CONTECH ENGINEERED SOLUTIONS

Structural Plate Design Guide

6th Edition

MULTI-PLATE®

Aluminum Structural Plate

Aluminum Box Culvert

SUPER-SPAN™

SUPER-PLATE®

BridgeCor®

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Steel and Aluminum Structural Plate Design Guide.

This design guide is provided to assist designers with most applications and design aspects of Contech Engineered Solutions' MULTI-PLATE, Aluminum Structural Plate, Aluminum Box Culverts, SUPER-SPAN/SUPER-PLATE and BridgeCor. In addition to this written guide, standard CAD details which can be used by any designer to aid with plan preparation are available. For additional information, contact your local Contech representative or call 800-338-1122 to find a Contech representative near you.

Outline of Typical Design Steps

The following steps describe a basic, typical procedure for designing a structural plate bridge or culvert but are not intended to represent all possible considerations that a prudent designer should investigate. Although not all of these steps will be covered in this document, additional design aids are available. Should the designer have questions regarding an aspect of structure designs, the designer can contact the local Contech representative for additional information.

Design Sequence

1. General Structure Selection
   - Guidelines for selection of hydraulic, roadway, pedestrian, or grade separation structure
2. Additional Selection Considerations
   - Refining structure selection
3. Check Service Life and Protection of Structure from Environment
   - Environmental effects
   - Design life
   - Material selection – galvanized steel or aluminum
   - Protection from aggressive environments
   - De-icing salts
4. Check Structure Hydraulics (not covered herein)
   - Performing hydraulic checks
   - Hydraulics of corrugated metal structures
   - Tools for hydraulic analysis*
   - Scour analysis
5. Check Structural Design
   - Design method
     - » American Association of State Highway and Transportation Officials (AASHTO)
     - » American Iron and Steel Institute (AISI)
     - » National Corrugated Steel Pipe Association (NCSPA)
   - Example calculations
   - Material properties
   - Load rating structural plate (not covered herein)**

* Hydraulic nomographs and FHWA HY-8 program assistance is available from your local Contech representative.

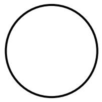
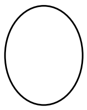
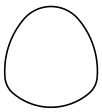
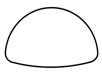
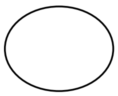
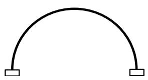
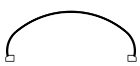
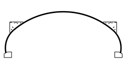
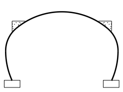
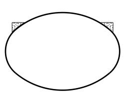
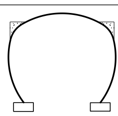
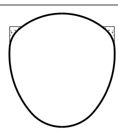
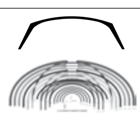
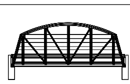
** NCSPA Design Data Sheet 19 is available from your local Contech representative.

6. Specify Bedding, Backfill and Check Foundation
   - Soil envelope under and around structure
   - Bedding
   - Foundation requirements
   - Backfill envelope – backfill recommendations
7. Structure End Treatment
   - Bevels, skews
   - Headwalls
   - Toewalls and cutoff walls
8. Specify Structure Installation Procedure
   - AASHTO Section 26
   - ASTM A807 for Steel Structures, ASTM B879 for Aluminum Structural Plate

References

1. AASHTO Material, Design, and Installation Specifications
   - MULTI-PLATE, SUPER-SPAN, Aluminum Structural Plate, Box Culvert and BridgeCor – material design and installation
   - Typical specifications
2. CAD Drawings
   - Structure shape and detail drawings are available to the designer upon request.
3. An NCSPA Corrugated Steel Pipe Design Manual is available from the NCSPA or your local Contech representative. More specific information on each step or topic is available from Contech Engineered Solutions.

These are the typical steps involved in designing a structural plate bridge. This brochure contains specific information about MULTI-PLATE, Aluminum Structural Plate, Aluminum Box Culverts, SUPER-SPAN/SUPER-PLATE, and BridgeCor.

STRUCTURE SHAPE GEOMETRY						
Shapes		Sizes=Span x Rise	Common Uses	Steel	Aluminum	Trade Name
Round		5′ to 50′-6″	Culverts, storm sewers, aggregate tunnels, vehicular and pedestrian tunnels and stream enclosures. Functions well in all applications, but especially in those with high cover	x x		MULTI-PLATE BridgeCor
					x	Aluminum Structure Plate
Vertical Ellipse		4′-8″ x 5′-2″ to 25′ x 27′-8″	Culverts, storm sewers, service tunnels, recovery tunnels and stream enclosures. Works well in higher cover applications.	x		MULTI-PLATE
					x	Aluminum Structure Plate
Underpass		12′-2″ x 11′-0″ to 20′-4″ x 17′-9″	Offers efficient shape for passage of pedestrians or livestock, vehicular traffic and bicycles with minimal buried invert.	x		MULTI-PLATE
					x	Aluminum Structure Plate
Pipe-Arch		6′-1″ x 4′-7″ to 20′-7″ x 13′-2″	Limited headroom. Has hydraulic advantages at low flow levels. Culverts, storm sewer, underpass and stream enclosures.	x		MULTI-PLATE
					x	Aluminum Structure Plate
Horizontal Ellipse		7′-4″ x 5′-6″ to 14′-11″ x 11′-2″	Culverts, bridges, low cover applications, wide centered flow, good choice when poor foundations are encountered.	x		MULTI-PLATE
					x	Aluminum Structure Plate
Arch (single radius)		6′ x 1′-10″ to 54′-4" x 27′-2″	Low clearance, large waterway opening. Aesthetic shapes and open natural bottoms for environmentally-friendly crossings.	x x		MULTI-PLATE BridgeCor
					x	Aluminum Structure Plate
Arch (2-radius)		18′-5″ x 8′-4″ to 50′-7″ x 19′-11″	Low clearance, large waterway opening. Aesthetic shapes and open natural bottoms for environmentally-friendly crossings.	x		BridgeCor
Low-Profile Arch*		19′-5″ x 6′-9″ to 45′-0″ x 18′-8″	Culvert, storm sewers, low headroom and large opening. Bridge structures, stream enclosures. Aesthetic shapes and open natural bottoms for environmentally friendly crossings.	x		SUPER-SPAN
					x	SUPER-PLATE***
High-Profile *		20′-1″ x 9′-1″ to 35′-4″ x 20′-0″	Culverts, storm sewers, bridges, Higher rise, large area opening. Open natural bottoms for environmentally friendly crossings.	x		SUPER-SPAN
					x	SUPER-PLATE
Horizontal Ellipse		19′-4″ x 12′-9″ to 37′-2″ x 22′-2″	Larger culverts and bridges. Low headroom, wide-centered flow, good choice when poor foundations are encountered.	x		SUPER-SPAN
					x	SUPER-PLATE
Pear-Arch		23′-11″ x 23′-4″ to 30'-4" x 25'-10"	Railroad underpasses or large clearance areas. Open natural bottoms for environmentally friendly crossings.	x		SUPER-SPAN
Pear		23′-8″ x 25′-5″ to 29'-11" x 31'-3"	Railroad underpasses or large clearance areas.	x		SUPER-SPAN
Box Culvert		8′-9″ x 2′-6″ to 40′9″ x 15′2″	Very low, wide bridges, culverts and stream enclosures, with limited headroom. Functions well as a fast small-span bridge replacement.	x		BridgeCor
					x	Aluminum Box Culvert
Elliptical/Circular Arch **		12′ to 102′	Culverts, bridges, tunnels, wetlands crossings, overpass/ underpass, underground containment, wine/cheese cellars and shelters.			CON/SPAN® BEBO® (precast concrete)
Vehicular ** Pedestrian **		spans up to 200′ spans up to 300′	County, city, parks, industrial complexes. Recreational, overpasses, industrial conveyor, pipe support.	x		Steadfast® Vehicular Truss Continental® Pedestrian Truss

* Larger steel sizes are available up through 70-foot spans with the BridgeCor® product line. Contact your local Contech representative for more information.
** The design process for these bridge structures is not covered in this document. Contact your local Contech representative for more information.
*** Low-Profile Arch SUPER-PLATE is only available up to 38'-8" x 15'-9".

Selection of Structure Shape

Contech manufactures and supplies structural plate in a wide variety of structure shapes and sizes in both galvanized steel and aluminum alloy. The large selection of structure types ensures that a designer will be able to select the optimum structure for virtually any application from low cover situations to extreme cover heights and from pedestrian underpasses to grade separations for airport runways or railroad passages.

The structures listed on page 4 are generally configured for use in specific drainage or traffic passage applications. They are prioritized from top to bottom. This will ensure the most efficient usage and best economy. For example, a designer should first check to see if a round structure will satisfy the project requirements. If there is inadequate headroom for a round structure, proceed to a pipe-arch, horizontal ellipse, or arch and on to Aluminum Box Culverts. If a larger structure is required, consider a SUPER-SPAN or BridgeCor type structure. More detailed structure dimensions and information can be found in later sections of this document.

Following are some tips on structure shape and size selection:

- ✔ It is usually best to select a shape that most closely matches the shape of the drainage channel. For example, a deep narrow channel will accept a round structure. Horizontal ellipses, low profile arches and Aluminum Box Culvert shapes are best suited to relatively wide, shallow channels.
- ✔ Look first at the end area requirement in square feet for the structure and divide the number by the vertical distance from the streambed to the surface elevation less approximately 1.5′ to 3.0′ for fill cover over the structure. This will somewhat underestimate the approximate minimum span required depending upon the structure shape.
- ✔ Look for the most efficient structure in terms of reducing design loads. For Aluminum Box Culverts, choose a structure that meets the hydraulic requirements and provides for cover of 3-4 feet. A taller structure which minimizes cover may be less cost-effective than one of similar span with slightly higher cover.
- ✔ For other plate structures:
  - Where fill over the structure is high, try to utilize the tallest structure feasible to minimize cover. As cover increases, so does gage as well as footing sizes.
  - Where fill over the structures is low, choose a structure that maintains the minimum allowable cover.

Additional Considerations

In addition to simple geometric and hydraulic concerns, the designer should consider other parameters that may influence structure type, shape and material including:

• Very High Fill

Fills over approximately 30′ should warrant the consideration of Key-Hole Slot MULTI-PLATE® discussed on page 16.

• Pipe Structure versus Arch on Footings

In general, a pipe with a full invert or pipe with a buried invert is preferable in terms of cost versus an arch because of the elimination of concrete footings. However, many regulations require natural, undisturbed stream bottoms. In this case, an arch on footings is typically less expensive than a traditional bridge.

• Bearing Capacity

See sections on individual structure types for recommendations on minimum bearing capacity and footings designs. Pipe arch design should include considerations of applied corner bearing pressure.

• Flow Characteristics

If flow is to be particularly abrasive, the designer should consider a natural invert (arch or buried invert), heavier invert plates, an aluminum structure, or applying a paved invert.

• Corrosive Soils

Analyze structure life projections based upon the CALTRANS/AISI method. If design life is not met using galvanized steel, consider asphalt coating the steel, adding a concrete field paved invert or using aluminum instead. See page 12 for recommendations for protection from de-icing salts.

• Corrosive Effluents

Analyze structure invert life projections based upon the CALTRANS/AISI method. If design life is not met using galvanized steel, consider either heavier gage invert plates, paved invert, natural invert, or aluminum. In particularly corrosive situations an arch on elevated footing walls (pedestal walls) may be the best solution.

Scour

If scour is a concern, a pipe structure or pipe structure with a buried invert may be more desirable than an arch. The invert eliminates footings subject to scour. Also, arches with partially buried structure legs (and footings) may satisfy scour depth. Often, when an arch on footings must be used, protecting the footings with rip-rap, sheet piling, permanent erosion control, hard armor interlocking blocks, etc., is more cost effective than deep footings or footings on piles. Scour analysis is outside the scope of this brochure.

FHWA Hydraulic Engineering Publication HEC-18 outlines the design for scour. FHWA Hydraulic Engineering Publication HEC-23 outlines the design procedures for scour counter measures.

Protect footings from scour with Armortec® hard armor solution

Selection of Structure Based Upon Clearance Requirements

The following describes the process of selecting a structure with sufficient clearance for the passage of vehicular or pedestrian traffic.

It should be noted that the dimensions of finished corrugated metal structures may differ from the nominal dimensions described in literature. For instance, taller single radius arches may "peak" slightly during backfilling, thus slightly decreasing the effective span.

If clearance tolerance is critical, it is recommended that a slightly larger structure be selected or that the structure shape be monitored during erection and backfilling. Proper control of compaction and the use of high quality granular backfill material will minimize structure movement during backfilling. Contact your Contech representative for assistance or recommendations regarding monitoring and the use of particular shapes.

MULTI-PLATE® and Aluminum Structural Plate vertical ellipses and underpass shapes are configured specifically for vehicular and pedestrian traffic. The structure invert is often "paved" to provide a smooth surface.

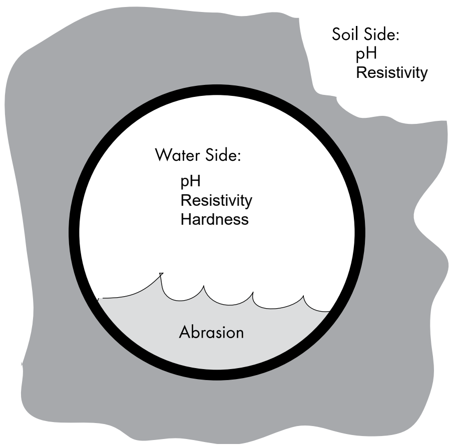
While arch structures often appear to be the best choice for many applications, the same shape in a round or elliptical shape may be more economical due to the elimination of footings. For example, a round structure or horizontal ellipse with the invert buried and/or paved are often used in lieu of an arch for grade separation structures.

Horizontal ellipse SUPER-SPAN

Designing For Service Life

After a structure shape and size is selected based upon hydraulic or clearance requirements and the structure gage is determined, the designer should normally proceed to an analysis of the possible effects of the environment on structure performance. This may lead the designer to specific selections of material, structure type, coating, or invert protection.

Structure life can be affected by the corrosive action of the backfill in contact with the outside of a structure or more commonly by the corrosive and abrasive action of the flow in the invert of the structure. The design life analysis of the structure should include a check for both water side and soil side environments to determine which is most critical or which governs structure life.



The choice of material or structure type can be extremely important to service life. For example, if it is determined that water flowing through a structure is projected to limit the life of the invert through abrasive or corrosive action, an arch may be used with a natural invert or the invert may be paved. Other possible remedies may exist depending upon other structure requirements.

Corrosion Studies for Metal Structures

Galvanized steel structural plate has been used in the United States since 1931. Aluminum Structural Plate has been in use since the early 1960's. Tens of thousands of structures are in use in a wide variety of applications and environments. This wealth of experience provides unsurpassed "in-the-ground" performance knowledge. Several rational methods exist for determination of the effects of corrosion upon galvanized steel and aluminum drainage structures. Numerous federal agencies, including the Federal Highway Administration and U.S. Army Corps of Engineers as well as a large number of state departments of transportation, have published guidelines on the subject. All have valuable information pertinent to possible corrosive effects on both steel and aluminum materials.

Galvanized Steel MULTI-PLATE®

With regard to the durability of galvanized steel MULTI-PLATE, this design guide will outline the guidelines established by the California Department of Transportation (CALTRANS). The CALTRANS design method originated from a study that inspected over 7,000 galvanized steel corrugated metal pipe (CMP) drainage structures throughout the state of California. Through this field study they were able to develop a reliable method for predicting the service life of smaller diameter corrugated galvanized steel pipes. The data collected reflected the combined effects of corrosion and a wide range of abrasive levels. The conclusion of the CALTRANS study defined the end of the structure life to be coincident with the first perforation (or approximately 12% metal loss) in the invert of culverts that have received no special maintenance.

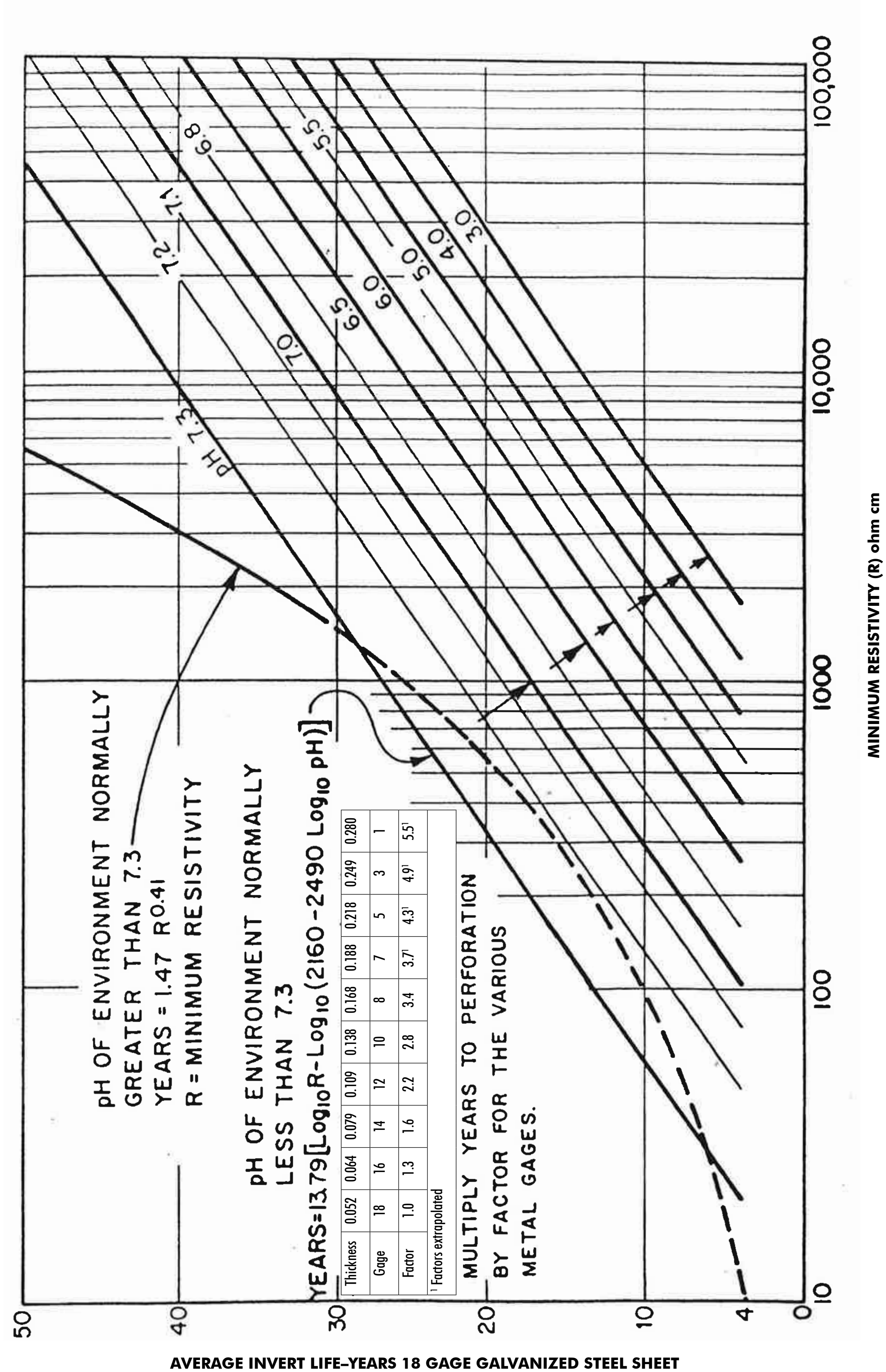
The service life of 2 oz. per square foot of zinc-coated galvanized CMP is determined by using the CALTRANS chart for estimating invert life (see page 8). This chart predicts a variable service life based on pH and resistivity of water and soil and has been the industry standard for many years. The results included the combined effects of soil-side and interior corrosion, as well as the average effects of abrasion. For pipes where the pH was greater than 7.3, soil-side corrosion controlled and and life was predicted by resistivity. For pipes were pH was less than 7.3, the interior invert corrosion generally controlled and both pH and resistivity were important.

It is important to note, the consequences of small perforations are minimal in gravity flow pipe systems, such as most storm sewers and larger culverts, and may not accurately reflect the estimated service life outlined by CALTRANS. Because of this fact, the original CALTRANS curves have been converted to average service life curves using data on weight loss and pitting in bare steel developed by National Institute of Standards and Technology. Using this information, the American Iron and Steel Institute (AISI) developed a durability chart using the end of an average effective service life to be estimated at approximately a 25% metal loss in the invert. The AISI chart can be found at NCSPA.org.

In addition, the structural plate covered in this design guide utilizes a 3 oz. per square foot of zinc coating and uses heavier gage material as part of the structural design. This is a 50% increase in additional barrier coating and adds additional base metal thickness that was not investigated in the original CALTRANS study. These two additional key factors will provide a longer service life than predicted in these charts.

If the designer has site specific knowledge and understands the key design parameters, the AISI method may be more applicable in the pipe service life design. Many state DOT's find the CALTRANS method to be a conservative estimate of the average observed service life of galvanized steel structures

Figure 1. CALTRANS Chart For Estimating Average Invert Life For Plain Galvanized Culverts



Thickness	0.052	0.064	0.079	0.109	0.138	0.168	0.188	0.218	0.249	0.280
Gage	18	16	14	12	10	8	7	5	3	1
Factor	1.0	1.3	1.6	2.2	2.8	3.4	3.7[1]	4.3[1]	4.9[1]	5.5[1]

[1] Factors extrapolated

in their states. Although a gravity flow drainage structure of any kind functions properly well beyond the occurrence of the first perforation, the use of the CALTRANS method best illustrates the variety of environmental conditions found throughout the country.

An important factor when choosing a design method, either CALTRANS or AISI, is knowledge of the structure backfill type. A structure backfilled with very fine material may be affected by the loss of this material through perforations. Thus, the CALTRANS method may be valid. If the backfill is more granular, which is usually the case with plate structures, then first perforation is probably inconsequential and, therefore, the AISI method would be more appropriate.

The CALTRANS chart for estimating average invert life is shown on page 8.

The designer should note that other factors will affect the rate of metal loss. The primary factor is the presence of dissolved salts such as $CaCO_3$ and $MgCO_3$. Total hardness is a measure of the level of dissolved salts and defined water runoff as hard or soft water.

Hardness levels greater than 300 mg/L indicate dissolved salts (hard water) of a level that will cause the formation of a mineral “scale” on the galvanized surface that will provide excellent protection and increased service life in the absence of abrasion. Inspections have shown 50-year-old structures with mineral scale and pristine metal conditions beneath.

Hardness levels below 300 mg/L warrant further consideration by the designer and the possible use of coatings, invert protection/paving or aluminum.

In general, the recommended environmental range for use of galvanized steel Structural Plate that will provide a minimum service life of 50 years is:

water side & soil side

$6 \leq pH \leq 10$ $6 \leq pH \leq 10$

$2000 \text{ ohm-cm} \leq R \leq 8000 \text{ ohm-cm}$*

* Values greater than 8000 ohm-cm for water side resistivity may indicate low level of dissolved salts (soft water). Water hardness should be tested. Invert protection may be required to meet the designated service life.

Aluminum Structural Plate

Studies similar to those conducted by CALTRANS have been performed upon a large number of Aluminum Structural Plate installations for the same purpose although none have produced a mathematical model like that for galvanized steel. Aluminum loss rates have been so low as to preclude a reliable model.

Aluminum alloy reacts much differently than galvanized steel when in contact with air, soil, and water. Instead of zinc/steel system of galvanic protection, aluminum resists corrosion by a passive formation of a very tenacious aluminum-oxide layer on its surface. This oxide layer has been shown in field and laboratory observation to be stable in an environment of pH between 4 and 9 and resistivity greater than 500 ohm-cm. Within this range, corrosion rates are minimal and prediction of service life is a matter of assigning a pit rate based upon laboratory testing. Conservatively, a pit rate based on 0.001”/yr may be used.

In this case:

0.100” thick plate 0.001”/yr = 100 yrs design life.

Actual field observations of aluminum alloy pipe (ALCLAD) and Aluminum Structural Plate support this estimation.

In tidal brackish and saltwater environments, Aluminum Structural Plate will perform well if backfilled with free-draining material. The pH and resistivity requirements outlined previously must also be met. Sea water normally exhibits a $pH = 7.5 – 8.0$ and resistivity < 100/ohm-cm, but given the neutral pH and a free draining backfill, Aluminum Structural Plate still performs well.

Notes: For more detailed information on the subject of corrosion or copies of the referenced documents or guidelines, contact your Contech representative.

Steel Structural Plate Pipe Arch
Installed c. 1940
Inspected in 2012

Abrasion

The potential for metal loss in the invert of a drainage structure due to abrasive flows is often overlooked by designers and its effects are often mistaken for corrosion. Environments conducive to abrasive flows are well defined but due to the periodic nature of this event, it is easy to miss.

Three factors must combine to cause invert abrasion:

- Abrasive bedload
- Sufficient velocity to carry the bedload
- Flow duration and frequency

Examples of abrasive materials include but are not limited to sands, gravels, and stone. The designer should not underestimate the abrasive action of sand transported in sustained flows. When flow velocities reach approximately 5-6 feet-per-second, sand and gravels can become mobile or suspended.

Most commonly, abrasive bedloads remove protective mineral scale and produce oxidation on galvanized steel which will accelerate corrosion. Upstream stilling basins that allow abrasive particles to settle or drop out prior to entering the structure can be very effective in extending the service life.

Guidelines for abrasion levels are excerpted from the FHWA Memorandum on Design Guidance and Specification Changes for Drainage Pipe Alternative Selection and are shown on the next page.

Both of these factors, velocity and abrasiveness, may be present at a particular site. However, if the flow necessary to carry the bedload occurs only a few times during the life of the structure, abrasion may not be a concern. The designer should refer to the 2- or 5-year event velocity and then use this to decide if abrasion is a valid concern.

Should abrasion be determined to be a limiting factor in structure life, several solutions are available to the designer. These solutions include:

- Use of a structure with a buried invert
- Use of an arch structure
- Concrete invert pavement (see page 12)
- Heavier gage invert plates
- Stilling basins near the invert

Notes: Aluminum performs better than galvanized steel when subjected to abrasion. In some cases, the formation of the oxidized steel layer (in hard water) is removed by abrasion, exposing the galvanized coating beneath. After years of abrasion have taken place, the protective galvanized coating is abraded away and corrosion of the bare steel begins. This corrosion/abrasion cycle continues for the life of the structure.

Aluminum may lose its oxide layer when abraded away but it quickly reforms at low flows, therefore limiting corrosion. Aluminum does not have a protective coating to lose after years of abrasive flow.

This is not meant to suggest that Aluminum Structural Plate should be used in heavily abrasive environments. However, its performance can be expected to be superior to galvanized steel.

FHWA Memorandum on Design Guidance and Specification Changes for Drainage Pipe Alternative Selection

The durability and service life of a drainage pipe after installation is directly related to the environmental conditions encountered at the site and the type of materials and coatings from which the culvert was fabricated. Two principal causes of early failure in drainage pipe materials are corrosion and abrasion. The environmental damage caused by corrosion and abrasion can be delayed by the type of materials, coatings and invert protection.

It is the Federal Lands Highway (FLH) policy to specify alternative drainage pipe materials on projects where feasible and to comply with the provisions of the Federal-Aid Policy Guide Section 611.411(d). All permanent drainage pipe installations shall be designed for a minimum of 50 years with a maintenance-free service life. A shorter service life may be used for temporary installations, and a longer service life may be considered in unusual situations.

All suitable pipe materials, including reinforced concrete, steel, aluminum and plastic pipe shall be considered as alternatives on FLH projects. The portion of this pipe selection criteria covering metal pipe complies with the guidance contained in Federal Highway Administration (FHWA) Technical Advisory T 5040.12 dated October 22, 1979, and incorporates information contained in FHWA-FLP-91-006, Durability of Special Coatings for Corrugated Steel Pipe.

Abrasion: An estimate of the potential for abrasion is required at each pipe location in order to determine the need for invert protection. Four levels of abrasion are referred to in this guidance and the following guidelines are established for each level:

- **Level 1:** Nonabrasive conditions exist in areas of no bed load and very low velocities. This is the condition assumed for the soil side of drainage pipes.
- **Level 2:** Low abrasive conditions exist in areas of minor bed loads of sand and velocities of 5 feet per second (1.5 meters per second) or less.
- **Level 3:** Moderate abrasive conditions exist in areas of moderate bed loads of sand and gravel and velocities between 5 and 15 fps (1.5 m/s and 4.5 m/s).
- **Level 4:** Severe abrasive conditions exist in areas of heavy bed loads of sand, gravel, and rock and velocities exceeding 15 fps (4.5 m/s).

These definitions of abrasion levels are intended as guidance to help the designer consider the impacts of bedload wear on the invert of pipe materials. Sampling of the streambed materials is not required, but visual examination and documentation of the size of the materials in the streambed and the average slope of the channel will give the designer guidance on the expected level of abrasion. Where existing culverts are in place in the same drainage area, the conditions of inverts should also be used as guidance. ***The expected stream velocity should be based upon a typical flow and not a 10- or 50-year design flood.***

Corrosion: Alkalinity/Acidity (pH) and Resistivity—Determinations of pH and resistivity are required at each pipe location in order to specify pipe materials capable of providing a maintenance free service life. The samples shall be taken in accordance with the procedures described in AASHTO T 288 and T 289. Samples should be taken from both the soil and water side environments to ensure that the most severe environmental conditions are selected for determining the service life of the drainage pipe. Soil samples should be representative of backfill material anticipated at the drainage site. Avoid taking water samples during flood flows or for two days following flood flows to insure more typical readings. In locations where streams are dry for much of the year, water samples may not be possible or necessary. In areas of known uniform pH and resistivity readings, a random sampling plan may be developed to obtain the needed information.

In corrosive soil conditions where water side corrosion is not a factor, consider specifying less corrosive backfill material to modify the soil side environment. The mitigating effect of the specified backfill should be taken into account in making alternative pipe materials selections in situations where soil side conditions control.

Adjustments for Abrasion

Once the minimum structural gage is selected and service life requirement checked on "The CALTRANS Chart for Estimating Average Invert Life" (on page 8) adjustments should be made based on the abrasion potential of the site.

Steel

At **non-abrasive** or **low abrasive** sites, no additional protection is needed. At sites that are **moderately abrasive**, increase the thickness of the material by one standard thickness or add invert protection like a concrete paved invert. At **severely abrasive** sites, increase the thickness of the material by one standard thickness and add a concrete paved invert.

Aluminum

At **non-abrasive**, **low abrasive** or **moderately abrasive** sites, no additional protection is needed. At **severely abrasive** sites, increase the thickness of the material by one standard thickness and add a concrete paved invert.

Additional Service Life Considerations

Dissimilar Metals

Metals with a substantial difference in electrical potential should be insulated from each other. Electrical potential may be established by referring to the electromotive scale. The only significant concern with regard to structural plate is the use of "black" steel in conjunction with aluminum. Black steel should not be in contact with aluminum. Hot Dipped Galvanized steel is compatible with Aluminum Structural Plate.

Concrete or Grout in Contact with Aluminum

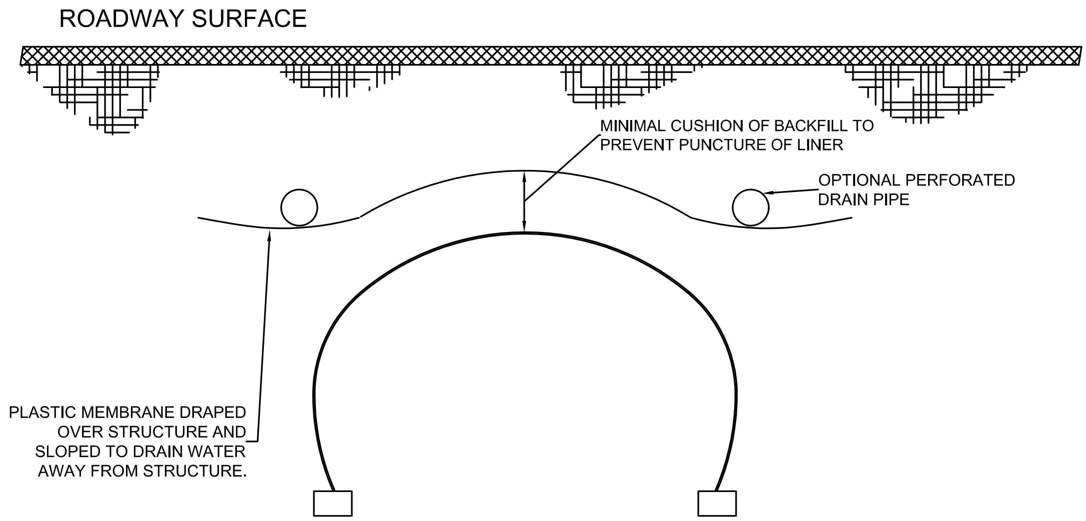
During the relatively short period while concrete cures, minor etching (<0.001") of the surface of the plate will occur. If the designer is concerned with cosmetic etching of the aluminum, the surface may be coated with asphalt or primer paint.

De-icing Salts

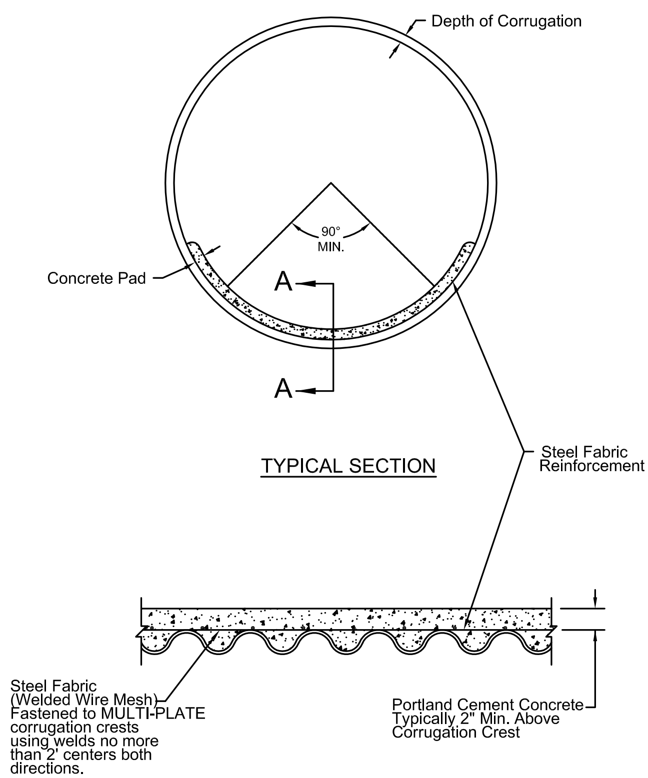
The potential for use of de-icing salts on roadway surfaces above structural plate must be addressed during the design phase. Calcium chloride and magnesium chloride as well as other de-icing materials can cause corrosion of galvanized steel and aluminum.

It is recommended that the designer consider the use of either an asphalt coating on the exterior of the structure or a polymeric membrane over the structure. Details for each of these solutions are presented on the following pages.

In addition, impermeable clay layers above the select backfill have been used to shed water from the crown of the structure.



OPTIONAL MEMBRANE PROTECTION FROM DE-ICING SALTS



SECTION A-A

CONTECH® ENGINEERED SOLUTIONS LLC
www.ContechES.com

STRUCTURAL PLATE DETAILS
MEMBRANE PROTECTION AND
CONCRETE PAVED INVERT

Structural Design of Corrugated Metal Structures

Gage (Metal Thickness) Determination and Resulting Safety Factors

According to the American Association of State Highway and Transportation Officials (AASHTO) Standard Specifications for Highway Bridge, corrugated metal plate structures are "Soil – Corrugated Metal Structure Interaction Systems." The implication is that plate structures are composites comprised of the surrounding soil envelope which act in conjunction with the structures' inherent strength to support traffic and soil loads.

Design methods for corrugated metal plate structures are well established and provide the designer with straightforward, conservative procedures. Current AASHTO design procedures also address foundation, backfill and end treatment. (See page 29 for listing of all applicable design specifications.)

The basic plate structure design process for the determination of the structure gage consists of:

1. Determine the backfill soil density adjacent to and above the metal structure.
2. Calculate the design pressure applied by the soil column and live load.
3. Compute the compression in the structure wall.
4. Determine the required thickness based upon checks for wall yielding and buckling (using the correct corrugated section properties).
5. Check for sufficient bolted longitudinal (plate to plate) seam strength.
6. Check for minimum stiffness required for proper handling, assembly, and installation.

Dead Loads

Dead loads are those developed by the soil fill above the structure plus those of any stationary surcharge loads such as buildings. Dead loads are calculated by multiplying the soil density by the height of cover.

Dead Load (DL) = γ x H

Where: DL = Dead load pressure (lb/ft^2)

γ = unit weight of soil (120 pcf)

H = Height of fill over structure (ft)

Live Loads

Live loads consist of traffic loads applied to the surface or roadway above the structure. These loads also consider the effect of impact loads. Live loads reaching the structure diminish with increasing heights of cover. Overall, this manual considers H-20, H-25, HS-20, HS-25, and HL-93 highway loads. Cooper railroad loads (E-80) are addressed in the Amercian Railroad Engineering and Maintenance of Way Association (AREMA) specification which is similar to the procedure outlined. Airport loading and off-highway loads such as mining equipment are special loading conditions.

Live loads reaching the structure are more complicated to determine. Using information provided by AASHTO, the National Corrugated Steel Pipe Association (NCSPA) has prepared a very comprehensive method for determination of the loads reaching the corrugated metal structure.

Highway Live Load Pressures

AASHTO design results in a live load pressure distribution are provided in the following table:

TABLE 1.
LIVE LOAD PRESSURES FOR DESIGN
AASHTO

Height of Cover (Feet)	H-20 Loading (psf)	H-25 Loading (psf)
1	2270	2580
2	850	1000
3	420	510
4	285	350
5	210	250
6	160	190
7	120	150
8	100	120
9	--	100

For additional information on the methodology for developing these live load pressures or AASHTO, AISI, and AREMA tables, contact your local Contech representative.

AASHTO Section 12: Design Equations (Service Load Design)

- **Design Pressure P**
  P = Live load + Dead Load (lb/sq ft)
  Live load (Table 1)
  Dead load (height of cover x unit weight of soil)

- **Wall Thrust**
  $T_s = P \times S/2$
  T_s = wall thrust (lb/ft)
  S = diameter or max span (ft)

- **Wall area**
  $A = T_s/f_a$
  T_s = wall thrust (lb/ft)
  f_a = allowable stress (min. yield point FS = 2) lb/sq in)

- **Buckling**
  If f_{cr} is less than f_a, Area (A) must be recalculated using f_{cr} in lieu of f_a.

  Where:
  r = radius of gyration (inches)

  $$\text{If } S < \frac{r}{k}\sqrt{\frac{24E_M}{f_u}}$$

  $$\text{then } f_{cr} = f_u - \frac{f_u^2}{48E_M}(ks/r)^2$$

  $$\text{If } S > \frac{r}{k}\sqrt{\frac{24E_M}{f_u}}$$

  $$\text{then } f_{cr} = \frac{12E_M}{(kS/r)^2}$$

  f_u = min. tensile strength (psi)
  f_{cr} = critical buckling strength (psi)
  k = soil stiffness factor = 0.22
  S = pipe diameter or max span (inches)
  E_M = modulus of elasticity of metal (psi)

- **Flexibility Factor**
  $FF = S^2/E_M I$

  [FF= Flexibility factor (in/lb)]
  S = pipe diameter or max span (in)
  E_M = modulus of elasticity of metal (psi)
  I = moment of inertia (in^4/in)

Limiting Flexibility Factor Values

a) Steel 6"x2" corrugations
   round = 0.02
   pipe-arch = 0.03
   arch = 0.03
   underpass = 0.02

b) Aluminum 9" x 2 1/2" corrugations
   round = 0.025
   pipe-arch = 0.036
   arch = 0.036
   underpass = 0.025

- **Seam Strength**
  $SS = T_s \times FS$
  Safety factor = 3
  SS = seam strength = lb/ft

AISI requires a seam strength safety factor of two, while AASHTO requires a seam strength safety factor of three.

"The Chief" a 5,000,000 lb. drag line over steel SUPER-SPAN™ at Peabody Coal in Zanesville, Ohio

When Seam Strength Governs Structure Design

When the design analysis shows the seam strength of a structure (using the standard four bolt per foot seam) is the limiting factor, which can occur when fill heights become significant, the design engineer can adjust the following factors: increase the gage to add seam strength and/or consider the use of six or eight bolts per foot.

The following table provides seam strength values for four, six and eight bolts per foot.

**TABLE 2.
ULTIMATE SEAM STRENGTH
OF BOLTED STEEL STRUCTURAL PLATE LONGITUDINAL SEAMS
IN POUNDS PER FT OF SEAM**

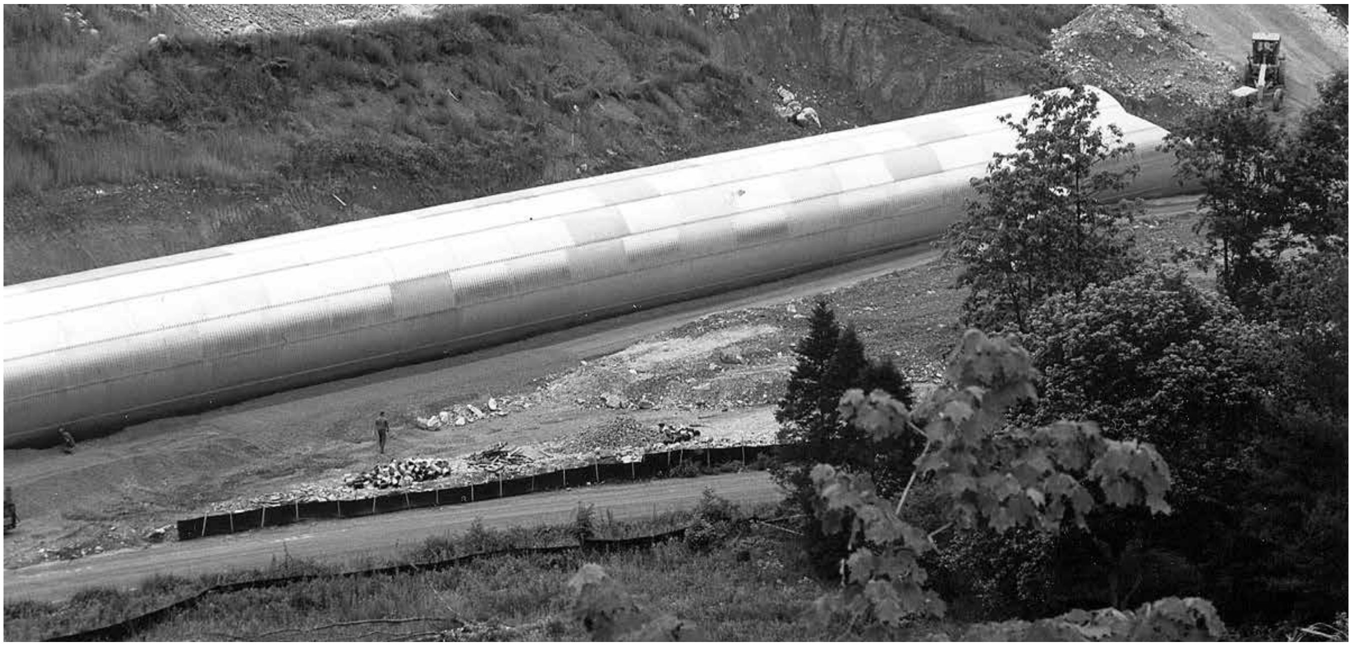
Gage	Specified Thickness (in.)	6" x 2" Corrugation		
		4 Bolts Per Ft.	6 Bolts Per Ft.	8 Bolts Per Ft.
12	0.111	42,000		
10	0.140	62,000		
8	0.170	81,000		
7	0.188	93,000		
5	0.218	112,000		
3	0.249	132,000		
1	0.280	144,000	180,000	194,000
5/16	0.318			235,000
3/8	0.380			285,000

Notes:
1. Bolts used are 3/4" diameter – high strength bolts, meeting ASTM A449.
2. Bolts and nuts also used for connecting arch plates to receiving angles and structural reinforcement to structural plates.
3. 5/16 and 3/8 require 7/8" fasteners.

