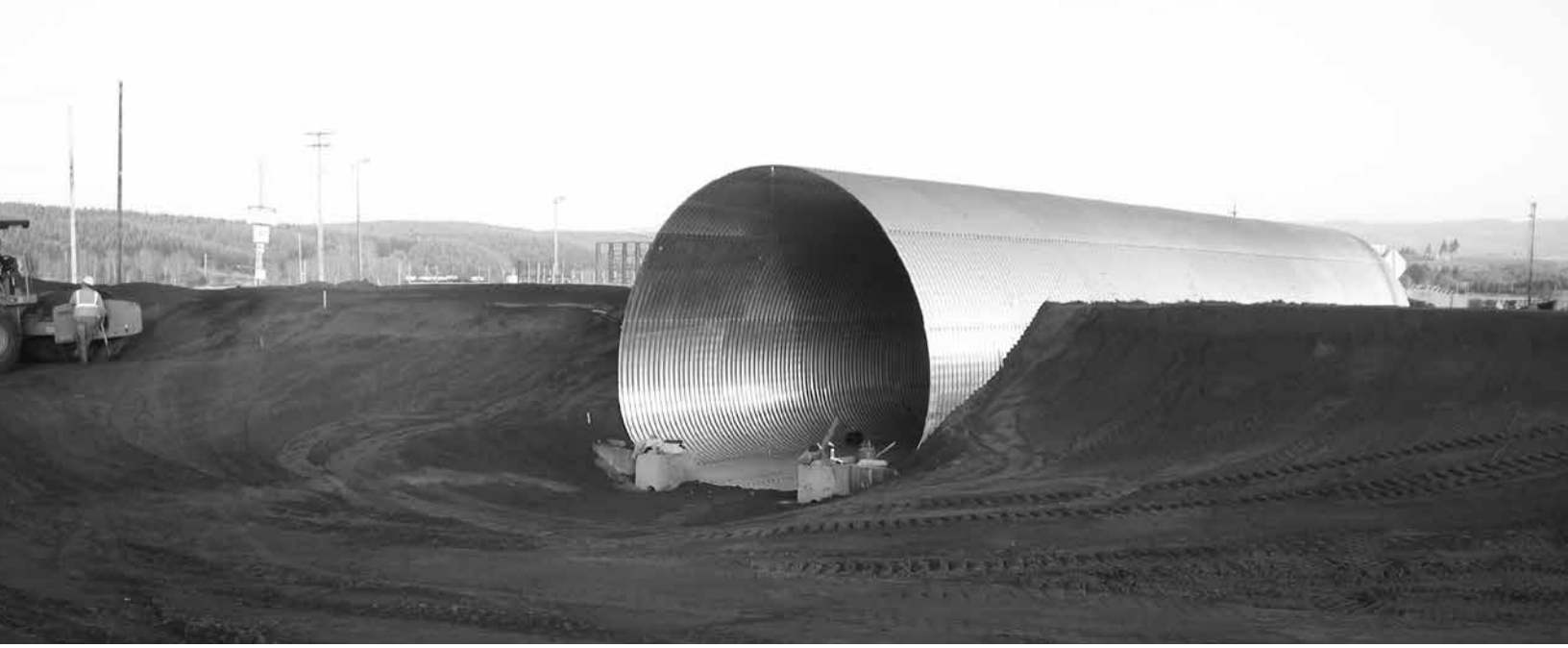
CONTECH®
ENGINEERED SOLUTIONS

MULTI-PLATE® Pipe-Arch and Underpass Assembly & Installation Guide

CONTECH®
STRUCTURAL PLATE



MULTI-PLATE® Pipe-Arch and Underpass Assembly & Installation Guide

Table of Contents

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 MULTI-PLATE® (MP) 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 MULTI-PLATE.**

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

1. Only trained and authorized equipment operators are to be permitted to unload the MULTI-PLATE 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 MULTI-PLATE 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 MULTI-PLATE and accessories while it is being unloaded. Do not stand near the MULTI-PLATE 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 lifting assembled MULTI-PLATE structures.
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.

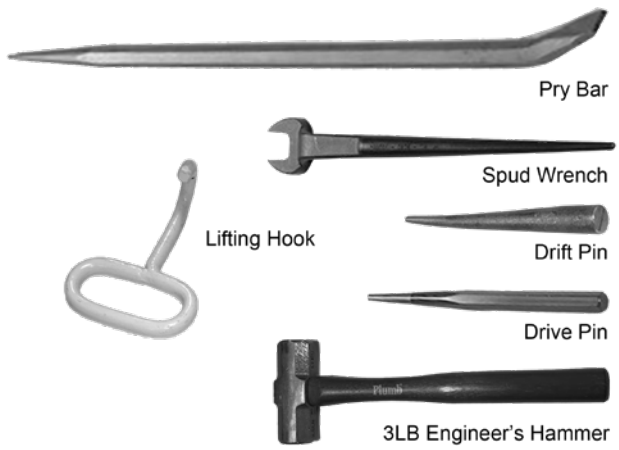
ASSEMBLY

Suggested Tool List

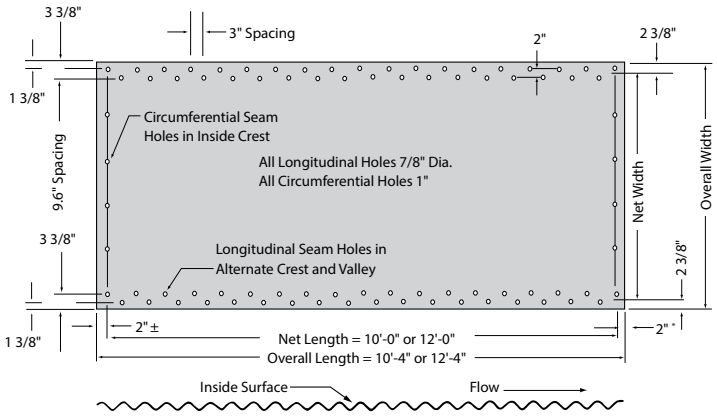
- ☑ Band Cutters to cut packaging bands around bundled material.
- ☑ Lifting devices, such as cables/chains with safety hooks or Clevis for moving individual plates.
- ☑ 3 lb. Engineer's Hammer, Lifting Hook, and Pry bar.
- ☑ Tapered Drive Pin or Drift Pins for use in positioning plates, sheets, components 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).
- ☑ 7/8" reamer bit and 1 ¼" 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.

Additional Tools



Standard Plate Detail

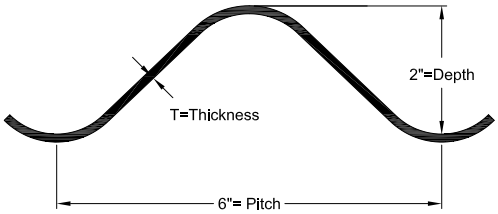


Notes:
1. For square-end structures on which headwalls are to be built, design should allow for a 2" lip at each end of the structure.
2. A 4-bolt per foot pattern is detailed above.

