

CHAPTER 6 – BRIDGES AND MAJOR DRAINAGE STRUCTURES

6.1 GENERAL

All culvert pipe, box culverts and bridges which will ultimately be maintained by the Town shall conform to:

- *AASHTO Standard Specifications for Highway Bridges*, latest edition and applicable interims.
- *CDOT Standard Specifications for Road and Bridge Construction*, latest edition.
- *CDOT Bridge Manual: Volume I and Volume II*.

6.2 STRUCTURAL DESIGN LOADINGS

Any structure over a 20 foot span must be designed to an HS-20 loading.

- 6.2.1** All box culvert and bridges shall have the year of construction permanently indented on the downstream headwall face in legible numbers. The numbers shall be 3 inches high by 1-1/2 (1.5) inches wide by approximately 3/8 inches deep in the headwall face.

6.3 CERTIFICATION OF DESIGN

All box culvert and bridge designs shall be certified by a registered Professional Engineer who is competent to perform such designs.

6.4 WATERWAY OPENING DESIGN CRITERIA

Culvert and bridge waterway opening designs shall conform to the parameters of Chapter 11 of the Bennett "Storm Drainage Design and Technical Criteria" Manual.

6.5 CONCRETE STRUCTURE TESTING AND INSPECTIONS

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

6.5.1 Plans and Specifications Review

It is the Owner/Developer's responsibility to familiarize the materials testing firm with the plans and specifications approved by the Town Engineer prior to any construction.

6.5.2 Structural and Inspection Requirements-General

The contents of this subsection 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 subsection does not contain the complete requirements and criteria to be used for testing and inspection.

6.5.2.1 The Design Structural Engineer or their representative, familiar with assumptions inherent in the structure design, shall review the construction in sufficient detail to confirm that the construction is appropriate.

6.5.2.2 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 the Town Engineer at or prior to the request for probationary acceptance of the bridge or major drainage structure.

6.5.3 Material Testing Requirements-General

Testing of materials shall conform to the requirements of AASHTO's *Standard Specifications for Highway Bridges*, latest edition, applicable interims, and applicable CDOT Standards.

6.5.4 Foundation Testing & Inspection Requirements

Unstable foundation material shall be removed to a minimum of 2 feet below the finish grade elevation and be replaced with Class 1 structural backfill material if there is no suitable material available on site. Class 1 structural backfill shall meet the requirements of Table 6.1 when tested with laboratory sieves.

SIEVE DESIGNATION	DRY SITES % Wt. PASSING LAB SIEVES	WET SITES % Wt. PASSING LAB SIEVES
2"	100	100
#4	30-100	90-100
#50	10-60	10-60
#200	5-20	0-2

In addition, this material shall have a Liquid Limit not exceeding 2S and a Plasticity Index of not over 6 when determined in conformity with AASHTO T89 and T90, respectively.

Testing of the foundation will be done at random locations with a minimum depth requirement of 1 foot and the minimum moisture and density for the foundation material as required by T99 or T180. If Class 1 structural backfill material is used, the minimum moisture shall not be lower than 2 percentage points under optimum moisture at 95 percent compaction as determined by AASHTO T180 Modified, tested at random through the depth of the fill.

6.5.5 Inspection of Forms and Falsework

- A. Forms shall be clean of all dirt, mortar, and foreign material. Forms which will later be removed, shall be thoroughly coated with an approved form oil.
- B. Forms shall be mortar-tight and of a quality (in addition to the bracing) to withstand the deposited concrete.
- C. Unless otherwise specified, forms for exposed surfaces shall be constructed with triangular fillets 3/4 inches at all exterior corners.

6.5.6 Inspection of Reinforcing Steel

- A. The material grade and size shall be as specified by the Design Engineer on the certified construction drawings.
- B. Tying
 - 1. To prevent shifting, slab bars should be tied sufficiently, at least 3 times in any bar length, at every intersection around the periphery and at spacing according to bar sizes:

#5 and Smaller	Staggered 5'-0" to 6'-0"
#6 to #9	8'-0" to 10'-0"
#10 and #11	10'-0" to 12'-0"
 - 2. To prevent shifting, wall bars should be tied sufficiently, at least 3 times in any bar length at every third or fourth intersection and at spaces according to bar sizes, staggered:

#5 and Smaller	3'-0"
#6 to #9	4'-0" to 5'-0"
#10 and #11	6'-0" to 8'-0"

Upper and lower mats shall be tied or otherwise fastened at 4 foot maximum spacing in each direction. Minimum splice length shall be 24 bar diameters.
 - 3. Supports for reinforcing steel shall be slabs on grade or footings, concrete blocking or approved blocking material. All other reinforcing steel shall be supported with steel chairs or pre-cast mortar.

