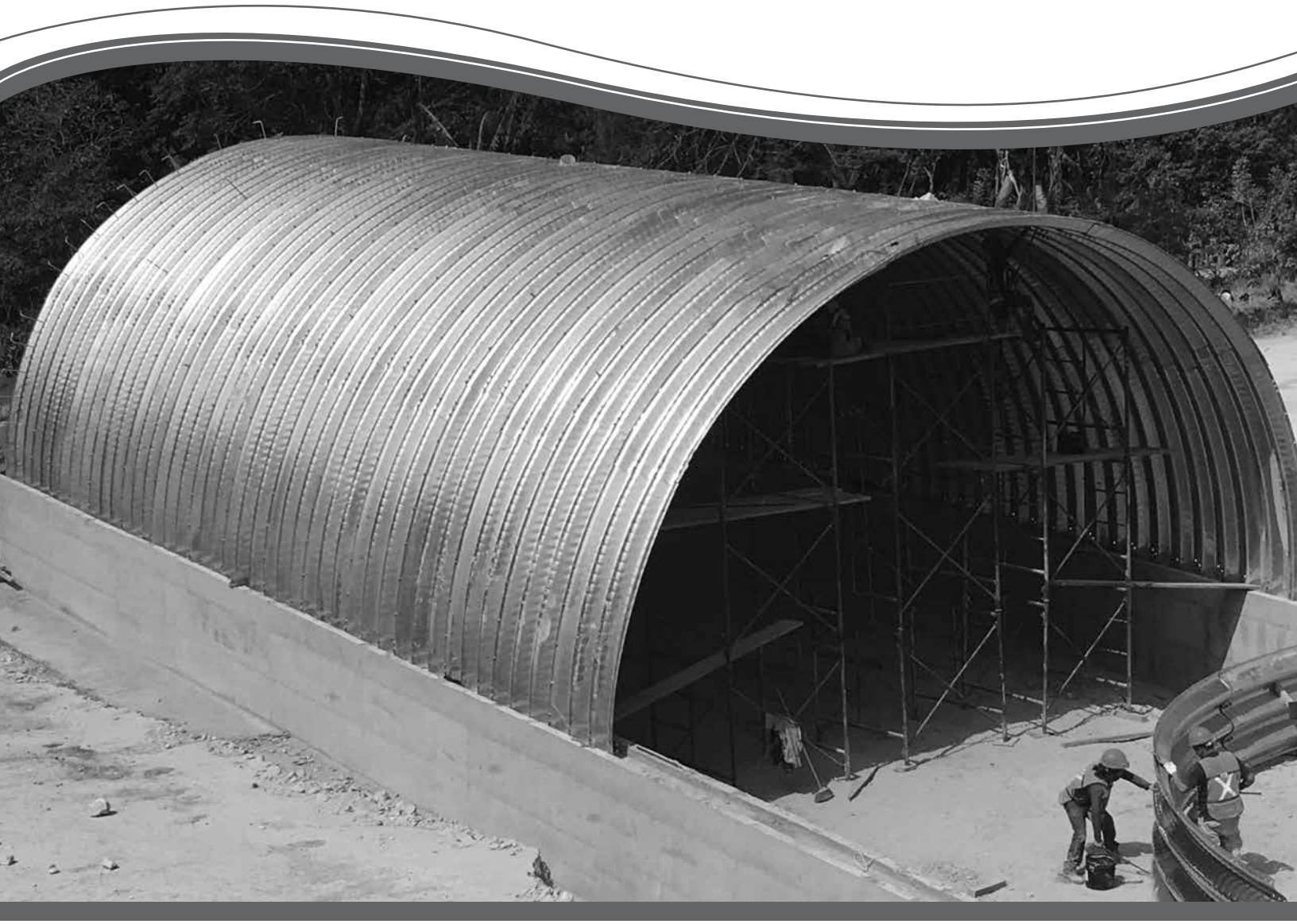
CONTECH®
ENGINEERED SOLUTIONS
A QUIKRETE® COMPANY

BridgeCor® Arch & Box Culvert Assembly & Installation Guide



CONTECH®
STRUCTURAL PLATE

BridgeCor® Arch & Box Culvert Assembly & Installation Guide

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Note to Contractor:

If at any time you have any questions, please don't hesitate to call the Winchester Plant Technical Services Team at 859-744-3339 for assistance.

Introduction

AS WITH ANY INSTRUCTIONS, PLEASE READ THROUGH THIS INFORMATION COMPLETELY BEFORE ATTEMPTING ANY FIELD WORK OR ASSEMBLY.

The following is a guideline for the assembly and installation of a Contech BridgeCor® structure. Prior to assembly, reference any assembly drawings provided, these guidelines, the Structural Plate Design Guide and the engineer's plans and specifications.

For each different structure shipped to the job site, a copy of the assembly drawings, the bill of materials (BOM) and these instructions are enclosed in a keg with a color coded lid. If the order calls for two or more identical structures, only one drawing will be furnished. The drawings provide the specific plate layout for each structure and must be used to guide assembly.

Safety Instructions

Review these instructions with your supervisors and crews. It is our intent you have a safe and successful project for you and your customer. Anytime a question or problem arises, contact your Contech representative before you proceed.

NOTICE: PRIOR TO ASSEMBLY, REFERENCE THE ENGINEER'S PROJECT PLANS AND SPECIFICATIONS. DURING ASSEMBLY AND INSTALLATION, ALL OSHA SAFETY REGULATIONS SHALL BE OBSERVED.

This safety alert symbol indicates important safety messages. When you see this symbol, be alert to the possibility of personal injury, and be sure you understand the message that follows.

Terms you should know

WARNING **Alerts you to hazards or unsafe practices that CAN result in severe personal injury or property damage.**

SAFETY INSTRUCTIONS **Messages about procedures or actions that must be followed for safe handling of BridgeCor.**

WARNING **Falling plates and accessories can cause severe personal injury or death. Read and follow all safety instructions before unloading BridgeCor® and accessories.**

UNLOADING AND HANDLING

Plates and fasteners are typically shipped in bundles which may weigh up to 10,000 lbs. See the Bill of Materials for individual plate weights. The following equipment is recommended for unloading BridgeCor and accessories:

- Forklift
- Front-end loader with fork adapters
- Backhoe with fork adapters
- Cranes
- Non-metallic slings

Other unloading methods such as chains, wire rope, cinching, or hooks in the end of the bundles should not be used.

Failure to follow these instructions can result in serious injury, death and /or damage to BridgeCor and accessories.

1. Only trained and authorized equipment operators are to be permitted to unload the BridgeCor and accessories.
2. Wear approved safety hat and shoes, gloves, and eye protection.
3. Park the truck and trailer on level ground before unloading.
4. Keep all unauthorized persons clear of the area when the driver releases the binders from the trailer and during unloading.
5. Do not cut the steel strapping around the bundles until the bundles have been placed on level ground or secured, and will not be moved again as a unit. It is recommended that the steel strapping be cut with appropriate sized cutting tools. Stand to the side when cutting a strap. Always be aware that BridgeCor and accessories may move, roll, or fall when a strap is cut.

6. Do not lift bundles by the steel strapping around the bundles. **WARNING**

7. Know the capabilities and rated load capacities of your lifting equipment. Never exceed them.

8. Do not stand or ride on the load of BridgeCor and accessories while it is being unloaded. Do not stand near the BridgeCor and accessories while they are being unloaded. **WARNING**

9. If unloading at multiple site locations, make sure the truck driver secures the remaining load before proceeding to the next location.
10. The contractor shall be responsible for the safety of his/her employees and agents. Adequate safety indoctrination is his responsibility.
11. Safe practices on construction work as outlined in the latest edition of the "Manual of Accident Prevention in Construction," published by The Associated General Contractors, shall be used as a guide and observed.
12. The contractor shall comply with all applicable city, state, and federal safety codes in effect in the area where he is performing the work. This conformance shall include the provision of the current issue of the "OSHA Safety and Health Standards (29 CFR 1926/1910)" as published by the U.S. Department of Labor.

ASSEMBLY AND INSTALLATION

1. Contech recommends using non-metallic slings for all BridgeCor and accessories handling requirements.
2. Chains with hooks may be used to handle the plates and accessories, being careful to not cause damage.
3. Do not push bundles off the trailers or permit plates and accessories to drop to the ground.
4. Prior to assembly, review and understand the engineer's project plans and specifications. Quality control is the responsibility of the contractor unless otherwise provided for in the contract documents.
5. Thoroughly review and study the product catalog, assembly instructions, assembly drawings, and bill of material prepared for your order and enclosed by Contech with the shipment.
6. Observe all OSHA safety regulations and guidelines during assembly and installation.

7. During and prior to the construction of permanent erosion control and end treatment protection, special precautions may be necessary to avoid damage.

8. The maximum allowable live loads and dead loads are those specified by the project engineer. The structure must be protected from unbalanced loads and from any structural loads or hydraulic forces that might bend or distort the structure. Flotation of the structure must be prevented.

Notwithstanding the instructions contained in this guide, it is the responsibility of the consignee or consignee's agent to devise safe unloading and handling procedures.

STORAGE

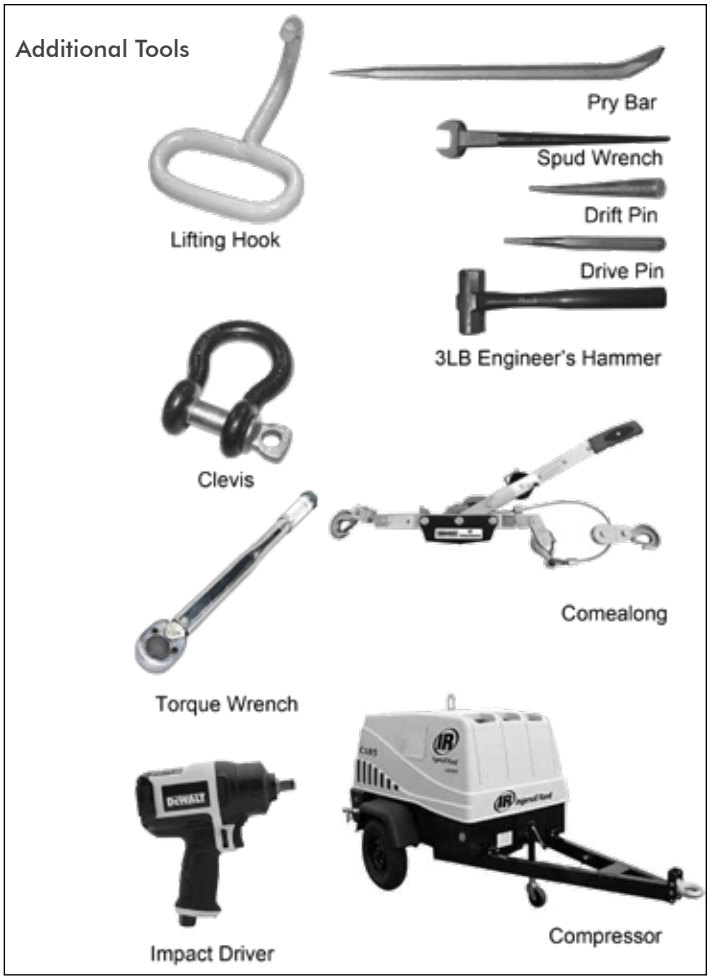
When steel bundles are exposed to moisture for extended time periods, a wet storage stain may occur. The purchaser should use reasonable handling and storage procedures for the materials to assure that a stain-free product is installed. See page 7 for more information.