TABLE 1. DETAILS OF UNCURVED MULTI-PLATE® SECTIONS

Net Width (Inches) Nominal Detail			Overall Width (Inches)	Spaces (9.6 Inches)	Number of Circumferential Bolt Holes
9 Pi	28.8	28 13/16	33 9/16	3	4
15 Pi	48.0	48	52 3/4	5	6
18 Pi	57.6	57 5/8	62 3/8	6	7
21 Pi	67.2	67 3/16	71 15/16	7	8
24 Pi	76.8	76 13/16	81 9/16	8	9

For MULTI-PLATE, Pi = 3.2

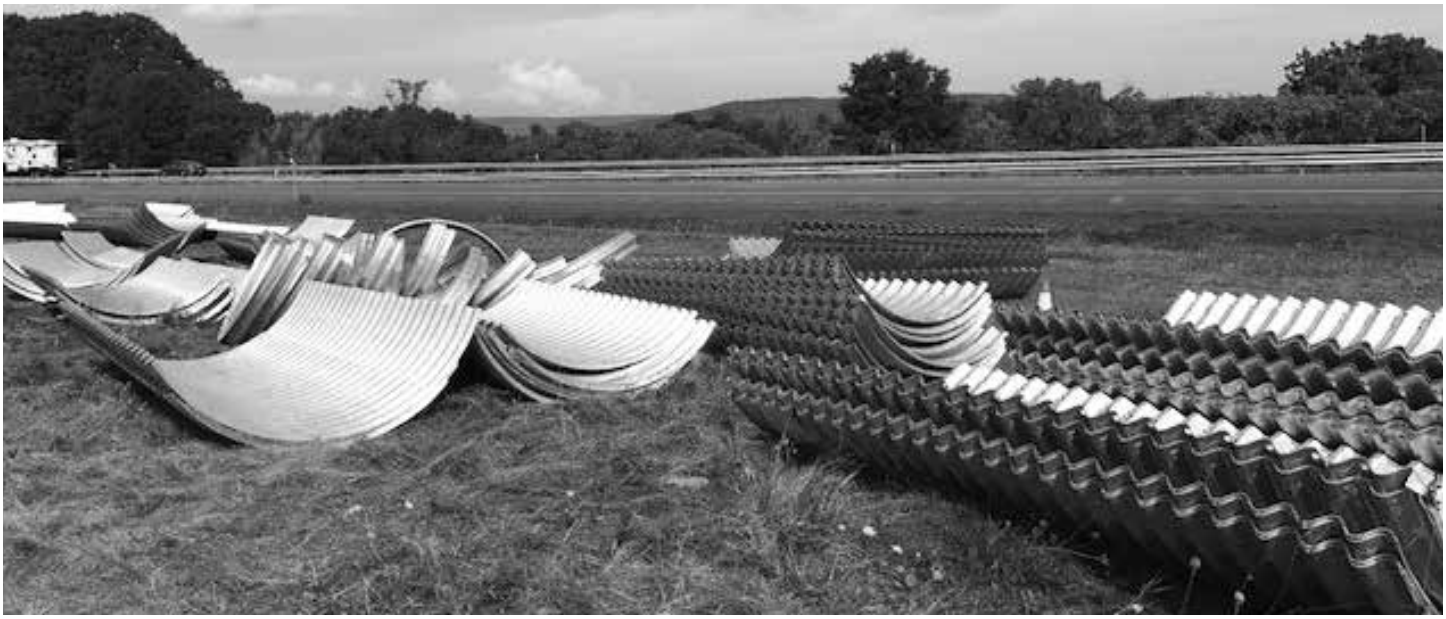


Standard 6" x 2" Corrugation

TABLE 2. APPROXIMATE WEIGHT OF MULTI-PLATE® SECTIONS

Pi	Net Length (Feet)	Gage Thickness, T (Inches) Galvanized, in Pounds, without Fasteners						
		12 (0.111)	10 (0.140)	8 (0.170)	7 (0.188)	5 (0.218)	3 (0.249)	1 (0.280)
9	10	161	205	250	272	316	361	405
9	12	193	246	299	325	379	432	485
15	10	253	323	393	428	498	568	638
15	12	303	386	470	511	595	678	762
18	10	299	382	465	506	589	671	754
18	12	357	456	555	604	703	801	900
21	10	345	441	536	583	679	774	869
21	12	412	526	640	697	810	924	1038
24	10	396	504	613	667	775	886	995
24	12	473	603	732	797	927	1060	1190

Notes:
1. Weights are based on a zinc coating of 3 oz./sq. ft., total both sides.
2. All weights are subject to manufacturing tolerances.
3. Specified thickness is a nominal galvanized thickness. Reference AASHTO M 167.
4. All bolts are 3/4" in diameter.



MULTI-PLATE® 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 100 – 300 ft.-lbs. of torque (150-300 ft.-lbs. of torque for asphalt coated or seam sealant applications).

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.

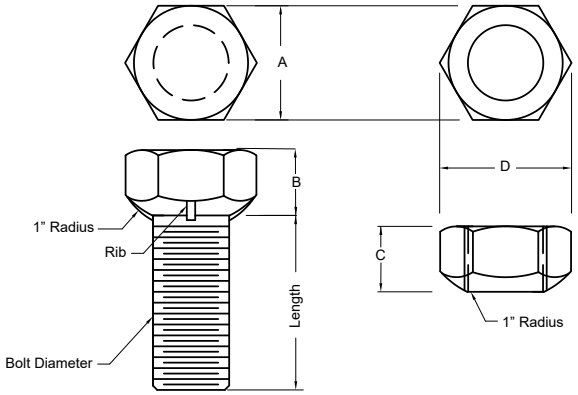


TABLE 3. BOLT LENGTH AND USAGE

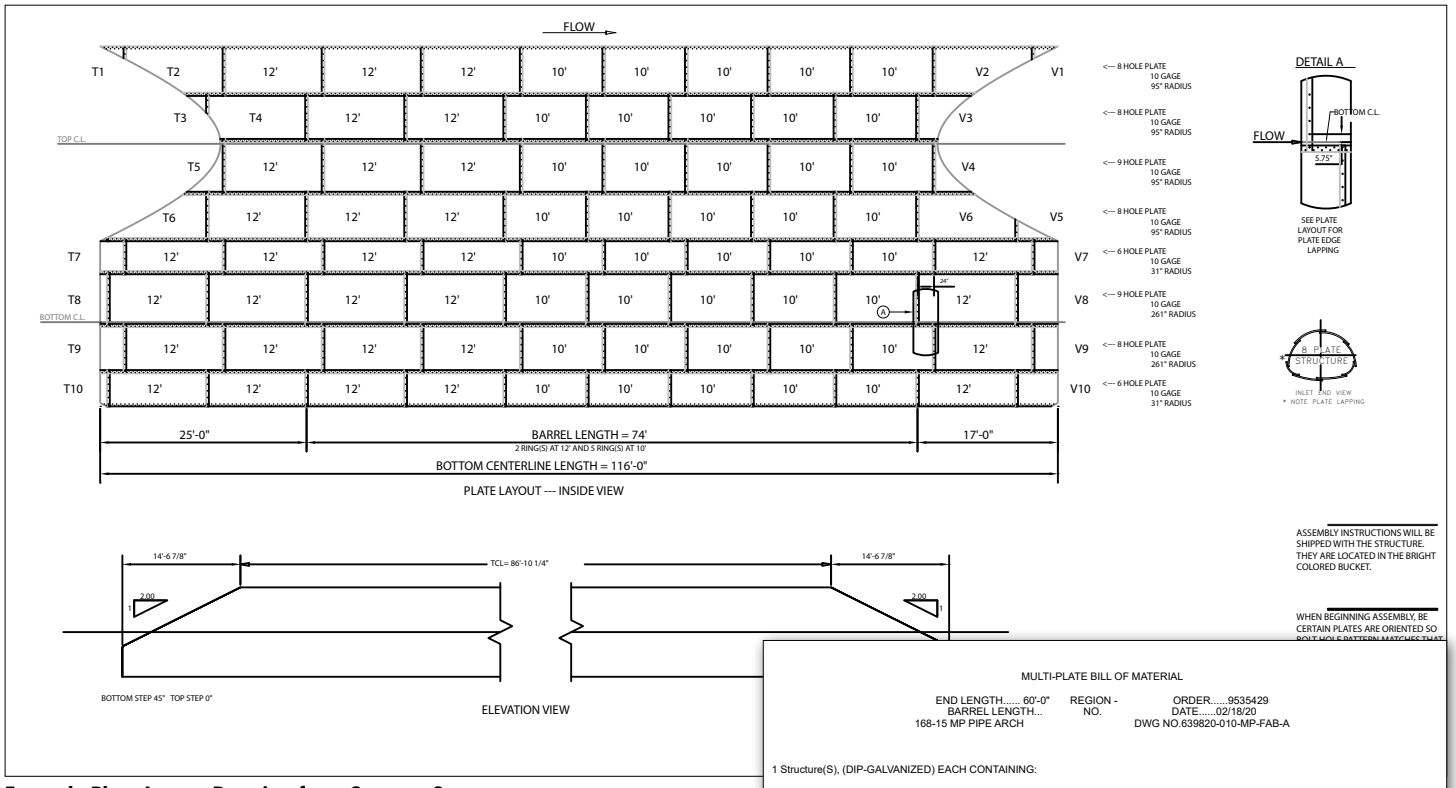
Plate Gages	Bolt Lengths	Bolt Diameter
12, 10 and 8	1¼″ and 1½″	¾″
7 and 5	1½″ and 1¾″	¾″
3 and 1	1½″ and 2″	¾″

