CBC Engineers

Dayton Office

March 16, 2020

Contech Engineered Solutions LLC
9025 Centre Pointe Drive
Suite 400
West Chester, Ohio 45069

Attn: Mr. Erik Early
Design Engineer

Re: Review of AASHTO Calculations and Shop Drawings, Design of Concrete Spread Footings, and Design of Concrete Headwalls and Wingwalls for a Twin 24'-0" x 10'-4" MULTI-PLATE Arch Structure (617696); Retreat at Timber Ridge, El Paso County, Colorado; CBC Report No. 23088D-1-0320-05

Ladies and Gentlemen:

We are pleased to submit our report for the above referenced project. This report contains the review of the AASHTO calculations and shop drawings, design of concrete spread footings, and design of concrete headwalls and wingwalls for a twin MULTI-PLATE arch structure at the subject project location. The sole responsibility of CBC Engineers & Associates, Ltd. is to provide the above mentioned items. Others are responsible for all other aspects of the design of the structure, and the only responsibility of CBC Engineers & Associates, Ltd. is as listed above. The calculations, drawings, and specifications are attached with this report.

If you have any questions, please contact us.

Respectfully submitted,

CBC Engineers & Associates, Ltd.

Deepa Nair, M.S., P.E.
Project Engineer

COLORADO LICENSED
MITCHELL T. HARDERT
PE-45539
PROFESSIONAL ENGINEER

Mitchell T. Hardert, P.E.
Chief Engineer

DN/MTH/leh
ec: Erik Early (eearly@conteches.com)
ec: Darrell Sanders (dsanders@conteches.com)
ec: Melinda Fugate (mfugate@conteches.com)
1-File

CONTECH
ENGINEERED SOLUTIONS

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RE: Timber Ridge Twin MULTI-PLATE™ Structures

Dear Sir or Madam:

The most complete reference on design and service life for galvanized corrugated steel structures is provided by the National Corrugated Steel Pipe Association (NCSPA).

On their website they provide a "plate service life calculator". When the structure in question is an open bottom structure as are the twin barrels of the Timber Ridge project, the calculator uses the most appropriate method to calculate the service life, which in this case is the American Iron and Steel Institute's method (AISI).

Using this method the 8 gage open bottom structures will provide an estimated service life of over 75 years, with a substantial safety factor, as long as the pH of the water and backfill material is 6.0 or above and the Resistivity of the water and backfill material is 2000 ohm-cm or above.

See the attached report.

The backfill material should be well graded granular material meeting AASHTO M 145 classes of A-1, A-2-4, or A-2-5

If road salts will be used above the structures, an impermeable membrane would be recommended for use in the fill above the crown of the structure.

Sincerely,

Darrell Sanders, PE
Contech Engineered Solutions, LLC

COLORADO LICENSED PROFESSIONAL ENGINEER
DARRELL J. SANDERS
55263

3/17/2020

Cc: Mr. Doug Maxwell, Contech

Service Life Calculator (Plate)

Gage: 12	100 Years
Gage: 10	100 Years
Gage: 8	100 Years
Gage: 7	100 Years
Gage: 5	100 Years
Gage: 3	100 Years
Gage: 1	100 Years
Gage: 5/16	100 Years
Gage: 3/8	100 Years

Calculation Method
AISI

Desired Service Life (Years)
75

Resistivity (Ohm-cm)
2000

pH
6.0

Abrasion Level
Level 1: Non-abrasive

Is the culvert an open-bottom structure?
Yes

If an open bottom structure is selected the service life is calculated using the AISI methodology.

Is the culvert asphalt coated
No

Are concrete paved inverts being installed?
No

Will road salts be used near the structure?
No

Real Deal On Steel E-News

PRESS RELEASE: NCSPA ANNOUNCES MICHAEL MCGOUGH AS NEW EXECUTIVE DIRECTOR

FOR IMMEDIATE RELEASE: 01/13/2020 Diana Brooks National Corrugated Steel Pipe Association (NCSPA) 540-743-1354 dbrooks@NCSPA.org NCSPA ANNOUNCES MICHAEL MCGOUGH AS NEW EXECUTIVE DIRECTOR Dallas, Texas: The National Corrugated Steel Pipe Association (NCSPA) announced that its Board of Directors has promoted Michael McGough as Executive Director.... Read More

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SECTION I

TEXT

1.0 AUTHORIZATION

Authorization to proceed with this project was given by Mr. Erik Early of Contech Engineered Solutions LLC. Work was to proceed in accordance with CBC Engineers & Associates, Ltd. Quotation No. 20-050-05, Revision No. 1 dated March 3, 2020, and the terms and conditions of the Master Agreement for Engineering Services dated July 30, 2009.

2.0 PROJECT DESCRIPTION AND SCOPE

The proposed structure consists of a twin MULTI-PLATE arch structure with a span of 24'-0" and a rise of 10'-4" to be installed in El Paso County, Colorado. The 6" x 2" deep corrugated structural plates for the MULTI-PLATE arch structure are proposed to be 8 gage (0.170"). The scope of this project is to provide a peer review of the AASHTO structural calculations and shop drawings, design of concrete spread footings, and design of concrete headwalls and wingwalls for the above referenced structure at the subject project location. The following table describes the structure.

TABLE 1

STRUCTURE CHARACTERISTICS

Number of Structures	2
Structure Type	MULTI-PLATE arch
Span (ft.-in.)	24'-0"
Rise (ft.-in.)	10'-4"
Length Out to Out (ft.-in.)	120'-0"
Live Load	HL-93
Design Cover (ft.)	6.0 feet to 7.25 feet @ 120 pcf

3.0 FOUNDATION EVALUATION

We have been provided a geotechnical report prepared by Entech Engineering, Inc. (their report No. 190975 dated August 8, 2019) for the subject project. We have been instructed to design the concrete spread footings for the MULTI-PLATE arch structure and headwalls/wingwalls for an allowable bearing capacity of 3,500 psf in an email from Austin Nossokoff, P.E., of Entech Engineering, Inc. dated March 3, 2020.

We have accordingly designed the concrete spread footings for an allowable bearing capacity of 3,500 psf. A friction factor of 0.45 has also been utilized. It should be noted that CBC Engineers & Associates, Ltd. has not made any independent evaluation of the foundation and/or geotechnical conditions. We are relying totally on the information furnished to us as being correct and indicative of the allowable bearing capacity and friction factor at the actual structure location. We recommend that a geotechnical engineer examine the foundation soils once the foundation has been excavated, and that the allowable bearing capacity and friction factor be field verified before the footings are constructed. All recommendations in the project geotechnical report should be followed during construction. Any foundation improvement required to achieve an allowable bearing capacity of at least 3,500 psf and a coefficient of friction of 0.45, and to protect against frost and scour and settlement, is the responsibility of others than CBC Engineers & Associates, Ltd.

4.0 FOOTING EVALUATION

The load on a footing consists of the load on top of the structure carried by each leg of the structure, which is equal to the unit weight of the soil times the height of cover over the structure divided into each leg; plus the weight of the soil on the outside edges of the footing outside the structure, plus the weight of the structure itself plus the live load. The weight of the soil over the footings that is excavated can be deducted from the pressure at the bottom of the footing in the consideration of the bearing capacity. The footing also must be designed for any horizontal thrust which is created by the angle of entry into the footing. Since the structure has a span of 24'-0" and a rise of 10'-4", the structure essentially does enter the footing at an angle and there is, therefore, a horizontal component to the footing reactions towards the outside of the structure. The service state loading of the footing according to AASHTO LRFD Bridge Design Specifications is R_h= 2,454 R_v= 16,171 plf. Figure 1 shows the loads on the footing.

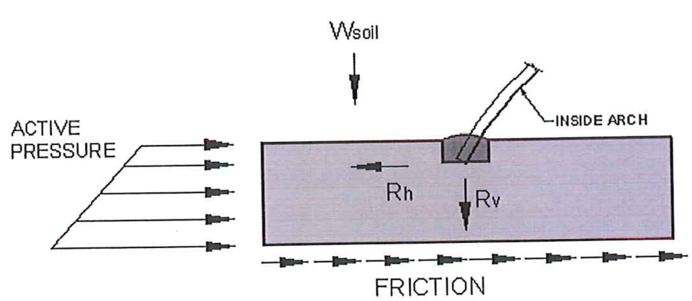


Figure 1

Based on the above loads and an allowable bearing capacity of 3,500 psf, the width of the inner footing for the twin MULTI-PLATE arch structure must be 12'-9" with a minimum thickness of 2'-8" beneath the keyway, and the width of the two (2) outer footings must be 9'-4" with a minimum thickness of 2'-8" beneath the keyway. The steel required in the footings consists of #6 bars at 6" center to center transversely at the bottom and #6 bars at 6" center to center at the top for the outer footings and #6 bars at 6" center to center transversely at the bottom and #6 bars at 6" center to center at the top for the inner footings. The longitudinal reinforcement should be #5 bars as shown on the footing details. The details for the footings can be found on the drawings attached in Appendix C.

5.0 REVIEW OF AASHTO CALCULATIONS AND SHOP DRAWINGS

We have evaluated AASHTO structural calculations and shop drawings for the 8-gage MULTI-PLATE arch and agree that they conform to accepted industry standards for this structure type. We have not made an independent verification of the data used to perform the design calculations, and are assuming all initial assumptions and data are correct as presented to us. AASHTO structural calculations for the MULTI-PLATE arch have been performed for a height of cover varying from 6.0 feet to 7.25 feet at a unit weight of 120 pcf combined with HL-93 live loading. The select backfill around and over the MULTI-PLATE arch structure must be in strict conformance with the project specifications, the manufacturer's requirements and accepted industry standards. Contractor is responsible for any required bracing/shoring to prevent any distortion of the structure during installation and for knowing and following all applicable safety requirements. Care must be exercised to maintain balanced loading on the structure during any backfilling or construction operations, and the structure must be properly backfilled to maintain this balanced loading. The dimension of the structure should be within 2% of the design dimensions at all locations during and at the completion of installation, and this should be verified by field measuring during construction. The reviewed AASHTO structural calculations and shop drawings are included in Appendix A and Appendix B of this report, respectively.

6.0 DESIGN OF CONCRETE HEADWALLS AND WINGWALLS

Concrete headwalls have been designed to be connected to the upstream and downstream ends of the structure. The geometry of the headwalls and wingwalls has been prepared according to the design information from Classic Consulting dated April 5, 2019 (Project No. 1185.00). The maximum height of the upstream and downstream headwall is approximately 12.2 feet and 11.4 feet respectively above the top of the 36" thick footings. The design of any required vehicle barriers and their connection to the headwalls is the responsibility of others than CBC. There is a wingwall connected to the headwall on each side of the structure as shown on the drawings. An expansion joint will be placed between the headwall and wingwall sections and between headwall sections as shown on the drawings. The length of the headwall at the ends is about 54'-8". The required geometry of the headwalls and wingwalls should be verified prior to construction.

The headwalls at both ends have been designed to carry the lateral soil pressure resulting from the backfill around the structure, and lateral live load pressure from the HL-93 live load surcharge. The dimensions and reinforcing steel have been designed using AASHTO LRFD factored loads to resist the loads applied to the headwall, and to protect against temperature and shrinkage effects. The headwalls have been designed to be founded on the MULTI-PLATE arch footings as shown on the drawings.

The wingwalls at both sides have been designed to carry the lateral soil pressure resulting from the maximum backfill above the footings. No live load surcharge has been considered in the design of wingwalls as per AASHTO methodology (horizontal distance from wingwalls to nearest roadway is greater than the maximum overall height of wingwalls as per project drawings). The dimensions and reinforcing steel have also been designed using AASHTO LRFD factored loads to resist the loads applied to the wingwalls, and to protect against temperature and shrinkage effects. The foundations for the wingwalls have been designed for an allowable bearing capacity of 3,500 psf and a friction factor of 0.45 as described previously.

As mentioned above, the MULTI-PLATE arch structure will be tied into the headwalls with 3/4" diameter hook bolts as shown on the construction drawings. The headwalls and wingwall sections will be tied into each other using #4 epoxy coated dowels at 12" O.C. vertically embedded 2'-0" into the headwall and wingwall sections. Dimensions and the reinforcing steel required for the headwalls and wingwalls is as shown on the attached drawings in Appendix C. The calculations are attached in Appendix A. The backfill behind the headwalls should meet the requirements of the select backfill for the MULTI-PLATE arch and should have a minimum internal friction angle of 34 degrees and a maximum unit weight of 120 pcf. The select backfill behind the wingwalls extending to a minimum distance of 15.0 feet behind the back face of the walls must be a well-graded, angular, durable granular material placed and compacted to achieve a minimum internal friction angle of 34 degrees and a maximum unit weight of 120 pcf. These values to be field verified. All Federal, State, and Local regulations shall be strictly adhered to relative to excavation side-slope geometry and any required excavation shoring.

7.0 SCOUR

It is beyond the scope of this report to evaluate scour and it is the responsibility of others than CBC Engineers & Associates, Ltd. The depth of all foundations should be evaluated for scour before foundations are constructed, and scour countermeasures (by others) provided as necessary to protect the foundations.

8.0 WARRANTY

Our professional services have been performed, our findings obtained and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. No other warranty, expressed or implied, is made.

This report has been prepared for the exclusive use of Contech Engineered Solutions, LLC for specific application to the structure herein described. Specific recommendations have been provided in the various sections of the report. The report shall, therefore, be used in its entirety. This report is not a bidding document and shall not be used for that purpose. Anyone reviewing this report must interpret and draw their own conclusions regarding specific construction techniques and methods chosen. CBC Engineers & Associates, Ltd. is not responsible for the independent conclusions, opinions or recommendations made by others.

SECTION II

SPECIFICATIONS

I – GENERAL

1.0 STANDARDS AND DEFINITIONS

1.1 STANDARDS - All standards refer to latest edition unless otherwise noted.

1.1.1 ASTM D-698-70 (Method C) "Standard Test Methods for Moisture. Density Relations of Soils and Soil Aggregate Mixtures Using 5.5-lb (2.5 kg.) Rammer and 12-inch (305-mm) Drop".

1.1.2 ASTM D-2922 "Standard Test Method for Density of Soil and Soil Aggregate in Place by Nuclear methods (Shallow Depth)".

1.1.3 ASTM D-1556 "Standard Test Method for Density of Soil in place by the Sand-Cone Method".

1.1.4 ASTM D-1557 "Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort."

1.1.5 All construction and materials shall be in accordance with the latest AASHTO LRFD Bridge Design Specifications.

1.2 DEFINITIONS

1.2.1 Owner - In these specifications the word "Owner" shall mean Elite Properties of America, LLC.

1.2.2 Engineer - In these specifications the word "Engineer" shall mean the Owner designated engineer.

1.2.3 Design Engineer - In these specifications the words "Design Engineer" shall mean CBC Engineers and Associates, Ltd.

1.2.4 Contractor - In these specifications the word "Contractor" shall mean the firm or corporation undertaking the execution of any work under the terms of these specifications.

1.2.5 Approved - In these specifications the word "approved" shall refer to the approval of the Engineer or his designated representative.

1.2.6 As Directed - In these specifications the words "as directed" shall refer to the directions to the Contractor from the Owner or his designated representative.

2.0 GENERAL CONDITIONS

2.1 The Contractor shall furnish all labor, material and equipment and perform all work and services except those set out and furnished by the Owner, necessary to complete in a satisfactory manner the site preparation, excavation, filling, compaction, grading, footing construction, headwall/wingwall construction as shown on the plans and as described therein.

This work shall consist of all mobilization clearing and grading, grubbing, stripping, removal of existing material unless otherwise stated, preparation of the land to be filled, filling of the land, spreading and compaction of the fill, and all subsidiary work necessary to complete the grading of the cut and fill areas to conform with the lines, grades, slopes, and specifications.

This work is to be accomplished under the observation of the Owner or his designated representative.

2.2 Prior to bidding the work, the Contractor shall examine, investigate and inspect the construction site as to the nature and location of the work, and the general and local conditions at the construction site, including, without limitation, the character of surface or subsurface conditions and obstacles to be encountered on and around the construction site; and shall make such additional investigation as he may deem necessary for the planning and proper execution of the work.

If conditions other than those indicated are discovered by the Contractor, the Owner should be notified immediately. The material which the Contractor believes to be a changed condition should not be disturbed so that the owner can investigate the condition.

2.3 The construction shall be performed under the direction of an experienced engineer who is familiar with the design plan.

II – FOOTINGS

1.0 EXCAVATION FOR FOOTINGS

1.1 Footing excavation shall consist of the removal of all material, of whatever nature, necessary for the construction of foundations.

1.2 It shall be the responsibility of the Contractor to identify and relocate all existing utilities which conflict with the proposed footing locations shown on the plan. The Contractor must call the appropriate utility company at least 48 hours before any excavation to request exact field location of utilities, and coordinate removal and installation of all utilities with the respective utility company.

1.3 The side of all excavations shall be cut to prevent sliding or caving of the material above the footings.

1.4 Excavated material shall be disposed in accordance with the plan established by the Engineer.

1.5 The footings for the MULTI-PLATE arch, and headwalls/wingwalls are designed for an allowable bearing capacity of the non-yielding foundation material of 3,500 psf and a friction factor of 0.45. These values shall be verified in the field before construction. The evaluation and design of any required foundation improvement to achieve the design allowable bearing capacity and friction factor, and to protect against frost and scour and settlement, is the responsibility of others than CBC.

2.0 CONCRETE FOOTING DIMENSIONS

The footings shall be reinforced in accordance with the construction drawings.

III – HEADWALLS/WINGWALLS

1.0 The headwalls/wingwalls shall consist of reinforced concrete conforming to Chapter IV of these specifications and to Division II, Section 8, of the AASHTO Standard Specifications for Highway Bridges having a minimum compression strength of 4,000 psi.

2.0 Reinforcing steel shall conform to ASTM A-615, Grade 60, having minimum yield strength of 60,000 psi.

3.0 The headwalls shall be anchored to the MULTI-PLATE arch in the manner shown on the plans and shall be formed and poured in accordance with the plan dimensions.

4.0 Round weep holes spaced not over 5 feet on center shall be placed in the walls above finished grade as shown on the construction drawings. A granular envelope, consisting of #57 stone (clean ¾" aggregate) or equivalent, shall be placed behind each weep hole for a distance of approximately 1 foot from all edges of the weep hole. A free-draining geotextile screen shall be placed between the weep hole and the stone to prevent erosion of the stone.

5.0 The select backfill behind the headwalls must be a well-graded, angular, durable granular material conforming to the select backfill specifications for the MULTI-PLATE arch placed and compacted to achieve a minimum internal friction angle of 34 degrees and a maximum unit weight of 120 pcf. The material must be placed in strict conformance with the project specifications, the manufacturer's requirements, and industry standards. The select backfill behind the wingwalls extending to a minimum distance of 15.0 feet behind the back face of the walls must be a well-graded, angular, durable granular material placed and compacted to achieve a minimum internal friction angle of 34 degrees and a maximum unit weight of 120 pcf. These values must be field verified.

6.0 All Federal, State, and Local regulations shall be strictly adhered to relative to excavation side-slope geometry and any required excavation shoring.

IV – CONCRETE FOR FOOTINGS AND HEADWALLS/WINGWALLS

1.0 CODES AND STANDARDS

1.1 Reinforced concrete shall conform to the requirements of AASHTO Standard Specifications for Highway Bridges, Division II - Construction, Section 8, "Concrete Structures", for Class A concrete, having a minimum compressive strength of 4,000 psi.

2.0 STANDARDS FOR MATERIALS

2.1 Portland Cement - Conforming to ASTM Specification C-150, Type I or II.

2.2 Water - The water shall be drinkable, clean free from injurious amounts of oils, acids, alkalis, organic materials, or deleterious substances.

2.3 Aggregates - Fine and coarse aggregates shall conform to current ASTM Specification C-33 "Specification for Concrete Aggregates" except that local aggregates which have been shown by tests and by actual service to produce satisfactory qualities may be used when approved by the Engineer.

2.4 Submittals - Test data and/or certifications to the Owner shall be furnished upon request.

3.0 PROPORTIONING OF CONCRETE

3.1 COMPOSITION

3.1.1 The concrete shall be composed of cement, fine aggregate, coarse aggregate and water.

3.1.2 The concrete shall be homogeneous, readily placeable and uniformly workable and shall be proportioned in accordance with ACI-211.1.

3.1.3 Proportions shall be established on the basis of field experience with the materials to be employed. The amount of water used shall not exceed the maximum 0.45 water/cement ratio, and shall be reduced as necessary to produce concrete of the specified consistency at the time of placement.

3.1.4 An air-entraining admixture, conforming to the requirements of ASTM C260, shall be used in all concrete furnished under this contract. The quantity of admixture shall be such as to produce an air content in the freshly mixed concrete of 6 percent plus or minus 1 percent as determined in accordance with ASTM C231 or C173.

3.2 Qualities Required - As indicated in the table below:

TABLE IV-1

QUALITIES REQUIRED

ITEM	QUALITY REQUIRED
AASHTO Class	A
Type of Cement	I or II
Compressive Strength f'c @ 28 days	4,000 psi
Slump, inches	2 - 4 in.

3.3 Maximum Size of Coarse Aggregates - Maximum size of coarse aggregates shall not be larger than 19 mm (3/4 inches).

3.4 Rate of Hardening of Concrete - Concrete mix shall be adjusted to produce the required rate of hardening for varied climatic conditions:

Under 40°F Ambient Temperature - Accelerate calcium chloride at 2% is acceptable when used within the recommendations of ACI-306R "Cold Weather Concreting." Admixtures containing chloride ion in excess of 1% by weight of admixture shall not be used in reinforced concrete.

4.0 MIXING AND PLACING

4.1 Equipment - Ready Mix Concrete shall be used and shall conform to the "Specifications for Ready-Mix Concrete," ASTM C-94. Approval is required prior to using job mixed concrete.

4.2 Preparation - All work shall be in accordance with ACI-304, "Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete." All construction debris and extraneous matter shall be removed from within the forms. Concrete shall be placed on clean surfaces, free from water. Concrete that has to be dropped four (4) feet or more shall be placed through a tremie.

4.3 All concrete shall be consolidated by internal mechanical vibration immediately after placement. Vibrators shall be of a size appropriate for the work, capable of transmitting vibration to concrete at frequencies of not less than 4,500 impulses per minute.

5.0 FORM WORK

5.1 Forms shall be of wood, steel or other approved material and shall be set and held true to the dimensions, lines and grades of the structure prior to and during the placement of concrete.

5.2 Forms shall not be removed until the concrete has sufficient strength to prevent concrete damage and/or drainage.

6.0 CURING

6.1 Fresh concrete shall be protected from rains, flowing water and mechanical injury for a period of four (4) days. Loads shall not be placed on the concrete until it has reached its design strength.

7.0 REINFORCING STEEL

7.1 MATERIAL

7.1.1 All reinforcing bars shall be deformed bars (ASTM-A615) Grade 60.

7.2 BENDING AND SPLICING

7.2.1 Bar reinforcement shall be cut and bent to the shapes shown on the plans. Fabrication tolerances shall be in accordance with ACI 315. All bars shall be bent cold, unless otherwise permitted.

7.2.2 All reinforcement shall be furnished in the full lengths indicated on the plans unless otherwise permitted. Except for splices shown on the plans and splices for No. 5 or smaller bars, splicing of bars will not be permitted without written approval. Splices shall be staggered as far as possible.

7.2.3 In lapped splices, the bars shall be placed and wired in such a manner as to maintain the minimum distance to the surface of the concrete shown on the plans.

7.2.4 Substitution of different size bars will be permitted only when authorized by the engineer. The substituted bars shall have an area equivalent to the design area, or larger.

7.3 PLACING AND FASTENING

7.3.1 Steel reinforcement shall be accurately placed as shown on the plans and firmly held in position during the placing and setting of concrete. Bars shall be tied at all intersections around the perimeter of each mat and at not less than 2 foot centers or at every intersection, whichever is greater, elsewhere. Welding of cross bars (tack welding) will not be permitted for assembly of reinforcement.

7.3.2 Reinforcing steel shall be supported in its proper position by use of mortar blocks, wire bar supports, supplementary bars or other approved devices.

Such devices shall be of such height and placed at sufficiently frequent intervals so as to maintain the distance between the reinforcing and the formed surface or the top surface within 1/4 inch of that indicated on the plans.

V - FILTER FABRIC (GEOTEXTILE SCREEN)

1.0 Filter fabric shall be placed at all locations shown on the construction drawings, and as necessary between all dissimilar materials to prevent soil migration and to maintain a soil-tight system.

2.0 Filter fabric cloth shall conform to Contech specification for C60-NW or equivalent and shall meet the following ASTM tests:

2.1 ASTM D4751 - Apparent opening size equal to #70 U.S. Standard Sieve Size.

2.2 ASTM D4632 (Grab Tensile Test) - Minimum Strength = 160 pounds.

2.3 ASTM D4632 (Grab Elongation) - 30-70%.

2.4 ASTM D4533 (Trapezoidal Tear) - Minimum Strength = 60 pounds.

2.5 ASTM D4355 (Stabilized for Heat and Ultra-Violet Degradation) - 70% strength retained.

3.0 The minimum fabric coefficient of permeability (ASTM D4491) shall be 0.24 cm/sec.

4.0 The fabric shall be non-woven with a minimum thickness (ASTM D5199) of 60 mils.

5.0 Fabric shall not be placed over sharp or angular rocks that could tear or puncture it.

6.0 Care should be exercised to prevent any puncturing or rupture of the filter fabric. Should such rupture occur the damaged area should be covered with a patch of filter fabric using an overlap minimum of one (1) foot.