ASSEMBLY

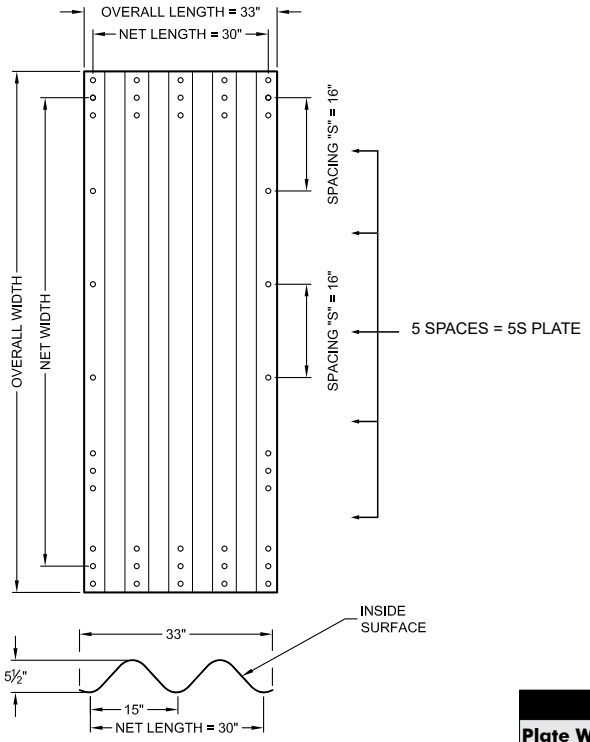
Suggested Tool List

- ☑ Band Cutters to cut packaging bands around bundled material.
- ☑ Lifting devices, such as cables/chains with safety hooks or Clevis for moving individual plates.
- ☑ 3 lb. Engineer's Hammer, Lifting Hook, and Pry bar.
- ☑ Tapered Drive Pin or Drift Pins for use in positioning plates, sheets, components or sections of material. The preferred material is tempered steel bar stock.
- ☑ Spud Wrench and/or Socket Wrench with appropriate sockets.
- ☑ Metered Torque Wrench. Many projects require verification of the bolt torque.
- ☑ Come-along for use in pulling the plates, sheets, components, or sections together (if required).
- ☑ Reamer bit and socket.
- ☑ Generator or air compressor for fasteners.
- ☑ Power source (air or electric).
- ☑ Air hose. Universal quick-fit fittings are found on most compressors.
- ☑ Electric extension cords with proper ground provisions and adequate wire gage.
- ☑ Air/electric impact wrench with adequate capacity for the torque ranges as noted. Torque levels are for installation, not residual, in-service requirements.
- ☑ Scaffolding and/or Ladders for larger structures as needed.

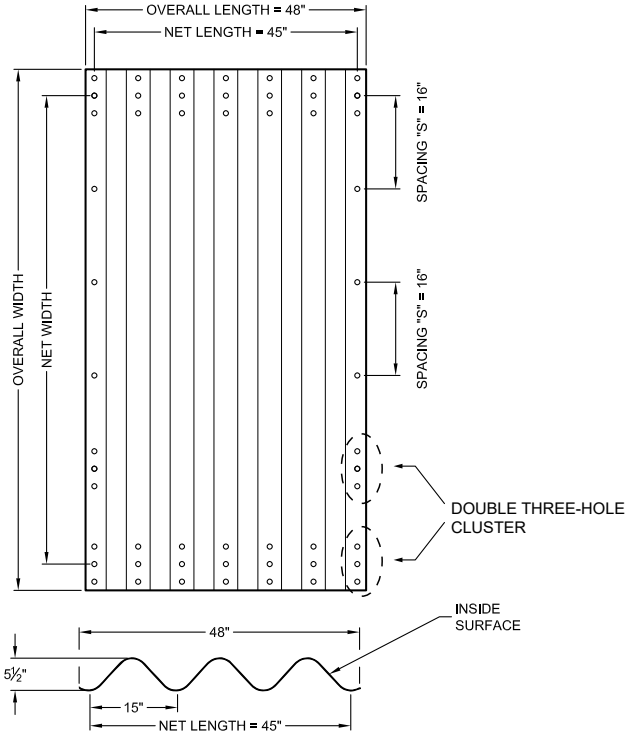
Note: Cordless tools are not recommended.



Standard Plate Detail



15" x 5.5" Corrugation, 30" Long Detail



15" x 5.5" Corrugation, 45" Long Detail

Notes:
1. The plate length is subject to manufacturing capabilities.
2. All bolts are per ASTM A449 (with suitable nuts) and are 3/4" diameter for all thicknesses except 5/16" and 3/8", which are 7/8" diameter.

TABLE 1. DETAILS OF UNCURVED BRIDGECOR SECTIONS

Nominal	Net Width (Inches)	Overall Width (Inches)	Spaces (16 inches)	Number of Circumferential Bolt Holes
4 S	64	73	4	5
5 S	80	89	5	6
6 S	96	105	6	7
7 S	112	121	7	8
8 S	128	137	8	9
9 S	144	153	9	10
10 S	160	169	10	11
11 S	176	185	11	12
12 S	192	201	12	13
13 S	208	217	13	14
14 S	224	233	14	15

For BridgeCor, S = 16 inches.

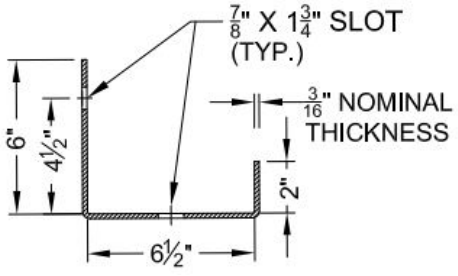
TABLE 2. APPROXIMATE WEIGHT OF 45" LONG BRIDGECOR PLATES

Plate Width S	Overall Width (Feet)	8 (0.170)	7 (0.188)	5 (0.218)	3 (0.249)	1 (0.280)
4 S	6.1	219	242	280	321	361
5 S	7.4	267	295	342	391	440
6 S	8.8	315	348	404	461	519
7 S	10.1	363	401	465	531	598
8 S	11.4	411	454	527	602	677
9 S	12.8	459	507	588	672	756

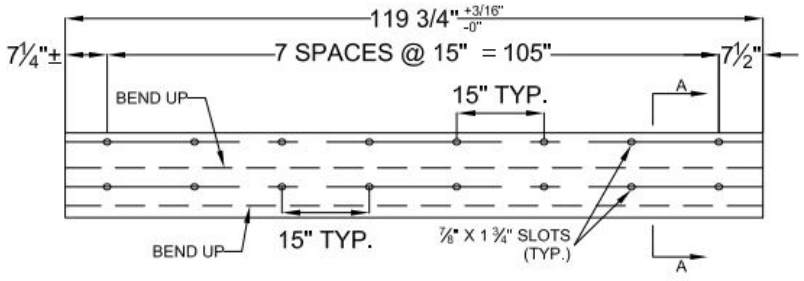
TABLE 3. APPROXIMATE WEIGHT OF 30" LONG BRIDGECOR PLATES

Plate Width S	Overall Width (Feet)	8 (0.170)	7 (0.188)	5 (0.218)	3 (0.249)	1 (0.280)	5/16* (0.318)	3/8* (0.380)
4 S	6.1	152	165	192	218	250	285	339
5 S	7.4	185	201	234	267	305	347	414
6 S	8.8	218	248	276	315	360	409	489
7 S	10.1	251	286	318	362	414	471	563
8 S	11.4	284	323	360	410	469	534	638
9 S	12.8	317	361	402	458	524	596	712
10 S	14.1	350	381	444	506	578	637	n/a
11 S	15.4	384	436	486	554	633	704	n/a
12 S	16.8	417	474	528	601	688	765	n/a
13 S	18.1	450	512	570	649	742	826	n/a
14 S	19.4	483	549	612	697	797	878	n/a

1. Weights are based on a zinc coating of 3 oz./sq. ft. of double-exposed surface.
2. All weights are subject to manufacturing tolerances.
3. Specified thickness is a nominal galvanized thickness. Reference AASHTO M 167.
4. S = 16 inches
5. Weight of plates are without fasteners.



Unbalanced Channel Cross Section



Unbalanced Channel for BridgeCor® Arch

BridgeCor® Bolts and Nuts

Hot-dipped galvanized steel (specially heat-treated) bolts meeting ASTM A449 specification with suitable nuts are used to assemble structural plate structures.

The underside of the bolt head is uniformly rounded and ribbed to prevent bolt head rotation while tightening. Unlike conventional bolts, once the nut is finger tight, final tightening can typically be accomplished by one worker with an air driven impact wrench to 150-300 ft.-lbs. of torque for 3/4" bolts and 200-350 ft.-lbs. of torque for 7/8" bolts.

In addition, one side of the nut is spherically formed to help align and center the fastener into the punched holes. The rounded side shall be placed against the structure.