**TABLE 3.
ULTIMATE SEAM STRENGTH
OF BOLTED ALUMINUM STRUCTURAL PLATE LONGITUDINAL SEAMS
IN POUNDS PER FT OF SEAM**

Thickness, inches	Ultimate Seam Strength
0.100	28,000
0.125	41,000
0.150	54,100
0.175	63,700
0.200	73,400
0.225	83,200
0.250	93,100

Notes:
1. Bolts are 3/4" diameter meeting ASTM A307/A449



24'-0" diameter steel MULTI-PLATE® designed for 60 feet of fill owned by VDOT in Dryden, Virginia

Section Properties

TABLE 4.
STEEL CONDUITS

Gage	Thickness (Inches)	6" x 2" Corrugations			
		A_s Sq. In./Ft.	r (Inches)	Section Modulus	I x 10^{-3} In.^{4}/In.
12	0.111	1.556	0.682	0.0574	60.411
10	0.140	2.003	0.684	0.0733	78.175
8	0.170	2.449	0.686	0.0888	96.163
7	0.188	2.739	0.688	0.0989	108.000
5	0.218	3.199	0.690	0.1147	126.922
3	0.249	3.650	0.692	0.1302	146.172
1	0.280	4.119	0.695	0.1458	165.836
5/16	0.318	4.671	0.698	0.1640	190.000
3/8	0.380	5.613	0.704	0.1950	232.000

TABLE 5.
ALUMINUM CONDUITS

Thickness (Inches)	6" x 2" Corrugations			
	A_s Sq. In./Ft.	r (Inches)	Section Modulus	I x 10^{-3} In.^{4}/In.
0.100	1.404	0.8438	0.767	83.065
0.125	1.750	0.8444	0.951	103.991
0.150	2.100	0.8449	1.131	124.883
0.175	2.449	0.8454	1.309	145.895
0.200	2.799	0.8460	1.484	166.959
0.225	3.149	0.8468	1.657	188.179
0.250	3.501	0.8473	1.828	209.434

Steel Structural Plate Pipe, Pipe-Arch, and Arch Material Requirements—AASHTO M 167

TABLE 6.
MECHANICAL PROPERTIES FOR DESIGN

f_u Minimum Tensile Strength (psi)	f_y Minimum Yield Point (psi)	E_m Mod. of Elast. (psi)
45,000	33,000	29 x 10^6

Aluminum Structural Plate Pipe, Pipe-Arch, and Arch Material Requirements—AASHTO M 219, Alloy 5052

TABLE 7.
MECHANICAL PROPERTIES FOR DESIGN

Thickness (inches)	f_u Minimum Tensile Strength (psi)	f_y Minimum Yield Point (psi)	E_m Mod. of Elast. (psi)
0.100 to 0.175	35,000	24,000	10 x 10^6
0.176 to 0.250	34,000	24,000	10 x 10^6

AASHTO Section 12 (Service Load Design)

Design Examples

Example 1

Given: Pipe diameter = 22′ Round (Steel)
Height of cover = 10′
γ = unit weight of soil (120 pcf)
Live Load (LL) = H-20
Backfill = Compacted 90% AASHTO T 180
A-1, A-2, A-3

Solution:

1. Design Pressure P (refer to Table 1):

10′ of cover, Live Load = 0

Dead Load = H (10′) x γ(120 pcf)
Therefore P = 1200 psf

2. Wall Thrust:

$$Ts = P \times \frac{Span}{2} = 1200 \text{ psf} \times \frac{22'}{2} = 13{,}200 \text{ lb/ft}$$

3. Wall Area:

$$A = T_s/f_a$$

Where: T_s = Wall Thrust
f_a = allowable stress
(minimum yield point F.S. = 2)

Therefore:
$$f_a = \frac{f_y}{2} = \frac{33{,}000}{2} = 16{,}500 \text{ psi}$$
$$A = \frac{13{,}200 \text{ lb/ft}}{16{,}500 \text{ psi}} = 0.8 \text{ in}^2\text{/ft required}$$

From Table 4, use 0.111 thickness

4. Buckling
(See page 14 for key to terms)
Wall area A = 1.556 in^2/ft to be checked for possible buckling.

If allowable buckling stress, $f_{cr}/FS < f_a$

then area must be rechecked using f_{cr}/FS in lieu of f_a.

FS = 2.0

If $S < \frac{r}{k}\sqrt{\frac{24 E_m}{f_u}}$ then $f_{cr} = f_u - \frac{f_u^2}{48 E_m}\left(ks/r\right)^2$

If $S > \frac{r}{k}\sqrt{\frac{24 E_m}{f_u}}$ then $f_{cr} = \frac{12 E_m}{\left(kS/r\right)^2}$

In this example span is greater than $\frac{r}{k}\sqrt{\frac{24 E_m}{f_u}}$

Therefore $f_{cr} = \frac{12 \times 29 \times 10^6}{(.22 \times 264/.682)^2}$

$f_{cr} = 47{,}986$

$f_{cr} >$ fa 47,986 > 16,500

therefore, 0.111″ is OK

5. Seam Strength (SS):
Required SS = Ts (FS)
SS = 13,200 x 3.0
SS = 39,600 required
actual seam strength
from Table 2 = 43,000 lbs/ft
therefore 0.111″ is OK

6. Handling and Installation Strength
(Flexibility factor, FF):
FF = $S^2/E_m \times I$ for round pipe 0.02.
Therefore, I must equal 120.17×10^{-3} in.^{4}/in.
Where: S = Span in inches
E_m = Modulus of elasticity
I = Moment of inertia
Refer to Table 4 for I values
Therefore, use 0.218″

Based upon this AASHTO Section 12 check, this 22′ (264″) diameter structure could be built using 0.218″ thickness (5 gage) MULTI-PLATE® and exceed all safety factors.

Example 2

Given: MULTI-PLATE® PIPE ARCH-20′-5″ x 13′-0″
Corner radius 31″
Height of cover = 6′
Live Load (LL) = H-20
γ = unit weight of soil (120 pcf)

By following the steps described in example #1, the minimum gage would be 0.111″ (12 gage)

For pipe-arches, flexibility factor must be less than 0.03

Actual Flexibility Factor = 0.034 > 0.03 maximum

Therefore, next heavier gage of 0.140″ (10 gage) must be used.

Example 3

Given: MULTI-PLATE® Arch 23′ span x 11′6″ rise
Height of cover H = 19′
Live load (LL) = H-20
γ = unit weight of soil (120 pcf)

By following the steps in examples 1 and 2, this structure can be built using 8 gage (0.170″)

Notes: Design of Aluminum Structural Plate incorporating reinforcing ribs requires using combined properties of the ribs and corrugated shell. In addition, a plastic moment capacity check should be performed. Contech can supply design height-of-cover tables that provide the optimum rib and shell thickness combination.

Key-Hole Slot MULTI-PLATE® Structures Under High Fill

Standard MULTI-PLATE can be designed to handle very high fill heights. The ability to deflect under load produces soil arching resulting in reduced design pressure. A modified version of MULTI-PLATE, Key-Hole Slot MULTI-PLATE, is specifically designed to handle high fill heights using a special bolted seam that yields or slips under load. (See Figure 2).

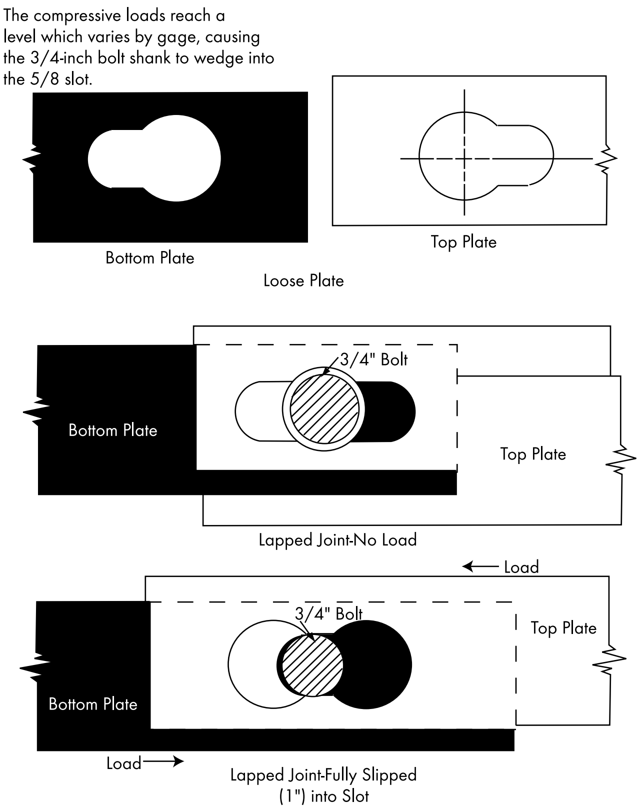


Figure 2—Key-Hole slot MULTI-PLATE® at work

This controlled yielding action in the structure seams decreases the structure circumference, promoting a high degree of soil arching over the structure. For these typically deeper installations, A-1-a backfill per AASHTO M 145 is desired as backfill for these types of flexible structures.

While specific design criteria must be applied to any project, the use of Key-Hole Slot MULTI-PLATE versus standard MULTI-PLATE can decrease the gage (material thickness) by one to three gages. A CALTRANS deep burial study compared standard MULTI-PLATE to Key-Hole Slot MULTI-PLATE and found that the average thrust created at the springline level of the Key-Hole Slot structure was approximately 50% of standard structure.

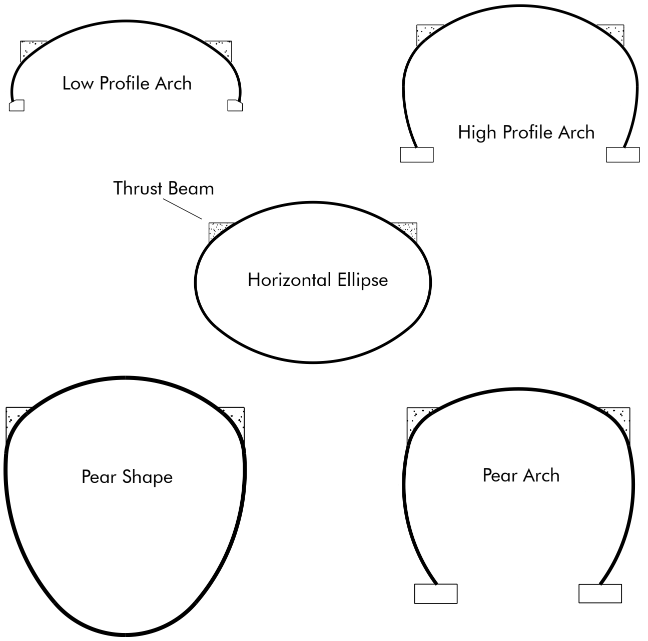
This reduction in thrust in turn reduces the required seam strength, and therefore, the structure wall gage or thickness. The designer is urged to contact a Contech representative for additional information on Key–Hole Slot MULTI-PLATE.

High Covers made possible with Key-Hole Slot MULTI-PLATE®

SUPER-SPAN™ and SUPER-PLATE® Design

Design of SUPER-SPAN and SUPER-PLATE (Long Span) structures follow AASHTO Section 12.7.

SUPER-SPAN and SUPER-PLATE feature relatively large radius or flatter curvature in the top or sides (larger than standard structural plate designs). These shapes include:



The primary differences in long span design procedures and standard plate structures design procedures are:

- Design checks for buckling and flexibility are not applied because of special features not found in other Structural Plate structures and also because of the use of high quality backfill and shape monitoring during backfill.
- Special features such as longitudinal thrust beams are incorporated to assist in the ability of the structure to transfer load to the surrounding soil envelope. Thrust beams also work to isolate the top arc, diminishing the need for a buckling analysis.
- Gage of the top plates and minimum cover are determined by the top radius (see Table 8)
- Maximum central angle of top is 80 degrees
- Ratio of top radius to side radius is equal to or greater than 2.0 and less than or equal to 4.4

SUPER-SPAN structure near Cumming, Georgia

Gage or thickness for SUPER-SPAN is a function of the structure's top radius and the live and dead loads. Table 8 below provides the recommended gages and minimum covers for SUPER-SPAN. The designer should also note that Contech Engineered Solutions provides a Shape Control Technician as a condition of the sale of a SUPER-SPAN or SUPER-PLATE. The Shape Control Technician will be on-site until the select backfill reaches the minimum height of cover required to ensure proper finished structure shape.

Aluminum SUPER-PLATE long spans are available in most of the same sizes and shapes as steel SUPER-SPANs.

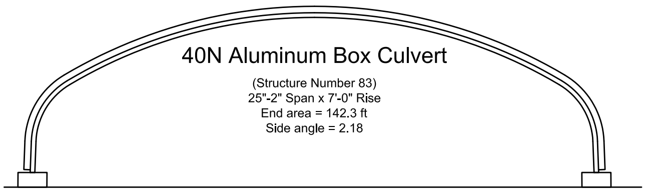
Further information is available in the SUPER-SPAN and SUPER-PLATE section of this design guide and technical guidelines contained in this brochure.

TABLE 8.
MINIMUM THICKNESS — MININUM COVER TABLE, FT. H-20, HS-20, H-25, HS-25 LIVE LOAD

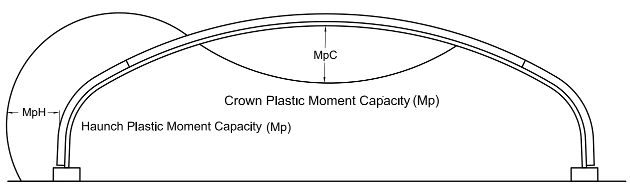
	Wall Thickness (Inches)					
Top Radius R_T Ft.	**0.111 (12 Ga.)**	**0.140 (10 Ga.)**	**0.170 or 0.188 (8 or 7 Ga.)**	**0.218 (5 Ga.)**	**0.249 (3 Ga.)**	**0.280 (1 Ga.)**
15′	2.5′	2.5′	2.5′	2.0′	2.0′	2.0′
15′-17′		3.0′	3.0′	2.5′	2.0′	2.0′
17′-20′			3.0′	2.5′	2.5′	2.5′
20′-23′				3.0′	3.0′	3.0′
23′-25′					4.0′	4.0′

For additional information regarding this table, refer to notes on page 83. Contact a Contech representative for Pear and Pear-Arch shapes.

Aluminum Box Culvert Design



The structural design of Aluminum Box Culvert (ALBC) does not follow the processes previously discussed in this guide. Due to the shape of the box culvert, the "ring compression" method used to quantify design pressures does not apply. The relatively large radius crowns are subject to high moment forces. Therefore, a separate method is used to ensure that the Aluminum Box Culvert can support both the earth loads and the live loads applied to these structures under relatively shallow fills. Primarily, the design procedure quantifies the capacity of the corrugated aluminum shell and reinforcing ribs to resist bending moments.



Due to the indeterminate nature of the structural elements, finite element analysis was developed to evaluate the plastic moment capacity of the structure. The design requirements for Aluminum Box Culverts are contained in the AASHTO Highway Bridge Design Manual Section 12.8.

Contech Engineered Solutions has also generated height of cover tables that meet the requirements of AASHTO for both HS-20, HS-25 and HL-93 live loads that supply the plate gages and reinforcing ribs necessary for a given height of cover. These values are contained in the Aluminum Box Culvert section of this manual. Note that the allowable range of minimum and maximum cover heights is limited for this category of structure. Additionally, live load is restricted to standard highway vehicles. Heavy construction loads and other heavy live load traffic are not permitted over these structures without special provisions.

Minimum Cover Over Plate Structures

Establishing minimum cover over plate structure is one of the most important factors in ensuring the successful installation of soil-corrugated metal interaction structures. Properly compacted soil over and around the structure plays an important part in distributing the load that reaches the structure. Without minimum cover, loads applied by vehicles can result in unacceptable structure deformation.

Contech Engineered Solutions publishes suggested minimum height of cover tables in each following section. When highway type loads are expected, minimum height of cover over steel or aluminum structural plate (excluding SUPER-SPAN or Aluminum Box Culvert structures) amounts to one eighth of the span or diameter of the structure with a minimum of 12" in all cases. E-80 railroad loadings require a minimum cover of about one sixth of the diameter or span. In some cases, a reinforced concrete load-relieving slab may be used when minimum cover is not achievable.

With the combination of a plate and rib, minimum cover over Aluminum Box Culverts is often lower than for standard plate structures. The required minimum cover and permissible maximum cover are limited to the values indicated in Tables 48A, 48B, 49A and 49B based on the live load classification and assuming the proper reinforcing rib and plate gage combinations shown in the height of cover tables for Aluminum Box Culverts.

Minimum cover over SUPER-SPAN structures is dependent upon the top radius of the structure. Minimum cover may be determined from Table 8 on the previous page.

Minimum cover is measured from the top of the structure to the bottom of a flexible pavement and to the top of a rigid pavement. Particular attention should be given to the height of cover near roadway shoulders as they slope away from the road crown. Minimum cover heights must be maintained throughout the life of the structure. Gravel (unpaved) roads can be mistakenly graded below the minimum cover height resulting in unacceptable loading conditions. It is recommended that unpaved roads incorporate at least 6" more than the minimum allowable cover depth to allow for rutting.

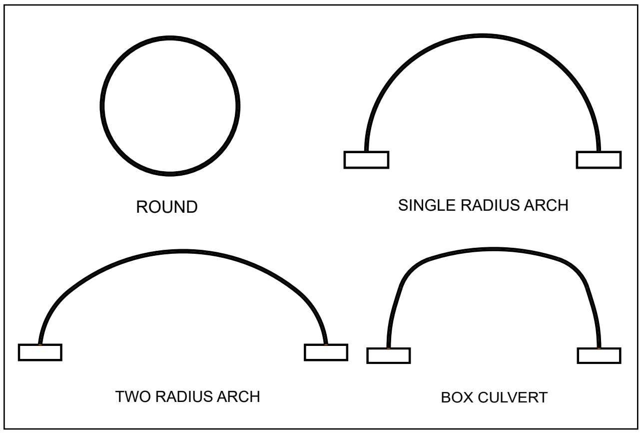
It should be understood that often the greatest live load applied to the structure may be the load applied by construction equipment. Refer to page 22 for additional information and guidance regarding required minimum cover for construction equipment and other heavy vehicle loads. Off-highway live loads such as mine haul trucks should be evaluated carefully. Contech can assist the designer with establishing minimum cover for this type of loading condition.

BridgeCor® Design

The design procedure for BridgeCor is outlined in AASHTO LRFD Section 12.8.9 - Deep Corrugated Structural Plate Structures. These structures are designed as long-span culverts but must also meet provisions for flexure and general buckling. BridgeCor structures can be made in multiple shapes and sizes to meet site specific project requirements.

Structures designed under this specification must be analyzed by accepted finite element analysis. This analysis must consider the type of soils and loads applied to the system to determine the thrust, bending and stiffness properties of the structural plate.

These shapes include:



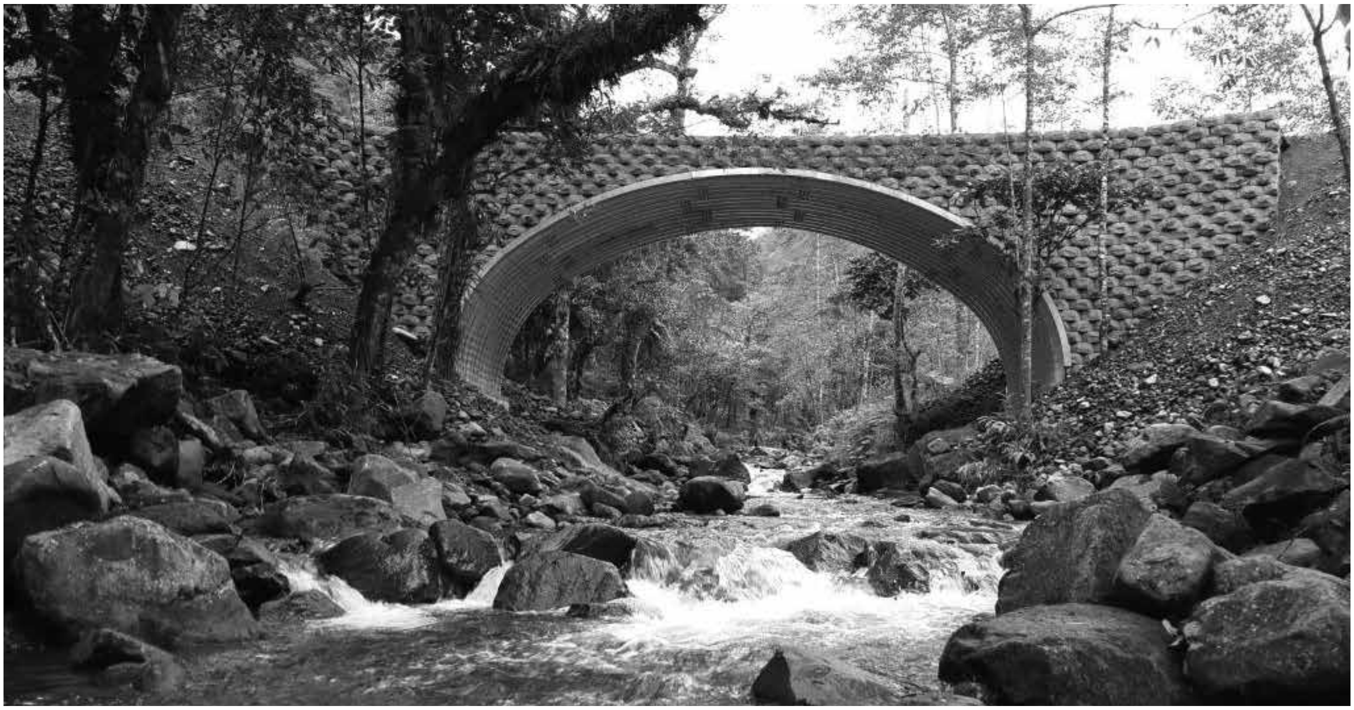
Custom shapes are available upon request.

To properly analyze these properties using finite element analysis it is important to have a geotechnical report for each specific project. This information will allow the designer to optimize both the gage of the steel and the limits of the structural backfill adjacent to the BridgeCor structure.

This design procedure is more comprehensive than a typical ring compression design for MULTI-PLATE structures. Therefore, it will require additional time to properly evaluate a BridgeCor solution for any application. Proper planning is critical to a successful project.

BridgeCor Monitoring

Due to the potential large sizes of BridgeCor structures and the information outlined in AASHTO Specification Section 26 – Metal Culverts, it is a requirement to monitor the shape of the structure during the backfill process. Depending on the size and complexity of a structure, guidelines have been established to determine what level of monitoring will be required on all projects. There are four levels of monitoring outlined for BridgeCor. These levels range from a preconstruction conference with a contractor to a full monitoring program similar to the process outlined for a SUPER-SPAN structure. Contact your local Contech representative for additional information.



BridgeCor 2-radius arch

Minimum Cover for Heavy Off-Road Construction Equipment

Operating heavy construction equipment over or adjacent to flexible pipe installations will likely require additional protection for the pipe structure compared to that provided by the required minimum cover heights for normal highway traffic. Therefore, for temporary construction vehicle loads, additional compacted cover may be required over the top of the pipe structure to help balance loads and dissipate the effects of these larger live loads. The contractor is responsible for providing adequate minimum cover to avoid damage and/or distortion to the metal structure.

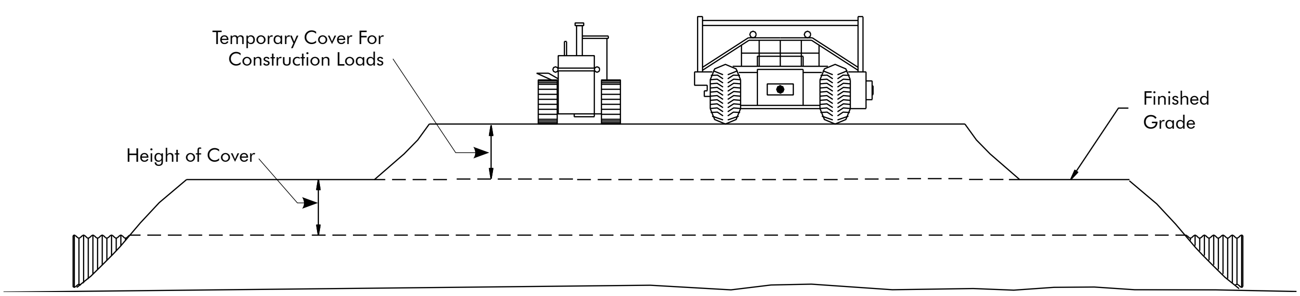
The actual minimum cover heights required for heavier construction vehicle live loads will vary based on the anticipated construction equipment (size, weight and axle loads). Other factors influencing the minimum cover height requirements are structure size, shape and gage combined with local site conditions.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

As a general guideline, an adequate amount of minimum cover can be achieved by providing approximately twice the depth of fill material required for highway traffic. This temporary cover is to consist of a quality fill such as an A-1, A-2-4, A-2-5, or A-3 material per AASHTO M 145 and is to be placed in a controlled and balanced manner over the pipe structure and compacted to a minimum of 90% compaction per AASHTO T 180.

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.

Aluminum Box Culverts

The addition of temporary soil cover for heavy construction loads is not feasible or permissible for Aluminum Box Culvert structures. By design, these structures are limited in the range of permissible fill heights and live loads. Contact your local Contech representative for questions about permissible live loads and allowable soil cover heights (minimum and maximum) for Aluminum Box Culverts.



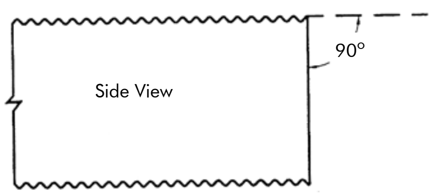
Notes:
1. The contractor is responsible for providing adequate minimum cover to avoid damage and/or distortion to the metal structure.
2. Minimum cover will vary based on local site conditions. Requirements shall be based on the structure shape and size, material gage and anticipated construction equipment (size, weight, and axle loads).
3. Temporary protection from construction equipment loads is measured from the crown of the structure to the top of the maintained construction roadway surface.

Grade Separation Structure

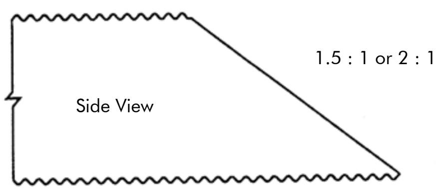
Structure End Treatments

Once the designer has selected a structure and has determined the structural requirements, attention should be turned to protecting the ends of the structure. Hydraulic efficiency, protection of the structure backfill, and structure alignment may dictate the usage of modified structure ends (bevels and skews), headwalls, or cut-off walls. The range of possible end treatments include but are not limited to:

Projecting square end

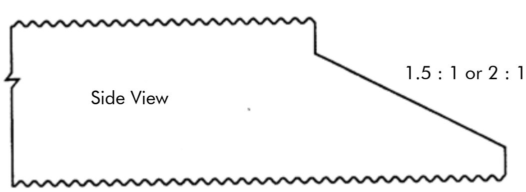


Beveled
(structure cut at an angle relative to horizontal plane)



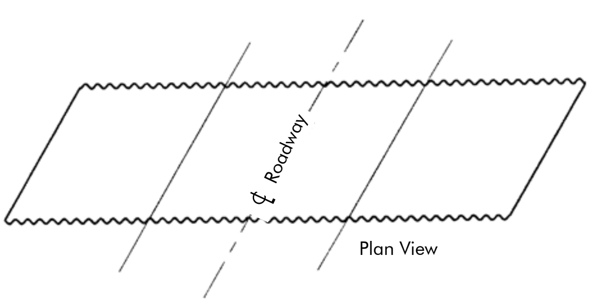
Elevation View

Step-beveled end

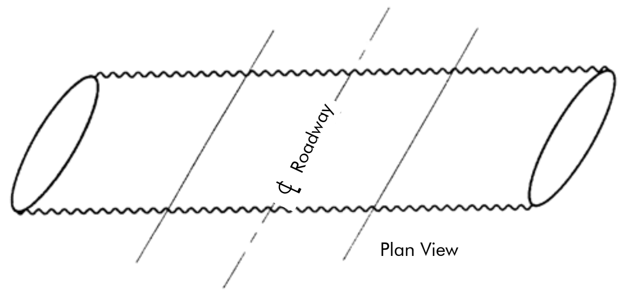


Elevation View

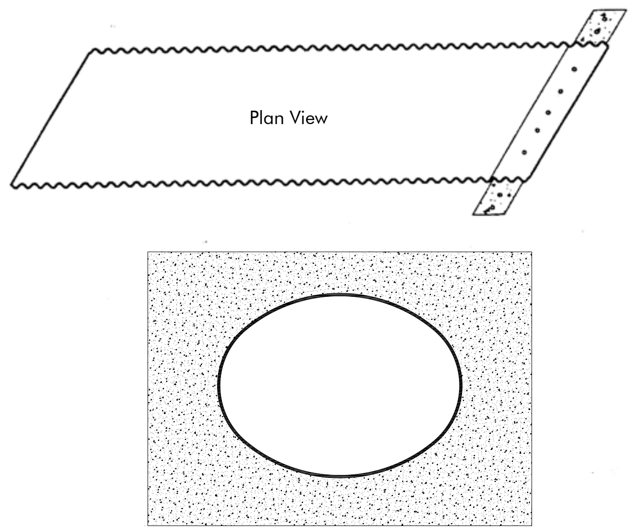
Skewed
(structure cut at an angle relative to vertical plane)



Beveled and skewed

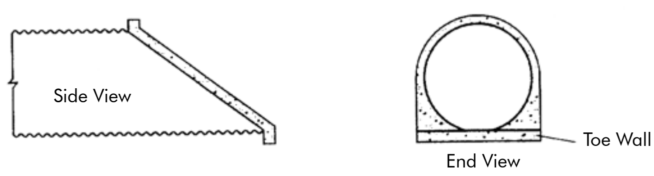


Skewed with concrete headwall

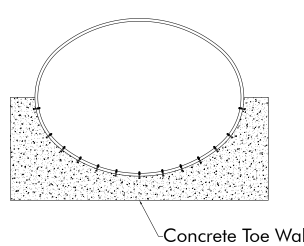


Ellipse End View

Beveled with concrete slope collar



Any of the above with concrete or sheet pile toewall



Projecting square end structures are generally the most cost-effective end treatment option. The square end should, at a minimum, project from sloping side fill enough to allow the invert to meet the toe of the slope. All structures can be supplied with square ends. Larger structures may need a headwall to prevent inlet flotation.

Beveled ends are often desirable because they can be supplied to match the side slope of an embankment. Beveled ends also provide for better hydraulic entrance efficiency when compared to square-ended structures. Whenever structures with full inverts and/or beveled ends are used, the designer should always consider a concrete toewall to anchor the leading edge of the invert, thus minimizing the possibility of hydraulic uplift forces lifting the invert of the structure.

Beveled ends on larger structures must be supported. A beveled section is comprised of incomplete rings of plates acting as retaining walls. Because of this, bevels should be limited to 1.5:1 – 2:1 angles. Flatter bevels may be considered but a rigid reinforced concrete slope collar may be necessary to stabilize the beveled end of the structure. Fully beveled ends are not recommended for pipe-arch and underpass shapes. Step bevels provide for better structural soundness.

Step-beveled ends minimize the number of cut or incomplete plate rings while still providing a sloped end. This also provides a stiffer leading edge at the invert. For this reason, step-beveled ends are desirable over fully beveled ends.

Recommended step-bevel dimensions are:

- **Round**
  Top step = 0.25 x diameter
  Bottom step = 0.25 x diameter
- **Pipe-Arch and Underpass**
  Top and bottom steps match top and bottom longitudinal seam of plates (see sketch). Consult your Contech representative for exact dimensions and plate layout.
- **Horizontal Ellipses**
  Same as pipe-arch and underpass.
- **Arches**
  A single top step and a small (usually 6" high) bottom step are recommended for arch structures. The top step should be 0.25 x rise.

Skewed Ends allow the designer to match the skew of the structure to the roadway. As with beveled ends, skewed ends are less stable because of incomplete plate rings. Soil loads at the structure end can act upon the extended end of the skew and cause deflection of the plates. A concrete headwall should be considered with skew angles. The designer may use a reinforced concrete headwall or slope collar to support the skewed end. More commonly, the structure end will be skewed in combination with a beveled end (skewed to the roadway and beveled to match the side slope.) In this case, the same rules apply to maximum bevel angle and skew angle without a reinforced concrete structure surrounding the skewed and beveled end.

The designer must always consider "warping" the side slope fill to balance soil loads on each side of the structure (see drawing on page 28).

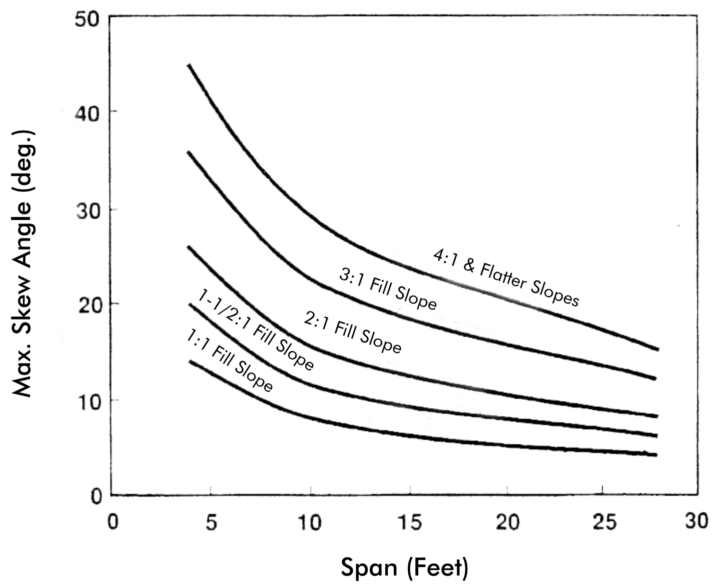


Figure 3. Suggested limits for skews to embankments unless the embankment is warped for support or full head walls are provided.

Cast-in-place (C.I.P.) concrete headwalls are recommended whenever the designer requires improved hydraulic efficiency, the structure is skewed more than 15 degrees to the roadway or when the designer expects sustained high level flows that can cause scour and erosion at the entrance or exit ends of the structure. By erecting a rigid concrete headwall structure, the skew angle may go beyond 15 degrees.

C.I.P. concrete headwalls are secured to the plate structure by the use of anchor bolts placed circumferentially at the end of the structure. Anchor bolts may either be straight ¾" diameter or "hook" bolts. The spacing circumferentially and the choice of bolt type is a function of headwall design which is outside the scope of this document. Typical headwall details are shown on the next few pages. CAD details are available on request from a Contech representative.

C.I.P. Concrete slope collars placed around a beveled end structure guard against deflection of end plates, control erosion and backfill loss, and provide an aesthetic end treatment. They are anchored to the structure by the use of anchor bolts as with concrete headwalls.

Cut-Off Walls are a necessity on hydraulic structures as with all corrugated metal structures with full inverts. Aluminum Box Culverts with full inverts are provided with a bolt-on 26" deep toewall plate. The designer should determine the depth to which the toewall should extend.

C.I.P. Concrete Cut-off or Toewalls should be considered on almost every hydraulic structure with an invert. Undercutting on the inlet end can lead to loss of backfill, piping of water around the exterior of the structure, and undesirable uplift forces that can damage the structure. It is the responsibility of the engineer to determine the appropriate depth of the toewall to protect the invert bedding. Slope protection is also advised to preclude water entering the structure backfill.

Contech Engineered Solutions advises the designer to take all necessary precautions to protect the ends of corrugated metal hydraulic structures. Damage to the structure ends may result in inlet blockage. The designer is also advised that whenever heavy debris flow is expected, the use of a large single span structure is recommended over smaller, multiple structures.

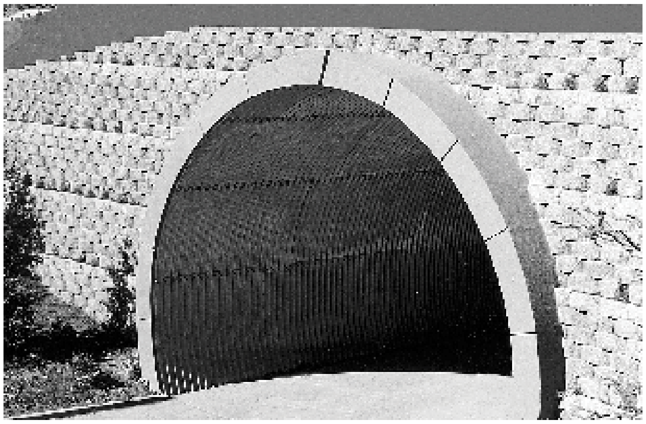
Appropriate end treatment design is beyond the scope of this design guide. Additional information can be obtained from the local DOT guidelines, the FHWA Circular Memo, "Plans for Culvert Inlet and Outlet Structures" and chapters within the NCSPA Corrugated Steel Pipe (CSP) Design Manual.

Modular Block Headwalls can be utilized to provide an aesthetically pleasing end treatment. If the structure is expected to be subjected to hydraulic forces, special consideration must be given to the possible loss of backfill through the block wall face and at the junction of the blocks with the structure. Geotextile fabrics placed in critical areas can minimize the loss of fill.

The designer should also consider other factors such as but not limited to:

- Scouring forces acting on the footing of the wall.
- Rapid draw-down forces that can occur if the backfill becomes saturated.
- Settlement of the structure relative to the wall. Settlement joints may be necessary.

Contact your Contech representative for more details on modular block headwalls design.



Keystone Modular Block Headwall with MULTI-PLATE underpass

BridgeCor, SUPER-SPAN and SUPER-PLATE End Treatments

Any of the presented headwall options can be used with these structures.

Metal Wall End Treatments

Aluminum Box Culverts can be supplied with a pre-designed corrugated aluminum headwall and wingwall system. These headwalls are only provided on square ended (non-skew cut) structures. See the Aluminum Box Culvert section starting on page 64 for details.

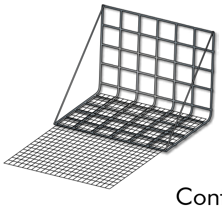
Beveled ends are not utilized on Aluminum Box Culverts.

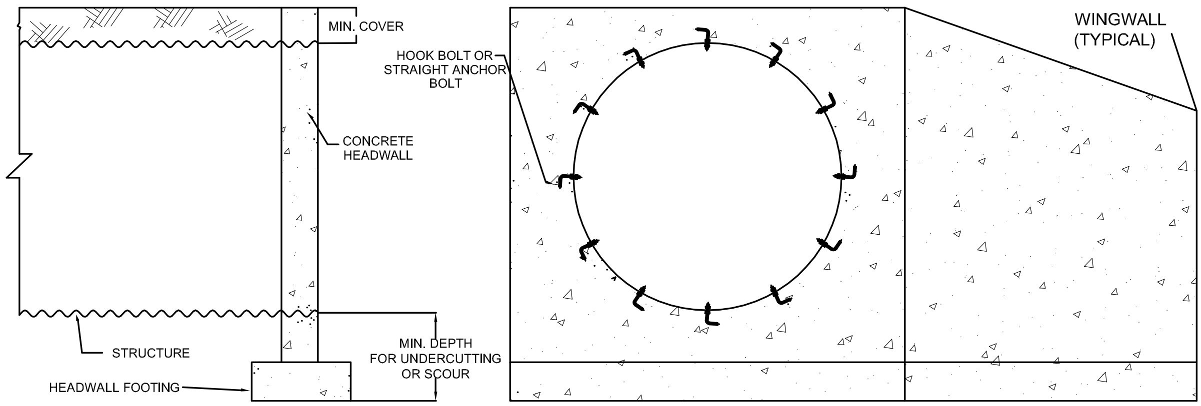
C.I.P. concrete headwalls may be used and are required if the structure is to be skew cut. The structure may be anchored to the C.I.P. headwall in the same fashion as with steel structures discussed earlier. C.I.P. headwall standard designs are available from your Contech representative.

Steel wall systems can be considered on a project basis - contact your local Contech representative.

Welded Wire Wall System

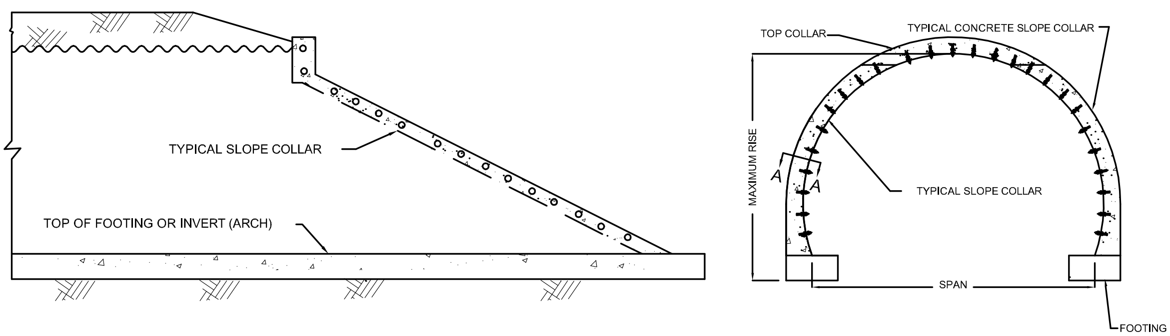
The Contech Wire Wall System utilizes black or galvanized wire facing baskets in conjunction with geogrid reinforcement to create a gravity wall system for use in permanent and temporary wall applications. The combination of a flexible wire wall system adjacent to a flexible pipe system makes an ideal end treatment solution for Contech products, especially in areas where differential settlement may occur.