APPENDIX A

CALCULATIONS

Structural Design Check for Corrugated Steel Plate Arch

Per AASHTO LRFD Bridge Design Specifications, Section 12, 8th Edition 2017

CONTECH ENGINEERED SOLUTIONS

Project Name:	Timber Ridge	CRM #:	617,696
Location:	Colorado Springs, CO	Date:	1/23/2020

Select Shape Below or Select "User Defined": 24' X 10'-4"

Corrugation Type	6 X 2 in.	
Loading Case	1	(lanes)
Gage	8	
Bolting Type	4 Bolts/ft.	
S, Span	288	(in.)
R, Rise	124	(in.)
R_t, Top Rise	124	(in.)
A_T, Area Above Springline	188.0	(sq. ft.)
Δ, Return Angle	-8.63	(°)
H, Height of Cover	6	(ft.)
Design Truck (LRFD Highway Load is HL-93)	HL-93	
ρ, Density of Cover Material (120 pcf default)	0.12	(kcf)

A_w, Pipe Wall Area	2.449	(sq. in./ft.)	(Table A12-3)
I, Moment of Inertia	0.0962	(in.^{4}/in.)	(Table A12-3)
r, Radius of Gyration	0.686	(in.)	(Table A12-3)
E_m, Modulus of Elasticity	29000	(ksi)	(Table A12-10)
F_u, Tensile Strength	45	(ksi)	(Table A12-10)
F_y, Yield Strength	33	(ksi)	(Table A12-10)
Lt, Surface Load Contact Length	0.83	(ft.)	(3.6.1.2.5)
wt, Surface Load Contact Width	1.67	(ft.)	(3.6.1.2.5)
Tandem Controls			
s_w, Wheel	6.00	(ft)	
s_a, axle spacing	4.00	(ft)	
LLDF	1.15		
H_{int-t}, Wheel Interaction Depth	2.52	(ft)	
W_w, live load patch length Ww=wt/12+sw+LLDF x H + 0.06 Di/12	16.01	(ft)	
H_{int-p}, Axle Interaction Depth	2.75		
Number of Interacting Wheels	4		
DL, Design Lane Load	0.64	(klf)	(3.6.1.2.4)
l_w, live load patch length lw=lt/12+sa+LLFD(H)	11.73	(ft)	
A_{LL}, Area of live load patch at H	187.81	(ft^2)	
FFR, Flexibility Factor Required	30	(in./kip)	(Table 12.5.6.1-1)
k, Soil Stiffness Factor	0.22		(12.7.2.4)
IM, Dynamic Load Factor = 33(1.0-0.125H)	8.25	(%)	
m, Multiple Presence Factor	1.2		(Table 3.6.1.1.2-1)
PT, Design Tandem Load	12.5	(kip/wheel group)	(3.6.1.2.2)
SS, Seam Strength	81	(kip/ft.)	(Table A12-8)
Φ_w, Wall Area and Buckling	1		(Table 12.5.5-1)
Φ_{SS}, Seam Strength	0.67		(Table 12.5.5-1)
η_{EV}, Redundancy Factor	1.05		(1.3.4, 12.5.4)
η_{LL}, Redundancy Factor	1.00		(1.3.4, 12.5.4)
γ_{EV}, Dead Load Factor	1.95		(Table 3.4.1-2)
γ_{LL}, Live Load Factor	1.75		(Table 3.4.1-1)

Structural Design Check for Corrugated Steel Plate Arch

Per AASHTO LRFD Bridge Design Specifications, Section 12, 8th Edition 2017

$P_L = (P(1+IM/100)m)/A_{LL}$		0.35	(ksf)			(3.6.1.2.6b-7)
P_{FD}, Factored Dead Load Crown Pressure	$=\eta_{EV}\,\gamma_{EV} \times H \times \rho$	1.4742	(ksf)			(3.5.1)
P_{FL}, Factored Live Load Crown Pressure	$=\eta_{LL}\,\gamma_{LL}\,P_L$	0.6052	(ksf)			
P_{DL}, Factored Design Lane Load Crown Pressure	$=\eta_{LL}\,\gamma_{LL}\,m\,DL/10$	0.1344	(ksf)			

Factored Thrust (standard structures)

F_{min}	= greater of 15/S or 1	1.00	(dimensionless)			(12.7.2.2-4)
F_1	= greater of 0.75S/lw or F_{min}	1.53	(dimensionless)			(12.7.2.2-3)
C_L, Width of Culvert on which LL is applied	$= lw \le S$	11.73	(ft)			(12.7.2.2-2)
T_L, Factored Thrust	$=(P_{FD}+P_{DL})S/2+(P_{FL}\,C_L\,F_1)/2$	24.75	(kip/ft)			(P12.7.2.2)
R_w, Wall Resistance	$R_w = \Phi_w F_y A_w$	80.817	(kip/ft.)	> T	24.750 OK	(12.7.2.3-1)
F_{cr}, Critical Buckling Stress		32.590	(ksi)			

If: $S < \frac{r}{k}\sqrt{\frac{24E_m}{F_u}}$ Then: $F_{cr} = F_u - \frac{\left(\frac{F_u k S}{r}\right)^2}{48E_m}$ (12.7.2.4-1)

Upper Case Controls

But if: $S > \frac{r}{k}\sqrt{\frac{24E_m}{F_u}}$ Then: $F_{cr} = \frac{12E_m}{\left(\frac{kS}{r}\right)^2}$ (12.7.2.4-2)

R_b, Buckling Resistance	If: $F_{cr} > F_y$, then $F_{cr} = F_y$	32.590	(ksi)	<	33	
	$R_b = \Phi_w F_{cr} A_w$	79.813	(kip/ft.)	> T	24.750 OK	(12.7.2.3-1)
FF, Flexibility Factor	$FF = S^2/(E_m I)$	29.731	(in./kip)	< FFR	30 OK	(12.7.2.6-1)
R_s, Factored Seam Strength	$R_s = \Phi_{SS} SS$	54.270	(kip/ft.)	> T	24.750 OK	(12.7.2.5)

Footing Reactions:

V_{DL}, Dead Load Reaction	$V_{DL} = [S/12(H + R_r/12) - A_T]\rho/2$	12.2400	(kip/ft.)		(12.8.4.2)
V_{LL}, Live Load Reaction	$V_{LL} = 2L_cP/(8+2(H+R/12))$ Assumes loading case of 2 lanes	2.459	(kip/ft.)		(12.8.4.2)
R_V, Vertical Reaction	$R_V = (V_{DL}+V_{LL})\cos\Delta$	14.533	(kip/ft.)	downward	(12.8.4.2-1)
R_H, Horizontal Reaction	$R_H = (V_{DL}+V_{LL})\sin\Delta$	-2.205	(kip/ft.)	outward	(12.8.4.2-2)

Structural Design Check for Corrugated Steel Plate Arch

Per AASHTO LRFD Bridge Design Specifications, Section 12, 8th Edition 2017

CONTECH ENGINEERED SOLUTIONS

Project Name: Timber Ridge **CRM #:** 617,696

Location: Colorado Springs, CO **Date:** 1/23/2020

Corrugation Type	6 X 2 in.		Select Shape Below or Select "User Defined"
Loading Case	1	(lanes)	
Gage	8		24' X 10'-4"
Bolting Type	4 Bolts/ft.		
S, Span	288	(in.)	
R, Rise	124	(in.)	
R_t, Top Rise	124	(in.)	
A_T, Area Above Springline	188.0	(sq. ft.)	
Δ, Return Angle	-8.63	(°)	
H, Height of Cover	7.25	(ft.)	
Design Truck (LRFD Highway Load is HL-93)	HL-93		
ρ, Density of Cover Material (120 pcf default)	0.12	(kcf)	

A_w, Pipe Wall Area	2.449	(sq. in./ft.)	(Table A12-3)
I, Moment of Inertia	0.0962	(in.^{4}/in.)	(Table A12-3)
r, Radius of Gyration	0.686	(in.)	(Table A12-3)
E_m, Modulus of Elasticity	29000	(ksi)	(Table A12-10)
F_u, Tensile Strength	45	(ksi)	(Table A12-10)
F_y, Yield Strength	33	(ksi)	(Table A12-10)
Lt, Surface Load Contact Length	0.83	(ft.)	(3.6.1.2.5)
wt, Surface Load Contact Width	1.67	(ft.)	(3.6.1.2.5)
Tandem Controls			
s_w, Wheel	6.00	(ft)	
s_a, axle spacing	4.00	(ft)	
LLDF	1.15		
H_{int-t}, Wheel Interaction Depth	2.52	(ft)	
W_w, live load patch length Ww=wt/12+sw+LLDF x H + 0.06 Di/12	17.44	(ft)	
H_{int-p}, Axle Interaction Depth	2.75		
Number of Interacting Wheels	4		
DL, Design Lane Load	0.64	(klf)	(3.6.1.2.4)
l_w, live load patch length lw=lt/12+sa+LLFD(H)	13.17	(ft)	
A_{LL}, Area of live load patch at H	229.75	(ft^2)	
FFR, Flexibility Factor Required	30	(in./kip)	(Table 12.5.6.1-1)
k, Soil Stiffness Factor	0.22		(12.7.2.4)
IM, Dynamic Load Factor = 33(1.0-0.125H)	3.09375	(%)	
m, Multiple Presence Factor	1.2		(Table 3.6.1.1.2-1)
PT, Design Tandem Load	12.5	(kip/wheel group)	(3.6.1.2.2)
SS, Seam Strength	81	(kip/ft.)	(Table A12-8)
Φ_w, Wall Area and Buckling	1		(Table 12.5.5-1)
Φ_{SS}, Seam Strength	0.67		(Table 12.5.5-1)
η_{EV}, Redundancy Factor	1.05		(1.3.4, 12.5.4)
η_{LL}, Redundancy Factor	1.00		(1.3.4, 12.5.4)
γ_{EV}, Dead Load Factor	1.95		(Table 3.4.1-2)
γ_{LL}, Live Load Factor	1.75		(Table 3.4.1-1)

Structural Design Check for Corrugated Steel Plate Arch

Per AASHTO LRFD Bridge Design Specifications, Section 12, 8th Edition 2017

CONTECH ENGINEERED SOLUTIONS

$P_L = (P(1+IM/100)m)/A_{LL}$		0.27	(ksf)			(3.6.1.2.6b-7)
P_{FD}, Factored Dead Load Crown Pressure	$=\eta_{EV}\,\gamma_{EV} \times H \times \rho$	1.7813	(ksf)			(3.5.1)
P_{FL}, Factored Live Load Crown Pressure	$= \eta_{LL}\,\gamma_{LL}\,P_L$	0.4711	(ksf)			
P_{DL}, Factored Design Lane Load Crown Pressure	$= \eta_{LL}\,\gamma_{LL}\,m\,DL/10$	0.1344	(ksf)			
Factored Thrust (standard structures)						
F_{min}	= greater of 15/S or 1	1.00	(dimensionless)			(12.7.2.2-4)
F_1	= greater of 0.75S/lw or F_{min}	1.37	(dimensionless)			(12.7.2.2-3)
C_L, Width of Culvert on which LL is applied	$= lw \le S$	13.17	(ft)			(12.7.2.2-2)
T_L, Factored Thrust	$=(P_{FD}+P_{DL})S/2+(P_{FL}\,C_L\,F_1)/2$	27.23	(kip/ft)			(P12.7.2.2)
R_w, Wall Resistance	$R_w = \Phi_w F_y A_w$	80.817	(kip/ft.)	> T	27.229	OK (12.7.2.3-1)
F_{cr}, Critical Buckling Stress		32.590	(ksi)			
If:	$S < \frac{r}{k}\sqrt{\frac{24E_m}{F_u}}$	Then:	$F_{cr} = F_u - \frac{\left(\frac{F_u k S}{r}\right)^2}{48E_m}$			(12.7.2.4-1)
		Upper Case Controls				
But if:	$S > \frac{r}{k}\sqrt{\frac{24E_m}{F_u}}$	Then:	$F_{cr} = \frac{12E_m}{\left(\frac{kS}{r}\right)^2}$			(12.7.2.4-2)
R_b, Buckling Resistance	If: $F_{cr} > F_y$, then $F_{cr} = F_y$	32.590	(ksi)	<	33	
	$R_b = \Phi_w F_{cr} A_w$	79.813	(kip/ft.)	> T	27.229	OK (12.7.2.3-1)
FF, Flexibility Factor	$FF = S^2/(E_m I)$	29.731	(in./kip)	< FFR	30	OK (12.7.2.6-1)
R_s, Factored Seam Strength	$R_s = \Phi_{SS} SS$	54.270	(kip/ft.)	> T	27.229	OK (12.7.2.5)

Footing Reactions:

V_{DL}, Dead Load Reaction	$V_{DL} = [S/12(H + R_t/12) - A_T]\rho/2$	14.0400	(kip/ft.)		(12.8.4.2)
V_{LL}, Live Load Reaction	$V_{LL} = 2L_cP/(8+2(H+R/12))$ Assumes loading case of 2 lanes	2.317	(kip/ft.)		(12.8.4.2)
R_V, Vertical Reaction	$R_V = (V_{DL}+V_{LL})\cos\Delta$	16.172	(kip/ft.)	downward	(12.8.4.2-1)
R_H, Horizontal Reaction	$R_H = (V_{DL}+V_{LL})\sin\Delta$	-2.453	(kip/ft.)	outward	(12.8.4.2-2)

MULTI-PLATE ARCH (24'-0" X 10'-4") FOOTING DESIGN :
(AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS)

Project No: CBC 23088 Project Title: Retreat at Timber Ridge

Structure Size: MULTI-PLATE Span, S (ft)= 24 Rise, R (ft)= 10.3333

Allowable bearing capacity (psf) 3500

$Rv = (V_{dl} + V_{LL}) x COS (A)^o$ Vertical Footing Reaction Component

$Rh = (V_{dl} + V_{LL}) x SIN (A)^o$ Horizontal Footing Reaction Component

$Vdl = (H_2 xS - A_t) xGamma/2$ Gamma = Unit Weight of Soil

120 pcf

$V_{LL} = n \cdot (AL) / (L_W + 2xH_1)$

S=	24.00	ft	Span
R=	10.33	ft	Rise
H=	7.25		Height of cover above the crown
H1=	17.58	ft.	Height of cover above the footing to traffic surf
H2=	17.58	ft.	Height of cover above the springline
A^o =	8.63	^{o}	Return angle
At =	188.00	sq.ft.	Area of the top portion above springline
AL =	50000.00	lbs.	HL-93
n =	2.00		Traffic lanes
Lw =	8.00	ft.	Lane width

Vdl =	14039.5	lbs/ft.	Rv=	16171.0		
			Rh=	2454.3		
V_{LL} =	2316.6	lbs/ft.	Rvd=	13880.6	Rhd=	2106.7

Factored Footing Reaction AASHTO LRFD SECTION 3.4.1-1 **STRENGTH LIMIT CASE**

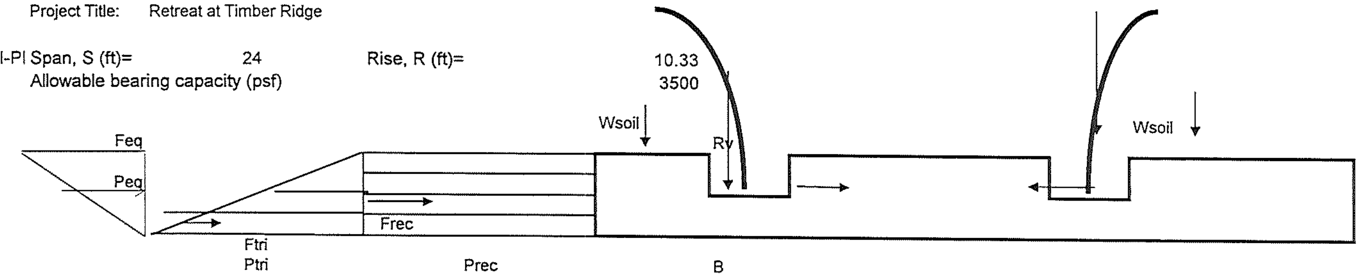
LOAD FACTORS:
Beta Coefficient = 1.25 for Dead Load
= 1.75 for Live Load
= 1.95 for Vertical Earth Press.

Rvu = **31075.3** lbs/ft.

Rhu = **4716.34** lbs/ft.

MULTI-PLATE ARCH (INNER) FOOTING DESIGN :
(AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS)
INNER FOOTING
Project No: 23088 Project Title: Retreat at Timber Ridge

Structure Size: MULTI-PI Span, S (ft)= 24 Rise, R (ft)= 10.33
Allowable bearing capacity (psf) 3500



DATA

HEIGHT OF COVER (ft)	7.25
Hc to INVERT (ft)	17.583
Rv (plf)	32341.9
Rh (plf)	0.0
ALL. BEARING (psf)	3500

FOOTING GEOMETRY

WIDTH, B (ft)	12.75
Central WIDTH, w (ft)	3.33
THICKNESS, t (ft)	2.170
HEIGHT, h (ft)	2.500

FOOTING LOADS

SOIL WEIGHT, Ws1 (plf)	7026.17
MOMENT ARM (ft)	0.000
CONCRETE WEIGHT, Wc1 (plf)	4781.3
MOMENT ARM (ft)	0.00
Rv (plf)	32341.9
MOMENT ARM (ft)	0.00
Rh (plf)	0.0
MOMENT ARM (ft)	2.170

OUTSIDE SOIL PRESSURE

At rest COEFFICIENT, Ko	0.0
Prec (psf)	0.0
Ptri (psf)	0.0
Frec (plf)	0.0
MOMENT ARM (ft)	1.25
Ftri (plf)	0.0
MOMENT ARM (ft)	0.8

BEARING PRESSURE CALCULATION (STATIC)

SUM OF VERTICALS, Q (plf)	44149.4	
SUM OF MOMENTS, Mo (ft-#/ft)	0.0	(CLOCKWISE POSITIVE)
ECCENTRICITY, e (ft)	0.0000	B/6 =
BEARING PRESSURES, q (psf)		
MAXIMUM PRESSURE (psf)	3463	
MINIMUM PRESSURE (psf)	3463	

MULTI-PLATE ARCH (INNER) FOOTING DESIGN :

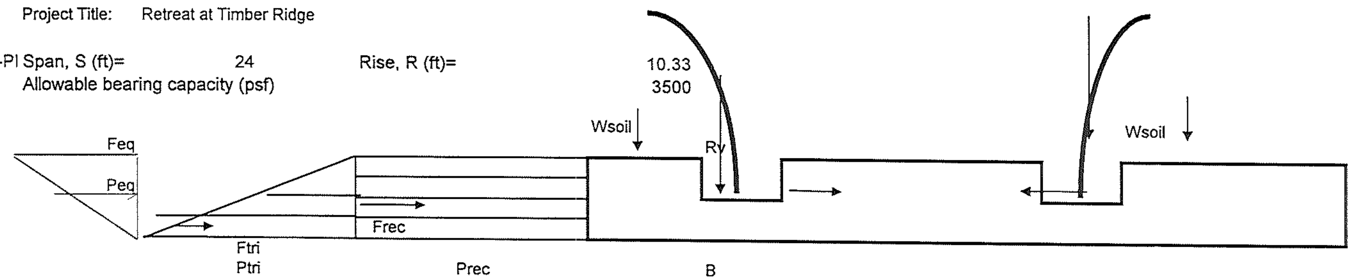
(AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS)

INNER FOOTING

Project No: 23088 Project Title: Retreat at Timber Ridge

Structure Size: MULTI-PI Span, S (ft)= 24 Rise, R (ft)= 10.33

Allowable bearing capacity (psf) 3500



DATA

HEIGHT OF COVER (ft)	7.25
Hc to INVERT (ft)	17.583
Rv (plf)	62150.6
Rh (plf)	0.0
ALL. BEARING (psf)	3500

FOOTING GEOMETRY

WIDTH, B (ft)	12.75
Central WIDTH, w (ft)	3.33
THICKNESS, t (ft)	2.170
HEIGHT, h (ft)	2.500

FOOTING LOADS

SOIL WEIGHT, Ws1 (plf)	9134.02	1.3
MOMENT ARM (ft)	0.000	
CONCRETE WEIGHT, Wc1 (plf)	5976.6	1.25
MOMENT ARM (ft)	0.00	
Rv (plf)	62150.6	
MOMENT ARM (ft)	0.00	
Rh (plf)	0.0	
MOMENT ARM (ft)	2.170	

OUTSIDE SOIL PRESSURE

At rest COEFFICIENT, Ko	0.0
Prec (psf)	0.0
Ptri (psf)	0.0
Frec (plf)	0.0
MOMENT ARM (ft)	1.25
Ftri (plf)	0.0
MOMENT ARM (ft)	0.8

BEARING PRESSURE CALCULATION (STATIC)

SUM OF VERTICALS, Q (plf)	77261.2	
SUM OF MOMENTS, Mo (ft-#/ft)	0.0	(CLOCKWISE POSITIVE)
ECCENTRICITY, e (ft)	0.0000	B/6 =
BEARING PRESSURES, q (psf)		
MAXIMUM PRESSURE (psf)	6060	
MINIMUM PRESSURE (psf)	6060	

MULTI-PLATE ARCH (INNER) FOOTING DESIGN :

(AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS)

INNER FOOTING

Project No: 23088 Project Title: Retreat at Timber Ridge

Structure Size: MULTI-PL Span, S (ft)= 24 Rise, R (ft)= 10.33

Allowable bearing capacity (psf) 3500

	Cantilever Length (a):		4.71	ft.	
	Footing width:		12.75	ft.	
	Concrete Beam :	b=	12	in.	
		h=	30	in.	
		d =	26.63	in.	
		f'_c =	4000	psi	
Factored	Bending Moment @ arch connection Mu=		67,214.53	ft.- lb	< outer footings
Service	Bending Moment @ arch connection Ms=		38,408.39	ft- lb	

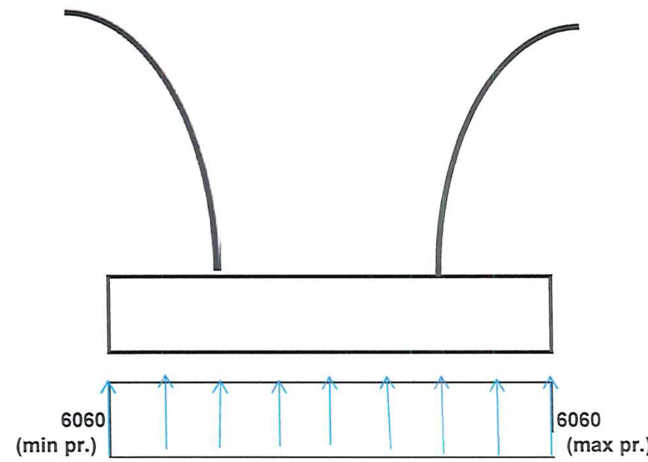
(See attached calculations for the reinforcement)

Shear @ the arch connection Vu = 28541.20 lbs

Required Depth : $d = Vu/(0.85 x 2 x (f'_c)^{0.5} \times b$

d= 22.12 in. < 26.63 in. provided

O.K. for SHEAR



MULTI-PLATE ARCH (INNER) FOOTING DESIGN :

(AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS)

INNER FOOTING

Project No: 23088 Project Title: Retreat at Timber Ridge

Structure Size:	MULTI-PLATE	Span, S (ft)=	24	Rise, R (ft)=	10.33
		Allowable bearing capacity (psf)			3500

1.0 CHECK FOR THE DISTRIBUTION OF REINFORCEMENT FOR FLEXURAL CRACKING CONTROL:

AASHTO LRFD SPECIFICATIONS SECTION 5.7.3.4

Size of the bar #	6
Width of the footing,b (in)	12.0
Net design depth,d (in)	26.63
dc(in)	3.38
bar diameter (in)	0.75
c/s area of the bar(in^2)	0.44
spacing(in)	6.0
no: of bars (n)	2
Area of steel,As(in^2)	0.88
fy(kips/in^2)	60
f'c(kips/in^2)	4000
M(ft-kips) (service load moment)	38.41
M(ft-kips) (factored load moment)	67.2
γ e (exposure factor)	0.75
fss (ksi)	20.1
$\beta s = 1 + \frac{dc}{0.7(h - dc)}$	1.181

Note: $sact < 700\gamma e/\beta s.fss - 2\,de$

700γe/βs.fss - 2 de 15.4 O.K

2.0 CHECK FOR MINIMUM REINFORCEMENT FOR CRACKING CONTROL:

AASHTO LRFD SPECIFICATION 5.7.3.3.2

Total Depth (in) 30

fcr(psi)	*Ig(in^4)*	*yt*	*Mcr (ft-k)*
480.0	27000.0	15.0	72.0

Criterion:

φMn ≥ the lesser of Mcr and 1.33 Mu

3.0 (1.33Mu)

Mu(ft-kips)	*a(in)(assumed)*	*b(in)*	*d(in)*	*As (in^2)*	*a cal(in)*
89.40	1.12	12.0	26.6	0.76	1.12

As provided = 0.88 sq.in

φMn(ft-kips) > 1.33 Mu(ft-Kips) O.K

4.0 CHECK FOR TEMPERATURE AND SHRINKAGE REINFORCEMENT:

AASHTO LRFD SPECIFICATIONS SECTION 5.10.8

As = 0.00186 b.h

For longitudinal bars : b=	153	
h=	30	
No of bars prov =	32	
As =	9.9	#5 longitudinal bars
As req=	8.5	
For transverse bars: b=	12	
h=	30	
No: of bars prov	2	
As req=	0.67	
As prov=	0.88	#6@6" @ top and #6@6"@ bottom

MULTI-PLATE ARCH (24'-0" X 10'-4") FOOTING DESIGN :
(AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS)

Project No: CBC 23088 Project Title: Retreat at Timber Ridge, El Paso, CO

Structure Size: MULTI-PLATE Span, S (ft)= 24 Rise, R (ft)= 10.3333

Allowable bearing capacity (psf) 3500

$Rv = (V_{dl} + V_{LL}) x \cos(A)^{o}$ Vertical Footing Reaction Component

$Rh = (V_{dl} + V_{LL}) x \sin(A)^{o}$ Horizontal Footing Reaction Component

$Vdl = (H_2 xS - A_t) xGamma/2$ Gamma = Unit Weight of Soil 120 pcf

$V_{LL} = n \cdot (AL) / (L_W + 2xH_1)$

S=	24.00	ft	Span
R=	10.33	ft	Rise
H=	7.25		Height of cover above the crown
H1=	17.58	ft.	Height of cover above the footing to traffic surf
H2=	17.58	ft.	Height of cover above the springline
A^{o} =	8.63	^{o}	Return angle
At =	188.00	sq.ft.	Area of the top portion above springline
AL =	50000.00	lbs.	HL-93
n =	2.00		Traffic lanes
Lw =	8.00	ft.	Lane width

Vdl =	14039.5	lbs/ft.	Rv=	16171.0		
			Rh=	2454.3		
V_{LL} =	2316.6	lbs/ft.	Rvd=	13880.6	Rhd=	2106.7

Factored Footing Reaction AASHTO LRFD SECTION 3.4.1-1 **STRENGTH LIMIT CASE**

LOAD FACTORS:
Beta Coefficient = 1.25 for Dead Load
= 1.75 for Live Load
= 1.95 for Vertical Earth Press.

