CONTECH®
ENGINEERED SOLUTIONS
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Aluminum Structural Plate Pipe-Arch Assembly & Installation Guide

CONTECH®
STRUCTURAL PLATE

Aluminum Structural Plate Pipe-Arch and Underpass 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 Aluminum Structural Plate (ALSP) 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 ALSP.**

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

UNLOADING AND HANDLING

Plates and fasteners are typically shipped in bundles which may weigh up to 5,000 lbs. The bundles should always be unloaded with the "outside" of the plate up. If the bundles are improperly unloaded; such as upside down, on their sides, or pushed off the truck; the plates may be damaged and/or difficult to separate. Damaged plates may cause unnecessary work for the assembly crew. See the Bill of Materials for individual plate weights. The following equipment is recommended for unloading ALSP 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 ALSP and accessories.

1. Only trained and authorized equipment operators are to be permitted to unload the ALSP 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 ALSP 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 ALSP and accessories while it is being unloaded. Do not stand near the ALSP 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 ALSP structures.
2. Chains with clevises 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 aluminum 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

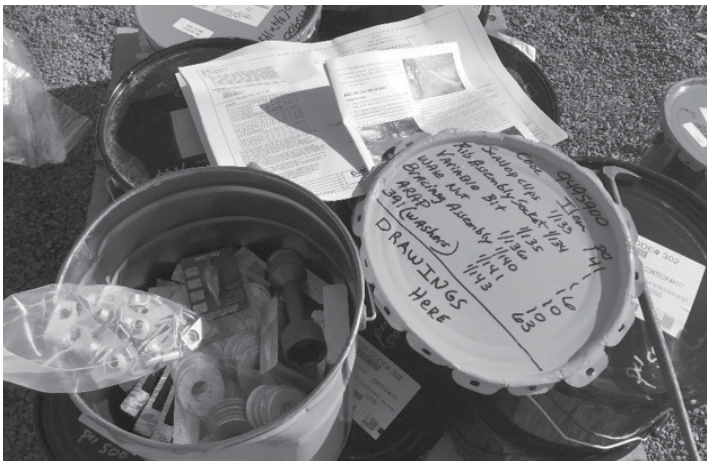
Suggested Tool List

- ☑ 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.

ALSP Tools

Unloading Plate Bundles



Fastener Kegs

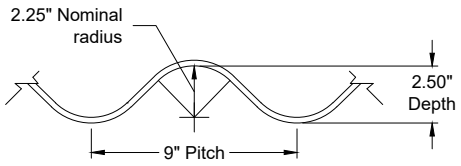
Initial Assembly

Adding Haunch Plates

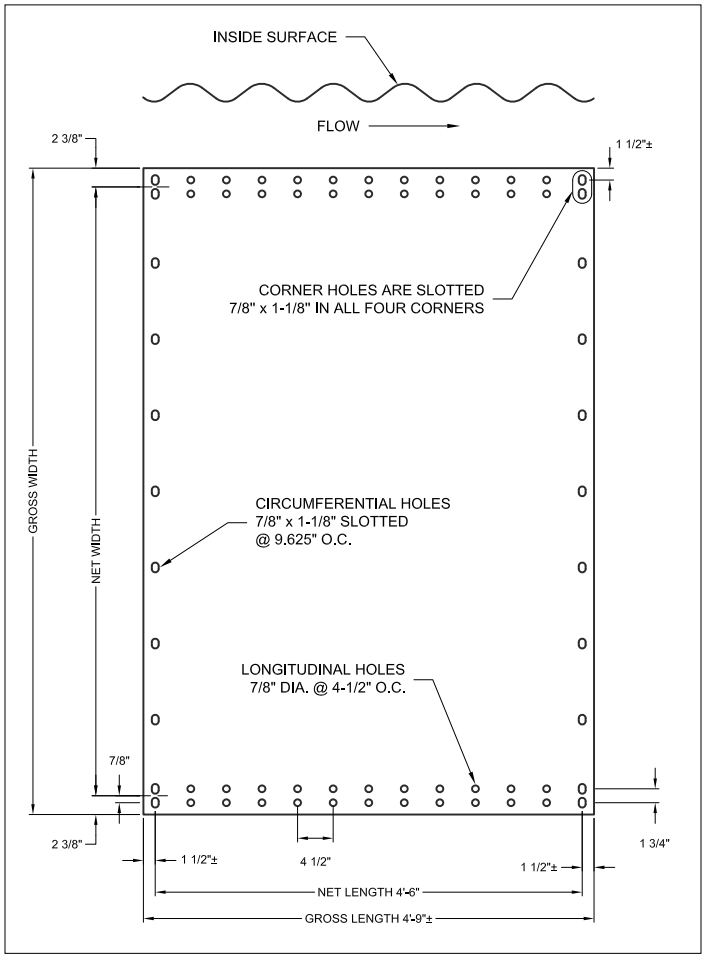
Standard Plate Details

TABLE 1. DETAILS OF UNCURVED ALSP PLATE								
Plate "N"	Net Width (Inches)	Gross Width (Inches)	Plate Thickness (Inches) Weight per Plate, lbs (without fasteners)					
			0.125	0.150	0.175	0.200	0.225	0.250
8	77-0	81-3/4	66	79	92	105	119	132
9	86-5/8	91-3/8	74	88	103	118	133	148
10	96-1/4	101-0	81	98	114	130	147	164
11	105-7/8	110-5/8	89	107	125	143	161	179
12	115-1/2	120-1/4	97	116	136	155	175	195
13	125-1/8	129-7/8	105	126	147	168	189	210
14	134-3/4	139-1/2	113	135	157	180	203	226
15	144-3/8	149-1/8	120	144	168	192	217	241
16	154-0	158-3/4	128	154	179	205	231	257
17	163-5/8	168-3/8	136	163	190	217	245	273
18	173-1/4	178-0	144	172	201	230	259	288
19	182-7/8	187-5/8	151	182	212	242	273	304
20	192-1/2	197-1/4	159	191	223	254	288	319

For ALSP, 1 N = 9.625"



9" x 2-1/2" Corrugation



Standard Plate Detail

PLATE LENGTH (LONGITUDINAL)

All standard plates have a net length of 4.5′. Longitudinal bolt holes at 4.5″ centers provide a standard 5.33 bolts per foot of longitudinal seams in two parallel rows at 1.75″ centers. The outside crest of the end corrugations are punched for circumferential seam holes on centers of 9.625″ (1N).

PLATE WIDTH (CIRCUMFERENTIAL)

Individual circumferential plate widths are noted in terms of N (N = 9.625″ or 3 pi). Standard plates are fabricated in net widths of one "N" increments from: 8N (77.00″) through 20N (192.50″).

The N nomenclature translates circumference directly into nominal diameter in inches. For example, two 10N plates give a diameter of 60″ (2 x 10N x 3 pi), three 12N plates = 108″ (3 x 12N x 3 pi), etc. Various plate lengths are used to obtain a specific structure shape and size.

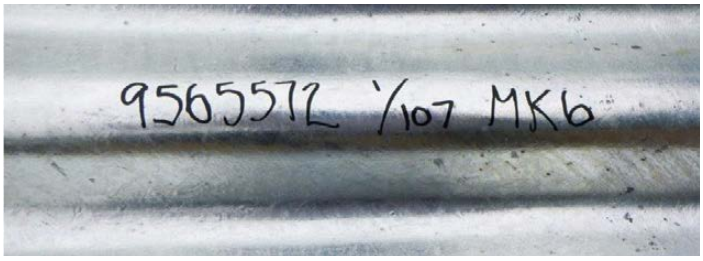
The various lengths of plates are assembled or placed in the structure in accordance with the assembly drawing (plate layout drawing furnished by CONTECH). The letters appearing in the stencil data, on the "inside" of the plate, designate the full uncut plates to be assembled. All lettered plates are interchangeable and may be placed in any location requiring plates of that letter.

The plates are marked to identify the following:

9565572- Order number

1/107 - BOM Item number

MK6-Plate mark number



CONTECH ALUM. 5052 H141 PER ASTM B-746 AASHTO M219
ALERIS 42/269 6070 01 03 21 125

- CONTECH – Manufacturer name
- ALUM. 5052 – Alloy
- H141 – Material temper
- ASTM B-746 AASHTO M219 – Material specifications
- ALERIS – Supplier name
- 42/269 6070 01 03 21 – Material heat number (may vary by supplier)
- 125 – Material thickness (inches)

ALSP Bolts and Nuts

3/4" diameter hot-dipped galvanized steel (specially heat-treated) bolts meeting ASTM A307 or A449 specifications with suitable nuts are used to assemble ALSP. Aluminum fasteners are available for salt water installations and are provided upon request. Contact your local Contech representative.

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 100-150 ft.-lbs. of torque.