Notes:
1. The longer bolts are used in 3 plate lap seams.
2. For asphalt coated plates, bolts are ¼″ longer.

TABLE 4. TYPICAL BOLT AND NUT

Diameter (Inches)	A (Inches)	B (Inches)	C (Inches)	D (Inches)
¾	1¼	9/16	13/16	1 7/16

Sample Drawing



Example Plate Layout Drawing from Contract Set

MULTI-PLATE BILL OF MATERIAL

END LENGTH..... 60'-0" REGION - ORDER.....9535429
BARREL LENGTH... NO. DATE.....02/18/20
168-15 MP PIPE ARCH DWG NO.639820-010-MP-FAB-A

1 Structure(S), (DIP-GALVANIZED) EACH CONTAINING:

ITEM	QTY	GA	STAMP PI	STAMP LT	GALV RAD.	ITEM NUMBER	LIFT WGT	1 OF EACH WEIGHT	SIZE
1/101	5	8	24	12	264	101264815429	723	3615	13
1/102	6	8	24	10	264	102264815429	605	3630	16
1/103	5	8	24	12	100	103100815429	723	3615	13
1/104	6	8	24	10	100	104100815429	605	3630	16
1/105	5	8	21	12	100	105100815429	632	3160	15
1/106	6	8	21	10	100	106100815429	529	3174	18
1/107	5	8	15	12	31	107031815429	464	2320	21
1/108	6	8	15	10	31	108031815429	388	2328	25

TOTAL PLATES 25472

(DIP-GALVANIZED) EACH CONTAINING:

ITEM	QTY		WEIGHT
1/109	2250	- 3/4X1-1/4 GALV.M.P.BOLT (319)	720
1/110	250	- 3/4" X 1 1/2" GALV. BOLTS (320)	88
1/111	6	- 3/4" X 3" GALV. SERVICE BOLTS (323)	3
1/112	2506	- 3/4" GALV. NUTS (302)	501

TOTAL BOLT & NUT WGT 1312

GRAND TOTAL 26784

Example Bill of Material (BOM)

MULTI-PLATE® 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 MULTI-PLATE, 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

The marked bolt container will contain the bill of materials (BOM) and a drawing set which will have a plan view of the structure, showing the inside surface as if it were laid out flat.

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.

MULTI-PLATE corrugations of 6-inch pitch and 2-inch depth are perpendicular to the length of each plate. Standard specified thickness of the galvanized plates vary from 0.111 inches (12 gage) to 0.380 inches (3/8 gage). See detail on page 5.

PLATE LENGTH (LONGITUDINAL)

Plate length can be determined by counting the number of corrugations, which are on 6" centers crest to crest. The standard plates for MULTI-PLATE are furnished in two lengths, nominally 10 feet (124") and 12 feet (148") long. Depending on the required length of the structure, other plate lengths (6ft, 8ft, or cut plates) may be furnished.

PLATE WIDTH (CIRCUMFERENTIAL)

There are five plate widths as detailed in Table 1 on page 5. To determine plate arc widths – count the circumferential bolt holes. The number of circumferential bolt holes in each plate will help you identify the nominal arc width for that plate. 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 12 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.

Plate Stamped Number Identification

Sub Item	Radius	Gage	Order Item	Plant Order
110	071	2	3	0442

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

Gage	Mark
12	2
10	0
8	8
7	7

Gage	Mark
5	5
3	3
1	1

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.

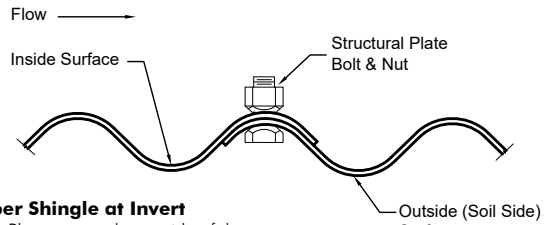
To determine the specific number of bolts for a structure, check the BOM. All containers are stenciled with the individual bolt size.

BOLTING

Bolting procedures may vary depending on the size and gage of the structure. Generally speaking, on smaller diameter lighter gage structures, a loose bolting procedure works best. On larger 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.

Sometimes it is desirable to insert and tighten all of the bottom plate bolts as the bottom is assembled. If this is done, be certain that the plates are properly aligned before tightening the bolts. Always assemble the side and top plates with as few bolts as possible while assembling the structure.

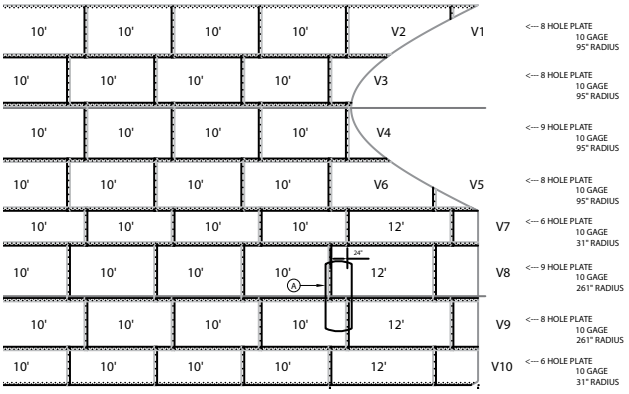


Proper Shingle at Invert
Note: Place nut on the outside of the structure once there is no longer contact with the bedding.

MULTI-PLATE® Assembly Instructions for Pipe-Arch and Underpass Shapes

PLATE ASSEMBLY

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



The beginning and end rings are shown for square end structures and these contain combinations of 10' and 12' rings required to obtain the proper plate stagger. Special plates in cut end structures are shown on the plate layout together with the necessary 10' and 12' long plates required to obtain proper seam stagger in the barrel. Barrel rings in the circumferential direction contain plates of all the same length.