Rvu = **31075.3** lbs/ft.

Rhu = **4716.34** lbs/ft.

MULTI-PLATE ARCH (OUTER) FOOTING DESIGN :

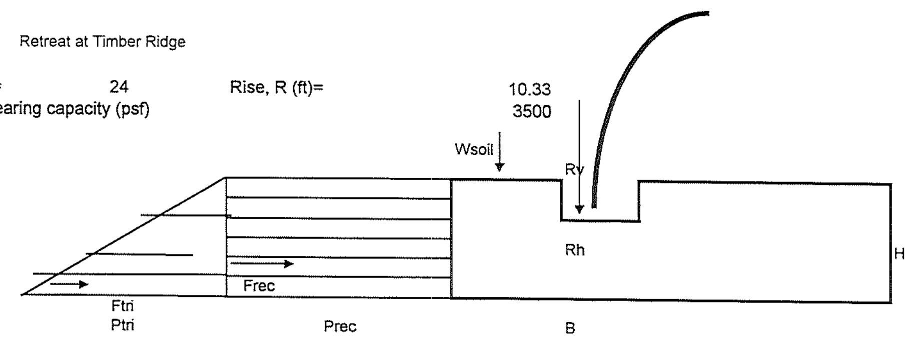
(AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS)

OUTER FOOTING

Project No: 23088 Project Title: Retreat at Timber Ridge

Structure Size: MULTI-PLATE Span, S (ft)= 24 Rise, R (ft)= 10.33

Allowable bearing capacity (psf) 3500



DATA

HEIGHT OF COVER (ft)	7.25
Hc to INVERT (ft)	17.583
Rv (plf)	16171
Rh (plf)	2454
Rvd(plf)=	13881
Rh dl(plf)=	2106.7
ALL. BEARING (psf)	3500

FOOTING GEOMETRY

WIDTH, B (ft)	9.33
OUTSIDE WIDTH, w (ft)	6.08
THICKNESS, t (ft)	2.170
HEIGHT, h (ft)	2.500

FOOTING LOADS

SOIL WEIGHT, Ws1 (plf)	12834.89
MOMENT ARM (ft)	3.042
CONCRETE WEIGHT, Wc1 (plf)	3498.8
MOMENT ARM (ft)	4.67
Rv (plf)	16171.0
MOMENT ARM (ft)	6.08
Rh (plf)	-2454.3
MOMENT ARM (ft)	2.170

OUTSIDE SOIL PRESSURE

At rest COEFFICIENT, Ko	0.5
Prec (psf)	1055.0
Ptri (psf)	150.0
Frec (plf)	2637.5
MOMENT ARM (ft)	1.25
Ftri (plf)	187.5
MOMENT ARM (ft)	0.8

BEARING PRESSURE CALCULATION (STATIC)

SUM OF VERTICALS, Q (plf)	32504.6	
SUM OF MOMENTS, Mo (ft-#/ft)	151854.3	(CLOCKWISE POSITIVE)
ECCENTRICITY, e (ft)	0.0068	B/6 = 1.5550
BEARING PRESSURES, q (psf)		
MAXIMUM PRESSURE (psf)	3499	**<3500 psf**
MINIMUM PRESSURE (psf)	3469	

MULTI-PLATE ARCH (OUTER) FOOTING DESIGN :

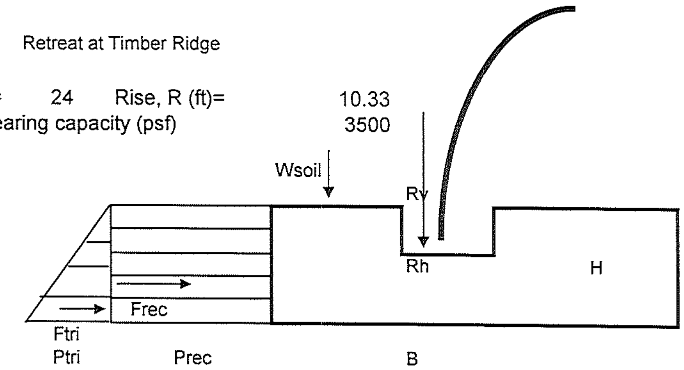
(AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS)

OUTER FOOTING

Project No: 23088 Project Title: Retreat at Timber Ridge

Structure Size: MULTI-PLATE Span, S (ft)= 24 Rise, R (ft)= 10.33

Allowable bearing capacity (psf) 3500



DATA

HEIGHT OF COVER (ft)	7.25
Hc to INVERT (ft)	17.583
Rvfac (plf)	31075
Rhfac (plf)	4716
ALL. BEARING (psf)	3500

FOOTING GEOMETRY

WIDTH, B (ft)	9.33
OUTSIDE WIDTH, w (ft)	6.08
THICKNESS, t (ft)	2.170
HEIGHT, h (ft)	2.500

FOOTING LOADS

SOIL WEIGHT, Ws1 (plf)	16685.35	1.3
MOMENT ARM (ft)	3.042	
CONCRETE WEIGHT, Wc1 (plf)	4373.4	1.25
MOMENT ARM (ft)	4.67	
Rvfac (plf)	31075.3	
MOMENT ARM (ft)	6.08	
Rhfac (plf)	-4716.3	
MOMENT ARM (ft)	2.170	

OUTSIDE SOIL PRESSURE

At rest COEFFICIENT, Ko	0.5	1.35
Prec (psf)	1424.2	
Ptri (psf)	202.5	
Frec (plf)	3560.6	
MOMENT ARM (ft)	1.25	
Ftri (plf)	253.1	
MOMENT ARM (ft)	0.8	

BEARING PRESSURE CALCULATION

SUM OF VERTICALS, Q (plf)	52134.1	
SUM OF MOMENTS, Mo (ft-#/ft)	254608.9	(CLOCKWISE POSITIVE)
ECCENTRICITY, e (ft)	0.2187	B/6 = 1.5550
BEARING PRESSURES, q (psf)		
MAXIMUM PRESSURE (psf)	6374	
MINIMUM PRESSURE (psf)	4802	

MULTI-PLATE ARCH (OUTER) FOOTING DESIGN :

(AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS)

OUTER FOOTING

Project No: 23088   Project Title: Retreat at Timber Ridge

Structure Size: MULTI-PLATE   Span, S (ft)= 24   Rise, R (ft)= 10.33

Allowable bearing capacity (psf) 3500

DATA

Cantilever Length :		6.08	ft.
Footing width:		9.33	ft.
Concrete Beam :	b=	12	in.
	h=	30	in.
	d =	26.63	in.
	dv=	23.96	in.
	f'_c =	4000	psi
Service: Bending Moment @ arch connection Mu=		57,054.00	ft.- lb

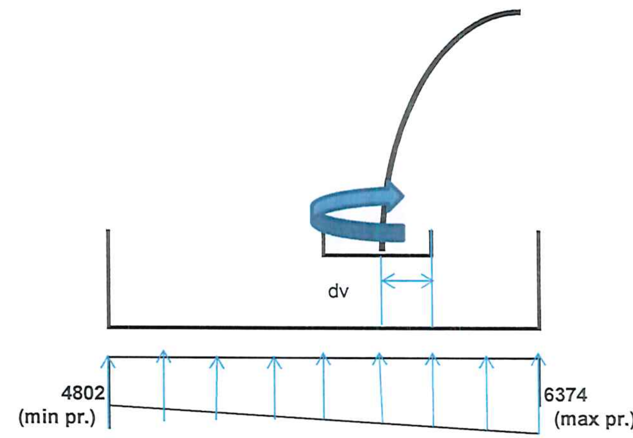
(See attached calculations for the reinforcement)

Max. Factored pressure @ arch connection=		5826.71	psf
Max. Factored pressure @ dv from the arch connection=		6163.16	psf
Shear @ the arch connection	Vu =	32326.61	lbs

Required Depth : $d = Vu/(0.85 \times 2 \times (f'_c)^{0.5} \times b$

d= 25.06 in. < 26.63 in. provided

O.K. for SHEAR



MULTI-PLATE ARCH (OUTER) FOOTING DESIGN :

(AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS)

OUTER FOOTING

Project No: 23088 Project Title: Retreat at Timber Ridge

Structure Size: MULTI-PLATE Span, S (ft)= 24 Rise, R (ft)= 10.33

Allowable bearing capacity (psf) 3500

DATA

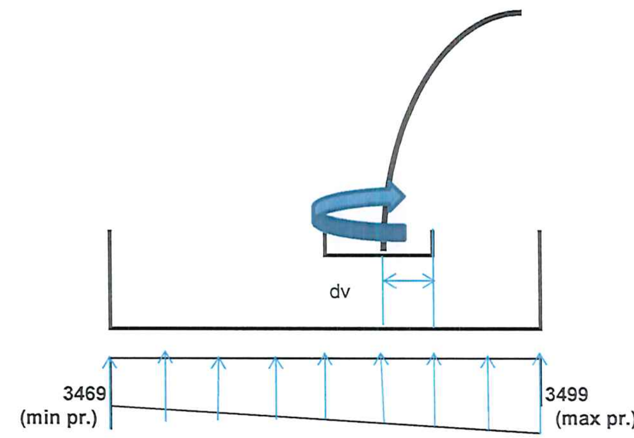
Cantilever Length :		6.08	ft.
Footing width:		9.33	ft.
Concrete Beam :	b=	12	in.
	h=	30	in.
	d =	26.63	in.
	dv=	23.96	in.
	f'_c =	4000	psi

Service Bending Moment @ arch connection Mu= 25,504.90 ft.- lb

(See attached calculations for the reinforcement)

Max. UnFactored pressure @ arch connection= 3488.50 psf

Max. UnFactored pressure @ dv from the arch connection= 3494.99 psf



MULTI-PLATE ARCH (OUTER) FOOTING DESIGN :

(AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS)

OUTER FOOTING

Project No: 23088 Project Title: Retreat at Timber Ridge

Structure Size: MULTI-PLATE Span, S (ft)= 24 Rise, R (ft)= 10.33

Allowable bearing capacity (psf) 3500

1.0 CHECK FOR THE DISTRIBUTION OF REINFORCEMENT FOR FLEXURAL CRACKING CONTROL:

AASHTO LRFD SPECIFICATIONS SECTION 5.7.3.4

Size of the bar #	6
Width of the footing,b (in)	12.0
Net design depth,d (in)	26.63
dc(in)	3.38
bar diameter (in)	0.75
c/s area of the bar(in^2)	0.44
spacing(in)	6.0
no: of bars (n)	2.00
Area of steel,As(in^2)	0.88
fy(kips/in^2)	60
f'c(kips/in^2)	4000
M(ft-kips) (service load moment)	25.50
M(ft-kips) (factored load moment)	57.1
γ e (exposure factor)	0.75
fss (ksi)	13.3
$\beta s = 1 + \frac{dc}{0.7(h-dc)}$	1.181

Note: $sact < 700\gamma e/\beta s.fss - 2\ de$

700γe/βs.fss - 2 de 26.7 ***O.K***

2.0 CHECK FOR MINIMUM REINFORCEMENT FOR CRACKING CONTROL:

AASHTO LRFD SPECIFICATION 5.7.3.3.2

Total Depth (in) 30

fcr(psi)	*Ig(in^4)*	*yt*	*Mcr (ft-k)*
480.0	27000.0	15.0	72.0

Criterion:

φMn ≥ the lesser of Mcr and 1.33 Mu

3.0 (1.33Mu)

Mu(ft-kips)	*a(in)(assumed)*	*b(in)*	*d(in)*	*As (in^2)*	*a cal(in)*
75.88	0.95	12.0	26.6	0.64	0.95

As provided = 0.88 sq.in

φMn(ft-kips) > 1.33 Mu(ft-Kips) ***O.K***

4.0 CHECK FOR TEMPERATURE AND SHRINKAGE REINFORCEMENT:

AASHTO LRFD SPECIFICATIONS SECTION 5.10.8

As = 0.00186 b.h

For longitudinal bars : b=	112	
h=	30	
No of bars prov =	22	min
As =	6.8	#5 longitudinal bars
As req=	6.2	
For transverse bars: b=	12	
h=	30	
No: of bars prov	2.00	
As req=	0.67	
As prov=	0.88	

CONCRETE HEADWALL DESIGN

CBC # 23088
Retreat at Timber Ridge, El Paso, CO
SQUARE END

Material Properties:
120 pcf = γ_{soil}
150 pcf = $\gamma_{concrete}$
34° = ϕ'
4,000 psi = Concrete strength
60,000 psi = Steel yield strength
Cast-in-Place = Type of Structure

Shape: Round/Ellipse/Pipe Arch
10.33 ft = Rise
24.00 ft = Span
2.17 ft = Height of cover
0.00 ft = Stickup
1.67 ft = Left end width of headwall
1.67 ft = Right end width of headwall
15.0 in = Top Thickness
15.0 in = Bottom Thickness
0.00 in = Toe

Analysis based on:
Active conditions
0.42 = Ka - horizontal
240 psf Live Load Surcharge
10 kip Impact Load

Headwall/Soil Interface:
90.0° = θ, Angle of Headwall to Horizontal
0.0° = α, Soil Angle of Inclination
0.0° = δ, Soil-Concrete Interface Friction Angle

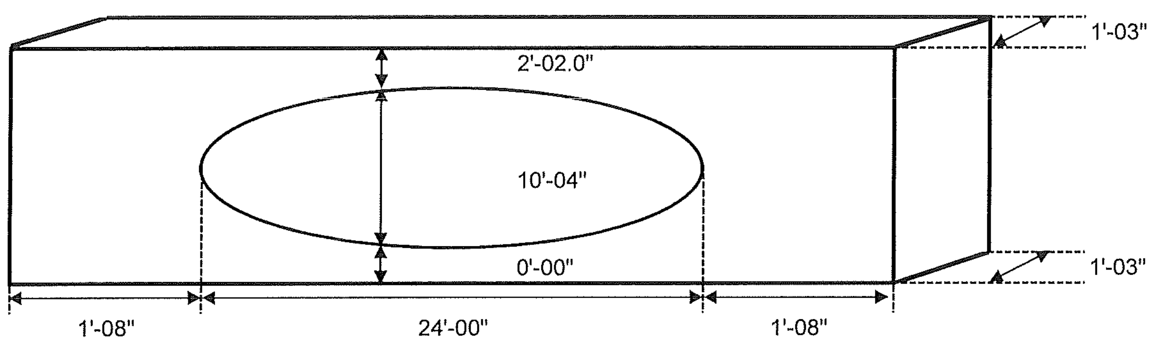
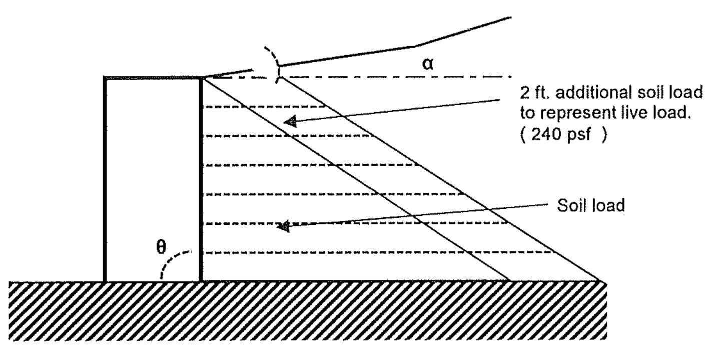


FIGURE 1



TOP BEAM - HORIZONTAL BENDING

Retreat at Timber Ridge, El Paso, CO

DATA

Concrete Strength f'_c	4,000 psi
Steel Yield Strength f_y	60,000 psi
Length L	27.33 ft
Thickness h	12.00 in
[Height of Cover + Stickup] b	2.17 ft

UNFACTORED LOADS - Active conditions

Earth Surchage Load W_{sur}	218.74 plf
Soil Load W_{soil}	118.66 plf
Load from the skew (plf)	0

FACTORED LOADS - Active conditions

$\eta_R = 1$

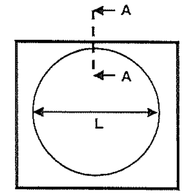
$\gamma_{ES} = 1.75$

$\gamma_{EH} = 1.50$

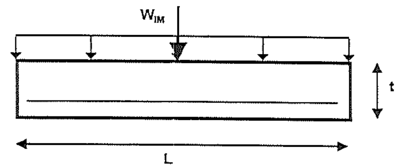
Earth Surchage Load W_{sur}	382.79 plf	
Soil Load W_{soil}	178.00 plf	
Impact load (lbs/ft)	0,000 lbs	(See attached sheet)

RESULTS

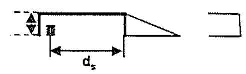
Max. Unfactored Moment $M_{s\,(lateral)}$	31.50 k-ft
Max. Factored Moment $M_{u\,(lateral)}$	52.36 k-ft



FRONT VIEW
N.T.S.



TOP VIEW
N.T.S.



SECTION A-A
N.T.S.

HEADWALL DESIGN :

(AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS)

CBC # 23088 (TOP BEAM)

FLEXURAL CRACKING CONTROL:

AASHTO LRFD SPECIFICATIONS SECTION 5.7.3.4 *TOP BEAM*

Size of the bar #	*#8*
Width of the beam,b (in)	*26.00*
Net design depth,d (in)	*8.88*
dc(in)	*3.13*
bar diameter (in)	*1*
c/s area of the bar(in^2)	*0.79*
spacing(in)	*3.0*
no: of bars (n)	*5.0*
Area of steel,As(in^2)	*3.95*
fy(kips/in^2)	*60*
f'c(kips/in^2)	*4000*
M(ft-kips) (service load moment)	*31.50*
M(ft-kips) (factored load moment)	*52.4*
γ e (exposure factor)	*0.75*
fss (ksi)	*11.4*
$\beta s = 1 + \dfrac{dc}{0.7(h - dc)}$	*1.503*

Note: $sact < 700\gamma e/\beta s.fss - 2\,dc$		
700γe/βs.fss - 2 de	*24.4*	*O.K*

2.0 CHECK FOR MINIMUM REINFORCEMENT FOR CRACKING CONTROL:

AASHTO LRFD SPECIFICATION 5.7.3.3.2

Total Depth (in) *12*

fcr(psi)	*Ig(in^4)*	*yt*	*Mcr (ft-k)*
480.0	*3744.0*	*6.0*	*25.0*

Criterion:

φMn ≥ the lesser of Mcr and 1.33 Mu

	Mu(ft-kips)	*a(in)(assumed)*	*b(in)*	*d(in)*	*As (in^2)*	*a cal(in)*
3.0 (Mu)	*52.36*	*0.94*	*26.0*	*8.9*	*1.38*	*0.94*

As provided = 4.0 sq.in

φMn(ft-kips) > 1.33 Mu(ft-Kips) *O.K*

END BEAM - BENDING AT BOTTOM

Retreat at Timber Ridge, El Paso, CO

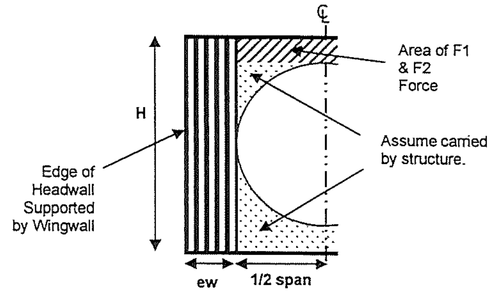
DATA

Concrete Strength f'_c	4,000 psi
Steel Yield Strength f_y	60,000 psi
Height H	12.20 ft
Thickness h	12.00 in
End Width b	1.67 ft
Length L = 1/2 Span	12.00 ft

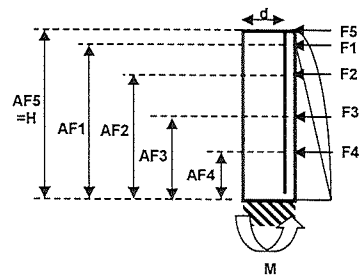
FORCES AND MOMENT ARMS	Unfact.	Fact.	$\eta_R = 1$
F1 ES Force - Top Beam (kips)	2.62	4.59	$\gamma_{ES} = 1.75$
Moment Arm	11.12 ft		
F2 Soil Force - Top Beam (kips)	1.42	2.14	$\gamma_{EH} = 1.5$
Moment Arm	10.75 ft		
F3 ES Force - End Beam (kips)	2.05	3.59	$\gamma_{ES} = 1.75$
Moment Arm	6.10 ft		
F4 Soil Force - End Beam (kips)	6.26	9.40	$\gamma_{EH} = 1.5$
Moment Arm	4.07 ft		
Impact load (kips)	0.00	0.00	$\gamma_{LL} = 1.75$
Moment Arm	26.00 ft	26.00	

RESULTS

Max. Unfactored Moment M_s	82.49 k-ft
Max. Factored Moment M_u	134.16 k-ft



FRONT VIEW
N.T.S.



HEADWALL DESIGN :

(AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS)

CBC # 23088

SQUARE END

AASHTO LRFD SPECIFICATIONS SECTION 5.7.3.4 *END BEAM*

Size of the bar #	*#9*
Width of the beam,b (in)	*20.0*
Net design depth,d (in)	*9.44*
dc(in)	*2.56*
bar diameter (in)	*1.128*
c/s area of the bar(in^2)	*1*
spacing(in)	*3.8*
no: of bars (n)	*4.0*
Area of steel,As(in^2)	*4.0*
fy(kips/in^2)	*60*
f'c(kips/in^2)	*4000*
M(ft-kips) (service load moment)	*82.49*
M(ft-kips) (factored load moment)	*134.2*
γ e (exposure factor)	*0.75*
fss (ksi)	*32.0*
$\beta s = 1 + \frac{dc}{0.7(h - dc)}$	*1.388*

Note: $sact < 700\gamma e/\beta s.fss - 2\,dc$

700γe/βs.fss - 2 de *6.7* *O.K*

2.0 CHECK FOR MINIMUM REINFORCEMENT FOR CRACKING CONTROL:

AASHTO LRFD SPECIFICATION 5.7.3.3.2

Total Depth (in) *12*

fcr(psi)	*Ig(in^4)*	*yt*	*Mcr (ft-k)*
480.0	*2880.0*	*6.0*	*19.2*

Criterion:

φMn ≥ the lesser of Mcr and 1.33 Mu

	Mu(ft-kips)	*a(in)(assumed)*	*b(in)*	*d(in)*	*As (in^2)*	*a cal(in)*
3.0 (Mu)	*134.16*	*3.40*	*20.0*	*9.4*	*3.9*	*3.40*

As provided = 4.0 sq.in

φMn(ft-kips) > 1.33 Mu(ft-Kips) *O.K*

TOP BEAM - HORIZONTAL BENDING
Retreat at Timber Ridge, El Paso, CO

DATA

Concrete Strength f'_c	4,000 psi
Steel Yield Strength f_y	60,000 psi
Length L	27.33 ft
Thickness h	12.00 in
[Height of Cover + Stickup] b	1.36 ft

UNFACTORED LOADS - Active conditions

Earth Surchage Load W_{sur}	134.06 plf
Soil Load W_{soil}	44.58 plf
Load from the skew (plf)	0

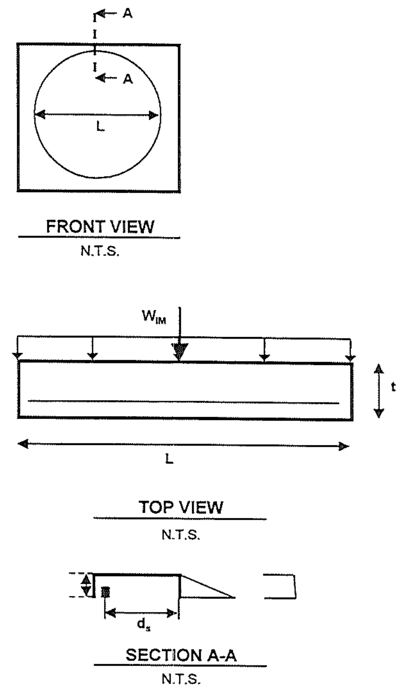
FACTORED LOADS - Active conditions

$\eta_R = 1$
$\gamma_{ES} = 1.75$
$\gamma_{EH} = 1.50$

Earth Surchage Load W_{sur}	234.61 plf	
Soil Load W_{soil}	66.86 plf	
Impact load (lbs/ft)	0,000 lbs	(See attached sheet)

RESULTS

Max. Unfactored Moment $M_{s\ (lateral)}$	16.68 k-ft
Max. Factored Moment $M_{u\ (lateral)}$	28.15 k-ft



HEADWALL DESIGN :

(AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS)

CBC # 23088 (TOP BEAM)

FLEXURAL CRACKING CONTROL:

AASHTO LRFD SPECIFICATIONS SECTION 5.7.3.4 *TOP BEAM*

Size of the bar #	#8
Width of the beam,b (in)	16.00
Net design depth,d (in)	8.88
dc(in)	3.13
bar diameter (in)	1
c/s area of the bar(in^2)	0.79
spacing(in)	3.0
no: of bars (n)	3.0
Area of steel,As(in^2)	2.37
fy(kips/in^2)	60
f'c(kips/in^2)	4000
M(ft-kips) (service load moment)	16.68
M(ft-kips) (factored load moment)	28.1
γ e (exposure factor)	0.75
fss (ksi)	10.0
$\beta s = 1 + \frac{dc}{0.7(h - dc)}$	1.503

Note: $sact < 700\gamma e/\beta s.fss - 2\,dc$

$700\gamma e/\beta s.fss$ - 2 de 28.8 O.K

2.0 CHECK FOR MINIMUM REINFORCEMENT FOR CRACKING CONTROL:

AASHTO LRFD SPECIFICATION 5.7.3.3.2

Total Depth (in) 12

fcr(psi)	Ig(in^4)	yt	Mcr (ft-k)
480.0	2304.0	6.0	15.4

Criterion:

φMn ≥ the lesser of Mcr and 1.33 Mu

3.0 (Mu)

Mu(ft-kips)	a(in)(assumed)	b(in)	d(in)	As (in^2)	a cal(in)
28.15	0.81	16.0	8.9	0.74	0.81

As provided = 2.4 sq.in

φMn(ft-kips) > 1.33 Mu(ft-Kips) O.K

END BEAM - BENDING AT BOTTOM

Retreat at Timber Ridge, El Paso, CO

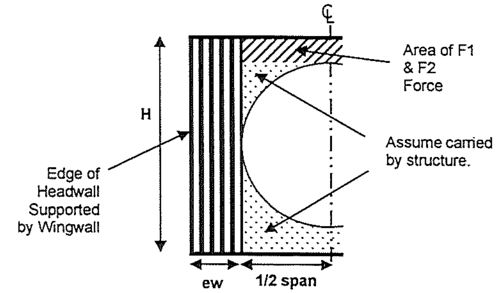
DATA

Concrete Strength f'_c	4,000 psi
Steel Yield Strength f_y	60,000 psi
Height H	11.36 ft
Thickness h	12.00 in
End Width b	1.67 ft
Length L = 1/2 Span	12.00 ft

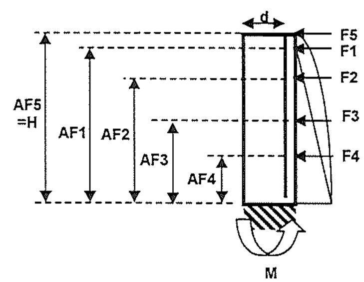
FORCES AND MOMENT ARMS	Unfact.	Fact.	η_R = 1
F1 ES Force - Top Beam (kips)	1.61	2.82	γ_{ES} = 1.75
Moment Arm	10.68 ft		
F2 Soil Force - Top Beam (kips)	0.53	0.80	γ_{EH} = 1.5
Moment Arm	10.45 ft		
F3 ES Force - End Beam (kips)	1.91	3.35	γ_{ES} = 1.75
Moment Arm	5.68 ft		
F4 Soil Force - End Beam (kips)	5.43	8.15	γ_{EH} = 1.5
Moment Arm	3.79 ft		
Impact load (kips)	0.00	0.00	γ_{LL} = 1.75
Moment Arm	26.00 ft	26.00	

RESULTS

Max. Unfactored Moment M_s	54.20 k-ft
Max. Factored Moment M_u	88.31 k-ft



FRONT VIEW
N.T.S.