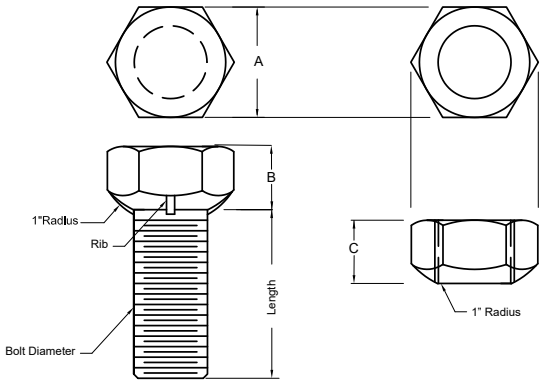
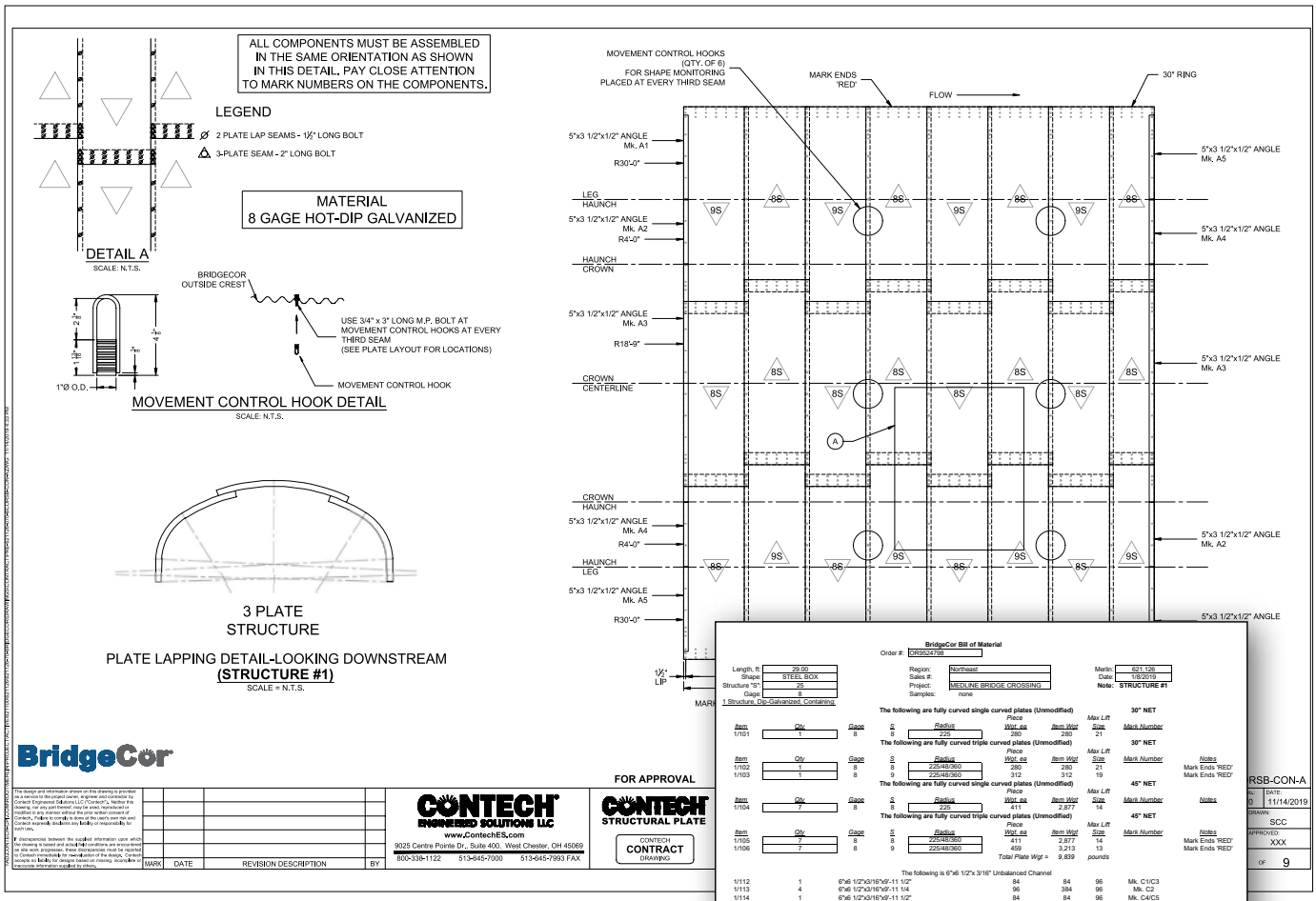


TABLE 4. TYPICAL BOLT AND NUT

Diameter (Inches)	A (Inches)	B (Inches)	C (Inches)
3/4	1 1/4	9/16	13/16
7/8	1 7/16	3/4	7/8

Notes:
1. The longer bolts are used in 3 plate lap seams.
2. In some cases 3″ bolts can be used as a service type bolt.

Sample Drawing



Example Plate Layout Drawing from Contract Set

Example Bill of Material (BOM)

BridgeCor® General Assembly Instructions

PLANNING BEFORE ASSEMBLY

It is important for you to know the jobsite conditions, be familiar with the materials, and understand the plans and specifications. Necessary arrangements and preparations including those suggested below should be made before the assembly crew moves onto the project. This should save time and expedite assembly.

STORAGE

The rapid corrosion of zinc surfaces under certain adverse conditions, generally referred to as wet storage stain and sometimes as "white rust" is a condition familiar to users of galvanized materials. When wet storage staining is found on galvanized materials, it is not usually sufficient to be detrimental to the protection of the steel. Normally, the stain disappears with weathering.

Because the wet storage stain may be unsightly, any attack may seem more serious than it is in actuality. The thick zinc coating provided by hot dip galvanizing of the plates after fabrication usually results in wet storage stain being of little or no significance to the durability of the coating in its intended service.

The purchaser should use reasonable handling and storage procedures for the materials at the construction site to assure that a stain-free product is installed.

When relatively long outdoor storage is necessary, plates should be raised from the ground and separated with strip spacers to provide free access of air to all parts of the surface. They also should be inclined in a manner which will give maximum drainage. The material should also be stored under cover whenever possible. Bolts and nuts should be stored inside and periodically checked to ensure that the containers are free from moisture or condensation.

ASSEMBLY CONSIDERATIONS

1. The staging area needed must be fairly flat, free of large brush, stumps, or trees and as close to the installation site as possible. In those cases where there are no level places to assemble the structure, make arrangements to level an area for staging.
   The staging area required is generally: a width of [2x (Span) + 15'] by the length of the structure.

2. Depending on the size and weight of the BridgeCor, a preassembled structure can often be lifted and set into place. For example, removing the existing bridge while the structure is being assembled may be the most effective approach to the project. (Reference the section on Lifting.) See the Bill of Materials, the Structural Plate Design Guide or a Contech representative for the handling weight of the structure.

CREW SIZE

Crew size can vary depending on several factors such as allowable time, structure size, site conditions, etc. Generally, an even numbered crew is most efficient since the work is done in pairs. A crew of four workers, one material organizer, and one crane operator is ideal with manpower increased as the individual project requires.

TOOLS REQUIRED

Reference the "Suggested Tool List" on page 4.

DESCRIPTION OF MATERIAL

BridgeCor plates are field assembled into round, arch, and box culvert structures. Corrugations of 15-inch pitch and 5.5-inch depth are perpendicular to the length of each plate..

The various lengths of cut (e.g. T1, V1, T2, etc.) and uncut plates are assembled or placed in the structure in accordance with the assembly drawing (plate layout drawing furnished by Contech).

Normally, all of the plates in the barrel of the structure are not shown on the assembly drawing. However, enough of the plates are shown to establish the proper seam stagger and a repetitive pattern in the barrel. This pattern establishes the correct location for all of the plates. Since the plates are not symmetric, they must be oriented such that their location matches that shown on the assembly drawing. Reference the detail "A" in the sample plate layout drawing on the previous page for proper orientation of the plate bolt hole pattern. Should it prove difficult to match the plate and the assembly drawing, a Contech representative should be notified for assistance.

Thickness. Standard specified thickness of the galvanized plates vary from 0.170 (8 gage) to 0.380 inches (3/8").

Please reference the standard plate details shown on page 5 of this document.

PLATE LENGTH (LONGITUDINAL)

BridgeCor plates are furnished in either 2.50 foot net lengths or 3.75 foot net lengths. Please refer to the assembly drawings for the specific plate sizes. Actual length of a square-ended structure is three inches longer than its net length because a 1 ½-inch lip protrudes beyond each end of every plate for lapping purposes.

PLATE WIDTH (CIRCUMFERENTIAL)

Standard plates come in multiples of 16 inches (S=16 inches or 5 * Pi) and are fabricated in six net covering widths. The "S" nomenclature translates circumference directly into nominal diameter in inches. Each plate is identified by a stamped number in the corner of the plate located in the first inside crest at one end. The number consists of digits which identify the plate (see the table and image below).

Plate gage and plate radius can be determined from the stamp number that is embossed in the end corrugation on the inside of the structure. For custom cut or welded plates, the mark number is shown on the third line of the stencil (MK 2 in this case). See page 8.

Plate Stamped Number Identification

Order	Item	Heat	Gage
9786176	1\101	330704	8GA

Note: Only a single digit is included for the gage mark. The gage marks shown in the are used on the plate stamp.

Table 1. Gage Marks

Gage	Mark
8	8
7	7
5	5
3	3
1	1
5/16"	F
3/8"	T

BOLTS

Bolts will be furnished in some combination of six lengths, 1-1/4", 1-1/2", 1-3/4", 2", 2 ½" and 3" depending on specific plate lap and thickness.

For longitudinal holes, when 3/4" bolts are supplied, 7/8" diameter holes will be punched on 3" centers. When 7/8" bolts are supplied, 1"diameter holes are punched on 3" centers.

For circumferential holes, when 3/4" bolts are supplied, 1" diameter holes are punched. When 7/8" bolts are supplied, 1-1/8" diameter holes are punched. All holes are punched on 9.6" centers.

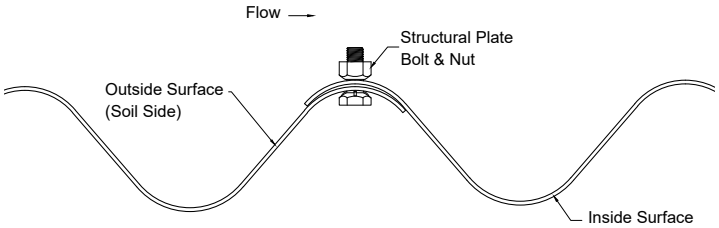
To determine the specific number of bolts for a structure, check the BOM. All containers are stenciled with the individual bolt size.

BOLTING

Bolting procedures may vary depending on the size and gage of the structure. Generally speaking, on smaller span and lighter gage structures, a loose bolting procedure works best. On larger and heavier gage structures, a tight bolting procedure, ring to ring may provide better results. The assembly contractor should use the procedure best suited for his particular project based on his experience.