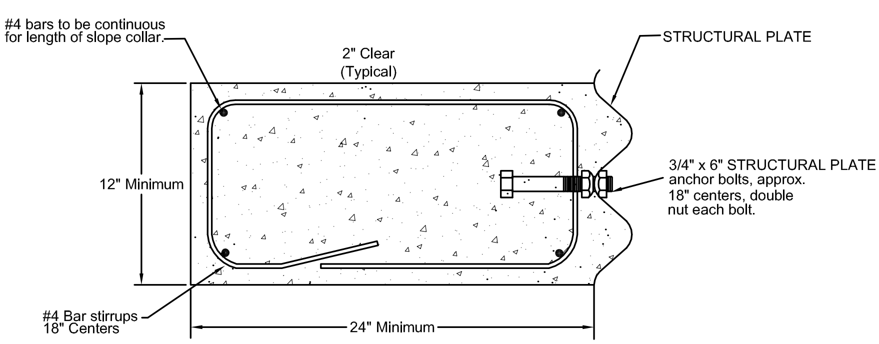




TYPICAL HEADWALL DETAIL

TYPICAL CONCRETE SLOPE COLLAR DETAIL





SECTION A-A

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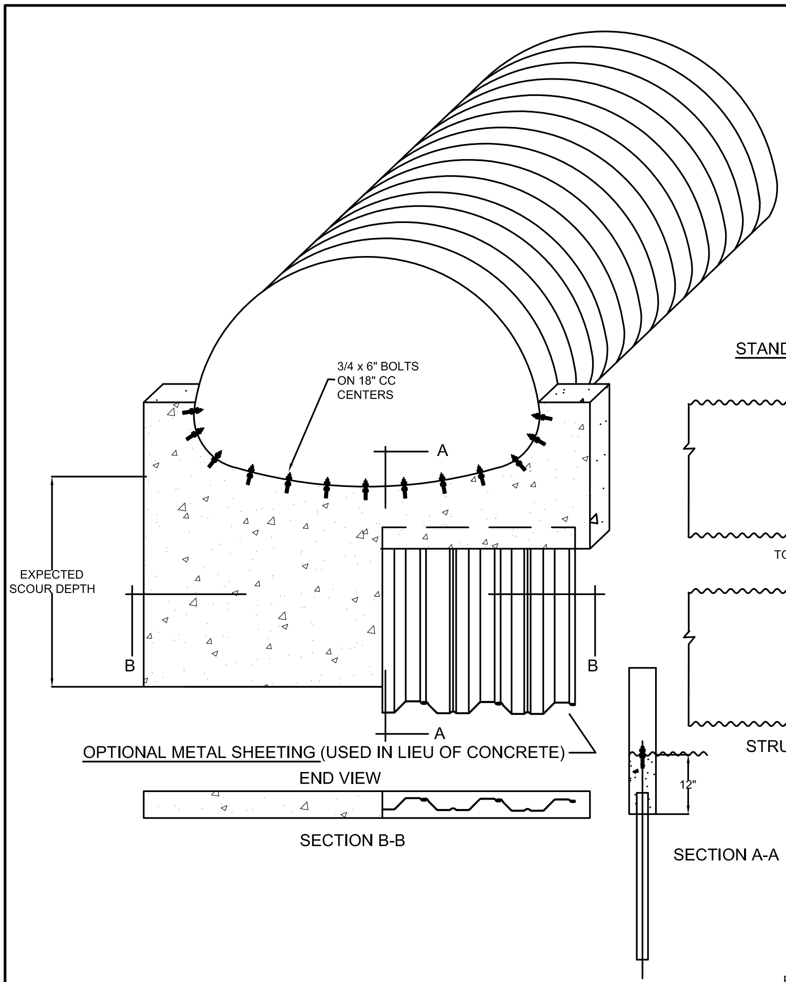
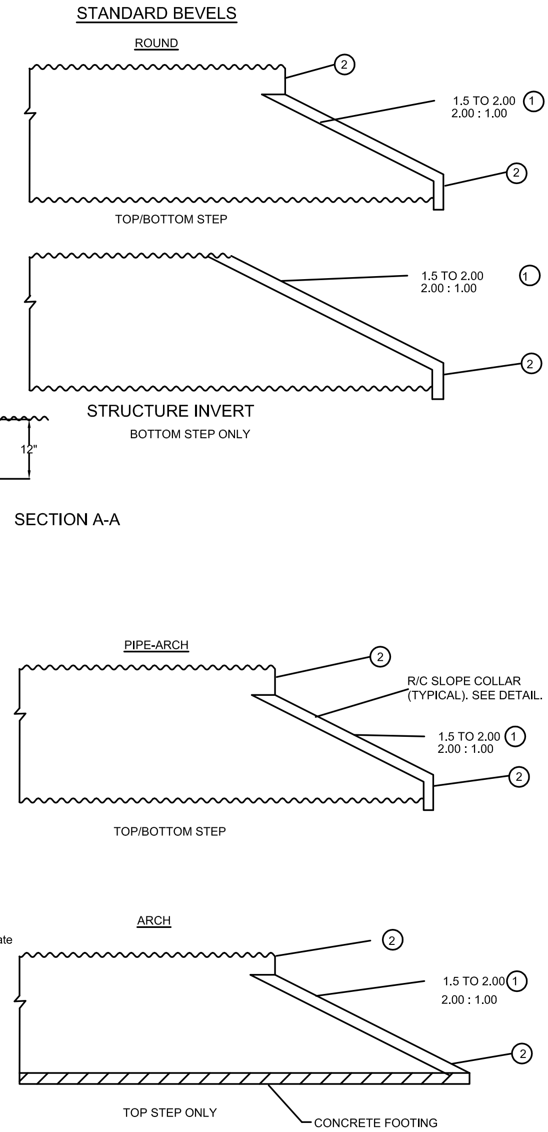
www.ContechES.com

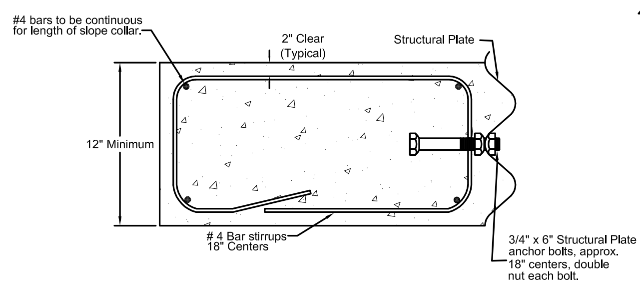
STRUCTURAL PLATE END TREATMENT
HEADWALLS AND SLOPE COLLARS

1 NOTE: IF FLATTER BEVELS ARE USED THE CONTRACTOR MAY NEED TO BRACE OR OTHERWISE SUPPORT THE CUT END DURING BACKFILL OPERATIONS.

2 NOTE: STEP DIMENSION VARIES WITH SHAPE AND DIAMETER. ARCH/ROUND STRUCTURE STEPS APPROX. .25 SPAN PIPE ARCH STEPS COINCIDE WITH PLATE LAPS.







This detail shows minimum dimensions recommended for structural soundness.
Certain hydraulic conditions may require a larger slope collar or other end treatment.

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STRUCTURAL PLATE BEVELS
& CUT OFF WALL

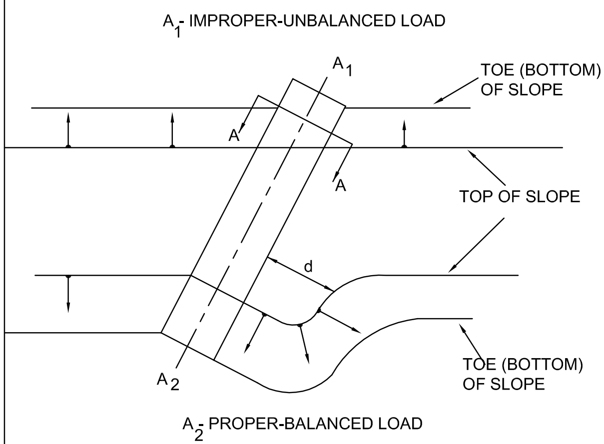


FIGURE 1

SINGLE STRUCTURE

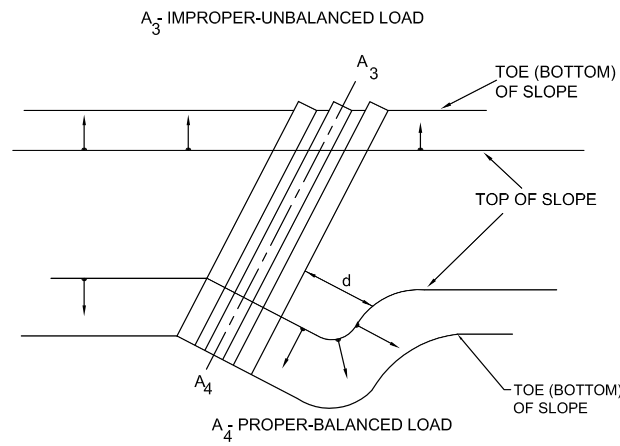
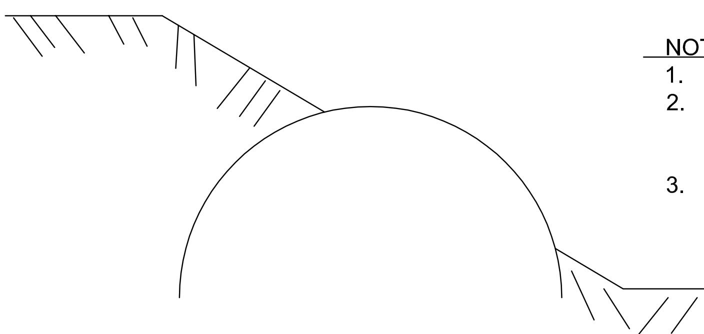


FIGURE 2

MULTIPLE STRUCTURE



SECTION A-A

NOTES:

1. $d \geq 1.5$ (PIPE RISE + PIPE COVER)
2. FIGURE 1 - (SINGLE STRUCTURE)
   @ A_1 - IMPROPER BALANCE
   @ A_2 - PROPER BALANCE (WARPED FILL)
3. FIGURE 2 - (MULTIPLE STRUCTURES)
   @ A_3 -IMPROPER BALANCE AND END STAGGER.
   @ A_4 -PROPER BALANCE AND UNIFORM (SQUARED OFF) ENDS (WARPED FILL).

NOTE

SECTION A-A SHOWS UNBALANCED SOIL LOADING ACROSS THE BARREL OF AN IMPROPERLY DESIGNED CULVERT.

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CORRUGATED STRUCTURES
SKEWED TO FILL SLOPE

Material, Design & Installation Specifications

Following is an outline of applicable AASHTO and ASTM specifications. Additional specifications are available from the American Railroad Engineers and Maintenance of Way Association (AREMA), Manual for Railway Engineering for railroad projects.

Description	AASHTO	ASTM
Steel MULTI-PLATE		
Material	M 167 – Standard Specification for Corrugated Steel Structural Plate	A761
Installation	Refer to AASHTO Standard Specifications for Highway Bridges (Sec. 26)	A807
	Refer to AASHTO LRFD Bridge Construction Specifications (Sec. 26)	
Design	Refer to AASHTO Standard Specifications for Highway Bridges (Sec. 12)	A796
	Refer to AASHTO LRFD Bridge Design Specifications (Sec. 12)	
Aluminum Structural Plate		
Material	M 219 – Standard Specification for Corrugated Aluminum Structural Plate	B746
Installation	Refer to AASHTO Standard Specifications for Highway Bridges (Sec. 26)	B789
	Refer to AASHTO LRFD Bridge Construction Specifications (Sec. 26)	
Design	Refer to AASHTO Standard Specifications for Highway Bridges (Sec. 12.6)	B790
	Refer to AASHTO LRFD Bridge Design Specifications (Sec. 12)	
Aluminum Box Culverts		
Material	M 219 – Standard Specification for Corrugated Aluminum Structural Plate	B864
Installation	Refer to AASHTO Standard Specifications for Highway Bridges (Sec. 12.8)	N/A
	Refer to AASHTO LRFD Bridge Construction Specifications (Sec. 26)	
Design	Refer to AASHTO Standard Specifications for Highway Bridges (Sec. 12.8)	N/A
	Refer to AASHTO LRFD Bridge Design Specifications (Sec. 12)	
SUPER-SPAN & SUPER-PLATE		
Material	M 167 – Standard Specification for Corrugated Steel Structural Plate	A761
	M 219 – Standard Specification for Corrugated Aluminum Structural Plate	
Installation	Refer to AASHTO Standard Specifications for Highway Bridges (Sec. 12 and Sec. 26)	A807/B789
	Refer to AASHTO LRFD Bridge Construction Specifications (Sec. 26)	
Design	Refer to AASHTO Standard Specifications for Highway Bridges (Sec. 12.7)	N/A
	Refer to AASHTO LRFD Bridge Design Specifications (Sec. 12)	
BridgeCor		
Material	M 167 – Standard Specification for Corrugated Steel Structural Plate	A761
Installation	Refer to AASHTO LRFD Bridge Construction Specifications (Sec. 26)	A807
Design	Refer to AASHTO LRFD Bridge Design Specifications (Sec. 12.8.9)	N/A

Complete copies of these specifications are available from AASHTO & ASTM.
Excerpts of these specifications are available from Contech Engineered Solutions LLC.

MULTI-PLATE pedestrian underpass with Keystone end treatment.

MULTI-PLATE®
Made to Perform, Built to Last.

Contech MULTI-PLATE structures provide designers of stormwater management systems underpasses and bridges with a versatile method of construction and a long history of strength, durability, and economy. A variety of shapes and sizes ensures that MULTI-PLATE structures fit most applications. Ease of design, construction, and proven reliability make them the frequent choice of experienced engineers.

MULTI-PLATE structures are made from sturdy, heavy gage, corrugated steel plates that are pre-formed to various shapes and sizes, then galvanized for long-term protection and performance. The plates are delivered to the job site and bolted together to form a MULTI-PLATE structure optimally suited for the project.

MULTI-PLATE is available in full round, arch, pipe-arch, horizontal and vertical ellipse, underpass, and long-span shapes—all in a wide range of sizes. Since 1931, MULTI-PLATE has been proven to offer:

Superior Durability

MULTI-PLATE's heavy gage steel uses an industry standard 3 oz. per square foot galvanized coating (both sides) capable of providing a service life of 75 years or longer. For additional information, see page 7.

When selecting the proper material for an application, designers need to evaluate the soil side of the structure along with the corrosive and abrasive action due to the flow at the invert of the structure. The use of structural plate gives designers more structure shape options to help minimize the impact of abrasion on the invert of the structure.

High Load-Carrying Capacity

As a steel-soil interaction system, MULTI-PLATE is designed to carry high combined live and dead loads. High traffic loads and deep cover applications are key benefits of specifying MULTI-PLATE.

A More Efficient Installation

Prefabricated plates are assembled in the field, translating into finished construction in days instead of weeks as with most concrete structures.

Versatility

MULTI-PLATE structures remove all of the shape, size and installation restrictions of precast or cast-in-place concrete.

Descriptions of Plates

MULTI-PLATE plates are field assembled into pipe, pipe-arches, ellipses, arches, and underpasses. Corrugations of 6-inch pitch and 2-inch depth are perpendicular to the length of each plate.

Thickness. Standard specified thickness of the galvanized plates vary from 0.111 to 0.380 inches.

Widths. Standard plates are fabricated in five net covering widths, 28.8 inches, 48.0 inches, 57.6 inches, 67.2 inches, and 76.8 inches. See Table 11.

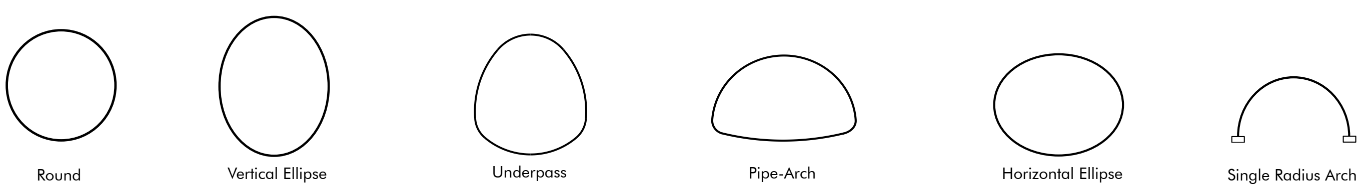
The "Pi" (Pi = 3.2) nomenclature translated circumference directly into nominal diameter in inches. For example, four 15-Pi plates give a diameter of 60 inches; four 21-Pi plates provide an 84-inch diameter, etc. Various plate widths may be combined to obtain almost any diameter.

Lengths. MULTI-PLATE plates are furnished in either 10-foot or 12-foot nominal lengths. Actual length of the square-end structure is about four inches longer than its nominal length because a 2-inch lip protrudes beyond each end of every plate for lapping purposes.

Longitudinal bolt holes. The plates are punched with 7/8-inch holes on 3-inch centers to provide the standard four bolts per foot of longitudinal seam in two staggered rows on 2-inch centers. They may also be punched to provide either six or eight bolts per foot of longitudinal seam on 0.280 inch thickness material, if required. One-inch holes, punched 8 bolts per foot of long seam are used for 0.318-inch and 0.380-inch thick material.

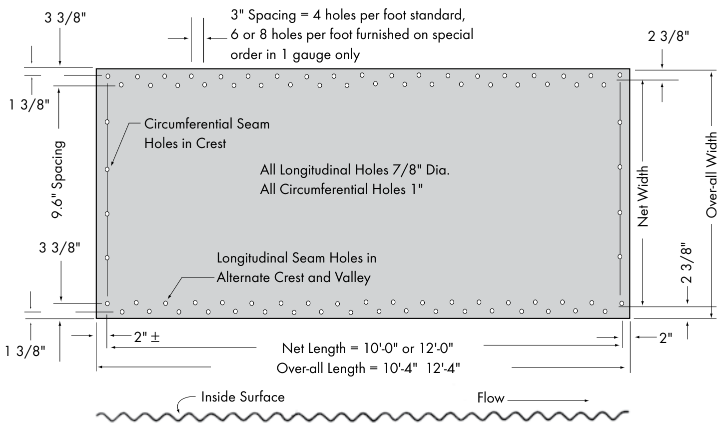
The inside crests of the end (circumferential) corrugations are punched with 1-inch-diameter holes for circumferential seams on centers of 9.6 inches or 9 $^{19/32}$ inches (equals 3-Pi).


Single Radius Arch



Standard Shapes

Standard Plate Detail

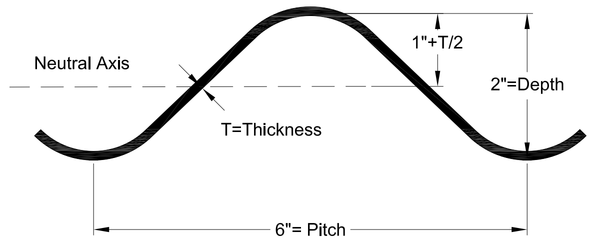


For square end structures on which headwalls are to be built, design should allow for a 2" lip at each end.

TABLE 11. 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 inches

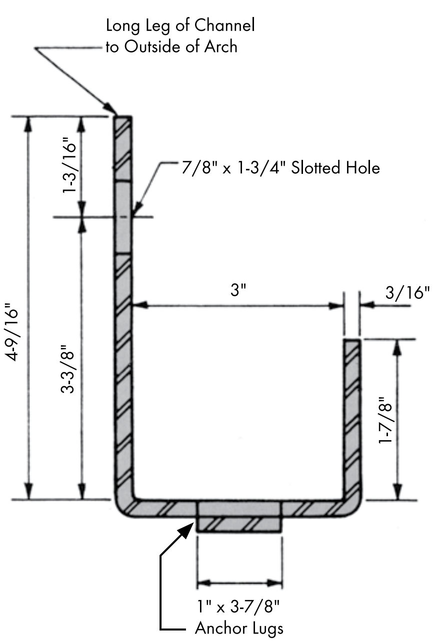


Standard 6" x 2" Corrugation

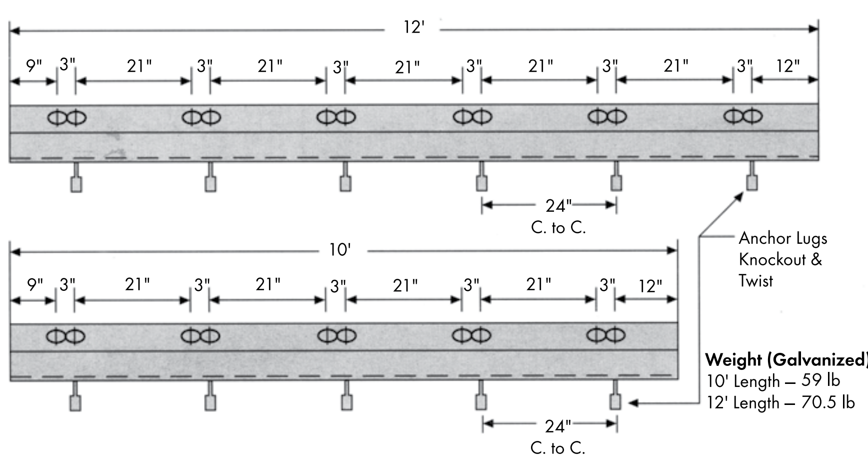
TABLE 12. APPROXIMATE WEIGHT OF MULTI-PLATE SECTIONS

Pi	Net Length (Feet)	Galvanized, in Pounds, without Fasteners — Specified 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.)	0.318 (5/16 In.)	0.380 (3/8 In.)
9	10	161	205	250	272	316	361	405	460	545
9	12	193	246	299	325	379	432	485	551	653
15	10	253	323	393	428	498	568	638	725	859
15	12	303	386	470	511	595	678	762	865	1026
18	10	299	382	465	506	589	671	754	856	1015
18	12	357	456	555	604	703	801	900	1022	1212
21	10	345	441	536	583	679	774	869	987	1170
21	12	412	526	640	697	810	924	1038	1179	1398
24	10	396	504	613	667	775	886	995	N/A	N/A
24	12	473	603	732	797	927	1060	1190	N/A	N/A

Notes:
1. Weights are based on a zinc coating of 3 oz./sq. ft., total both surfaces.
2. All weights are subject to manufacturing tolerances.
3. Specified thickness is a nominal galvanized thickness. Reference AASHTO M 167.
4. Gages 12 thru 1 use 3/4" bolts. 5/16 and 3/8 use 7/8" bolts.



Unbalanced Channel Cross Section



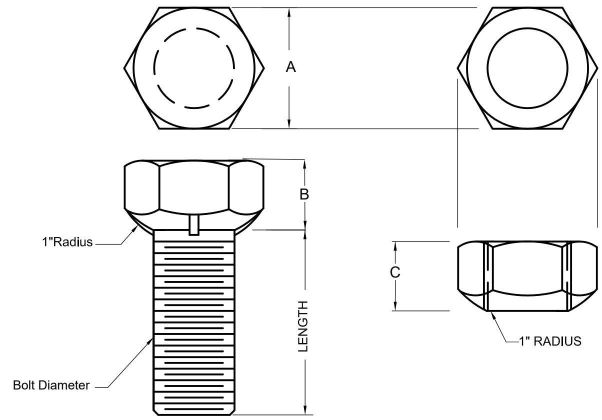
Unbalanced Channel for MULTI-PLATE® Arch

Bolts and Nuts

Hot-dipped galvanized, specially heat-treated $^{3}/_{4}$"or $^{7}/_{8}$" diameter steel bolts, meeting ASTM A307/A449 specifications, are typically used to assemble structural plate sections. The underside of the bolt head is uniformly rounded and does not require special positioning.

In addition, the underside of the bolt head is ribbed to prevent bolt head rotation while tightening. Unlike conventional bolts, once the nut is finger tight, final tightening can usually be accomplished by one worker.

Aluminum fasteners are available upon request.



Typical Bolt and Nut

Diameter (Inches)	A (Inches)	B (Inches)	C (Inches)
¾	1¼	$^{5}/_{8}$	$^{13}/_{16}$
$^{7}/_{8}$	1$^{7}/_{16}$	¾	$^{7}/_{8}$

TABLE 14. BOLT LENGTH AND USAGE

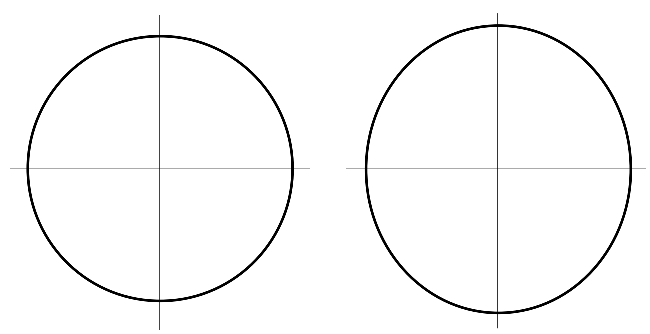
Plate Gages	Bolt Lengths
12, 10 and 8	1¼" and 1½"
7 and 5	1½" and 1¾"
3 and 1	1½" and 2"
5/16* and 3/8*	2" and 2½"

* These are used with 7/8" diameter bolts.
Notes: The longer bolts are used in 3 plate lap seams.

MULTI-PLATE® Round

TABLE 15. MULTI-PLATE ROUND PIPE

Pipe Diameter (Feet)	Pipe Diameter (Inches)	End Area (Sq. Ft.)	Pipe Diameter (Feet)	Pipe Diameter (Inches)	End Area Sq. Ft.
5.0	60	19.1	16.0	192	204.4
5.5	66	23.2	16.5	198	217.5
6.0	72	27.8	17.0	204	231.0
6.5	78	32.7	17.5	210	244.9
7.0	84	38.1	18.0	216	259.2
7.5	90	43.9	18.5	222	274.0
8.0	96	50.0	19.0	228	289.1
8.5	102	56.6	19.5	234	304.7
9.0	108	63.6	20.0	240	320.6
9.5	114	71.0	20.5	246	337.0
10.0	120	78.8	21.0	252	353.8
10.5	126	87.1	21.5	258	371.0
11.0	132	95.7	22.0	264	388.6
11.5	138	104.7	22.5	270	406.6
12.0	144	114.2	23.0	276	425.0
12.5	150	124.0	23.5	282	443.8
13.0	156	134.3	24.0	288	463.0
13.5	162	144.9	24.5	294	482.6
14.0	168	156.0	25.0	300	502.7
14.5	174	167.5	25.5	306	523.1
15.0	180	179.4	26.0	312	543.9
15.5	186	191.7			

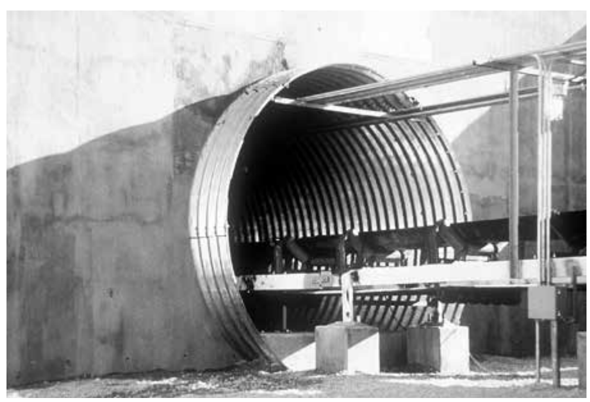


Round and 5% Vertical Ellipse Pipe

TABLE 16. PLATE ARRANGEMENT AND APPROXIMATE WEIGHT PER FOOT FOR MULTI-PLATE ROUND PIPE

Pipe Diameter (Inches)	Number of Plates Per Ring 12 through 1 Gage					Specified Thickness (Inches)								
	Pi				Total Plates	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.)	0.318 (5/16)	0.380 (3/8)
	15	18	21	24										
60	4				4	110	138	166	180	208	236	264	310	376
66	2	2			4	119	150	180	196	227	257	287	336	407
72		4			4	129	162	195	212	245	277	310	362	439
78		2	2		4	138	174	209	227	263	298	333	387	471
84			4		4	147	185	223	243	281	318	356	413	502
90			2	2	4	157	198	239	260	300	341	382	465	563
96				4	4	168	211	254	276	320	364	407	491	595
102	2	4			6	184	231	278	302	349	395	442	516	627
108		6			6	193	242	292	317	367	416	465	542	659
114		4	2		6	202	254	306	333	385	436	488	568	690
120		2	4		6	212	266	321	349	403	457	512	594	722
126			6		6	221	278	335	364	421	478	535	619	754
132			4	2	6	231	291	350	381	440	500	560	671	815
138			2	4	6	241	304	366	398	460	523	585	697	847
144				6	6	251	316	381	415	479	546	611	723	878
150		6	2		8	267	335	404	439	507	575	644	749	910
156		4	4		8	276	347	418	454	525	596	667	774	942
162		2	6		8	285	359	432	470	543	616	690	800	973
168			8		8	295	371	447	485	561	637	713	826	1005
174			6	2	8	305	384	462	502	581	660	738	878	1066
180			4	4	8	315	396	478	519	600	682	764	904	1098
186			2	6	8	325	409	493	536	620	705	789	929	1130
192				8	8	335	422	508	553	639	728	814	955	1161
198		4	6		10		440	530	576	666	755	845	981	1193
204		2	8		10		452	544	591	684	776	868	1006	1224
210			10		10		464	559	607	701	796	891	1032	1256
216			8	2	10		476	574	624	721	819	917	1085	1318
222			6	4	10			589	640	741	841	942	1110	1349
228			4	6	10			605	657	760	864	967	1136	1381
234			2	8	10			620	674	780	887	993	1161	1412
240				10	10			635	691	799	909	1018	1187	1444
246		2	10		12				713	824	935	1046	1213	1476
252			12		12				728	842	955	1069	1238	1507
258			10	2	12					861	978	1095	1291	1569
264			8	4	12					881	1001	1120	1316	1600
270			6	6	12					900	1023	1145	1342	1632
276			4	8	12					920	1046	1171	1368	1664
282			2	10	12						1069	1196	1393	1695
288				12	12						1091	1222	1419	1727
294			14		14						1115	1248	1446	1758
300			12	2	14						1137	1273	1497	1820
306			10	4	14						1160	1298	1523	1852
312			8	6	14						1183	1324	1548	1883

Notes:
1. Dimensions are to inside crests of corrugations and are subject to manufacturing tolerances.
2. These plate arrangements will be furnished unless noted otherwise on assembly drawings.
3. Approximate weights include galvanized steel material, bolts, and nuts.
4. Specified thickness is a nominal galvanized thickness.
5. Gages 12 thru 1 use 3/4" bolts. 5/16 and 3/8 use 7/8" bolts.
6. 24 pi plates are not available in 5/16 through 3/8. Inquire for number of plates per ring.



Aggregate Tunnel using MULTI-PLATE

MULTI-PLATE® Height of Cover Tables

Height-of-Cover Tables 18, 21, 24, 26 and 29A are presented for the designer's convenience for use in routine applications. These tables are based on the outlined design procedures, using the following values for the soil and steel parameters:

- Unit weight of soil – 120 pcf.
- Relative density of compacted backfill – minimum 90% standard per AASHTO T 180
- Yield point of steel – 33,000 psi
- Heights of cover are based on 3/4" bolts (4 bolts/ft) except 5/16 and 3/8 which use 7/8" bolts (8 bolts/ft). 6 and 8 bolts/ft are available for 1 Ga. structures.

TABLE 17. MULTI-PLATE® ROUND AND VERTICAL ELLIPSE PIPE 6" X 2"
AASHTO HEIGHT OF COVER LIMITS H-20, HS-20, H-25, HS-25 LIVE LOADS

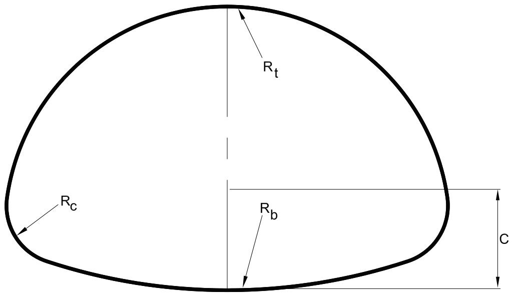
		Thickness In Inches (Gage) (Maximum Cover Height Shown In Feet)								
Span Diameter Ft.-In.	Minimum Cover (Inches)	0.111 (12 Ga.)	0.140 (10 Ga.)	0.170 (8 Ga.)	0.188 (7 Ga.)	0.218 (5 Ga.)	0.249 (3 Ga.)	0.280 (1 Ga.)	0.318 (5/16)	0.380 (3/8)
5-0	12	46	68	90	103	124	146	160	256	308
5-6	12	42	62	81	93	113	133	145	233	280
6-0	12	38	57	75	86	103	122	133	214	257
6-6	12	35	52	69	79	95	112	123	197	237
7-0	12	33	49	64	73	88	104	114	183	220
7-6	12	31	45	60	68	82	97	106	171	205
8-0	12	29	43	56	64	77	91	100	160	192
8-6	18	27	40	52	60	73	86	94	151	181
9-0	18	25	38	50	57	69	81	88	142	171
9-6	18	24	36	47	54	65	77	84	135	162
10-0	18	23	34	45	51	62	73	80	128	154
10-6	18	22	32	42	49	59	69	76	122	147
11-0	18	21	31	40	46	56	66	72	116	140
11-6	18	20	29	39	44	54	63	69	111	134
12-0	18	19	28	37	43	51	61	66	107	128
12-6	24	18	27	36	41	49	58	64	102	123
13-0	24	17	26	34	39	47	56	61	98	118
13-6	24	17	25	33	38	46	54	59	95	114
14-0	24	16	24	32	36	44	52	57	91	110
14-6	24	16	23	31	35	42	50	55	88	106
15-0	24	15	22	30	34	41	48	53	85	102
15-6	24	15	22	29	33	40	47	51	82	99
16-0	24		21	28	32	38	45	50	80	96
16-6	30		20	27	31	37	44	48	77	93
17-0	30		20	26	30	36	43	47	75	90
17-6	30		19	25	29	35	41	45	73	88
18-0	30			25	28	34	40	44	71	85
18-6	30			24	27	33	39	43	69	83
19-0	30			23	27	32	38	42	67	81
19-6	30			23	26	31	37	41	65	79
20-0	30				25	31	36	40	64	77
20-6	36				25	30	35	39	62	75
21-0	36				24	29	34	38	61	73
21-6	36					28	34	37	59	71
22-0	36					28	33	36	58	70
22-6	36					27	32	35	57	68
23-0	36						31	34	55	67
23-6	36						30	34	54	65
24-0	36							33	53	64
24-6	42							32	51	62
25-0	42							32	49	60
25-6	42							31	48	58
26-0	42								46	56

Notes:
1. Tables based upon AASHTO Sec. 12 Standard Specifications for Highway Bridges.
2. H-20, HS-20, H-25, HS-25 live loads
3. Minimum cover is defined as the vertical distance from the top of the corrugated structure to the bottom of flexible or top of rigid pavement.
4. Minimum cover for heavy off-road construction equipment loads must be checked.

TABLE 18. PLATE ARRANGEMENT AND APPROXIMATE WEIGHT PER FOOT FOR MULTI-PLATE® VERTICAL ELLIPSE SHAPES

Nominal Pipe Diameter Pi	5% Vertical Ellipse		Number of Plates Per Ring						Approximate Weight Per Foot of Structures, Lbs. Specified Thickness, Inches						
	Horizontal Inches	Vertical Inches	Area Sq. Ft.	Pi 15	Pi 18	Pi 21	Pi 24	Total Plates	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.)
60	56	62	19	4				4	110	138	166	180	208	236	264
66	62	68	23	2	2			4	119	150	180	196	227	257	287
72	68	75	28		4			4	129	162	195	212	245	277	310
78	73	81	32		2	2		4	138	174	209	227	263	298	333
84	79	88	38			4		4	147	185	223	243	281	318	356
90	85	94	44			2	2	4	157	198	239	260	300	341	382
96	91	101	50				4	4	168	211	254	276	320	364	407
102	97	107	56	2	4			6	184	231	278	302	349	395	442
108	103	114	63		6			6	193	242	292	317	367	416	465
114	109	120	71		4	2		6	202	254	306	333	385	436	488
120	115	127	79		2	4		6	212	266	321	349	403	457	512
126	120	133	87			6		6	221	278	335	364	421	478	535
132	126	139	95			4	2	6	231	291	350	381	440	500	560
138	132	146	104			2	4	6	241	304	366	398	460	523	585
144	138	152	114				6	6	251	316	381	415	479	546	611
150	142	157	124		6	2		8	267	335	404	439	507	575	644
156	148	163	134		4	4		8	276	347	418	454	525	596	667
162	154	170	144		2	6		8	285	359	432	470	543	616	690
168	159	176	155			8		8	295	371	447	485	561	637	713
174	165	183	167			6	2	8	305	384	462	502	581	660	738
180	171	189	179			4	4	8	315	396	478	519	600	682	764
186	177	195	191			2	6	8	325	409	493	536	620	705	789
192	182	202	204				8	8	335	422	508	553	639	728	814
198	189	209	217		4	6		10		440	530	576	666	755	845
204	195	215	230		2	8		10		452	544	591	684	776	868
210	201	222	244			10		10		464	559	607	701	796	891
216	206	228	258			8	2	10		476	574	624	721	819	917
222	212	235	273			6	4	10			589	640	741	841	942
228	218	241	288			4	6	10			605	657	760	864	967
234	224	247	303			2	8	10			620	674	780	887	993
240	229	253	319				10	10			635	691	799	909	1018
246	236	261	336		2	10		12				713	824	935	1046
252	242	267	352			12		12				728	842	955	1069
258	247	273	370			10	2	12					861	978	1095
264	253	280	387			8	4	12					881	1001	1120
270	259	286	405			6	6	12					900	1023	1145
276	264	291	423			4	8	12					920	1046	1171
282	271	299	442			2	10	12						1069	1196
288	276	305	461				12	12						1091	1222
294	283	312	481			14		14						1115	1248
300	289	319	501			12	2	14						1137	1273
306	294	325	521			10	4	14						1160	1298
312	300	332	542			8	6	14						1183	1324

Notes:
1. Dimensions are to inside crests of corrugations and are subject to manufacturing tolerances.
2. These plate arrangements will be furnished unless noted otherwise on assembly drawings.
3. Approximate weights include galvanized steel material, bolts, and nuts.
4. Specified thickness is a nominal galvanized thickness.
5. 24 pi plates are not available in 5/16 through 3/8. Inquire for number of plates per ring.



Pipe-Arch

TABLE 19. MULTI-PLATE® PIPE-ARCH

	Span Ft.-In.	Rise Ft.-In.	Area Sq. Ft.	R_t Inches	R_b Inches	C Inches**
R_c Corner Radius = 18"*	6-1	4-7	22	37	77	27
	6-4	4-9	24	38	99	25
	6-9	4-11	26	41	84	29
	7-0	5-1	29	42	105	27
	7-3	5-3	31	44	137	25
	7-8	5-5	33	47	110	28
	7-11	5-7	36	48	139	27
	8-2	5-9	38	49	183	25
	8-7	5-11	41	52	141	28
	8-10	6-1	43	53	179	26
	9-4	6-3	46	56	145	30
	9-6	6-5	49	57	178	28
	9-9	6-7	52	58	228	26
	10-3	6-9	55	62	179	29
	10-8	6-11	58	65	153	33
	10-11	7-1	61	66	181	31
	11-5	7-3	64	69	158	34
	11-7	7-5	68	70	184	32
	11-10	7-7	71	71	217	30
	12-4	7-9	74	75	187	34
	12-6	7-11	78	76	218	32
	12-8	8-1	82	77	260	30
	12-10	8-4	85	77	315	28
R_c Corner Radius = 31"	13-3	9-4	98	80	193	47
	13-6	9-6	102	81	220	45
	14-0	9-8	106	84	198	48
	14-2	9-10	111	86	224	46
	14-5	10-0	115	87	256	44
	14-11	10-2	120	90	228	48
	15-4	10-4	124	93	209	51
	15-7	10-6	129	94	232	49
	15-10	10-8	134	95	261	47
	16-3	10-10	138	99	237	51
	16-6	11-0	143	100	264	49
	17-0	11-2	148	103	241	53
	17-2	11-4	153	104	267	51
	17-5	11-6	158	105	298	49
	17-11	11-8	163	108	271	52
	18-1	11-10	168	109	300	50
	18-7	12-0	174	113	274	54
	18-9	12-2	179	114	302	52
	19-3	12-4	185	117	278	55
	19-6	12-6	191	118	305	53
	19-8	12-8	196	119	337	51
	19-11	12-10	202	120	374	49
	20-5	13-0	208	123	338	53
	20-7	13-2	214	124	374	51

MULTI-PLATE pipe arch is ideal for pedestrian underpasses

* Some pipe-arch sizes with 18-inch corner radius are not shown. Those not shown can duplicate sizes of pipe-arches shown with 31-inch corner radius. The 31-inch corner radius structures have a lower Rt/Rc ratio resulting in lower corner pressures.

** "C" is measured from the invert to the top of the corner plate.

TABLE 20. PLATE ARRANGEMENT AND APPROXIMATE WEIGHT PER FOOT FOR MULTI-PLATE® PIPE-ARCH

	Span	Rise	Pi	Number of Plates Per Ring											Total Plates	Approximate Weight Per Foot of Structure, Lbs. Specified Thickness, Inches						
				9 Pi		15 Pi			18 Pi		21 Pi		24 Pi			0.111	0.140	0.170	0.188	0.218	0.249	0.280
	Ft.-In.	Ft.-In.	Pi	C	B	C	B	T	B	T	B	T	B	T		(12 Ga.)	(10 Ga.)	(8 Ga.)	(7 Ga.)	5 Ga.)	(3 Ga.)	(1 Ga.)
	9 Pi Corner Pipe Arch Structure																					
R_c Corner Radius = 18″	6-1	4-7	66	2			1	1		1					5	119	150	180	196	227	257	287
	6-4	4-9	69	2			1			2					5	124	156	188	204	236	267	299
	6-9	4-11	72	2					1	2					5	129	162	195	212	245	277	310
	7-0	5-1	75	2					1	1		1			5	133	168	202	219	254	288	322
	7-3	5-3	78	2					1			2			5	138	174	209	227	263	298	333
	7-8	5-5	81	2							1	2			5	143	179	216	235	272	308	345
	7-11	5-7	84	2							1	1		1	5	147	185	223	243	281	318	356
	8-2	5-9	87	2							1			2	5	152	192	231	251	290	330	369
	8-7	5-11	90	2									1	2	5	157	198	239	260	300	341	382
	8-10	6-1	93	2				1		2			1		6	163	205	246	268	310	352	395
	9-4	6-3	96	2	1			1	1	2					7	171	215	258	281	324	368	412
	9-6	6-5	99	2	1				1	3					7	176	221	266	289	334	380	425
	9-9	6-7	102	2	1				1	2		1			7	180	226	273	296	342	389	435
	10-3	6-9	105	2			2			2		1			7	185	232	280	304	352	399	447
	10-8	6-11	108	2			1		1	2		1			7	189	238	287	312	361	409	458
	10-11	7-1	111	2			1		1	1		2			7	194	245	295	320	370	421	471
	11-5	7-3	114	2					2	1		2			7	199	251	302	329	380	432	484
	11-7	7-5	117	2					2			3			7	204	257	310	337	390	443	496
	11-10	7-7	120	2					2			2		1	7	212	267	321	349	404	458	513
	12-4	7-9	123	2					1		1	2		1	7	217	273	329	358	413	469	525
	12-6	7-11	126	2					1		1	1		2	7	222	279	336	365	422	480	537
	12-8	8-1	129	2					1		1			3	7	226	285	343	373	431	490	549
	12-10	8-4	132	2					1	3	1	1			8	232	292	352	382	442	502	562
	15 Pi Corner Pipe Arch Structure																					
R_c Corner Radius = 31″	13-3	9-4	138			2			2					3	7	245	308	371	403	466	529	593
	13-6	9-6	141			2			2	3		1			8	253	317	382	415	480	544	609
	14-0	9-8	144			2			1	3	1	1			8	257	323	389	423	489	554	620
	14-2	9-10	147			2			1	2	1	2			8	262	329	397	431	498	565	632
	14-5	10-0	150			2			1	1	1	3			8	267	335	404	439	507	575	644
	14-11	10-2	153			2				1	2	3			8	271	341	411	446	516	585	655
	15-4	10-4	156			2				1	1	3	1		8	277	348	419	455	526	597	668
	15-7	10-6	159			2					1	4	1		8	281	354	426	463	535	607	679
	15-10	10-8	162			2					1	3	1	1	8	286	360	434	471	545	618	692
	16-3	10-10	165			2						3	2	1	8	291	366	441	479	554	630	705
	16-6	11-0	168			2						2	2	2	8	296	373	449	488	564	641	717
	17-0	11-2	171			2	1		2			2		2	9	305	383	461	501	579	657	735
	17-2	11-4	174			2	1		2			1		3	9	310	389	468	509	589	668	748
	17-5	11-6	177			2	1		2					4	9	315	395	476	517	598	679	760
	17-11	11-8	180			2			3					4	9	319	401	483	525	607	690	772
	18-1	11-10	183			2			3	2		3			10	326	410	494	537	621	703	787
	18-7	12-0	186			2			2	2	1	3			10	331	416	501	545	629	714	799
	18-9	12-2	189			2			2	1	1	4			10	336	422	508	552	638	724	810
	19-3	12-4	192			2			1	1	2	4			10	340	428	516	560	647	734	822
	19-6	12-6	195			2			1		2	5			10	345	434	523	568	656	745	833
	19-8	12-8	198			2			1		2	4		1	10		440	530	576	666	756	846
	19-11	12-10	201			2			1		2	3		2	10		447	538	585	676	767	859
	20-5	13-0	204			2					3	3		2	10		453	545	592	685	778	870
	20-7	13-2	207			2					3	2		3	10		459	553	601	695	789	883

C = Corner   B = Bottom   T = Top

Notes:
1. Dimensions are to inside crests of corrugations and are subject to manufacturing tolerances.
2. These plate arrangements will be furnished unless noted otherwise on assembly drawings.
3. Approximate weights include galvanized steel material, bolts, and nuts.
4. Some pipe-arch sizes with 18-inch corner radius are not shown. Those not shown can duplicate sizes of pipe-arches shown with 31-inch corner radius. The 31-inch corner radius structures have a lower Rt/Rc ratio resulting in lower corner pressures.