HEADWALL DESIGN :

(AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS)

CBC # 23088

SQUARE END

AASHTO LRFD SPECIFICATIONS SECTION 5.7.3.4 *END BEAM*

Size of the bar #	#9
Width of the beam,b (in)	20.0
Net design depth,d (in)	9.44
dc(in)	2.56
bar diameter (in)	1.128
c/s area of the bar(in^2)	1
spacing(in)	5.0
no: of bars (n)	3.0
Area of steel,As(in^2)	3.0
fy(kips/in^2)	60
f'c(kips/in^2)	4000
M(ft-kips, (service load moment)	54.20
M(ft-kips, (factored load moment)	88.3
γ e (exposure factor)	0.75
fss (ksi)	25.8
$\beta s = 1 + \frac{dc}{0.7(h - dc)}$	1.388

Note: $sact < 700\gamma e/\beta s.fss - 2\,dc$		
$700\gamma e/\beta s.fss$ - 2 de	9.5	O.K

2.0 CHECK FOR MINIMUM REINFORCEMENT FOR CRACKING CONTROL:

AASHTO LRFD SPECIFICATION 5.7.3.3.2

Total Depth (in) 12

fcr(psi)	Ig(in^4)	yt	Mcr (ft-k)
480.0	2880.0	6.0	19.2

Criterion:

φMn ≥ the lesser of Mcr and 1.33 Mu

3.0	Mu(ft-kips)	a(in)(assumed)	b(in)	d(in)	As (in^2)	a cal(in)
(Mu)	88.31	2.06	20.0	9.4	2.3	2.06

As provided = 3.0 sq.in

φMn(ft-kips) > 1.33 Mu(ft-Kips) O.K

CBC Engineers&Associates, Ltd.

125 Westpark Rd.
Centerville, OH 45459

Title : RETREAT AT TIMBER RIDGE, CO
Job # : 23088 Dsgnr: CBC
Description....
WINGWALL MAX HT. 5 FEET

Page: ______
Date: MAR 20,2020

Retain Pro 9 © 1989 - 2011 Ver: 9.27 8171
Registration #: RP-1110505 RP9.27

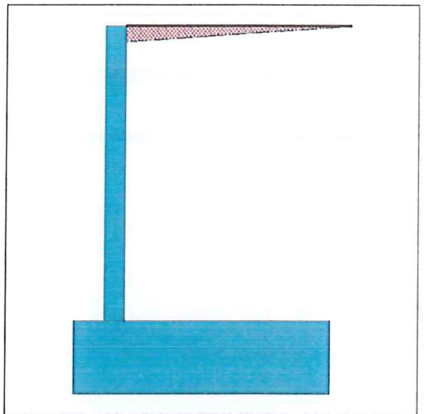
Cantilevered Retaining Wall Design

Criteria

Retained Height	=	12.20 ft
Wall height above soil	=	0.00 ft
Slope Behind Wall	=	0.00 : 1
Height of Soil over Toe	=	0.00 in
Water height over heel	=	0.0 ft

Soil Data

Allow Soil Bearing	=	3,500.0 psf
Equivalent Fluid Pressure Method		
Heel Active Pressure	=	46.0 psf/ft
Toe Active Pressure	=	46.0 psf/ft
Passive Pressure	=	0.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.450
Soil height to ignore for passive pressure	=	0.00 in



Thumbnail

Surcharge Loads

Surcharge Over Heel = 0.0 psf
NOT Used To Resist Sliding & Overturning
Surcharge Over Toe = 0.0 psf
NOT Used for Sliding & Overturning

Axial Load Applied to Stem

Axial Dead Load	=	0.0 lbs
Axial Live Load	=	0.0 lbs
Axial Load Eccentricity	=	0.0 in

Lateral Load Applied to Stem

Lateral Load	=	0.0 #/ft
...Height to Top	=	0.00 ft
...Height to Bottom	=	0.00 ft
The above lateral load has been increased by a factor of		1.00
Wind on Exposed Stem	=	0.0 psf

Adjacent Footing Load

Adjacent Footing Load	=	0.0 lbs
Footing Width	=	0.00 ft
Eccentricity	=	0.00 in
Wall to Ftg CL Dist	=	0.00 ft
Footing Type		Line Load
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Design Summary

Wall Stability Ratios

Overturning	=	5.56	OK
Sliding	=	1.95	OK
Total Bearing Load	=	22,094 lbs	
...resultant ecc.	=	8.79 in	
Soil Pressure @ Toe	=	2,389 psf	OK
Soil Pressure @ Heel	=	1,146 psf	OK
Allowable	=	3,500 psf	

Soil Pressure Less Than Allowable

ACI Factored @ Toe	=	3,345 psf	
ACI Factored @ Heel	=	1,604 psf	
Footing Shear @ Toe	=	0.0 psi	OK
Footing Shear @ Heel	=	8.9 psi	OK
Allowable	=	94.9 psi	

Sliding Calcs (Vertical Component NOT Used)

Lateral Sliding Force	=	5,106.2 lbs	
less 100% Passive Force	= -	0.0 lbs	
less 100% Friction Force	= -	9,942.1 lbs	
Added Force Req'd	=	0.0 lbs	OK
....for 1.5 : 1 Stability	=	0.0 lbs	OK

Load Factors

Building Code	
Dead Load	1.250
Live Load	1.750
Earth, H	1.500
Wind, W	1.600
Seismic, E	1.000

Stem Construction

			Top Stem
			Stem OK
Design Height Above Ftg	ft	=	0.00
Wall Material Above "Ht"		=	Concrete
Thickness		=	12.00
Rebar Size		=	# 6
Rebar Spacing		=	6.00
Rebar Placed at		=	Edge
Design Data			
fb/FB + fa/Fa		=	**0.587**
Total Force @ Section	lbs	=	5,134.1
Moment....Actual	ft-#	=	20,877.1
Moment.....Allowable		=	35,545.0
Shear.....Actual	psi	=	44.5
Shear.....Allowable	psi	=	94.9
Wall Weight		=	150.0
Rebar Depth 'd'	in	=	9.63
LAP SPLICE IF ABOVE	in	=	37.00
LAP SPLICE IF BELOW	in	=	
HOOK EMBED INTO FTG	in	=	9.96
Masonry Data			
f'm	psi	=	
Fs	psi	=	
Solid Grouting		=	
Modular Ratio 'n'		=	
Short Term Factor		=	
Equiv. Solid Thick.		=	
Masonry Block Type		=	Medium Weight
Masonry Design Method		=	ASD
Concrete Data			
f'c	psi	=	4,000.0
Fy	psi	=	60,000.0

CBC Engineers&Associates, Ltd.

125 Westpark Rd.
Centerville, OH 45459

Title : RETREAT AT TIMBER RIDGE, CO
Job # : 23088 Dsgnr: CBC
Description....
WINGWALL MAX HT. 5 FEET

Page: ______
Date: MAR 20,2020

Retain Pro 9 © 1989 - 2011 Ver: 9.27 8171
Registration #: RP-1110505 RP9.27

Cantilevered Retaining Wall Design

Footing Dimensions & Strengths

Toe Width	=	1.50 ft
Heel Width	=	11.00
Total Footing Width	=	12.50
Footing Thickness	=	36.00 in
Key Width	=	0.00 in
Key Depth	=	0.00 in
Key Distance from Toe	=	0.00 ft

f'c = 4,000 psi Fy = 40,000 psi
Footing Concrete Density = 150.00 pcf
Min. As % = 0.0000
Cover @ Top 0.00 @ Btm.= 0.00 in

Footing Design Results

		Toe	Heel
Factored Pressure	=	3,345	1,604 psf
Mu' : Upward	=	3,685	103,416 ft-#
Mu' : Downward	=	709	133,972 ft-#
Mu: Design	=	2,976	30,556 ft-#
Actual 1-Way Shear	=	0.00	8.90 psi
Allow 1-Way Shear	=	94.87	94.87 psi
Toe Reinforcing	=	None Spec'd	
Heel Reinforcing	=	None Spec'd	
Key Reinforcing	=	None Spec'd	

Other Acceptable Sizes & Spacings

Toe: Not req'd, Mu < S * Fr
Heel: Not req'd, Mu < S * Fr
Key: No key defined

Summary of Overturning & Resisting Forces & Moments

.....OVERTURNING.....

Item		Force lbs	Distance ft	Moment ft-#
Heel Active Pressure	=	5,313.2	5.07	26,918.5
Surcharge over Heel	=			
Toe Active Pressure	=	-207.0	1.00	-207.0
Surcharge Over Toe	=			
Adjacent Footing Load	=			
Added Lateral Load	=			
Load @ Stem Above Soil	=			
Total	=	5,106.2	**O.T.M.** =	26,711.5

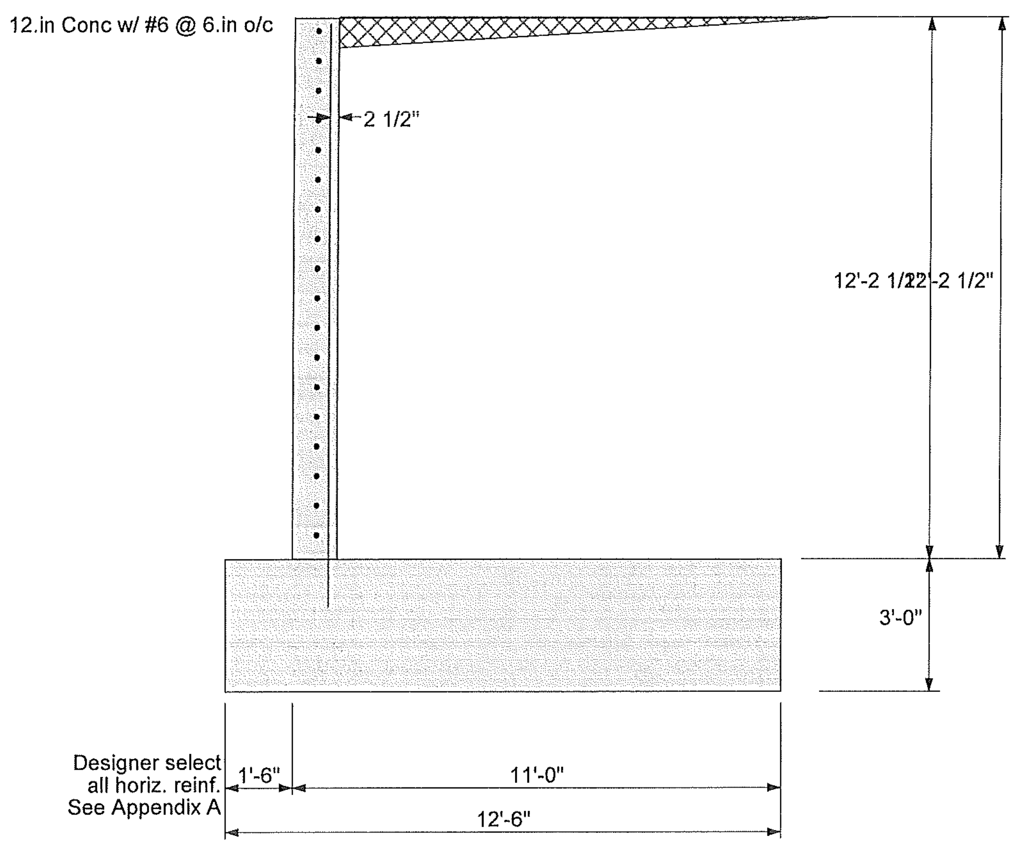
Resisting/Overturning Ratio = **5.56**
Vertical Loads used for Soil Pressure = 22,093.7 lbs

.....RESISTING.....

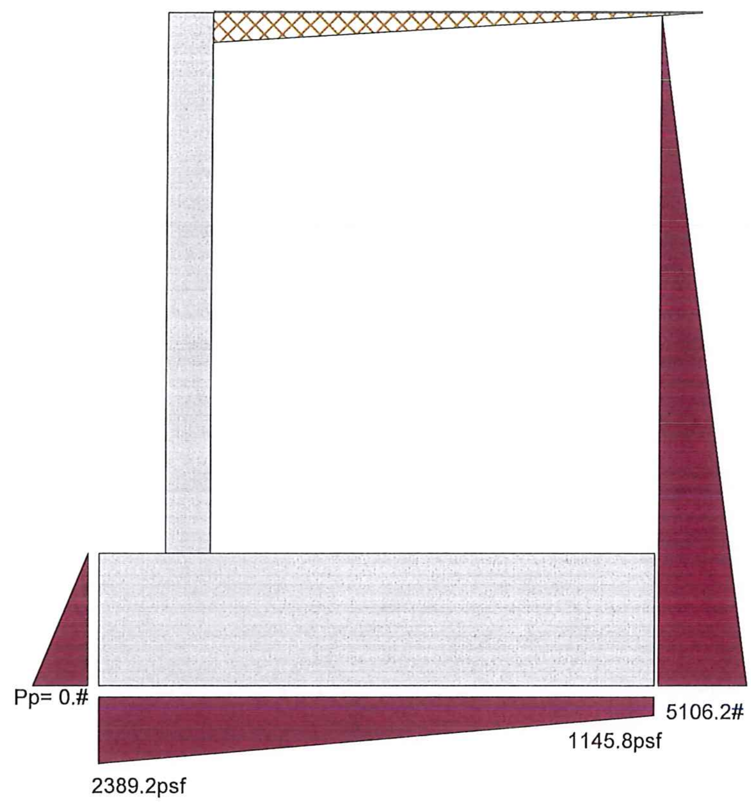
Item		Force lbs	Distance ft	Moment ft-#
Soil Over Heel	=	14,638.8	7.50	109,791.0
Sloped Soil Over Heel	=			
Surcharge Over Heel	=			
Adjacent Footing Load	=			
Axial Dead Load on Stem	=			
* Axial Live Load on Stem	=			
Soil Over Toe	=			
Surcharge Over Toe	=			
Stem Weight(s)	=	1,829.9	2.00	3,659.7
Earth @ Stem Transitions	=			
Footing Weight	=	5,625.0	6.25	35,156.3
Key Weight	=			
Vert. Component	=			
Total =		22,093.7 lbs	R.M.=	148,607.0

* Axial live load NOT included in total displayed, or used for overturning resistance, but is included for soil pressure calculation.

DESIGNER NOTES:



12.in Conc w/ #6 @ 6.in o/c
2 1/2"
12'-2 1/2"
12'-2 1/2"
3'-0"
Designer select
all horiz. reinf.
See Appendix A
1'-6"
11'-0"
12'-6"



Pp= 0.#
5106.2#
1145.8psf
2389.2psf

CBC Engineers&Associates, Ltd.

125 Westpark Rd.
Centerville, OH 45459

Title : RETREAT AT TIMBER RIDGE, CO — Page: ______
Job # : 23088 — Dsgnr: CBC — Date: MAR 20,2020
Description....
WINGWALL MAX HT. 5 FEET

Retain Pro 9 © 1989 - 2011 Ver: 9.27 8171
Registration #: RP-1110505 RP9.27

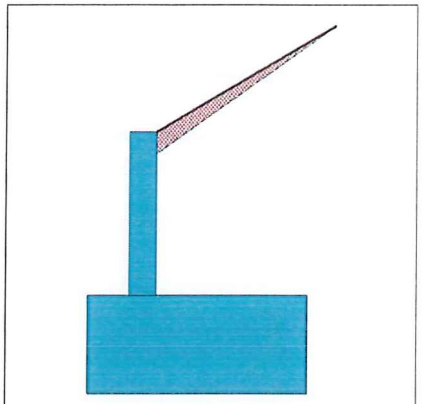
Cantilevered Retaining Wall Design

Criteria

Retained Height	=	5.00 ft
Wall height above soil	=	0.00 ft
Slope Behind Wall	=	2.00 : 1
Height of Soil over Toe	=	0.00 in
Water height over heel	=	0.0 ft

Soil Data

Allow Soil Bearing	=	3,500.0 psf
Equivalent Fluid Pressure Method		
Heel Active Pressure	=	46.0 psf/ft
Toe Active Pressure	=	46.0 psf/ft
Passive Pressure	=	0.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	120.00 pcf
Footing||Soil Friction	=	0.450
Soil height to ignore for passive pressure	=	0.00 in



Thumbnail

Surcharge Loads

Surcharge Over Heel = 0.0 psf
NOT Used To Resist Sliding & Overturning
Surcharge Over Toe = 0.0 psf
NOT Used for Sliding & Overturning

Axial Load Applied to Stem

Axial Dead Load	=	0.0 lbs
Axial Live Load	=	0.0 lbs
Axial Load Eccentricity	=	0.0 in

Lateral Load Applied to Stem

Lateral Load	=	0.0 #/ft
...Height to Top	=	0.00 ft
...Height to Bottom	=	0.00 ft
The above lateral load has been increased by a factor of		1.00
Wind on Exposed Stem	=	0.0 psf

Adjacent Footing Load

Adjacent Footing Load	=	0.0 lbs
Footing Width	=	0.00 ft
Eccentricity	=	0.00 in
Wall to Ftg CL Dist	=	0.00 ft
Footing Type		Line Load
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Design Summary

Wall Stability Ratios

Overturning	=	4.17	OK
Sliding	=	1.57	OK
Total Bearing Load	=	8,558 lbs	
...resultant ecc.	=	6.63 in	
Soil Pressure @ Toe	=	1,513 psf	OK
Soil Pressure @ Heel	=	627 psf	OK
Allowable	=	3,500 psf	

Soil Pressure Less Than Allowable

ACI Factored @ Toe	=	2,118 psf	
ACI Factored @ Heel	=	877 psf	
Footing Shear @ Toe	=	0.0 psi	OK
Footing Shear @ Heel	=	5.1 psi	OK
Allowable	=	94.9 psi	

Sliding Calcs (Vertical Component NOT Used)

Lateral Sliding Force	=	2,450.9 lbs	
less 100% Passive Force	= -	0.0 lbs	
less 100% Friction Force	= -	3,850.9 lbs	
Added Force Req'd	=	0.0 lbs	OK
....for 1.5 : 1 Stability	=	0.0 lbs	OK

Load Factors

Building Code	
Dead Load	1.250
Live Load	1.750
Earth, H	1.500
Wind, W	1.600
Seismic, E	1.000

Stem Construction

			Top Stem
			Stem OK
Design Height Above Ftg	ft	=	0.00
Wall Material Above "Ht"		=	Concrete
Thickness		=	12.00
Rebar Size		=	# 6
Rebar Spacing		=	6.00
Rebar Placed at		=	Edge
Design Data			
fb/FB + fa/Fa		=	0.040
Total Force @ Section	lbs	=	862.5
Moment....Actual	ft-#	=	1,437.5
Moment.....Allowable		=	35,545.0
Shear.....Actual	psi	=	7.5
Shear.....Allowable	psi	=	94.9
Wall Weight		=	150.0
Rebar Depth 'd'	in	=	9.63
LAP SPLICE IF ABOVE	in	=	37.00
LAP SPLICE IF BELOW	in	=	
HOOK EMBED INTO FTG	in	=	9.96
Masonry Data			
f'm	psi	=	
Fs	psi	=	
Solid Grouting		=	
Modular Ratio 'n'		=	
Short Term Factor		=	
Equiv. Solid Thick.		=	
Masonry Block Type		=	Medium Weight
Masonry Design Method		=	ASD
Concrete Data			
f'c	psi	=	4,000.0
Fy	psi	=	60,000.0

Cantilevered Retaining Wall Design

Footing Dimensions & Strengths

Toe Width	=	1.50 ft
Heel Width	=	6.50
Total Footing Width	=	8.00
Footing Thickness	=	36.00 in
Key Width	=	0.00 in
Key Depth	=	0.00 in
Key Distance from Toe	=	0.00 ft

f'c = 4,000 psi Fy = 40,000 psi
Footing Concrete Density = 150.00 pcf
Min. As % = 0.0000
Cover @ Top 0.00 @ Btm.= 0.00 in

Footing Design Results

		Toe	Heel
Factored Pressure	=	2,118	877 psf
Mu' : Upward	=	2,295	17,569 ft-#
Mu' : Downward	=	709	26,892 ft-#
Mu: Design	=	1,587	9,323 ft-#
Actual 1-Way Shear	=	0.00	5.13 psi
Allow 1-Way Shear	=	94.87	94.87 psi
Toe Reinforcing	=	None Spec'd	
Heel Reinforcing	=	None Spec'd	
Key Reinforcing	=	None Spec'd	

Other Acceptable Sizes & Spacings

Toe: Not req'd, Mu < S * Fr
Heel: Not req'd, Mu < S * Fr
Key: No key defined

Summary of Overturning & Resisting Forces & Moments

.....OVERTURNING.....

Item		Force lbs	Distance ft	Moment ft-#
Heel Active Pressure	=	2,657.9	3.58	9,524.3
Surcharge over Heel	=			
Toe Active Pressure	=	-207.0	1.00	-207.0
Surcharge Over Toe	=			
Adjacent Footing Load	=			
Added Lateral Load	=			
Load @ Stem Above Soil	=			
Total	=	2,450.9	O.T.M. =	9,317.3

Resisting/Overturning Ratio = **4.17**
Vertical Loads used for Soil Pressure = 8,557.5 lbs

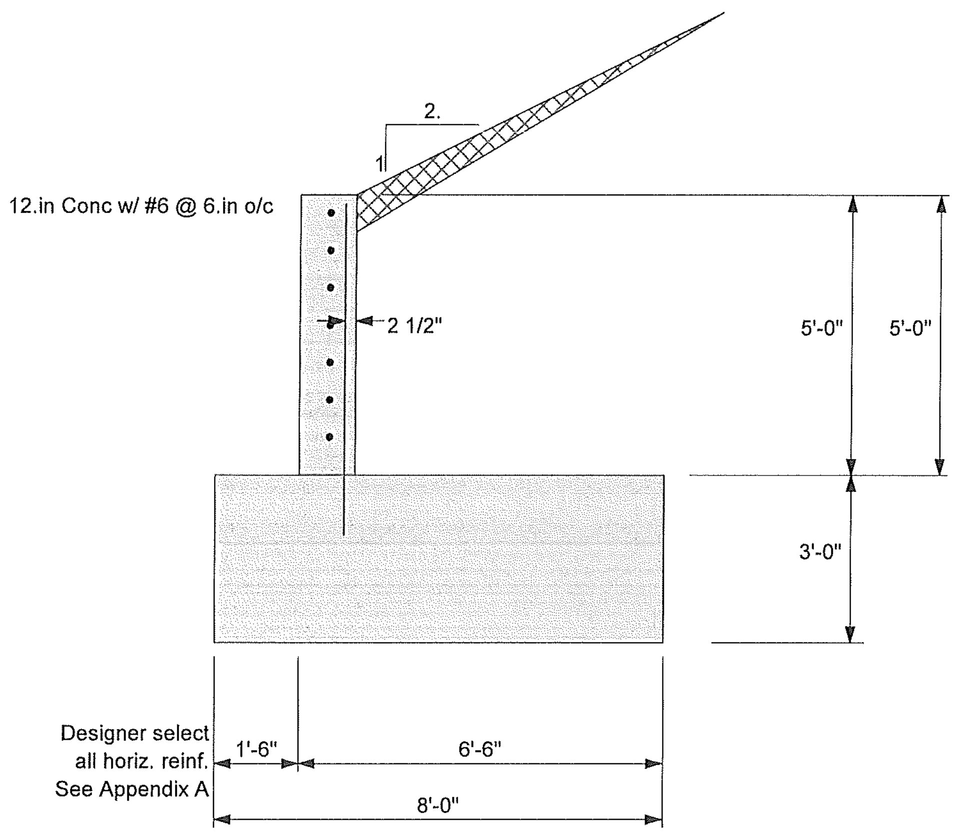
Vertical component of active pressure NOT used for soil pressure

.....RESISTING.....