To facilitate alignment, initial assembly should be done with a minimum number of bolts. Insert sufficient bolts in each seam to hold the plates in position, but do not tighten the nuts, thus leaving the plate free to move slightly to help in matching the remaining bolt holes. Bolting the circumferential seam is best done by first placing bolts near the middle of the plate. About three rings behind plate assembly, insert the remaining bolts, using pins or a pry bar to align holes. After all the bolts are in place, tighten the nuts. Note, aligning of bolt holes is done easier when bolts are loose while drifting of holes is best done with adjacent bolts tight.

All bolts to be tightened to 150-300 ft.-lbs. of torque. A good plate fit is far more important than high bolt torque.

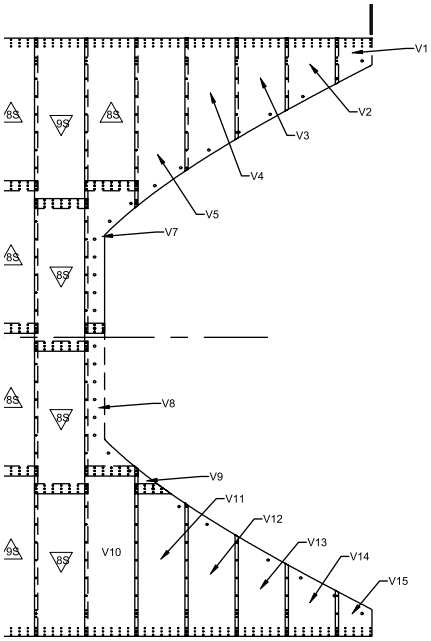


Note: The nut may be placed on either side of the plate.

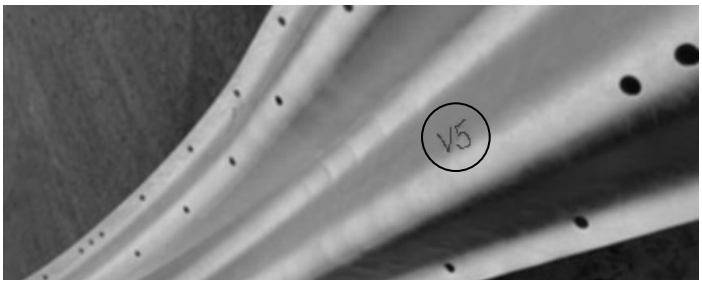
BridgeCor® Assembly Instructions for Arch Shapes

PLATE ASSEMBLY

The various widths of plates are positioned in the barrel in accordance with the plate layout drawings furnished with the structure. The numbers shown on the drawing in the barrel area or on the plates indicate the number of bolt holes across the end of each plate.



The beginning and end rings are shown for square end structures in the drawings on page 6. The plates are identified on the drawings with triangles that have the plate widths inside them (triangles are a label only shown on the drawings). These triangles point towards a double three hole cluster on the plates in the circumferential seam. The orientation of this double cluster of holes must be followed on the rings for proper plate stagger. Special plates in cut end structures are shown on the plate layout drawings, see above, together with the necessary plates required to obtain proper seam stagger in the barrel.

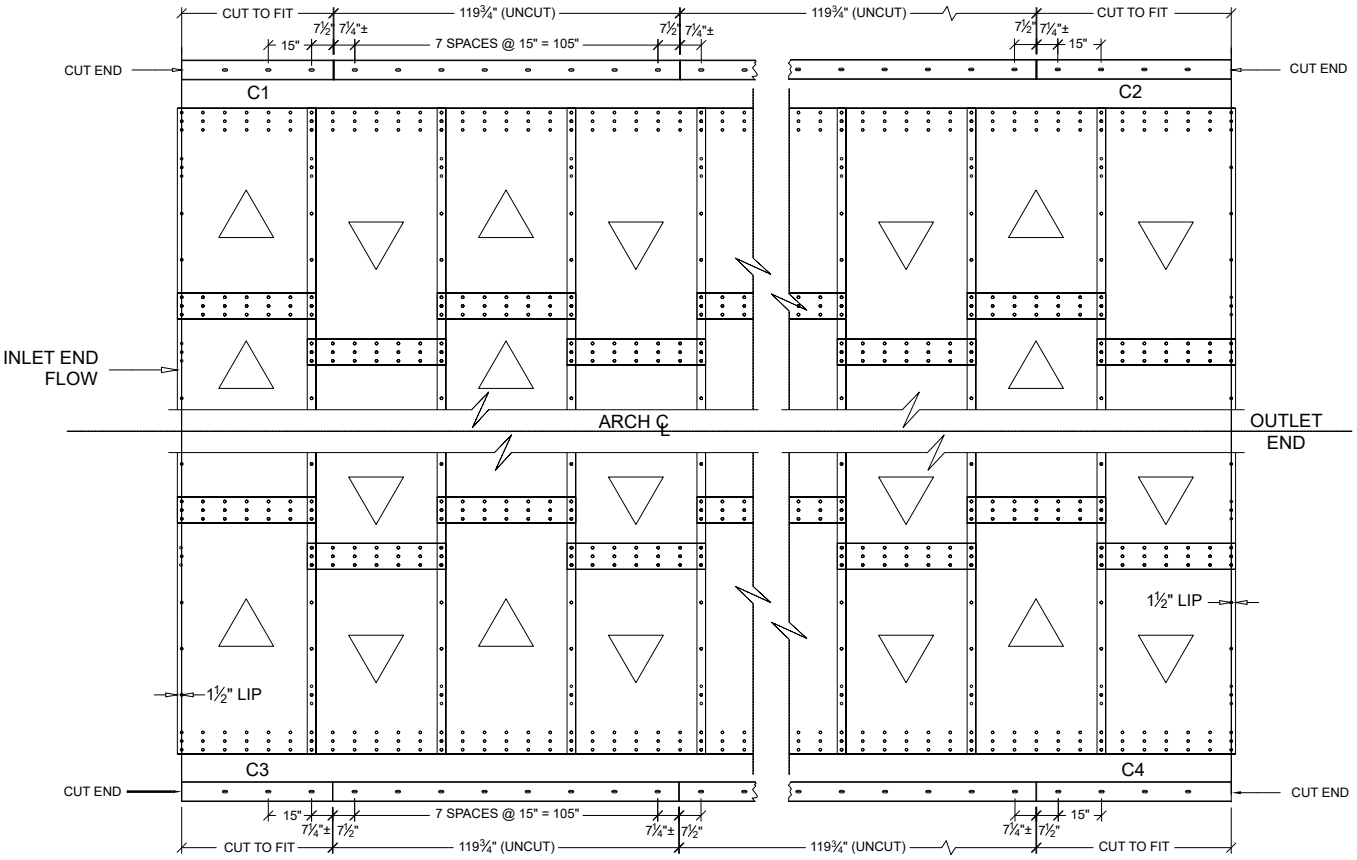


For cut plates and elbow cut and welded plates, numbers appear on the plate layout corresponding to the embossed numbers on the plates themselves. (e.g. T1, V1, T2…) Reference the structure assembly drawings furnished with the order.

BridgeCor® Unbalanced Channel Details

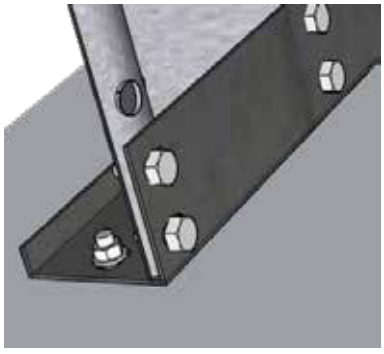
UNBALANCED CHANNEL (UBC) INSTALLATION

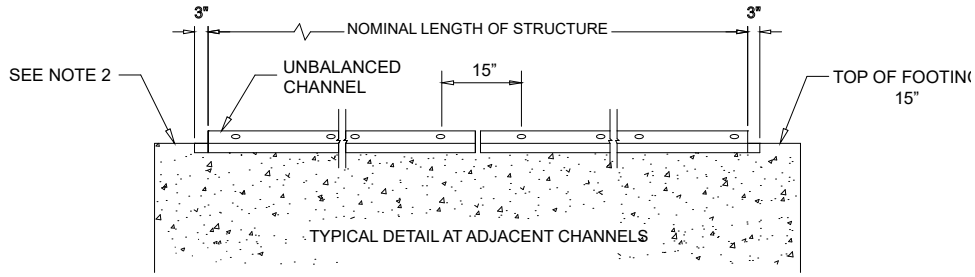
An unbalanced channel is used as a construction tool to help secure the plate during the assembly process. This channel is cast in the concrete footing during the footing construction. It is important to have the channel square with the subgrade, parallel to the opposite footing and located properly to ensure the hole alignment in the channel matches the holes in the plates.



NOTES:

1. BE CERTAIN THAT UNBALANCED CHANNELS ARE LINED UP PROPERLY AT 90° TO CENTERLINE OF ARCH AND THAT THE APPROPRIATE BASE CHANNEL HOLES ARE DIRECTLY ACROSS FROM EACH OTHER WHEN SETTING CHANNEL IN THE CONCRETE FOUNDATION. BASE CHANNELS ARE INSTALLED WITH THE LONG LEG TO THE OUTSIDE OF THE STRUCTURE.
2. PLATE LIP EXTENDS APPROXIMATELY 1 1/2" BEYOND END OF BASE CHANNEL. IF FOOTINGS ARE LONGER THAN BASE CHANNEL(NOMINAL STRUCTURE LENGTH) PROVIDE A 6"Wx5"Hx3"L SLOT IN THE CONCRETE. THIS ALLOWS THE PLATE TO EXTEND BEYOND THE BASE CHANNEL IN THE FOOTING SLOT.
3. REFERENCE SEPARATE DRAWING FOR UNBALANCED CHANNEL.
4. THE LONG LEG OF THE UNBALANCED CHANNEL IS ADJACENT TO THE OUTSIDE OF THE ARCH.





ELEVATION VIEW

Foundations for BridgeCor® Arch Shapes

General Foundation Types

- Cast-In-Place Foundation
- Steel EXPRESS® Foundation
- Precast EXPRESS® Foundation
- Foundation in Existing Rock

Cast-in-Place Foundations

GENERAL INFORMATION

1. Foundation must be built in accordance to the project specifications and details.
2. Structures can be installed sitting within a keyway or within an unbalanced channel. See lower right diagram.
3. When unbalanced channels are used, they are generally set using anchor bolts that are cast into the foundation. Please refer to the plate layout drawings for anchor bolts size and spacing. This anchors the UBC into the finished CIP foundation. If the structure is placed pre-assembled and spreading occurs while lifting, use come-alongs and/or struts to maintain the correct span.