TABLE 21. MULTI-PLATE® PIPE-ARCH 6″ X 2″
AASHTO HEIGHT OF COVER LIMITS H-20, HS-20, H-25, HS-25 LIVE LOADS

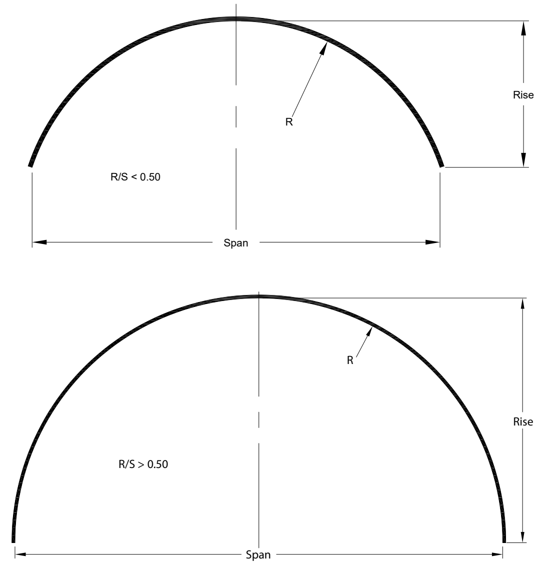
Span Ft.-In.	Rise Ft.-In.	Minimum Cover (Inches)	Corner Radius (Inches)	Maximum Cover Heights Shown in Feet						
				0.111 (12 Ga.)	0.140 (10 Ga.)	0.170 (8 Ga.)	0.188 (7 Ga.)	0.218 (5 Ga.)	0.249 (3 Ga.)	0.280 (1 Ga.)
9 Pi Corner Pipe Arch Structure										
6-1	4-7	12	18	16	16	16	16	16	16	16
6-4	4-9	12	18	15	15	15	15	15	15	15
6-9	4-11	12	18	14	14	14	14	14	14	14
7-0	5-1	12	18	14	14	14	14	14	14	14
7-3	5-3	12	18	13	13	13	13	13	13	13
7-8	5-5	12	18	13	13	13	13	13	13	13
7-11	5-7	12	18	12	12	12	12	12	12	12
8-2	5-9	18	18	12	12	12	12	12	12	12
8-7	5-11	18	18	11	11	11	11	11	11	11
8-10	6-1	18	18	11	11	11	11	11	11	11
9-4	6-3	18	18	10	10	10	10	10	10	10
9-6	6-5	18	18	10	10	10	10	10	10	10
9-9	6-7	18	18	10	10	10	10	10	10	10
10-3	6-9	18	18	9	9	9	9	9	9	9
10-8	6-11	18	18	9	9	9	9	9	9	9
10-11	7-1	18	18	9	9	9	9	9	9	9
11-5	7-3	18	18	8	8	8	8	8	8	8
11-7	7-5	18	18	8	8	8	8	8	8	8
11-10	7-7	18	18	8	8	8	8	8	8	8
12-4	7-9	24	18	8	8	8	8	8	8	8
12-6	7-11	24	18	8	8	8	8	8	8	8
12-8	8-1	24	18	7	7	7	7	7	7	7
12-10	8-4	24	18	7	7	7	7	7	7	7
15 Pi Corner Pipe Arch Structure										
13-3	9-4	24	31	12	12	12	12	12	12	12
13-6	9-6	24	31	12	12	12	12	12	12	12
14-0	9-8	24	31	12	12	12	12	12	12	12
14-2	9-10	24	31	12	12	12	12	12	12	12
14-5	10-0	24	31	11	11	11	11	11	11	11
14-11	10-2	24	31	11	11	11	11	11	11	11
15-4	10-4	24	31	11	11	11	11	11	11	11
15-7	10-6	24	31	11	11	11	11	11	11	11
15-10	10-8	24	31	10	10	10	10	10	10	10
16-3	10-10	30	31	10	10	10	10	10	10	10
16-6	11-0	30	31	10	10	10	10	10	10	10
17-0	11-2	30	31	10	10	10	10	10	10	10
17-2	11-4	30	31	10	10	10	10	10	10	10
17-5	11-6	30	31	9	9	9	9	9	9	9
17-11	11-8	30	31	9	9	9	9	9	9	9
18-1	11-10	30	31	9	9	9	9	9	9	9
18-7	12-0	30	31	9	9	9	9	9	9	9
18-9	12-2	30	31	9	9	9	9	9	9	9
19-3	12-4	30	31		8	8	8	8	8	8
19-6	12-6	30	31		8	8	8	8	8	8
19-8	12-8	30	31		8	8	8	8	8	8
19-11	12-10	30	31		8	8	8	8	8	8
20-5	13-0	36	31		8	8	8	8	8	8
20-7	13-2	36	31		8	8	8	8	8	8

Notes:
1. Tables based upon AASHTO Sec. 12 Standard Specifications for Highway Bridges.
2. H-20, HS-20, H-25, HS-25 live loads.
3. Minimum cover is defined as the vertical distance from the top of the corrugated structure to the bottom of flexible or top of rigid pavement.
4. Minimum cover for heavy off-road construction equipment must be checked.

Additional Notes for pipe-arch HOC Table
1. Maximum cover requires minimum 4000 psf allowable bearing capacity for backfill around haunch of pipe-arch.
2. Maximum cover limited by corner bearing pressure.

TABLE 22. MULTI-PLATE® ARCHES

Dimensions					Nominal Arc Length
Span Ft.-In.	Rise Ft.-In.	Waterway Area Ft.²	Rise/Span Ratio	Radius Inches	Pi
6-0	1-10	7.9	0.30	41	27
	2-4	10.0	0.38	37	30
	3-2	15.0	0.53	36	36
7-0	2-5	12.1	0.34	45	33
	2-10	14.9	0.41	43	36
	3-8	20.4	0.52	42	42
8-0	2-11	17.0	0.36	51	39
	3-4	20.3	0.42	49	42
	4-2	26.6	0.52	48	48
9-0	2-11	19.2	0.33	59	42
	3-11	26.5	0.43	55	48
	4-8	33.6	0.52	54	54
10-0	3-6	25.4	0.35	64	48
	4-5	33.5	0.44	61	54
	5-3	41.4	0.52	60	60
11-0	3-6	27.8	0.32	73	51
	4-6	36.9	0.41	68	57
	5-9	50.0	0.52	66	66
12-0	4-1	35.3	0.34	78	57
	5-0	45.2	0.42	73	63
	6-3	59.4	0.52	72	72
13-0	4-1	38.1	0.33	87	60
	5-1	48.9	0.40	81	66
	6-9	69.7	0.52	78	78
14-0	4-8	47.0	0.31	91	66
	5-7	58.5	0.38	86	72
	7-3	80.7	0.44	84	84
15-0	4-8	48.9	0.52	101	69
	5-8	62.8	0.33	93	75
	6-7	74.8	0.44	91	81
	7-9	92.6	0.52	90	90
16-0	5-3	60.1	0.31	105	75
	7-1	86.2	0.42	97	87
	8-4	105.3	0.52	96	96
17-0	5-3	63.4	0.31	115	78
	7-2	91.9	0.42	103	90
	8-10	118.8	0.52	102	102
18-0	5-9	74.8	0.32	119	84
	7-8	104.6	0.43	109	96
	8-11	126.0	0.50	108	105
19-0	6-4	87.1	0.33	123	90
	8-3	118.1	0.43	115	102
	9-5	140.7	0.50	114	111
20-0	6-4	91.0	0.32	133	93
	8-3	124.4	0.42	122	105
	10-0	156.3	0.50	120	117
21-0	6-11	104.6	0.33	137	99
	8-10	139.2	0.42	128	111
	10-6	172.6	0.50	126	123
22-0	6-11	109.3	0.32	146	102
	8-11	145.9	0.40	135	114
	11-0	189.8	0.50	132	129
23-0	8-0	133.6	0.35	147	111
	9-10	171.1	0.43	140	123
	11-6	207.8	0.50	138	135
24-0	8-6	149.4	0.36	152	117
	10-4	188.3	0.43	146	129
	12-0	226.6	0.50	144	141
25-0	8-7	155.6	0.34	160	120
	10-10	206.3	0.43	152	135
	12-6	246.2	0.50	150	147
26-0	8-7	161.4	0.33	169	123
	11-0	214.9	0.42	158	138
	13-1	266.7	0.50	156	153



Single Radius Arch

MULTI-PLATE Arch Pedestrian Underpass

Notes:
1. Dimensions are to inside crests of corrugations are are subject to manufacturing tolerances.
2. To determine proper gage, use Table 24 and/or design information found on Pages 13-18.
3. For additional arch sizes, contact your Contech representative.

TABLE 23. PLATE ARRANGEMENT AND APPROXIMATE WEIGHT PER FOOT FOR SINGLE RADIUS MULTI-PLATE® ARCH

Arch Arc Length	Number of Plates Per Ring						Approximate Weight Per Foot of Structure, Pounds Specified Thickness, Inches						
							0.111	0.140	0.170	0.188	0.218	0.249	0.280
Pi	9 Pi	15 Pi	18 Pi	21 Pi	24 Pi	Total Plates	(12 Ga.)	(10 Ga.)	(8 Ga.)	(7 Ga.)	(5 Ga.)	(3 Ga.)	(1 Ga.)
24					1	1	42	53	64	69	80	91	102
27	1		1			2	50	63	76	82	95	108	120
30		2				2	55	69	83	90	104	118	132
33		1	1			2	60	75	90	98	113	128	144
36		1		1		2	64	81	97	106	122	139	155
39			1	1		2	69	87	105	114	131	149	167
42			1		1	2	74	93	112	121	140	159	178
45				1	1	2	79	99	119	130	150	171	191
48					2	2	84	105	127	138	160	182	204
51		1	2			3	92	115	139	151	174	198	221
54			3			3	96	121	146	159	184	208	233
57			2	1		3	101	127	153	167	193	218	244
60			1	2		3	106	133	160	174	201	229	256
63				3		3	110	139	168	182	210	239	267
66				2	1	3	116	145	175	190	220	250	280
69				1	2	3	121	152	183	199	230	262	293
72					3	3	126	158	191	207	240	273	305
75			3	1		4	133	168	202	219	254	288	322
78			2	2		4	138	174	209	227	263	298	333
81			1	3		4	143	179	216	235	272	308	345
84			2		2	4	147	185	223	243	281	318	356
87				3	1	4	152	192	231	251	290	330	369
90				2	2	4	157	198	239	260	300	341	382
93				1	3	4	163	205	246	268	310	352	395
96			3	2		5	168	211	254	276	320	364	407
99			2	3		5	175	220	265	288	333	377	422
102			1	4		5	179	226	272	296	342	388	434
105				5		5	184	232	279	303	351	398	446
108				4	1	5		238	287	312	361	409	458
111				3	2	5		245	295	320	370	421	471
114				2	3	5		251	302	329	380	432	484
117				1	4	5		257	310	337	390	443	496
120					5	5		264	318	345	400	455	509
123			1	5		6			328	356	412	467	523
126			3		3	6			335	364	421	478	535
129				5	1	6			343	372	431	489	547
132				4	2	6				381	440	500	560
135				3	3	6				389	450	512	573
138				2	4	6				398	460	523	585
141				1	5	6				406	470	534	598
144			1	6		7					479	546	611
147				7		7					491	557	624
150				6	1	7					503	567	636
153				5	2	7					515	575	650

Notes:
1. Dimensions are to inside crests of corrugations and are subject to manufacturing tolerances.
2. These plate arrangements will be furnished unless noted otherwise on assembly drawings.
3. Approximate weights include galvanized steel material, bolts, and nuts.
4. 24 Pi plates are not available in 5/16 through 3/8. Inquire for number of plates per ring.

TABLE 24. MULTI-PLATE® ARCH 6" X 2"
AASHTO HEIGHT OF COVER LIMITS H-20, HS-20, H-25, HS-25 LIVE LOADS

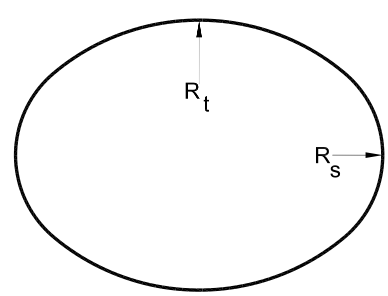
Span Ft.-In.	Rise Ft.-In.	Minimum Cover (Inches)	Thickness in Inches (Gage) (Maximum Cover Height Shown In Feet)								
			0.111 (12 Ga.)	0.140 (10 Ga.)	0.170 (8 Ga.)	0.188 (7 Ga.)	0.218 (5 Ga.)	0.249 (3 Ga.)	0.280 (1 Ga.)	0.318 (5/16)	0.380 (3/8)
6-0	1-10 2-4 3-2	12	39	57	75	86	103	122	133	214	257
7-0	2-5 2-10 3-8	12	34	49	64	73	88	104	114	183	220
8-0	2-11 3-4 4-2	12	29	43	56	64	77	91	100	160	192
9-0	2-11 3-11 4-8	18	26	38	50	57	69	81	88	142	171
10-0	3-6 4-5 5-3	18	23	34	45	51	62	73	80	128	154
11-0	3-6 4-6 5-9	18	21	31	40	46	56	66	72	116	140
12-0	4-1 5-0 6-3	18	19	28	37	43	51	61	66	107	128
13-0	4-1 5-1 6-9	24	18	26	34	39	47	56	61	98	118
14-0	4-8 5-7 7-3	24	17	24	32	36	44	52	57	91	110
15-0	4-8 5-8 6-7 7-9	24	15	22	30	34	41	48	53	85	102
16-0	5-3 7-1 8-4	24	14	21	28	32	38	45	50	80	96
17-0	5-3 7-2 8-10	30	14	20	26	30	36	43	47	75	90
18-0	5-9 7-8 8-11	30	13	19	25	28	34	40	44	71	85
19-0	6-4 8-3 9-5	30	12	18	23	27	32	38	42	67	81
20-0	6-4 8-3 10-0	30		17	22	25	31	36	40	64	77
21-0	6-11 8-10 10-6	36		16	21	24	29	34	38	61	73
22-0	6-11 8-11 11-0	36			20	23	28	33	36	58	70
23-0	8-0 9-10 11-6	36			19	22	27	31	34	55	67
24-0	8-6 10-4 12-0	36			18	21	25	30	33	53	64
25-0	8-7 10-10 12-6	42				20	24	29	32	49	60
26-0	8-7 11-0 13-1	42					23	28	30	46	56

Notes:
1. Tables based upon AASHTO Sec. 12 Standard Specifications for Highway Bridges.
2. H-20, HS-20, H-25, HS-25 Live Loads.
3. Minimum cover is defined as the vertical distance from the top of the corrugated structure to the bottom of flexible or top of rigid pavement.
4. Minimum cover for heavy off-road construction equipment loads must be checked.
5. Footing reactions can be provided by supplier.

TABLE 25. MULTI-PLATE® HORIZONTAL ELLIPSE						
Structure Number	**Span Ft.-In.**	**Rise Ft.-In.**	**Area Sq. Ft.**	**R_t (Inches)**	**R_s (Inches)**	**Total Pi**
24E15	7-4	5-6	32	54	27	78
27E15	8-1	5-9	36	61	27	84
30E15	8-10	6-0	41	68	27	90
30E18	9-2	6-9	48	68	32	96
33E15	9-7	6-4	47	75	27	96
33E18	9-11	7-0	54	75	32	102
36E15	10-4	6-7	53	82	27	102
36E18	10-8	7-3	60	82	32	108
36E21	11-0	8-0	68	82	38	114
39E15	11-1	6-10	58	88	27	108
39E18	11-4	7-6	66	88	32	114
39E21	11-8	8-3	75	88	38	120
39E24	12-0	8-11	84	88	43	126
42E15	11-9	7-1	64	95	27	114
42E18	12-1	7-10	73	95	32	120
42E21	12-5	8-6	82	95	38	126
42E24	12-9	9-2	92	95	43	132
45E15	12-6	7-4	71	102	27	120
45E18	12-10	8-1	80	102	32	126
45E21	13-2	8-9	90	102	38	132
45E24	13-6	9-6	100	102	43	138
48E18	13-7	8-4	87	109	32	132
48E21	13-11	9-0	97	109	38	138
48E24	14-3	9-9	109	109	43	144
48E27	14-7	10-5	119	109	49	150
48E30	14-11	11-2	130	109	54	156

Notes:
1. Dimensions are to inside crests of corrugations and are subject to manufacturing tolerances.
2. Plate arrangements can be determined by the structure number, (i.e. Structure 45E21 has a plate makeup consisting of 24 pi and 21pi top and bottom plates and a 21pi plate in each side for a total of 132 pi).

Additional Notes for Horizontal Ellipse Table
1. Maximum cover requires minimum 4000 psf allowable bearing capacity for backfill around haunch of horizontal arch.
2. Maximum cover limited by corner bearing pressure.



Horizontal Ellipse

TABLE 26. MULTI-PLATE® HORIZONTAL ELLIPSE 6″ X 2″
AASHTO HEIGHT OF COVER LIMITS H-20, HS-20, H-25, HS-25 LIVE LOADS

Structure Number	Size		All Structures are 12 Gage	
	Span Ft.-In.	Rise Ft.-In.	Minimum Cover (Inches)	Maximum Cover (Feet) Over Horizontal Ellipse For Corner Bearing Pressure of 2 Tons per Ft.
24E15	7-4	5-6	12	16
27E15	8-1	5-9	18	14
30E15	8-10	6-0	18	13
30E18	9-2	6-9	18	15
33E15	9-7	6-4	18	11
33E18	9-11	7-0	18	14
36E15	10-4	6-7	18	10
36E18	10-8	7-3	18	13
36E21	11-0	8-0	18	15
39E15	11-1	6-10	18	10
39E18	11-4	7-6	18	12
39E21	11-8	8-3	18	14
39E24	12-0	8-11	18	16
42E15	11-9	7-1	18	9
42E18	12-1	7-10	24	11
42E21	12-5	8-6	24	13
42E24	12-9	9-2	24	15
45E15	12-6	7-4	24	8
45E18	12-10	8-1	24	10
45E21	13-2	8-9	24	12
45E24	13-6	9-6	24	14
48E18	13-7	8-4	24	9
48E21	13-11	9-0	24	11
48E24	14-3	9-9	24	13
48E27	14-7	10-5	24	14
48E30	14-11	11-2	24	16

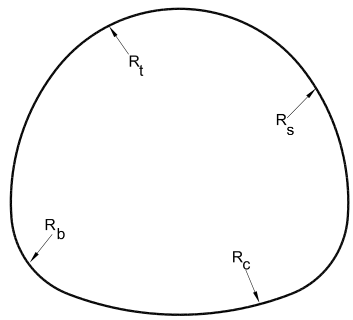
Notes:
1. Tables based upon AASHTO Sec. 12 Standard Specifications for Highway Bridges.
2. H-20, HS-20, H-25 & HS-25 Live Loads.
3. Minimum cover is defined as the vertical distance from the top of the corrugated structure to the bottom of flexible or top of rigid pavement.
4. Minimum cover for heavy off-road construction equipment loads must be checked for specific applications.
5. Heavier gages may be supplied.

Horizontal Ellipse Assembly

TABLE 27. MULTI-PLATE® UNDERPASS

Span Ft.-In.	Rise Ft.-In.	Area Sq. Ft.	R_t Inches	R_s Inches	R_c Inches	R_b Inches
Junior Underpasses						
5-8	5-9	27	28	53	18	Flat
5-9	6-6	31	30	75	18	Flat
5-9	7-4	36	29	95	18	Flat
5-10	7-8	38	30	113	18	Flat
5-10	8-2	40	28	117	18	Flat
Standard Underpasses						
12-2	11-0	107	67	93	38	134
12-11	11-3	116	73	95	38	144
13-2	11-11	126	73	103	38	159
13-10	12-3	136	77	108	38	164
14-1	12-10	147	77	115	38	182
14-6	13-5	158	78	130	38	174
14-10	14-0	169	79	136	38	192
15-6	14-4	180	84	138	38	201
15-9	15-1	192	83	150	38	212
16-4	15-5	204	86	157	38	215
16-5	16-1	217	88	158	38	271
16-9	16-3	224	89	167	38	247
17-3	17-0	239	90	174	47	215
18-4	16-11	252	100	157	47	249
19-2	17-2	266	105	156	47	264
19-6	17-7	280	107	158	47	297
20-4	17-10	295	113	156	47	314

MULTI-PLATE Underpass



Underpass

TABLE 28. PLATE ARRANGEMENT FOR MULTI-PLATE® UNDERPASS

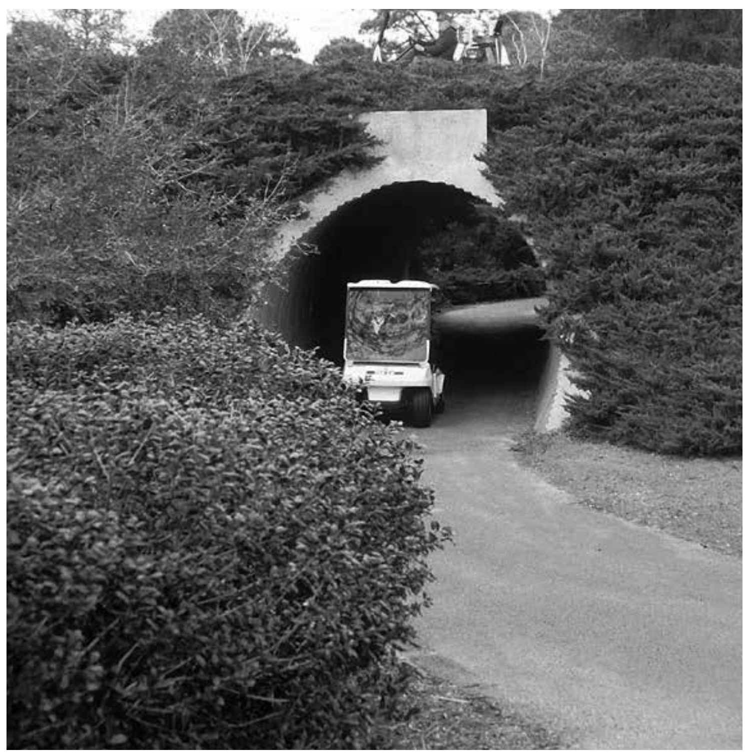
Span, Ft.-In.	Rise, Ft.-In.	Total Pi	Top 15	Top 18	Top 21	Top 24	Sides 9	Sides 15	Sides 18	Sides 21	Sides 24	Corners 9	Corners 15	Corners 18	Bottom 9	Bottom 15	Bottom 18	Bottom 21	Bottom 24	Total Plates Per Ring
Junior Underpasses																				
5-8	5-9	72	1					2				2			1					6
5-9	6-6	78			1			2				2			1					6
5-9	7-4	84			1				2			2			1					6
5-10	7-8	87				1			2			2			1					6
5-10	8-2	90			1					2		2			1					6
Standard Underpasses																				
12-2	11-0	141		1	1					2			2			2				8
12-11	11-3	147			2					2			2			1	1			8
13-2	11-11	153			2						2		2			1	1			8
13-10	12-3	159			1	1					2		2				2			8
14-1	12-10	165			1	1	2		2				2				2			10
14-6	13-5	171				2	2		2				2				1	1		10
14-10	14-0	177				2		4					2				1	1		10
15-6	14-4	183	1	2				4					2					2		11
15-9	15-1	189	1	2				2	2				2					2		11
16-4	15-5	195		3				2	2				2					1	1	11
16-5	16-1	201		2	1				4				2					2		11
16-9	16-3	204		2	1				4				2					1	1	11
17-3	17-0	210		2	1				4					2				1	1	11
18-4	16-11	216		1	2				4					2					2	11
19-2	17-2	222			3				4					2		1	2			12
19-6	17-7	228			3				2	2				2		1	2			12
20-4	17-10	234			2	1			2	2				2			3			12

Notes:
1. These plate arrangements will be furnished unless noted otherwise on assembly drawings.
2. Dimensions are to inside crests of corrugations and are subject to manufacturing tolerances.

TABLE 29. APPROXIMATE WEIGHT PER FOOT FOR MULTI-PLATE® UNDERPASS									
Span Ft.-In.	**Rise Ft.-In.**	**Approximate Weight Per Foot of Structure, Pounds**							**Area Sq. Ft.**
		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.)**	
Junior Underpasses									
5-8	5-9	126	158	192	213	246	279	312	27
5-9	6-6	137	172	207	231	267	303	339	31
5-9	7-4	147	185	223	249	287	326	365	36
5-10	7-8	152	191	231	258	298	338	378	38
5-10	8-2	158	198	239	266	308	349	391	40
Standard Underpasses									
12-2	11-0	253	318	382	415	480	544	609	107
12-11	11-3	262	329	397	431	498	565	632	116
13-2	11-11	272	342	412	448	518	587	657	126
13-10	12-3	282	354	427	464	536	609	682	136
14-1	12-10	299	375	452	491	567	642	719	147
14-6	13-5	309	388	466	507	586	664	743	158
14-10	14-0	318	399	481	522	604	685	766	169
15-6	14-4	331	415	500	543	627	711	795	180
15-9	15-1	340	427	514	558	645	731	818	192
16-4	15-5		439	529	575	664	753	843	204
16-5	16-1		451	543	590	682	773	865	217
16-9	16-3		457	550	598	691	784	877	224
17-3	17-0		469	565	614	710	805	901	239
18-4	16-11			580	630	728	826	925	252
19-2	17-2			599	650	752	852	954	266
19-6	17-7			613	666	770	873	977	280
20-4	17-10			628	682	789	894	1001	298

Notes:
1. Dimensions are to inside crests of corrugations and are subject to manufacturing tolerances.
2. Approximate weights include galvanized steel material, bolts, and nuts.

TABLE 29A. MULTI-PLATE® UNDERPASS H-20, HS-20, H-25, HS-25 LIVE LOADS MAXIMUM					
Size Bearing Span Ft.-In.	**Rise Ft.-In.**	**Radius, Inches R_c Corner**	**Minimum Specified Thickness Required Inches**	**Cover Inches**	**Maximum Height of Cover**
Junior Underpasses					
5-8	5-9	18	0.111	12	26
5-9	6-6	18	0.111	12	24
5-9	7-4	18	0.111	12	24
5-10	7-8	18	0.111	12	24
5-10	8-2	18	0.111	12	24
Standard Underpasses					
12-2	11-0	38	0.111	24	22
12-11	11-3	38	0.111	24	20
13-2	11-11	38	0.111	24	20
13-10	12-3	38	0.111	24	19
14-1	12-10	38	0.111	24	19
14-6	13-5	38	0.111	24	19
14-10	14-0	38	0.111	24	19
15-6	14-4	38	0.111	24	15
15-9	15-1	38	0.111	24	15
16-4	15-5	38	0.140	36	15
16-5	16-1	38	0.140	36	14
16-9	16-3	38	0.140	36	14
17-3	17-0	47	0.140	36	17
18-4	16-11	47	0.170	36	16
19-2	17-2	47	0.170	36	15
19-6	17-7	47	0.170	36	15
20-4	17-10	47	0.188	36	14



Golf Cart Underpass

Notes:
1. Maximum height of cover over underpass for corner bearing pressures of 2 tons per sq. ft.

Galvanized Steel Structural Plate Specification

Scope: This specification covers the manufacture and installation of the galvanized steel structural plate structure detailed in the plans.

Material: The galvanized steel structural plate structure shall consist of plate and appurtenant items as shown on the plans and shall conform to the requirements of AASHTO M 167/ASTM A761. All manufacturing processes, including corrugating, punching, curving and galvanizing, shall be performed within the United States using raw materials made in the United States.

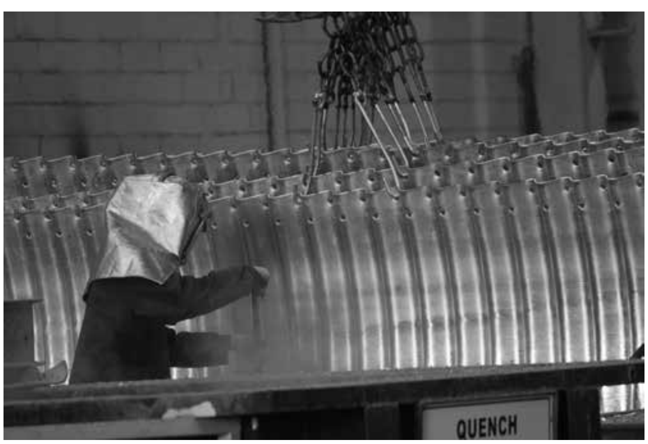
Assembly bolts and nuts shall be galvanized and meet the provisions of ASTM A449, Type 1 and ASTM A563, Grade C, respectively.

Assembly: The structure shall be assembled in accordance with the shop drawings provided by the manufacturer and per the manufacturer's recommendations. Bolts shall be tightened using an applied torque of between 100 and 300 ft.-lbs. When seam sealant tape is used, bolts shall be installed and retightened to these torque levels after 24 hours. Torque levels are for installation, not residual, in-service requirements.

Installation: The structure shall be installed in accordance with the plans and specifications, the manufacturer's recommendations, and the AASHTO Standard Specifications for Highway Bridges, Section 26 (Division II).

Backfill: The structure shall be backfilled using clean, well graded granular material that meets the requirements of AASHTO M 145 for soil classification A-1, A-2-4, A-2-5, or A-3. Backfill must be placed symmetrically on each side of the structure in 8-inch uncompacted lifts. Each lift shall be compacted to a minimum of 90 percent density per AASHTO T 180.

Notes: Construction loads that exceed highway load limits are not allowed on the structure without approval from the Engineer.



Hot-Dip Galvanizing Process

Galvanized Steel Key-Hole Slot Structural Plate Specification

Scope: This specification covers the manufacture and installation of the galvanized steel structural plate structure detailed in the plans.

Material: The galvanized steel structural plate structure shall consist of plates and appurtenant items as shown on the plans and shall conform to the requirements of AASHTO M 167/ ASTM A761 except the longitudinal seam bolt holes shall be key-hole shaped as shown in the plans. All manufacturing processes including corrugating, punching, curving and galvanizing, shall be performed within the United States using raw materials made in the United States.

Assembly bolts and nuts shall be galvanized and meet the provisions of ASTM A449, Type 1 and ASTM A563, Grade C, respectively.

Assembly: The structure shall be assembled in accordance with the shop drawings provided by the manufacturer and per the manufacturer's recommendations. Bolts shall be tightened using an applied torque of between 100 and 300 ft.-lbs.

Installation: The structure shall be installed in accordance with the plans and specifications, the manufacturer's recommendations, and the AASHTO Standard Specifications for Highway Bridges, Section 26 (Construction).

Backfill: The structure shall be backfilled using clean, well graded granular material that meets the requirements of AASHTO M 145 for soil classifications A-1-a. Backfill must be placed symmetrically on each side of the structure in 8-inch uncompacted lifts. Each lift shall be compacted to a minimum of 90 percent density per AASHTO T 180. Backfill limits shall be in accordance with the details shown on the plans.

Notes: Construction loads that exceed highway load limits are not allowed on the structure without approval from the Project Engineer.

Installation

A successful installation is dependent on these five critical components being followed:

- Good foundation
- Use of structural backfill
- 8" lifts of backfill evenly placed on both sides of the structure
- Adequate compaction of backfill
- Adequate minimum cover over the structure

Required Elements
Satisfactory site preparation, trench excavation and bedding and backfill operations are essential to develop the strength of any flexible conduit. In order to obtain proper strength while preventing settlement, it is necessary that the soil envelope around the structure be of good granular material, properly placed, and carefully compacted.

Pipe-arch and underpass shapes pose special installation problems not found in other shapes. These two shapes generate high corner bearing pressures against the side fill and foundation. Therefore, special installation care must be implemented to achieve a composite soil structure.

A qualified Engineer should be engaged to design a proper foundation, adequate bedding, backfill, and erosion control.

Trench Excavation
If the adjacent embankment material is structurally adequate, the trench requires only a bottom clear width of the structure's span plus sufficient room for compaction equipment.

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

It is recommended that the bedding be a relatively loose granular material that is roughly shaped to fit the bottom of the structure, be a minimum of twice the corrugation depth in thickness and have a maximum particle size of one half the corrugation depth.

It should be noted that the bedding depth can vary based on the amount of cover and the shape of the structure's invert. The bedding should be shaped to match structures with flatter inverts.

Backfill
Satisfactory backfill material, proper placement and compaction are key factors in obtaining maximum strength and stability. Compaction needs to be achieved under the haunches by carefully tamping a granular or select material.

The backfill material should be free of rocks, frozen lumps, and foreign material that can cause hard spots or decompose to create voids. Backfill material should be well graded granular material that meets the requirements of AASHTO M 145 for soil classifications A-1, A-2-4, A-2-5, or A-3. Backfill must be placed symmetrically on each side of the structure in six-inch loose lifts. Each lift is to be compacted to a minimum of 90 percent density per AASHTO T 180.

A high percentage of silt or fine sand in the native soils suggests the need for a *well graded* granular backfill material to prevent soil migration.

During backfill, only small tracked vehicles (D4 or smaller) should be near the structure as fill progresses above the crown and to the finished grade. The Engineer and Contractor are cautioned that the minimum cover may need to be increased to handle temporary construction vehicle loads (larger than D4).

For more information, refer to ASTM A807 and AASHTO Standard Specifications for Highway Bridges Div. II – Construction Section 26.

Bolting
If the plates are well aligned, the torque applied with a power wrench need not be excessive. Bolts should be torque initially to a minimum 100 foot pounds and a maximum 300 foot pounds. A good plate fit is far better than high torque.

Complete detailed assembly instructions and drawings are provided with each structure.

Erosion Control
During installation and prior to the construction of permanent erosion control and end treatment protection, special precautions may be necessary. The structure must be protected from unbalanced loads and from any structural loads or hydraulic forces that may bend or distort the unsupported ends of the structure. Erosion or washout of previously soils support must be prevented to ensure that the structure maintains its load capacity.

Aluminum Structural Plate
Lightweight and Lower Installed Cost

Contech Aluminum Structural Plate gives you all the advantages of steel MULTI-PLATE, plus the lightweight, which adds to the ease of installation when compared to traditional concrete structures.

Aluminum structural plate is 1/50 of the weight of reinforced concrete pipe in an equivalent size. This weight factor reduces assembly and equipment costs, helps gain access to remote sites and allows easy handling of long, preassembled structures.

Lower Job Site Unloading Costs

Lightweight plates and reinforcing ribs arrive at the job site in strapped and nested bundles. Individual plates and ribs are generally light enough to be handled by one worker. Bundles can be handled with light-duty lifting equipment.

Lower Job Site Assembly Costs

Most structures contain plate and rib sizes that can be assembled without lifting equipment. As a quality assurance measure, at least one ring of plates for each order is plant-assembled and checked prior to shipment.

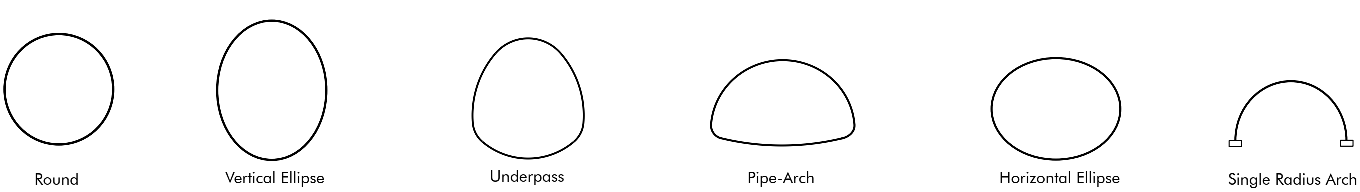
Aluminum Structural Plate can be manufactured into large sections with multiple radii in the same plate. This reduces the number of longitudinal seams, therefore, lowering assembly costs. Off-site assembly is an added feature of lightweight aluminum, with obvious cost-saving benefits.

Typical Aluminum Structural Plate applications include small bridges, grade separations, underpasses, culverts, stream enclosures, storm sewers and rehabilitating existing structures through relining.

National Specifications

Contech's Aluminum Structural Plate design meets or exceeds AASHTO Standard Specifications for Highway Bridges (Sec. 12.6), AASHTO LRFD Bridge Design Specifications (Sec. 12) and ASTM B790. Material meets or exceeds AASHTO M 219 or ASTM B746. Installation is covered by AASHTO Standard Specifications for Highway Bridges (Sec. 26), AASHTO LRFD Bridge Construction Specifications (Sec. 26) and ASTM B789.

Lifting of Preassembled Aluminum Pipe Arch



Typical Shapes

Product Details

Description of Plates

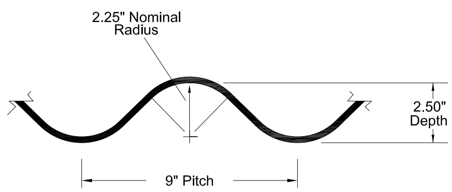
Aluminum Structural Plate's corrugation pattern has a 9-inch pitch and 2-1/2 inch depth. The corrugations are perpendicular to the length of the structure.

Thickness. Nominal plate thicknesses are available from 0.125" to 0.250" in uniform increments of 0.025". (Uncurved plates are available in 0.100" plate thickness.)

Widths. Individual circumferential plate widths are noted in terms of N (N = 9.625" or 3pi). Standard plates are fabricated in net covering widths in one "N" increments from:

8N (77.00"), through 20N (192.50") (see Table 30)

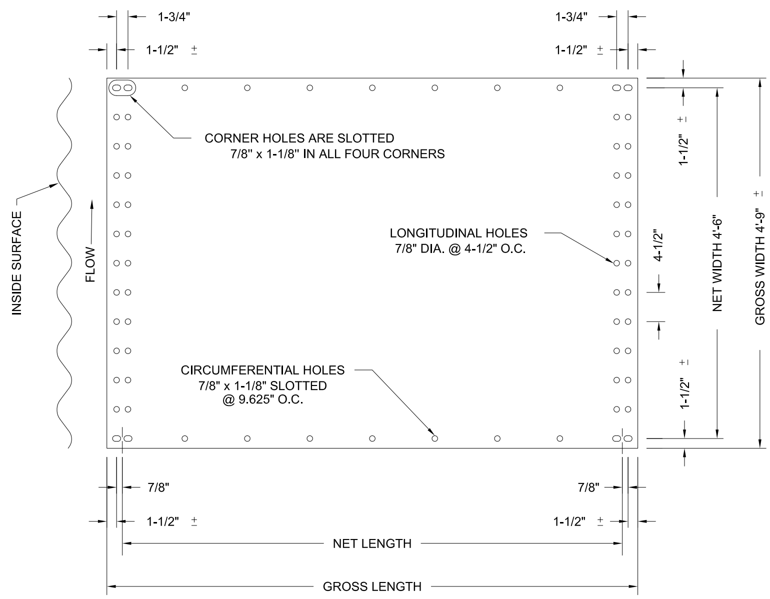
The N nomenclature translates circumference directly into nominal diameter in inches. For example, two 10N plates give a diameter of 60" (2 x 10N x 3 pi), three 12N plates = 108" (3 x 12N x 3 pi), etc. Various plate lengths are used to obtain a specific structure shape and size.



9" x 2-1/2" Corrugation

Lengths. All standard plates have a net length of 4'-6". Longitudinal bolt holes at 4-$^{1}/_{2}$" centers provide a standard 5.33 bolts per foot of longitudinal seams in two parallel rows at 1- $^{3}/_{4}$" centers. The outside crests of the end corrugations are punched for circumferential seam holes on center of 9.625" (or 3 pi).

Materials. Plates are fabricated from an aluminum alloy with material properties that conform to AASHTO M 219 and ASTM B209 specifications.



Standard Plate Detail

TABLE 30. DETAILS OF UNCURVED ALSP PLATE			
Plate "N"	**Net Width Inches**	**Gross Width Inches**	**Circumferential Spaces at 9.625"**
8	77-0	81-3/4	8
9	86-5/8	91-3/8	9
10	96-1/4	101-0	10
11	105-7/8	110-5/8	11
12	115-1/2	120-1/4	12
13	125-1/8	129-7/8	13
14	134-3/4	139-1/2	14
15	144-3/8	149-1/8	15
16	154-0	158-3/4	16
17	163-5/8	168-3/8	17
18	173-1/4	178-0	18
19	182-7/8	187-5/8	19
20	192-1/2	197-1/4	20

For ALSP, 1 N = 9.625""

TABLE 30A. ALSP PLATE WEIGHTS						
Plate "N"	**Weight per Plate, lbs (without fasteners)**					
	.125	**.150**	**.175**	**.200**	**.225**	**.250**
8	66	79	92	105	119	132
9	74	88	103	118	133	148
10	81	98	114	130	147	164
11	89	107	125	143	161	179
12	97	116	136	155	175	195
13	105	126	147	168	189	210
14	113	135	157	180	203	226
15	120	144	168	192	217	241
16	128	154	179	205	231	257
17	136	163	190	217	245	273
18	144	172	201	230	259	288
19	151	182	212	242	273	304
20	159	191	223	254	288	319

Aluminum Structural Plate Rib Design

TABLE 30A. SECTION PROPERTIES OF PLATES ONLY
9" X 2-1/2" CORRUGATION

Thickness Inches	Moment of Inertia In.⁴/Ft.	Section Modulus In.³/Ft.	Radius of Gyration Inches	Area of Section In.²/Ft.	Ultimate Seam Strength kip/ft.
0.100	0.997	0.767	0.844	1.404	28.0
0.125	1.248	0.951	0.844	1.750	41.0
0.150	1.499	1.131	0.845	2.100	54.1
0.175	1.751	1.309	0.845	2.449	63.7
0.200	2.004	1.484	0.846	2.799	73.4
0.225	2.258	1.657	0.847	3.149	83.2
0.250	2.513	1.828	0.847	3.501	93.1

Notes:
1. Design Yield Stress is 24 ksi.
2. 0.100" Thickness can not be curved.