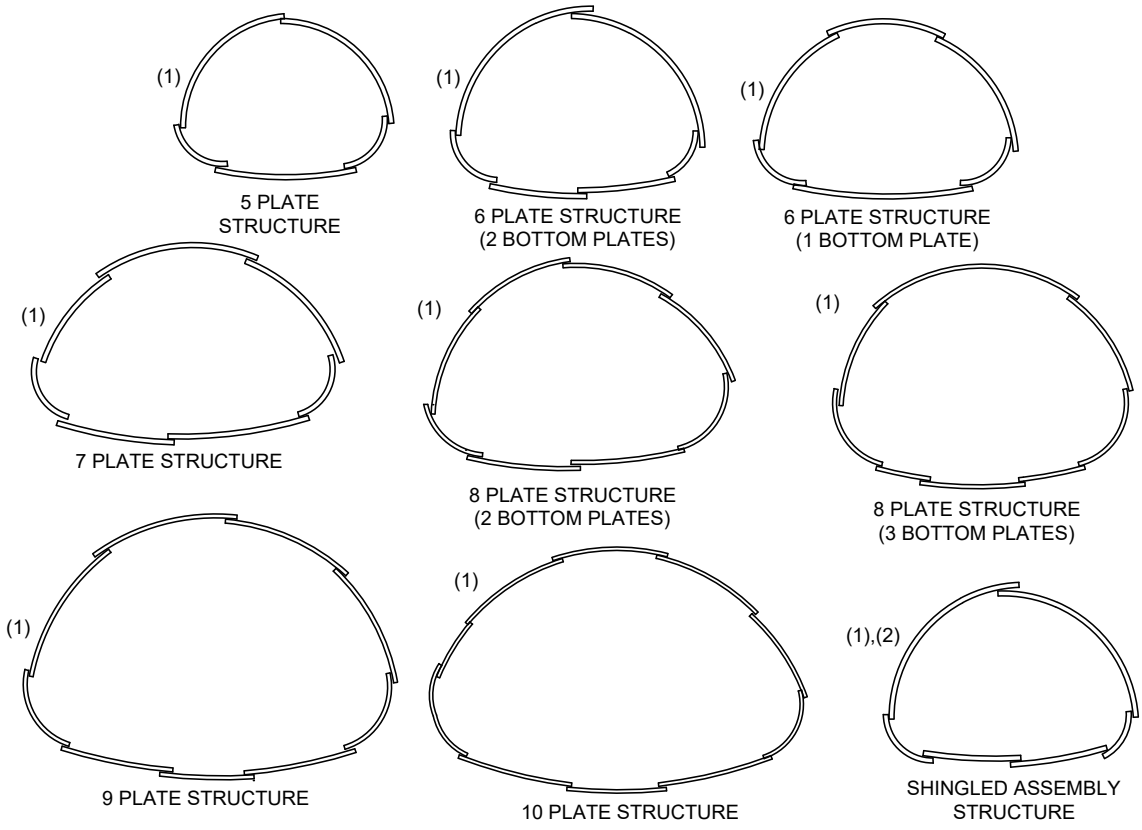
For cut plates and elbow cut and welded plates, numbers appear on the plate layout corresponding to the embossed numbers on the plates themselves (e.g. T1, V1, T2 ...). Reference the structure assembly drawings furnished with the order.

The structure is assembled in three stages: 1)bottom/invert; 2)sides; and 3)top/crown. Please refer to page 9 for proper end view orientations.

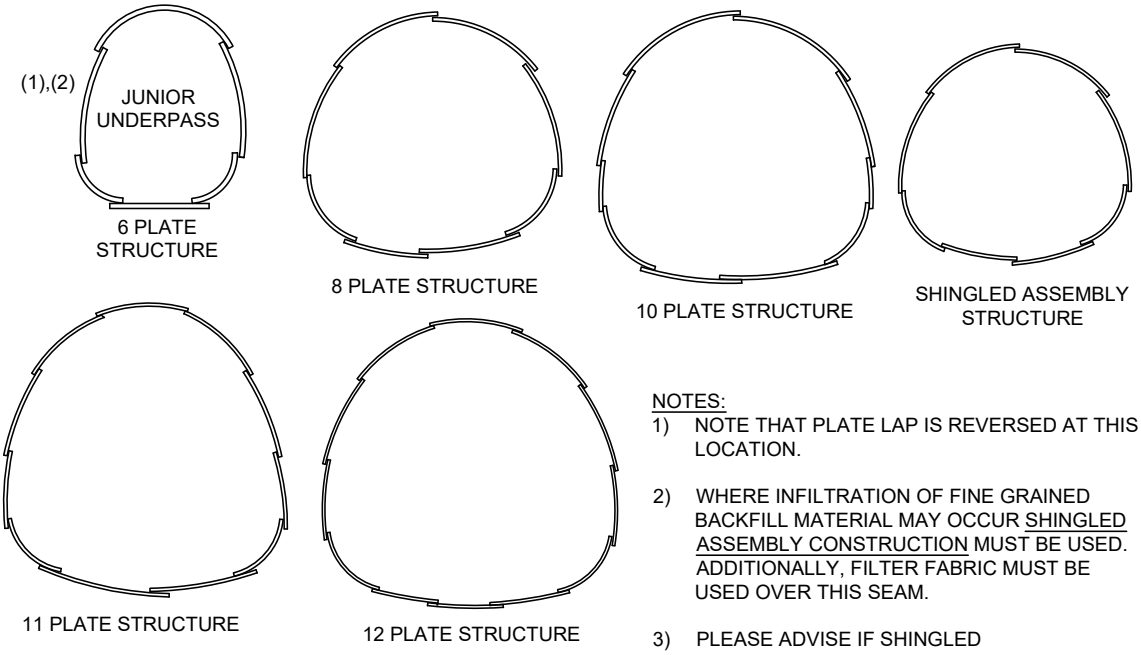
The bottom invert plates are assembled by laying the first bottom plate at the outlet end, then placing each succeeding plate in the longitudinal row so it laps one (1) corrugation of the preceding plate. Position the invert plates accurately with a stringline. When beginning construction, the corner bolt hole pattern must match the pattern shown on the plate layout drawing. Assemble four plates at the invert, then three plates on each side of them. Next, continue adding side plates to the first and second rings until the outlet end top/crown plate can be placed. This will aid in establishing the required shape dimensions before assembly advances too far to make any corrections that may be needed.

MULTI-PLATE® Pipe-Arch and Underpass Plate Orientation

VIEW LOOKING DOWNSTREAM (MULTI-PLATE PIPE-ARCH)



VIEW LOOKING DOWNSTREAM (MULTI-PLATE UNDERPASS)



NOTES:

1) NOTE THAT PLATE LAP IS REVERSED AT THIS LOCATION.
2) WHERE INFILTRATION OF FINE GRAINED BACKFILL MATERIAL MAY OCCUR SHINGLED ASSEMBLY CONSTRUCTION MUST BE USED. ADDITIONALLY, FILTER FABRIC MUST BE USED OVER THIS SEAM.
3) PLEASE ADVISE IF SHINGLED ASSEMBLY IS REQUIRED.

ASSEMBLY CONSIDERATIONS

1. If the structure includes a skew or bevel those plates should be installed after the main barrel of a 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. Special bracing and/or scaffolding may be required. 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. Skewed and beveled plates may be cut in the shop prior to delivery to the site. 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. 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.
2. 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.
3. For pipe-arch and underpass shapes, it is crucial that the plate lapping/orientations is as shown on page 9. Please reference Detail A on the Plate Layout Drawing.
4. 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.