4. Reinforcing steel shall be clean and free of all foreign material before concrete is placed.
5. All clearances shall be in compliance with approved plans and specifications.
6. A daily log of all work shall be kept by a resident project observer. A copy of this log shall be furnished to the Town Engineer at or prior to the request for probationary acceptance.

6.5.7 Concrete Testing and Inspections

6.5.7.1 Materials Specifications

A. Class A, B or D concrete shall be used on structures 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	LARORATORY DESIGN MINIMUM (a) COMPRESSIVE STRENGTH 28 DAYS (45 DAYS FOR TYPE V CEMENT) (PSI)	CEMENT CONTENT (CEMENT FACTOR RANGE) (b) MIN MAX LBS LBS PER PER	WATER CEMENT RATIO FIELD MAXIMUM (C)	% ENTRAINED & ENTRAPPED AIR (TOTAL RANGE)	CONSISTENCY AASHTO DESIGNATION T 119 (d) (RANGE IN INCHES)	FINE AGGREAGE AASHTO DESIGNATION M6 (e) PERCENT TOTAL AGGREGATE RANGE
A	3750	550 600	0.500	4-7	467	34-39
B	3750	550 600	0.530	5-8	67	34-44
(f) D	5625	635 800	0.443	5-7	67	36-42

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

*From CDOT Standard Specifications Section 601.02

The following notes apply to Table 6.2:

- A. Not a field specification requirement. The desired minimum field strength is 80 percent of the specified laboratory strength.
- B. Laboratory mix design will require at least 15 to 20 pounds more cement than the minimum amount shown. This will allow for field adjustment of entrained air and water as necessary for controlling consistency and still remain within the limits of Table 6.2.
- C. The water/cement ratio reported in the laboratory mix design will be sufficiently below that shown to permit the addition of water during field mixing in the amount allowed by the Specifications.
- D. The point of acceptance for consistency requirements will be at the mixer discharge for transit-mixed concrete.
- E. For concrete-aggregate gradation see Table 6.3.
- F. An approved water reducer will be required for this class.
- G. The design slump will be between 1 and 2-1/2 inches and will be shown on the mix design sheet for the combination of materials to be used. The field slump shall be within 3/4 inch of the design slump.
- H. The maximum field water-cement ratio will depend on the desired ultimate strength. A maximum of 0.443 when used in deck concrete and for other structures will be shown on the design mix.
- I. Unless otherwise authorized, the temperature of the mixed concrete shall be not less than 50°F and not more than 80°F at the time of placing it in the forms.

TABLE 6.3 CONCRETE AGGREGATE GRADATION TABLE* PERCENTAGES PASSING DESIGNATED SIEVES AND NOMINAL SIZE DESIGNATION COURSE AGGREGATES (FROM AASHTO M 43)										
	NO.3	NO.4	NO.6	NO.7	NO.8	NO.57	NO.67	NO.357	NO. 467	FINE AGGREGATE AASHTO M6
SIEVE SIZE	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"	3/8" to 100
2-1/2"	100	-	-	-	-	-	-	100	-	-
2"	90-100	100	-	-	-	-	-	95-100	-	-
1-1/2"	35-70	90-100	-	-	-	100	-	-	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	0-5	95-100
8	-	-	-	0-5	0-10	-	0-5	-	-	-
16	-	-	-	-	0-5	-	-	-	-	45-80
50	-	-	-	-	-	-	-	-	-	10-30
100	-	-	-	-	-	-	-	-	-	2-10

*From CDOT Standard Specifications Section 703

Additional primary grading may be permitted, when produced on the project, provided the theoretical combination meets the specifications for combined aggregate sizes. Size No. 357 is a combination of No.3 and No. 57. Size No. 467 is a combination of No.4 and No. 67.