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. TYPICAL BOLT AND NUT

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

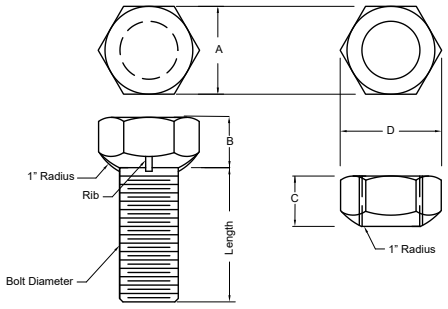
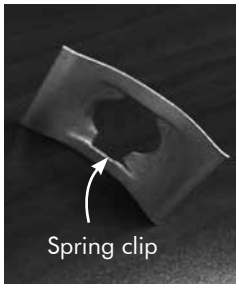


TABLE 2. BOLT LENGTH AND USAGE

3/4" Diameter Bolt Lengths (Plate Only)				
Plate Thickness (Inches)	**1 Plate**	**2 Plate Lap**	**3 Plate Lap**	**4 Plate Lap**
0.125	N/A	1¼"	1¼"	1¼"
0.150-0.200	N/A	1¼"	1½"	2"
0.225-0.250	N/A	1½"	2"	N/A
3/4" Diameter Bolt Lengths (with Reinforcing Rib, if Required)				
Plate Thickness (Inches)	**1 Plate**	**2 Plate Lap**	**3 Plate Lap**	**4 Plate Lap**
0.125-0.175	1¼"	1½"	2"	2"
0-200-0.250	1½"	2"	2"	2"



BOLTS

Bolts are furnished in three lengths, 1-1/4", 1-1/2" and 2". To determine the approximate number of bolts for a structure, check the PLD and the BOM. All containers are stenciled with the individual bolt size. Note: Always place the rounded side of the nut in contact with the plates.

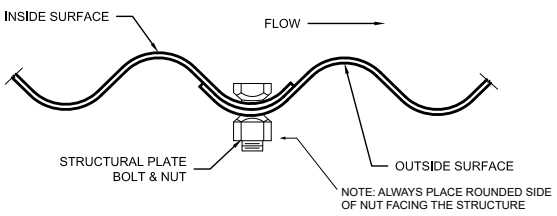
BOLTING

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.

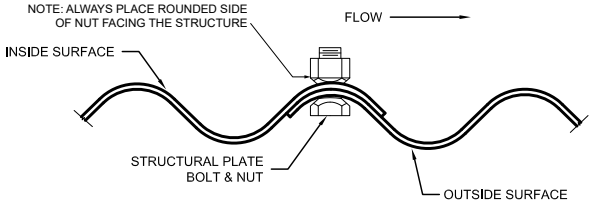
To facilitate alignment, initial assembly should be done with a minimum number of bolts. Insert sufficient bolts in each seam to hold the plates in position, but do not tighten the nuts, thus leaving the plate free to move slightly to help in matching the remaining bolt holes. Bolting the circumferential 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.

Typical Bolt and Nut

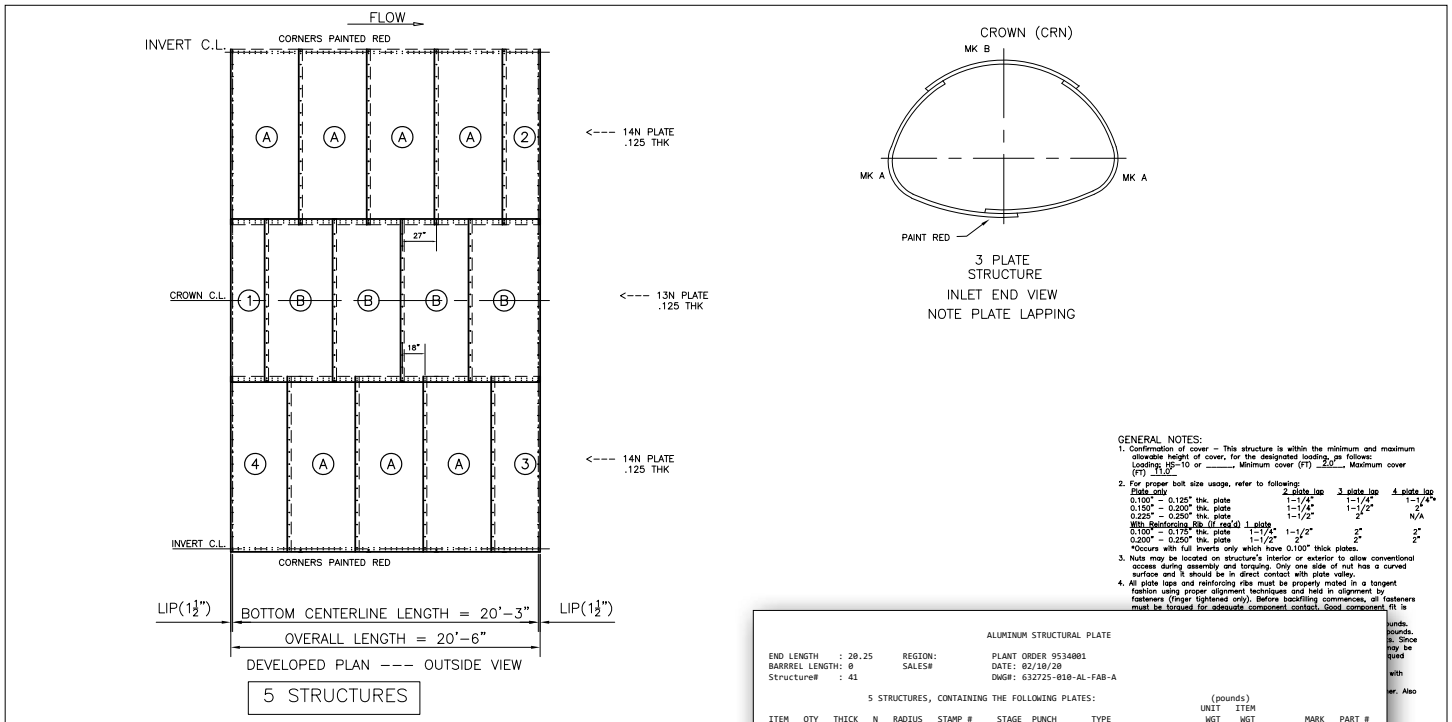


SHELL ONLY



INVERT ONLY

Sample Drawing



GENERAL NOTES:

1. Confirmation of cover – This structure is within the minimum and maximum allowable height of cover, for the designated loading, as follows: Loading MS-10 or _____, Minimum cover (FT) 2.0, Maximum cover (FT) 11.0
2. For proper bolt size usage, refer to following:

Plate only	2 plate lap	3 plate lap	4 plate lap
0.100" – 0.125" thk. plate	1-1/4"	1-1/4"	1-1/4"*
0.150" – 0.200" thk. plate	1-1/4"	1-1/2"	2"
0.225" – 0.250" thk. plate	1-1/2"	2"	N/A
With Reinforcing Rib (if req'd) 1 plate			
0.100" – 0.175" thk. plate	1-1/4"	1-1/2"	2"	2"
0.200" – 0.250" thk. plate	1-1/2"	2"	2"	2"

*Occurs with full inverts only which have 0.100" thick plates.

3. Nuts may be located on structure's interior or exterior to allow conventional access during assembly and torquing. Only one side of nut has a curved surface and it should be in direct contact with plate valley.
4. All plate laps and reinforcing ribs must be properly mated in a tangent fashion using proper alignment techniques and held in alignment by fasteners (finger tightened only). Before backfilling commences, all fasteners must be torqued for adequate component contact. Good component fit is

	INLET	OUTLET
SKEW	90	90
BEVEL	0	0

TYPE STRUCTURE PIPE ARCH
SIZE 41
SPAN = 12'7
RISE = 7'5
LENGTH @ ℄ 20'-3"
PLATE THICKNESS 0.125
REINFORCING RIB SPACING AS SHOWN
REINFORCING RIB TYPE AS SHOWN
NUMBER OF STRUCTURES 5

MARK	DATE	REVISION DESCRIPTION	BY

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

CONTRACT DRAWING

Example Plate Layout Drawing (Assembly Drawing) from Contract Set

ALUMINUM STRUCTURAL PLATE

END LENGTH : 20.25 REGION: PLANT ORDER 9534001
BARRREL LENGTH: 0 SALES# DATE: 02/10/20
Structure# : 41 DWG#: 632725-010-AL-FAB-A

5 STRUCTURES, CONTAINING THE FOLLOWING PLATES:

ITEM	QTY	THICK	N	RADIUS	STAMP #	STAGE	PUNCH	TYPE	(pounds) UNIT WGT	ITEM WGT	MARK	PART #
1/101	5	.125	13	90.50	10109024001	C	E	CROWN PLATES	104.57	314	1	SPPAL125CE13
1/102	5	.125	14	31.75	10203124001	C	E	HAUNCH PLATES	112.31	337	2	SPPAL125CE14
1/103	5	.125	14	31.75	10303124001	C	E	HAUNCH PLATES	112.31	421	3	SPPAL125CE14
1/104	5	.125	14	31.75	10403124001	C	E	HAUNCH PLATES	112.31	505	4	SPPAL125CE14
1/105	35	.125	14	31.75	10503124001	C	E	HAUNCH PLATES	112.31	3931	A	SPPAL125CE14
1/106	20	.125	13	90.50	10609024001	C	E	CROWN PLATES	104.57	2092	B	SPPAL125CE13