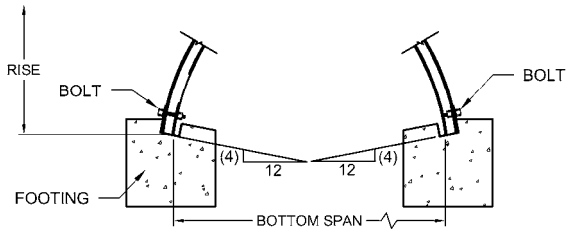
EXPRESS® Foundations (Steel or Precast)

GENERAL INFORMATION

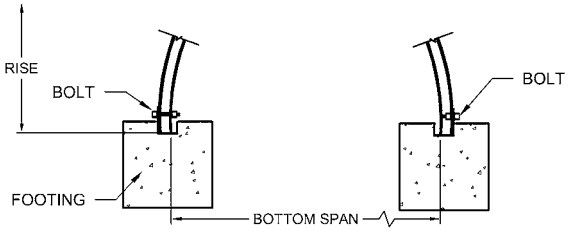
1. Structures are typically installed within a keyway. Unbalanced channels are attached to structure legs to help distribute structure dead loads to cross members prior to concrete pouring.

2. Structure can be set within the keyway prior to the footing concrete pour or after.

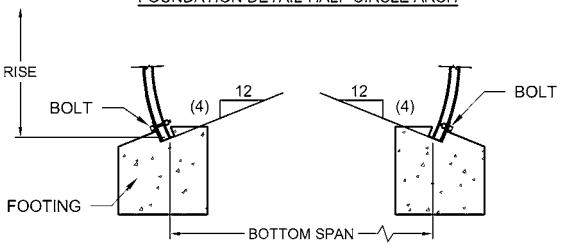
3. For additional information regarding these types of foundations, please refer to their specific assembly and installation guides.



FOUNDATION DETAIL-LESS THAN HALF CIRCLE ARCH



FOUNDATION DETAIL-HALF CIRCLE ARCH

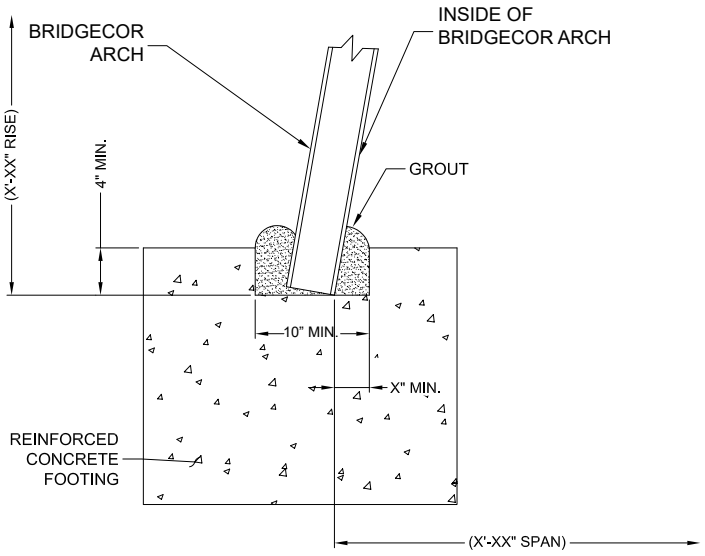


FOUNDATION DETAIL-MORE THAN HALF CIRCLE ARCH

Foundation in Existing Rock

GENERAL INFORMATION

1. When installing arch structures in existing rock foundations, minimal excavation may be needed to achieve project specific grade requirements.
2. Structures are typically installed within an unbalanced channel.
3. Please contact your Contech representative for more detail.



NOTES:

1) SIZE AND REINFORCING OF FOOTING TO BE CONTROLLED BY SOIL-BEARING CAPACITY AND LOADING CONDITIONS.

2) BLOCKING OR SHIMMING SIDE PLATES TO ACHIEVE AND MAINTAIN PROPER BOTTOM SPAN AND SIDE RETURN ANGLE MAY BE REQUIRED.

3) GROUT SHOULD BE NON-METALLIC, NON-SHRINK MATERIAL, WITH A MINIMUM 4,000 PSI COMPRESSIVE STRENGTH

4) GROUT AND SHIMMING MATERIAL SHOULD NOT CONTAIN ANY CORROSION-PROMOTING AGENTS.

Assembly Using Unbalanced Channels (UBC)

Starting at the inlet end, assemble three or four plates on one side only, referencing the plate layout drawing for plate location. Bolt the first row of plates to the stationary unbalanced channel. Please see details on page 12 for proper plate lapping.

The attachment of the plates to the unbalanced channel is made by bolting through the middle row of holes on the outside crests of the corrugation.

After placing and bolting a few plates on one side, start at the inlet end again connecting plates on the opposite side of the structure to the unbalanced channel. This will require the use of a 2" bolt on both sides. It may help to support the plates with temporary shoring until the first ring is complete. Continue by placing side and top plates into position as shown on the plate layout drawing (PLD) until at least two full rings are completed.

At this point, check the eccentricity of the structure.

A plumb bob dropped from the crown centerline with measurements to the bolt at the top of the unbalanced channel will determine if the structure is square to the channels. To square up the structure, loosen enough bolts so the structure can flex, remove the bolts from one unbalanced channel and drift the lower edge up stream or down stream as necessary.

Following this check to ensure a symmetrical arch, continue to move downstream placing the plates in the same sequence until all of the plates are in place. Check to ensure that all bolts have been inserted and tightened to the required torque.

Assembly Using Keyway/Slotted Footing

For structures that will sit on a keyway in the foundation (no unbalanced channel being used), use the following guidelines.

Choose an area as flat as possible for assembly on the ground to avoid plate alignment issues. Have dunnage on hand to support the arch where required. Starting at the upstream end, build the first ring laying on the ground, following the plate layout drawings and the plate lapping details on page 12 of this document. Build the second ring on top of the first ring as per the plate layout drawing paying close attention to the longitudinal stagger. Loose bolt the structure on the ground until both rings are complete and the structure shape is established at proper span and rise. Check span and rise and if structure is not at desired shape, use blocking and staking to work the plates into span and rise per plans. Completely torque all bolts prior to lifting the arch into place.

Lift the first rings(s) and set in the foundation keyway. After the first ring(s) are set, recheck rise and span. Moving downstream continue to assemble by placing side plate and top plates into position as shown on the plate layout drawings (PLD). As you move downstream adding plates to the structure, ensure that the lower plates are always leading or ahead of the plates that are above it on the ring, moving up towards the crown plates. The plates will want to slide down; use a pry bar to push them into the correct location.

Continue to move downstream placing the plates in the same sequence until all of the plates are in place.

ADDITIONAL ASSEMBLY CONSIDERATIONS

1. Due to plate length and bolt hole diameter tolerances, periodic checks should be made to ensure that the structure length is not deviating from the nominal length. Standard structure length tolerance is +/- 1/2" per 10 LF.

2. If the structure includes a skew or bevel those plates should be installed after the main barrel of the structure has been completed. The completed rings support the skewed or bevel plates and help prevent them from distorting the design shape of the structure. When cast-in-place concrete collars are to be installed, the Installer will need to allow for formwork to be erected on the end of the structure.

3. Skewed structure ends will include a variable corrugation profile through the plane of the skew. As a result, when forming cast-in-place collars or headwalls, this "roughness" will be present and should be factored into construction of formwork. Based on manufacturing tolerances for the plate and depending on project aesthetic requirements or the level of precision required with headwall or collar layout, field trimming may be required to provide a straight edge along the plane of the skew or bevel. Skewed and beveled plates may be cut in the shop prior to delivery to the site. However, many contractors will prefer to cut skewed plates in the field when the formwork for the concrete headwall or collar is constructed to ensure the plane of the cut is at the desired location. Some contractors may also prefer to cut the plates in the field after the concrete headwall or collar is placed. This provides additional space for setting formwork at the face of the concrete headwall or collar and will allow for a clean, straight cut after the formwork is removed.

4. The skewed ends will not support the weight of the cast-in-place headwalls during placement and will need to be supported until the headwall reaches an adequate compressive strength as determined by the wall designer. Special bracing and/or scaffolding is required. The shape must be completely supported to proper span and rise during headwall construction.

   Design of temporary shoring to support the structure during construction is not provided by Contech and typically not provided by the wall designer. Temporary shoring is the responsibility of the wall contractor and/or a qualified construction engineer or formwork specialist.

5. Water forces, including unexpected flooding, may bend assembled plates or cause flotation of the structure. The contractor should secure the upstream end by backfilling and constructing final end treatment as soon as possible.

LIFTING

The lifting of preassembled sections of structures or entire structures is a proven and fairly common method of installation. However, attention must be given to proper techniques and safety measures. Structures must be lifted carefully in a controlled and balanced fashion.

The use of a spreader beam with multiple lifting points is desirable and serves to better distribute lift loads. Additionally, the lift loads should be transmitted vertically to the structure, minimizing eccentric forces on lift assemblies and excessive bending.

Many structures, depending on the size, have been lifted into place using eyebolts with plate assemblies. The type, number and location of lifting devices will be dependent upon the size, length and weight of the structure. Lifting devices are normally located at a seam with appropriate reinforcement, washers, etc. used to distribute the load.

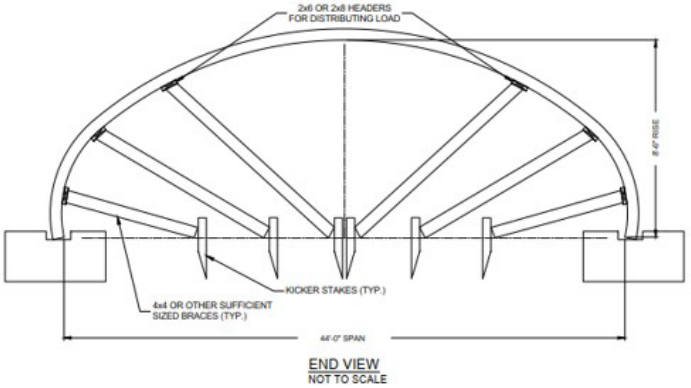
Rigging a structure to be lifted into place should be done by proportioning the weight between the lifting points to achieve balanced loading and control. The rigging plan must be approved by the Engineer of Record; for additional guidance contact you Contech representative.