6.5.7.2 Testing Frequency and Related Inspections

- A. At least 6 compressive strength cylinders shall be taken from the same concrete delivery truck to provide: 3 cylinders for testing of attained strength for form removal cured under the same conditions as the placement, and 3 cylinders cured for design compliance to be cured at the laboratory. This is required for each pour per day with at least 1 for each 100 cubic yards.
- B. Slump, air content, unit weight and mix temperature shall be tested every 100 cubic yards of pavement placed. The first 3 loads shall be tested for slump and air content. If anyone test fails to meet requirements, slump and air content tests shall continue until 3 continuous loads meet requirements. Thereafter, slump shall be tested at least every fifth load.

6.5.7.3 Placement (Inspection)

- A. Concrete placement shall be done in a manner so that the concrete is not segregated or altered before placement. The concrete shall not be allowed to free fall more than 5 feet. Concrete shall be placed in lifts not to exceed 18 inches.
- B. A sufficient number of vibrators shall be used to properly consolidate the concrete as required.

6.5.7.4 Weepholes should be installed in the structure at the locations noted on the plans or specifications and the inlet side shall be surrounded with one cubic foot of filter material coarse aggregate as shown on Tables 6.4 and 6.5. Aggregate shall be placed in a burlap sack and tied securely.

TABLE 6.4 GRADATION SPECIFICATION FOR FILTER MATERIAL*			
SIEVE SIZE OR DESIGNATION	CLASS A	CLASS B	CLASS C
3"	100	-	-
1-1/2"	-	100	-
3/4"	20-90	-	100
#4	0-20	20-60	60-100
#16	-	10-30	-
#50	-	0-10	10-30
#100	-	-	0-10
#200	0-3	0-3	0-3

TABLE 6.5 RECOMMENDED FILTER CLASS* PERCENTAGE OF SOIL PASSING DESIGNATED SIEVES (1)			
SIEVE SIZE OR DESIGNATION	USE CLASS A, B OR C (2)	USE CLASS B OR C (2)	USE CLASS C
#10	Less than 85 and less than 25	Less than 85	More than 85
#40			

(1) Based on the minus 3" portion or the soil adjacent to the filter material.

(2) To drain large quantities of water, use the most open grading recommended.

*From CDOT Standard Specifications Section 703.09

6.5.7.6 Construction joints and expansion joints shall be constructed as on the plans and specifications.

6.5.7.7 The year of construction should be indentured on the downstream headwall face.

6.5.7.8 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. A time clock shall be used to monitor temperature. The minimum curing period shall be 7 days. Methods of curing are to be in conformance with Colorado Department of Transportation Specifications. Curing of Bridge Decks shall also follow the current CDOT Specifications.

6.5.7.9 Finishing of Hardened Concrete Surfaces

A. All formed surfaces shall be given a Class 1 finish immediately following curing as defined by CDOT Specification 601.14

B. Culvert headwall and wingwall surfaces above ground, where visible from a traveled way, shall receive a Class 2 or Class 5 finish at the Contractor's option.

6.5.8 Riprap

Rock used for riprap or wire-enclosed riprap shall be hard, durable, angular in shape, and free from cracks, overburden, shale and organic matter. Neither breadth nor thickness of a single stone shall be less than 1.3 its length and rounded stone shall not be used. The rock shall sustain a loss of not more than 40 percent after 500 revolutions in an abrasion test (Los Angeles machine-ASTM C-535) and shall sustain a loss of not more than 10 percent after 12 cycles of freezing and thawing (AASHTO T-103 for ledge rock procedure A). Rock having a minimum specific gravity of 2.65 is preferred; however, in no case should rock have a specific gravity less than 2.50. Classification and gradation for riprap are shown in Table 6.6 and Figure 6-1 and are based on minimum specific gravity of 2.50 for the rock. Because of its relatively small size and weight, riprap types VL and L must be buried with native soil and revegetated to protect the rock from vandalism.