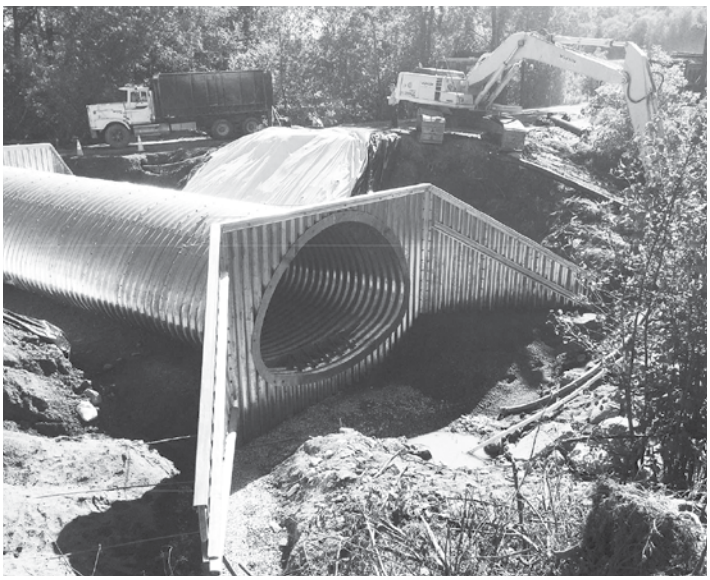
Plate Wgt = 7,600 pounds

1/107	5	RIB ASSEMBLY SOCKET			2.00	10	SAFSK
1/108	3000	BOLT	STEEL	3/4" x 1 1/4" (319)	.32	960	MPBFAGB34114
1/109	500	BOLT	STEEL	3/4" x 1 1/2" (320)	.35	175	MPBFAGB34112
1/110	3500	NUT	STEEL	3/4" (302)	.20	700	MPBFAGN34
1/111	1000	SPRING HOLDING CLIPS	(GALV.)	3/4" (444)	.01	10	SAFHC

Fastener Wgt = 1,855 pounds
Total Wgt = 9,455 pounds

Example Bill of Material (BOM)

Adding Ribs to Structure



Aluminum Headwall Option

ALSP 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 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 assembly area required for all two or three-plate structures is a width of [2x(Span) + 15'] by the length of the structure.

   The assembly area for all four and five-plate structures is a width of [(Span) + 15'] by the length of the structure. These structures are not moved or turned during the assembly procedure. The extra 15', in either case, is needed to layout plates and to provide the necessary working area

2. Because aluminum is lightweight, the assembled structure can often be lifted with light-duty equipment. See the Structural Plate, BOM, Structural Plate Design Guide, or contact a Contech representative for the handling weight of the structure. It may be advantageous to preassemble the structure. For example, removing the existing bridge and preparing the foundations while the structure is being assembled may be the most effective approach to the project. Two and four plate arch structures have a double row of bolts (longitudinal seam) in the top. This double row of bolts in the top of the culvert makes preassembly sometimes easier than assembly in place. (Reference the section on Lifting.)

CREW SIZE

Crew size can vary from three to six men. A four-man crew is generally the most efficient. Five and six-man crews are generally used only when time is a critical factor in assembling the structure. A three-man crew is usually inefficient since it is more efficient to work in pairs.

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. 1, 2, 3, etc.) and uncut plates are assembled or placed in the structure in accordance with the assembly drawing (plate layout drawing furnished by Contech). All cut plates or otherwise altered plates (such as plates with hook bolt holes) will have mark numbers painted on the outside surface of the plate. If the cut plates are too narrow, a wired tag will contain the required stencil data. The plate numbers will coincide with mark numbers shown on the assembly drawing. Standard plates (A, B, C, etc.) will not be marked.

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. The plates must be oriented such that their location matches that shown on the assembly drawing. Should it prove difficult to match the plate and the assembly drawing, a Contech representative should be notified for assistance.

ALSP corrugations of 9-inch pitch and 2.5-inch depth are perpendicular to the length of each plate. Standard specified thickness of the plates vary from 0.100 inches through 0.250 inches in uniform increments of 0.025". Uncurved plates are available in 0.100" plate thickness only.

All plates and ribs are shipped to the jobsite prepunched and curved in strapped nestable bundles. Each bundle will contain only plates or ribs having the same curvature. Unloading plate and rib bundles off the truck should be planned accordingly. The bundles should always be unloaded with the "outside" of the plate up. If the bundles are improperly unloaded; such as upside down, on their sides, or pushed off the truck; the plates may be damaged and/or difficult to separate. Damaged plates may cause unnecessary work for the assembly crew.

Reinforcing Ribs

When circumferential ribs are used with Aluminum Structural Plate, they reinforce the structure to reduce minimum cover and provide additional stiffness. These circumferential ribs are bolted to the structure's crown and haunches (if applicable) at spacings of 9", 18", 27" or 54" centers through pre-punched holes in both the ribs and the structural plate. Reference your project assembly drawings. A Rib Assembly Socket is provided by Contech on structures that utilize ribs. This socket is manufactured with a ¾" drive.

Rib Assembly Socket

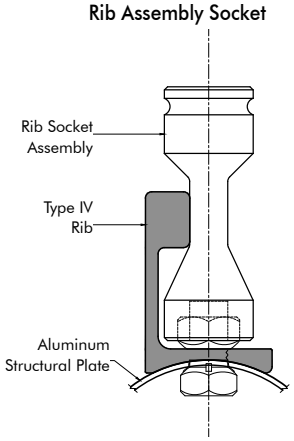


TABLE 2. ADDED HANDLING WEIGHT AND ADDITIONAL BOLTS PER FOOT OF STRUCTURE FOR TYPE II REINFORCING RIB

Total N of Rib	9" o.c.		18" o.c.		27" o.c.		54" o.c.	
	Wt./Ft.	Bolts/ft	Wt./Ft.	Bolts/Ft.	Wt./Ft.	Bolts/Ft.	Wt./Ft.	Bolts/Ft.
5	15.7	7.3	7.7	3.3	5.0	2.0	2.3	0.7
6	18.6	8.6	9.1	3.9	5.9	2.3	2.7	0.8
7	21.5	9.8	10.5	4.4	6.8	2.7	3.2	0.9
8	24.3	11.0	11.9	5.0	7.7	3.0	3.6	1.0
9	27.2	12.2	13.3	5.6	8.7	3.3	4.0	1.1
10	30.1	13.4	14.7	6.1	9.6	3.7	4.5	1.2
11	32.9	14.7	16.1	6.7	10.5	4.0	4.9	1.3
12	35.8	15.9	17.5	7.2	11.4	4.3	5.3	1.4
13	38.7	17.1	18.9	7.8	12.3	4.7	5.7	1.6
14	41.5	18.3	20.3	8.3	13.2	5.0	6.2	1.7
15	44.4	19.6	21.7	8.9	14.2	5.3	6.6	1.8
16	47.3	20.8	23.1	9.4	15.1	5.7	7.0	1.9
17	50.2	22.0	24.5	10.0	16.0	6.0	7.4	2.0

Type II Rib

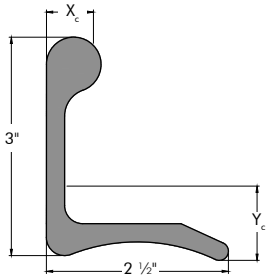


TABLE 3. ADDED HANDLING WEIGHT AND ADDITIONAL BOLTS PER FOOT OF STRUCTURE FOR TYPE IV REINFORCING RIB

Total N of Rib	9" o.c.		18" o.c.		27" o.c.		54" o.c.	
	Wt./Ft.	Bolts/ft	Wt./Ft.	Bolts/Ft.	Wt./Ft.	Bolts/Ft.	Wt./Ft.	Bolts/Ft.
5	20.0	7.3	9.8	3.3	6.4	2.0	3.0	0.7
6	23.7	8.6	11.6	3.9	7.6	2.3	3.6	0.8
7	27.4	9.8	13.4	4.4	8.8	2.7	4.2	0.9
8	31.0	11.0	15.2	5.0	10.0	3.0	4.7	1.0
9	34.7	12.2	17.1	5.6	11.2	3.3	5.3	1.1
10	38.4	13.4	18.9	6.1	12.4	3.7	5.9	1.2
11	42.1	14.7	20.7	6.7	13.5	4.0	6.4	1.3
12	45.8	15.9	22.5	7.2	14.7	4.3	7.0	1.4
13	49.4	17.1	24.3	7.8	15.9	4.7	7.5	1.6
14	53.1	18.3	26.1	8.3	17.1	5.0	8.1	1.7
15	56.8	19.6	27.9	8.9	18.3	5.3	8.7	1.8
16	60.5	20.8	29.7	9.4	19.5	5.7	9.2	1.9
17	64.1	22.0	31.5	10.0	20.7	6.0	9.8	2.0

Type IV Rib

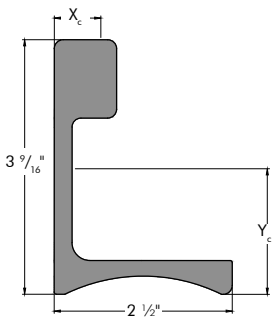
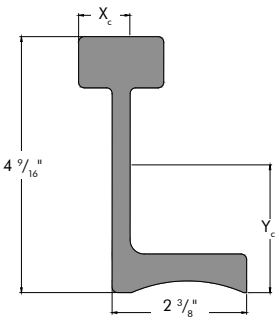


TABLE 4. ADDED HANDLING WEIGHT AND ADDITIONAL BOLTS PER FOOT OF STRUCTURE FOR TYPE VI REINFORCING RIB

Total N of Rib	9" o.c.		18" o.c.		27" o.c.		54" o.c.	
	Wt./Ft.	Bolts/ft	Wt./Ft.	Bolts/Ft.	Wt./Ft.	Bolts/Ft.	Wt./Ft.	Bolts/Ft.
5	28.8	7.3	14.2	3.3	9.4	2.0	4.5	0.7
6	34.1	8.6	16.9	3.9	11.1	2.3	5.3	0.8
7	39.4	9.8	19.5	4.4	12.8	2.7	6.2	0.9
8	44.8	11.0	22.1	5.0	14.6	3.0	7.0	1.0
9	50.1	12.2	24.7	5.6	16.3	3.3	7.8	1.1
10	55.4	13.4	27.4	6.1	18.0	3.7	8.7	1.2
11	60.8	14.7	30.0	6.7	19.8	4.0	9.5	1.3
12	66.1	15.9	32.7	7.2	21.5	4.3	10.4	1.4
13	71.4	17.1	35.3	7.8	23.2	4.7	11.2	1.6
14	76.8	18.3	37.9	8.3	25.0	5.0	12.0	1.7
15	82.1	19.6	40.6	8.9	26.7	5.3	12.9	1.8
16	87.4	20.8	43.2	9.4	28.5	5.7	13.7	1.9
17	92.8	22.0	45.8	10.0	30.2	6.0	14.5	2.0

Type VI Rib



Notes:
1. Bolts and nuts are included in the tables above.
2. For Total N of rib on a structure, see the plate layout drawing and BOM.