WARNING

THE CONTRACTOR MUST REVIEW ANY LIFTING PROCEDURE TO ENSURE THAT AN ADEQUATE SAFETY FACTOR HAS BEEN PROVIDED. THE CONTRACTOR MUST LIFT THE STRUCTURE INTO PLACE IN SUCH A MANNER AS TO NOT DAMAGE THE STRUCTURE. REVIEW ALL SAFETY GUIDELINES. ONCE THE ASSEMBLED STRUCTURE HAS BEEN LIFTED AND PLACED, CHECK THE BOLT TORQUE AND RE-TIGHTEN AS NECESSARY.

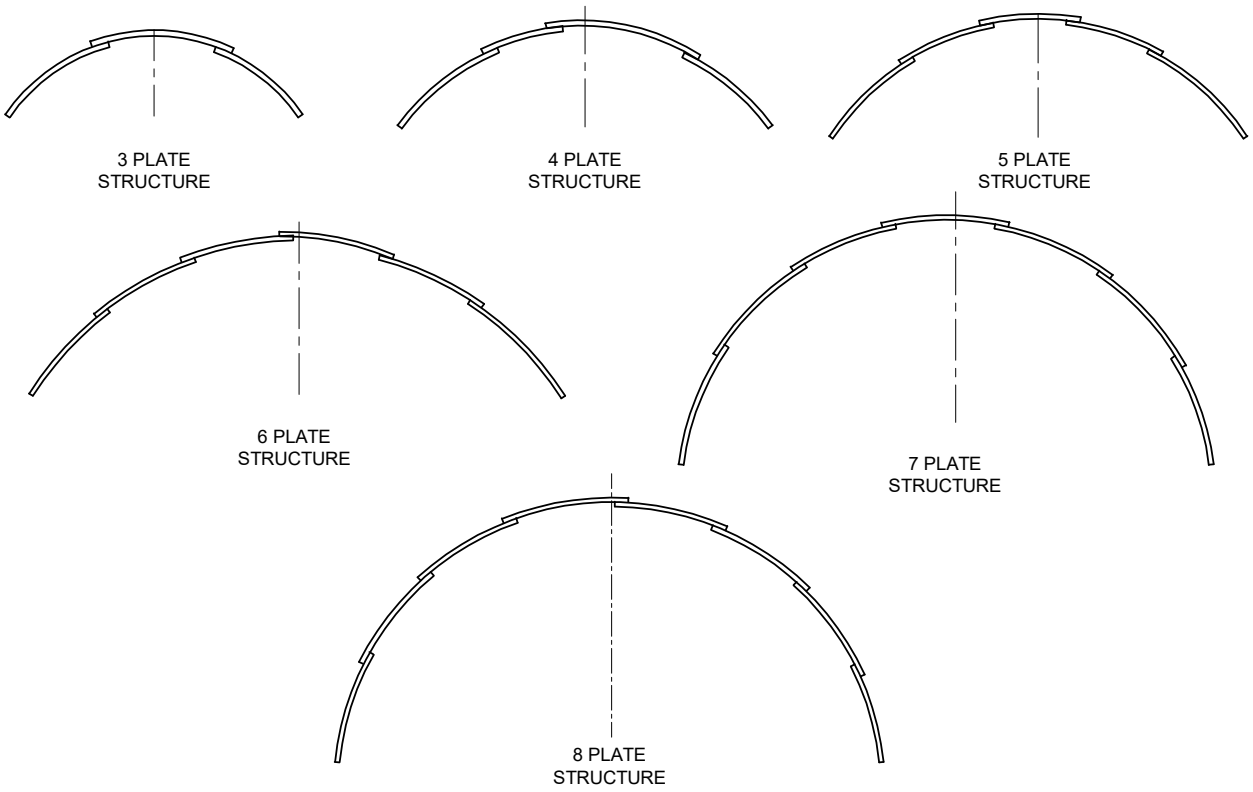
CAUTION

DO NOT ATTEMPT ANY LOADING OF A STRUCTURE (INCLUDING LIFTING A PREASSEMBLED STRUCTURE INTO PLACE) PRIOR TO THE TORQUING OF ALL NUTS. COME-A-LONGS AND/OR STRUTS MAY BE REQUIRED TO MAINTAIN STRUCTURE SPAN DIMENSION FOR OUT OF TRENCH ASSEMBLY AND INSTALLATION.

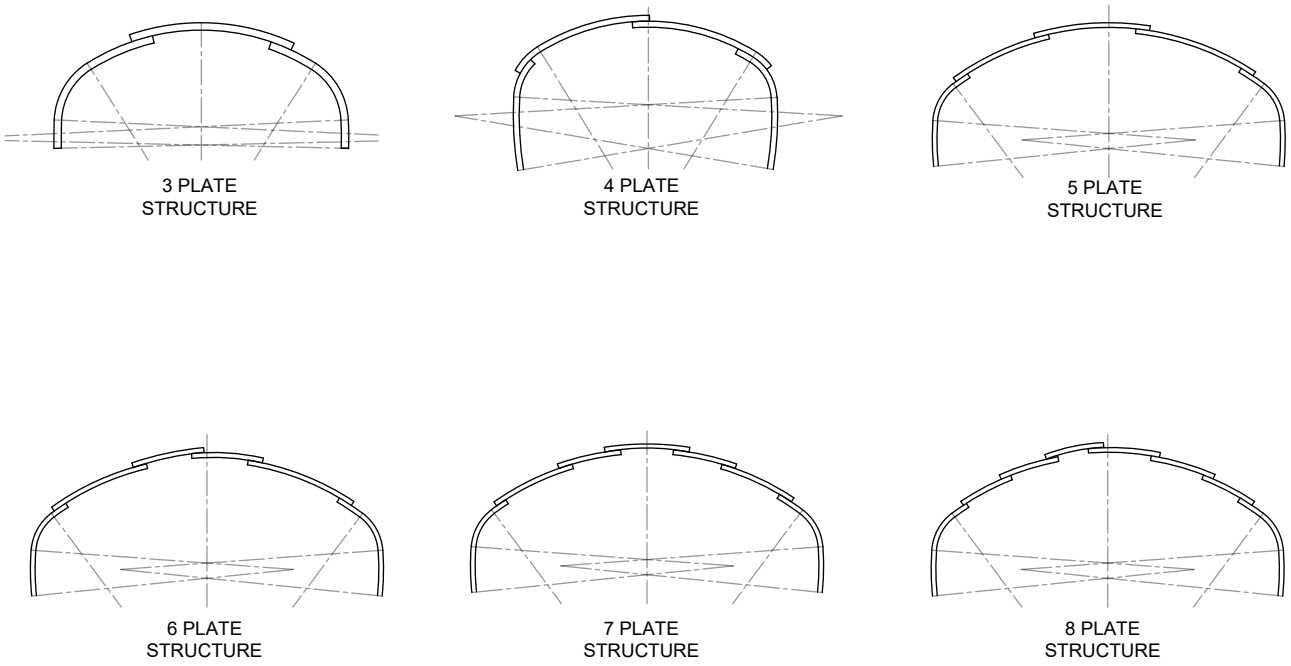


BridgeCor® Plate Orientation

SINGLE RADIUS ARCH



BOX CULVERT



INSTALLATION

Basic Principles for BridgeCor® Arch and Box Culverts

Project plans and specifications provide the basic requirements for construction and installation. However, site conditions may vary from those anticipated during design. The contractor and construction engineer must recognize these variations. Often, alternate or additional construction considerations are necessary. The following guidelines provide specific considerations and details for various conditions in a step-by-step construction sequence. (This summary is listed at the end of this manual.)

1. Check alignment in relation to the plans as well as the actual site conditions.
2. Excavate to the correct width, line and grade.
3. Provide a uniform, stable foundation—correct site conditions as necessary.
4. Unload, handle and store the plates and fasteners correctly and safely.
5. Assemble the structure properly – check alignment, follow special procedures for any items detailed on the plate layout drawings. Make sure to achieve properly aligned plate laps, bolt torque, and assembled dimensions.
6. Use a suitable (granular) backfill material as required in the plans and specifications.
7. Maintain proper backfill width.
8. Place and compact the backfill in 8 inch thickness of uncompacted lifts to a minimum 90% density per AASHTO T-180.
9. Maintain balanced fill placement and loading during all phases of installation, keeping fill height differential side to side to 2' maximum.
10. Provide shape control monitoring as required.
11. Install the necessary end treatment quickly to protect the structure from erosion and uplift.
12. Protect the structure from heavy construction equipment loads, other heavy loads and hydraulic forces.

LOCATION

Before installing any structure, it is best to first recheck the planned alignment and grade (position and percent of slope) of the foundations in relation to the topography of the site. Even when complete construction plans are supplied, a careful examination of the site must be completed.

EXCAVATION

Embankment Condition

Typically, the excavation required for an embankment condition is to remove the topsoil, muck, organic matter and other fill deemed unsuitable by the project engineer and prepare a stable foundation at the proper elevation and grade.

Trench Condition

When structural plate is installed in a trench, there are some general guidelines that should be followed.

All trench excavation should proceed only after OSHA and other safety requirements are met. Trench excavation normally proceeds in the upstream direction. Most trenching equipment is more efficiently operated in this manner. For arches, plate sections should be assembled in the downstream direction. If an acceptable in-situ material is to be used as backfill, it should be stockpiled at a safe distance from the edge of the trench. As a general rule, when trench walls are unsupported, the distance from the trench edge to the toe of the stockpiled material should not be less than one-half the depth of the trench. When trench walls are protected by some form of sheeting or shoring, a safe minimum distance between the trench edge and stockpiled material must still be maintained, but will vary with soil and bracing types.

Care should always be exercised in the operation of equipment in the vicinity of an open trench. Operated too close to the trench, equipment weight and vibration may collapse the trench walls. The three phases of construction in a trench (excavation, structure installation, and backfilling) should be scheduled in close sequence with each other. An open trench is dangerous and vulnerable to accidents. An open excavation can result in damage to the project under construction. The two main hazards that must always be considered in trenching work are:

- Stability of trench walls; and
- Water that may accumulate in the trench resulting from seepage and surface runoff.

To minimize accidents and losses resulting from trenching operations the following procedures should be followed:

- Begin excavation only when installation of structural plate can immediately follow.
- Protect trench walls to insure their stability throughout the construction period.
- Follow procedures that will keep the trench free of seepage and surface waters.
- Excavate the trench at the same rate as the structure installation with a minimum distance, as dictated by safety, separating the two operations.
- Backfill the trench as soon as practicable after structural plate installation.

Trench Width and Shape

The absolute minimum trench width on each side of the structure is 8' according to AASHTO specifications. The actual width and shape of the trench depends on the size and shape of the arch. Refer to backfilling details on the plans for specific dimensions. Any change should be approved by the Engineer.