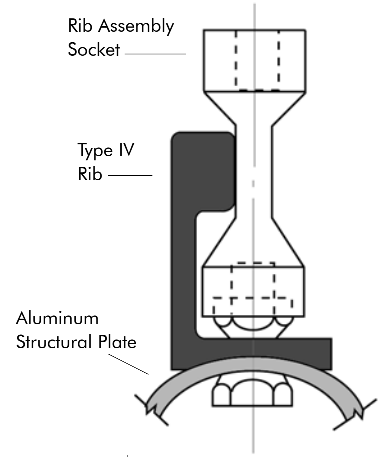
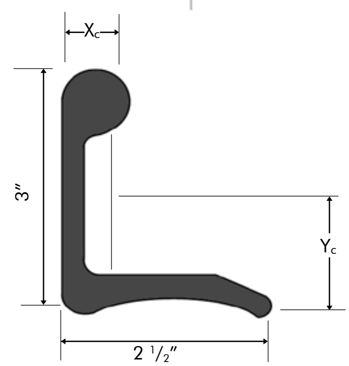


TABLE 31. PLATE & RIB COMPOSITE SECTION PROPERTIES

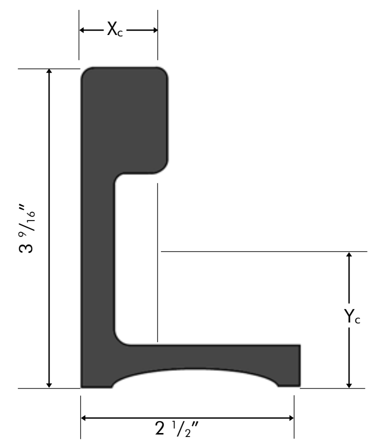
Rib Type		0.125	0.150	0.175	0.200	0.225	0.250
		Metal Thickness, Inches					
		Plastic Moment Capacity, M_p (kip-ft./ft.)					
No Rib		2.65	3.18	3.71	4.24	4.77	5.30
Type II	@ 54	4.62	5.46	6.04	6.61	7.17	7.74
	@ 27	6.18	7.25	7.94	8.60	9.25	9.87
	@ 18	7.41	8.66	9.48	10.26	11.00	11.71
	@ 9	10.63	12.13	13.08	14.05	15.03	16.02
Type IV	@ 54	5.87	6.82	7.43	8.04	8.63	9.21
	@ 27	8.32	9.59	10.39	11.14	11.85	12.55
	@ 18	10.42	11.90	12.84	13.72	14.57	15.39
	@ 9	16.45	18.46	19.41	20.38	21.37	22.37
Type VI	@ 54	8.74	9.51	10.24	10.95	11.64	12.32
	@ 27	13.76	14.33	15.16	16.19	17.36	17.48
	@ 18	20.09	20.56	20.79	21.30	21.74	22.58
	@ 9	32.24	34.35	36.46	38.54	39.88	40.63



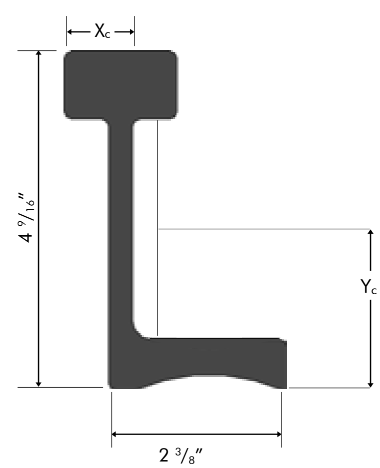
Type II Rib

TABLE 32. SECTION PROPERTIES OF ALSP REINFORCING RIB

	Type VI Rib	Type IV Rib	Type II Rib
Alloy	6061-T6	6061-T6	6061-T6
Area	3.62 in.²	2.27 in.²	1.71 in.²
Center of Mass	X_c = 0.91 inches Y_c = 2.27 inches	X_c = 0.652 inches Y_c = 1.76 inches	X_c = 0.645 inches Y_c = 1.02 inches
Moment of Inertia	I_{xc} = 9.700 in.⁴ I_{yc} = 1.014 in.⁴	I_{xc} = 3.555 in.⁴ I_{yc} = 1.050 in.⁴	I_{xc} = 1.802 in.⁴ I_{yc} = 0.787 in.⁴
Radius of Gyration	R_{xc} = 1.636 inches R_{yc} = 0.529 inches	R_{xc} = 1.251 inches R_{yc} = 0.680 inches	R_{xc} = 1.026 inches R_{yc} = 0.678 inches
Section Modulus	S_x = 4.38 in.³	S_x = 1.90 in.³	S_x = 1.046 in.³
Plastic Modulus	Z_x = 5.66 in.³	Z_x = 2.68 in.³	Z_x = 1.705 in.³
Plastic Moment	M_p = 16.52 kip-ft.	M_p = 7.81 kip-ft.	M_p = 4.97 kip-ft.
Yield Strength	F_y = 35 ksi	F_y = 35 ksi	F_y = 35 ksi
Tensile Strength	F_u = 38 ksi	F_u = 38 ksi	F_u = 38 ksi
Minimum Curving Radius	104 in.	104 in.	60 in.



Type IV Rib



Type VI Rib

Height of Cover and Details Tables for Aluminum Structural Plate

Instructions to Read Tables 33, 36, 38, 41 and 43:
The tables are presented for the designer's convenience in selecting metal thickness, reinforcing rib type and rib spacing for minimum cover applications. For structures with maximum covers greater than those shown in the table, heavier plate and rib combinations may be possible.

Allowable cover (minimum and maximum) is measured from the outside valley of the crown plate to the bottom of flexible pavement or from the outside valley of the crown plate to the top of rigid pavement.

To find the minimum material requirements for the aluminum structural plate structure:

1. Locate the structure required.
2. Select the cover in the top row that is equal to or less than that required for the project.
3. The table selection shows metal thickness, rib type, rib spacing and maximum cover. Example: .125-II-27 .125″ – thick plate with Type II ribs at 27″ on centers.

Example: .125-II-27 .125″ = Plate Thickness II = Type II Reinforcing Rib 27 = Reinforcing Ribs on 27″ Centers

Round, Vertical Ellipse

TABLE 33. ROUND STRUCTURES (H-20, HS-20 LIVE LOAD)									TABLE 34. ROUND, ELLIPSE DETAILS				
Metal Thickness (Inches) — Reinforcing Rib Type-Rib Spacing (Inches) (Maximum Cover — Ft.)									Ellipse Dimensions (Inches)		Total N		
			Minimum Height-of-Cover (Feet)									Rib	
Diameter Ft.-In.	Round (Inches)	Approx. Area Sq. Ft.	1.25	1.50	2.00	2.50	3.00	3.50	Span	Rise	Structure	Round	Ellipse
6-0	72	27.5	.125	.125	.125	.125	.125	.125	67	75	24		
			(37)	(37)	(37)	(37)	(37)	(37)					
6-6	78	32.4	.175	.125	.125	.125	.125	.125	73	81	26		
7-0	84	37.8	(50)	(32)	(32)	(32)	(32)	(32)	79	88	28		
7-6	90	43.6	.250	.150	.125	.125	.125	.125	85	94	30		
8-0	96	49.7	(64)	(37)	(28)	(28)	(28)	(28)	91	101	32		
8-6	102	56.3		.200	.125	.125	.125	.125	97	107	34		
9-0	108	63.3		(45)	(25)	(25)	(25)	(25)	103	114	36		
9-6	114	70.7			.125	.125	.125	.125	109	120	38		
10-0	120	78.5			(22)	(22)	(22)	(22)	115	127	40	10	
10-6	126	86.7	.150-II-9	.125-II-18	.125-II-27	.125	.125	.125	120	133	42	10	
11-0	132	95.4	(27)	(20)	(20)	(20)	(20)	(20)	126	139	44	10	
11-6	138	104.4		.125-II-9	.125-II-27	.125	.125	.125	132	146	46	10	11
12-0	144	113.9		(18)	(18)	(18)	(18)	(18)	138	152	48	12	11
12-6	150	123.7		.150-II-9	.125-II-27	.150	.125	.125	142	157	50	12	12
13-0	156	134.0		(23)	(17)	(23)	(17)	(17)	148	164	52	12	12
13-6	162	144.7		.200-II-9	.125-II-18	.125-II-27	.150	.150	153	170	54	12	13
14-0	168	155.7		(29)	(16)	(16)	(21)	(21)	159	176	56	12	13
14-6	174	167.2		.250-II-9	.125-II-9	.125-II-27	.125-II-27	.125-II-54	165	183	58	13	14
15-0	180	179.1		(34)	(15)	(15)	(15)	(15)	171	189	60	13	14
15-6	186	191.4			.125-II-9	.125-II-27	.150-II-54	.150-II-54	177	195	62	14	15
16-0	192	204.2			(14)	(14)	(18)	(18)	182	202	64	14	15
16-6	198	217.3			.150-II-9	.150-II-27	.150-II-27	.150-II-27	189	209	66	15	16
17-0	204	230.8			(17)	(17)	(17)	(17)	195	215	68	15	16
17-6	210	274.8	.200-VI-9	.175-VI-9	.175-IV-18	.175-II-27	.175-II-54	.175-II-54	200	222	70	16	16
18-0	216	259.1	(22)	(19)	(19)	(19)	(19)	(19)	206	228	72	16	16
18-6	222	273.9		.175-VI-9	.175-VI-18	.175-IV-27	.175-II-54	.175-II-54	212	235	74	16	17
19-0	228	289.1		(18)	(18)	(18)	(18)	(18)	217	241	76	18	18
19-6	234	304.7		.200-VI-9	.200-VI-18	.200-IV-27	.200-IV-54	.200-IV-54	224	247	78	18	17
20-0	240	321.0		(20)	(20)	(20)	(20)	(20)	229	254	80	18	18
20-6	246	337.0		.225-VI-9	.225-VI-18	.225-IV-27	.225-II-27	.225-II-27	235	260	82	18	19
21-0	252	354.0		(22)	(22)	(22)	(22)	(22)	241	267	84	20	20

Notes for Aluminum Structural Plate HOC Tables:
1. Table based on AASHTO Sec. 12 Standard Specifications for Highway Bridges.
2. H-20, HS-20 Live Load (Contact your local Contech representative for H-25,HS-25 and HL-93 Loading).
3. Minimum cover is defined as the vertical distance from the top of the corrugated structure to the bottom of flexible or top of rigid pavement.
4. Minimum cover for heavy off-road construction equipment loads must be checked.
5. Greater cover heights possible with heavier gage and rib combinations.
6. Handling weights and plate make-up are on page 60 and 61.

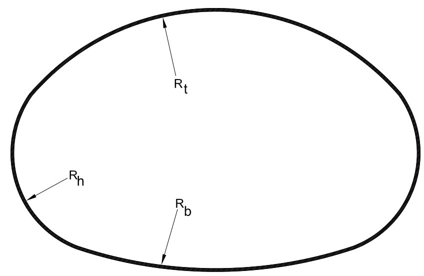
Notes:
1. N = 9.625″
2. Dimensions are to inside corrugation crests and are subject to manufacturing tolerances.
3. Minimum reinforcing rib length, if required. Ribs are not available for vertical ellipse structures less than 46 N.
4. Areas shown are for round pipe. Areas for vertical ellipses are slightly less

Pipe-Arch

TABLE 35. PIPE-ARCH DETAILS

Span Ft.-In.	Rise Ft.-In.	Approx Area Sq. Ft.	Inside Radius (Inches) Crown (R_t)	Invert (R_i)	Arc Length N Crown	Haunch	Invert	Total N Structure	Rib (Min)
Haunch Radius (R_h) = 31.75″									
6-7	5-8	29.6	41.5	69.9	8	7	3	25	
6-11	5-9	31.9	43.7	102.9	9	7	3	26	
7-3	5-11	34.3	45.6	188.3	10	7	3	27	
7-9	6-0	36.8	51.6	83.8	9	7	5	28	
8-1	6-1	39.3	53.3	108.1	10	7	5	29	
8-5	6-3	41.9	54.9	150.1	11	7	5	30	11
8-10	6-4	44.5	63.3	93.0	10	7	7	31	10
9-3	6-5	47.1	64.4	112.6	11	7	7	32	11
9-7	6-6	49.9	65.4	141.6	12	7	7	33	10
9-11	6-8	52.7	66.4	188.7	13	7	7	34	11
10-3	6-9	55.5	67.4	278.8	14	7	7	35	12
10-9	6-10	58.4	77.5	139.6	13	7	9	36	11
11-1	7-0	61.4	77.8	172.0	14	7	9	37	12
11-5	7-1	64.4	78.2	222.0	15	7	9	38	13
11-9	7-2	67.5	78.7	309.5	16	7	9	39	14
12-3	7-3	70.5	90.8	165.2	15	7	11	40	13
12-7	7-5	73.7	90.5	200.0	16	7	11	41	14
12-11	7-6	77.0	90.4	251.7	17	7	11	42	13
13-1	8-2	83.0	88.8	143.6	18	6	13	43	14
13-1	8-4	86.8	81.7	300.8	21	6	11	44	13
14-0	8-5	90.3	100.4	132.0	18	6	15	45	14
14-0	8-7	94.2	90.3	215.7	21	6	13	46	14
14-0	9-5	101.5	86.2	159.3	23	5	14	47	13
14-3	9-7	105.7	87.2	176.3	24	5	14	48	13
14-8	9-8	109.9	90.9	166.2	24	5	15	49	14
14-11	9-11	114.2	91.8	183.0	25	5	15	50	14
15-4	10-0	118.6	95.5	173.0	25	5	16	51	15
15-8	10-2	123.1	96.4	189.6	26	5	16	52	15
16-1	10-4	127.6	100.2	179.7	26	5	17	53	14
16-4	10-6	132.3	101.0	196.1	27	5	17	54	16
16-9	10-8	136.9	105.0	186.5	27	5	18	55	17
17-0	10-10	141.8	105.7	202.5	28	5	18	56	17
17-3	11-0	146.7	106.5	221.7	29	5	18	57	16
17-9	11-2	151.6	110.4	208.9	29	5	19	58	17
18-0	11-4	156.7	111.1	227.3	30	5	19	59	17
18-5	11-6	161.7	115.8	215.3	30	5	20	60	18
18-8	11-8	167.0	115.8	233.7	31	5	20	61	18
19-2	11-9	172.2	119.9	221.5	31	5	21	62	19
19-5	12-0	177.6	120.5	239.7	32	5	21	63	19
19-10	12-1	182.9	124.7	227.7	32	5	22	64	18
20-1	12-3	188.5	125.2	245.3	33	5	22	65	18
20-1	12-6	194.4	122.5	310.8	35	5	21	66	19
20-10	12-7	199.7	130.0	251.2	34	5	23	67	19
21-1	12-9	205.5	130.5	270.9	35	5	23	68	20
21-6	12-11	211.2	134.8	257.3	35	5	24	69	19
Haunch Radius (R_h) = 47.0″									
20-1	13-11	216.6	124.0	225.4	34	7	20	68	19
20-7	14-3	224.0	126.2	257.6	36	7	20	70	19
21-6	14-7	241.5	133.0	238.6	36	7	22	72	19
22-0	14-11	254.7	135.0	270.0	38	7	22	74	19

Notes:
1. N = 9.625″
2. Dimensions are to inside corrugation crests and are subject to manufacturing tolerances.
3. To determine the proper gage, use information on Page 53, Table 36.
4. The Arc Length N column reflects the peripheral length of a certain radius. Actual plate make-up, in a ring for a pipe-arch structure, will vary because of multiple radii in a single plate.



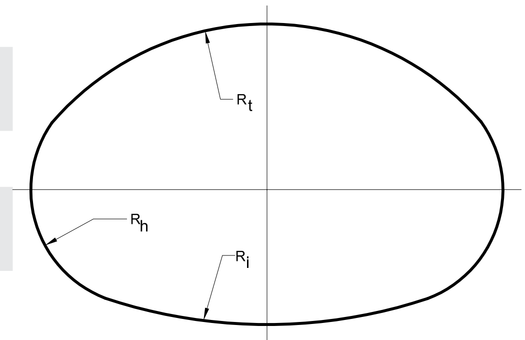
Pipe-Arch

TABLE 36. PIPE-ARCH STRUCTURES (H-20, HS-20 LIVE LOAD)

Metal Thickness (Inches) — Reinforcing Rib Type — Rib Spacing (Inches)
(Maximum Cover-Ft.)

Span Ft.-In.	Rise Ft.-In.	Approx. Area Sq. Ft.	Minimum Height-of-Cover (Feet) 1.25	1.50	2.00	2.50	3.00	3.50
6-7	5-8	29.6	.175	.125	.125	.125	.125	.125
6-11	5-9	31.9	(24)	(24)	(24)	(24)	(24)	(24)
7-3	5-11	34.3	.250	.150	.125	.125	.125	.125
7-9	6-0	36.8	(19)	(19)	(19)	(19)	(19)	(19)
8-1	6-1	39.3						
8-5	6-3	41.9		.200	.125	.125	.125	.125
8-10	6-4	44.5		(16)	(16)	(16)	(16)	(16)
9-3	6-5	47.1	.125-II-9	.125-II-27	.125	.125	.125	.125
9-7	6-6	49.9	(15)	(15)	(15)	(15)	(15)	(15)
9-11	6-8	52.7						
10-3	6-9	55.5		.150-II-18	.125-II-27	.125	.125	.125
10-9	6-10	58.4		(13)	(13)	(13)	(13)	(13)
11-1	7-0	61.4						
11-5	7-1	64.4		.125-II-9	.125-II-27	.125	.125	.125
11-9	7-2	67.5		(13)	(13)	(13)	(13)	(13)
12-3	7-3	70.5			.125-II-27	.150	.125	.125
12-7	7-5	73.7			(11)	(11)	(11)	(11)
12-11	7-6	77.0						
13-1	8-2	83.0						
13-1	8-4	86.8						
14-0	8-5	90.3			.125-II-18	.125-II-27	.125	.125
14-0	8-7	94.2			(10)	(10)	(10)	(10)
14-0	9-5	101.5						
14-3	9-7	105.7			.125-II-9	.125-II-27	.125	.125
14-8	9-8	109.9			(11)	(11)	(11)	(11)
14-11	9-11	114.2						
15-4	10-0	118.6			.125-II-9	.125-II-27	.150	.125
15-8	10-2	123.1			(9)	(9)	(9)	(9)
16-1	10-4	127.6						
16-4	10-6	132.3						
16-9	10-8	136.9			.125-VI-27	.125-II-18	.125-II-54	.150
17-0	10-10	141.8			(8)	(8)	(8)	(8)
17-3	11-0	146.7						
17-9	11-2	151.6						
18-0	11-4	156.7			.125-VI-27	.125-IV-27	.125-IV-54	.175
18-5	11-6	161.7			(8)	(8)	(8)	(8)
18-8	11-8	167.0						
19-2	11-9	172.2			.150-IV-9	.150-IV-27	.150-IV-54	.200
19-5	12-0	177.6			(7)	(7)	(7)	(7)
19-10	12-1	182.9						
20-1	12-3	188.5			.175-IV-9	.175-IV-27	.175-IV-54	.200
20-1	12-6	194.4			(7)	(7)	(7)	(7)
20-1	13-11	199.7						
20-7	14-3	205.5						
20-10	12-7	211.2						
21-1	12-9	216.6			.150-VI-18	.175-IV-18	.150-IV-54	.150-IV-54
21-6	12-11	224.0			(7)	(7)	(7)	(7)
21-6	14-7	241.5						
22-0	14-11	254.7						

Notes:
1. Tables based upon AASHTO Sec. 12 Standard Specifications for Highway Bridges.
2. H-20, HS-20 Live Loads (Contact your local Contech representative for HS-25, H-25 and HL-93 loading).
3. Minimum cover is defined as the vertical distance from the top of the corrugated structure to the bottom of flexible or top of rigid pavement.
4. Minimum cover for heavy off-road construction equipment loads must be checked.
5. Plate and rib combinations shown meet or exceed AASHTO Sec. 12.6 Standard Specifications for Highway Bridges.
6. Minimum cover heights < span/8 determined by moment capacity analysis.
7. Backfill in haunch area min. 4,000 psf bearing capacity.
8. Handling weights and plate make-up are on page 60 and 61.



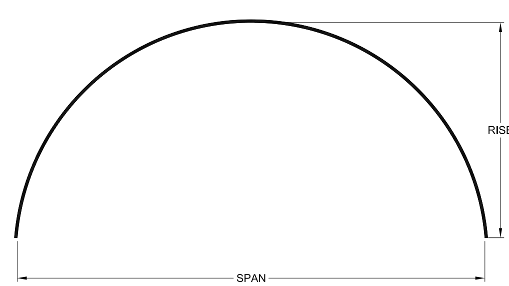
Pipe-Arch

Single Radius Arch

TABLE 37. ARCH DETAILS

Span Ft.-In.	Rise Ft.-In.	Approx Area Sq. Ft.	Radius (Inches)	Rise/ Span Ratio	Total N Structure	Total N Rib
6-0	1-10	7.8	40.50	.30	9	
	2-4	10.2	37.25	.38	10	
	2-9	12.6	36.25	.46	11	
	3-2	14.9	36.00	.52	12	
7-0	2-4	12.0	45.25	.34	11	
	2-10	14.8	43.00	.40	12	
	3-3	17.5	42.00	.46	13	
	3-8	20.3	42.00	.52	14	
8-0	2-11	17.0	50.50	.36	13	
	3-4	20.2	48.75	.42	14	
	4-2	26.4	48.00	.52	16	
9-0	2-11	19.1	59.00	.33	14	8
	3-10	26.3	54.50	.43	16	
	4-8	33.4	54.00	.50	18	
10-0	3-6	25.3	64.00	.35	16	10
	4-5	33.3	60.50	.44	18	10
	5-2	41.2	60.00	.52	20	9
11-0	3-6	27.8	72.75	.32	17	11
	4-6	36.8	67.50	.41	19	11
	5-9	49.9	66.00	.52	22	10
12-0	4-1	35.3	77.50	.34	19	11
	5-0	45.0	73.25	.42	21	11
	6-3	59.3	72.00	.52	24	12
13-0	4-1	38.1	86.50	.31	20	12
	5-1	48.9	80.50	.39	22	12
	5-11	59.3	78.25	.46	24	12
	6-9	69.5	78.00	.52	26	12
14-0	4-8	46.9	91.25	.33	22	14
	5-7	58.4	86.00	.40	24	14
	6-5	69.5	84.25	.46	26	14
	7-3	80.6	84.00	.52	28	14
15-0	4-8	50.0	100.50	.31	23	15
	5-8	62.6	93.50	.38	25	15
	6-7	74.7	91.00	.44	27	15
	7-5	86.5	90.00	.49	29	15
	7-9	92.5	90.00	.52	30	14
16-0	5-3	60.0	105.00	.32	25	15
	6-2	73.3	99.25	.39	27	15
	7-1	86.2	96.75	.44	29	15
	7-11	98.9	96.00	.49	31	15
	8-3	105.2	96.00	.52	32	14
17-0	5-3	63.5	114.25	.31	26	16
	6-3	77.9	107.00	.37	28	16
	7-2	91.7	103.50	.42	30	16
	8-0	105.2	102.25	.47	32	16
	8-10	118.7	102.00	.52	34	16
18-0	5-9	74.8	118.75	.32	28	18
	6-9	89.9	112.50	.38	30	18
	7-8	104.5	109.25	.43	32	18
	8-6	118.8	108.25	.47	34	18
	8-11	125.9	108.00	.50	35	17
19-0	6-4	86.9	123.50	.33	30	18
	7-4	102.7	118.00	.38	32	18
	8-2	118.0	115.25	.43	34	18
	9-0	133.2	114.25	.48	36	18
	9-5	140.7	114.00	.50	37	17
20-0	6-4	91.2	132.50	.32	31	19
	7-4	108.4	125.75	.37	33	19
	8-3	124.4	122.25	.41	35	19
	9-2	140.4	120.50	.46	37	19
	10-0	156.3	120.00	.50	39	19
	10-4	164.2	120.00	.52	40	20
21-0	6-4	95.4	142.00	.30	32	20
	7-5	113.5	133.75	.35	34	20
	8-4	130.7	129.25	.40	36	20
	9-3	147.6	127.50	.44	38	20
	10-1	164.3	126.00	.48	40	20
	10-10	181.0	126.00	.52	42	20
22-0	6-11	109.2	142.25	.31	34	20
	7-11	127.9	139.00	.36	36	20
	8-11	146.0	135.00	.40	38	20
	9-9	163.6	133.00	.44	40	20
	10-7	181.1	132.00	.48	42	20
	11-5	198.6	132.00	.52	44	20
23-0	7-6	123.8	151.00	.33	36	20
	8-0	133.6	147.25	.35	37	21
	8-6	143.2	144.50	.37	38	20
	8-11	152.7	142.25	.39	39	21
	9-5	162.0	140.75	.41	40	20
	9-10	171.3	139.50	.43	41	21
	10-3	180.5	139.00	.45	42	20
	10-8	189.6	138.25	.47	43	21
	11-1	198.8	138.0	.48	44	20
	11-6	207.9	138.00	.50	45	21
	11-11	217.1	138.00	.52	46	20

Notes
1. N = 9.625″
2. Dimensions to inside corrugation crests are subject to manufacturing tolerances.
3. To determine proper gage, use the information on Page 55, Table 38.
4. Arch shapes shown are single radius with a rise/span ratio of 0.30 or greater.
5. Handling weights and plate make-up are on page 60 and 61.



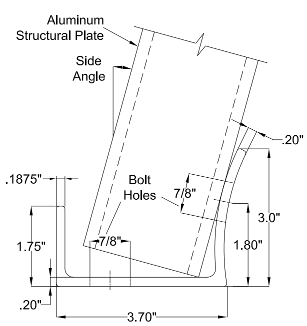
Single Radius Arch

TABLE 38. ARCH STRUCTURES (H-20, HS-20 LIVE LOAD)

Span Ft.-In.	Rise Ft.-In.	Approx. Area Sq. Ft.	Metal Thickness (Inches) — Reinforcing Rib Type-Rib Spacing (Inches) (Maximum Cover-Ft.) Minimum Height of Cover (Feet) 1.25	1.50	2.00	2.50	3.00	3.50
6-0	1-10	7.8	0.125	.125	.125	.125	.125	.125
	2-4	10.2	(37)	(37)	(37)	(37)	(37)	(37)
	2-9	12.6						
	3-2	14.9						
7-0	2-4	12.0	.175	.125	.125	.125	.125	.125
	2-10	14.8	(50)	(32)	(32)	(32)	(32)	(32)
	3-3	17.5						
	3-8	20.3						
8-0	2-11	17.0	.250	.150	.125	.125	.125	.125
	3-4	20.2	(64)	(37)	(28)	(28)	(28)	(28)
	4-2	26.4						
9-0	2-11	19.1		.200	.125	.125	.125	.125
	3-10	26.3		(45)	(25)	(25)	(25)	(25)
	4-8	33.4						
10-0	3-6	25.3	.125-II-9	.125-II-18	.125	.125	.125	.125
	4-5	33.3	(22)	(22)	(22)	(22)	(22)	(22)
	5-2	41.2						
11-0	3-6	27.8		.125-II-18	.125-II-27	.125	.125	.125
	4-6	36.8		(20)	(20)	(20)	(20)	(20)
	5-9	49.9						
12-0	4-1	35.3		.125-II-9	.125-II-27	.125	.125	.125
	5-0	45.0		(18)	(18)	(18)	(18)	(18)
	6-3	59.3						
13-0	4-1	38.1		.150-II-9	.125-II-27	.150	.125	.125
	5-1	48.9		(23)	(17)	(23)	(17)	(17)
	5-11	59.3						
	6-9	69.5						
14-0	4-8	46.9		.200-II-9	.125-II-18	.125-II-27	.125	.125
	5-7	58.4		(29)	(16)	(16)	(16)	(16)
	6-5	69.5						
	7-3	80.6						
15-0	4-8	50.0		.250-II-9	.125-II-9	.125-II-27	.125	.125
	5-8	62.6		(34)	(15)	(15)	(15)	(15)
	6-7	74.7						
	7-5	86.5						
	7-9	92.5						
16-0	5-3	60.0			.125-II-9	.125-II-27	.150	.125
	6-2	73.3			(14)	(14)	(18)	(14)
	7-1	86.2						
	7-11	98.9						
	8-3	105.2						
17-0	5-3	63.5			.225-II-18	.150-II-27	.175	.150
	6-3	77.9			(17)	(17)	(20)	(17)
	7-2	91.7						
	8-0	105.2						
	8-10	118.7						
18-0	5-9	74.8	.200-VI-9	.150-VI-9	.175-IV-18	.125-IV-27	.200	.175
	6-9	89.9	(22)	(16)	(19)	(12)	(22)	(19)
	7-8	104.5						
	8-6	118.8						
	8-11	125.9						
19-0	6-4	86.9		.150-VI-9	.125-VI-18	.125-IV-27	.125-IV-54	.125-IV-54
	7-4	102.7		(15)	(11)	(11)	(11)	(11)
	8-2	118.0						
	9-0	133.2						
	9-5	140.7						
20-0	6-4	91.2		.150-VI-9	.150-VI-9	.150-IV-27	.175-II-54	.200
	7-4	108.4		(15)	(15)	(15)	(16)	(20)
	8-3	124.4						
	9-2	140.4						
	10-0	156.3						
	10-4	164.2						
21-0	6-4	95.4		.175-VI-9	.175-VI-18	.175-IV-18	.175-II-54	.225
	7-5	113.5		(16)	(16)	(16)	(16)	(22)
	8-4	130.7						
	9-3	147.6						
	10-1	164.3						
	10-10	181.0						
22-0	6-11	109.2		.225-VI-9	.175-VI-18	.175-IV-18	.175-IV-27	.250
	8-0	127.9		(21)	(16)	(16)	(16)	(23)
	8-11	146.0						
	9-9	163.6						
	10-7	181.1						
	11-5	198.6						
23-0	7-6	123.8			.250-VI-18	.250-VI-18	.225-IV-54	.250-II-27
	8-0	133.6			(23)	(17)	(20)	(22)
	8-6	143.2						
	8-11	152.7						
	9-5	162.0						
	9-10	171.3						
	10-3	180.5						
	10-8	189.6						
	11-1	198.8						
	11-6	207.9						
	11-11	217.1						

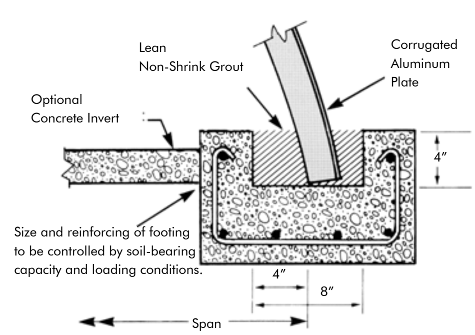
Notes for Aluminum Structural Plate HOC Tables:

1. Tables based upon AASHTO Sec. 12 Standard Specifications for Highway Bridges.
2. H-20, HS-20 Live Loads. (Contact your local Contech representative for H-25, HS-25, and HL-93 Loading.)
3. Minimum cover is defined as the vertical distance from the top of the corrugated structure to the bottom of flexible or top of rigid pavement.
4. Minimum cover for off highway construction loads must be checked.
5. Minimum cover heights < span/8 determined by moment capacity analysis.
6. Greater cover heights possible with other plate thickness/rib combinations.
7. Arch footing reaction are available upon request.



Aluminum Receiving Channel

Weight is equal to 2 lbs per foot per side.



Slotted Concrete Footing

Aluminum Structural Plate

Underpass

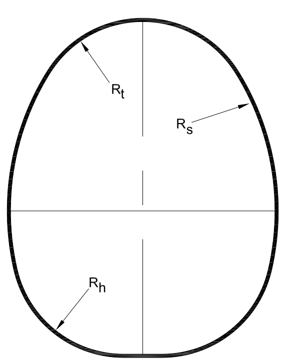
TABLE 39. PEDESTRIAN/ANIMAL UNDERPASS DETAILS

Span Ft.-In.	Rise Ft.-In.	Approx. Area Sq. Ft.	Inside Radius (Inches) Crown (R_t)	Side (R_s)	Haunch (R_h)	Arc Length (Inches) Crown	Side	Haunch	Bottom	Total N Structure	Rib
6-1	5-9	28	31.8	48.2	31.8	43.0	20.5	68.6	9.2	24	
6-3	6-1	30	31.8	51.3	31.8	50.2	28.6	60.7	11.1	25	
6-3	6-6	32	31.8	55.0	31.8	56.5	36.8	53.9	11.6	26	
6-2	6-11	34	31.8	71.3	31.8	70.4	38.0	51.3	10.2	27	
6-4	7-3	37	31.8	72.4	31.8	67.3	45.0	50.0	11.6	28	
6-3	7-9	39	31.8	74.7	31.8	69.2	54.0	45.7	9.8	29	
6-5	8-1	42	31.8	75.8	31.8	66.9	60.5	44.4	11.3	30	

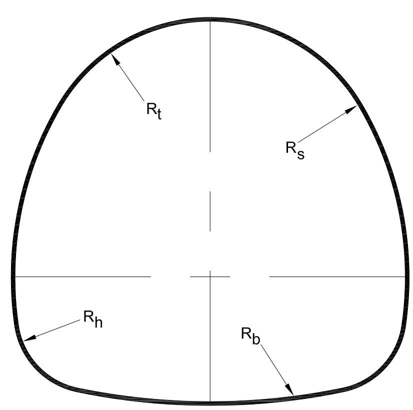
TABLE 39. PEDESTRIAN/ANIMAL UNDERPASS DETAILS

Span Ft.-In.	Rise Ft.-In.	Approx. Area Sq. Ft.	Inside Radius (Inches) Crown (R_t)	Side (R_s)	Haunch (R_h)	Invert (R_b)	Arc Length (Inches) Crown	Side	Haunch	Bottom	Total N Structure	Rib
12-1	11-0	107.5	70	83	38	133	13	8	4	10	47	10
12-10	11-2	116.6	75	83	38	144	14	8	4	11	49	11
13-0	12-0	126.7	74	93	38	152	14	9	4	11	51	11
13-8	12-4	136.7	78	96	38	158	15	9	4	12	53	12
14-0	12-11	147.4	79	102	38	174	15	10	4	12	55	12
14-6	13-5	156.7	76	144	38	192	16	9	5	13	57	12
14-9	14-1	169.8	81	118	38	182	16	11	4	13	59	12
15-5	14-5	179.2	80	158	38	217	17	10	5	14	61	13
15-7	15-2	193.6	85	132	38	195	17	12	4	14	63	13
16-3	15-6	206.1	89	135	38	201	18	12	4	15	65	13
16-5	16-0	216.0	87	170	38	330	19	12	5	14	67	13
16-8	16-4	222.3	86	188	38	277	19	12	5	15	68	13
17-3	17-1	238.4	89	182	48	219	19	12	6	15	70	16
18-5	16-11	252.0	99	159	48	262	20	12	6	16	72	17
19-0	17-3	266.0	103	166	48	264	21	12	6	17	74	18
19-7	17-7	280.2	107	160	48	315	21	13	6	17	76	18
20-5	17-9	294.4	113	158	48	336	22	13	6	18	78	19

Notes:
1. N = 9.625″
2. Dimensions are to inside corrugation crests and are subject to manufacturing tolerances. The designer should allow sufficient clearance for manufacturing tolerances and installation deflection.
3. To determine proper gage, use information on Page 57, Table 41.
4. The Arc Length N or Inches column reflects the peripheral length of a certain radius. Actual plate make-up, in a ring for an underpass structure, will vary because of multiple radii in a single plate.
5. See sidefill and foundation design on Page 57.



Pedestrian Underpass



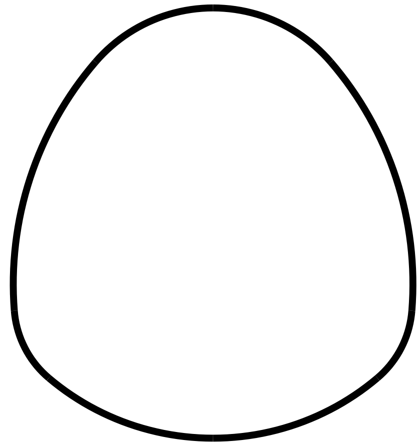
Vehicular Underpass

TABLE 41. UNDERPASS STRUCTURES (H-20, HS-20 LIVE LOAD)

Metal Thickness (Inches) – Reinforcing Rib Type – Rib Spacing (Inches) (Maximum Cover – Ft.)

Span Ft.-In.	Rise Ft.-In.	Approx. Area Sq. Ft.	Minimum Height-of-Cover (Feet)					
			1.25	1.50	2.00	2.50	3.00	3.50
6-1	5-9	28	.150	.125	.125	.125	.125	.125
6-3	6-1	30	(46)	(33)	(33)	(33)	(33)	(33)
6-3	6-6	32						
6-2	6-11	34						
6-4	7-3	37						
6-3	7-9	39						
6-5	8-1	42						
12-1	11-0	107.5		.125-II-9	.125-II-27	.125	.125	.125
				(18)	(18)	(18)	(18)	(18)
12-10	11-2	116.6		.125-II-9	.125-II-27	.150	.125	.125
13-0	12-0	126.7		(17)	(17)	(17)	(17)	(17)
13-8	12-4	136.7		.125-II-9	.125-II-18	.125-II-27	.125-II-54	.125-II-54
14-0	12-11	147.4		(16)	(16)	(16)	(16)	(16)
14-6	13-5	156.7		.125-II-9	.125-II-18	.125-II-27	.125-II-54	.125-II-54
14-9	14-1	169.8		(16)	(16)	(16)	(16)	(16)
15-5	14-5	179.2			.125-II-9	.125-II-27	.150-II-54	.150-II-54
15-7	15-2	193.6			(15)	(15)	(15)	(15)
16-3	15-6	206.1			.150-II-9	.150-II-27	.150-II-27	.150-II-27
16-5	16-0	216.0			(14)	(14)	(14)	(14)
16-8	16-4	222.3						
17-3	17-1	238.4			.150-II-18	.150-II-27	.150-II-27	.150-II-27
18-5	16-11	252.0			(16)	(16)	(16)	(16)
19-0	17-3	266.0		.200-VI-9	.200-VI-18	.200-II-18	.200-II-27	.200-IV-27
19-7	17-7	280.2		(19)	(19)	(19)	(19)	(19)
20-5	17-9	294.4						

Note:
1. Maximum cover based on allowable corner bearing pressure of approximately 4,000 psf (2tsf).
2. Handling weights and plate make-up are on page 60 and 61.



Underpass

Sidefill and Foundation Design

Horizontal ellipse, pipe-arch, and underpass shapes generate high bearing pressures against the sidefill and foundation in the areas of the smaller radius haunches. The height of cover is directly affected by these bearing pressures. The surrounding soil and foundation, therefore, must be checked to ensure that they are adequate to react against these pressures without excessive strain. Bearing pressures immediately adjacent to the plate can be approximated by the following formula:

$$P_c = [\gamma(H_c) + LL]\left(\frac{R_t}{R_h}\right)$$

P_c = Corner Bearing Pressure (Lb./Sq.Ft.)
γ = unit weight of soil (120 pcf)
H_c = Height-of-Cover (feet)
LL = Wheel Load Pressure at Cover Depth (Lb./Sq. Ft.)
R_t = Radius, crown (inches) (See Tables 34 through 39)
R_h = Radius, haunch (inches) (See Tables 34 through 39)
(R_s = R_h for Horizontal Ellipse)

Ellipse

TABLE 42. HORIZONTAL ELLIPSE DETAILS

Structure Number	Span Ft.-In.	Rise Ft.-In.	Area Sq. Ft.	Approx. R_t Inches	Approx. R_s Inches	Total N Structure	Total N Rib
10E6	9-2	6-8	48.4	68	32	32	11
11E6	9-11	7-0	54.3	75	32	34	12
12E6	10-7	7-3	59.6	81	32	36	13
12E7	10-11	7-11	68.0	81	37	38	13
13E6	11-4	7-6	66.2	88	32	38	14
13E7	11-8	8-3	74.8	88	37	40	14
13E8	12-0	8-11	83.8	88	43	42	14
14E6	12-1	7-9	72.8	95	32	40	15
14E7	12-5	8-6	82.0	95	37	42	15
14E8	12-9	9-2	91.5	95	43	44	15
15E6	12-10	8-1	79.7	102	32	42	16
15E7	13-2	8-9	89.4	102	37	44	16
15E8	13-6	9-6	99.4	102	43	46	16
16E6	13-7	8-4	86.8	109	32	44	17
16E7	13-11	9-0	97.1	109	37	46	17
16E8	14-3	9-9	107.6	109	43	48	17
16E9	14-7	10-5	118.5	109	49	50	17
16E10	14-11	11-2	129.7	109	54	52	17

Larger sizes are available. Contact your Contech representative.

Notes:
1. N = 9.625”
2. Dimensions are to inside corrugation crests and are subject to manufacturing tolerances.

Installation of Aluminum Horizontal Ellipses

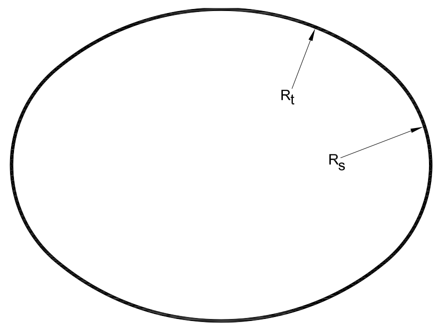


TABLE 43. HORIZONTAL ELLIPSE STRUCTURES (H-20, HS-20 LIVE LOAD)

Metal Thickness (Inches) — Reinforcing Rib Type-Rib Spacing (Inches) (Maximum Cover-Ft.)

Structure Number	Span Ft.-In.	Rise Ft.-In.	Total N Structure	Total N Rib	1.25	1.50	2.00	2.50	3.00	3.50
					Approx. Minimum Height-of-Cover (Feet)					
10E6	9-2	6-8	32	11	.125-II-9 (14)	.125-II-18 (14)	.125 (14)	.125 (14)	.125 (14)	.125 (14)
11E6	9-11	7-0	34	12						
12E6	10-7	7-3	36	13	.150-II-9 (13)	.125-II-18 (13)	.225-II-27 (13)	.125 (13)	.125 (13)	.125 (13)
12E7	10-11	7-11	38	13						
13E6	11-4	7-6	38	14	.225-II-9 (11)	.125-II-9 (11)	.125-II-27 (11)	.125 (11)	.125 (11)	.125 (11)
13E7	11-8	8-3	40	14						
13E8	12-0	8-11	42	14						
14E6	12-1	7-9	40	15						
14E7	12-5	8-6	42	15		.150-II-9 (10)	.125-II-27 (10)	.150 (10)	.125 (10)	.125 (10)
14E8	12-9	9-2	44	15						
15E6	12-10	8-1	42	16						
15E7	13-2	8-9	44	16	.175-VI-18	.125-VI-18	.125-IV-27	.125-II-27	.125	.125
15E8	13-6	9-6	46	16	(9)	(9)	(9)	(9)	(9)	(9)
16E6	13-7	8-4	44	17						
16E7	13-11	9-0	46	17						
16E8	14-3	9-9	48	17	.125-VI-9	.125-VI-18	.125-IV-27	125-II-27	.125	.125
16E9	14-7	10-5	50	17	(11)	(11)	(11)	(11)	(11)	(11)
16E10	14-11	11-2	52	17						

Notes for Aluminum Structural Plate HOC Tables
1. Tables based upon AASHTO Sec. 12 Standard Specifications for Highway Bridges.
2. H-20, HS-20 Live Loads (Contact your local Contech representative for H-25, HS-25 Loading).
3. Minimum cover is defined as the vertical distance from the top of the corrugated structure to the bottom of flexible or top of rigid pavement.
4. Minimum cover for heavy off-road construction equipment loads must be checked.
5. Minimum cover heights < span/8 determined by moment capacity analysis.
6. Backfill in haunch area min. 4,000 psf bearing capacity.
7. Handling weights and plate make-up are on page 60 and 61.