Reinforcing Ribs, cont.

STRUCTURES WITH REINFORCING RIBS

Assembly methods of ribbed structures follow those of non-ribbed structural plate products. All ribs are marked with numbers corresponding to the assembly drawing. Reinforcing ribs are spaced at 9", 18", 27" or 54" depending on the design of the structure. Follow the assembly drawing in placing a specific rib in its proper place on the structure. All reinforcing ribs must be oriented the same with respect to the vertical leg of the rib.

When assembling the crown and/or side plates, it is best to temporarily place one or two bolts in the ends of the circumferential seam before attaching a rib. Use the drift pin to line up and hold together the overlapping plates and the rib before bolts are placed.

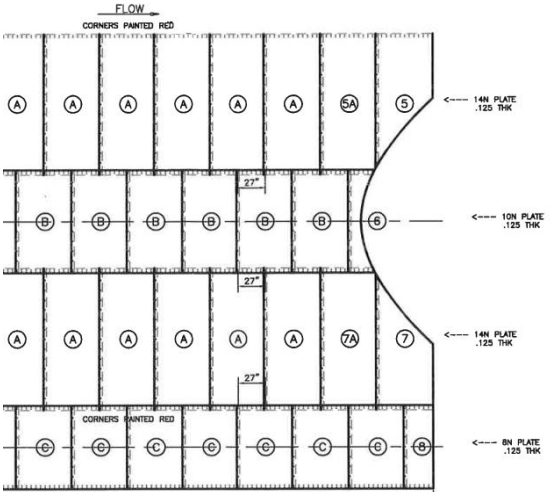
Check to make sure that no holes remain in the structure.

Tighten and torque all bolts. Torque rib splices first, then crown and/or side ribs and finally any remaining plate seams. Bolt torque requirements are 100-150 ft-lbs for all plate thicknesses and components. **Do not over torque; a good plate fit is far better than high torque.**

ALSP 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 indicate the plate width, "N" value and plate thickness. Please reference table on page 5 of this document.



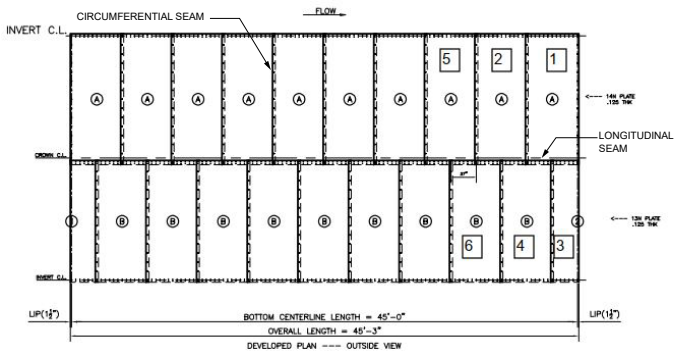
The beginning and end rings for square end structures contain a combination of full length plates (example A, B, C, etc...), and short plates to close a ring and obtain the proper plate stagger. Special plates in cut end structures are shown on the plate layout together with the necessary standard 4.5' long plates required to obtain proper seam stagger in the barrel. Barrel rings in the circumferential direction contain plates of all the same length (4.5').

For cut plates (example 1, 2, etc...), elbow cut and welded plates (example 3L, 3R, etc...), the numbers that appear on the plate layout drawing correspond to the numbers on the plates. Reference the structure assembly drawings furnished with the order. Standard plates marked with letters will be bundled together, but not marked individually. Please refer to page 16 for proper end view orientation for the plate configurations described below.

Two-Plate Structures

ASSEMBLY PROCEDURE FOR TWO-PLATE PIPE-ARCH & UNDERPASS

For the purpose of illustration and sequence, you will see numbers in squares on this drawing. These numbers relate to the numbers in parenthesis on the text below and are meant to represent the sequence in which the plates are recommended to be assembled. The markings in squares will not be shown on your assembly drawings, nor will they be marked on the individual plates. The numbers and letters in circles, on the drawings, represent the mark numbers on the plates. These numbers will be marked on the plates and shown on the drawings and bill of materials.



One technique for the assembly of a two plate structure may be to build the first ring laying on it's side on the ground, rotating it to it's final upright position and then following the plate by plate guidelines described below. Another technique is assembling all plates in their upright position.

The use of spring clips in the invert longitudinal seam is suggested as a method of keeping the bolts in place as you bring the next plate on top of them.

Lay out the plates in two rows as shown on the assembly drawings with the correct cut plates positioned at the inlet and outlet end. Assembly should begin from the outlet end so that the plates shingle properly with respect to water flow. Upstream plates should be placed on top of downstream plates. Refer to the details on pages 8 and 16 for proper lapping.

Bolt together (lightly torque) plates (1) and (2) at the circumferential seam starting at the center and working towards both ends. Omit the longitudinal seam bolts at each end. Close the ring by attaching plate (3) at both longitudinal seams (lightly torqued). Three-plate laps occur at the corners of all plates in the body of the structure. Always omit corner bolts until all three plates are attached.

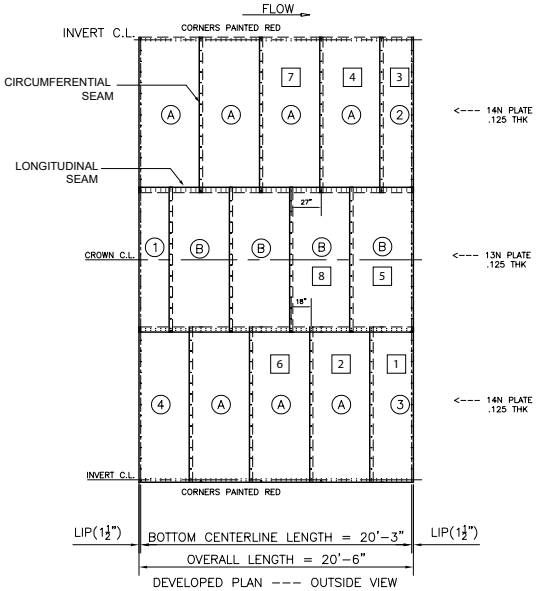
Refer to page 16 for proper plate orientation and ensure this is maintained throughout the structure. Attach plate (4) next, starting with the circumferential seam. At the three-plate laps, use a pry bar or drift pins as necessary to align the holes. Longer bolts are utilized at three-plate laps.

Complete the attachment of plate (4) by bolting the longitudinal seams. Attach plate (5) next, followed by (6) and follow this pattern until the entire structure is assembled, including any cut plates that may be needed on the inlet end of the structure. Bolts should remain lightly torqued until all bolts in a seam have been connected. Torquing bolts too early limits the ability to adjust plates and align bolt holes. The appropriate bolt torque range is 100-150 ft-lbs. **Do not over torque; a good plate fit is far better than high torque.**

Three-Plate Structures

ASSEMBLY PROCEDURE FOR THREE-PLATE PIPE-ARCH & UNDERPASS

For the purpose of illustration and sequence, you will see numbers in squares on this drawing. These numbers relate to the numbers in parenthesis on the text below and are meant to represent the sequence in which the plates are recommended to be assembled. The markings in squares will not be shown on your assembly drawings, nor will they be marked on the individual plates. The numbers and letters in circles, on the drawings, represent the mark numbers on the plates. These numbers will be marked on the plates and shown on the drawings and bill of materials.



One technique for the assembly of a three plate structure may be to assemble all the plates in their upright position. Another technique is to build the first ring laying on it's side on the ground, rotating it to it's final upright position and then following the plate by plate guidelines described below.

The use of spring clips in the invert longitudinal seam is suggested as a method of keeping the bolts in place as you bring the next plate on top of them.

Three-plate pipe-arch and underpass structures have one crown and two haunch plates. The invert corners of the haunch plates are painted red. Lay out the haunch plates in two rows as shown on the assembly drawings with the correct cut plates positioned at the inlet and outlet end. Leave a space the distance of the span between them. Assembly should begin from the outlet end so that the plates shingle properly with respect to water flow. Upstream plates should be placed on top of (inside) downstream plates. Refer to the assembly drawings and the details on pages 8 and 16 of this booklet for proper lapping.