Figure 6 (on page 17) provides guidelines about minimum spacing between multiple structures. These same guidelines can be used to provide the necessary width between the structural plate and trench wall to adequately place and compact typical backfill. Lesser spacing may be used with slurries and other backfill materials that do not require mechanical compaction.

PREPARING SUBGRADES

The subgrade requirements should be detailed on the plan sheets. However, field conditions may vary requiring special attention and alterations that are discovered only during excavation. Any alterations should first be approved by the project engineer. The strength of the subgrade must be capable of supporting the foundation, structure and the select backfill envelope. The critical factor is to achieve uniformity along the structure.

HANDLING DIFFERENT TYPES OF SUBGRADES

When the excavated grade line reveals both soft and hard spots, the subgrade must be changed to make it as uniform as possible. Sometimes hard spots can be excavated below grade and replaced with softer material. Alternatively, it may be more economical to excavate the entire subgrade slightly below grade line and replace it with suitable, uniform material. In any event, any abrupt changes from hard to soft subgrade must be avoided.

When soft, unstable material is encountered at the subgrade level, it must be excavated below the bottom of footing elevation and improved as necessary. The zone of select material must be adequate to support the foundation of the structure and backfill. When unexpected materials are encountered, consult the project engineer.

Whenever a subgrade is stabilized by undercutting and replacing substandard, poor quality materials with a coarsely graded granular fill material, consideration of the adjacent bedding and backfill material becomes even more important. The adjacent side fill zones must also be properly supported to prevent excessive differential settlement that could lead to dragdown loads on the structure. Additionally, finer graded fill materials can migrate into the more coarsely graded fill. Use of a geotextile separator should be considered to prevent such migration of fill particles. The use of intermittent piles, pile bents or concrete cradles may be required due to inadequate subgrade strength. This may create the potential risk for differential settlement issues for the structural plate and for the adjacent side fill and thus should be avoided.

ARCH SUBGRADES

Arches are erected on a prepared reinforced concrete foundation. Setting a structure in a concrete foundation can be in done either a keyway slot or in an unbalanced channel.

KEYWAY SLOT

A keyway slot is formed into the concrete foundation wide and deep enough to accept the corrugated plate. After assembly, a non-shrink, non-metallic grout is placed to fill the void. This eliminates ponding of water in the formed keyway.

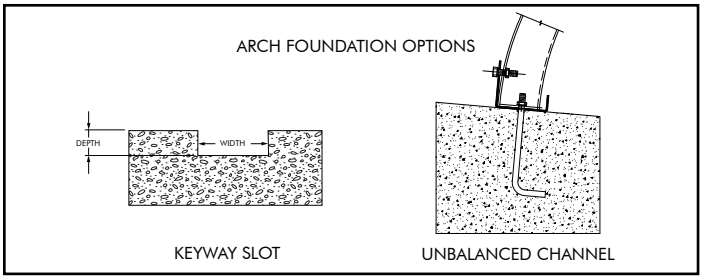


Figure 1. Arch foundation options

FIELD-APPLIED COATING FOR BRIDGECOR

Field coated asphalt coatings shall be applied per the manufacturer's application instructions and AASHTO M243 and ASTM A-849.

The coating shall be applied to a clean surface, free of dirt, oil, grease, or other foreign matter, when the atmospheric temperature is above 40°F. and the humidity is low enough that the surface of the metal can be kept dry.

Coating may be applied by spray or brush as required by the manufacturer to attain a uniform dry thickness of 0.05 inch.

STREAM DIVERSION

If the stream is temporarily diverted during construction, the diversion ditch or temporary drainage pipe must be adequate to carry the flow. Reduced construction times are helpful in limiting this exposure. The structure installation must be protected from storm flows by a temporary dike, cofferdam, etc.

If the structure must carry the flow during the construction stage, the upstream end must be protected with the proper end treatment. This will ensure that the flow is not diverted around or beside the structure thereby scouring out backfill as it is placed or floating the structure. In phased construction, it is desirable to construct and backfill the upstream end first.

BACKFILLING
BridgeCor® Arch and Box Culverts

PLACING THE BACKFILL

It is important to emphasize the necessity of adequate backfill and proper placement. Faulty compaction has led to more trouble with structure installations, flexible and rigid, than all other factors combined!

For trench installations, backfill must follow as closely behind the excavation and assembly stages as possible. Embankment installations typically are backfilled after the entire structure, or a major portion of it, is assembled. Unless the embankment and backfill materials are placed simultaneously, one must be benched so the other can be compacted against it.

Continue placing the backfill equally on both sides of the structure in 8-inch uncompacted lifts, thoroughly compacting each to a minimum 90% density per AASHTO T-180. Backfill lift(s) shall be placed symmetrically on each side, with no side to side differential exceeding 24". Such compacted lift(s) must extend to the limits shown on the plans on each side of the structure, or to the side of a trench, or to the natural ground line.

A frequent problem during backfilling is having the material dumped in piles around the structure. It is the responsibility of the contractor to ensure that these piles get evenly spread so that there is a maximum depth of 8 inches of uncompacted lifts. If the filling crew works too fast, the compaction crew never has a chance to adequately compact the first material before more is placed in the trench.

Backfill must be placed and fully compacted to the minimum cover level as indicated on the plans before the structure is subjected to highway loads. When dealing with construction equipment that may exceed legal highway loads, an extra thickness of compacted fill, beyond that required for minimum cover, is required. See construction loads on page 18.

Care must be taken in backfilling arches, especially half-circle arches, because they have a tendency to shift sideways (roll) or to peak under backfilling loads. The recommended way is to place in a balanced fashion backfill on each side of the structure in 8" loose lifts and compacted to a minimum 90% density per AASHTO T-180, with no more than a 2' differential on each side. Prevent distortion of the shape as necessary by varying compaction methods and equipment. Place the backfill material in radial lifts beginning approximately at 75% of the rise of the structure as seen on figure 2. If one side is backfilled more than the other, the arch will move away from the larger load. If both sides are backfilled equally and tamped thoroughly, the top of the arch may peak unless enough fill has been placed over it to resist the upward thrust.

When backfilling arches before headwalls are placed, the first material should be placed midway between the ends of the arch, forming as narrow a ramp as possible until the top of the arch is reached. See figure 2 (side view without headwalls). The ramps should be built evenly from both sides of the arch and the backfill material should be thoroughly compacted as it is placed. After the two ramps have been built to the depth specified to the top of the arch, the remainder of the backfill should be placed and compacted by extending the ramp both ways from the center to the ends, and as evenly as practicable on both sides of the arch.

If the headwalls are built before the arch is backfilled, the backfill material should first be placed adjacent to each headwall. Place and compact material uniformly on both sides of the structure until the top of the arch is reached. Then backfill should proceed toward the center by extending the ramp, with care being taken to place and compact the material evenly on both sides of the arch. Top loading will help control peaking.

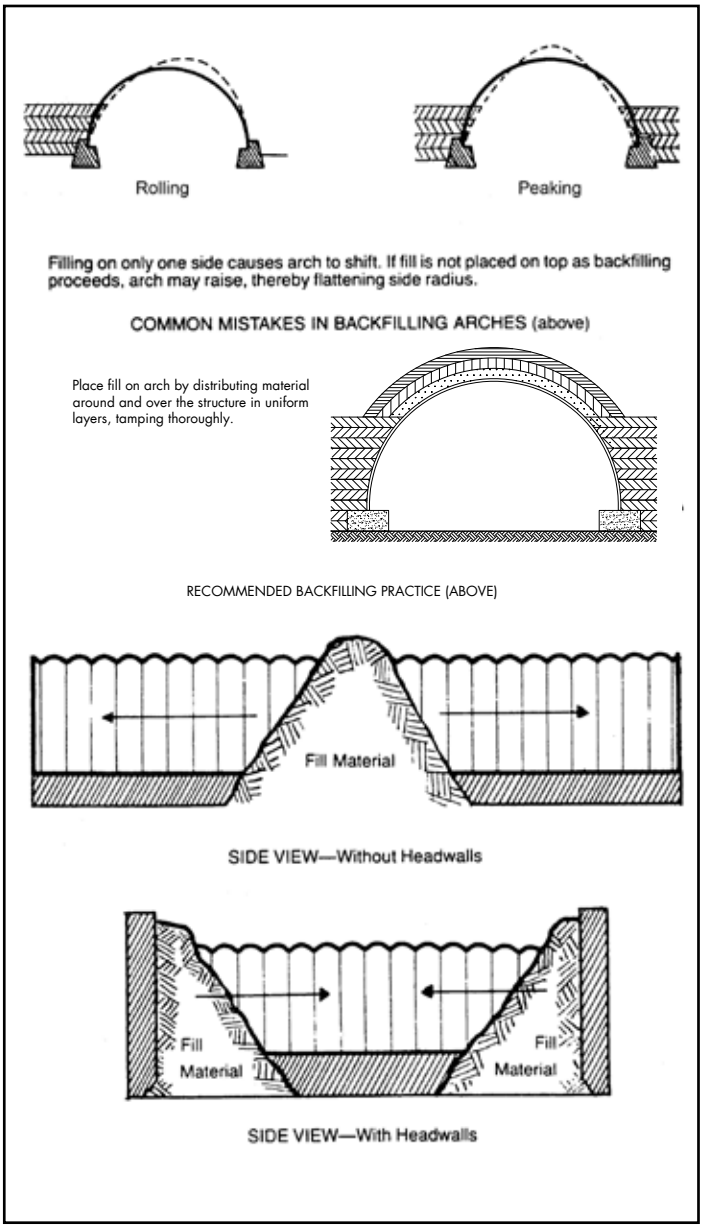


Figure 2. Recommended backfilling practice for structural plate arches.

PROPER MATERIAL PLACEMENT AND COMPACTION

The areas immediately next to the structure shall be compacted by hand-operated methods. Larger compaction equipment shall be brought within no closer than 4 feet in most embankment installations. Changes in dimension or plumb of the structure warn that heavy machines must work further away or replaced with lighter, more suitable equipment. Full compaction density levels may not be achieved in the first several inches of fill over the top of the structure due to flexing and vibration.

When required, as determined by the geotechnical engineer, a geotextile or graded soil filter may be used between the select backfill and the in-situ soil to prevent migration of fines and possible internal erosion.

Spread backfill material with equipment running parallel to, not at right angles to the structure. See figures 3 and 4.

BACKFILL PLACEMENT GUIDELINES

Compact the backfill by working parallel to, but not immediately adjacent to, the structure. Place fill evenly on both sides. Peaking or rolling of the structure must be avoided. (Note discussion of shape control, below.)