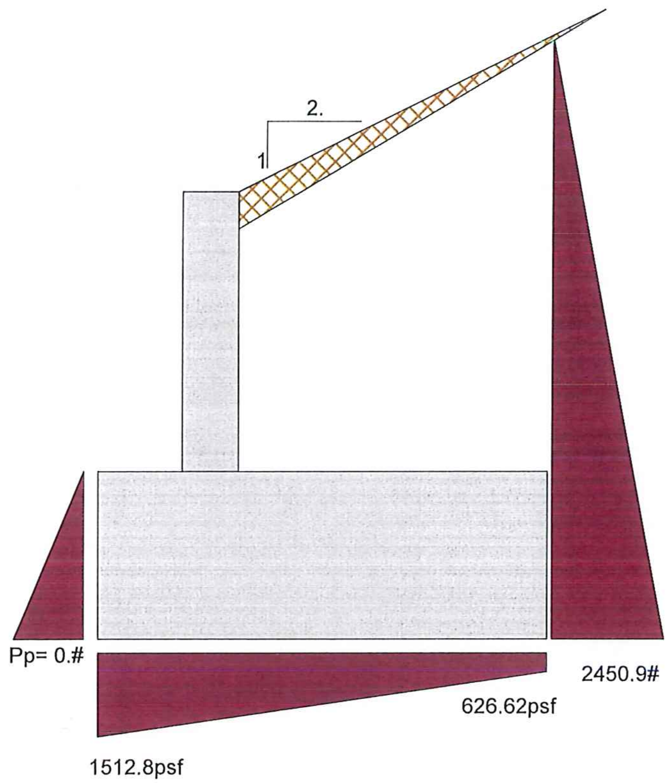
		Force lbs	Distance ft	Moment ft-#
Soil Over Heel	=	3,300.0	5.25	17,325.0
Sloped Soil Over Heel	=	907.5	6.17	5,596.3
Surcharge Over Heel	=			
Adjacent Footing Load	=			
Axial Dead Load on Stem	=			
* Axial Live Load on Stem	=			
Soil Over Toe	=			
Surcharge Over Toe	=			
Stem Weight(s)	=	750.0	2.00	1,500.0
Earth @ Stem Transitions	=			
Footing Weight	=	3,600.0	4.00	14,400.0
Key Weight	=			
Vert. Component	=			
Total =		8,557.5 lbs	R.M.=	38,821.3

* Axial live load NOT included in total displayed, or used for overturning resistance, but is included for soil pressure calculation.

DESIGNER NOTES:



2.
1
12.in Conc w/ #6 @ 6.in o/c
2 1/2"
5'-0"
5'-0"
3'-0"
Designer select
all horiz. reinf.
See Appendix A
1'-6"
6'-6"
8'-0"


2.
1
Pp= 0.#
2450.9#
626.62psf
1512.8psf

APPENDIX B

SHOP DRAWINGS

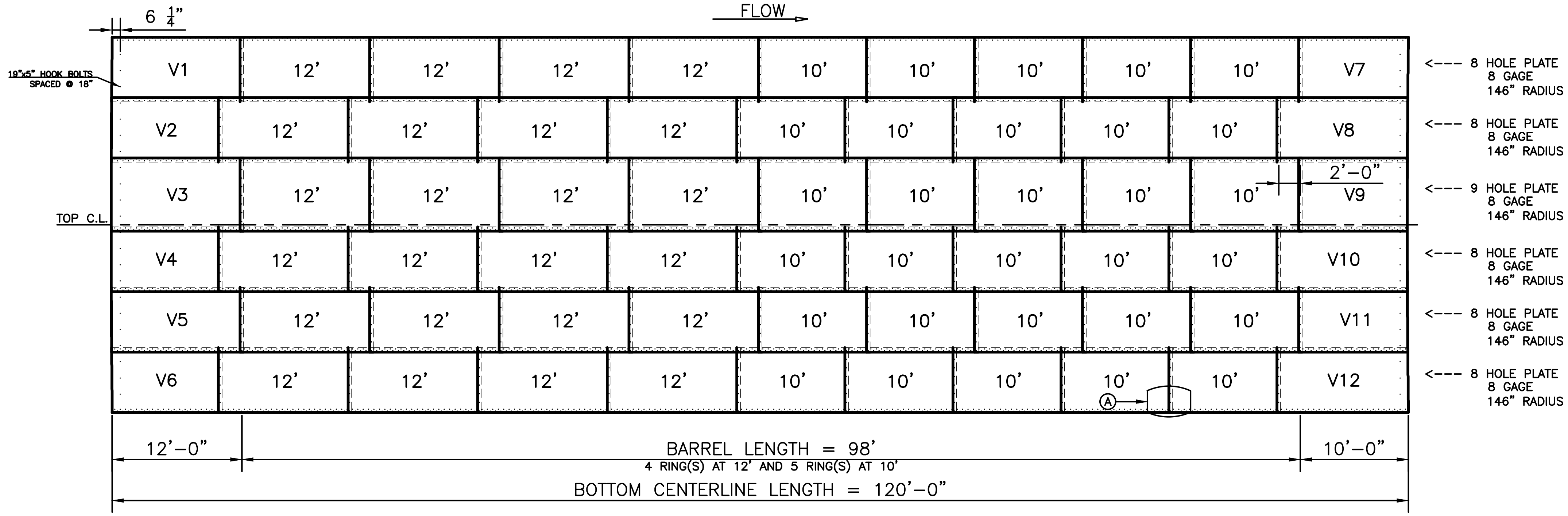
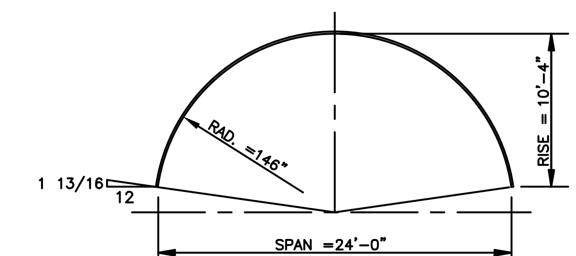
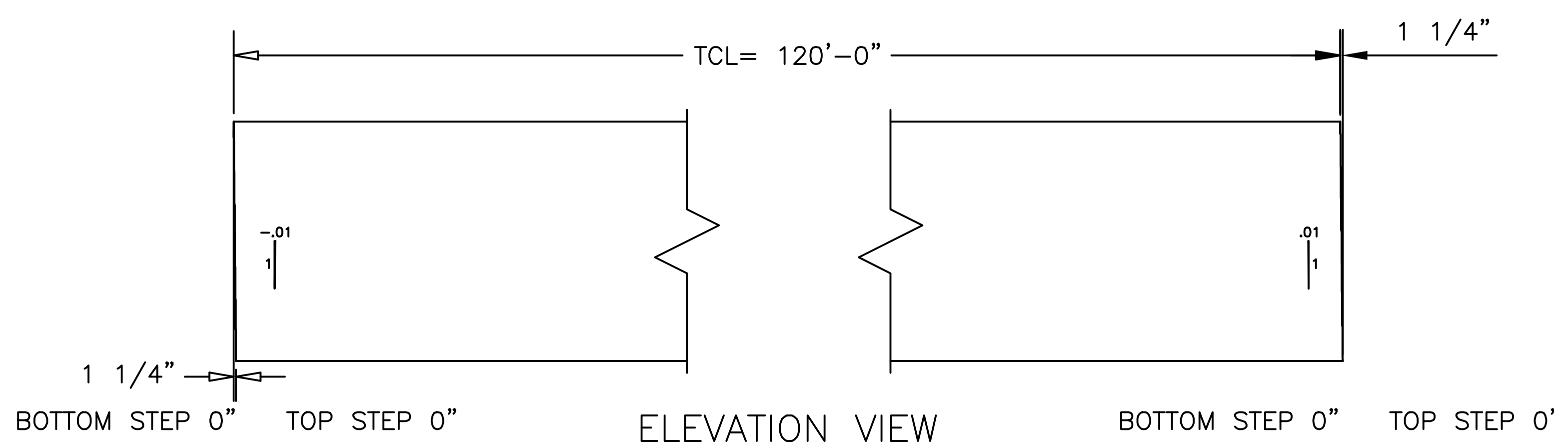


PLATE LAYOUT --- OUTSIDE VIEW

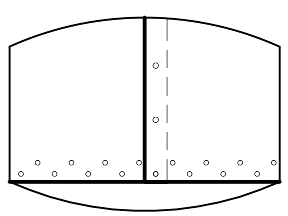


TYPICAL SECTION



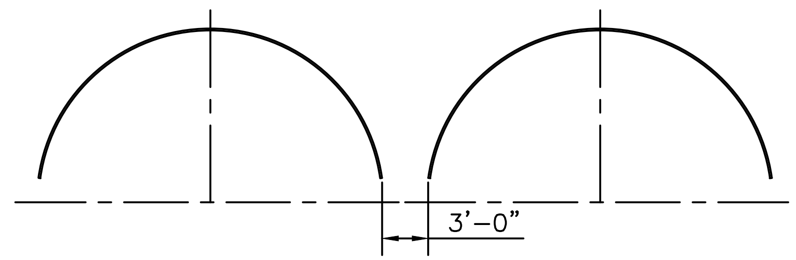
ELEVATION VIEW

DETAIL A



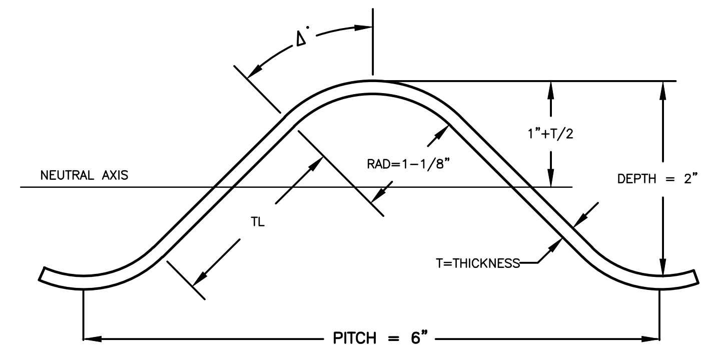
CIRCUMFERENTIAL PLATE LAPPING AS SHOWN HERE IS TYPICAL THROUGHOUT STRUCTURE

	INLET	OUTLET	
			TYPE STRUCTURE SINGLE RADIUS ARCH
SKEW	90	90	SIZE 129-24
			SPAN = 24'-0"
BEVEL	-.01	.01	RISE = 10'-4"
			LENGTH @ CL 120'-0"



END SECTION

STEEL MULTI-PLATE



CORRUGATION PROFILE

IMPORTANT

ASSEMBLY INSTRUCTIONS WILL BE SHIPPED WITH THE STRUCTURE. THEY ARE LOCATED IN THE BRIGHT COLORED BUCKET.

IMPORTANT

WHEN BEGINNING ASSEMBLY, BE CERTAIN PLATES ARE ORIENTED SO BOLT HOLE PATTERN MATCHES THAT SHOWN ON THIS DRAWING AND ASSEMBLY INSTRUCTIONS.

TORQUE NOTE

PLATE LAPS MUST BE PROPERLY MATED IN A TANGENT FASHION USING PROPER ALIGNMENT TECHNIQUES AND ADEQUATE BOLT TORQUE TO SEAT THE CORRUGATION. FOR PLAIN, GALVANIZED PLATES, AN INSTALLATION BOLT TORQUE OF 100–300 ft–lbs IS RECOMMENDED. WHEN SEAM SEALANT TAPE OR ASPHALT (SHOP) COATED PLATES ARE USED, BOLTS SHALL BE INSTALLED AT 150–300 ft–lbs AND RETIGHTENED TO THESE LIMITS AFTER 4 TO 6 HOURS. TORQUE LEVELS ARE FOR INSTALLATION, NOT RESIDUAL, IN–SERVICE REQUIREMENTS.

THE ASSEMBLY BOLTS AND NUTS ARE SPECIALLY DESIGNED WITH ROUNDED OR SPHERICAL THROATS FOR FITTING EITHER THE CREST OR VALLEY OF THE CORRUGATIONS, PROVIDING MAXIMUM BEARING CONTACT AREA WITH THE PLATES WITHOUT THE USE OF WASHERS. NOTE THAT THE BOLTS AND NUTS SHOULD BE INSTALLED SUCH THAT THE ROUNDED PORTION IS IN CONTACT WITH THE PLATES.

Approved By	Date		Rev.	Date	By	Description
MTH	3/20/20	CBC Engineers				
Project No. CBC-23088	Rev. -					

PLANT ORDER NO.

DRAWING #: 617696-010-MP-CON-C

SALES ORDER NO.

MARK	DATE	REVISION DESCRIPTION	BY
1	2/13/2020	CHANGED THE CL LENGTH	BTS

CONTECH ENGINEERED SOLUTIONS LLC
www.ContechES.com
700 Tech Drive, Winchester, KY 40391
859-744-3339 859-744-9665 FAX

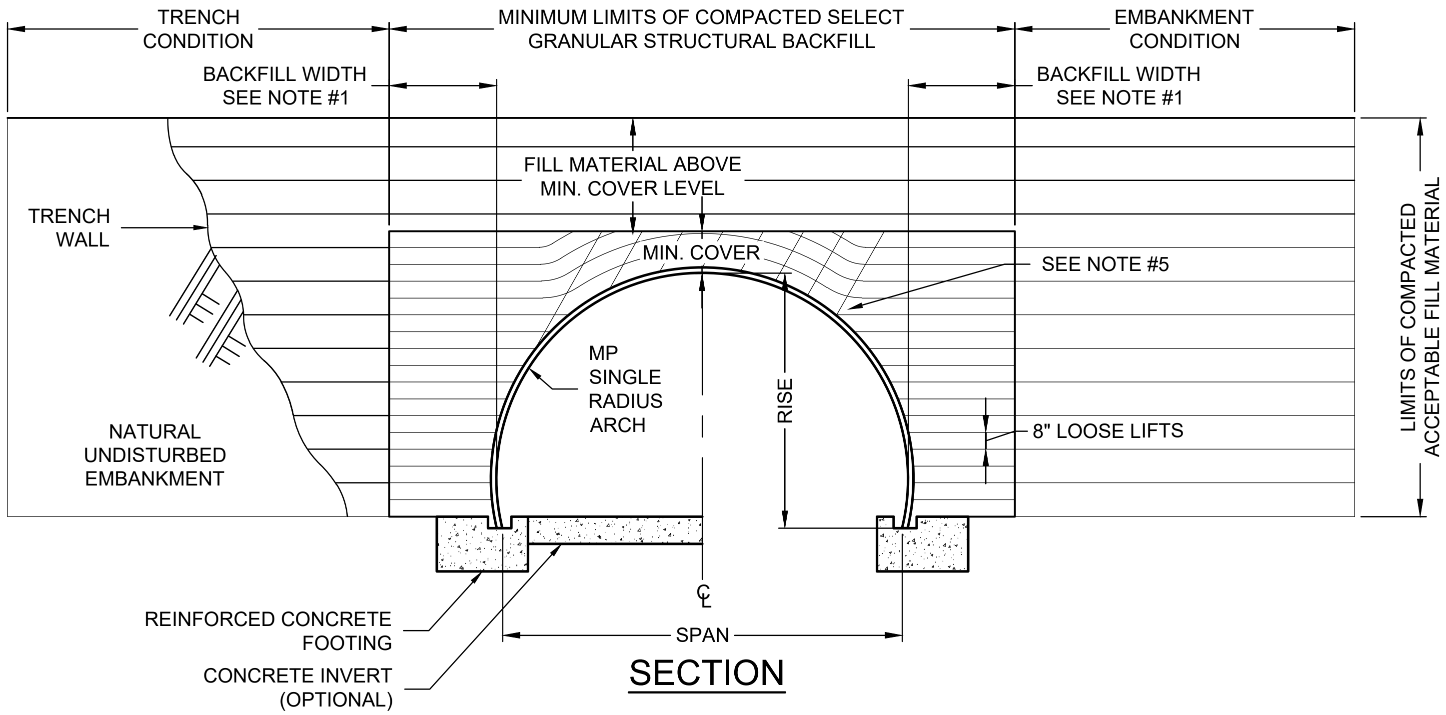
CONTECH STRUCTURAL PLATE

CONTRACT DRAWING

TIMBER RIDGE

COLORADO SPRINGS, CO

PROJECT No.: 617696	SEQ. No.: 010	DATE: 2/20/2020
DESIGNED:	DRAWN: BTS	
CHECKED:	APPROVED:	
SHEET NO.: 1 OF 2		



SECTION

SELECT GRANULAR STRUCTURAL BACKFILL LIMITS.

INITIAL LIFTS OVER THE CROWN OF STRUCTURE AS INDICATED BY SHADED AREA TO BE COMPACTED TO REQUIRED DENSITY WITH HAND OPERATED EQUIPMENT OR WITH LIGHTWEIGHT (D-4 OR LIGHTER) EQUIPMENT.

NOTES:

1. TRENCH WIDTH AND/OR SELECT BACKFILL WIDTH SHALL BE DETERMINED BY THE ENGINEER DEPENDING ON SITE SPECIFIC CONDITIONS. TYPICAL BACKFILL WIDTH IS 4 FEET FOR STRUCTURE SPANS 14 FEET AND LESS, AND 6 FEET FOR STRUCTURE SPANS GREATER THAN 14 FEET.

2. ALL SELECT GRANULAR BACKFILL TO BE PLACED IN A BALANCED FASHION IN THIN LIFTS (8" LOOSE TYPICALLY) AND COMPACTED TO 90 PERCENT DENSITY PER AASHTO T-180.

3. COMPLETE AND REGULAR MONITORING OF THE SINGLE RADIUS ARCH STRUCTURE IS NECESSARY DURING THE BACKFILL PROCESS TO AT LEAST THE MINIMUM COVER LEVEL.

4. PREVENT DISTORTION OF SHAPE AS NECESSARY BY VARYING COMPACTION METHODS AND EQUIPMENT.

5. PLACE SELECT GRANULAR BACKFILL IN RADIAL LIFTS AT APPROXIMATELY 75% OF THE RISE OF THE SINGLE RADIUS ARCH STRUCTURE.

	INLET	OUTLET	TYPE STRUCTURE SINGLE RADIUS ARCH
			SIZE 129–24
SKEW	90	90	SPAN = 24'–0"
BEVEL	–.01	.01	RISE = 10'–4"
			LENGTH @ CL 120'–0"

ADDITIONAL SELECT GRANULAR STRUCTURAL BACKFILL NOTES:

SATISFACTORY BACKFILL MATERIAL, PROPER PLACEMENT, AND COMPACTION ARE KEY FACTORS IN OBTAINING MAXIMUM STRENGTH AND STABILITY.

THE BACKFILL MATERIAL SHOULD BE FREE OF ROCKS, FROZEN LUMPS, AND FOREIGN MATERIAL THAT COULD CAUSE HARD SPOTS OR DECOMPOSE TO CREATE VOIDS. BACKFILL MATERIAL SHOULD BE WELL GRADED GRANULAR MATERIAL THAT MEETS THE REQUIREMENTS OF AASHTO M-145 FOR SOIL CLASSIFICATIONS A-1, A-2-4, A-2-5 OR A-3 MODIFIED. RECYCLED CONCRETE/SLAG ARE NOT RECOMMENDED FOR STRUCTURAL BACKFILL MATERIAL.
SEE THE STRUCTURAL PLATE BACKFILL GROUP CLASSIFICATION TABLE ON THIS SHEET. BACKFILL MUST BE PLACED SYMMETRICALLY ON EACH SIDE OF THE STRUCTURE IN 8" LOOSE LIFTS. EACH LIFT IS TO BE COMPACTED TO A MINIMUM OF 90% DENSITY PER AASHTO T-180.

A HIGH PERCENTAGE OF SILT OR FINE SAND IN THE NATIVE SOILS SUGGESTS THE NEED FOR A WELL GRADED GRANULAR BACKFILL MATERIAL TO PREVENT SOIL MIGRATION. IF THE PROPOSED BACKFILL IS NOT A WELL GRADED GRANULAR MATERIAL, A NON-WOVEN GEOTEXTILE FILTER FABRIC SHALL BE PLACED BETWEEN THE SELECT BACKFILL AND THE IN SITU MATERIAL.

DURING BACKFILL, ONLY LIGHTWEIGHT TRACKED VEHICLES (D-4 OR LIGHTER) SHOULD BE NEAR THE STRUCTURE AS FILL PROGRESSES ABOVE THE CROWN AND TO THE FINISHED GRADE. THE ENGINEER AND CONTRACTOR ARE CAUTIONED THAT THE MINIMUM COVER MAY NEED TO BE INCREASED TO HANDLE TEMPORARY CONSTRUCTION VEHICLE LOADS (HEAVIER THAN D-4).

STRUCTURAL PLATE BACKFILL GROUP CLASSIFICATION, REFERENCE AASHTO M-145

GROUP CLASSIFICATION	A-1-a	A-1-b	A-2-4	A-2-5	A-3
Sieve Analysis Percent Passing					
No. 10 (2.000 mm)	50 max.	----	----	----	----
No. 40 (0.425 mm)	30 max.	50 max.	----	----	51 max.*
No. 200 (0.075 mm)	15 max.	25 max.	35 max.	35 max.	10 max.
Atterberg Limits for Fraction Passing No. 40 (0.425 mm)					
Liquid Limits	----	----	40 max.	41 min.	----
Plasticity Index	6 max.	6 max.	10 max.	10 max.	Non Plastic
Usual Materials	Stone Fragment, Gravel and Sand		Silty or Clayey Gravel and Sand		Coarse Sand

*Modified from AASHTO M-145.

Fine beach sands, windblown sands, stream deposited sands, etc., exhibiting fine, rounded particles and typically classified by AASHTO M-145 as A-3 Materials should not be used.

Reference the most current version of ASTM D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System), for comparable soil groups.

1.0 STANDARDS AND DEFINITIONS

1.1 STANDARDS - All standards refer to the current ASTM/AASHTO edition unless otherwise noted.

1.1.1 ASTM A761 "Corrugated Steel Structural Plate, Zinc Coated for Field-Bolted Pipe, Pipe-Arches and Arches" (AASHTO Designation M-167).

1.1.2 AASHTO Standard Specification for Highway Bridges - Section 12 Division I - Design, AASHTO LRFD Bridge Design Specifications Section 12.

1.1.3 AASHTO Standard Specification for Highway Bridges - Section 26 Division II - Construction, AASHTO LRFD Bridge Construction Specifications - Section 26. ASTM A807, Standard Practice for Installing Corrugated Steel Structural Plate Pipe.

1.2 DEFINITIONS

1.2.1 Owner - In these specifications the word "Owner" shall mean The Owner of Muilti-Plate Arch.

1.2.2 Engineer - In these specifications the word "Engineer" shall mean the Engineer of Record or Owner's designated engineering representative.

1.2.3 Manufacturer - In these specifications the word "Manufacturer" shall mean CONTECH ENGINEERED SOLUTIONS 800-338-1122

1.2.4 Contractor - In these specifications the word "Contractor" shall mean the firm or corporation undertaking the execution of any installation work under the terms of these specifications.

1.2.5 Approved - In these specifications the word "approved" shall refer to the approval of the Engineer or his designated representative.

1.2.6 As Directed - In these specifications the words "as directed" shall refer to the directions to the Contractor from the Owner or his designated representative.

2.0 GENERAL CONDITIONS

2.1 Any installation guidance provided herein shall be endorsed by the Engineer; discrepancies herein are governed by the Engineer's plans and specifications.

2.2 The Contractor shall furnish all labor, material and equipment and perform all work and services except those set out and furnished by the Owner, necessary to complete in a satisfactory manner the site preparation, excavation, filling, compaction, grading as shown on the plans and as described therein. This work shall consist of all mobilization clearing and grading, grubbing, stripping, removal of existing material unless otherwise stated, preparation of the land to be filled, filling of the land, spreading and compaction of the fill, and all subsidiary work necessary to complete the grading of the cut and fill areas to conform with the lines, grades, slopes, and specifications. This work is to be accomplished under the observation of the Owner or his designated representative.

2.3 Prior to bidding the work, the Contractor shall examine, investigate and inspect the construction site as to the nature and location of the work, and the general and local conditions at the construction site, including without limitation, the character of surface or subsurface conditions and obstacles to be encountered on and around the construction site and shall make such additional investigation as he may deem necessary for the planning and proper execution of the work.

If conditions other than those indicated are discovered by the Contractor, the Owner shall be notified immediately. The material which the Contractor believes to be a changed condition shall not be disturbed so that the owner can investigate the condition.

2.4 The construction shall be performed under the direction of the Engineer.

2.5 All aspects of the structure design and site layout including foundations, backfill, end treatments and necessary scour consideration shall be performed by the Engineer.

3.0 ASSEMBLY AND INSTALLATION

3.1 Bolts and nuts shall conform to the requirements of ASTM A449. The single radius arch structure shall be assembled in accordance with the plate layout drawings provided by the Manufacturer and per the Manufacturer's recommendations.

Bolts shall be tightened using an applied torque of between 100 and 300 ft.-lbs.

3.2 The single radius arch structure shall be installed in accordance with the plans and specifications, the Manufacturer's recommendations, and AASHTO Standard Specification for Highway Bridges - Section 26 Division II - Construction/AASHTO LRFD Bridge Construction Specifications - Section 26.

3.3 Trench excavation shall be made in embankment material that is structurally adequate. The trench width shall be shown on the plans. Poor quality in situ embankment material must be removed and replaced with suitable backfill as directed by the Engineer.

3.4 Bedding preparation is critical to both structure performance and service life. The bed should be constructed to uniform line and grade to avoid distortions that may create undesirable stresses in the structure and/or rapid deterioration of the roadway. The bed should be free of rock formations, protruding stones, frozen lumps, roots, and other foreign matter that may cause unequal settlement.