6.5.8.1 Procedure for Material Source Approval

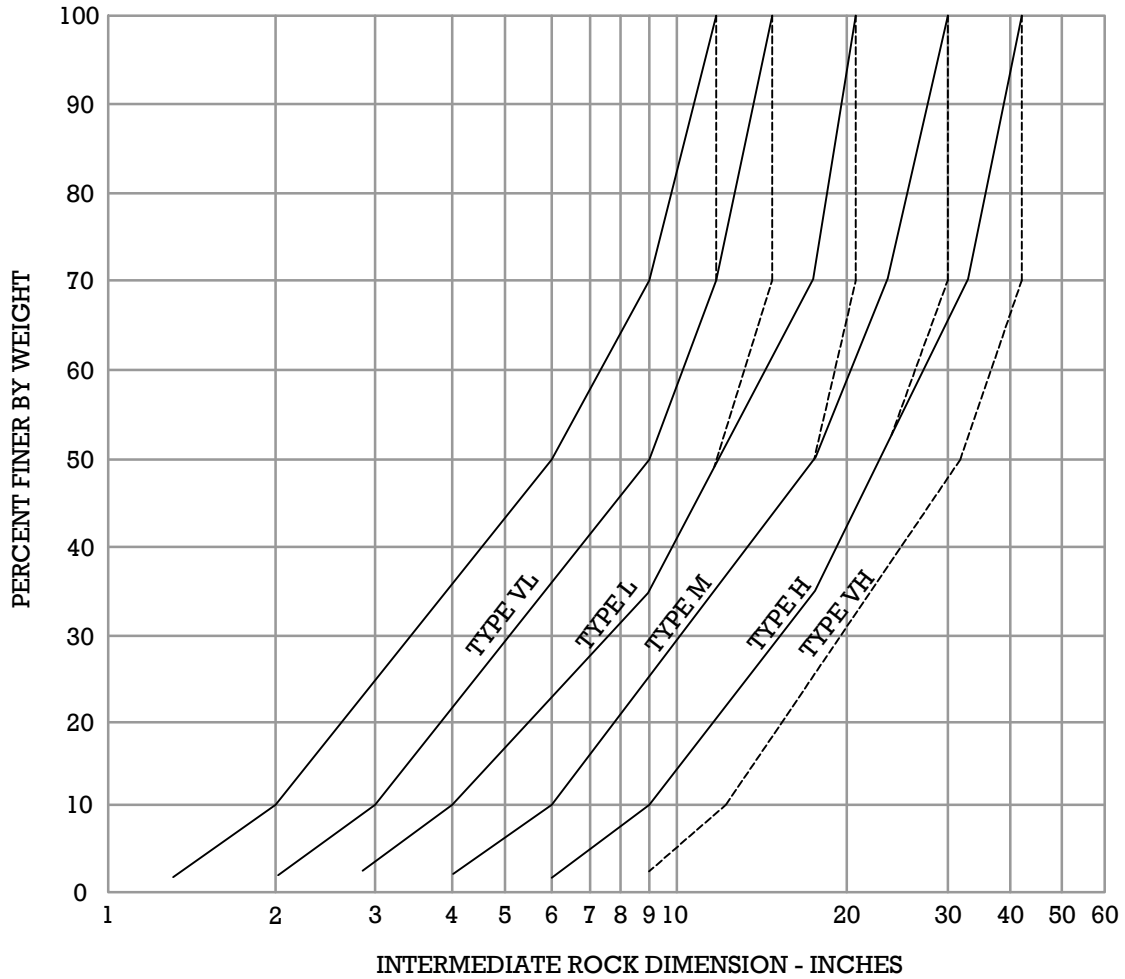
All riprap used in Bennett shall be subject to annual approval according to the requirements of Chapter 5.

TABLE 6.6 CLASSIFICATION AND GRADATION OF ORDINARY RIPRAP*			
RIPRAP DESIGNATION	% SMALLER THAN GIVEN SIZE BY WEIGHT	INTERMEDIATE ROCK DIMENSIONS (INCHES)	D50* (INCHES)
TYPE VL	70-100	12	
	50-70	9	
	35-50	6	6**
	2-10	2	
TYPE L	70-100	15	
	50-70	12	
	35-50	9	9**
	2-10	3	
TYPE M	70-100	21	
	50-70	18	
	35-50	12	12
	2-10	4	
TYPE H	100	30	
	50-70	24	
	65-50	18	18
	2-10	6	
TYPE VH	100	42	
	50-70	33	
	65-50	24	24
	2-10	9	

d50* = Mean Particle Size

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

*From Urban Drainage and Flood Control District Standard.



ROADWAY DESIGN & CONSTRUCTION STANDARDS

GRADATION OF
ORDINARY RIPRAP

Scale: N.T.S

Issued: 12/31/18

Revised: _____

Figure No. 6.1