Typical End View of a Pipe-Arch with a Step-Beveled End

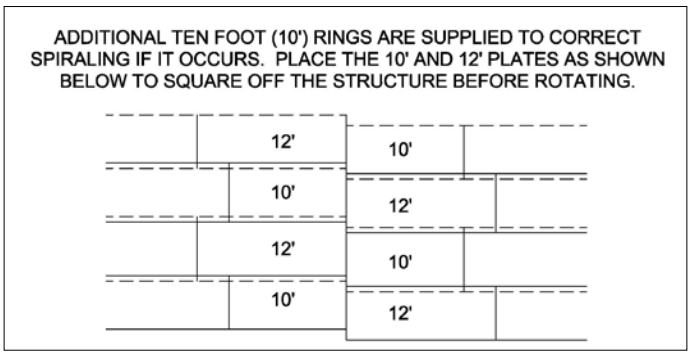
IMPORTANT NOTICE ON SPIRALING

In spite of all precautions taken in manufacture and assembly, a long structure, in some cases, tends to spiral (rotation of the longitudinal seams). However, this tendency can be minimized and controlled by being alert to this possibility and taking prompt corrective action. This phenomenon is most commonly caused by erection methods. Structures that have experienced spiraling have generally been 200' or longer. The following suggestions will help control this tendency:

1. Assemble the overall run in shorter sections. Then join the sections together in the trench. It is important to monitor these connections to ensure that the spiraling is being corrected.
2. During assembly in place, leaving the bolts loose until all of the plates have been assembled permits additional adjustment to prevent spiraling.
3. Providing enough 10 foot plates to allow a return to a straight circumferential joint, if required, every 100'. The straight circumferential joint is used when spiraling reaches one half a bolt spacing (4.8"). Then rotate the structure back one circumferential bolt hole. This will limit the spiral to within approximately 5" from the centerline.

Rotation to another circumferential hole may not be possible with pipe-arches, ellipses and other non-round shapes. When spiraling occurs with such shapes, return to straight circumferential seams for a series of rings until the structure is back online. Drilling or reaming the circumferential bolt holes should permit a rotation of about 1" per each circumferential seams.

Should the structure start to spiral, begin in the middle of the circumferential seam and work one bolt at a time, proceeding in both directions towards the end of the plate. If you tighten the plate on the longitudinal seam first, all flexibility of the assembly is lost. See "Spiral Notice" below for suggested control of the spiraling tendency on longer structures.



Spiral Notice

Note: The above depicted procedure may not be possible with non-round shapes.

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 slings and/or full perimeter cables is recommended. 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 your Contech representative.

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.

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.

INSTALLATION

Basic Principles for MULTI-PLATE® Pipe-Arch and Underpasses

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. Haunch the structure properly.
9. Place the backfill in 8-inch thick uncompacted lifts and thoroughly compact each lift to a minimum 90% density (AASHTO T-180).
10. Maintain balanced fill placement and loading during all phases of installation, keeping fill height differential side to side to a 2' maximum amount.
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 structure 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, and plate sections are also more easily joined when progressing in this 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 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 width and shape of the trench should be as shown on the plans. Any change should be approved by the Engineer.

The trench width must be wide enough to allow the critical lower quadrants of a structure with an invert to be properly backfilled (haunched).

Figure 12 (on page 18) provides guidelines about minimum spacing between multiple structures. Please refer to the contract drawings for 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 FOUNDATIONS

The structure foundation 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 critical factor is to achieve uniformity along the structure. The foundation has a tendency to yield under the structure in relation to the embankments alongside the structure.

Bedding is the material located between the prepared foundation soils and the invert (or bottom) of the structure. Bedding is an important part of the installation, because it provides the interface between the rigid or unyielding foundation and the steel structure. Structures with inverts require proper bedding preparation. The bedding layer consists of loose granular soil that will fill in the structure corrugations as the structure is assembled and backfilled to ensure the structure is fully supported.

Although corrugated steel drainage structures can experience some uneven settlement without distorting, they should be placed on a firm yet yielding, uniform foundation for best performance and long service life.

All structures with an invert must be installed with the area under the haunches well compacted and all voids filled. The most popular method of preparing the foundation is by excavating to a flat surface and then carefully tamping the fill under the haunches of the structure. See Figure 1 for typical methods of bedding the structures.

All structural plate must be placed on stable earth or fine granular foundation. Never install them on sod, frozen earth or on a bed that contains large boulders or rock. When poor foundations with low bearing strength are encountered, it may be necessary to stabilize the poor foundation by a method described in the next section.

Care must be taken to prevent water leaking through the fill or along the length of the structure. When granular materials have been used for structure bedding and select backfill, the exposed ends of the fill slopes should be sealed against infiltration. This can be done by utilizing slope paving, cut-off walls, construction of slope faces utilizing impermeable fill or some similar type of end treatment that guards against water infiltration and migration through the structure select fill and bedding zones.

UNEVEN FOUNDATIONS

When the excavated grade line reveals both soft and hard spots, the foundation 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 foundation slightly below grade line and replace it with suitable, uniform material. In any event, any abrupt changes from hard to soft foundation must be avoided.

SOFT FOUNDATIONS

When soft, unstable material is encountered at the foundation level, it must be excavated below the flow line grade and backfilled to grade with sand, gravel, crushed stone or other suitable material. The zone of select material must be adequate to support the structure and backfill. When unexpected materials are encountered, consult the project engineer. See Figure 2.

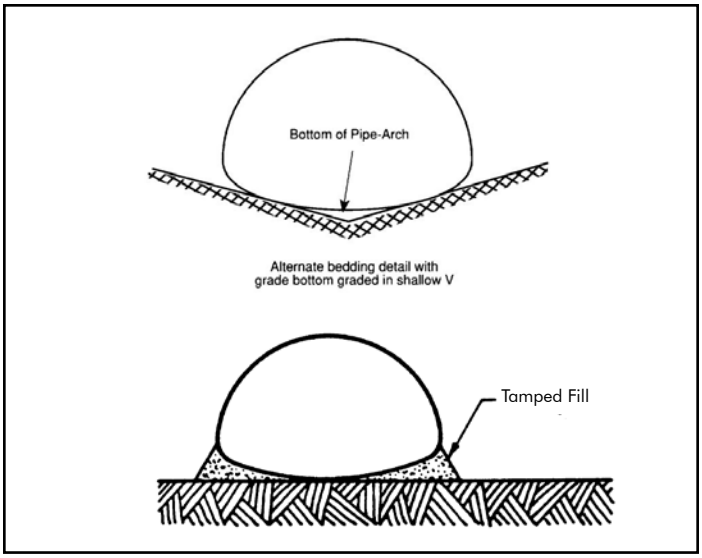


Figure 1. Methods for attaining proper compaction under haunches of structural plate pipe-arches and underpasses.

POCKETS OF UNSTABLE SOIL

If unstable foundation material is in small pockets, it is best to excavate all of the poor foundation and replace it with suitable backfill material. Frequently, a relatively thin mat of granular material will provide satisfactory support, but it may be necessary to replace very soft foundations to a depth great enough to support not only the structure, but also the heavier backfill placed beside it.