SUPER-SPAN Structure for Access Roads

MULTI-PLATE Conveyor Covers

Single Radius Arch for Residential Development

BridgeCor Stream Crossing

Aluminum Structural Plate – Handling Weights & Plate Make-Up

TABLE 44. APPROXIMATE HANDLING WEIGHT OF STRUCTURE (POUNDS PER FOOT)										
Total "N"	Nominal Thickness (Inches)						Round or Arch		Pipe-Arch	
	.125	.150	.175	.200	.225	.250	Bolts per Foot	Plates per Ring	Bolts per Foot	Plates per Ring
8	19	22	24	27	31	36	6.9	1	6.9	1
9	21	24	27	30	34	39	7.1	1	7.1	1
10	23	26	30	33	37	41	7.3	1	7.3	1
11	24	28	32	36	40	44	7.6	1	7.6	1
12	26	31	35	39	44	48	7.8	1	7.8	1
13	28	33	37	42	47	52	8.0	1	8.0	1
14	30	35	40	45	50	55	8.2	1	8.2	1
15	32	37	43	48	53	59	8.4	1	8.4	1
16	34	39	45	51	57	62	8.7	1	8.7	1
17	36	42	48	54	60	66	8.9	1	8.9	1
18	37	44	50	57	63	70	9.1	1	9.1	1
19	44	50	57	63	71	79	14.4	2	14.4	2
20	46	52	60	66	74	82	14.7	2	14.7	2
21	47	54	62	69	77	85	14.9	2	14.9	2
22	48	56	64	72	80	88	15.1	2	15.1	2
23	50	59	67	75	84	92	15.3	2	15.3	2
24	52	62	70	78	88	96	15.5	2	15.5	2
25	54	64	72	81	91	100	15.8	2	15.8	2
26	56	66	74	84	94	104	16.0	2	16.0	2
27	58	68	77	87	97	107	16.2	2	16.2	2
28	60	70	80	90	100	110	16.4	2	16.4	2
29	62	72	83	93	103	114	16.7	2	21.8	3
30	64	74	86	96	106	118	16.9	2	22.0	3
31	66	76	88	99	110	121	17.1	2	22.2	3
32	68	78	90	102	114	124	17.3	2	22.4	3
33	70	81	93	105	117	128	17.5	2	22.7	3
34	72	84	96	108	120	132	17.8	2	22.9	3
35	73	86	98	111	123	136	18.0	2	23.1	3
36	74	88	100	114	126	140	18.2	2	23.3	3
37	80	95	107	121	136	149	23.5	3	23.5	3
38	82	97	109	123	138	152	23.8	3	23.8	3
39	84	99	112	126	141	156	24.0	3	24.0	3
40	86	101	114	129	144	159	24.2	3	24.2	3
41	88	103	117	132	147	162	24.4	3	24.4	3
42	90	105	120	135	150	165	24.7	3	24.7	3
43	92	107	123	138	153	169	24.9	3	30.0	4
44	94	109	126	141	156	173	25.1	3	30.2	4
45	96	111	129	144	160	177	25.3	3	30.4	4
46	98	113	131	147	163	180	25.5	3	30.7	4
47	100	115	133	150	167	183	25.8	3	30.9	4
48	102	117	135	153	171	186	26.0	3	31.1	4
49	104	120	138	156	174	190	26.2	3	31.3	4
50	106	123	141	159	177	194	26.4	3	31.5	4
51	108	126	144	162	180	198	26.7	3	31.8	4
52	109	128	146	165	183	202	26.9	3	32.0	4
53	109	130	148	169	186	208	27.1	3	32.2	4
54	111	132	150	171	189	210	32.4	4	32.4	4
55	116	136	155	176	195	215	32.7	4	32.7	4
56	120	140	160	180	200	220	32.9	4	32.9	4
57	122	142	163	183	203	224	33.1	4	33.1	4
58	124	144	166	186	206	228	33.3	4	33.3	4
59	126	146	169	189	209	232	33.5	4	33.5	4
60	128	148	172	192	212	236	33.8	4	33.8	4
61	130	150	174	195	216	239	34.0	4	34.0	4
62	132	152	176	198	220	242	34.2	4	34.2	4
63	134	154	178	201	224	245	34.4	4	34.4	4
64	136	156	180	204	228	248	34.7	4	34.7	4
65	138	159	183	207	231	252	34.9	4	34.9	4
66	140	162	186	210	234	256	35.1	4	35.1	4
67	142	165	189	213	237	260	35.3	4	35.3	4
68	144	168	192	216	240	264	35.5	4	35.5	4
69	145	170	194	219	243	268	35.8	4	35.8	4
70	146	172	196	222	246	272	36.0	4	36.0	4
71	147	174	198	225	249	276	36.2	4	36.2	4
72	148	176	200	228	252	280	36.4	4	41.5	5
73	153	180	206	233	257	286	36.7	4	41.8	5
74	158	183	212	237	262	291	36.9	4	42.0	5
75	160	185	214	240	266	295	42.2	5	42.2	5
76	162	187	217	243	269	298	42.4	5	42.4	5
77	164	189	219	246	273	301	42.7	5	42.7	5
78	166	191	221	249	277	304	42.9	5	42.9	5
80	170	195	225	255	285	310	43.3	5	43.3	5
81	172	198	228	258	288	314	43.5	5	43.5	5
82	174	201	231	261	291	318	43.8	5	43.8	5
83	176	204	234	264	294	322	44.0	5	44.0	5
84	178	207	237	267	297	326	44.2	5	44.2	5

Notes:
1. Handling weights are approximate and include bolts and nuts.
2. To obtain the estimated total weight and bolt count per foot of the structure, use the Total N value of a structure (see Tables 34, 35, 37, 39, 40 and 42).
3. If a structure has reinforcing ribs, see Tables 45- 47 for additional weight and bolt count.
4. For an arch, deduct 5.33 bolts per foot from column titled "Bolts per Foot."
5. On an arch, bolts and nuts for receiving angles are not included above.
6. Values in the column titled "Plates per Ring in a Structure" shall be shown on the assembly drawings provided.
7. For Ellipse and Underpass shapes, contact your local Contech representative.

Reinforcing Rib

When circumferential ribs are used with Aluminum Structural Plate, they reinforce the structure to reduce minimum cover and provide added stiffness. These circumferential ribs are bolted to the structure's crown and haunches (if applicable) at spacings of 9", 18", 27" or 54" centers.

Rib Assembly Socket

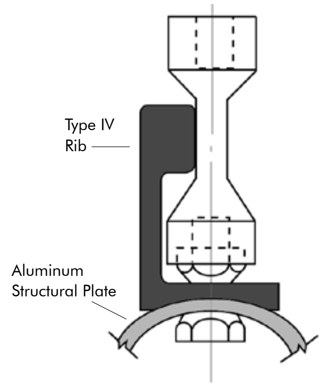


TABLE 45. ADDED HANDLING WEIGHT AND ADDITIONAL BOLTS PER FOOT OF STRUCTURE FOR TYPE II REINFORCING RIB

Total N	9" o.c.		18" o.c.		27" o.c.		54" o.c.	
of Rib	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

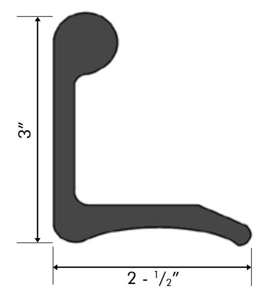


TABLE 46. ADDED HANDLING WEIGHT AND ADDITIONAL BOLTS PER FOOT OF STRUCTURE FOR TYPE IV REINFORCING RIB

Total N	9" o.c.		18" o.c.		27" o.c.		54" o.c.	
of Rib	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

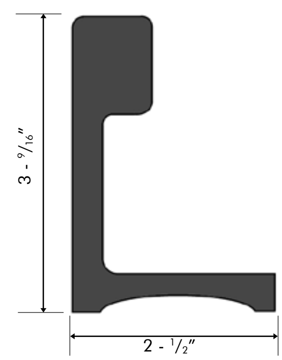
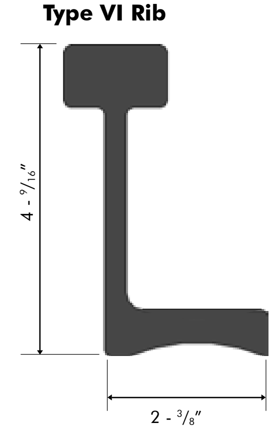


TABLE 47. ADDED HANDLING WEIGHT AND ADDITIONAL BOLTS PER FOOT OF STRUCTURE FOR TYPE VI REINFORCING RIB

Total N	9" o.c.		18" o.c.		27" o.c.		54" o.c.	
of Rib	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

Notes:
1. Bolts and nuts are included in the column titled "Wt/Ft."
2. For Total N of rib on a structure, see Tables 34, 35, 37, 39, 40 and 42.

Type VI Rib



Mimimum curving values are 60" for Type II Ribs and 104" for Type IV and Type VI Ribs.

Aluminum Structural Plate Specification

Scope: This specification covers the manufacture and installation of the Aluminum Structural Plate structure detailed in the plans.

Material: The Aluminum Structural Plate structure shall consist of plates and appurtenant items as shown on the plans and shall conform to the requirements of AASHTO M 219 and ASTM B746. The corrugated plate (and ribs if required) shall be curved and bolt hole punched at the plant. Plate thickness and rib spacings shall be as indicated on the plans. All manufacturing processes including corrugating, punching, and curving, shall be performed within the United States.

Bolts and nuts shall conform to the requirements of ASTM A307 or A449 for steel fasteners or ASTM F467 and F468 for aluminum fasteners.

Assembly: The structure shall be assembled in accordance with the shop drawings provided by the manufacturer and per the manufacturer's recommendations. Bolts shall be tightened using an applied torque between 90 and 135 ft.-lbs. depending on the location in the structure.

Installation: The structure shall be installed in accordance with the plans and specifications, the manufacturer's recommendations and the AASHTO Standard Specifications for Highway Bridges, Section 26 (Division II).

Backfill: The structure shall be backfilled using clean, well graded granular material that meets the requirements of AASHTO M 145 for soil classifications A-1, A-2-4, A-2-5, or A-3. Backfill must be placed symmetrically on each side of the structure in 8-inch uncompacted lifts. Each lift shall be compacted to a minimum of 90 percent density per AASHTO T 180.

Notes: Construction loads that exceed highway load limits are not allowed on the structure without approval from the Project Engineer.

Assembly of Aluminum Structural Plate Single Radius Arch

Installation

Required Elements

Satisfactory site preparation, trench excavation, bedding and backfill operations are essential to develop the strength of any flexible conduit. In order to obtain proper strength while preventing settlement, it is necessary that the soil envelope around the structure be of good granular material, properly placed, and carefully compacted.

Pipe-arch and underpass shapes pose special installation concerns not found in other shapes. These two shapes generate high corner bearing pressures against the side fill and foundation, see page 57 for the corner bearing pressure. Therefore, special installation care must be implemented to achieve a composite soil structure.

A qualified Engineer should be engaged to design a proper foundation, adequate bedding, and backfill.

Trench Excavation

If the adjacent embankment material is structurally adequate, the trench requires only a bottom clear width of the structure's span plus sufficient room for compaction equipment.

Bedding

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

It is recommended that the bedding be a relatively loose granular material that is roughly shaped to fit the bottom of the structure, be a minimum of twice the corrugation depth in thickness and have a maximum particle size of one half the corrugation depth.

It should be noted that the bedding depth can vary based on the amount of cover and the shape of the structure's invert. The bedding should be shaped to match structures with flatter inverts.

Assembly

Assembly drawings and detailed assembly instructions are shipped with each order. Structures can be preassembled and lifted into place all at once or in sections, allowing for staged construction. If the site conditions allow, structures can be assembled in place. A qualified engineer should be engaged to determine the most appropriate site conditions. For additional information contact your local Contech representative.

Backfill

Satisfactory backfill material, proper placement and compaction are key factors in obtaining maximum strength and stability. Compaction needs to be achieved under the haunches by carefully tamping a granular or select material.

The backfill material should be free of rocks, frozen lumps and foreign material that could cause hard spots or decompose to created voids. Backfill material should be well graded granular material that meets the requirements of AASHTO M 145 for soil classifications A-1, A-2, or A-3. Backfill must be placed symmetrically on each side of the structure in 8-inch uncompacted lifts. Each lift is to be compacted to a minimum of 90 percent density per AASHTO T 180.

A high percentage of silt or fine sand in the native soils suggests the need for a well graded granular backfill material to prevent soil migration.

During backfill, only small tracked vehicles (D4 or smaller) should be near the structure as fill progresses above the crown and to the finished grade. The engineer and contractor are cautioned that the minimum cover may need to be increased to handle temporary construction vehicle loads (larger than D4).

Salt Water Installation

In salt water installations, the bedding and backfill around the structure must be clean granular material. If the backfill is subject to possible infiltration by the adjacent native soil, the clean granular backfill should be wrapped in a geotextile.

Precautions

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

The structure must be protected from unbalanced loads from any structural loads or hydraulic forces that might bend or distort the unsupported ends of the structure.

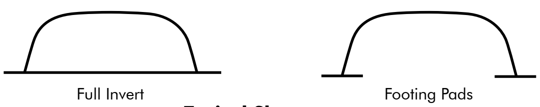
Erosion or washout of previously placed soil support must be prevented to ensure that the structure maintains its load capacity.

Aluminum Box Culverts

The Solution for Small Bridge Replacement: Aluminum Box Culverts

Contech Aluminum Box Culverts are a practical and cost-efficient solution for small bridge replacement. They have a lower installed cost because they are faster and easier to install than cast-in-place concrete structures. There are no forms to set and remove, no delays due to curing time, large installation crews are unnecessary and no special equipment is needed. Also, no heavy cranes are required as with precast concrete structures.

These wide-span, low-rise structures are available in a large range of standard sizes (from 8′-9″ span x 2′-6″ rise to 35′-3″ span x 13′-7″ rise) that permit a minimum cover beginning as low as 17 inches, handling HS-20, HS-25, or HL-93 live loads.



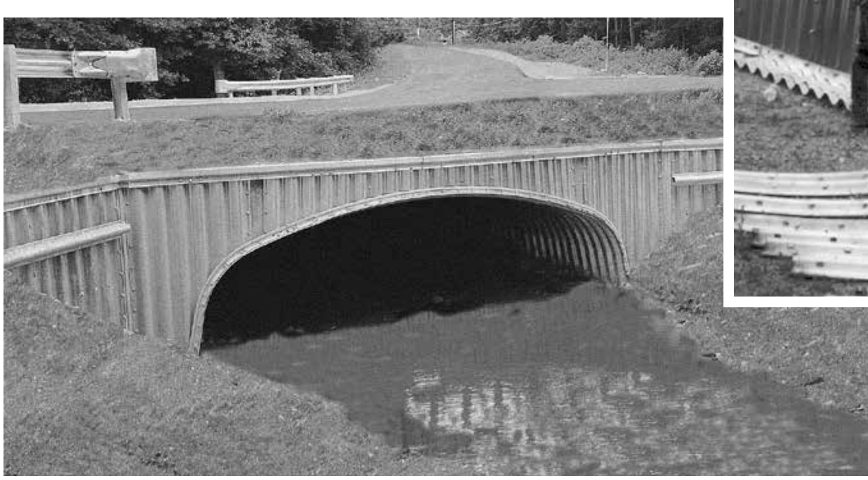
Typical Shapes

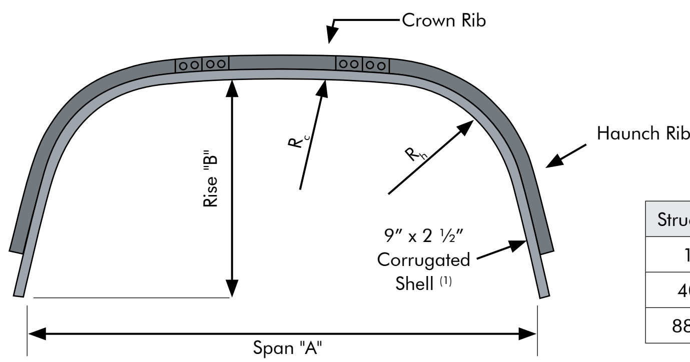

Lifting of Aluminum Box Culvert

Efficient Installations for Lower Installed Costs

Closing roads for bridge replacement causes extensive traffic detours, so minimizing installation time is critical. Depending on length of structure, Aluminum Box Culverts may be erected in place and are usually ready to be backfilled within several days. For more efficient installations, Aluminum Box Culverts can be completely assembled nearby while the site is being prepared. Light equipment can then be used to pick and set them in place. For more information, contact your local Contech representative.

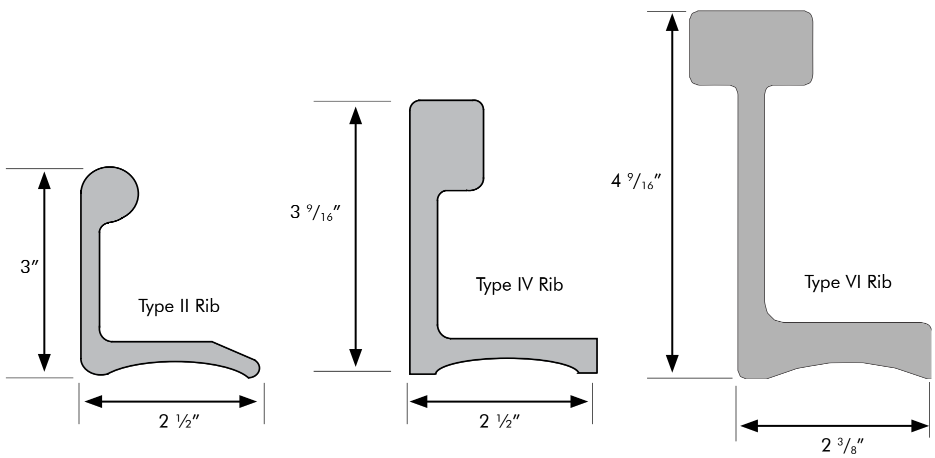

Installation of Ribs


Corrugated Aluminum Headwall Package



Structure #	R_c	R_h
1-39	297.50″	30.250″
40-87	258.75″	37.380″
88-143	310.75″	43.625″

Box Culvert Shell Cross Section



Box Culvert Rib Geometry

Notes: (refer to pages 66-69)

1. Structure 1 is a one-plate shell. Structures 2-26 are two plate shells. Structures 27-143 are three-plate shells.
2. In Shell Fill Height Table 48A, 48B, 49A and 49B, the HG\CG designation indicates thickness or gage of haunch (HG) and crown (CG) plates as follows: 2=.125″, 3=.150″, 4=.175″, 5=.200″, 6=.225″, 7=.250″. Example: 3\6=.150″ haunch and .225″ crown plate thickness. The HRS/CRS designation indicates the rib spacing on the haunch (HRS) and crown (CRS) plates. Example: 27/9=27″ o.c. haunch and 9″ o.c. crown.
3. Allowable cover (minimum and maximum) is measured from the outside valley of crown plate to bottom of flexible pavement or from the outside valley of crown plate to top of rigid pavement. Minimum cover is measured at the lowest fill area subjected to possible wheel loads (typically at the roadway shoulder). The roadway surface must be maintained to ensure minimum cover to prevent high-impact loads being imparted to the structure. Maximum cover is measured at highest fill and/or pavement elevation.
4. Select the structure with the lowest alphabetical sub-designation and cover range that will include the actual minimum and maximum cover. Example: Structure 51-A6 is more economical than 51-B6 if the cover is between 3.0 and 4.5 feet.
5. Shell Wt./Ft. shown is maximum handling weight and is based on heaviest component makeup for a specific span and rise combination. Weight per foot of shell includes plates, reinforcing ribs, rib splices, bolts, and nuts.
6. Total structure length can be any dimension, but whenever possible, it is recommended to work with a multiple of 4.5′ (net plate width). This practice usually results in lower total structure cost. Example: 50′ proposed structure ÷ 4.5′=11.1, nearest whole number is 11, therefore use 11 x 4.5′= 49.5′ for total structure length. When ordering a structure with headwalls on each end, total structure length must be a multiple of 9 inches.
7. Shell data in Table 48A is designed for standard highway HS-20 wheel loads, Table 48B for HS-25 loads and Tables 49A/49B for HL-93 load design information. Contact your local Contech representative for design information on other loadings.
8. Standard structure designs use Type VI ribs for most economical plate and rib combination. Plate and rib combinations using Type II and Type IV ribs are available for special designs.
9. The maximum cover for Aluminum Box Culverts with full inverts and footing pads should not exceed 4 feet. Special full invert and footing pad designs or slotted concrete footings can accommodate maximum covers to the limits shown in Tables 48A and 48B.

Box Culvert Shell-Plate and Rib Data (H-20, HS-20)

TABLE 48A. SHELL DATA — H-20, HS-20 LOADING
PLATE AND RIB COMBINATIONS WITH ALLOWABLE HEIGHT OF COVER

Structure Number	Span "A" Ft.-In.	Rise "B" Ft.-In.	Area Sq. Ft.	A6 HG/CG (Gage)	A6 HRS/CRS (Inches)	A6 Min. (Feet)	A6 Max. (Feet)	A6 Shell Wt./Ft. (Lbs.)	B6 HG/CG (Gage)	B6 HRS/CRS (Inches)	B6 Min. (Feet)	B6 Max. (Feet)	B6 Shell Wt./Ft. (Lbs.)	C6 HG/CG (Gage)	C6 HRS/CRS (Inches)	C6 Min. (Feet)	C6 Max. (Feet)	C6 Shell Wt./Ft. (Lbs.)
STRUCTURES 1 THROUGH 26 HAVE TYPE II HAUNCH AND TYPE IV CROWN RIBS																		
1	8-9	2-6	18.4	2/2	54/18	1.4	5.0	48										
2	9-2	3-3	25.4	2/2	54/18	1.4	5.0	53										
3	9-7	4-1	32.6	2/2	54/18	1.4	5.0	58										
4	10-0	4-10	40.2	2/2	54/18	1.4	5.0	61										
5	10-6	5-7	48.1	2/2	54/18	1.7	5.0	65	3/3	54/18	1.4	5.0	73					
6	10-11	6-4	56.4	2/2	54/18	2.0	5.0	69	2/2	27/18	1.4	5.0	77					
7	11-4	7-2	65.0	2/2	54/18	2.5	5.0	72	2/2	54/9	1.4	5.0	82					
8	10-2	2-8	23.0	2/2	54/18	1.7	5.0	56	3/3	54/18	1.4	5.0	62					
9	10-7	3-5	31.1	2/2	54/18	2.0	5.0	61	3/3	54/18	1.4	5.0	67					
10	10-11	4-3	39.5	2/2	54/18	2.0	5.0	65	3/3	54/18	1.4	5.0	72					
11	11-4	5-0	48.2	2/2	54/18	2.5	5.0	69	3/3	54/18	1.7	5.0	77	2/2	54/9	1.4	5.0	83
12	11-8	5-9	57.2	2/2	54/18	2.5	5.0	72	3/3	54/18	1.7	5.0	81	2/2	54/9	1.4	5.0	86
13	12-1	6-7	66.4	2/2	54/18	3.0	5.0	76	2/2	27/18	2.0	5.0	85	2/2	54/9	1.4	5.0	90
14	12-5	7-4	76.0	2/2	54/18	3.0	5.0	80	2/2	27/18	2.5	5.0	88	2/2	27/9	1.4	5.0	102
15	11-7	2-10	28.1	2/2	54/18	2.5	5.0	64	3/3	54/18	1.7	5.0	70	3/3	27/18	1.4	5.0	77
16	11-11	3-7	37.4	2/2	54/18	2.5	5.0	68	3/3	54/18	2.0	5.0	75	4/4	54/18	1.4	5.0	82
17	12-3	4-5	46.9	2/2	54/18	3.0	5.0	73	3/3	54/18	2.0	5.0	79	3/3	27/18	1.4	5.0	89
18	12-7	5-2	56.6	2/2	54/18	3.0	5.0	78	2/2	27/18	2.5	5.0	85	2/2	27/9	1.4	5.0	102
19	12-11	6-0	66.6	2/2	54/18	3.0	5.0	81	2/2	27/18	2.5	5.0	89	2/2	27/9	1.4	5.0	106
20	13-3	6-9	76.9	3/3	54/18	2.5	5.0	96	3/3	27/18	2.0	5.0	102	2/2	27/9	1.4	5.0	110
21	13-0	3-0	33.8	3/3	54/18	2.5	5.0	70	4/4	54/18	2.0	5.0	79	4/4	27/18	1.4	5.0	91
22	13-4	3-10	44.2	3/3	54/18	3.0	5.0	83	3/3	27/18	2.0	5.0	91	3/3	54/9	1.4	5.0	105
23	13-7	4-7	54.8	3/3	54/18	3.0	5.0	89	3/3	27/18	2.5	5.0	97	3/3	54/9	1.4	5.0	110
24	13-10	5-5	65.6	2/2	27/18	3.0	5.0	92	3/3	27/18	2.5	5.0	102	3/3	54/9	1.4	5.0	114
25	14-1	6-2	76.6	3/3	54/18	3.0	5.0	97	3/3	27/18	2.5	5.0	106	2/2	18/9	1.4	5.0	126
26	14-5	3-3	40.0	3/3	27/18	3.0	5.0	93	4/4	27/18	2.5	5.0	101	5/5	18/18	1.4	5.0	115
STRUCTURES 27 THROUGH 39 HAVE TYPE II HAUNCH AND TYPE VI CROWN RIBS																		
27	14-8	4-1	51.5	2/2	27/18	1.4	5.0	91										
28	14-10	4-10	63.2	2/2	27/18	1.4	5.0	106										
29	15-1	5-8	75.1	3/2	27/18	1.4	5.0	117										
30	15-4	6-5	87.2	3/2	27/18	1.4	5.0	121										
31	15-6	7-3	99.4	3/2	27/18	1.4	5.0	125										
32	15-9	8-0	111.8	2/2	27/18	2.0	5.0	121	3/2	18/18	1.4	5.0	136					
33	15-10	3-6	46.8	2/2	27/18	2.1	5.0	104	3/2	18/18	1.4	5.0	114					
34	16-0	4-3	59.5	2/2	27/18	2.3	5.0	110	3/2	18/18	1.4	5.0	121					
35	16-2	5-1	72.3	2/2	27/18	2.4	4.9	115	3/2	18/18	1.4	5.0	128					
36	16-4	5-11	85.2	2/2	27/18	2.6	4.5	119	3/2	18/18	1.4	5.0	133					
37	16-6	6-8	98.3	3/2	27/18	1.8	5.0	131	4/2	18/18	1.4	5.0	145					
38	16-8	7-6	111.5	3/2	27/18	1.9	5.0	135	4/2	18/18	1.4	5.0	150					
39	16-10	8-3	124.8	3/2	27/18	2.0	5.0	139	4/2	18/18	1.4	5.0	155					
STRUCTURES 40 THROUGH 87 USE ALL TYPE VI RIBS																		
40	17-9	3-10	54.4	2/2	54/18	2.0	5.0	112	2/2	27/18	1.4	5.0	124					
41	18-2	4-7	68.3	2/2	54/18	2.2	5.0	117	2/2	27/18	1.4	5.0	131					
42	18-7	5-4	82.5	2/2	54/18	2.4	5.0	123	2/2	27/18	1.4	5.0	139					
43	19-0	6-1	97.1	2/2	54/18	2.6	5.0	126	2/2	27/18	1.4	5.0	142					
44	19-5	6-11	111.9	2/2	54/18	2.8	5.0	130	2/2	18/18	1.4	5.0	159					
45	19-10	7-8	127.1	2/2	54/18	2.9	5.0	134	2/2	18/18	1.4	5.0	163					
46	20-3	8-5	142.6	2/2	27/18	1.9	5.0	137	2/2	18/18	1.4	5.0	166					
47	19-1	4-2	63.3	2/2	54/18	2.6	5.0	121	2/2	18/18	1.4	5.0	143					
48	19-5	4-11	78.3	2/2	54/18	2.8	5.0	126	2/2	18/18	1.4	5.0	152					
49	19-9	5-8	93.6	2/2	54/18	2.9	4.8	132	2/2	18/18	1.4	5.0	161					
50	20-1	6-6	109.2	2/2	27/18	1.9	5.0	151	2/2	18/18	1.4	5.0	165					
51	20-6	7-3	125.0	2/2	27/18	2.0	5.0	155	2/2	18/18	1.4	5.0	168					
52	20-10	8-1	141.2	2/2	27/18	2.1	5.0	159	2/2	18/18	1.4	5.0	172					
53	21-2	8-10	157.6	2/2	27/18	2.2	5.0	162	2/2	18/18	1.4	5.0	175					
54	20-4	4-6	73.1	2/2	27/18	2.0	5.0	142	2/2	18/18	1.4	5.0	152					
55	20-7	5-3	89.2	2/2	27/18	2.1	5.0	150	2/2	18/18	1.4	5.0	161					
56	20-11	6-1	105.5	2/2	27/18	2.2	5.0	157	2/2	18/18	1.4	5.0	170					
57	21-3	6-10	122.1	2/2	27/18	2.3	5.0	160	2/2	18/18	1.4	5.0	174					
58	21-6	7-8	139.0	2/2	27/18	2.3	5.0	164	2/2	18/18	1.4	5.0	177					
59	21-10	8-5	156.0	2/2	27/18	2.5	5.0	168	2/2	18/18	1.4	5.0	181					
60	22-1	9-3	173.3	2/2	27/18	2.5	4.8	171	2/3	18/18	1.4	5.0	189					
61	21-7	4-11	83.8	2/2	27/18	2.4	5.0	151	2/2	18/18	1.4	5.0	161					
62	21-10	5-8	101.0	2/2	27/18	2.5	5.0	159	2/2	18/18	1.4	5.0	170					
63	22-1	6-6	118.4	2/2	27/18	2.5	4.8	166	2/3	18/18	1.4	5.0	184					
64	22-3	7-3	135.9	2/2	27/18	2.6	4.6	169	2/3	18/18	1.4	5.0	188					
65	22-6	8-1	153.7	2/2	27/18	2.7	4.4	173	2/3	18/18	1.4	5.0	191					
66	22-9	8-10	171.6	2/2	27/18	2.8	4.2	177	2/4	18/18	1.4	5.0	195					
67	23-0	9-8	189.8	2/2	27/18	2.8	4.0	180	2/4	18/18	1.4	5.0	203					
68	22-9	5-4	95.5	2/2	27/18	2.8	4.2	160	2/4	18/18	1.4	5.0	180					
69	23-0	6-1	113.7	2/2	27/18	2.8	4.0	168	2/4	18/18	1.4	5.0	189					
70	23-2	6-11	132.1	3/3	27/18	2.6	4.4	188	2/5	18/18	1.4	5.0	203					
71	23-4	7-8	150.6	3/3	27/18	2.6	4.3	192	2/5	18/18	1.4	5.0	206					
72	23-6	8-6	169.3	3/3	27/18	2.7	4.2	197	2/5	18/18	1.4	5.0	210					
73	23-8	9-3	188.1	3/3	27/18	2.7	4.0	201	2/5	18/18	1.4	5.0	214					
74	23-10	10-1	207.0	3/3	27/18	2.8	3.9	205	2/5	18/18	1.4	5.0	217					
75	24-0	5-9	108.2	2/2	18/18	1.7	5.0	179	2/5	18/18	1.4	5.0	186					
76	24-1	6-6	127.5	2/2	18/18	1.7	5.0	188	2/6	18/18	1.4	5.0	210					
77	24-3	7-4	146.8	2/2	18/18	1.8	5.0	197	2/6	18/18	1.4	5.0	219					
78	24-4	8-2	166.2	2/2	18/18	1.8	5.0	201	2/6	18/18	1.4	5.0	223					
79	24-5	8-11	185.7	2/2	18/18	1.8	5.0	204	2/6	18/18	1.4	5.0	226					
80	24-7	9-9	205.3	2/2	18/18	1.8	5.0	208	2/6	18/18	1.4	5.0	230					
81	24-8	10-6	225.0	2/2	18/18	1.8	5.0	212	2/6	18/18	1.4	5.0	234					
82	25-2	6-2	122.0	2/2	18/18	1.9	4.9	188	2/6	18/18	1.4	5.0	210					
83	25-2	7-0	142.2	2/2	18/18	1.9	4.9	197	2/7	18/18	1.4	5.0	225					
84	25-3	7-9	162.4	2/2	18/18	1.9	4.9	206	2/7	18/18	1.4	5.0	234					
85	25-4	8-7	182.6	2/2	18/18	1.9	4.8	210	2/7	18/18	1.4	5.0	237					
86	25-4	9-5	202.9	2/2	18/18	1.9	4.8	214	2/7	18/18	1.4	5.0	241					
87	25-5	10-2	223.3	2/2	18/18	2.0	4.5	217	2/7	18/18	1.4	5.0	245					

See Notes page 65

Box Culvert Shell-Plate and Rib Data (H-25, HS-25)

TABLE 48B. SHELL DATA — H-25, HS-25 LOADING
PLATE AND RIB COMBINATIONS WITH ALLOWABLE HEIGHT OF COVER

Structure Number	Span "A" Ft.-In.	Rise "B" Ft.-In.	Area Sq. Ft.	D6 HG/CG (Gage)	D6 HRS/CRS (Inches)	D6 Min. (Feet)	D6 Max. (Feet)	D6 Shell Wt./Ft. (Lbs.)	E6 HG/CG (Gage)	E6 HRS/CRS (Inches)	E6 Min. (Feet)	E6 Max. (Feet)	E6 Shell Wt./Ft. (Lbs.)	F6 HG/CG (Gage)	F6 HRS/CRS (Inches)	F6 Min. (Feet)	F6 Max. (Feet)	F6 Shell Wt./Ft. (Lbs.)
STRUCTURES 1 THROUGH 20 HAVE TYPE II HAUNCH AND TYPE IV CROWN RIBS																		
1	8-9	2-6	18.4	2/2	54/18	1.7	5.0	48	3/3	54/18	1.4	5.0	53					
2	9-2	3-3	25.4	2/2	54/18	2.0	5.0	53	3/3	54/18	1.4	5.0	56					
3	9-7	4-1	32.6	2/2	54/18	2.0	5.0	58	3/3	54/18	1.4	5.0	60					
4	10-0	4-10	40.2	2/2	54/18	2.5	5.0	61	2/2	54/9	1.4	5.0	71					
5	10-6	5-7	48.1	2/2	54/18	2.5	5.0	65	2/2	54/9	1.4	5.0	75					
6	10-11	6-4	56.4	2/2	54/18	3.0	5.0	69	2/2	54/9	2.0	5.0	79	3/3	54/9	1.4	5.0	87
7	11-4	7-2	65.0	2/2	54/18	3.0	5.0	72	2/2	27/18	2.5	5.0	88	3/3	54/9	1.4	5.0	91
8	10-2	2-8	23.0	2/2	54/18	2.5	5.0	56	3/3	54/18	1.7	5.0	62	4/4	54/18	1.4	5.0	68
9	10-7	3-5	31.1	2/2	54/18	3.0	5.0	61	3/3	54/18	2.0	5.0	67	3/3	27/18	1.4	5.0	81
10	10-11	4-3	39.5	2/2	54/18	3.0	5.0	65	3/3	54/18	2.5	5.0	72	3/3	54/9	1.4	5.0	86
11	11-4	5-0	48.2	2/2	54/18	3.0	5.0	69	3/3	54/18	2.5	5.0	77	3/3	54/9	1.4	5.0	91
12	11-8	5-9	57.2	2/2	54/18	3.0	5.0	72	3/3	54/18	2.5	5.0	81	3/3	54/9	1.4	5.0	95
13	12-1	6-7	66.4	3/3	54/18	3.0	5.0	85	3/3	27/18	2.5	5.0	94	3/3	27/9	1.4	5.0	108
14	12-5	7-4	76.0	2/2	27/18	3.0	5.0	88	2/2	27/9	2.0	5.0	102	3/3	27/9	1.4	5.0	112
15	11-7	2-10	28.1	2/2	54/18	3.0	5.0	64	3/3	54/18	2.5	5.0	70	3/3	54/9	1.4	5.0	88
16	11-11	3-7	37.4	3/3	54/18	3.0	5.0	75	3/3	27/18	2.5	5.0	83	3/3	54/9	1.4	5.0	93
17	12-3	4-5	46.9	3/3	54/18	3.0	5.0	81	4/4	54/18	2.5	5.0	88	4/4	54/9	1.4	5.0	106
18	12-7	5-2	56.6	3/3	54/18	3.0	5.0	85	3/3	27/18	2.5	5.0	94	4/4	54/9	1.4	5.0	111
19	12-11	6-0	66.6	3/3	27/18	3.0	5.0	98	2/2	27/9	2.0	5.0	106	4/4	27/9	1.4	5.0	124
20	13-3	6-9	76.9	2/2	18/18	3.0	5.0	101	2/2	27/9	2.5	5.0	110	3/3	18/9	1.4	5.0	119
STRUCTURES 21 THROUGH 39 HAVE TYPE II HAUNCH AND TYPE VI CROWN RIBS																		
21	13-0	3-0	33.8	3/3	54/18	2.3	5.0	86	2/2	27/18	1.6	5.0	91	3/3	27/18	1.4	5.0	100
22	13-4	3-10	44.2	3/3	54/18	2.5	5.0	88	2/2	27/18	1.7	5.0	92	4/4	27/18	1.4	5.0	114
23	13-7	4-7	54.8	3/3	54/18	2.7	5.0	93	2/2	27/18	1.9	5.0	97	3/3	18/18	1.4	5.0	118
24	13-10	5-5	65.6	3/3	54/18	2.9	5.0	98	2/2	27/18	2.0	5.0	101	3/3	18/18	1.4	5.0	122
25	14-1	6-2	76.6	2/2	27/18	2.3	5.0	104	2/2	18/18	1.7	5.0	110	3/3	18/18	1.4	5.0	126
26	14-5	3-3	40.0	2/2	27/18	2.5	5.0	95	2/2	18/18	1.8	5.0	99	4/4	18/18	1.4	5.0	115
27	14-8	4-1	51.5	2/2	27/18	2.8	5.0	101	2/2	18/18	2.0	5.0	106	4/5	18/18	1.4	5.0	126
28	14-10	4-10	63.2	2/2	27/18	2.8	5.0	106	2/2	18/18	2.0	5.0	112	4/6	18/18	1.4	5.0	136
29	15-1	5-8	75.1	2/2	27/18	3.0	5.0	110	2/2	18/18	2.1	5.0	116	4/7	18/18	1.4	5.0	144
30	15-4	6-5	87.2	3/3	27/18	2.6	5.0	124	2/2	18/18	2.3	5.0	119	5/7	18/18	1.4	5.0	157
31	15-6	7-3	99.4	3/3	27/18	2.6	5.0	128	2/2	18/18	2.3	5.0	123	5/7	18/18	1.4	5.0	162
32	15-9	8-0	111.8	3/3	27/18	2.6	5.0	132	2/2	18/18	2.5	5.0	127	5/7	18/18	1.4	5.0	168
33	15-10	3-6	46.8	2/2	18/18	2.4	5.0	108	6/2	18/18	1.7	5.0	131	7/5	18/18	1.4	5.0	145
34	16-0	4-3	59.5	2/2	18/18	2.5	5.0	115	6/2	18/18	1.8	5.0	134	7/6	18/18	1.4	5.0	158
35	16-2	5-1	72.3	2/2	18/18	2.5	5.0	121	6/2	18/18	1.8	5.0	149	7/7	18/18	1.4	5.0	170
36	16-4	5-11	85.2	2/2	18/18	2.6	5.0	125	6/2	18/18	1.9	5.0	156	7/7	18/18	1.4	5.0	177
37	16-6	6-8	98.3	2/2	18/18	2.6	5.0	129	6/2	18/18	2.0	5.0	162	4/5	9/18	1.4	5.0	180
38	16-8	7-6	111.5	2/2	18/18	2.7	5.0	132	6/2	18/18	2.0	5.0	168	4/7	9/18	1.4	5.0	191
39	16-10	8-3	124.8	2/2	18/18	2.8	5.0	136	6/2	18/18	2.1	5.0	174	4/7	9/18	1.4	5.0	195
STRUCTURES 40 THROUGH 87 USE ALL TYPE VI RIBS																		
40	17-9	3-10	54.4	2/2	54/18	2.8	5.0	112	2/2	27/18	2.0	5.0	124	2/2	18/18	1.4	5.0	134
41	18-2	4-7	68.3	2/2	27/18	2.2	5.0	131	2/2	18/18	1.5	5.0	143	2/3	18/18	1.4	5.0	146
42	18-7	5-4	82.5	2/2	27/18	2.3	5.0	139	2/2	18/18	1.6	5.0	152	2/5	18/18	1.4	5.0	162
43	19-0	6-1	97.1	2/2	27/18	2.4	5.0	142	2/2	18/18	1.8	5.0	156	2/6	18/18	1.4	5.0	170
44	19-5	6-11	111.9	2/2	27/18	2.6	5.0	146	2/2	18/18	1.8	5.0	159	2/7	18/18	1.4	5.0	177
45	19-10	7-8	127.1	2/2	27/18	2.7	5.0	149	2/2	18/18	1.9	5.0	163	2/7	18/18	1.4	5.0	180
46	20-3	8-5	142.6	2/2	27/18	2.9	5.0	153	2/2	18/18	2.0	5.0	166	2/2	18/9	1.4	5.0	214
47	19-1	4-2	63.3	2/2	27/18	2.6	5.0	133	2/2	18/18	1.8	5.0	143	2/2	18/9	1.4	5.0	196
48	19-5	4-11	78.3	2/2	27/18	2.6	5.0	141	2/2	18/18	1.8	5.0	152	2/2	18/9	1.4	5.0	205
49	19-9	5-8	93.6	2/2	27/18	2.7	5.0	148	2/2	18/18	1.9	5.0	161	2/2	18/9	1.4	5.0	214
50	20-1	6-6	109.2	2/2	27/18	2.9	5.0	151	2/2	18/18	1.9	5.0	165	2/2	18/9	1.4	5.0	217
51	20-6	7-3	125.0	2/2	27/18	3.0	5.0	155	2/2	18/18	2.0	5.0	168	2/2	18/9	1.4	5.0	221
52	20-10	8-1	141.2	2/2	27/18	3.2	4.5	159	2/2	18/18	2.0	5.0	172	2/2	18/9	1.4	5.0	224
53	21-2	8-10	157.6	2/2	18/18	2.1	5.0	175	2/7	18/18	1.7	5.0	196	2/2	18/9	1.4	5.0	228
54	20-4	4-6	73.1	2/2	27/18	3.0	5.0	142	2/2	18/18	2.0	5.0	152	2/2	18/9	1.4	5.0	210
55	20-7	5-3	89.2	2/2	27/18	3.1	4.9	150	2/2	18/18	2.0	5.0	161	2/2	18/9	1.4	5.0	219
56	20-11	6-1	105.5	2/2	27/18	3.2	4.3	157	2/2	18/18	2.0	5.0	170	2/2	18/9	1.4	5.0	228
57	21-3	6-10	122.1	2/2	18/18	2.1	5.0	174	2/7	18/18	1.7	5.0	198	2/2	18/9	1.4	5.0	232
58	21-6	7-8	139.0	2/2	18/18	2.2	5.0	177	2/7	18/18	1.8	5.0	201	2/2	18/9	1.4	5.0	235
59	21-10	8-5	156.0	2/2	18/18	2.2	5.0	181	2/7	18/18	1.9	5.0	205	2/2	18/9	1.4	5.0	239
60	22-1	9-3	173.3	2/2	18/18	2.3	5.0	185	2/7	18/18	2.0	5.0	209	2/2	18/9	1.4	5.0	243
61	21-7	4-11	83.8	2/2	18/18	2.2	5.0	161	2/7	18/18	1.8	5.0	185	2/2	18/9	1.4	5.0	225
62	21-10	5-8	101.0	2/2	18/18	2.2	5.0	170	2/7	18/18	1.9	5.0	194	2/2	18/9	1.4	5.0	234
63	22-1	6-6	118.4	2/2	18/18	2.3	5.0	179	2/7	18/18	2.0	5.0	203	2/2	18/9	1.4	5.0	243
64	22-3	7-3	135.9	2/2	18/18	2.4	5.0	183	2/7	18/18	2.0	5.0	207	2/2	18/9	1.4	5.0	246
65	22-6	8-1	153.7	2/2	18/18	2.5	5.0	186	2/7	18/18	2.0	5.0	211	2/2	18/9	1.4	5.0	250
66	22-9	8-10	171.6	2/2	18/18	2.6	5.0	190	2/7	18/18	2.0	5.0	214	2/2	18/9	1.4	5.0	253
67	23-0	9-8	189.8	2/2	18/18	2.6	5.0	194	2/7	18/18	2.2	5.0	218	2/2	18/9	1.4	5.0	257
68	22-9	5-4	95.5	2/2	18/18	2.4	5.0	170	2/7	18/18	2.1	5.0	194	2/2	18/9	1.4	5.0	239
69	23-0	6-1	113.7	2/2	18/18	2.5	5.0	179	2/7	18/18	2.1	5.0	203	2/2	18/9	1.4	5.0	248
70	23-2	6-11	132.1	2/2	18/18	2.5	5.0	188	2/7	18/18	2.2	5.0	212	2/2	18/9	1.4	5.0	257
71	23-4	7-8	150.6	2/2	18/18	2.6	5.0	192	2/7	18/18	2.2	5.0	216	2/2	18/9	1.4	5.0	261
72	23-6	8-6	169.3	2/2	18/18	2.6	5.0	195	2/7	18/18	2.2	5.0	220	2/2	18/9	1.4	5.0	264
73	23-8	9-3	188.1	2/2	18/18	2.7	4.9	199	2/7	18/18	2.3	5.0	223	2/2	18/9	1.4	5.0	268
74	23-10	10-1	207.0	2/2	18/18	2.7	4.8	203	2/7	18/18	2.3	5.0	227	2/2	18/9	1.4	5.0	272
75	24-0	5-9	108.2	2/2	18/18	2.7	4.6	179	2/7	18/18	2.4	5.0	207	2/2	18/9	1.4	5.0	254
76	24-1	6-6	127.5	2/2	18/18	2.7	4.6	188	2/7	18/18	2.4	5.0	216	2/2	18/9	1.4	5.0	263
77	24-3	7-4	146.8	2/2	18/18	2.8	4.4	197	2/7	18/18	2.4	5.0	225	2/2	18/9	1.4	5.0	272
78	24-4	8-2	166.2	2/2	18/18	2.8	4.3	201	2/7	18/18	2.4	5.0	228	2/2	18/9	1.4	5.0	275
79	24-5	8-11	185.7	2/2	18/18	2.9	4.2	204	2/7	18/18	2.4	5.0	232	2/2	18/9	1.4	5.0	279
80	24-7	9-9	205.3	2/2	18/18	2.9	4.1	208	2/7	18/18	2.4	5.0	236	2/2	18/9	1.4	5.0	283
81	24-8	10-6	225.0	2/2	18/18	3.0	4.0	212	2/7	18/18	2.5	5.0	239	2/2	18/9	1.4	5.0	286
82	25-2	6-2	122.0	3/5	18/18	2.7	4.3	188	2/2	18/9	1.4	5.0	268					
83	25-2	7-0	142.2	3/5	18/18	2.7	4.3	197	2/2	18/9	1.4	5.0	277					
84	25-3	7-9	162.4	3/5	18/18	2.7	4.3	206	2/2	18/9	1.4	5.0	286					
85	25-4	8-7	182.6	3/5	18/18	2.7	4.2	210	2/2	18/9	1.4	5.0	290					
86	25-4	9-5	202.9	3/5	18/18	2.7	4.2	214	2/2	18/9	1.4	5.0	293					
87	25-5	10-2	223.3	3/5	18/18	2.8	4.2	217	2/2	18/9	1.4	5.0	297					