3.5 The structure shall be assembled in accordance with the Manufacturer's instructions. All plates shall be unloaded and handled with reasonable care. Plates shall not be rolled or dragged over gravel rock and shall be prevented from striking rock or other hard objects during placement in trench or on bedding.

3.6 The structure shall be backfilled using clean well graded granular material that meets the requirements for soil classifications A-1, A-2-4, A-2-5 or A-3 modified per AASHTO M-145. See the structural plate backfill group classification table on this sheet.

Backfill must be placed symmetrically on each side of the structure in 8 inch loose lifts. Each lift shall be compacted to a minimum of 90 percent density per AASHTO T-180.

3.7 If temporary construction vehicles are required to cross the structure, it is the Contractor's responsibility to contact the Engineer to determine the amount of additional minimum cover necessary to handle the specific loading condition.

Normal highway traffic is not allowed to cross the structure until the structure has been backfilled and paved. If the road is unpaved, cover allowance to accommodate rutting shall be as directed by the Engineer.

3.8 If a metal headwall and/or wingwall system is specified, the select granular structural backfill limits shall extend past the deadman anchor system. Contact the Engineer if stiff material or rock is encountered where the wingwalls and deadmen are to be installed.

THE ASSEMBLY BOLTS AND NUTS ARE SPECIALLY DESIGNED WITH ROUNDED OR SPHERICAL THROATS FOR FITTING EITHER THE CREST OR VALLEY OF THE CORRUGATIONS, PROVIDING MAXIMUM BEARING CONTACT AREA WITH THE PLATES WITHOUT THE USE OF WASHERS. NOTE THAT THE BOLTS AND NUTS SHOULD BE INSTALLED SUCH THAT THE ROUNDED PORTION IS IN CONTACT WITH THE PLATES.

Approved By	Date
MTH	3/20/20
Project No.	Rev.
CBC-23088	-

CBC Engineers

MARK	DATE	REVISION DESCRIPTION	BY
1	2/13/2020	CHANGED THE CL LENGTH	BTS

CONTECH ENGINEERED SOLUTIONS LLC
www.ContechES.com
700 Tech Drive, Winchester, KY 40391
859-744-3339 859-744-9665 FAX

CONTECH STRUCTURAL PLATE

CONTRACT DRAWING

TIMBER RIDGE

COLORADO SPRINGS, CO

PLANT ORDER NO.

SALES ORDER NO.

DRAWING #: 617696-010-MP-CON-C

PROJECT No.:	SEQ. No.:	DATE:
617696	010	2/20/2020
DESIGNED:	DRAWN: BTS	
CHECKED:	APPROVED:	

SHEET NO.: 2 OF 2

APPENDIX C

PRINTS

CONTECH ENGINEERED SOLUTIONS, LLC DESIGN OF CONCRETE SPREAD FOOTINGS, CONCRETE HEADWALLS AND WINGWALLS FOR A TWIN 24'X10'-4" MULTI-PLATE ARCH STRUCTURE (617696); RETREAT AT TIMBER RIDGE, EL PASO, COLORADO

INDEX

COLORADO LICENSED PROFESSIONAL ENGINEER
MITCHELL T. HARDERT
PE-45539

NOTE:
1.) CONCRETE SHALL BE f'c = 3,500 psi.
2.) ALL REINFORCEMENT SHALL BE ASTM A–615, GRADE 60.
3.) FOOTING IS DESIGNED FOR A 3,500 psf ALLOWABLE BEARING CAPACITY. THIS VALUE MUST BE FIELD VERIFIED PRIOR TO CONSTRUCTION.
4.) SCOUR IS NOT ADDRESSED HEREIN AND IS THE RESPONSIBILITY OF OTHERS THAN CBC ENGINEERS.

CBC Engineers

TITLE SHEET / INDEX

Drawn By: JBE	Date: 03/20/20	CONTECH ENGINEERED SOLUTIONS, LLC DESIGN OF CONCRETE SPREAD FOOTINGS, CONCRETE HEADWALLS AND WINGWALLS FOR A TWIN 24'x10'-4" MULTI-PLATE ARCH STRUCTURE (617696);RETREAT AT TIMBER RIDGE, EL PASO, COLORADO
Approved By:	Date:	

Scale	Project No.	Rev.	Sheet
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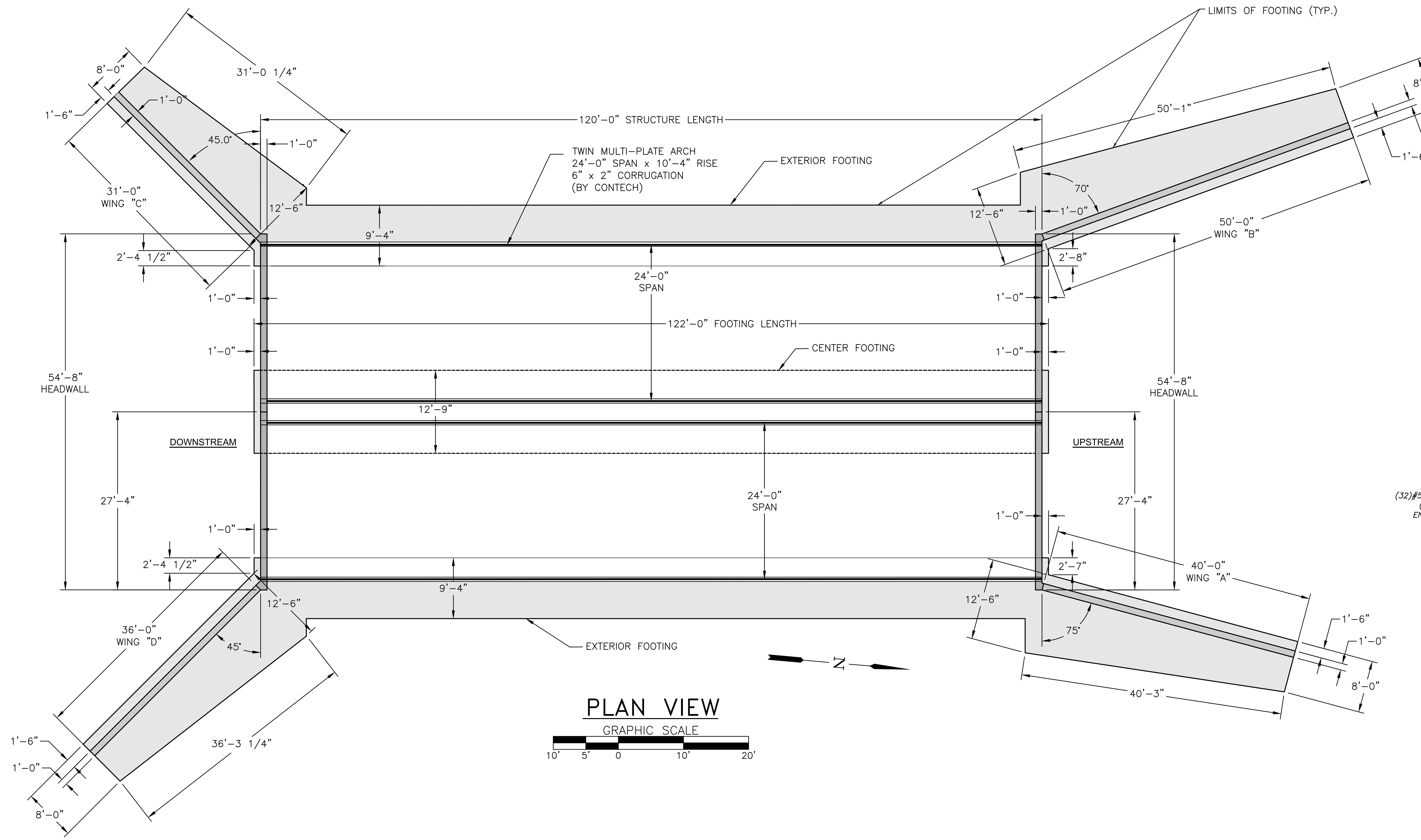
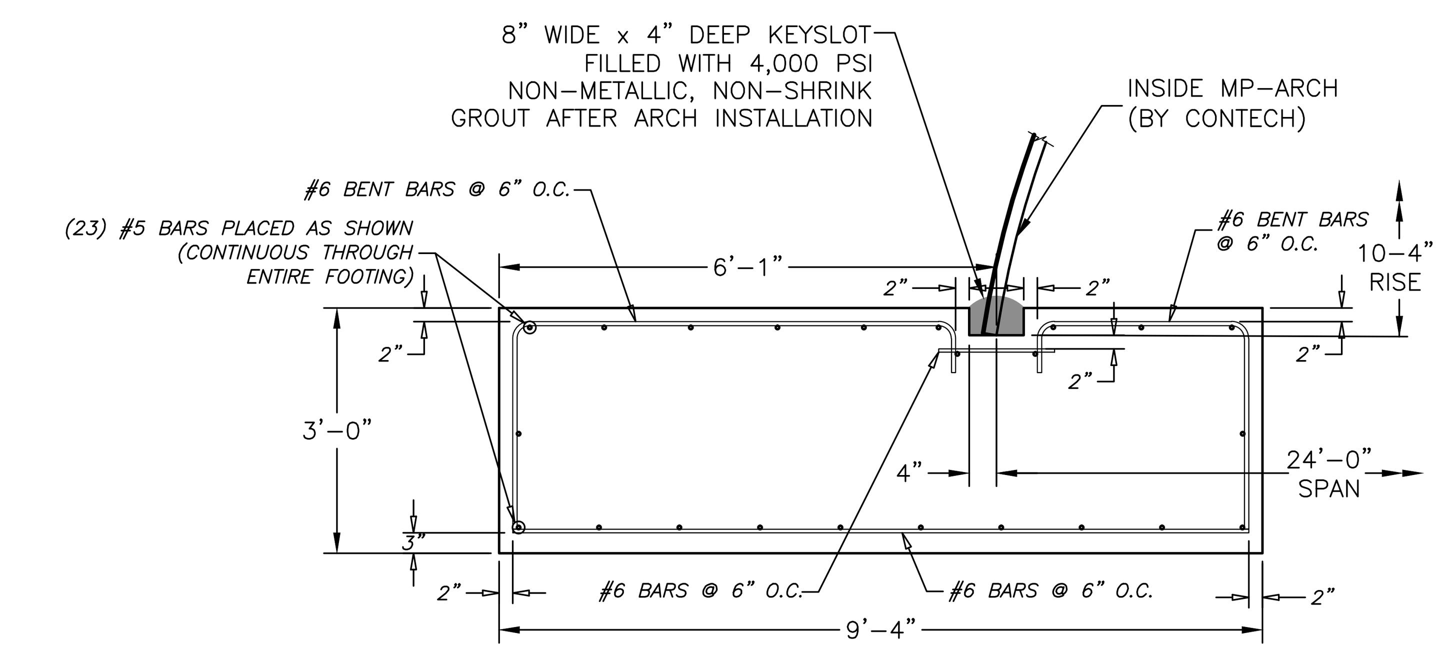


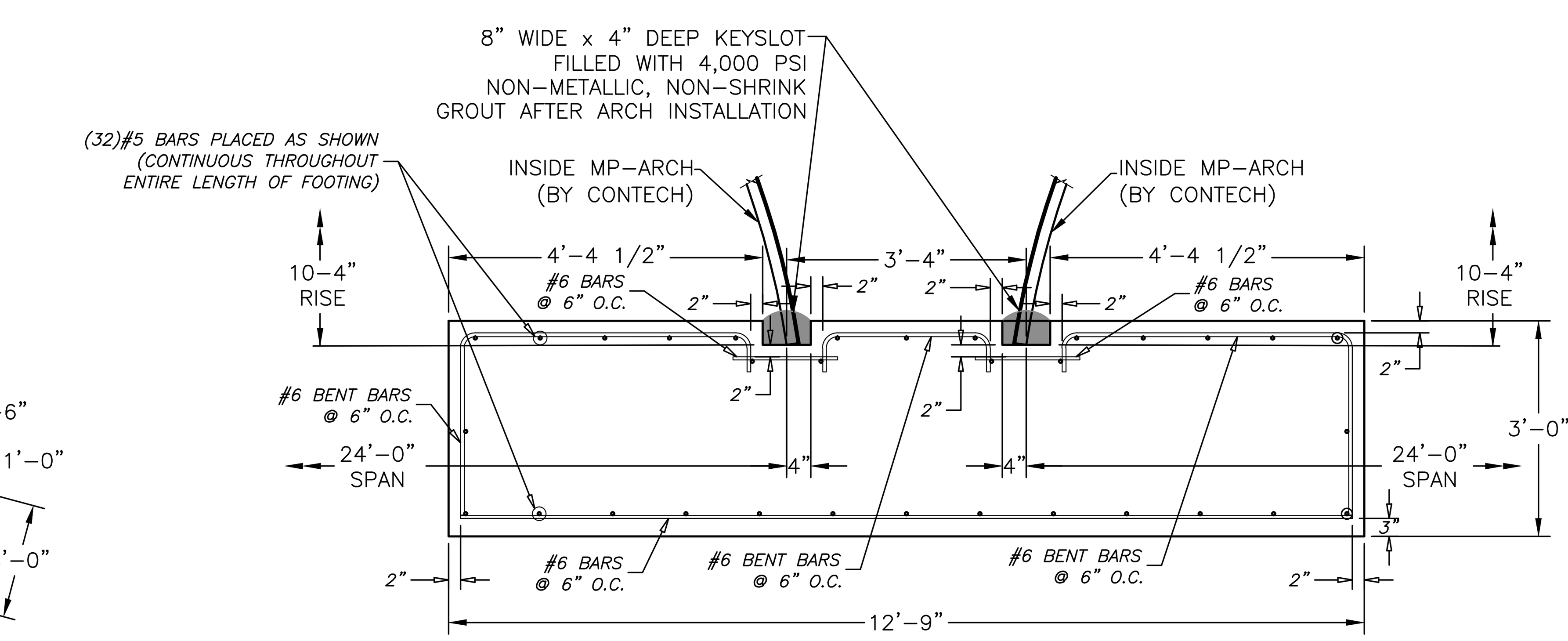
PLAN VIEW

GRAPHIC SCALE
10' 5' 0 10' 20'



EXTERIOR FOOTING

GRAPHIC SCALE
2' 1' 0 2' 4'



CENTER FOOTING

GRAPHIC SCALE
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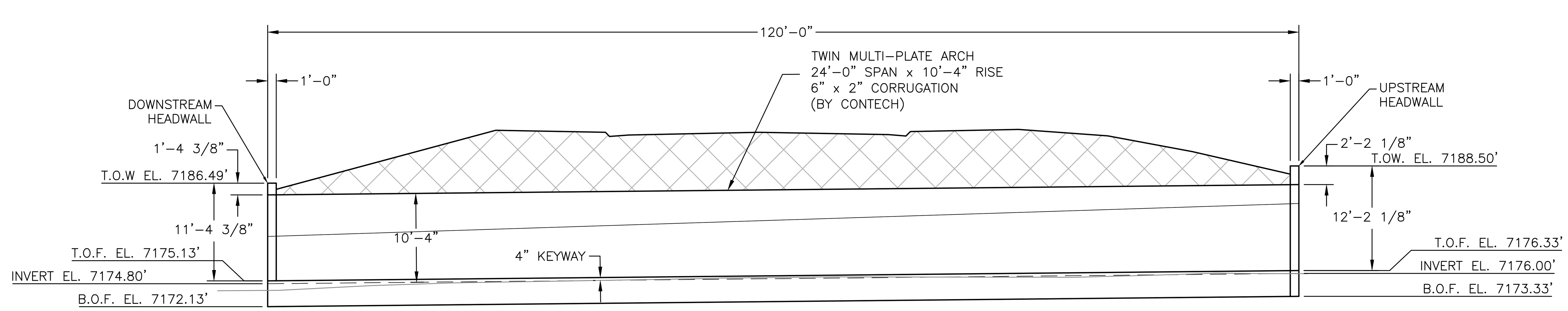

PROFILE THROUGH CENTERLINE OF STRUCTURE

GRAPHIC SCALE
10' 5' 0 10' 20'

NOTE:
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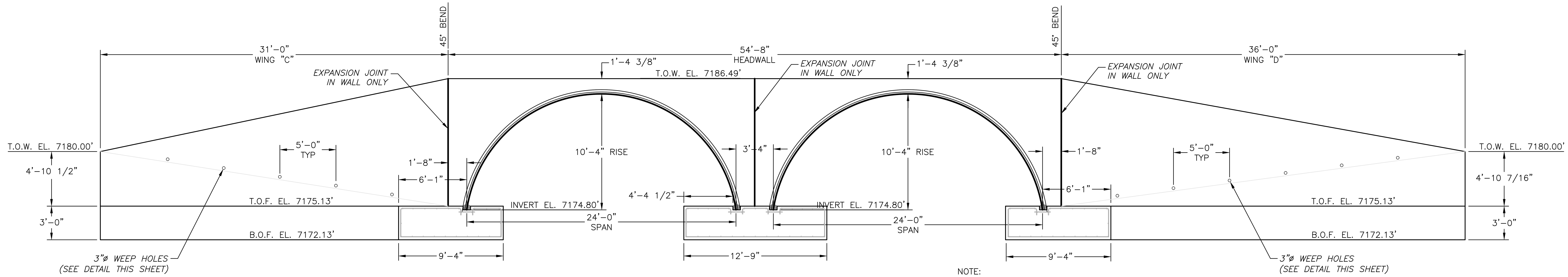
COLORADO LICENSED PROFESSIONAL ENGINEER MITCHELL T. HARGREAVES PE-45539

CBC Engineers

PLAN, PROFILE AND FOOTINGS

Drawn By: JBE	Date: 03/20/20	CONTECH ENGINEERED SOLUTIONS, LLC DESIGN OF CONCRETE SPREAD FOOTINGS, CONCRETE HEADWALLS AND WINGWALLS FOR A TWIN 24'x10'-4" MULTI-PLATE ARCH STRUCTURE (617696);RETREAT AT TIMBER RIDGE, EL PASO, COLORADO	
Approved By:	Date:		
Scale: GRAPHIC	Project No.: CBC-23088	Rev.: -	Sheet: 2 OF 8



NOTE:
WINGWALLS ARE ROTATED FOR CLARITY
SEE PLAN VIEW FOR EXACT LOCATIONS

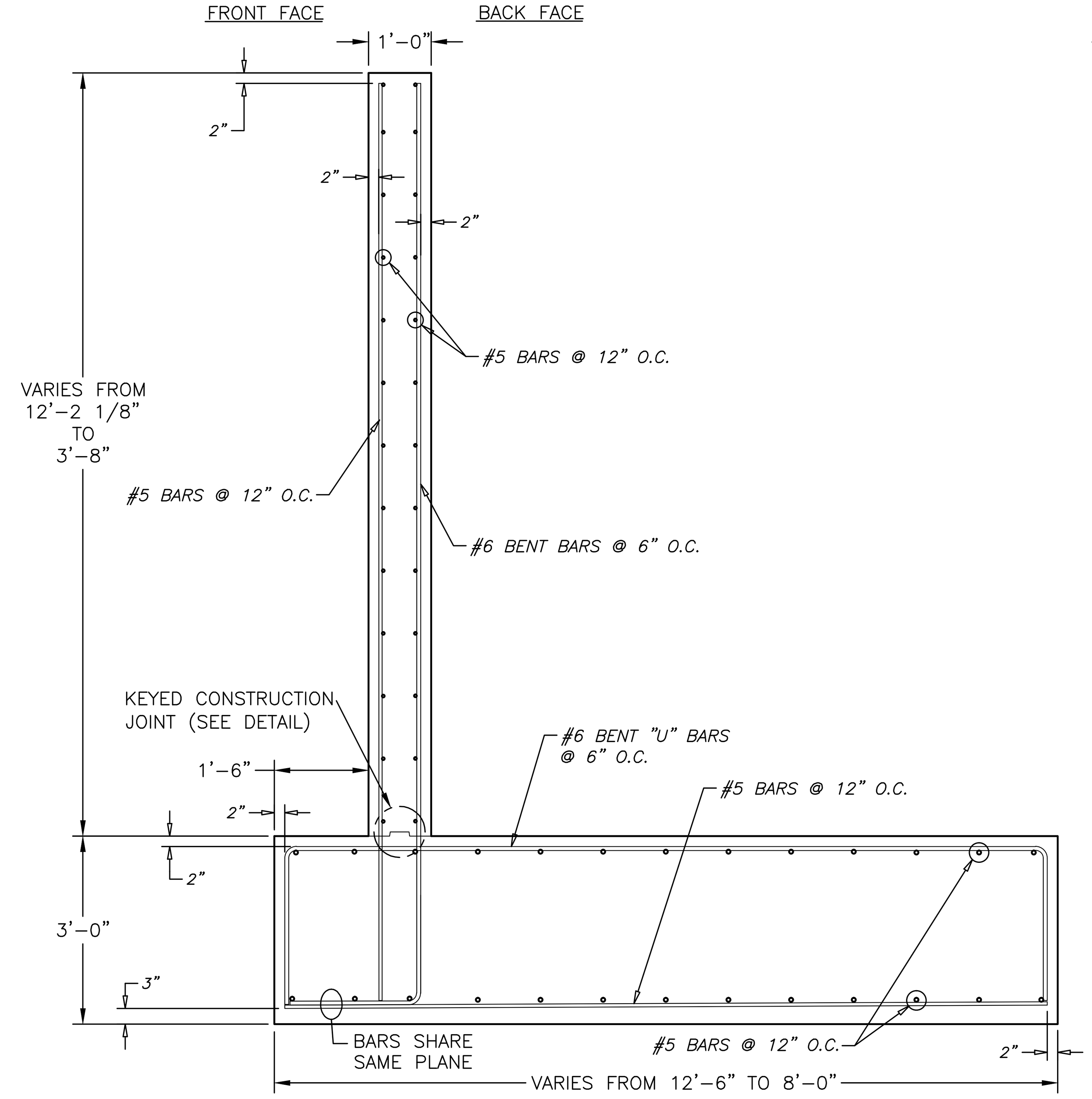
ELEVATION VIEW (DOWNSTREAM)

GRAPHIC SCALE
5' 2.5' 0 5' 10'

NOTE:
WINGWALLS ARE ROTATED FOR CLARITY
SEE PLAN VIEW FOR EXACT LOCATIONS

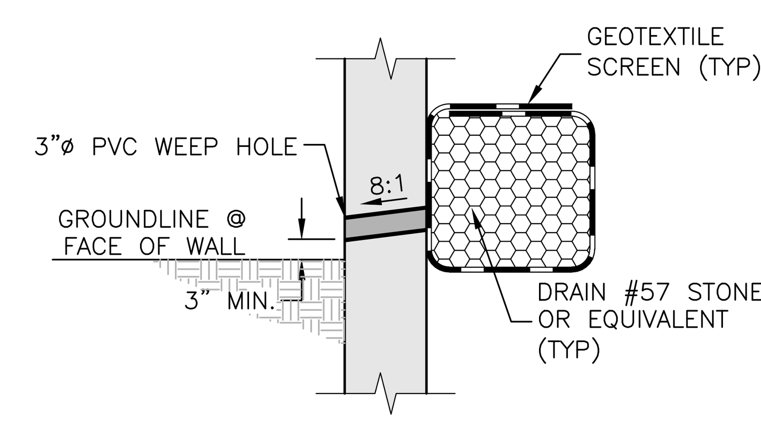
ELEVATION VIEW (UPSTREAM)

GRAPHIC SCALE
5' 2.5' 0 5' 10'



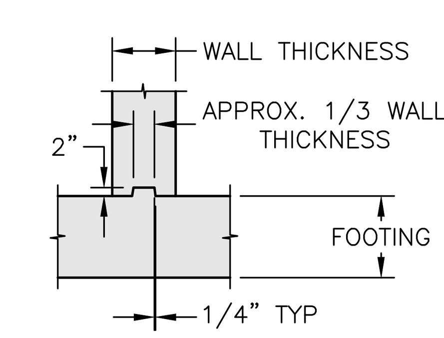
TYPICAL WINGWALL SECTION

GRAPHIC SCALE
2' 1' 0 2' 4'