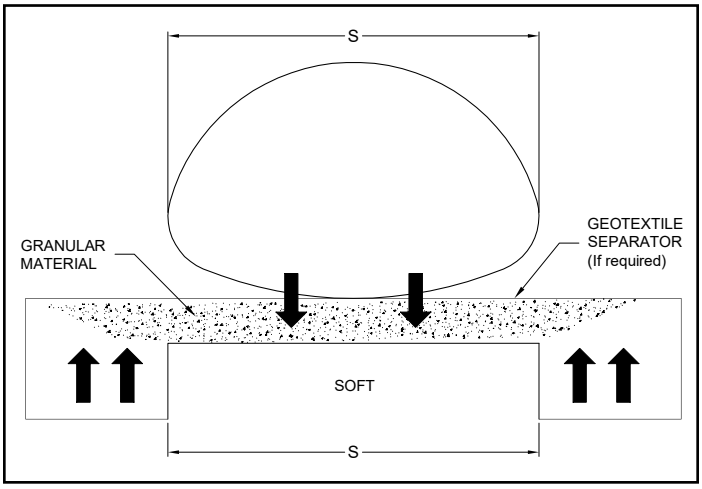


Figure 2. Soft foundation considerations

IMPROVED FOUNDATIONS

Whenever a foundation 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. Attempts to support structural plate structures on intermittent piles, pile bents or concrete cradles to provide support over zones of poor foundation support creates the potential risk of introducing differential settlement issues for the structure system and for the adjacent side fill and thus should be avoided.

SETTLEMENT UNDER HIGH FILL LOADS

(camber for embankment installations)

Cambering the center part of the foundation will compensate for unequal settlement under the weight of heavy embankments. This assures proper grade after settlement and prevents the structure from sagging in the middle as the foundation consolidates. Generally, sufficient camber can be obtained by installing the upstream half of the structure on a flat grade and the downstream half on steeper than normal grade as shown in Figure 3 (below). If camber is considered necessary based on foundation soil conditions, the amount of camber must be determined by a qualified soils engineer. If the structure is setting on cushioned rock or other adequate strength foundation, no camber is necessary, as anticipated settlement may be minor.

Be careful not to raise the center of the structure above the inlet, as this will pocket water in the structure.

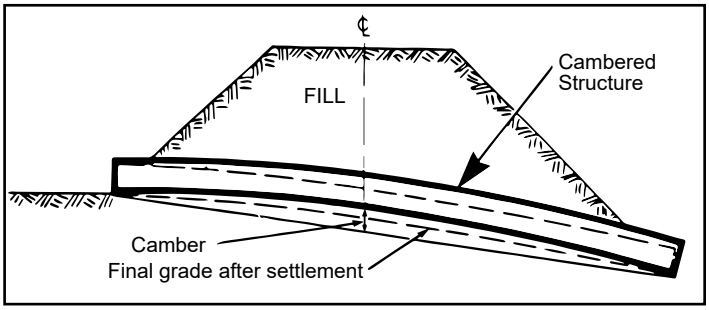


Figure 3. Correct method of cambering structure to compensate for unequal settlement under high fills. Should be in accordance with procedure given in the NCSPA Corrugated Steel Pipe Design Manual.

ROCK FOUNDATIONS

Rock encountered in the foundation must be removed to provide more than the minimum bedding thickness underneath the bottom of the structure. Excavate wide enough to avoid any possibility of the structure resting on rock and provide access to adequately haunch the structure as shown in Figure 4 (right). The excavated area is then backfilled with lightly compacted, granular soil to cushion the structure.

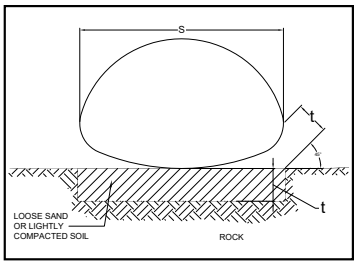


Figure 4. Method of handling rock foundations. t = 1/2" per foot of fill over structure, with 24" the maximum.

FIELD-APPLIED COATING FOR MULTI-PLATE

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 structure 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, etc. to 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.

Cast-in-Place Toewall

BACKFILLING
MULTI-PLATE® Pipe-Arch and Underpasses

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!

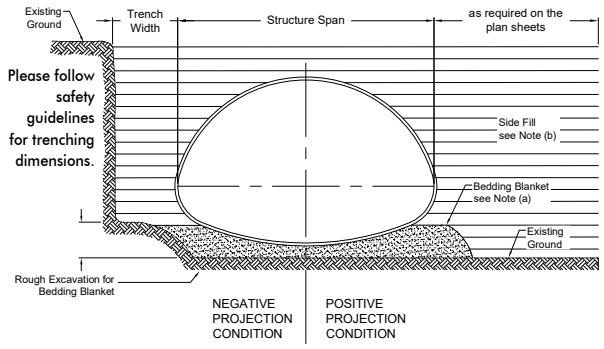
For trench installations, backfill must follow as closely behind the excavation and assembly stages as possible. Embankment installations typically are backfilled after the entire structure, or a major portion of it, is assembled. Unless the embankment and backfill materials are placed simultaneously,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

The backfill should be carefully compacted under the haunches (lower part of structure exterior, below widest part); special care should be taken in doing this for pipe-arches and underpasses.

Place the backfill equally on both sides of the structure in 8-inch uncompacted lifts, thoroughly compacting each lift(s) 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.

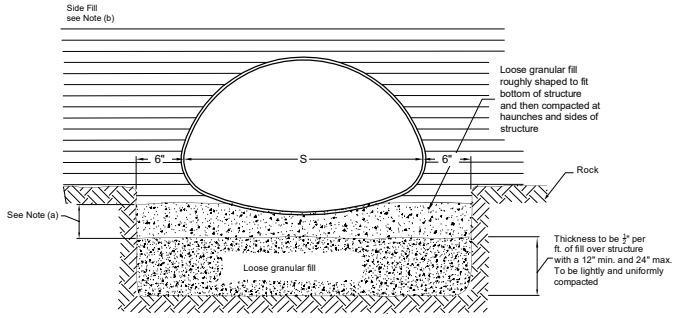
A frequent problem during backfilling is having the material dumped in piles around the structure. It is the responsibility of the contractor to ensure that these piles get evenly spread so that there is a maximum depth of 8 inches of loose lifts. If the filling crew works too fast, the compaction crew never has a chance to adequately compact the first material before more is placed in the trench. Please see Figure 5 on the right, and Figures 6 and 7 on the next page, for proper guidance.

Backfill must be placed and fully compacted to the minimum cover level as indicated on the plans before the structure is subjected to its design live load or 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 19.

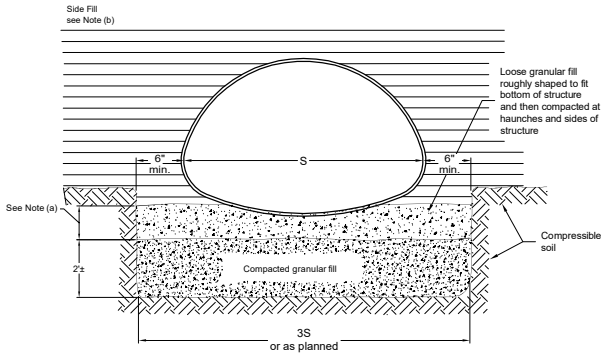


Pipe-Arch or Underpass Installation and Bedding

Notes:
(a) Bedding blanket of loose granular fill roughly shaped to fit bottom of structure, and a maximum width of 2/3 of the structure span. Minimum thickness before placing structure shall be 3".
(b) Side fill to be placed in 8-inch loose lifts, compacted to density specified for the adjacent embankment, but not less than 90% density.