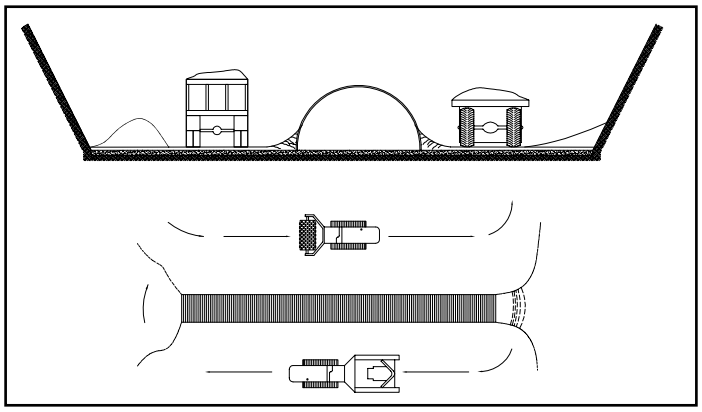


Figure 3. Proper Material Placement

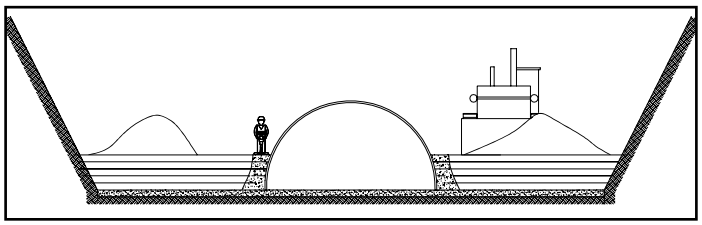


Figure 4. Hand Compaction and Heavy Equipment Procedure

For multiple barrel installations, sufficient space between the structures must be allowed for compaction equipment to operate properly.

As backfill progresses, place the select material in radial lifts at approximately 75% of the rise of the structure. See figure 5 below.

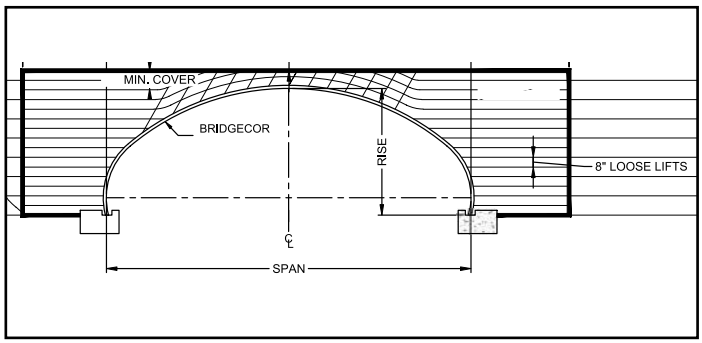


Figure 5. BridgeCor Arch Backfilling Placement

When the fill on both sides approaches the crown of the structure (see the Recommended Backfilling Practice in Figure 2), the same techniques of spreading shallow layers and compacting thoroughly must be followed as the fill covers the structure. For the initial layers over the structure, light hand or walk-behind compaction equipment is necessary.

After backfilling up to the minimum cover elevation over the top and no changes outside the allowable tolerances of the structure's dimensions have been observed, further filling to grade may continue using procedures applicable to embankment construction. See information regarding construction loading.

The bedding and backfill operation should be entirely conducted in the dry if at all possible, but with enough moisture to meet compaction standards.

SHAPE CONTROL

Shape control refers to monitoring the symmetry of the structure during the backfilling process. Two movements may occur during backfilling: "peaking," caused by the pressure of the compaction of the sidefill, and rolling or sidewall distortion, caused by generating compaction forces on one side of the structure relative to the other. See the top of Figure 2.

Shape changes are limited by using proper backfill compaction procedures and equipment as well as backfill, material quality, gradation and moisture content. Special attention should be paid to maintaining the structure's rise dimensions, symmetry and smooth, consistent curvature. The inside span and rise of the assembled structure shall be within 2% (or 5 inches, whichever is less) of the plan dimensions.

The "plumb-bob" method of deflection control is most convenient and effective for large structures. Suspend plumb bobs from the movement control hook locations as shown on the plate layout drawings, so that the points are a specific vertical distance from a marked point on the invert at start of backfill.

Peaking or deflection action can be detected when the points of the bobs move vertically. Corrective action is usually to keep heavy equipment further away from the structure. Placing and compacting backfill in thinner lifts and/or bringing the backfill to the proper moisture content will reduce the necessary compactive effort and help to control peaking.

Rolling action can be detected when the plumb-bobs move laterally. It is corrected by filling or compacting on the side towards which the plumb-bob has moved. For example, a roll to the right will be corrected by higher fill on the right.

Careful observance of the deflection control plumb-bobs and prompt remedial steps prevents peaking or rolling action from distorting the structure.

MULTIPLE BARREL INSTALLATIONS

Backfill must be balanced across all the structures at all times. Place backfill material with a stonebucket, conveyor or other device in a balanced and symmetrical fashion to assure that even pressure is felt on both sides of all the structures. The design should have provided adequate room between the structures to operate the equipment required for proper compaction of the backfill. Flowable fills that require no compaction effort can be used with minimal spacing between the structures.

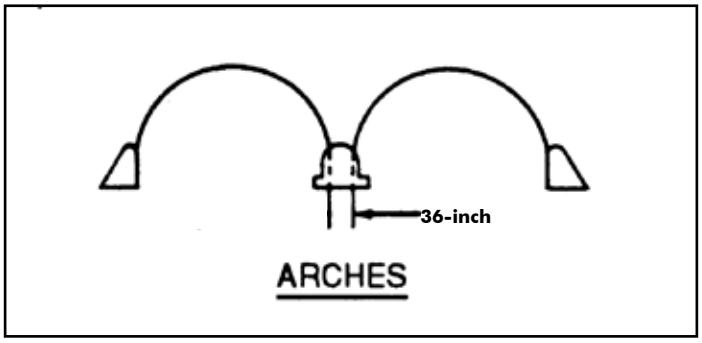


Figure 6. Minimum Barrel Spacing

The 36" minimum spacing must be confirmed by the required finite element analysis for the project.

Appropriate equipment should be considered in determining the spacing between the structures. More than the 36" minimum spacing may be needed for larger span structures. The space between structures should allow efficient operation and selection of compaction equipment. Please contact your Contech representative for assistance.

FINAL BACKFILLING

Once the envelope of select backfill material has been properly placed and compacted around and over the structure the remainder of the fill, if any, should be placed and compacted to prevent settlement at the surface. The specified backfill material and compaction level requirements are written to prevent surface subsidence, protect the pavement, etc.

When thick sheeting, such as wood, has been used to support the trench walls be sure to fill and compact the voids left when it is withdrawn or, cut it off above the crown of the structure.

Final backfill is compacted by conventional methods.

Figure 7. Adequate, uniform compaction is critical to building soil/steel structures.

COMPACTION EQUIPMENT

HAND COMPACTION

For compacting the areas under the haunches of a structure, hand tampers or light vibratory equipment is needed.

MECHANICAL COMPACTORS

Most types of power tampers are satisfactory in all except the most confined areas. However, they must be used carefully and completely over the entire area of each layer to obtain the desired compaction. Avoid striking the structure with power tamping tools.

ROLLER COMPACTORS

The fill adjacent to the structure should be tamped with hand or hand-held power equipment. However, where space permits, sheepsfoot, rubber tired and other types of rollers can be used to compact backfill beyond 3' to 4' from the structure.

VIBRATING COMPACTORS

Vibrating compactors can be used effectively on all types of backfill except heavy clays or other plastic soils. Small walk behind equipment is especially suited to trench installations.

STRUCTURE PROTECTION

Often, construction loads exceed the finished design loads for the structure. Additionally, during the various phases of assembly, backfill and construction, the structure typically is more vulnerable to loadings and hydraulic forces because its backfill, end treatment, etc. are not complete. The corrugated steel structure must be properly protected.

CONSTRUCTION LOADS

Frequently, it is necessary for heavy construction equipment to travel over installed corrugated steel structures during completion of grading, paving or other site work. Heavy construction equipment can impose concentrated loads far in excess of those the structure is designed to carry.

Additional analysis is required to determine if the construction vehicle is able to cross the structure. Please contact your Contech representative for guidance.

Temporary dead loads resulting from storage piles, crane placements, etc. must be evaluated as to structure capacity, loading balance, backfill support, adequate foundation strength, and other factors that may be applicable to the conditions.

HYDRAULIC PROTECTION

During installation, and prior to the completion of backfilling and the construction of permanent end treatment, slope protection, flow controls, etc., the structure is vulnerable to damage from storm and flow conditions. Hydraulic flow forces on unprotected ends, unbalanced backfill loads, loss of backfill and support due to erosion and uplift forces are examples of factors to be considered. While guidance is offered in some of the above sections, temporary protection may need to be constructed.

Hydraulic forces can damage structures without adequate protection if the foundation, bedding or backfill becomes saturated. Proper channeling of flow through active structures and placing end treatment and slope protection as soon as possible are advised. Structures installed between cofferdams or in trenches subject to inundation should be protected from the effects of ponded water.

SUMMARY

Proper installation of any drainage structure will result in longer and more efficient service. This installation manual is intended to call attention to both good practice and to warn against possible pitfalls. The principles apply to most conditions. It is not a specification but an aid to your own experience.

The following items should be checked to insure proper installation:

1. Check alignment in relation to the plans as well as the actual site conditions.
2. Make certain the structure length(s), sizes and necessary fittings and appurtenances, etc. are correct.
3. Excavate to the correct width, line and grade.
4. Provide a uniform, stable foundation—correct site conditions as necessary.
5. Unload, handle and store the structure correctly and safely.
6. Assemble the structure properly—check alignment, follow special procedures for any items detailed on the plate layout drawings. Make sure to achieve properly aligned plate laps, bolt torque, and assembled dimensions.
7. Use a suitable (granular) backfill material as required in the plans and specifications.
8. Maintain proper backfill width.
9. Place and compact the backfill in 8 inch thickness of uncompacted lifts to a minimum 90% density per AASHTO T-180.
10. Maintain balanced fill placement and loading during all phases of installation, keeping fill height differential side to side to 2' maximum.
11. Provide shape control monitoring as required.
12. Install the necessary end treatment quickly to protect the structure from erosion and uplift.
13. Protect the structure from heavy construction equipment loads, other heavy loads and hydraulic forces.

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