WEEP HOLE DETAIL

NOT TO SCALE



KEYED CONSTRUCTION JOINT DETAIL

NOT TO SCALE

NOTE:
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ELEVATION VIEWS AND WINGWALL SECTION

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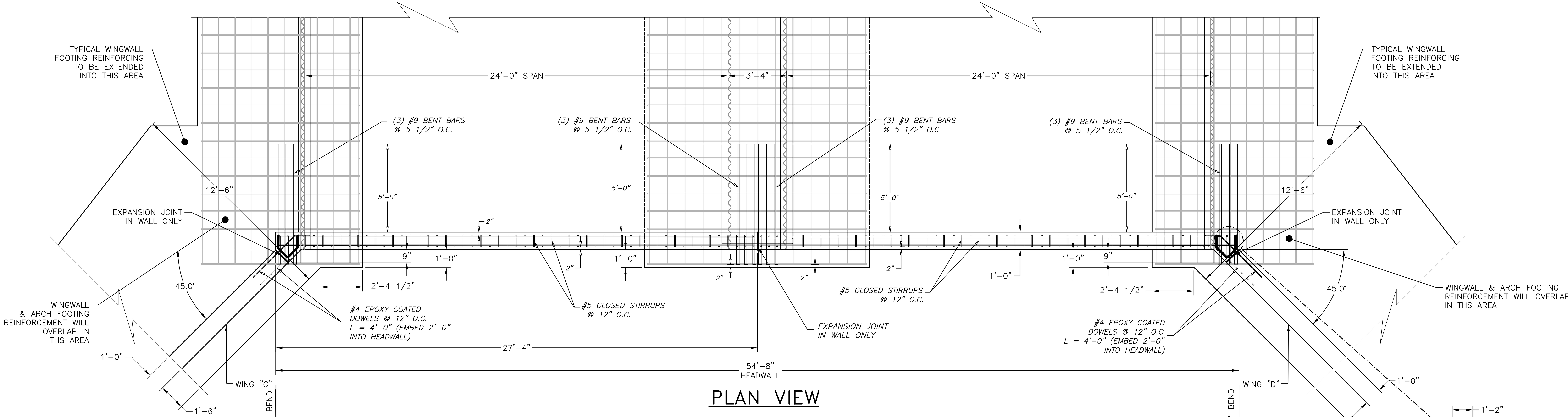
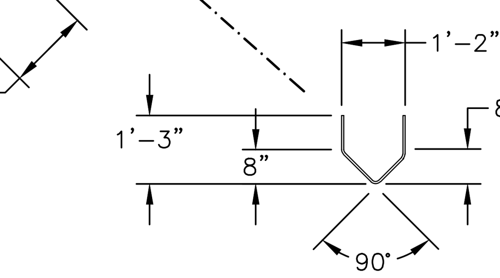
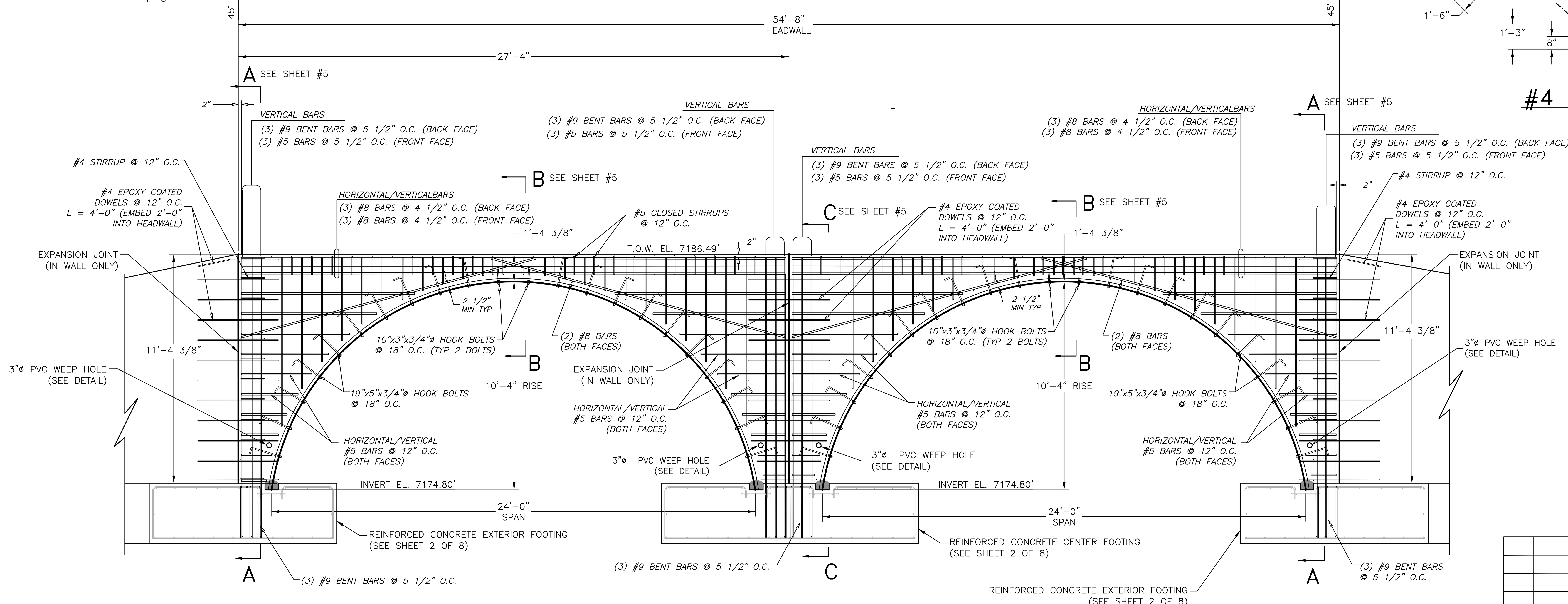


PLAN VIEW



#4 STIRRUPS



ELEVATION VIEW

DOWNSTREAM HEADWALL DETAILS

GRAPHIC SCALE

4' 2' 0 4' 8'

COLORADO LICENSED PROFESSIONAL ENGINEER MITCHELL T. HARDERT PE-45539

NOTE:

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DOWNSTREAM HEADWALL DETAILS

Drawn By	Date	
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Approved By	Date	

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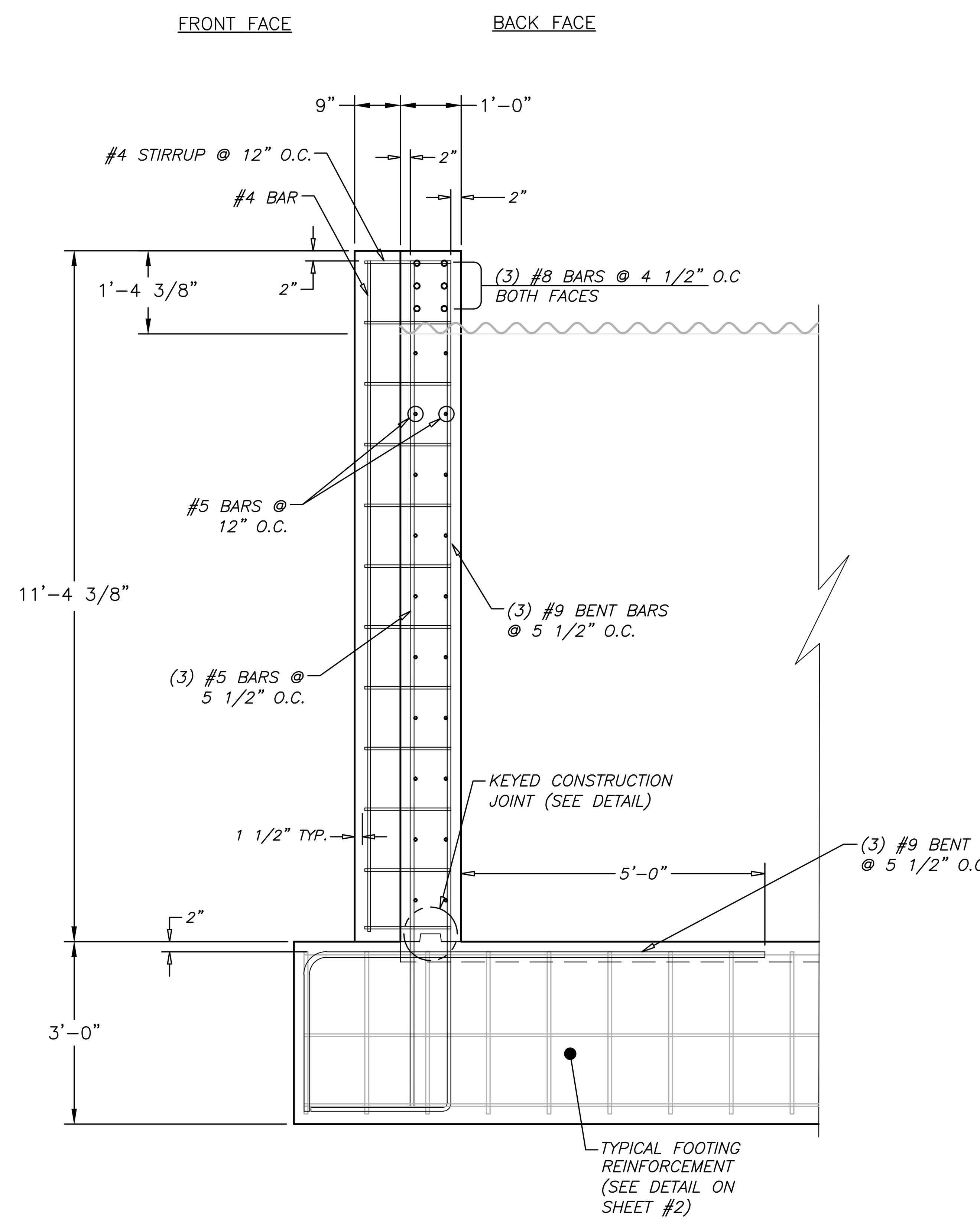
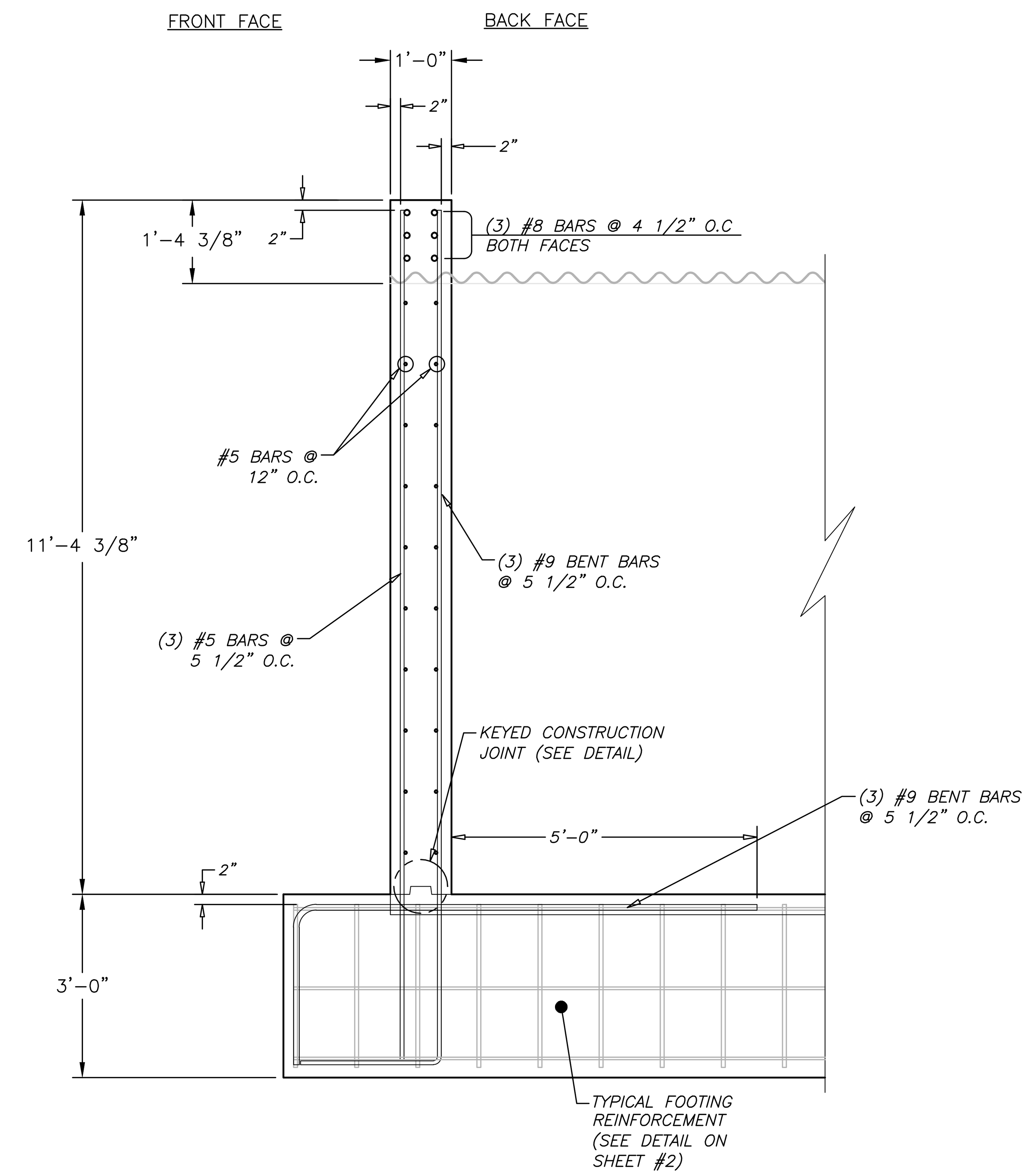


SECTION A–A

GRAPHIC SCALE

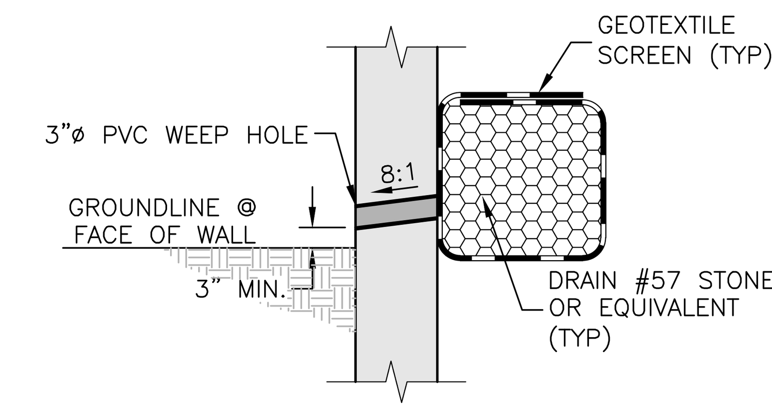
2' 1' 0 2' 4'



SECTION C–C

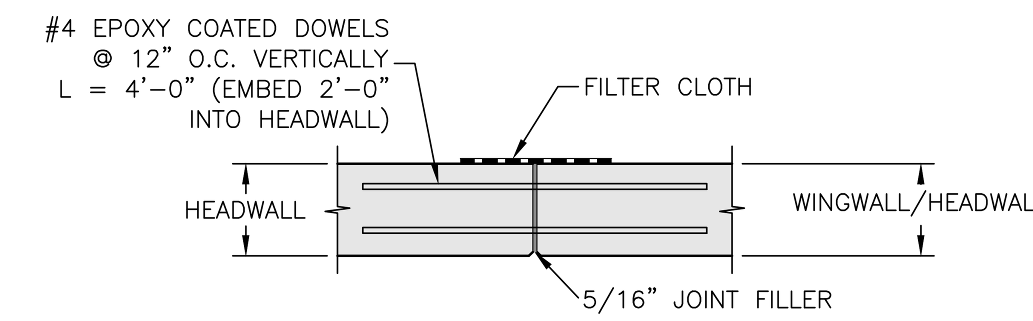
GRAPHIC SCALE

2' 1' 0 2' 4'



WEEP HOLE DETAIL

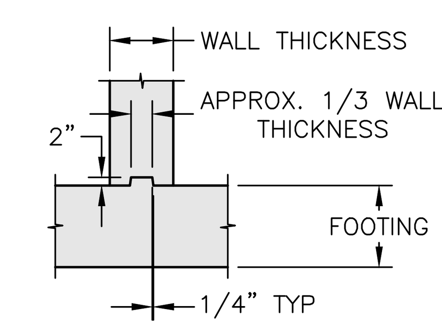
NOT TO SCALE



EXPANSION JOINT DETAIL

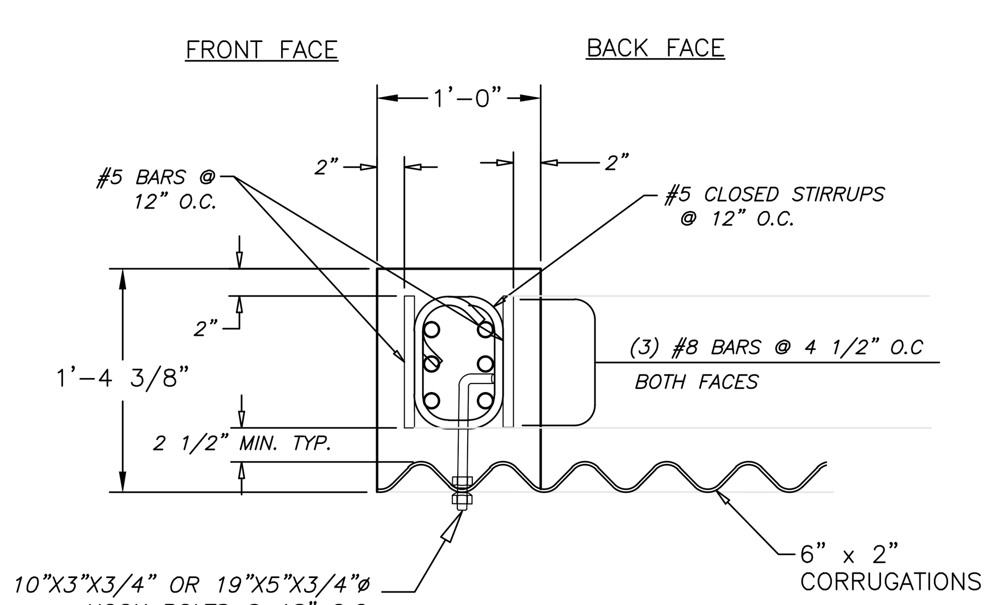
NOT TO SCALE

NOTES FOR EXPANSION JOINT:
A FILTER CLOTH THREE FEET IN WIDTH AND DOUBLE THICKNESS SHALL BE APPLIED TO ALL TRANSVERSE JOINTS IN THE FOOTING AND WALLS. THE MATERIAL SHALL BE CENTERED ON THE JOINT AND THE EDGES SEALED WITH A MASTIC OR WITH TWO SIDED TAPE. THE FILTER CLOTH SHALL BE A GEOTEXTILE MEETING THE APPROVAL OF THE ENGINEER.



KEYED CONSTRUCTION JOINT DETAIL

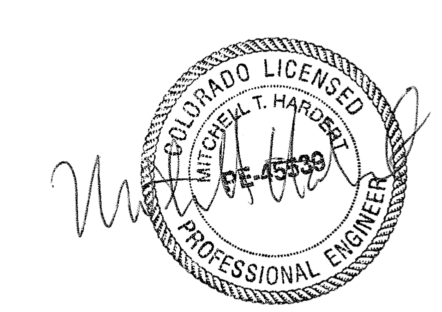
NOT TO SCALE



SECTION B–B

GRAPHIC SCALE

1' 0.5' 0 1' 2'



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CBC Engineers

DOWNSTREAM SECTIONS AND DETAILS

Drawn By: JBE	Date: 03/20/20	CONTECH ENGINEERED SOLUTIONS, LLC DESIGN OF CONCRETE SPREAD FOOTINGS, CONCRETE HEADWALLS AND WINGWALLS FOR A TWIN 24'x10'-4" MULTI-PLATE ARCH STRUCTURE (617696);RETREAT AT TIMBER RIDGE, EL PASO, COLORADO
Approved By:	Date:	

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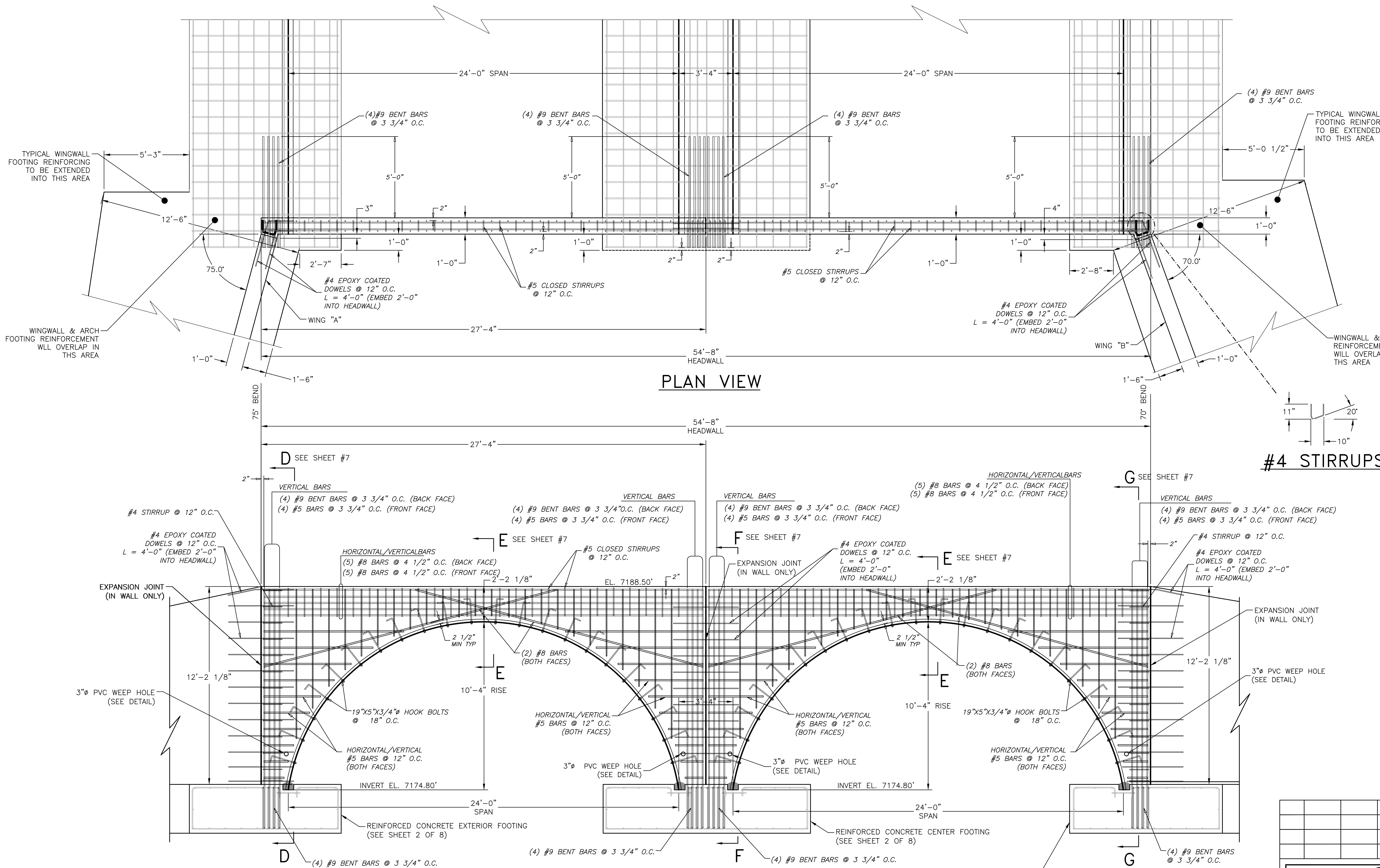

PLAN VIEW

#4 STIRRUPS

ELEVATION VIEW

DOWNSTREAM HEADWALL DETAILS

GRAPHIC SCALE

4' 2' 0 4' 8'

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UPSTREAM HEADWALL DETAILS

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Approved By	Date	

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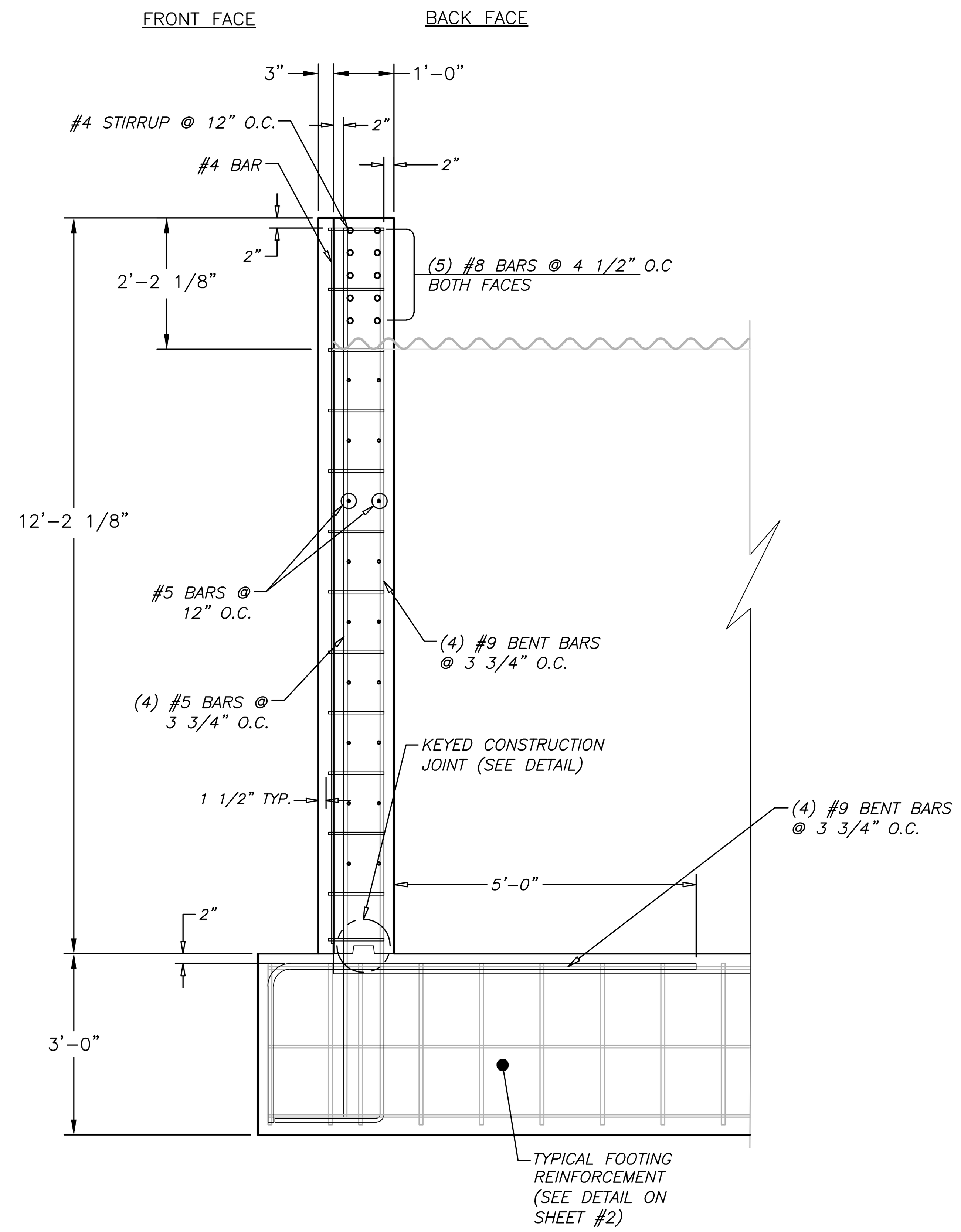
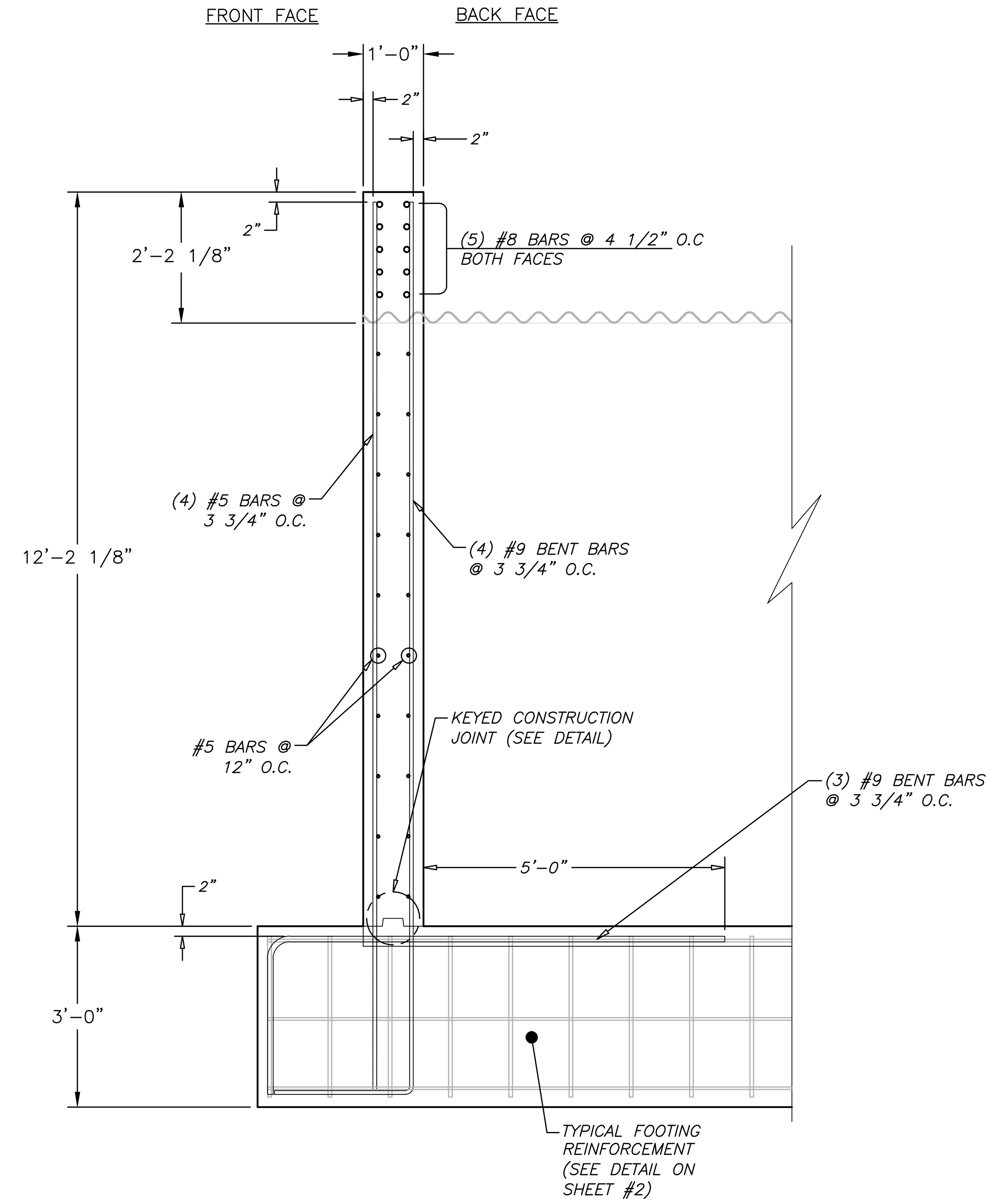