Structure Installed Over Rock



Foundation Stabilization

Figure 5. Bedding and Backfill Details.

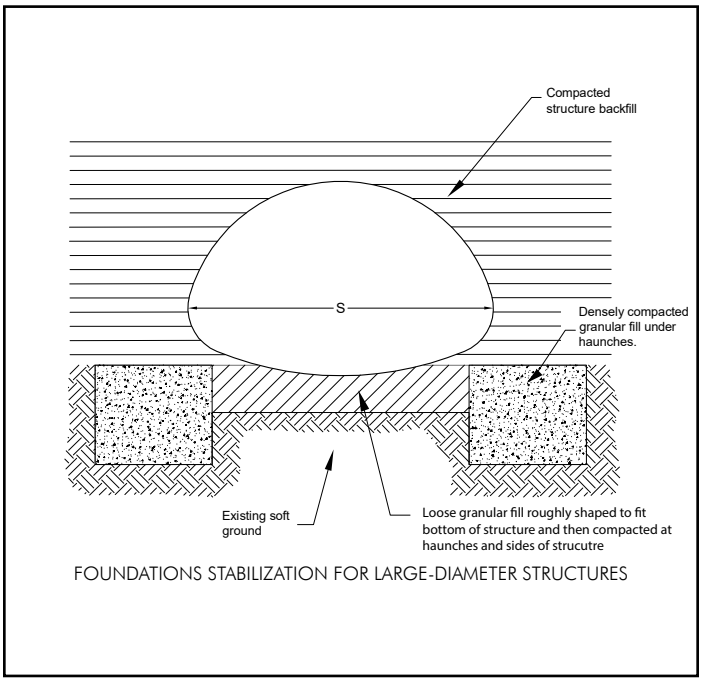


Figure 6. Bedding and Backfill Details (continued).

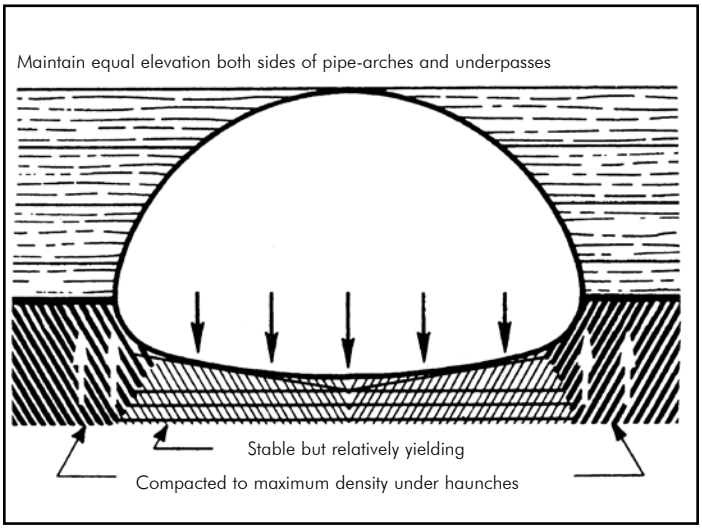


Figure 7. Recommended backfilling practice for larger pipe-arches and underpasses, using a vee-shaped bed.

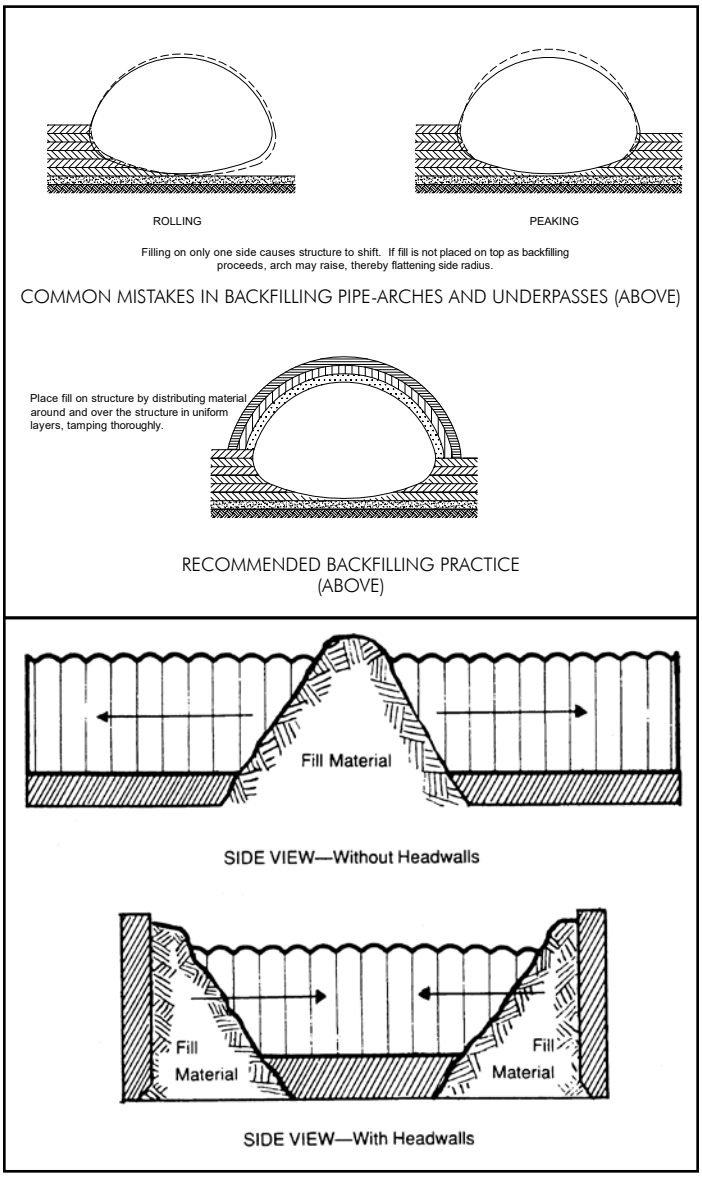


Figure 8. Recommended backfilling practice for structural plate.

Special attention must be given to compaction of the backfill under the haunches of the pipe-arches and underpasses. A softer or yielding foundation under the bottom, as compared to the corners, is essential. See Figure 7 above. A vee-shaped bed for pipe-arches and underpasses is recommended.

If the headwalls are built before the structure, 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 structure 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 structure. Top loading will help control peaking. See Figure 8 above.

PROPER MATERIAL PLACEMENT

The bedding and backfill operation should be entirely conducted in the dry if at all possible, but with enough moisture to meet compaction standards. There are cases where MULTI-PLATE structures are preassembled and lifted into the stream bed "in the wet," where is it not possible to build a cofferdam and divert the stream. Such conditions make it very difficult to ensure good base preparation and proper backfill. Soil strength consideration must be made by the designer in these cases, and expert advice obtained on backfill procedures.

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 be replaced with lighter, more suitable equipment. Please see Figure 9 below.

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.

SUMMARY OF 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 in the next column.)