See Notes page 65

Box Culvert Shell-Plate and Rib Data (HL-93)

TABLE 49A. SHELL DATA — LRFD HL-93
PLATE AND RIB COMBINATIONS WITH ALLOWABLE HEIGHT OF COVER

Structure Number	Span "A" Ft.-In.	Rise "B" Ft.-In.	Area Sq. Ft.	R1 HG/CG (Gage)	R1 HRS/CRS (Inches)	R1 Min. (Feet)	R1 Max. (Feet)	R1 Shell Wt./Ft. (Lbs.)	R2 HG/CG (Gage)	R2 HRS/CRS (Inches)	R2 Min. (Feet)	R2 Max. (Feet)	R2 Shell Wt./Ft. (Lbs.)	R3 HG/CG (Gage)	R3 HRS/CRS (Inches)	R3 Min. (Feet)	R3 Max. (Feet)	R3 Shell Wt./Ft. (Lbs.)
STRUCTURES 1 THROUGH 20 HAVE TYPE II HAUNCH AND TYPE IV CROWN RIBS																		
1	8-9	2-6	18.4	2/2	54/18	1.4	5.0	43										
2	9-2	3-3	25.4	2/2	54/18	1.4	5.0	50										
3	9-7	4-1	32.6	2/2	54/18	1.5	5.0	58	2/2	27/18	1.4	5.0	67					
4	10-0	4-10	40.2	2/2	54/18	1.7	5.0	61	2/2	27/18	1.4	5.0	70					
5	10-6	5-7	48.1	2/2	54/18	2.1	5.0	66	2/2	27/18	1.6	5.0	74	2/2	18/18	1.4	5.0	83
6	10-11	6-4	56.4	2/2	54/18	2.3	5.0	69	2/2	27/18	1.8	5.0	77	2/2	27/9	1.4	5.0	88
7	11-4	7-2	65.0	2/2	54/18	2.6	5.0	73	2/2	27/18	2.1	5.0	81	2/2	27/9	1.4	5.0	91
8	10-2	2-8	23.0	2/2	54/18	1.9	5.0	57	2/2	27/18	1.4	5.0	63					
9	10-7	3-5	31.1	2/2	54/18	2.1	5.0	61	2/2	27/18	1.6	5.0	68	2/2	18/18	1.4	5.0	76
10	10-11	4-3	39.5	2/2	54/18	2.3	5.0	66	2/2	27/18	1.8	5.0	74	2/2	27/9	1.4	5.0	88
11	11-4	5-0	48.2	2/2	54/18	2.6	5.0	70	2/2	27/18	2.1	5.0	78	2/2	27/9	1.4	5.0	92
12	11-8	5-9	57.2	2/2	54/18	2.8	5.0	73	2/2	27/18	2.3	5.0	81	2/2	27/9	1.4	5.0	95
13	12-1	6-7	66.4	2/2	54/18	3.1	5.0	77	2/2	27/18	2.6	5.0	85	2/2	27/9	1.4	5.0	99
14	12-5	7-4	76.0	2/2	54/18	3.4	5.0	80	2/2	27/9	1.5	5.0	102	2/2	18/9	1.4	5.0	111
15	11-7	2-10	28.1	2/2	54/18	2.7	5.0	64	2/2	27/18	2.3	5.0	70	2/2	27/9	1.4	5.0	88
16	11-11	3-7	37.4	2/2	54/18	2.9	5.0	69	2/2	27/18	2.5	5.0	76	2/2	27/9	1.4	5.0	94
17	12-3	4-5	46.9	2/2	54/18	3.2	5.0	73	2/2	27/18	2.7	5.0	82	2/2	18/9	1.4	5.0	108
18	12-7	5-2	56.6	2/2	54/18	4.1	5.0	77	2/2	27/18	2.9	5.0	85	2/2	18/9	1.4	5.0	111
19	12-11	6-0	66.6	3/3	54/18	2.9	5.0	90	2/2	27/9	1.8	5.0	106	3/3	18/9	1.4	5.0	121
20	13-3	6-9	76.9	3/3	54/18	3.2	5.0	94	2/2	27/9	2.0	5.0	110	3/3	18/9	1.4	5.0	125
STRUCTURES 21 THROUGH 39 HAVE TYPE II HAUNCH AND TYPE VI CROWN RIBS																		
21	13-0	3-0	33.8	3/3	54/18	2.0	5.0	81	2/2	27/18	1.4	5.0	83					
22	13-4	3-10	44.2	3/3	54/18	2.4	5.0	82	2/2	27/18	1.5	5.0	85	2/2	18/18	1.4	5.0	97
23	13-7	4-7	54.8	3/3	54/18	2.6	5.0	88	2/2	27/18	1.6	5.0	89	2/2	18/18	1.4	5.0	103
24	13-10	5-5	65.6	3/3	54/18	2.9	5.0	90	2/2	27/18	1.8	5.0	92	3/3	18/18	1.4	5.0	116
25	14-1	6-2	76.6	3/3	54/18	3.2	3.7	95	2/2	27/18	2.1	5.0	96	3/3	18/18	1.4	5.0	120
26	14-5	3-3	40.0	4/4	54/18	2.6	5.0	99	3/3	27/18	1.7	5.0	103	3/3	18/9	1.4	5.0	140
27	14-8	4-1	51.5	2/2	27/18	2.7	5.0	100	3/2	27/18	1.9	5.0	106	3/2	18/9	1.4	5.0	149
28	14-10	4-10	63.2	2/2	27/18	2.8	5.0	106	3/2	27/18	2.0	5.0	107	3/2	18/9	1.4	5.0	156
29	15-1	5-8	75.1	2/2	27/18	3.1	3.8	110	2/2	18/18	2.1	5.0	117	3/2	18/9	1.4	5.0	160
30	15-4	6-5	87.2	3/2	27/18	2.2	5.0	119	3/2	18/18	2.0	5.0	128	3/2	18/9	1.4	5.0	164
31	15-6	7-3	99.4	3/2	27/18	2.3	5.0	125	3/2	18/18	2.1	5.0	132	3/2	18/9	1.4	5.0	168
32	15-9	8-0	111.8	3/2	27/18	2.4	5.0	129	3/2	18/18	2.2	5.0	136	3/2	18/9	1.4	5.0	173
33	15-10	3-6	46.8	2/2	18/18	2.4	5.0	109	3/2	18/18	2.2	5.0	114	3/2	18/9	1.4	5.0	156
34	16-0	4-3	59.5	2/2	18/18	2.5	5.0	116	3/2	18/18	2.3	5.0	121	3/2	18/9	1.4	5.0	163
35	16-2	5-1	72.3	2/2	18/18	2.6	5.0	122	3/2	18/18	2.4	5.0	128	3/2	18/9	1.4	5.0	166
36	16-4	5-11	85.2	3/2	27/18	2.9	5.0	126	3/3	18/18	2.4	5.0	136	3/2	18/9	1.4	5.0	175
37	16-6	6-8	98.3	2/2	18/18	2.9	5.0	129	3/3	18/18	2.5	5.0	141	3/2	18/9	1.4	5.0	179
38	16-8	7-6	111.5	3/2	18/18	2.6	5.0	143	3/2	18/9	1.6	5.0	183	4/2	18/9	1.4	5.0	192
39	16-10	8-3	124.8	3/2	18/18	2.7	5.0	156	3/2	18/9	1.8	5.0	187	4/2	18/9	1.4	5.0	193
STRUCTURES 40 THROUGH 87 USE ALL TYPE VI RIBS																		
40	17-9	3-10	54.4	2/2	54/18	3.2	5.0	114	2/2	27/18	2.2	5.0	124	2/2	27/9	1.4	5.0	181
41	18-2	4-7	68.3	3/2	54/18	3.3	5.0	125	2/2	27/18	2.4	5.0	131	2/2	27/9	1.4	5.0	191
42	18-7	5-4	82.5	2/2	27/18	2.6	5.0	139	2/2	18/18	1.9	5.0	153	2/2	18/9	1.4	5.0	200
43	19-0	6-1	97.1	2/2	27/18	2.8	5.0	142	2/2	18/18	2.0	5.0	156	2/2	18/9	1.4	5.0	203
44	19-5	6-11	111.9	2/2	27/18	3.0	5.0	146	2/2	18/18	2.1	5.0	160	2/2	18/9	1.4	5.0	207
45	19-10	7-8	127.1	2/2	27/18	3.5	4.5	149	2/2	18/18	2.2	5.0	164	2/2	18/9	1.4	5.0	210
46	20-3	8-5	142.6	3/3	27/18	3.5	3.9	166	2/2	18/18	2.4	5.0	167	2/2	18/9	1.4	5.0	214
47	19-1	4-2	63.3	2/2	27/18	2.9	5.0	133	2/2	18/18	2.0	5.0	144	2/2	18/9	1.4	5.0	194
48	19-5	4-11	78.3	2/2	27/18	3.0	5.0	140	2/2	18/18	2.1	5.0	153	2/2	18/9	1.4	5.0	203
49	19-9	5-8	93.6	2/2	27/18	3.4	4.8	148	2/2	18/18	2.2	5.0	162	2/2	18/9	1.4	5.0	211
50	20-1	6-6	109.2	3/2	27/18	3.5	3.9	159	2/2	18/18	2.3	5.0	165	2/2	18/9	1.4	5.0	218
51	20-6	7-3	125.0	4/3	27/18	3.4	4.6	166	2/2	18/18	2.5	5.0	168	2/2	18/9	1.4	5.0	222
52	20-10	8-1	141.2	5/3	27/18	3.3	4.7	170	2/2	18/18	2.6	5.0	172	2/2	18/9	1.4	5.0	225
53	21-2	8-10	157.6	2/2	18/18	2.7	5.0	175	5/4	18/18	2.4	5.0	214	2/2	18/9	1.4	5.0	229
54	20-4	4-6	73.1	2/2	18/18	2.4	5.0	152	5/4	18/18	2.2	5.0	180	2/2	18/9	1.4	5.0	211
55	20-7	5-3	89.2	2/2	18/18	2.5	5.0	161	5/5	18/18	2.2	5.0	195	2/2	18/9	1.4	5.0	220
56	20-11	6-1	105.5	2/2	18/18	2.6	5.0	170	5/5	18/18	2.3	5.0	206	2/2	18/9	1.4	5.0	229
57	21-3	6-10	122.1	2/2	18/18	2.7	5.0	174	5/5	18/18	2.4	5.0	212	2/2	18/9	1.4	5.0	233
58	21-6	7-8	139.0	2/2	18/18	2.8	5.0	178	2/2	18/9	1.5	5.0	235	3/3	18/9	1.4	5.0	249
59	21-10	8-5	156.0	2/2	18/18	3.0	5.0	182	2/2	18/9	1.6	5.0	239	3/3	18/9	1.4	5.0	253
60	22-1	9-3	173.3	2/2	18/18	3.1	4.8	185	2/2	18/9	1.7	5.0	243	3/3	18/9	1.4	5.0	257
61	21-7	4-11	83.8	2/2	18/18	2.9	5.0	162	2/2	18/9	1.5	5.0	225	3/3	18/9	1.4	5.0	236
62	21-10	5-8	101.0	2/2	18/18	3.0	5.0	171	2/2	18/9	1.6	5.0	234	3/3	18/9	1.4	5.0	246
63	22-1	6-6	118.4	2/2	18/18	3.1	4.8	180	2/2	18/9	1.7	5.0	243	3/3	18/9	1.4	5.0	256
64	22-3	7-3	135.9	2/2	18/18	3.2	4.4	184	2/2	18/9	1.7	5.0	246	4/4	18/9	1.4	5.0	273
65	22-6	8-1	153.7	3/2	18/18	3.2	4.2	196	2/2	18/9	1.8	5.0	250	4/4	18/9	1.4	5.0	278
66	22-9	8-10	171.6	2/3	9/18	2.8	5.0	249	2/2	18/9	1.8	5.0	253	4/4	18/9	1.4	5.0	283
67	23-0	9-8	189.8	2/3	9/18	2.9	5.0	253	2/2	18/9	1.9	5.0	257	4/4	18/9	1.4	5.0	288
68	22-9	5-4	95.5	2/3	9/18	2.8	5.0	219	2/2	18/9	1.8	5.0	239	4/4	18/9	1.4	5.0	263
69	23-0	6-1	113.7	2/3	9/18	2.9	5.0	233	2/2	18/9	1.9	5.0	248	4/4	18/9	1.4	5.0	274
70	23-2	6-11	132.1	2/3	9/18	2.9	5.0	248	2/2	18/9	2.0	5.0	266	5/5	18/9	1.4	5.0	297
71	23-4	7-8	150.6	2/3	9/18	3.0	5.0	251	2/2	18/9	2.0	5.0	270	5/5	18/9	1.4	5.0	303
72	23-6	8-6	169.3	2/3	9/18	3.0	5.0	255	2/2	18/9	2.0	5.0	274	5/5	18/9	1.4	5.0	308
73	23-8	9-3	188.1	2/3	9/18	3.1	5.0	258	2/2	18/9	2.1	5.0	278	5/5	18/9	1.4	5.0	314
74	23-10	10-1	207.0	2/3	9/18	3.2	5.0	274	2/2	18/9	2.1	5.0	283	5/5	18/9	1.4	5.0	319
75	24-0	5-9	108.2	2/2	18/9	2.2	5.0	255	4/4	18/9	1.7	5.0	284	6/6	18/9	1.4	5.0	304
76	24-1	6-6	127.5	2/2	18/9	2.2	5.0	263	4/4	18/9	1.7	5.0	290	6/6	18/9	1.4	5.0	316
77	24-3	7-4	146.8	2/2	18/9	2.2	5.0	272	4/4	18/9	1.8	5.0	300	6/6	18/9	1.4	5.0	327
78	24-4	8-2	166.2	2/2	18/9	2.2	5.0	275	4/4	18/9	1.8	5.0	305	6/6	18/9	1.4	5.0	334
79	24-5	8-11	185.7	2/2	18/9	2.3	5.0	279	4/4	18/9	1.8	5.0	310	6/6	18/9	1.4	5.0	340
80	24-7	9-9	205.3	2/2	18/9	2.3	5.0	283	4/4	18/9	1.8	5.0	315	6/6	18/9	1.4	5.0	346
81	24-8	10-6	225.0	2/2	18/9	2.3	5.0	286	4/4	18/9	1.8	5.0	320	6/6	18/9	1.4	5.0	350
82	25-2	6-2	122.0	2/2	18/9	2.4	5.0	268	4/4	18/9	1.9	5.0	298	7/7	18/9	1.4	5.0	334
83	25-2	7-0	142.2	2/2	18/9	2.4	5.0	277	4/4	18/9	1.9	5.0	306	7/7	18/9	1.4	5.0	347
84	25-3	7-9	162.4	2/2	18/9	2.4	5.0	286	4/4	18/9	1.9	5.0	316	7/7	18/9	1.4	5.0	359
85	25-4	8-7	182.6	2/2	18/9	2.4	5.0	290	4/4	18/9	2.0	5.0	321	7/7	18/9	1.4	5.0	366
86	25-4	9-5	202.9	2/2	18/9	2.4	5.0	293	4/4	18/9	2.0	5.0	326	7/7	18/9	1.4	5.0	373
87	25-5	10-2	223.3	2/2	18/9	2.5	5.0	297	4/4	18/9	2.0	5.0	331	7/7	18/9	1.4	5.0	380

See Notes page 65

Box Culvert Shell-Plate and Rib Data (HL-93)

TABLE 49B. SHELL DATA – LRFD HL-93
PLATE AND RIB COMBINATIONS WITH ALLOWABLE HEIGHT OF COVER

Structure Number	Span "A" Ft.-In.	Rise "B" Ft.-In.	Area Sq. Ft.	R1 HG/CG (Gage)	R1 HRS/CRS (Inches)	R1 Min. (Feet)	R1 Max. (Feet)	R1 Shell Wt./Ft. (Lbs.)	R2 HG/CG (Gage)	R2 HRS/CRS (Inches)	R2 Min. (Feet)	R2 Max. (Feet)	R2 Shell Wt./Ft. (Lbs.)	R3 HG/CG (Gage)	R3 HRS/CRS (Inches)	R3 Min. (Feet)	R3 Max. (Feet)	R3 Shell Wt./Ft. (Lbs.)
STRUCTURES 88 THROUGH 143 USE ALL TYPE VI RIBS																		
88	26-7	5-5	111.6	3/3	9/18	4.0	5.0	246	3/3	9/9	2.3	5.0	314	3/4	9/9	2.0	5.0	320
89	27-0	6-3	132.4	3/3	9/18	4.0	5.0	261	3/3	9/9	2.3	5.0	329	3/4	9/9	2.0	5.0	335
90	27-5	7-0	153.4	3/3	9/18	4.0	5.0	276	3/3	9/9	2.3	5.0	344	3/4	9/9	2.0	5.0	350
91	27-10	7-9	174.8	3/3	9/18	4.0	5.0	292	3/3	9/9	2.3	5.0	360	3/4	9/9	2.0	5.0	366
92	28-3	8-7	196.5	3/3	9/18	4.0	5.0	296	3/3	9/9	2.3	5.0	364	3/4	9/9	2.0	5.0	370
93	28-8	9-4	218.6	3/3	9/18	4.0	5.0	300	3/3	9/9	2.3	5.0	368	3/4	9/9	2.0	5.0	374
94	29-2	10-1	241.0	3/3	9/18	4.0	5.0	304	3/3	9/9	2.3	5.0	372	3/5	9/9	2.0	5.0	383
95	27-10	5-10	125.4	3/3	9/18	4.0	5.0	261	3/3	9/9	2.3	5.0	329	3/4	9/9	2.0	5.0	335
96	28-3	6-8	147.3	3/3	9/18	4.0	5.0	276	3/3	9/9	2.3	5.0	344	3/4	9/9	2.0	5.0	350
97	28-7	7-5	169.4	3/3	9/18	4.0	5.0	292	3/3	9/9	2.3	5.0	360	3/4	9/9	2.0	5.0	366
98	29-0	8-3	191.8	3/3	9/18	4.0	5.0	307	3/3	9/9	2.3	5.0	375	3/5	9/9	2.0	5.0	386
99	29-4	9-0	214.6	3/3	9/18	4.0	5.0	311	3/3	9/9	2.3	5.0	379	3/5	9/9	2.0	5.0	390
100	29-8	9-9	237.6	3/3	9/18	4.0	5.0	315	3/3	9/9	2.3	5.0	383	3/5	9/9	2.0	5.0	394
101	30-1	10-7	260.9	3/3	9/18	4.0	5.0	319	3/3	9/9	2.4	5.0	387	3/5	9/9	2.0	5.0	398
102	29-1	6-4	140.2	3/3	9/18	4.0	5.0	276	3/3	9/9	2.3	5.0	344	3/5	9/9	2.0	5.0	357
103	29-5	7-1	163.2	3/3	9/18	4.0	5.0	292	3/3	9/9	2.3	5.0	360	3/5	9/9	2.0	5.0	373
104	29-8	7-11	186.4	3/3	9/18	4.0	5.0	307	3/3	9/9	2.3	5.0	375	3/5	9/9	2.0	5.0	388
105	30-0	8-8	209.8	3/3	9/18	4.0	5.0	322	3/3	9/9	2.4	5.0	390	3/5	9/9	2.0	5.0	403
106	30-4	9-5	233.6	3/3	9/18	4.0	5.0	326	3/3	9/9	2.4	5.0	394	3/5	9/9	2.0	5.0	407
107	30-8	10-3	257.5	3/3	9/18	4.0	5.0	330	3/3	9/9	2.4	5.0	398	3/5	9/9	2.0	5.0	411
108	31-0	11-0	281.8	3/3	9/18	4.0	5.0	335	3/3	9/9	2.4	5.0	403	3/5	9/9	2.0	5.0	416
109	30-3	6-9	156.1	3/3	9/18	4.0	5.0	287	3/3	9/9	2.5	5.0	360	3/5	9/9	2.0	5.0	373
110	30-6	7-7	180.1	3/3	9/18	4.0	5.0	302	3/3	9/9	2.4	5.0	375	3/5	9/9	2.0	5.0	388
111	30-10	8-4	204.4	3/3	9/18	4.0	5.0	317	3/3	9/9	2.4	5.0	390	3/5	9/9	2.0	5.0	403
112	31-1	9-2	228.8	3/3	9/18	4.0	5.0	332	3/3	9/9	2.4	5.0	405	3/5	9/9	2.0	5.0	418
113	31-4	9-11	253.5	4/3	9/18	4.0	5.0	346	3/3	9/9	2.5	5.0	409	3/5	9/9	2.0	5.0	422
114	31-8	10-9	278.4	4/3	9/18	4.0	5.0	351	3/3	9/9	2.5	5.0	414	3/5	9/9	2.0	5.0	427
115	31-11	11-6	303.5	4/3	9/18	4.0	5.0	356	3/3	9/9	2.5	5.0	418	3/5	9/9	2.0	5.0	431
116	31-5	7-3	173.1	4/3	9/18	4.0	5.0	304	3/3	9/9	2.5	5.0	375	3/5	9/9	2.0	5.0	388
117	31-8	8-0	198.2	4/3	9/18	4.0	5.0	320	3/3	9/9	2.5	5.0	390	3/5	9/9	2.0	5.0	403
118	31-10	8-10	223.4	4/3	9/18	4.0	5.0	336	3/3	9/9	2.5	5.0	405	3/5	9/9	2.0	5.0	418
119	32-1	9-8	248.8	4/3	9/18	4.0	5.0	352	3/3	9/9	2.5	5.0	420	3/5	9/9	2.0	5.0	433
120	32-3	10-5	274.4	4/3	9/18	4.0	5.0	357	3/3	9/9	2.5	5.0	424	3/5	9/9	2.0	5.0	437
121	32-7	11-3	300.1	4/3	9/18	4.0	5.0	362	3/3	9/9	2.5	5.0	429	3/5	9/9	2.0	5.0	442
122	32-8	12-0	326.1	4/3	9/18	4.0	5.0	367	3/3	9/9	2.5	5.0	433	3/5	9/9	2.0	5.0	446
123	32-7	7-9	191.3	4/3	9/18	4.0	5.0	314	3/3	9/9	2.5	5.0	390	3/5	9/9	2.0	5.0	403
124	32-9	8-6	217.3	4/3	9/18	4.0	5.0	330	3/3	9/9	2.5	5.0	405	3/5	9/9	2.0	5.0	418
125	32-11	9-4	243.4	4/3	9/18	4.0	5.0	346	3/3	9/9	2.5	5.0	420	3/5	9/9	2.0	5.0	433
126	33-1	10-2	269.7	4/3	9/18	4.0	5.0	362	3/3	9/9	2.5	5.0	435	3/5	9/9	2.0	5.0	448
127	33-3	10-11	296.4	4/3	9/18	4.0	5.0	367	3/3	9/9	2.5	5.0	440	3/6	9/9	2.0	5.0	454
128	33-5	11-9	322.8	4/3	9/18	4.0	5.0	372	3/3	9/9	2.5	5.0	444	3/6	9/9	2.0	5.0	466
129	33-8	12-6	349.5	4/3	9/18	4.0	5.0	376	3/3	9/9	2.5	5.0	448	3/6	9/9	2.0	5.0	470
130	33-8	8-3	210.5	4/3	9/18	4.0	5.0	325	3/3	9/9	2.5	5.0	405	3/6	9/9	2.0	5.0	427
131	33-9	9-1	237.5	4/3	9/18	4.0	5.0	340	3/3	9/9	2.5	5.0	420	3/6	9/9	2.0	5.0	442
132	33-11	9-10	264.5	4/3	9/18	4.0	5.0	356	3/3	9/9	2.5	5.0	435	3/6	9/9	2.0	5.0	457
133	34-0	10-8	291.7	4/3	9/18	4.0	5.0	372	3/3	9/9	2.5	5.0	451	3/6	9/9	2.0	5.0	473
134	34-2	11-5	319.0	4/3	9/18	4.0	5.0	377	3/3	9/9	2.5	5.0	455	3/6	9/9	2.0	5.0	477
135	34-3	12-3	346.4	4/3	9/18	4.0	5.0	382	3/3	9/9	2.5	5.0	459	3/6	9/9	2.0	5.0	481
136	34-5	13-1	373.8	4/3	9/18	4.0	5.0	387	3/3	9/9	2.5	5.0	463	3/6	9/9	2.0	5.0	485
137	34-9	8-9	230.9	4/3	9/18	4.0	5.0	335	3/3	9/9	2.5	5.0	420	3/6	9/9	2.0	5.0	442
138	34-10	9-7	258.1	4/3	9/18	4.0	5.0	351	3/3	9/9	2.5	5.0	435	3/6	9/9	2.0	5.0	457
139	34-11	10-4	286.7	4/3	9/18	4.0	5.0	367	3/3	9/9	2.5	5.0	451	3/6	9/9	2.0	5.0	473
140	35-0	11-2	314.6	4/3	9/18	4.0	5.0	382	3/3	9/9	2.5	5.0	466	3/6	9/9	2.0	5.0	488
141	35-1	12-0	342.7	4/3	9/18	4.0	5.0	387	3/3	9/9	2.5	5.0	470	3/6	9/9	2.0	5.0	492
142	35-2	12-9	370.8	4/3	9/18	4.0	5.0	392	3/3	9/9	2.5	5.0	474	3/6	9/9	2.0	5.0	496
143	35-3	13-7	399.0	4/3	9/18	4.0	5.0	394	3/3	9/9	2.5	5.0	476	3/6	9/9	2.0	5.0	500

Fully Assembled Aluminum Box Culvert Being Set in Place

See Notes page 65

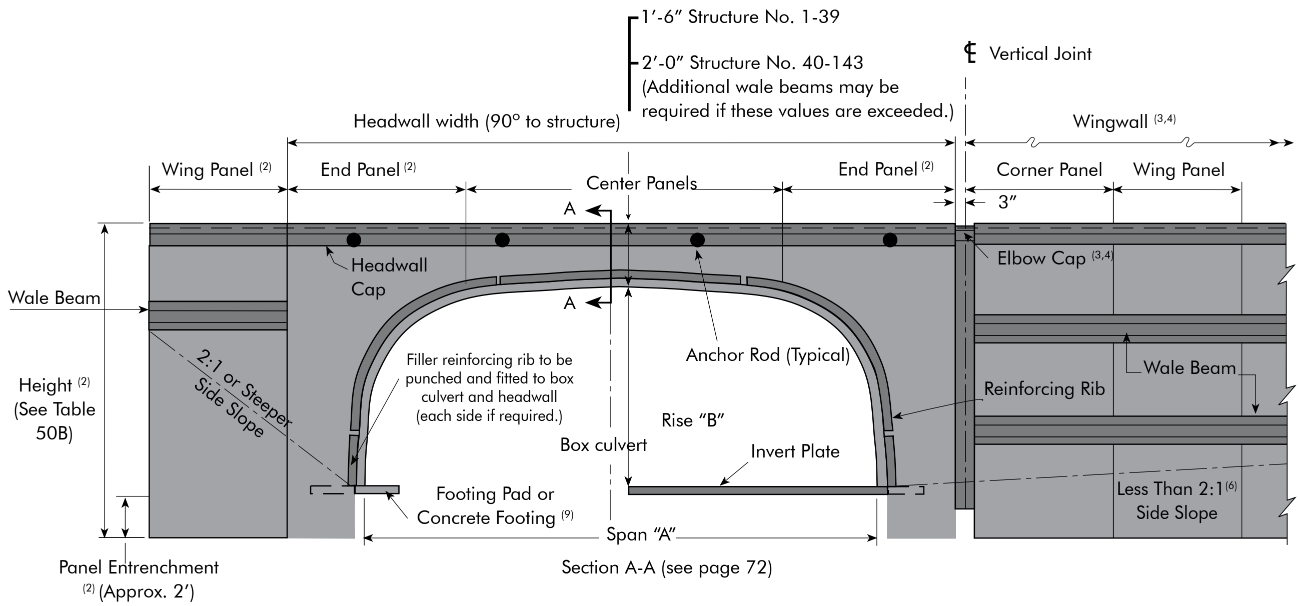
TABLE 49C. ALBC STRUCTURE AREA, PLATE AND RIB MAKE-UP

Box #	Inside Dimensions		Inside Flow Area	Crown Arc Length (N)	Haunch Arc Length (N)	Straight Leg Length "D" (N)	Total (N)	Plate Make-Up		Side Angle "E" (deg.)
	Span	Rise						Haunch (N)	Crown (N)	
1	8'-9"	2'-6"	18.4			.5	14	14	NA	
2	9'-2"	3'-3"	25.4			1.5	16	8		
3	9'-7"	4'-1"	32.6			2.5	18	9		
4	10'-0"	4'-10"	40.2	5	4	3.5	20	10		15.40
5	10'-6"	5'-7"	48.1			4.5	22	11		
6	10'-11"	6'-4"	56.4			5.5	24	12		
7	11'-4"	7'-2"	65.0			6.5	26	13		
8	10'-2"	2'-8"	23.0			.5	16	8		
9	10'-7"	3'-5"	31.1			1.5	18	9		
10	10'-11"	4'-3"	39.5			2.5	20	10		
11	11'-4"	5'-0"	48.2	7	4	3.5	22	11		13.55
12	11'-8"	5'-9"	57.2			4.5	24	12		
13	12'-1"	6'-7"	66.4			5.5	26	13		
14	12'-5"	7'-4"	76.0			6.5	28	14		
15	11'-7"	2'-10"	28.1			.5	18	9	TWO PLATE SHELL	
16	11'-11"	3'-7"	37.4			1.5	20	10		
17	12'-3"	4'-5"	46.9	9	4	2.5	22	11		11.70
18	12'-7"	5'-2"	56.6			3.5	24	12		
19	12'-11"	6'-0"	66.6			4.5	26	13		
20	13'-3"	6'-9"	76.9			5.5	28	14		
21	13'-0"	3'-0"	33.8			.5	20	10		
22	13'-4"	3'-10"	44.2			1.5	22	11		
23	13'-7"	4'-7"	54.8	11	4	2.5	24	12		9.87
24	13'-10"	5'-5"	65.6			3.5	26	13		
25	14'-1"	6'-2"	76.6			4.5	28	14		
26	14'-5"	3'-3"	40.0			.5	22	11		
27	14'-8"	4'-1"	51.5			1.5	24	8		
28	14'-10"	4'-10"	63.2			2.5	26	9		
29	15'-1"	5'-8"	75.1	13	4	3.5	28	10	8	8.02
30	15'-4"	6'-5"	87.2			4.5	30	11		
31	15'-6"	7'-3'	99.4			5.5	32	12		
32	15'-9"	8'-0"	111.8			6.5	34	13		
33	15'-10"	3'-6"	46.8			.5	24	8		
34	16'-0"	4'-3"	59.5			1.5	26	9		
35	16'-2"	5'-1"	72.3			2.5	28	10		
36	16'-4"	5'-11"	85.2	15	4	3.5	30	11	8	6.17
37	16'-6"	6'-8"	98.3			4.5	32	12		
38	16'-8"	7'-6"	111.5			5.5	34	13		
39	16'-10"	8'-3"	124.8			6.5	36	14		
40	17'-9"	3'-10"	54.4			.5	26	8		
41	18'-2"	4'-7"	68.3			1.5	28	9		
42	18'-7"	5'-4"	82.5			2.5	30	10		
43	19'-0"	6'-1"	97.1	17	4	3.5	32	11	10	14.90
44	19'-5"	6'-11"	111.9			4.5	34	12		
45	19'-10"	7'-8"	127.1			5.5	36	13		
46	20'-3"	8'-5"	142.6			6.5	38	14		
47	19'-1"	4'-2"	63.3			.5	28	8		
48	19'-5"	4'-11"	78.3			1.5	30	9		
49	19'-9"	5'-8"	93.6			2.5	32	10		
50	20'-1"	6'-6"	109.2	19	4	3.5	34	11	12	12.78
51	20'-6"	7'-3"	125.0			4.5	36	12		
52	20'-10"	8'-1"	141.2			5.5	38	13		
53	21'-2"	8'-10"	157.6			6.5	40	14		
54	20'-4"	4'-6"	73.1			.5	30	8		
55	20'-7"	5'-3"	89.2			1.5	32	9		
56	20'-11"	6'-1"	105.5			2.5	34	10		
57	21'-3"	6'-10"	122.1	21	4	3.5	36	11	14	10.67
58	21'-6"	7'-8"	139.0			4.5	38	12		
59	21'-10"	8'-5"	156.0			5.5	40	13		
60	22'-1"	9'-3"	173.3			6.5	42	14		
61	21'-7"	4'-11"	83.8			.5	32	9		
62	21'-10"	5'-8"	101.0			1.5	34	10		
63	22'-1"	6'-6"	118.4			2.5	36	11		
64	22'-3"	7'-3"	135.9	23	4	3.5	38	12	14	8.53
65	22'-6"	8'-1"	153.7			4.5	40	13		
66	22'-9"	8'-10'	171.6			5.5	42	14		
67	23'-0"	9'-8"	189.8			6.5	44	15		
68	22'-9"	5'-4"	95.5			.5	34	10		
69	23'-0"	6'-1"	113.7			1.5	36	11		
70	23'-2"	6'-11"	132.1			2.5	38	12		
71	23'-4"	7'-8"	150.6	25	4	3.5	40	13	14	6.42
72	23'-6"	8'-6"	169.3			4.5	42	14		
73	23'-8"	9'-3"	188.1			5.5	44	15		
74	23'-10"	10'-1"	207.0			6.5	46	16		
75	24'-0"	5'-9"	108.2			.5	36	10		
76	24'-1"	6'-6"	127.5			1.5	38	11		
77	24'-3"	7'-4"	146.8			2.5	40	12		
78	24'-4"	8'-2"	166.2	27	4	3.5	42	13	16	4.30
79	24'-5"	8'-11"	185.7			4.5	44	14		
80	24'-7"	9'-9"	205.3			5.5	46	15		
81	24'-8"	10'-6"	225.0			6.5	48	16		
82	25'-2"	6'-2"	122.0			.5	38	11		
83	25'-2"	7'-0"	142.2			1.5	40	12		
84	25'-3"	7'-9"	162.4	29	4	2.5	42	13	16	2.18
85	25'-4"	8'-7"	182.6			3.5	44	14		
86	25'-4"	9'-5"	202.9			4.5	46	15		
87	25'-5"	10'-2"	223.3			5.5	48	16		
88	26'-7"	5'-5"	111.6			.5	38	11		
89	27'-0"	6'-3"	132.4			1.5	40	12		
90	27'-5"	7'-0"	153.4			2.5	42	13		
91	27'-10"	7'-9"	174.8	29	4	3.5	44	14	16	15.22
92	28'-3"	8'-7"	196.5			4.5	46	15		
93	28'-8"	9'-4"	218.6			5.5	48	16		
94	29'-2"	10'-1"	241.0			6.5	50	17		
95	27'-10"	5'-10"	125.4			.5	40	12		
96	28'-3"	6'-8"	147.3			1.5	42	13		
97	28'-7"	7'-5"	169.4			2.5	44	14		
98	29'-0"	8'-3"	191.8	31	4	3.5	46	15	16	13.45
99	29'-4"	9'-0"	214.6			4.5	48	16		
100	29'-8"	9'-9"	237.6			5.5	50	17		
101	30'-1"	10'-7"	260.9			6.5	52	18		
102	29'-1"	6'-4"	140.2			.5	42	12		
103	29'-5"	7'-1"	163.2			1.5	44	13		
104	29'-8"	7'-11"	186.4			2.5	46	14		
105	30'-0"	8'-8"	209.8	33	4	3.5	48	15	18	11.68
106	30'-4"	9'-5"	233.6			4.5	50	16		
107	30'-8"	10'-3"	257.5			5.5	52	17		
108	31'-0"	11'-0"	281.8			6.5	54	18		
109	30'-3"	6'-9"	156.1			.5	44	13		
110	30'-6"	7'-7"	180.1			1.5	46	14		
111	30'-10"	8'-4"	204.4			2.5	48	15		
112	31'-1"	9'-2"	228.8	35	4	3.5	50	16	18	9.92
113	31'-4"	9'-11"	253.5			4.5	52	17		
114	31'-8"	10'-9"	278.4			5.5	54	18		
115	31'-11"	11'-6"	303.5			6.5	56	19		
116	31'-5"	7'-3"	173.1			.5	46	14		
117	31'-8"	8'-0"	198.2			1.5	48	15		
118	31'-10"	8'-10'	223.4			2.5	50	16		
119	32'-1"	9'-8"	248.8	37	4	3.5	52	17	18	8.15
120	32'-3"	10'-5"	274.4			4.5	54	18		
121	32'-7"	11'-3"	300.1			5.5	56	19		
122	32'-8"	12'-0"	326.1			6.5	58	20		
123	32'-7"	7'-9"	191.3			.5	48	14		
124	32'-9"	8'-6"	217.3			1.5	50	15		
125	32'-11"	9'-4"	243.4			2.5	52	16		
126	33'-1"	10'-2"	269.7	39	4	3.5	54	17	20	6.37
127	33'-3"	10'-11"	296.4			4.5	56	18		
128	33'-5"	11'-9"	322.8			5.5	58	19		
129	33'-8"	12'-6"	349.5			6.5	60	20		
130	33'-8"	8'-3"	210.5			.5	50	15		
131	33'-9"	9'-1"	237.5			1.5	52	16		
132	33'-11"	9'-10"	264.5			2.5	54	17		
133	34'-0"	10'-8"	291.7	41	4	3.5	56	18	20	4.62
134	34'-2"	11'-5"	319.0			4.5	58	19		
135	34'-3"	12'-3"	346.4			5.5	60	20		
136	34'-5"	13'-1"	373.8			6.5	62	21		
137	34'-9"	8'-9"	230.9			.5	52	16		
138	34'-10"	9'-7"	258.1			1.5	54	17		
139	34'-11"	10'-4"	286.7			2.5	56	18		
140	35'-0"	11'-2"	314.6	43	4	3.5	58	19	20	2.85
141	35'-1"	12'-0"	342.7			4.5	60	20		
142	35'-2"	12'-9"	370.8			5.5	62	21		
143	35'-3"	13'-7"	399.0			6.5	64	21		

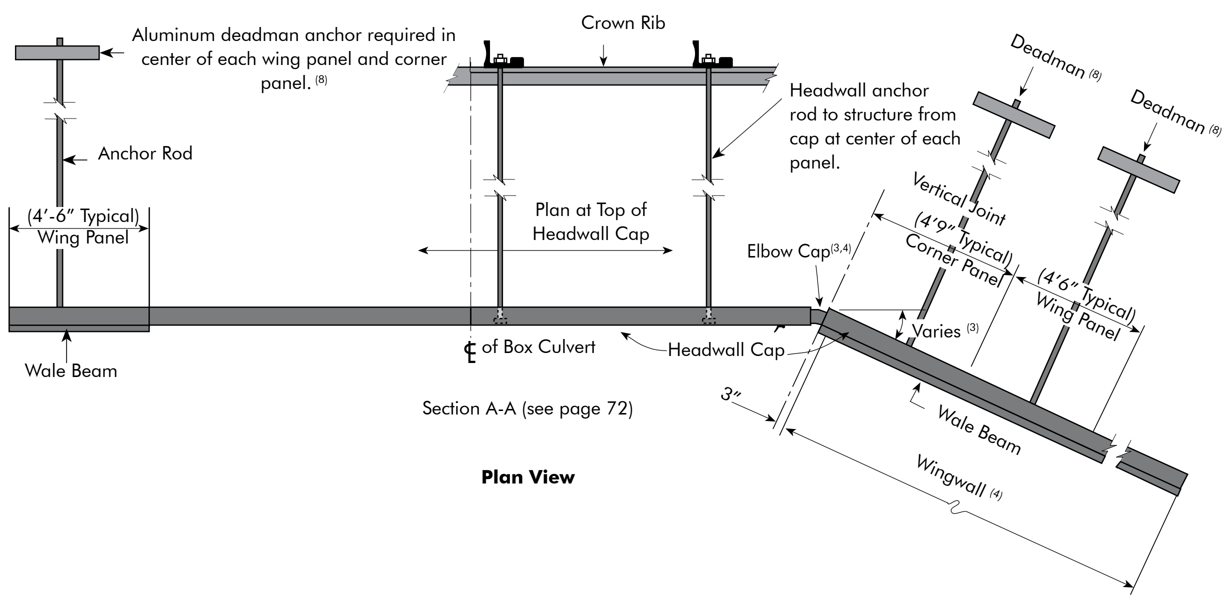
Notes:
1. Box #1 is a one plate shell.

Aluminum Box Culvert

Headwall and Wingwall Details



Typical Headwall Elevation



Plan View

Notes:

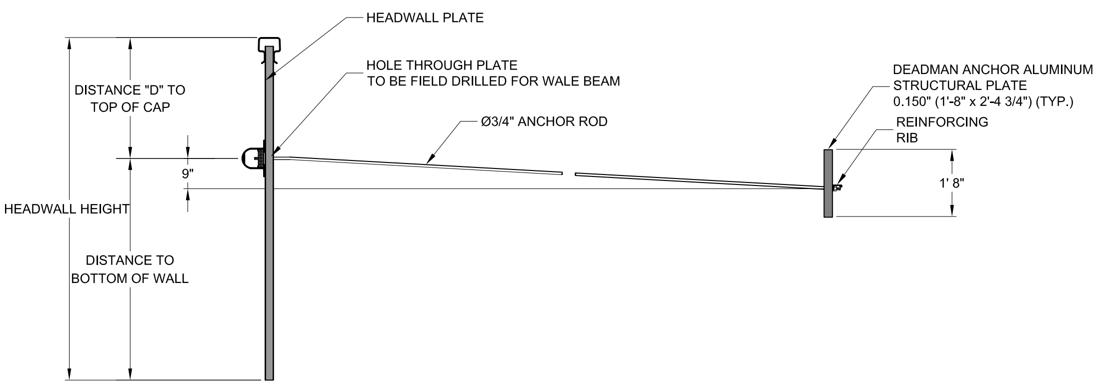
1. All panels are fabricated from aluminum structural plate as specified in ASTM B746.
2. Height of headwall listed in Table 50B permits approximately 24" entrenchment depth below the invert. All wingwall and headwall end panels must be trenched into existing ground.
3. Horizontal rotation on the wingwall should not exceed 90°.
4. The top of a headwall and its wingwall are always horizontal, unless beveled wingwalls are required.
5. Standard headwalls shown are for vertical orientation only.
6. If side slope is flatter than 2:1, a double tieback assembly is required for each deadman.
7. Standard headwalls are shown. HS-20, HS-25 and HL-93 wheel loads must be kept a minimum distance of 36" from the wall face. Special headwall packages can be fabricated to meet other loading requirements.
8. For details on single and dual deadman anchors, refer to next page.
9. Structures on concrete footings with headwalls require field modification of the headwall plates to fit around the footings.
10. Aluminum headwalls may be used only on square-ended structures. Structure length must be an increment of 9 inches, if these headwalls are utilized at both ends.