SECTION D–D

GRAPHIC SCALE
2' 1' 0 2' 4'



SECTION F–F

GRAPHIC SCALE
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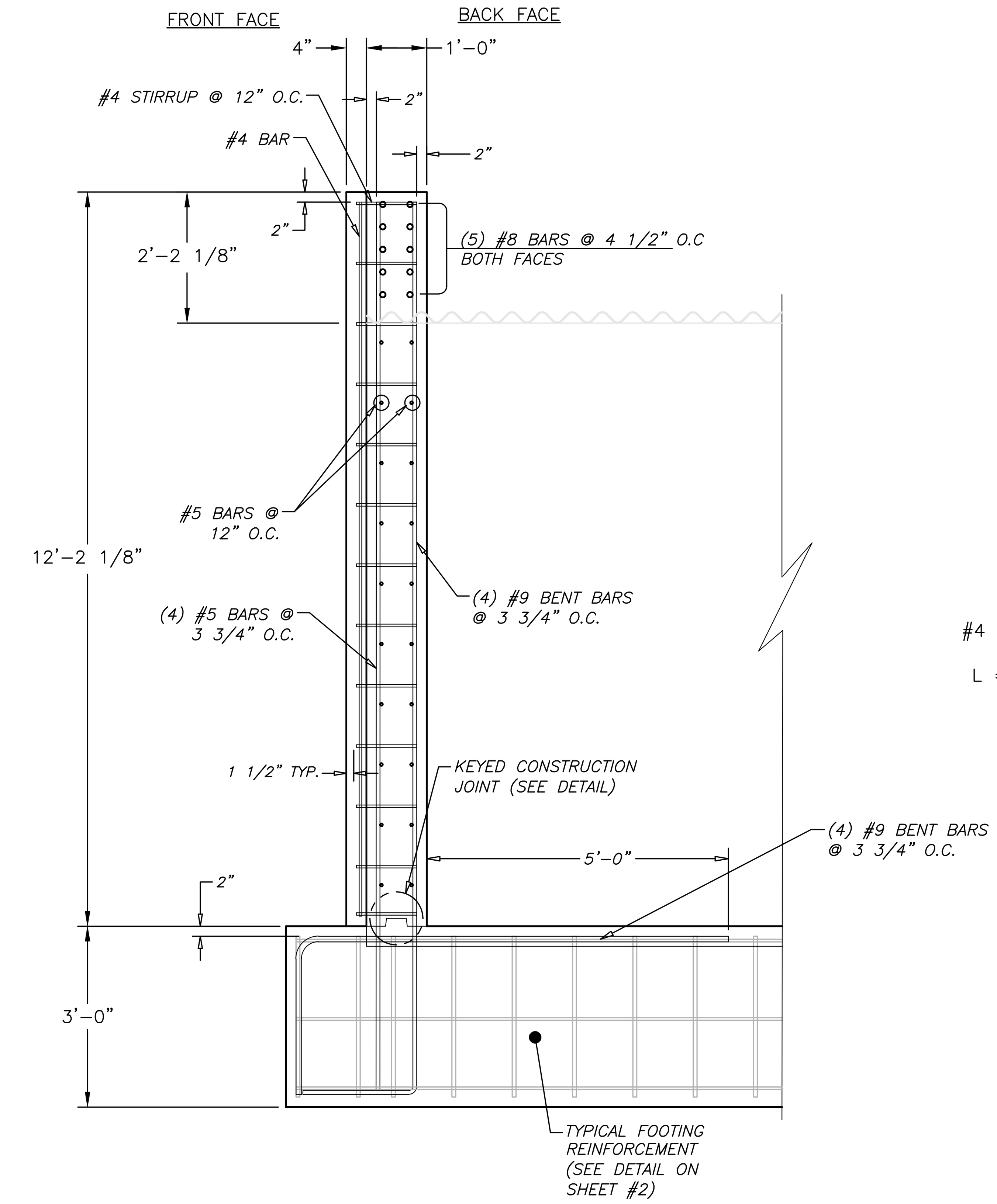

SECTION G–G

GRAPHIC SCALE
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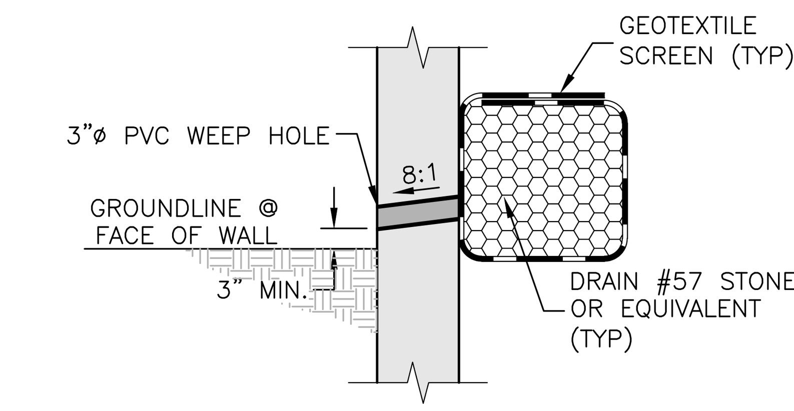
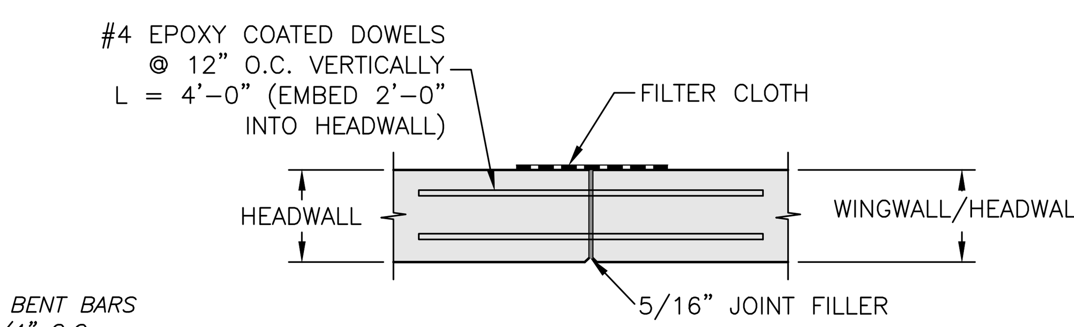


WEEP HOLE DETAIL

NOT TO SCALE



EXPANSION JOINT DETAIL

NOT TO SCALE

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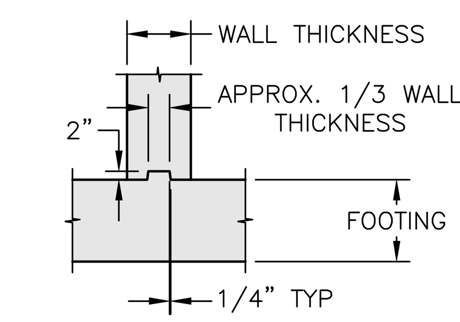

KEYED CONSTRUCTION JOINT DETAIL

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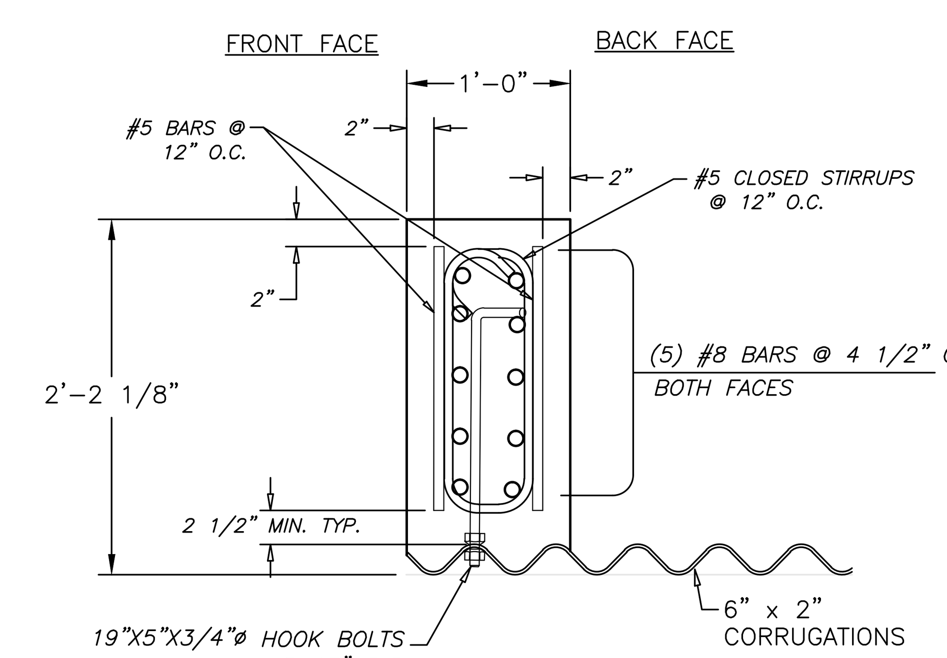

SECTION E–E

GRAPHIC SCALE
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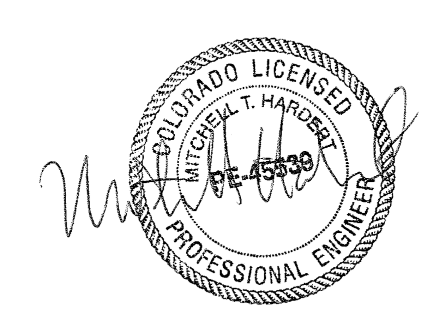

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CBC Engineers

UPSTREAM SECTIONS AND DETAILS

Drawn By	Date	
JBE	03/20/20	CONTECH ENGINEERED SOLUTIONS, LLC DESIGN OF CONCRETE SPREAD FOOTINGS, CONCRETE HEADWALLS AND WINGWALLS FOR A TWIN 24'x10'-4" MULTI-PLATE ARCH STRUCTURE (617696);RETREAT AT TIMBER RIDGE, EL PASO, COLORADO
Approved By	Date	

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I – GENERAL

1.0 STANDARDS AND DEFINITIONS

1.1 STANDARDS - All standards refer to latest edition unless otherwise noted.

1.1.1 ASTM D-698-70 (Method C) "Standard Test Methods for Moisture. Density Relations of Soils and Soil Aggregate Mixtures Using 5.5-lb (2.5 kg.) Rammer and 12-inch (305-mm) Drop".

1.1.2 ASTM D-2922 "Standard Test Method for Density of Soil and Soil Aggregate in Place by Nuclear methods (Shallow Depth)".

1.1.3 ASTM D-1556 "Standard Test Method for Density of Soil in place by the Sand-Cone Method".

1.1.4 ASTM D-1557 "Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort."

1.1.5 All construction and materials shall be in accordance with the latest AASHTO LRFD Bridge Design Specifications.

1.2 DEFINITIONS

1.2.1 Owner - In these specifications the word "Owner" shall mean Elite Properties of America, LLC.

1.2.2 Engineer - In these specifications the word "Engineer" shall mean the Owner designated engineer.

1.2.3 Design Engineer - In these specifications the words "Design Engineer" shall mean CBC Engineers and Associates, Ltd.

1.2.4 Contractor - In these specifications the word "Contractor" shall mean the firm or corporation undertaking the execution of any work under the terms of these specifications.

1.2.5 Approved - In these specifications the word "approved" shall refer to the approval of the Engineer or his designated representative.

1.2.6 As Directed - In these specifications the words "as directed" shall refer to the directions to the Contractor from the Owner or his designated representative.

2.0 GENERAL CONDITIONS

2.1 The Contractor shall furnish all labor, material and equipment and perform all work and services except those set out and furnished by the Owner, necessary to complete in a satisfactory manner the site preparation, excavation, filling, compaction, grading, footing construction, headwall/wingwall construction as shown on the plans and as described therein.

This work shall consist of all mobilization clearing and grading, grubbing, stripping, removal of existing material unless otherwise stated, preparation of the land to be filled, filling of the land, spreading and compaction of the fill, and all subsidiary work necessary to complete the grading of the cut and fill areas to conform with the lines, grades, slopes, and specifications.

This work is to be accomplished under the observation of the Owner or his designated representative.

2.2 Prior to bidding the work, the Contractor shall examine, investigate and inspect the construction site as to the nature and location of the work, and the general and local conditions at the construction site, including, without limitation, the character of surface or subsurface conditions and obstacles to be encountered on and around the construction site; and shall make such additional investigation as he may deem necessary for the planning and proper execution of the work.

If conditions other than those indicated are discovered by the Contractor, the Owner should be notified immediately. The material which the Contractor believes to be a changed condition should not be disturbed so that the owner can investigate the condition.

2.3 The construction shall be performed under the direction of an experienced engineer who is familiar with the design plan.

II – FOOTINGS

1.0 EXCAVATION FOR FOOTINGS

1.1 Footing excavation shall consist of the removal of all material, of whatever nature, necessary for the construction of foundations.

1.2 It shall be the responsibility of the Contractor to identify and relocate all existing utilities which conflict with the proposed footing locations shown on the plan. The Contractor must call the appropriate utility company at least 48 hours before any excavation to request exact field location of utilities, and coordinate removal and installation of all utilities with the respective utility company.

1.3 The side of all excavations shall be cut to prevent sliding or caving of the material above the footings.

1.4 Excavated material shall be disposed in accordance with the plan established by the Engineer.

1.5 The footings for the MULTI-PLATE arch, and headwalls/wingwalls are designed for an allowable bearing capacity of the non-yielding foundation material of 3,500 psf and a friction factor of 0.45. These values shall be verified in the field before construction. The evaluation and design of any required foundation improvement to achieve the design allowable bearing capacity and friction factor, and to protect against frost and scour and settlement, is the responsibility of others than CBC.

2.0 CONCRETE FOOTING DIMENSIONS

The footings shall be reinforced in accordance with the construction drawings.

III – HEADWALLS/WINGWALLS

1.0 The headwalls/wingwalls shall consist of reinforced concrete conforming to Chapter IV of these specifications and to Division II, Section 8, of the AASHTO Standard Specifications for Highway Bridges having a minimum compression strength of 4,000 psi.

2.0 Reinforcing steel shall conform to ASTM A-615, Grade 60, having minimum yield strength of 60,000 psi.

3.0 The headwalls shall be anchored to the MULTI-PLATE arch in the manner shown on the plans and shall be formed and poured in accordance with the plan dimensions.

4.0 Round weep holes spaced not over 5 feet on center shall be placed in the walls above finished grade as shown on the construction drawings. A granular envelope, consisting of #57 stone (clean ¾" aggregate) or equivalent, shall be placed behind each weep hole for a distance of approximately 1 foot from all edges of the weep hole. A free-draining geotextile screen shall be placed between the weep hole and the stone to prevent erosion of the stone.

5.0 The select backfill behind the headwalls must be a well-graded, angular, durable granular material conforming to the select backfill specifications for the MULTI-PLATE arch placed and compacted to achieve a minimum internal friction angle of 34 degrees and a maximum unit weight of 120 pcf. The material must be placed in strict conformance with the project specifications, the manufacturer's requirements, and industry standards. The select backfill behind the wingwalls extending to a minimum distance of 15.0 feet behind the back face of the walls must be a well-graded, angular, durable granular material placed and compacted to achieve a minimum internal friction angle of 34 degrees and a maximum unit weight of 120 pcf. These values must be field verified.

6.0 All Federal, State, and Local regulations shall be strictly adhered to relative to excavation side-slope geometry and any required excavation shoring.

IV – CONCRETE FOR FOOTINGS AND HEADWALLS/WINGWALLS

1.0 CODES AND STANDARDS

1.1 Reinforced concrete shall conform to the requirements of AASHTO Standard Specifications for Highway Bridges, Division II - Construction, Section 8, "Concrete Structures", for Class A concrete, having a minimum compressive strength of 4,000 psi.

2.0 STANDARDS FOR MATERIALS

2.1 Portland Cement - Conforming to ASTM Specification C-150, Type I or II.

2.2 Water - The water shall be drinkable, clean free from injurious amounts of oils, acids, alkalis, organic materials, or deleterious substances.

2.3 Aggregates - Fine and coarse aggregates shall conform to current ASTM Specification C-33 "Specification for Concrete Aggregates" except that local aggregates which have been shown by tests and by actual service to produce satisfactory qualities may be used when approved by the Engineer.

2.4 Submittals - Test data and/or certifications to the Owner shall be furnished upon request.

3.0 PROPORTIONING OF CONCRETE

3.1 COMPOSITION

3.1.1 The concrete shall be composed of cement, fine aggregate, coarse aggregate and water.

3.1.2 The concrete shall be homogeneous, readily placeable and uniformly workable and shall be proportioned in accordance with ACI-211.1.

3.1.3 Proportions shall be established on the basis of field experience with the materials to be employed. The amount of water used shall not exceed the maximum 0.45 water/cement ratio, and shall be reduced as necessary to produce concrete of the specified consistency at the time of placement.

3.1.4 An air-entraining admixture, conforming to the requirements of ASTM C260, shall be used in all concrete furnished under this contract. The quantity of admixture shall be such as to produce an air content in the freshly mixed concrete of 6 percent plus or minus 1 percent as determined in accordance with ASTM C231 or C173.

3.2 Qualities Required - As indicated in the table below:

TABLE IV-1
QUALITIES REQUIRED

ITEM	QUALITY REQUIRED
AASHTO Class	A
Type of Cement	I or II
Compressive Strength f'c @ 28 days	4,000 psi
Slump, inches	2 - 4 in.

3.3 Maximum Size of Coarse Aggregates - Maximum size of coarse aggregates shall not be larger than 19 mm (3/4 inches).

3.4 Rate of Hardening of Concrete - Concrete mix shall be adjusted to produce the required rate of hardening for varied climatic conditions:

Under 40°F Ambient Temperature - Accelerate calcium chloride at 2% is acceptable when used within the recommendations of ACI-306R "Cold Weather Concreting." Admixtures containing chloride ion in excess of 1% by weight of admixture shall not be used in reinforced concrete.

4.0 MIXING AND PLACING

4.1 Equipment - Ready Mix Concrete shall be used and shall conform to the "Specifications for Ready-Mix Concrete," ASTM C-94. Approval is required prior to using job mixed concrete.

4.2 Preparation - All work shall be in accordance with ACI-304, "Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete." All construction debris and extraneous matter shall be removed from within the forms. Concrete shall be placed on clean surfaces, free from water. Concrete that has to be dropped four (4) feet or more shall be placed through a tremie.

4.3 All concrete shall be consolidated by internal mechanical vibration immediately after placement. Vibrators shall be of a size appropriate for the work, capable of transmitting vibration to concrete at frequencies of not less than 4,500 impulses per minute.

5.0 FORM WORK

5.1 Forms shall be of wood, steel or other approved material and shall be set and held true to the dimensions, lines and grades of the structure prior to and during the placement of concrete.

5.2 Forms shall not be removed until the concrete has sufficient strength to prevent concrete damage and/or drainage.

6.0 CURING

6.1 Fresh concrete shall be protected from rains, flowing water and mechanical injury for a period of four (4) days. Loads shall not be placed on the concrete until it has reached its design strength.

7.0 REINFORCING STEEL

7.1 MATERIAL

7.1.1 All reinforcing bars shall be deformed bars (ASTM-A615) Grade 60.

7.2 BENDING AND SPLICING

7.2.1 Bar reinforcement shall be cut and bent to the shapes shown on the plans. Fabrication tolerances shall be in accordance with ACI 315. All bars shall be bent cold, unless otherwise permitted.

7.2.2 All reinforcement shall be furnished in the full lengths indicated on the plans unless otherwise permitted. Except for splices shown on the plans and splices for No. 5 or smaller bars, splicing of bars will not be permitted without written approval. Splices shall be staggered as far as possible.

7.2.3 In lapped splices, the bars shall be placed and wired in such a manner as to maintain the minimum distance to the surface of the concrete shown on the plans.

7.2.4 Substitution of different size bars will be permitted only when authorized by the engineer. The substituted bars shall have an area equivalent to the design area, or larger.

7.3 PLACING AND FASTENING

7.3.1 Steel reinforcement shall be accurately placed as shown on the plans and firmly held in position during the placing and setting of concrete. Bars shall be tied at all intersections around the perimeter of each mat and at not less than 2 foot centers or at every intersection, whichever is greater, elsewhere. Welding of cross bars (tack welding) will not be permitted for assembly of reinforcement.

7.3.2 Reinforcing steel shall be supported in its proper position by use of mortar blocks, wire bar supports, supplementary bars or other approved devices. Such devices shall be of such height and placed at sufficiently frequent intervals so as to maintain the distance between the reinforcing and the formed surface or the top surface within 1/4 inch of that indicated on the plans.

V - FILTER FABRIC (GEOTEXTILE SCREEN)

1.0 Filter fabric shall be placed at all locations shown on the construction drawings, and as necessary between all dissimilar materials to prevent soil migration and to maintain a soil-tight system.

2.0 Filter fabric cloth shall conform to Contech specification for C60-NW or equivalent and shall meet the following ASTM tests:

2.1 ASTM D4751 - Apparent opening size equal to #70 U.S. Standard Sieve Size.

2.2 ASTM D4632 (Grab Tensile Test) - Minimum Strength = 160 pounds.

2.3 ASTM D4632 (Grab Elongation) - 30-70%.

2.4 ASTM D4533 (Trapezoidal Tear) - Minimum Strength = 60 pounds.

2.5 ASTM D4355 (Stabilized for Heat and Ultra-Violet Degradation) - 70% strength retained.

3.0 The minimum fabric coefficient of permeability (ASTM D4491) shall be 0.24 cm/sec.

4.0 The fabric shall be non-woven with a minimum thickness (ASTM D5199) of 60 mils.

5.0 Fabric shall not be placed over sharp or angular rocks that could tear or puncture it.

6.0 Care should be exercised to prevent any puncturing or rupture of the filter fabric. Should such rupture occur the damaged area should be covered with a patch of filter fabric using an overlap minimum of one (1) foot.

COLORADO LICENSED
PE-45339
PROFESSIONAL ENGINEER

CBC Engineers

SPECIFICATIONS

Drawn By: JBE	Date: 03/20/20	CONTECH ENGINEERED SOLUTIONS, LLC DESIGN OF CONCRETE SPREAD FOOTINGS, CONCRETE HEADWALLS AND WINGWALLS FOR A TWIN 24'x10'-4" MULTI-PLATE ARCH STRUCTURE (617696);RETREAT AT TIMBER RIDGE, EL PASO, COLORADO
Approved By:	Date:	

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