Begin by placing plate (1) on its side with the downstream end resting on the ground. Lift plate (2) into place to align the circumferential seam and bolt together (lightly torqued) plates (1) and (2) starting at the center and working towards both ends. Plate (2) will be resting on top of plate (1). Omit the longitudinal seam bolts at each end.

Repeat this process with plates (3) and (4), then move the two assemblies together to align their longitudinal seams at the invert. Pay close attention to the longitudinal stagger, established on this first ring (as seen in the assembly drawings) of one side versus the other side. These ends will be painted red. Bolt together the longitudinal seam at the invert (lightly torqued). Insert the bolts from the bottom of the structure so the nuts will be accessible from the inside. Refer to page 16 for proper plate orientation and ensure this is maintained throughout the structure. 3-plate laps occur at the corners of all plates in the body of the structure. Always omit corner bolts until all three plates are attached. At the 3-plate laps, use a prybar or drift pin as necessary to align the holes. Longer bolts are utilized at three-plate laps.

Complete the ring by attaching the crown plate (5) at the longitudinal seams. At this point, measure the interior span and rise of the structure and ensure that those dimensions are as close as possible to the design values, and within their tolerances. If the seams of the structure have started flaring in or out, adjust the shape as required by pulling the seams with a drift pin. When the shape is properly established, torque the bolts completely prior to rotating the structure into its vertical position.

Ensure that all workers are positioned safely outside of the ring, then lift and rotate the structure into its final, vertical position. Before attaching additional plates, invert bolts must be pre-installed in the upstream edge, using spring clips to hold them in place. When this is complete, haunch plate (7) can be attached, followed by haunch plate (6) and crown plate (8).

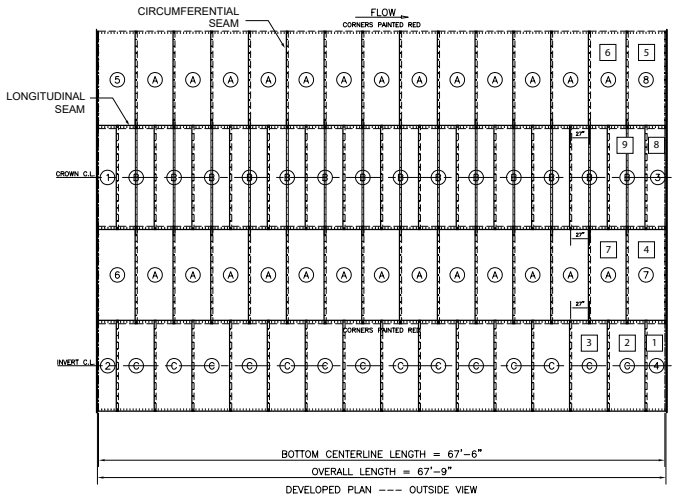
A person on the inside of the structure can insert a drift pin into the longitudinal seam of the plates. A person on the outside of the structure can lift and slide plates over the top until the longitudinal seam holes line up. Follow this pattern until the entire structure is assembled, including any cut plates that may be needed on the inlet end of the structure. Bolts should remain lightly torqued until all bolts in a seam have been connected. Torquing bolts too early limits the ability to adjust plates and align bolt holes. The appropriate bolt torque range is 100-150 ft-lbs. **Do not over torque; a good plate fit is far better than high torque.**

Four-Plate Structures

ASSEMBLY PROCEDURE FOR FOUR-PLATE PIPE-ARCH & UNDERPASS

For the purpose of illustration and sequence, you will see numbers in squares on this drawing. These numbers relate to the numbers in parenthesis on the text below and are meant to represent the sequence in which the plates are recommended to be assembled. The markings in squares will not be shown on your assembly drawings, nor will they be marked on the individual plates. The numbers and letters in circles, on the drawings, represent the mark numbers on the plates. These numbers will be marked on the plates and shown on the drawings and bill of materials.

One technique for the assembly of a four plate structure may be to assemble all the plates in their upright position. Another technique is to build the invert and haunch portion of the first ring, with its side laying on the ground. Then, rotate it to it's final upright position, following the plate by plate guidelines described below.



The use of spring clips in the invert longitudinal seam is suggested as a method of keeping the bolts in place as you bring the next plate on top of them.

Four-plate pipe-arch and underpass structures have one invert, one crown and two haunch plates. The invert corners of the haunch plates are painted red. Lay out the invert plates and haunch plates in three rows as shown on the assembly drawings with the correct cut plates positioned at the inlet and outlet end. Leave a space the distance of the span between the haunch plates. Assembly should begin from the outlet end so that the plates shingle properly with respect to water flow. Upstream plates should be placed on top of (inside) downstream plates. Refer to the assembly drawings and the details on pages 8 and 16 of this booklet for proper lapping.

Begin by placing plate (1) on its side with the downstream end resting on the ground. Preinstall bolts in the upstream circumferential seam using spring clips. Insert the bolts from the outside of the plate, so the nuts will be accessible from the inside. Repeat this process with plates (2) and (3). Lay down plate (1) and place plate (2) on top of it aligning the circumferential seam. Join plates (1) and (2) by attaching nuts to the preinstalled bolts (lightly torqued) starting at the center and working towards both ends. Repeat this process and add plate (3) to the invert. Omit the longitudinal seam bolts at each end on all plates.

After the three invert plates are connected, attach haunch plates (4) and (5) to the invert plates at the longitudinal seam (lightly torqued). The invert end of the haunch plates will be painted red. Insert the bolts from the bottom of the structure so the nuts will be accessible from the inside. Attach haunch plates (6) and (7) in the same way. Pay close attention to the longitudinal stagger, established on this first ring (as seen in the assembly drawings) of one side versus the other side.

Refer to page 16 for proper plate orientation and ensure this is maintained throughout the structure. 3-plate laps occur at the corners of all plates in the body of the structure. Always omit corner bolts until all three plates are attached. At the 3-plate laps, use a prybar or drift pin as necessary to align the holes. Longer bolts are utilized at three-plate laps.

Complete the ring by attaching crown plate (8), followed by (9). At this point, measure the interior span and rise of the structure and ensure that those dimensions are as close as possible to the design values, and within their tolerances. If the seams of the structure have started flaring in or out, adjust the shape as required by pulling the seams with a drift pin. Cabling or bracing the structure are also effective techniques. When the shape is properly established, torque the bolts completely prior to completing assembly.

Before attaching additional plates, invert bolts must be pre-installed in the upstream edge, using spring clips to hold them in place. When this is complete, continue attaching invert, haunch and crown plates in the same order as before. Assemble both sides together, with the invert plate always leading the haunch plates. Follow this pattern until the entire structure is assembled, including any cut plates that may be needed on the inlet end of the structure.

Bolts should remain lightly torqued until all bolts in a seam have been connected. Torquing bolts too early limits the ability to adjust plates and align bolt holes. The appropriate bolt torque range is 100-150 ft-lbs. **Do not over torque; a good plate fit is far better than high torque.**

Five-Plate Structures

ASSEMBLY PROCEDURE FOR FIVE-PLATE PIPE-ARCH & UNDERPASS

Five-plate structures have an invert, two haunch, and two crown plates. The invert corners of the haunch plates are painted red. There may be as many as ten cut plates; five on the upstream end, and five on the downstream end. Refer to the assembly drawings.

The assembly procedure for a five-plate structure is essentially the same as the four-plate structure. Refer to the End View detail on page 16 for proper lapping of the seams, and pay close attention to the longitudinal offset (stagger, usually 27") of one side versus the other side. Please use the numbers in the boxes on the detail to the right, as a guide for the sequence to assemble the plates.

The only difference in the assembly procedure of a five-plate structure is the placement of two crown plates instead of one as in the four-plate structure. The appropriate bolt torque range is 100-150 ft-lbs. **Do not over torque; a good plate fit is far better than high torque.**

