greater.
  - 3.** Bundle bars shall be tied together at not more than 6-foot centers.
  - 4.** All reinforcing shall have a clear coverage of 2 inches, except as shown on the plans. Clear coverage shall be measured from the surface of the concrete to the outside of the reinforcement.
  - 5.** All reinforcement shall be tied at all intersections except where spacing is less than 1 foot in each direction, in which case alternate sections shall be tied.
  - 6.** In concrete bridge decks the upper mat of bars shall be tied to the lower mat of bars at 4-foot maximum spacing in each direction. Slab bolsters for the bottom mat and high chairs for the top mat shall be placed at a maximum spacing of 4 feet on centers.

7. Precast concrete blocking or other approved blocking material shall be used to support footing bars and bars in slabs on grade. All other reinforcing steel shall be supported with steel chairs or precast mortar blocks. All chairs coming in contact with forms shall be CRSI Class 1 or Class 2, Type B.
8. Minimum splice lengths are as shown on the plans. Where bars of different size are spliced together, the splice length for the smaller bar will govern.

### 6.3.7 Concrete Testing and Inspection

#### 6.3.7.1 Materials Specifications

- a. Class B or D concrete shall be used on structure as listed on the following tables.

Table 6.2 Concrete Materials Specifications  
Table 6.3 Concrete Aggregate Gradation Table

**TABLE 6.2**

**CONCRETE MATERIAL SPECIFICATIONS\***

Concrete Class	Required 28 Day Field Compressive Strength (psi)	(1) Cement Content Minimum or Range (lbs/cu yd)	Air Content % Range (Total)	Additional Requirements
B	3000	565	5 – 8	(2) (4) (6) (7)
D	4500	615 to 660	5 – 8	(3) (5) (6) (7)

- (1) The cement content tolerance of + or – 1% specified in AASHTO M 157 will be allowed.
- (2) Class D concrete may be substituted for Class B.
- (3) Class D concrete requires the use of an approved water reducing admixture.
- (4) Class B Concrete shall be used when Standard Plans specify Class A concrete.
- (5) Bridge deck concrete shall have a maximum water /cement (w/c) ratio of 0.44. In determining the w/c ratio, the cement (c) shall be the sum of the weight of the cement and the weight of the fly ash.
- (6) The slump of the delivered concrete shall not exceed the slump of the approved concrete mix design by more than 1½ inches.
- (7) Superstructure concrete shall be made with ¾ inch nominal sized coarse aggregate: 100% passing the 1 inch sieve and 90% to 100% passing the ¾ inch sieve. All other concrete shall have a nominal coarse aggregate size of 1½ inches or smaller: 100% passing the 2" sieve and 95% to 100% passing the 1 ½ inch sieve. Bridge deck concrete shall contain a minimum of 55% of AASHTO Size No. 67 coarse aggregate.

NOTE: Concrete mixtures that do not conform to the above table, but are required for special uses will be designed for the purpose intended. These include light weight concrete, colored concrete, lean concrete, grouting mixtures, patching mixtures and concrete that require special cements, pozzolans or aggregates not covered in the Standard Specifications.

\*From the CDOT Standard Specifications Section 601.02.

**TABLE 6.3**

**CONCRETE AGGREGATE GRADATION TABLE\*  
PERCENTAGES PASSING DESIGNATED SIEVES AND NOMINAL SIZE DESIGNATION**

Sieve Size	Coarse Aggregates (From AASHTO M 43)									Fine Aggregate
	No. 3	No. 4	No. 6	No. 7	No. 8	No. 57	No. 67	No. 357	No. 467	AASHTO M 6
	2" to 1"	1 1/2" to 3/4"	3/4" to 3/8"	1/2" to #4	3/8" to #8	1" to #4	3/4" to #4	2" to #4	1 1/2" to #4	#4 to #100
2 1/2"	100							100		
2"	90-100	100						95-100	100	
1 1/2"	35-70	90-100				100			95-100	
1"	0-15	20-55	100			95-100	100	35-70		
3/4"		0-15	90-100	100			90-100		35-70	
1/2"	0-5		20-55	90-100	100	25-60		10-30		
3/8"		0-5	0-15	40-70	85-100		20-55		10-30	100
#4			0-5	0-15	10-30	0-10	0-10	0-5		95-100
#8				0-5	0-10	0-5	0-5		0-5	
#16					0-5					45-80
#50										10-30
#100										2-10

\*From the CDOT Standard Specifications Section 703.