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

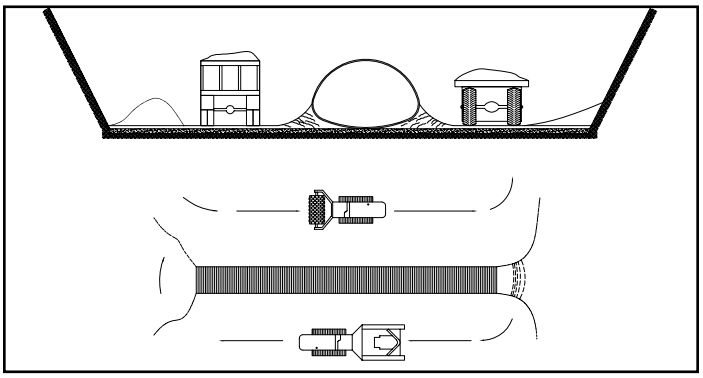


Figure 9. Proper material placement.

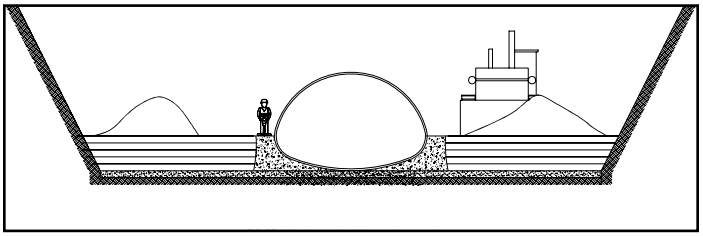


Figure 10.Hand compaction and heavy equipment procedure.

As backfill progresses, place the select material in radial lifts at approximately 75% of the rise of the structure. See Figure 11 below.

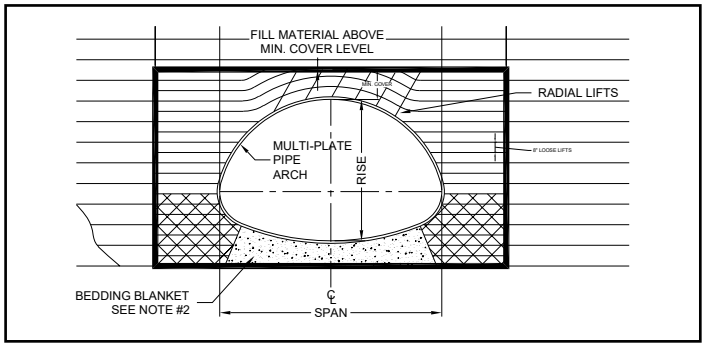


Figure 11. Backfill Detail

When the fill on both sides approaches the crown of the structure (see the Recommended Backfilling Practice in Figure 8), 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 2 ft. over the top or to a depth of 1/8th the span, whichever is greater, and no changes outside the allowable tolerances in the structure's dimensions have been observed, then further filling to grade may continue using procedures applicable to embankment construction. See information regarding construction loading.

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 8.

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 "plumb-bob" method of deflection control is most convenient and effective for large structures. Suspend plumb bobs from the shoulder (2 and 10 o'clock) positions 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.

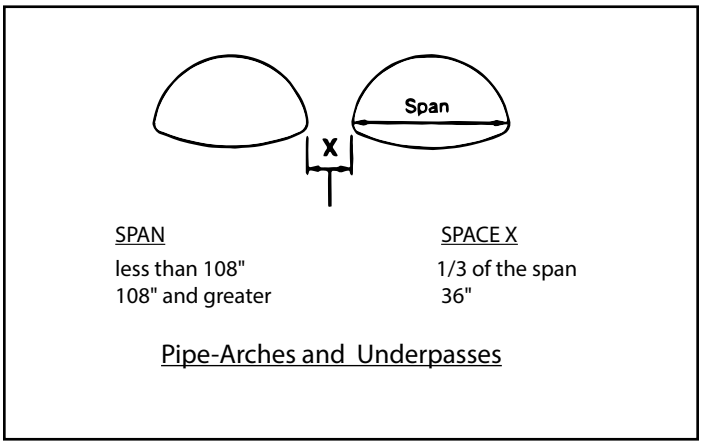


Figure 12.Minimum Barrel Spacing.

The recommended minimum spacing between structures is shown above. This spacing is when using all standard backfill materials and allows for room to compact the backfill.

The minimum spacing shown also provides adequate room between the structure and the trench wall for adequate material placement and compaction.

Appropriate equipment should be considered in determining the spacing between the structures. More than the 24" 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. The use of water flooding or jetting should be limited to compacting soils which are sufficiently permeable to dispose of the excess water and should not be used with cohesive soils.

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.

Figure 13. Adequate, uniform compaction is critical to building soil/steel structures.

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.

Adequate protection of the corrugated steel structure may require more than finished design fill. The amount of additional fill needed depends on the equipment axle loads.

The following table provides the minimum cover for typical structure sizes and axle loads. While providing extra cover is a simple way to protect the structure, it must be maintained so that rutting, surface grading, etc. does not reduce its effect. A minimum crossing width of 24 feet is recommended for typical equipment.

Heavy Wheel Load Table
Minimum Cover for Off Highway Equipment up to 450 Tons GVW

Span (ft)	Wall Thickness (inches)						
	0.111″ (12 GA)	0.140″ (10 GA)	0.170″ (8 GA)	0.188″ (7 GA)	0.218″ (5 GA)	0.249″ (3 GA)	0.280″ (1 GA)
5-10	2.5′	2.5′	2.5′	2.5′	2.5′	2.5′	2.5′
11-12	3.0′	3.0′	3.0′	3.0′	3.0′	3.0′	3.0′
13-14	3.5′	3.5′	3.5′	3.5′	3.5′	3.5′	3.5′
15-16	4.0′	4.0′	4.0′	4.0′	4.0′	4.0′	4.0′
17-18		4.5′	4.5′	4.5′	4.5′	4.5′	4.5′
19-20			5.0′	5.0′	5.0′	5.0′	5.0′

* Follow AASHTO or AISI guidelines for spans greater than 20 feet.

* Backfill should be excellent quality, compacted to a minimum 90% density per AASHTO T-180.

* In unpaved situations, the surface must be maintained, level and free of ruts or add 2 feet for rutting in un-maintained areas.

* Maintaining minimum cover is important. The contractor must provide the additional cover required to avoid damage to the structure. Minimum cover is measured from the top of the maintained construction roadway surface. Please see figure 15 below for guidance.

Figure 14. Minimum Cover.

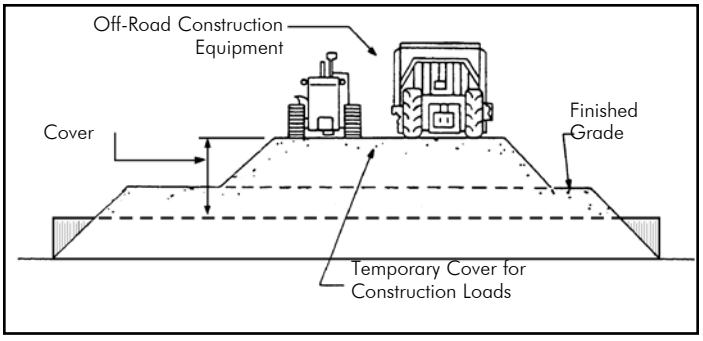


Figure 15. Minimum cover for construction loads.

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 treatments, 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 float structures without adequate protection or buckle inverts (large radius inverts are especially vulnerable to buckling) if the foundation, bedding or backfill becomes saturated. Proper channeling of flow through active structures and placing end treatments 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. Haunch the structure properly.
10. Place the backfill in 8-inch thick uncompacted lifts and thoroughly compact each lift to a minimum 90% density (AASHTO T-180).
11. Maintain balanced fill placement and loading during all phases of installation, keeping fill height differential side to side to 2′ maximum.
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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