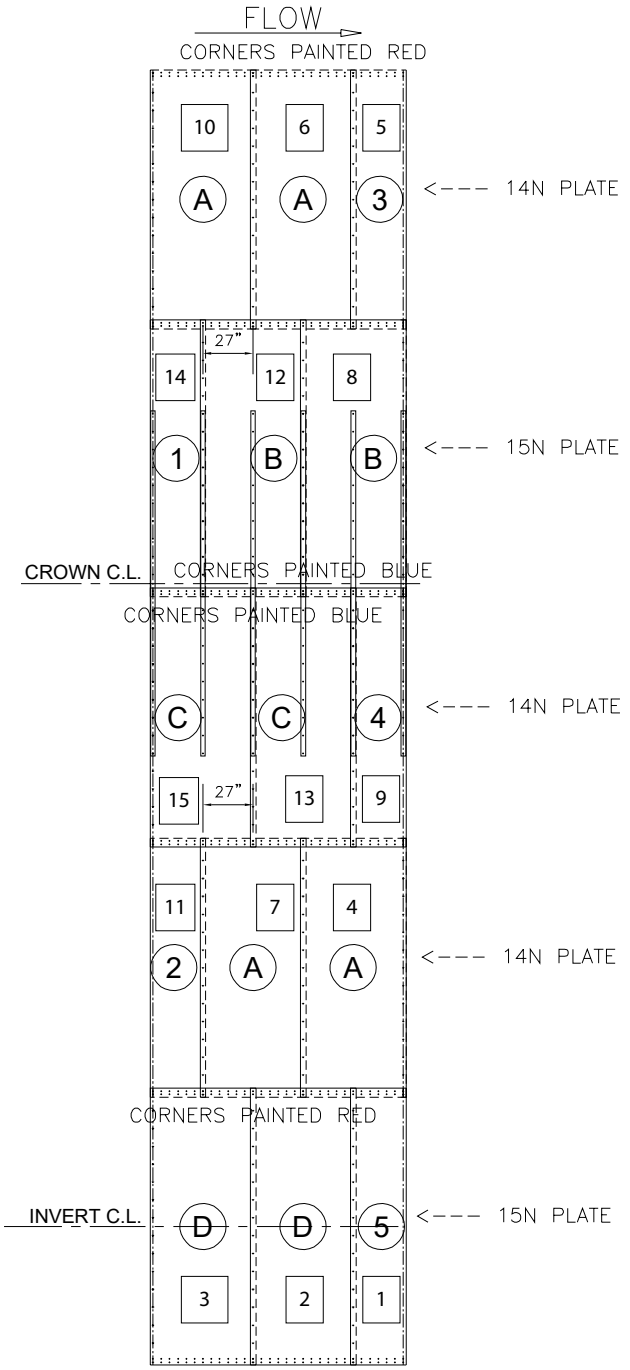
Six-Plate Structures

ASSEMBLY PROCEDURE FOR SIX-PLATE PIPE-ARCH & UNDERPASS

Six-plate structures have an invert, two haunch, two side and one crown plate. The invert corners of all haunch plates are painted red. There may be as many as twelve cut plates. Six on the upstream end and six on the downstream end. Refer to the assembly drawings.

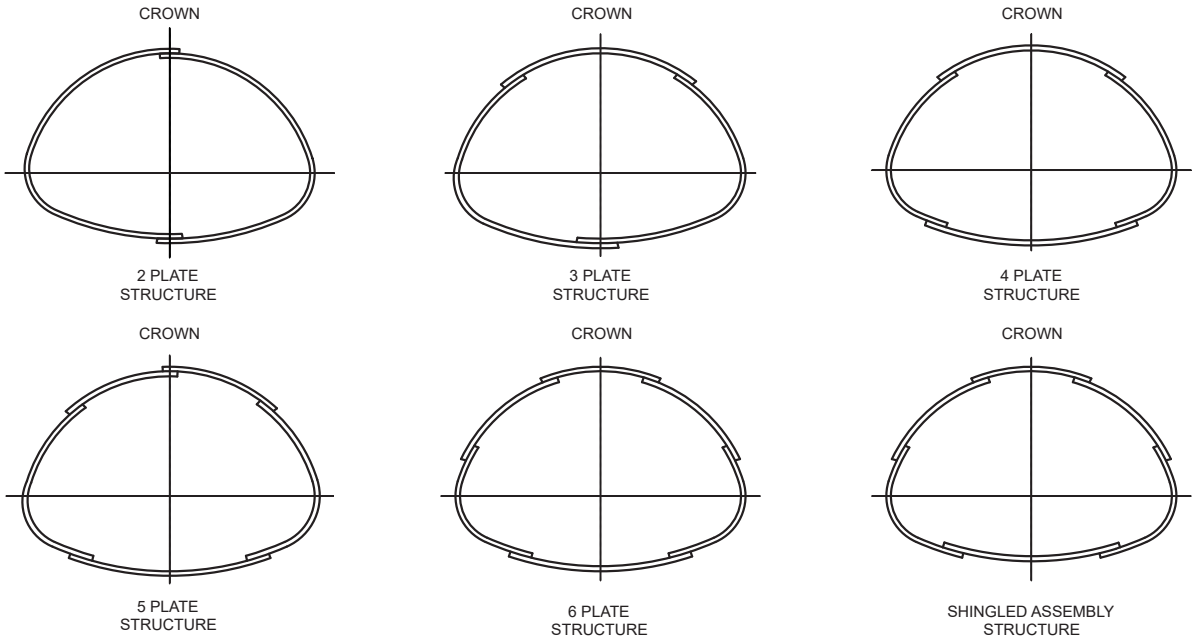
The assembly procedure for a six-plate structure is the same as for the four-plate structure. Refer to the End View detail on page 16 for proper lapping of the seams, and pay close attention to the longitudinal offset (stagger, usually 27") of one side versus the other side.

The only difference in the assembly procedure of a six-plate structure is the placement of two side plates in addition to the two haunch plates. The appropriate bolt torque range is 100-150 ft-lbs. **Do not over torque; a good plate fit is far better than high torque.**



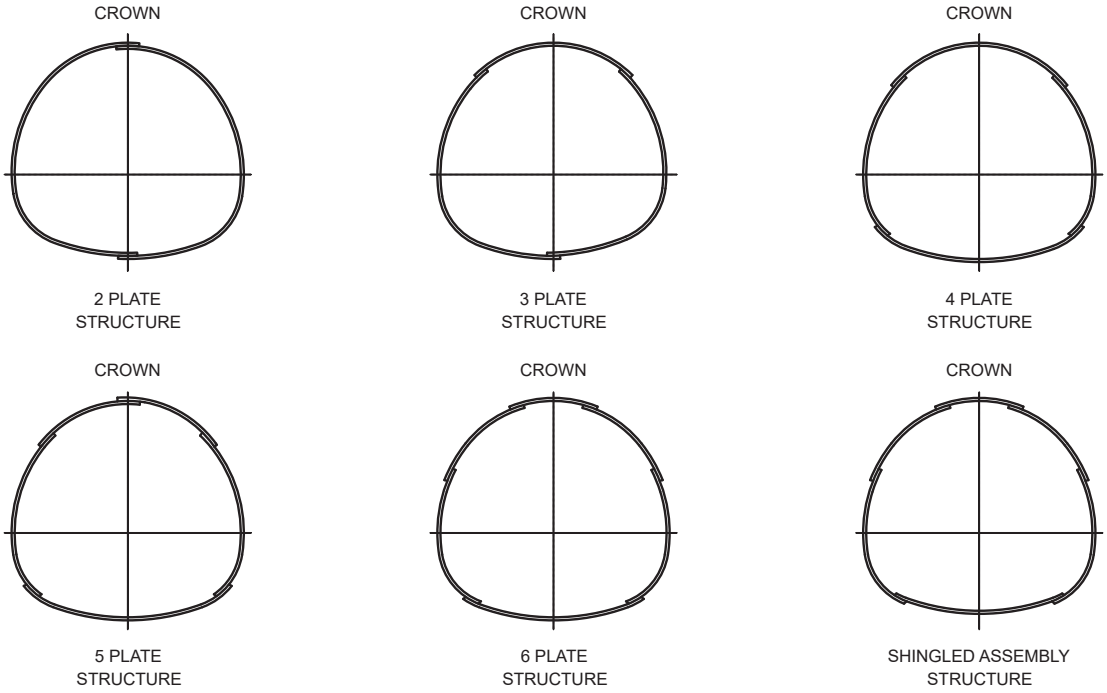
ALSP Pipe-Arch and Underpass Plate Orientation

VIEW LOOKING DOWNSTREAM (ALSP PIPE-ARCH)



NOTE
WHERE INFILTRATION OF FINE GRAINED BACKFILL MATERIAL MAY OCCUR, SHINGLED ASSEMBLY CONSTRUCTION MUST BE USED.

VIEW LOOKING DOWNSTREAM (ALSP UNDERPASS)



NOTE
WHERE INFILTRATION OF FINE GRAINED BACKFILL MATERIAL MAY OCCUR, SHINGLED ASSEMBLY CONSTRUCTION MUST BE USED.

ASSEMBLY CONSIDERATIONS

1. If the structure includes a skew or bevel those structures should be assembled per the procedures described on pages 11 or 12. 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 cause 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/orientation is as shown on page 16. Please reference 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.
5. Should the holes in the corrugation begin to shift off center, start 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, the ability to adjust the shape is reduced.
6. Should you encounter unpunched or mispunched holes, field drill another 7/8" diameter hole. Reference the standard plate detail on page 5 of this document for proper hole position and spacing.
7. 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. Should the structure start to spiral, please contact your Contech representative.

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

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.

The use of slings and/or full perimeter cables is recommended. Many structures, depending on the size, have also 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.

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 ALSP 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. Place haunch material around 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 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 10 (on page 25) 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 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 aluminum 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 aluminum 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.

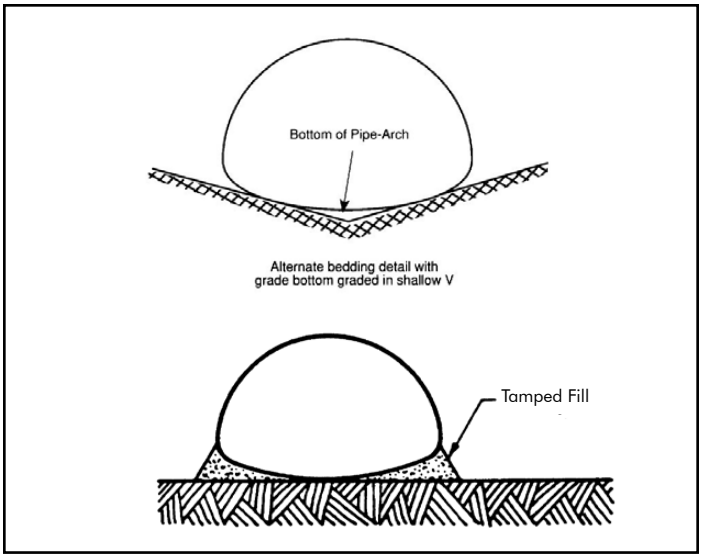


Figure 1. Methods for attaining proper compaction under haunches of structural plate pipe-arches and underpasses.