- b. The contractor shall submit design mix proportions, laboratory trial mix and aggregate data, for each class of concrete being placed on the project.
- c. The test data shall show the mix design proportions, of all ingredients including cement, fly ash, aggregate, and additives, plus trial mix data including slump, air content, unit weight, yield, water/cement ratio, and 28 day compressive strength results as trialed under laboratory conditions.
- d. The trial mix proportions must produce 28-day compressive strengths at least 115 percent of the required 28-day field compressive strengths.
- e. The contractor shall have the option of substituting approved fly ash for portland cement, up to a maximum of 20 percent by weight, in any class of concrete shown in Table 6.2, except concrete used for bridge decks shall have a maximum substitution of 10 percent.
- f. For concrete aggregate gradation see table 6.3.
- g. Unless otherwise authorized, the temperature of the mixed concrete shall be not less than 50° F and not more that 90° F at the time of placement.

**6.3.7.2 Testing Frequency and Related Inspections**

- a. At least one set of five compressive strength cylinders per 100 cubic yards of concrete or fraction thereof shall be taken from the same concrete delivery truck to provide: 2 cylinders for testing at 7 days and 3 cylinders for testing at 28 days.

- b. Slump, air content, unit weight and mix temperature shall be tested for each set of compressive strength cylinders. Air content and unit weight shall be tested at each batch until three tests are within the specification. Then the testing frequency shall be reduced to one random test every five batches. The slump shall not exceed the mix design by more than 1½ in.

**6.3.7.3 Placement (Inspection)**

- a. Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement.
- b. Concrete shall not be dropped more than 5 feet, unless confined by closed chutes or pipes.
- c. Unless otherwise directed, the concrete shall be consolidated with suitable mechanical vibrators operating within the concrete.

**6.3.7.4** Drainage and weep holes shall be installed in the structure at the locations shown on the plans or as ordered and the inlet side shall be surrounded with one cubic foot of filter material as shown on Table 6.4 and placed in a burlap sack, securely tied.

**6.3.7.5** Filter material shall consist of free draining sand, gravel, slag or crushed stone and conform to Table 6.4.

**TABLE 6.4**

**GRADATION SPECIFICATION FOR FILTER MATERIAL\***

Sieve Size	Mass Percent Passing Square Mesh Sieves		
	Class A	Class B	Class C
3"	100		
1 ½"		100	
¾"	20-90		100
No. 4	0-20	20-60	60-100
No. 16		10-30	
No. 50		0-10	10-30
No. 100			0-10
No. 200	0-3	0-3	0-3

\*From CDOT Specifications Section 703.09

**6.3.7.6** Construction joints and expansion joints shall be constructed as shown on the plans and specifications.

**6.3.7.7** When curing concrete other than bridge decks when the ambient temperature is below 35°F, the contractor shall maintain the concrete surface temperature above 50°F during the curing period. The minimum curing period shall be five days. Methods of curing are to be in conformance with CDOT specifications. Curing of bridge decks shall follow current CDOT specifications.

#### **6.3.7.8 Finishing of Hardened Concrete Surfaces**

- a.** All formed surfaces shall be given a Class 1 finish immediately following curing.
- b.** Class 5 finish shall be the final finish for the following surfaces:
  - 1.** All surfaces of bridge superstructure including undersurfaces of deck overhangs, and vertical faces of curbs, but excluding the top of slab and sidewalk, the undersurfaces between girders, inside vertical surfaces of T girders, and undersurfaces of slab and box girder spans and T girders.
  - 2.** All exposed surfaces of bridge piers including cap and debris wall, abutments, wing walls, and retaining walls. The finish shall extend at least 1 foot below finish ground or low water elevation.
  - 3.** All surfaces of pedestrian undercrossings except floors and surfaces to be covered with earth.
- c.** Culvert headwall and wing wall surfaces above ground, where visible from a traveled way, shall receive a Class 2 or Class 5 finish at the contractor's option.

#### **6.3.8 Riprap**

Riprap material and placement shall be per the approved plans and specifications and the Arapahoe County "Drainage Criteria Manual".