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.

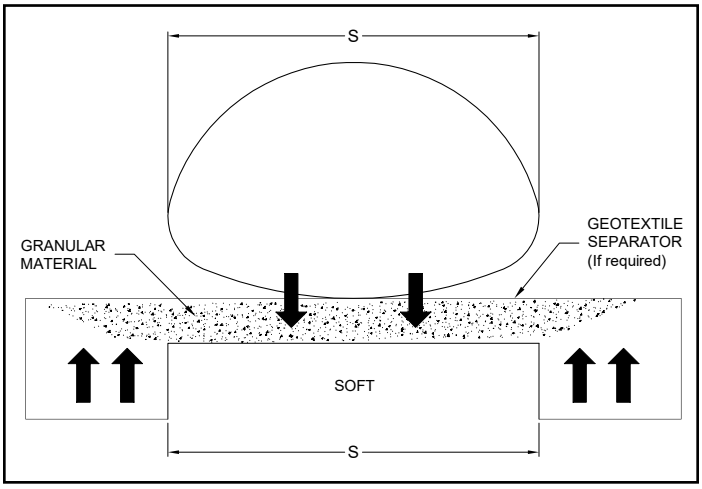


Figure 2. Soft foundation considerations

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.

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 3 (right). The excavated area is then backfilled with lightly compacted, granular soil to cushion the structure.

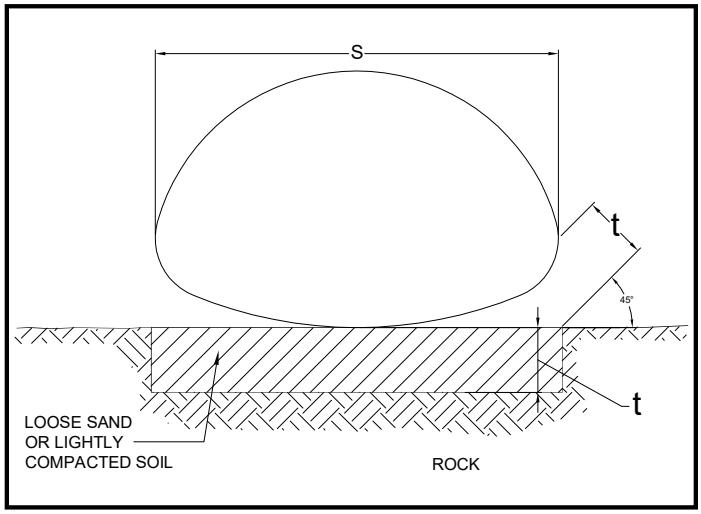


Figure 3. Method of handling rock foundations. t = 1/2" per foot of fill over structure, with 24" the maximum.

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.

ALSP Pipe Arch with an Aluminum Headwall Option

BACKFILLING
ALSP Pipe-Arch and Underpasses

PLACING THE BACKFILL

It is important to emphasize the necessity of adequate backfill and proper placement. Improper 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.

Continue placing the backfill equally on both sides of the structure in 8-inch uncompacted lifts, thoroughly compacting each lift(s) to a minimum 90% density (AASHTO T180). 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 4 on the right, and Figures 5 and 6 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 its design live load or exceed legal highway loads, an extra thickness of compacted fill, beyond that required for minimum cover, is required. See construction loads on page 26.

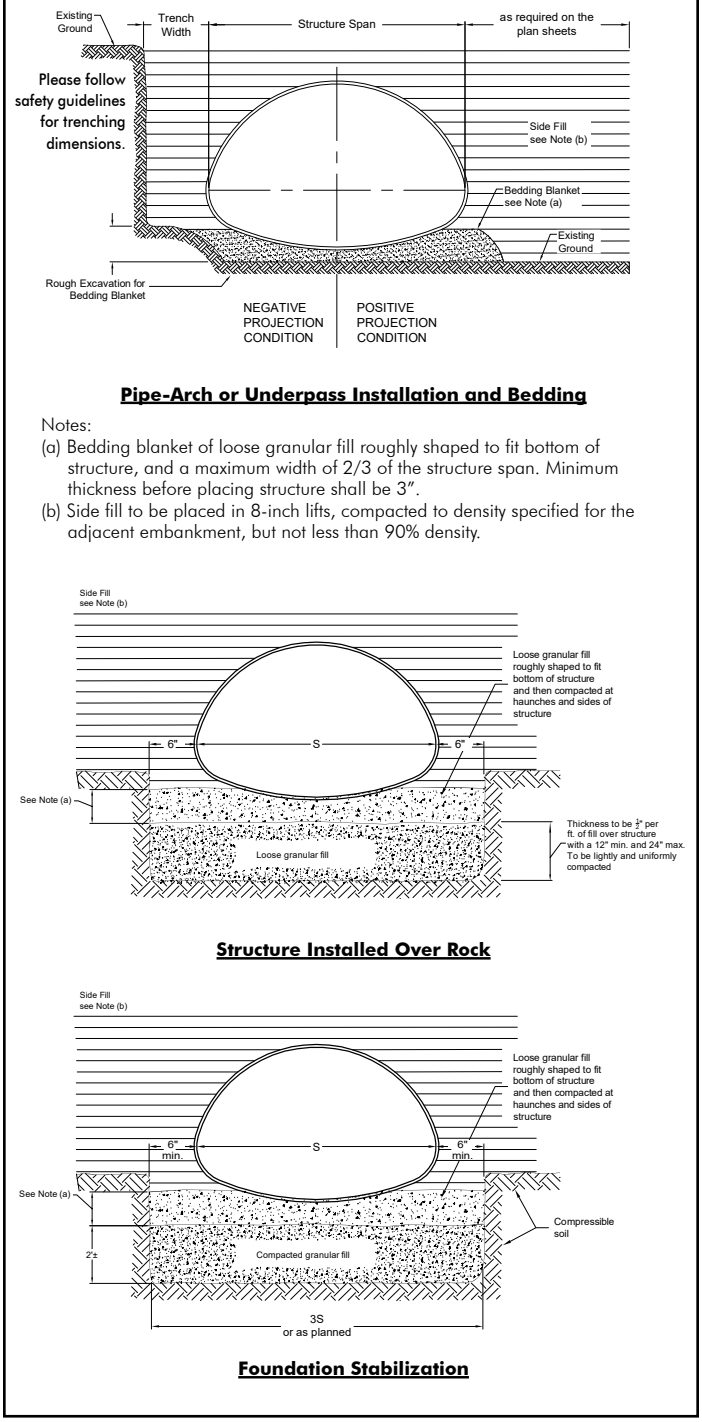


Figure 4. Bedding and Backfill Details.

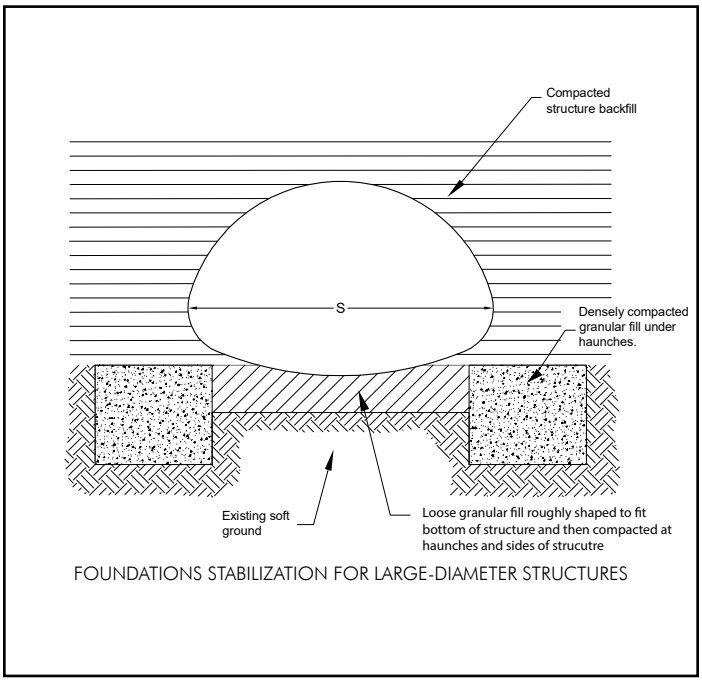


Figure 5. Bedding and Backfill Details (continued).

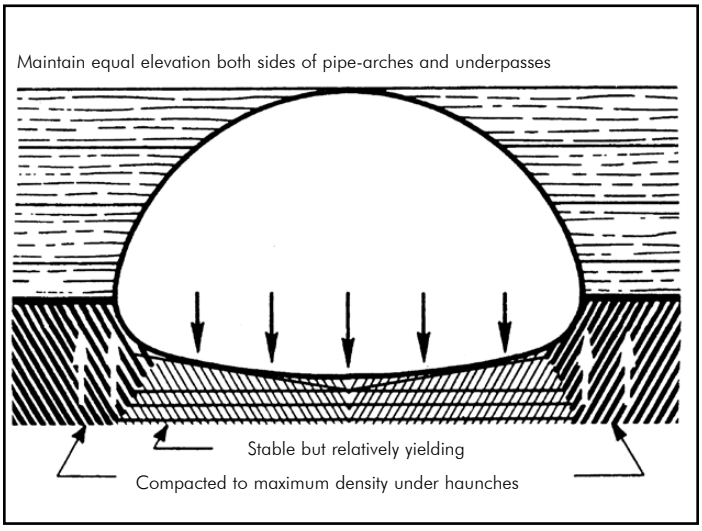


Figure 6. Recommended backfilling practice for larger pipe-arches and underpasses, using a vee-shaped bed.

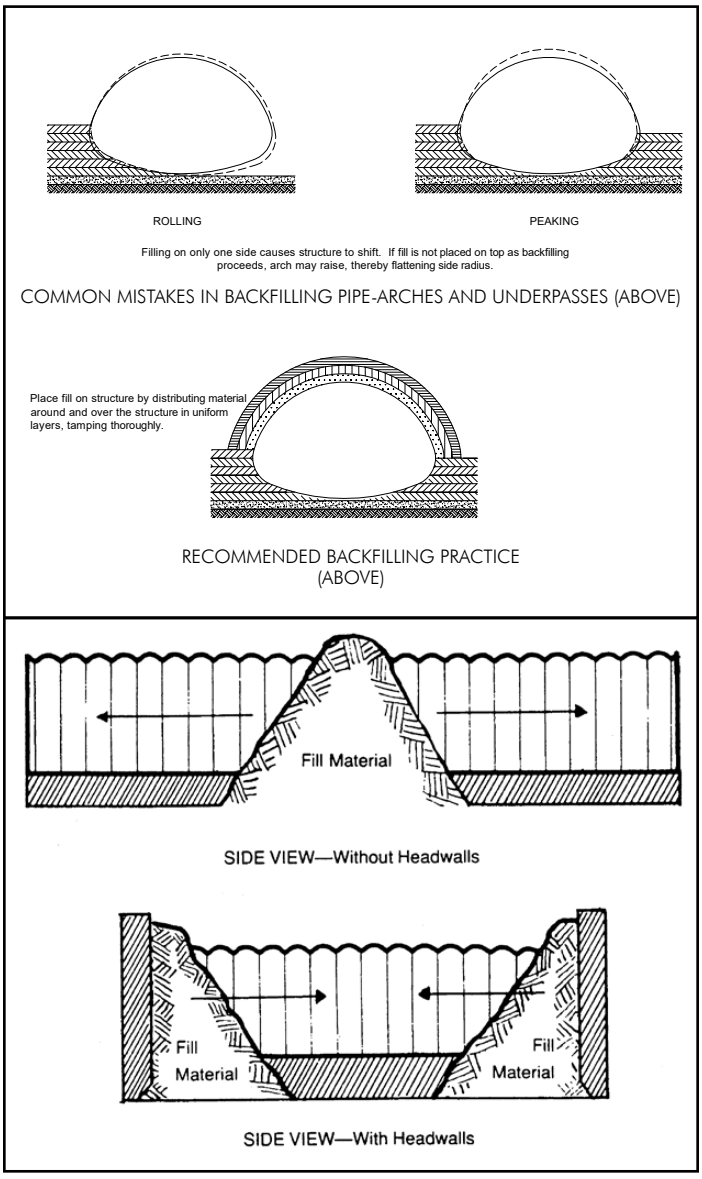


Figure 7. Recommended backfilling practice for structural plate.

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 6 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 7 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 ALSP 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.

SUMMAR OF BACKFILLL 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.

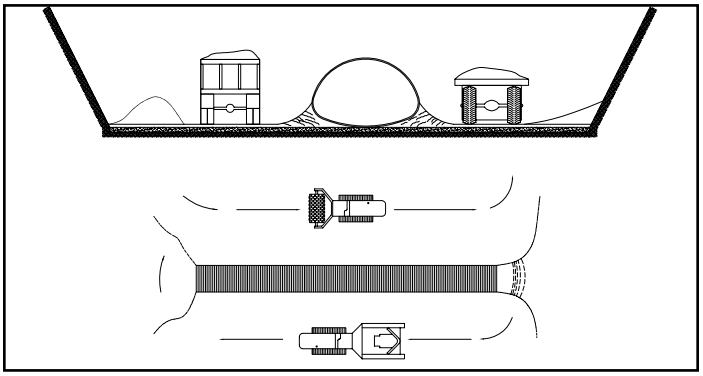


Figure 8. Proper material placement.

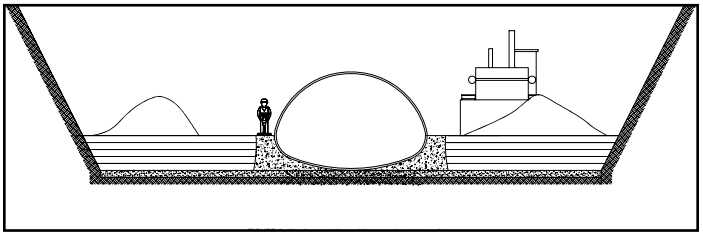


Figure 9. Hand compaction and heavy equipment procedure.

As backfill progresses, place the select material in radial lifts at approximately 75% of the rise of the structure. See Figure 10 below.

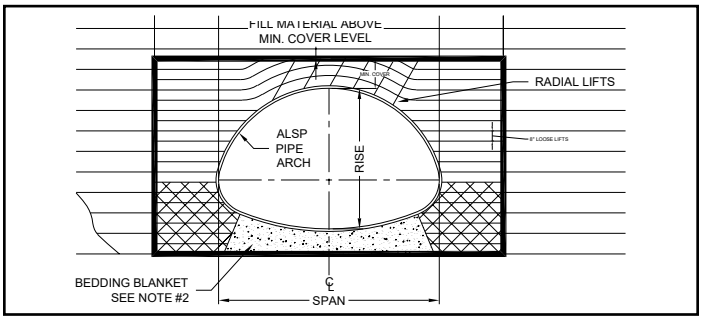


Figure 10. Backfill Detail.

When the fill on both sides approaches the crown of the structure (see the Recommended Backfilling Practice in Figure 7), 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 7.

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.

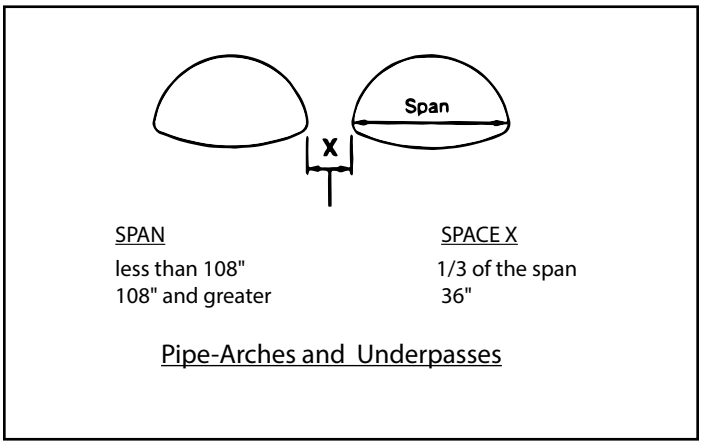


Figure 11.Minimum Barrel Spacing.

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 minimum spacing shown on Figure 10 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 aluminum structure must be properly protected.

Adequate, uniform compaction is critical to building soil/ aluminum structures.

CONSTRUCTION LOADS

Frequently, it is necessary for heavy construction equipment to travel over installed corrugated aluminum 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 aluminum structure may require more than finished design fill. The amount of additional fill needed depends on the equipment axle loads.

The actual minimum cover heights required for heavier construction vehicle live loads will vary based on the anticipated construction equipment (size, weight and axle loads). Other factors influencing the minimum cover height requirements are structure size, shape and gage combined with local site conditions. These factors need to be addressed by the engineer and/or contractor prior to the start of construction.

The cover depth required for protection from construction equipment loads is measured from the crown of the structure to the top of the maintained construction roadway surface. Additionally, the roadway surface for the construction loading and vehicular traffic conditions shall be well-maintained and free of ruts for the duration of the temporary vehicle crossings. Contact your local Contech representative for additional information.

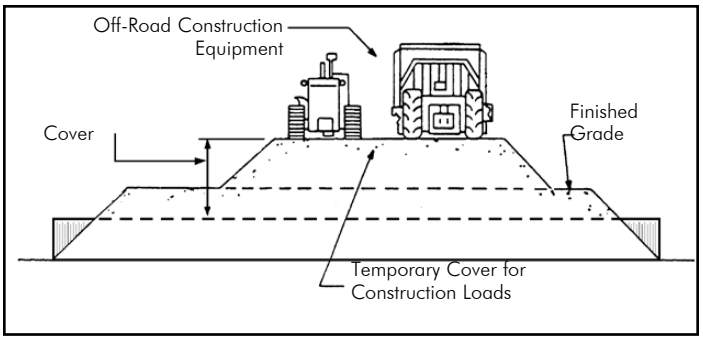


Figure 11.Minimum cover for construction loads.

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. Place haunch material around 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 to protect the structure from erosion and uplift.
13. Protect the structure from heavy construction equipment loads, other heavy loads and hydraulic forces.

NOTES

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