TABLE 50A

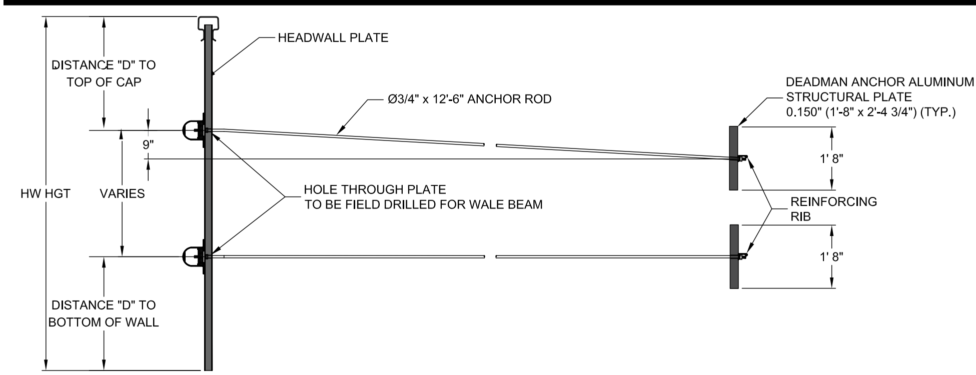
	HEADWALL			WINGWALLS					
				Single Anchor		Dual Anchors			
Wall Height	Center Panel Thickness	End Panel Thickness	Wale Beam - Distance from top of HW	Panel Thickness	Wale Beam - Distance from top of HW	Panel Thickness	Wale Beam - Distance from top of HW "D"	0.150" thick Deadman Size	3/4"dia Rod Length
6'2" to 8'7"	0.125"	0.150"	N/A	0.125"	3'0"	0.125"	2'6"	1'8" x 2' 4 3/4"	12'6"
9'4" to 11'9"	0.125"	0.150"	N/A	0.150"	3'6"	0.125"	3'0"	1'8" x 2' 4 3/4"	12'6"
12'7" to 14'2"	0.125"	0.150"	N/A	N/A	N/A	0.150"	3'6"	1'8" x 2' 4 3/4"	12'6"

ANYTHING GREATER THAN 14'2": INQUIRE

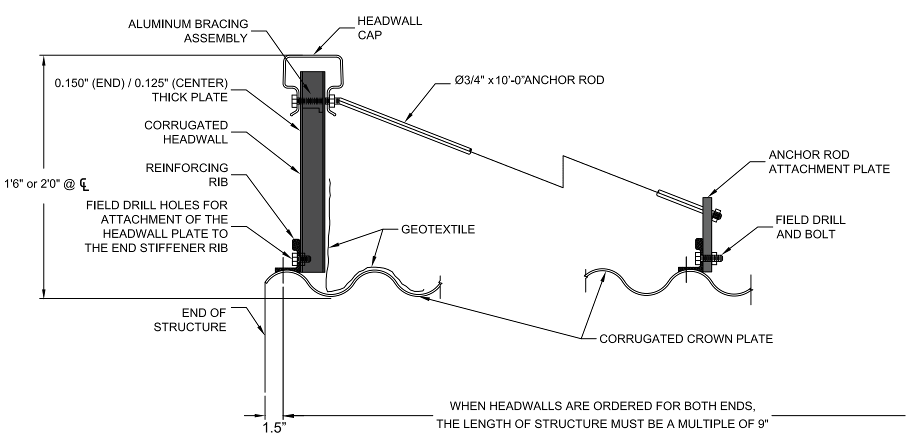
SINGLE ANCHOR DESIGN



DUAL ANCHOR DESIGN



HEADWALL ATTACHMENT TO CROWN



Section A-A (see page 71)

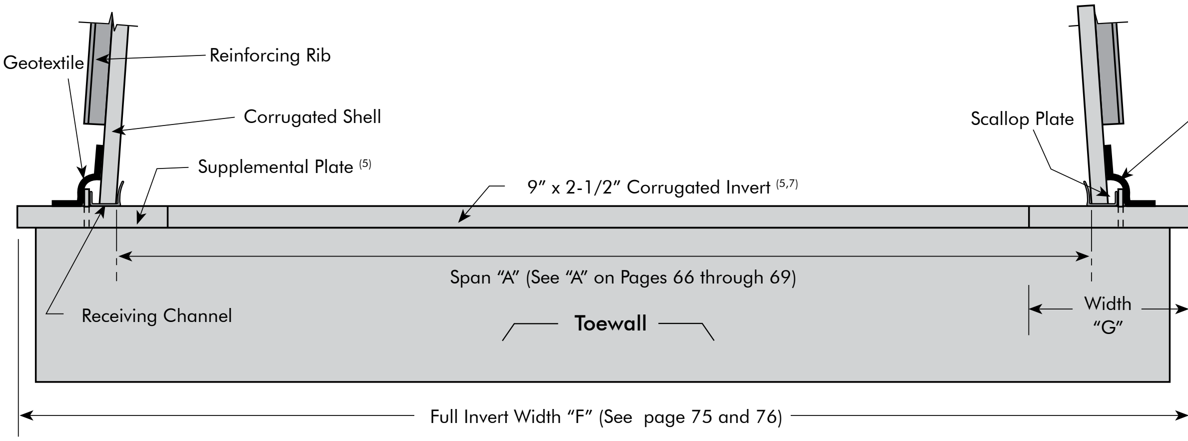
Aluminum Box Culvert

Headwall Dimensions for H-20, HS-20, H-25, HS-25, HL-93 Loading

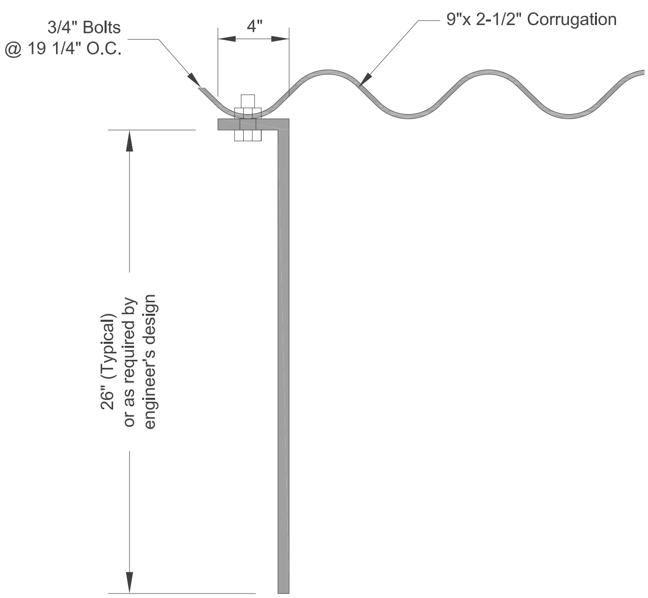
TABLE 50B. HEADWALL

No.	Width Ft.-In.	Height Ft.-In.	No. of Anchor Rods	No.	Width Ft.-In.	Height Ft.-In.	No. of Anchor Rods
1	13-6	6-2	3	88	33-0	9-4	7
2	13-6	6-11	3	89	33-0	10-2	7
3	13-6	7-9	3	90	33-0	10-11	7
4	13-6	8-6	3	91	33-0	11-9	7
5	13-6	9-4	3	92	33-0	12-7	7
6	13-6	10-2	3	93	33-0	13-4	7
7	13-6	10-11	3	94	33-0	14-2	7
8	15-0	6-11	3	95	34-6	10-2	8
9	15-0	7-9	3	96	34-6	10-11	8
10	15-0	8-6	3	97	34-6	11-9	8
11	15-0	9-4	3	98	34-6	12-7	8
12	15-0	10-2	3	99	34-6	13-4	8
13	15-0	10-11	3	100	34-6	14-2	8
14	15-0	11-9	3	101	34-6	15-1	8
15	16-6	6-11	4	102	36-0	10-2	8
16	16-6	7-9	4	103	36-0	10-11	8
17	16-6	8-6	4	104	36-0	11-9	8
18	16-6	9-4	4	105	36-0	12-7	8
19	16-6	10-2	4	106	36-0	13-4	8
20	16-6	10-11	4	107	36-0	14-2	8
21	18-0	6-11	4	108	36-0	15-1	8
22	18-0	7-9	4	109	37-6	10-11	8
23	18-0	8-6	4	110	37-6	11-9	8
24	18-0	9-4	4	111	37-6	12-7	8
25	18-0	10-2	4	112	37-6	13-4	8
26	19-6	6-11	4	113	37-6	14-2	8
27	19-6	7-9	4	114	37-6	15-1	8
28	19-6	8-6	4	115	37-6	15-11	8
29	19-6	9-4	4	116	37-6	11-9	8
30	19-6	10-2	4	117	37-6	12-7	8
31	19-6	10-11	4	118	37-6	13-4	8
32	19-6	11-9	4	119	37-6	14-2	8
33	21-0	7-9	5	120	37-6	15-1	8
34	21-0	8-6	5	121	37-6	15-11	8
35	21-0	9-4	5	122	37-6	16-8	8
36	21-0	10-2	5	123	37-6	11-9	8
37	21-0	10-11	5	124	37-6	12-7	8
38	21-0	11-9	5	125	37-6	13-4	8
39	21-0	12-7	5	126	37-6	14-2	8
40	22-6	7-9	5	127	37-6	15-1	8
41	22-6	8-6	5	128	37-6	15-11	8
42	22-6	9-4	5	129	37-6	16-8	8
43	22-6	10-2	5	130	40-6	12-7	9
44	22-6	10-11	5	131	40-6	13-4	9
45	22-6	11-9	5	132	40-6	14-2	9
46	22-6	12-7	5	133	40-6	15-1	9
47	24-0	8-6	5	134	40-6	15-11	9
48	24-0	9-4	5	135	40-6	16-8	9
49	24-0	10-2	5	136	40-6	17-5	9
50	24-0	10-11	5	137	42-0	13-4	9
51	24-0	11-9	5	138	42-0	14-2	9
52	24-0	12-7	5	139	42-0	15-1	9
53	24-0	13-4	5	140	42-0	15-11	9
54	25-6	8-6	6	141	42-0	16-8	9
55	25-6	9-4	6	142	42-0	17-5	9
56	25-6	10-2	6	143	42-0	17-5	9
57	25-6	10-11	6				
58	25-6	11-9	6				
59	25-6	12-7	6				
60	25-6	13-4	6				
61	27-0	9-4	6				
62	27-0	10-2	6				
63	27-0	10-11	6				
64	27-0	11-9	6				
65	27-0	12-7	6				
66	27-0	13-4	6				
67	27-0	14-2	6				
68	28-6	9-4	6				
69	28-6	10-2	6				
70	28-6	10-11	6				
71	28-6	11-9	6				
72	28-6	12-7	6				
73	28-6	13-4	6				
74	28-6	14-2	6				
75	30-0	9-4	7				
76	30-0	10-2	7				
77	30-0	10-11	7				
78	30-0	11-9	7				
79	30-0	12-7	7				
80	30-0	13-4	7				
81	30-0	14-2	7				
82	31-6	10-2	7				
83	31-6	10-11	7				
84	31-6	11-9	7				
85	31-6	12-7	7				
86	31-6	13-4	7				
87	31-6	14-2	7				

Aluminum Box Culvert with Full Aluminum Headwall Package



Aluminum Full Invert Option (2,3,5,6)



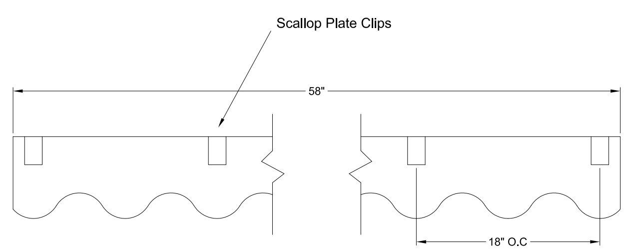
Aluminum Bent Sheet Toewall Detail

Note: Flat sheet toewalls are available only for structures having a full corrugated aluminum invert.

Notes:

1. N=9.625" or 9 $^{5}/_{8}$". Use N as a conversion factor. For example, for Structure No. 1, Width "F" is 13 x N, or 125.13".
2. Minimum allowable soil-bearing pressure is 4,000 Lbs./Sq. Ft. for structures and details shown in this catalog. This applies specifically for width "G" below the receiving channel. Other conditions can be accommodated. Contact a Contech Representative for more information.
3. The maximum cover for Aluminum Box Culverts with full inverts and footing pads should not exceed 4 feet. Special full invert and footing pad designs or slotted concrete footings can accommodate maximum covers to the limits shown in Tables 48A-48B and 49A-49B.
4. Weight per foot of full invert includes receiving channels, scallop plates, nuts, bolts, and all plates.
5. Full invert plates thickness are as shown. When reactions to the invert require additional thickness, supplemental plates of the thickness and width listed in Table 51 are furnished to bolt between the full invert and the receiving channel.
6. Invert widths 21N and greater are two-pieces.
7. Invert plates must not be overlapped on adjacent structures unless appropriate design modifications are incorporated.

Installation of Aluminum Box Culvert Toewall



Aluminum Scallop Plate (Full Invert Only)

Aluminum Box Culvert

Invert Details

TABLE 51A FULL INVERT (H-20, HS-20)					
Structure Number	Width "F" (N)	Supplemental Plate Thickness (Inches)	Width "G" (N)	Weight/Ft. (Lbs.)	Bolts/Ft. (Each)
1	13		2	26.1	5.78
2	14		2	27.6	6.00
3	14		2	27.6	6.00
4	15		2	29.1	6.22
5	16		2	30.5	6.44
6	16		2	30.5	6.44
7	17		2	32.0	6.67
8	15		2	29.1	6.22
9	16		2	30.5	6.44
10	16		2	30.5	6.44
11	17		2	32.0	6.67
12	17		2	32.0	6.67
13	18		2	33.5	6.89
14	18		2	33.5	6.89
15	17		2	32.0	6.67
16	17		2	32.0	6.67
17	18		2	33.5	6.89
18	18		2	33.5	6.89
19	19		2	35.0	7.11
20	19		2	35.0	7.11
21	19		2	35.0	7.11
22	19		2	35.0	7.11
23	19		2	35.0	7.11
24	20		2	37.9	10.00
25	20		2	37.9	10.00
26	20	.100	2	43.7	10.22
27	21	.100	2	45.2	10.22
28	21	.100	2	45.2	10.22
29	21	.100	2	45.2	10.22
30	22	.100	2	46.7	10.44
31	22	.100	2	46.7	10.44
32	22	.100	2	46.7	10.44
33	22	.100	2	46.7	10.44
34	22	.100	2	46.7	10.44
35	23	.100	2	48.2	10.67
36	23	.100	2	48.2	10.67
37	23	.100	2	48.2	10.67
38	23	.100	2	48.2	10.67
39	24	.100	2	49.7	10.67
40	26	.100	3	55.2	11.33
41	26	.100	3	55.2	11.33
42	27	.100	3	56.6	11.56
43	27	.100	3	56.6	11.56
44	28	.100	3	58.1	11.78
45	28	.100	3	58.1	11.78
46	29	.100	3	59.6	12.00
47	27	.100	3	56.6	11.56
48	28	.100	3	58.1	11.78
49	28	.100	3	58.1	11.78
50	29	.100	3	59.6	12.00
51	29	.100	3	59.6	12.00
52	29	.125	3	61.5	12.00
53	30	.125	3	63.0	12.22
54	29	.125	3	61.5	12.00
55	29	.125	3	61.5	12.00
56	30	.125	3	63.0	12.22
57	30	.125	3	63.0	12.22
58	30	.125	3	63.0	12.22
59	31	.125	3	64.5	12.44
60	31	.125	3	64.5	12.44
61	30	.125	3	63.0	12.22
62	31	.125	3	64.5	12.44
63	31	.150	3	66.4	12.44
64	31	.150	3	66.4	12.44
65	32	.150	3	67.9	12.67
66	32	.150	3	67.9	12.67
67	32	.150	3	67.9	12.67
68	32	.150	3	67.9	12.67
69	32	.150	3	67.9	12.67
70	32	.150	3	67.9	12.67
71	33	.150	3	69.4	12.89
72	33	.150	3	69.4	12.89
73	33	.150	3	69.4	12.89
74	33	.150	3	69.4	12.89
75	33	.150	3	71.3	12.89
76	34	.175	3	72.8	13.11
77	34	.175	3	72.8	13.11
78	34	.175	3	72.8	13.11
79	34	.175	3	72.8	13.11
80	34	.175	3	72.8	13.11
81	34	.175	3	72.8	13.11
82	35	.200	3.5	78.8	13.33
83	35	.200	3.5	78.8	13.33
84	35	.200	3.5	78.8	13.33
85	36	.200	3.5	80.3	13.56
86	36	.200	3.5	80.3	13.56
87	36	.200	3.5	80.3	13.56

TABLE 51B FULL INVERT (H-25, HS-25, HL-93)					
Structure Number	Width "F" (N)	Supplemental Plate Thickness (Inches)	Width "G" (N)	Weight/Ft. (Lbs.)	Bolts/Ft. (Each)
1	13		2	26.1	5.78
2	14		2	27.6	6.00
3	14		2	27.6	6.00
4	15		2	29.1	6.22
5	16		2	30.5	6.44
6	16		2	30.5	6.44
7	17		2	33.0	6.67
8	15		2	29.8	6.23
9	16		2	30.5	6.44
10	16		2	33.0	6.67
11	17		2	33.0	6.67
12	17		2	33.0	6.67
13	18	.100	2	38.8	6.67
14	18	.100	2	38.8	6.67
15	17	.100	2	38.8	6.67
16	17	.100	2	38.8	6.67
17	18	.100	2	38.8	6.67
18	18	.100	2	42.0	7.11
19	19	.100	2	42.0	7.11
20	19	.100	2	42.0	7.11
21	19	.100	2	42.0	7.11
22	19	.100	2	42.0	7.11
23	19	.100	2	42.0	7.11
24	20	.100	2	46.3	12.45
25	20	.100	2	46.3	12.45
26	20	.100	2	46.3	12.45
27	21	.100	2	47.9	12.67
28	21	.100	2	47.9	12.67
29	21	.100	2	47.9	12.67
30	22	.100	2	47.9	12.67
31	22	.100	2	49.5	12.89
32	22	.100	2	49.5	12.89
33	22	.100	2	49.5	12.89
34	22	.100	2	49.5	12.89
35	23	.100	2	51.1	13.11
36	23	.100	2	51.1	13.11
37	23	.100	2	51.1	13.11
38	23	.100	2	51.1	13.11
39	24	.100	3	55.6	13.34
40	26	.150	3	61.5	13.56
41	26	.150	3	61.5	13.56
42	27	.150	3	63.0	13.78
43	27	.150	3	63.0	13.78
44	28	.150	3	64.9	14.00
45	28	.150	3	64.9	14.00
46	29	.150	3	66.5	14.23
47	27	.150	3	63.0	13.78
48	28	.150	3	64.9	14.00
49	28	.150	3	64.9	14.00
50	29	.150	3	68.0	14.45
51	29	.150	3	68.0	14.45
52	29	.150	3	68.0	14.45
53	30	.175	3	70.0	14.45
54	29	.175	3	68.0	14.45
55	29	.175	3	70.0	14.45
56	30	.175	3	71.9	14.67
57	30	.175	3	71.9	14.67
58	30	.175	3	71.9	14.67
59	31	.175	3	73.4	14.89
60	31	.175	3	73.4	14.89
61	30	.175	3	71.9	14.67
62	31	.175	3	73.4	14.89
63	31	.175	3	73.4	14.89
64	31	.175	3	73.4	14.89
65	32	.175	3	75.0	15.11
66	32	.175	3	75.0	15.11
67	32	.175	3	75.0	15.11
68	32	.175	3	75.0	15.11
69	32	.175	3	75.0	15.11
70	32	.175	3	75.0	15.11
71	33	.175	3	76.6	15.34
72	33	.175	3	76.6	15.34
73	33	.175	3	76.6	15.34
74	33	.175	3	76.6	15.34
75	33	.200	3	78.7	15.34
76	34	.200	3	80.2	15.56
77	34	.200	3	80.2	15.56
78	34	.200	3	80.2	15.56
79	34	.200	3	80.2	15.56
80	34	.200	3	80.2	15.56
81	34	.200	3	80.2	15.56
82	35	.250	3.5	88.5	15.78
83	35	.250	3.5	88.5	15.78
84	35	.250	3.5	88.5	15.78
85	36	.250	3.5	88.5	15.78
86	36	.250	3.5	88.5	15.78
87	36	.250	3.5	88.5	15.78

Notes:
1. For structures 1-87, invert plates are 0.100" thick.

TABLE 51C. FULL INVERT (H-25, HS-25, HL-93)

No.	Invert Plate Thickness (Inches)	Invert Width (N)	Supplemental Plate Thickness (Inches)	Supplemental Plate Quantity	Supplemental Plate Width (N)	Weight/Foot (Lbs.)
88	0.125	37	0.175	2	4	113
89	0.125	38	0.175	2	4	115
90	0.125	38	0.175	2	4	115
91	0.125	39	0.175	2	4	117
92	0.125	40	0.175	2	4	119
93	0.125	40	0.175	2	4	119
94	0.125	40	0.175	2	4	119
95	0.125	39	0.175	2	4	119
96	0.125	39	0.175	2	4	119
97	0.125	40	0.175	2	4	119
98	0.125	40	0.175	2	4	119
99	0.125	41	0.175	2	4	120
100	0.125	41	0.175	2	4	120
101	0.125	42	0.250	2	6	165
102	0.125	40	0.250	2	6	161
103	0.125	41	0.250	2	6	163
104	0.125	41	0.250	2	6	163
105	0.125	42	0.250	2	6	165
106	0.125	44	0.250	2	6	168
107	0.125	45	0.250	2	6	170
108	0.125	45	0.250	2	6	170
109	0.125	44	0.250	2	6	170
110	0.125	44	0.250	2	6	170
111	0.125	45	0.250	2	6	170
112	0.125	45	0.250	2	6	170
113	0.125	45	0.250	2	6	170
114	0.125	46	0.250	2	6	172
115	0.125	46	0.250	2	6	172
116	0.125	45	0.250	2	6	172
117	0.125	46	0.250	2	6	172
118	0.125	46	0.250	2	6	172
119	0.125	46	0.250	2	6	172
120	0.125	47	0.250	2	6	174
121	0.125	47	0.250	2	6	174
122	0.125	47	0.250	3	6	214
123	0.125	47	0.250	3	6	214
124	0.125	47	0.250	3	6	214
125	0.125	47	0.250	3	6	214
126	0.125	48	0.250	3	6	216
127	0.125	48	0.250	3	6	216
128	0.125	48	0.250	3	6	216
129	0.125	48	0.250	3	6	216
130	0.125	48	0.250	3	6	216
131	0.125	48	0.250	3	6	216
132	0.125	49	0.250	3	6	217
133	0.125	49	0.250	3	6	217
134	0.125	49	0.250	3	6	217
135	0.125	49	0.250	3	6	217
136	0.125	49	0.250	3	6	217
137	0.125	49	0.250	3	6	217
138	0.125	50	0.250	3	6	219
139	0.125	50	0.250	3	6	219
140	0.125	50	0.250	3	6	219
141	0.125	50	0.250	3	6	219
142	0.125	50	0.250	3	6	219
143	0.125	50	0.250	3	6	219

Assembly of ALBC Shell onto Full Invert

TABLE 52A. FOOTING PADS

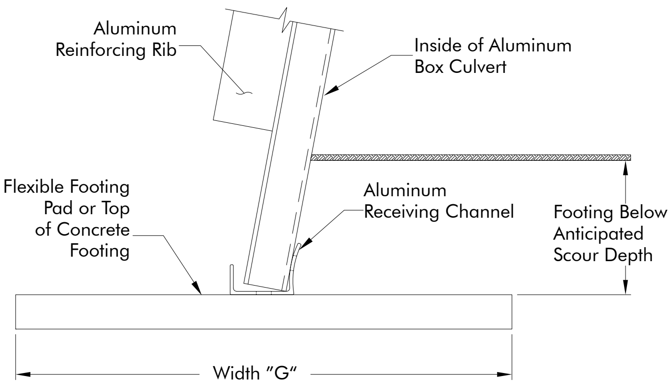
Structure No.	H-20, HS-20 Loading Plate Thickness (Inches)	H-20, HS-20 Loading Width "G"(N)	H-25, HS-25, HL-93 Loading Plate Thickness (Inches)	H-25, HS-25, HL-93 Loading Width "G" (N)	Weight/Ft. (Lbs.)
1	.100	2	.100	2	11.9
2	.100	2	.100	2	11.9
3	.100	2	.100	2	11.9
4	.100	2	.100	2	11.9
5	.100	2	.100	2	11.9
6	.100	2	.100	2	11.9
7	.100	2	.100	2	11.9
8	.100	2	.100	2	11.9
9	.100	2	.100	2	11.9
10	.100	2	.100	2	11.9
11	.100	2	.100	2	11.9
12	.100	2	.100	2	11.9
13	.100	2	.125	2	11.9
14	.100	2	.125	2	11.9
15	.100	2	.125	2	11.9
16	.100	2	.125	2	11.9
17	.100	2	.125	2	11.9
18	.100	2	.125	2	11.9
19	.100	2	.125	2	11.9
20	.100	2	.125	2	11.9
21	.100	2	.125	2	11.9
22	.100	2	.125	2	11.9
23	.100	2	.125	2	11.9
24	.100	2	.125	2	11.9
25	.100	2	.125	2	11.9
26	.125	2	.150	2	13.2
27	.125	2	.150	2	13.2
28	.125	2	.150	2	13.2
29	.125	2	.150	2	13.2
30	.125	2	.150	2	13.2
31	.125	2	.150	2	13.2
32	.125	2	.150	2	13.2
33	.125	2	.150	2	13.2
34	.125	2	.150	2	13.2
35	.125	2	.150	2	13.2
36	.125	2	.150	2	13.2
37	.125	2	.150	2	13.2
38	.125	2	.150	2	13.2
39	.125	2	.200	3	22.2
40	.200	3	.250	3	22.2
41	.200	3	.250	3	22.2
42	.200	3	.250	3	22.2
43	.200	3	.250	3	22.2
44	.200	3	.250	3	22.2
45	.200	3	.250	3	22.2
46	.200	3	.250	3	22.2
47	.200	3	.250	3	22.2
48	.200	3	.250	3	22.2
49	.200	3	.250	3	22.2
50	.200	3	.250	3	22.2
51	.200	3	.250	3	22.2
52	.225	3	.250	3	24.1
53	.225	3	.275	3	24.1
54	.225	3	.275	3	24.1
55	.225	3	.275	3	24.1
56	.225	3	.275	3	24.1
57	.225	3	.275	3	24.1
58	.225	3	.275	3	24.1
59	.225	3	.275	3	24.1
60	.225	3	.275	3	24.1
61	.225	3	.275	3	24.1
62	.225	3	.275	3	24.1
63	.250	3	.275	3	26.0
64	.250	3	.275	3	26.0
65	.250	3	.275	3	26.0
66	.250	3	.275	3	26.0
67	.250	3	.275	3	26.0
68	.250	3	.275	3	26.0
69	.250	3	.275	3	26.0
70	.250	3	.275	3	26.0
71	.250	3	.275	3	26.0
72	.250	3	.275	3	26.0
73	.250	3	.275	3	26.0
74	.250	3	.275	3	26.0
75	.275	3	.300	3.5	28.0
76	.275	3	.300	3.5	28.0
77	.275	3	.300	3.5	28.0
78	.275	3	.300	3.5	28.0
79	.275	3	.300	3.5	28.0
80	.275	3	.300	3.5	28.0
81	.275	3	.300	3.5	28.0
82	.300	3.5	.350	3.5	33.8
83	.300	3.5	.350	3.5	33.8
84	.300	3.5	.350	3.5	33.8
85	.300	3.5	.350	3.5	33.8
86	.300	3.5	.350	3.5	33.8
87	.300	3.5	.350	3.5	33.8

TABLE 52B. FOOTING PADS (HL-93)

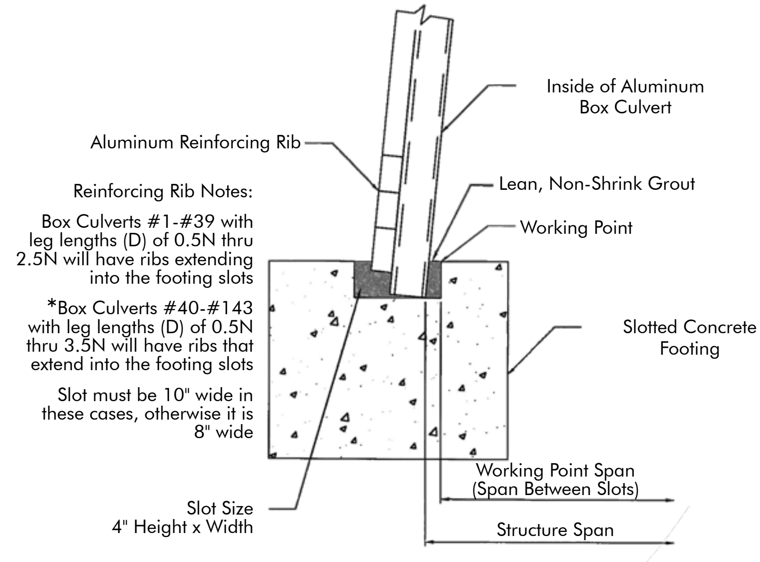
Structure No.	Total Thickness (Inches)	Plate Thickness Quantity	Plate Thickness (Inches)	Width "G" (N)	Weight/Foot (Lbs.)
88	0.500	2	0.250	4	53
89	0.500	2	0.250	4	53
90	0.500	2	0.250	4	53
91	0.500	2	0.250	4	53
92	0.500	2	0.250	4	53
93	0.500	2	0.250	4	53
94	0.500	2	0.250	4	53
95	0.500	2	0.250	4	53
96	0.500	2	0.250	4	53
97	0.500	2	0.250	4	53
98	0.500	2	0.250	4	53
99	0.500	2	0.250	4	53
100	0.500	2	0.250	4	53
101	0.600	3	0.200	6	96
102	0.600	3	0.200	6	96
103	0.600	3	0.200	6	96
104	0.600	3	0.200	6	96
105	0.600	3	0.200	6	96
106	0.600	3	0.200	6	96
107	0.600	3	0.200	6	96
108	0.600	3	0.200	6	96
109	0.600	3	0.200	6	96
110	0.600	3	0.200	6	96
111	0.600	3	0.200	6	96
112	0.600	3	0.200	6	96
113	0.600	3	0.200	6	96
114	0.600	3	0.200	6	96
115	0.600	3	0.200	6	96
116	0.600	3	0.200	6	96
117	0.600	3	0.200	6	96
118	0.600	3	0.200	6	96
119	0.600	3	0.200	6	96
120	0.600	3	0.200	6	96
121	0.600	3	0.200	6	96
122	0.900	4	0.225	6	144
123	0.900	4	0.225	6	144
124	0.900	4	0.225	6	144
125	0.900	4	0.225	6	144
126	0.900	4	0.225	6	144
127	0.900	4	0.225	6	144
128	0.900	4	0.225	6	144
129	0.900	4	0.225	6	144
130	0.900	4	0.225	6	144
131	0.900	4	0.225	6	144
132	0.900	4	0.225	6	144
133	0.900	4	0.225	6	144
134	0.900	4	0.225	6	144
135	0.900	4	0.225	6	144
136	0.900	4	0.225	6	144
137	0.900	4	0.225	6	144
138	0.900	4	0.225	6	144
139	0.900	4	0.225	6	144
140	0.900	4	0.225	6	144
141	0.900	4	0.225	6	144
142	0.900	4	0.225	6	144
143	0.900	4	0.225	6	144

Notes:

1. N=9.625". Use N as a conversion factor. For example, for Structure No. 1, Width "G" is 2 x N, or 19.25".
2. Minimum allowable soil-bearing pressure is 4,000 Lbs./Sq. Ft. for structures and details shown in this catalog. This applies specifically for width "G" below the footing pad. Other conditions can be accommodated. Contact a Contech representative for more information.
3. The maximum cover for Aluminum Box Culverts with full inverts and footing pads should not exceed 4 feet. Special full invert and footing pad designs or slotted concrete footings can accommodate maximum covers to the limits shown in Tables 48A-48B and 49A-49B.
4. Weight per foot of footing pads includes receiving channels, nuts, bolts, and plates.
5. When the thickness listed is greater than .250", the footing pads will be two or more pieces equaling the composite thickness required.
6. Footing pads must not be overlapped on adjacent structures unless appropriate design modifications are incorporated.



Aluminum Footing Pad Option



Slotted Concrete Footing Option

*See note above. For D dimension see page 70.

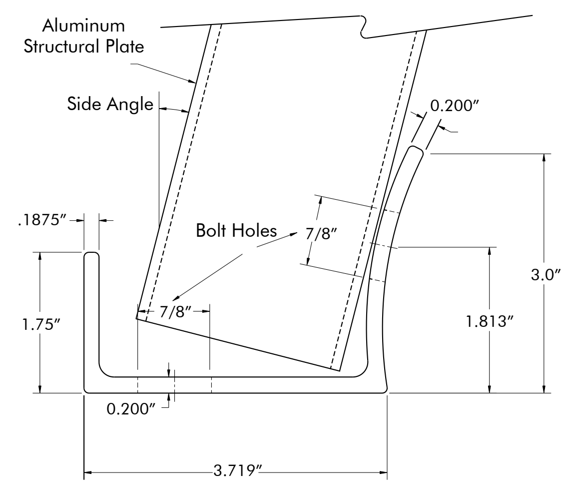
Scour Considerations

In most cases, using a full aluminum invert with toe plate extensions at the inlet and outlet ends will eliminate the potential for scour through the structure. If it is desirable to span the stream crossing, scour should be investigated. The most efficient counter measure, as listed below, should be chosen based on site specific conditions. The selected alternative should be designed by the registered professional engineer for the project.

These counter measures include:

- Rip rap protection
- Concrete paving
- Lower footings below anticipated scour depth
- Bearing foundation on competent rock
- Undercut erodible soils and replace with non-erodible material
- Construction of guide banks including sheet piling
- Implementation of permanent erosion control mats where vegetation can be established, such as Pyramat®
- Implementation of hard armor interlocking blocks where vegetation cannot be established, such as ArmorFlex® or A-Jacks®

Please contact your Contech representative for more details and design guidance.

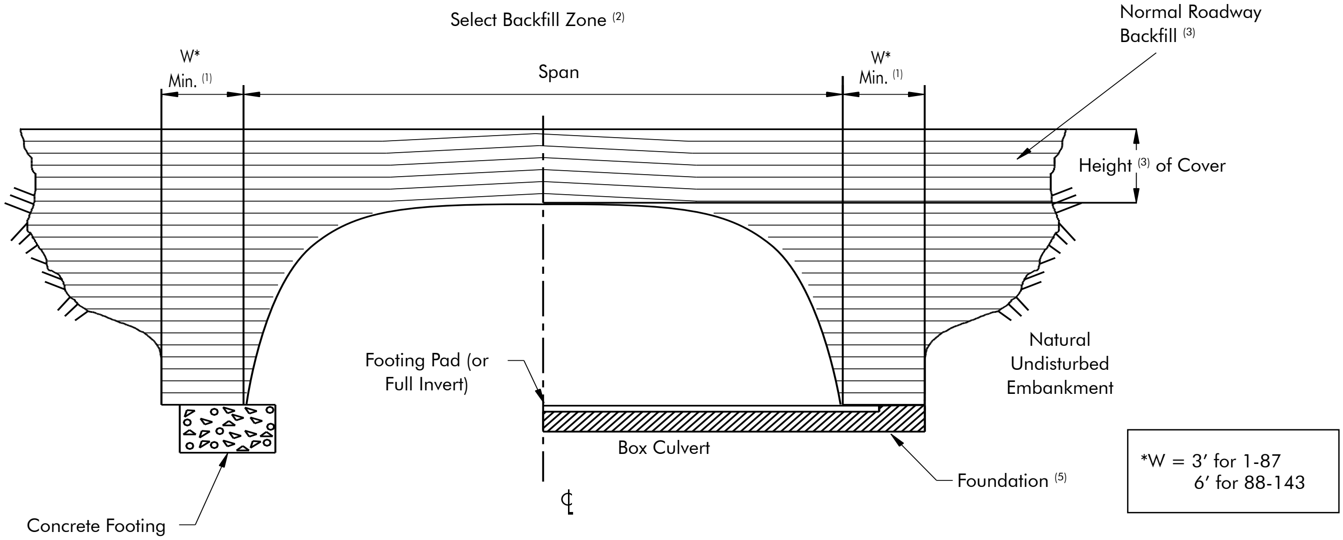


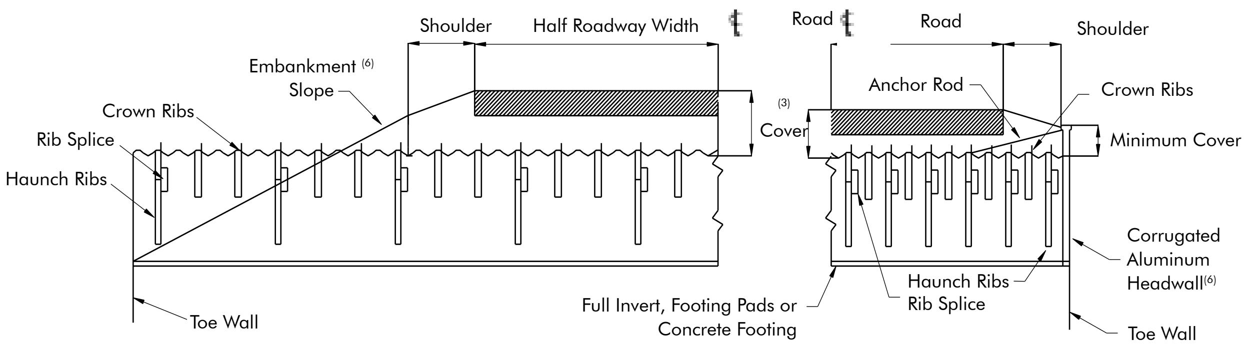
Aluminum Receiving Channel

Weight = 2 lbs per foot per side.

Aluminum Box Culvert

Typical Backfill Cross Section





Typical End Treatments

Notes:

1. If W is less than the required width, a concrete grout material may be required as backfill.
2. Backfill to be well graded granular, A-1, A-2-4, A-2-5, or A-3 for box culverts #1 through #87. For box culverts #88 through #143, A-1, A-2-4, A-2-5 backfill material should be used, per AASHTO M 145, placed in six- to eight-inch lifts symmetrically on each side compacted to minimum 90% density per AASHTO T 180. D4 dozer or smaller to operate near and above structure during backfilling to finish grade. Refer to AASHTO Sec. 26 installation specification.
3. Fill in these zones, must be placed in 8" maximum lifts and compacted to minimum 90% density per AASHTO T 180.
4. Minimum cover may need to be increased to handle temporary construction vehicle loads (larger than D4) but not to exceed maximum allowable cover for the specific box culvert design.
5. When using a full invert or footing pads, the foundation shall have a minimum of 4,000 psf bearing capacity and include a 6" stable well graded granular bed. Lower bearing capacities can be accommodated through special design or the use of concrete footings.
6. Standard aluminum headwalls shown are for vertical orientation only.
7. The type and extent of end treatment on the box culvert should be chosen and designed so as to prevent the loss of backfill due to high flow conditions.
8. Bolt torque requirements - plate lap must be properly mated in a tangent fashion using proper alignment techniques and adequate bolt torque to seat the corrugation. The recommended installation bolt torque for Aluminum Box Culverts is 90 –115 ft-lbs for full inverts and 115 –135 ft-lbs for all other components.
9. For assembly information, see the manufacturer's detailed assembly drawings and instructions.

Aluminum Box Culvert Specification

Scope

This specification covers the manufacture and installation of the aluminum box culvert structure detailed in the plans.

Material

The aluminum box culvert shall consist of plates, ribs, and appurtenant items as shown on the plans and shall conform to the requirements of ASTM B864 and AASHTO M 219. Plate thicknesses, rib spacings, end treatment, and type of invert and foundation shall be as indicated on the plans.

Bolts and nuts shall conform to the requirements of ASTM A307 or ASTM A449 and shall be galvanized in accordance with ASTM A153.

Assembly

The box culvert shall be assembled in accordance with the shop drawings provided by the manufacturer and per the manufacturer's recommendations. Bolts shall be tightened using an applied torque between 90 and 135 ft-lbs depending on the location of the bolts in the structure.

Installation

The box culvert shall be installed in accordance with the plans and specifications, the manufacturer's recommendations and the AASHTO Standard Specification for Highway Bridges, Section 26 (Division II).

Bedding

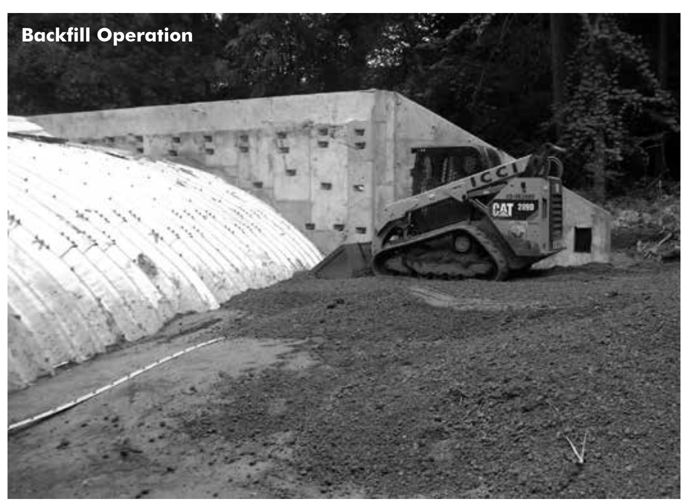
The bedding should be constructed to a uniform line and grade using material outlined in the backfill section. The foundation must be capable of providing a bearing capacity of at least two tons per square foot.

Backfill

The structure shall be backfilled using clean, well graded granular material that meets the requirements of AASHTO M 145 for soil classifications. A-1, A-2-4, A-2-5, or A-3 for box culverts #1 through #87. For box culverts #88 through #143, A-1, A-2-4, A-2-5 backfill material should be used. Backfill must be placed symmetrically on each side of the structure in 8-inch uncompacted lifts. Each lift shall be compacted to a minimum of 90 percent density per AASHTO T 180.


Assembly


Lifting


Backfill Operation

SUPER-SPAN™ and SUPER-PLATE®

Over 4000 SUPER-SPANS in Place

Since 1967, more than 4,000 structures have been built on five continents. That makes SUPER-SPAN the most widely accepted, long-span, corrugated steel design in the world.

SUPER-SPAN structures with individual spans up to 40 feet are serving as bridges, railroad overpasses, stream enclosures, vehicular tunnels, culverts, and conveyor conduits. Installations have involved almost every job condition possible, including severe weather and unusual construction time constraints.

National Specifications

SUPER-SPAN's popularity has resulted in a national specification written for long-span, corrugated metal structures by the American Association of State Highway and Transportation Officials. AASHTO Standard Specifications (Section 12.7) and AASHTO LRFD Bridge Design Specifications (Sec. 12) for Highway Bridges provide for the selection of acceptable combinations of plate thickness, minimum cover requirements, plate radius and other design factors. Material is covered by AASHTO M 167 AND ASTM A761. Installation is covered by AASHTO Standard Specification for Highway Bridges (Sec. 12 and 26), AASHTO LRFD Bridge Design Specifications (Sec. 12) and Construction Specifications (Sec. 26) and ASTM A807/A789.

Acceptance

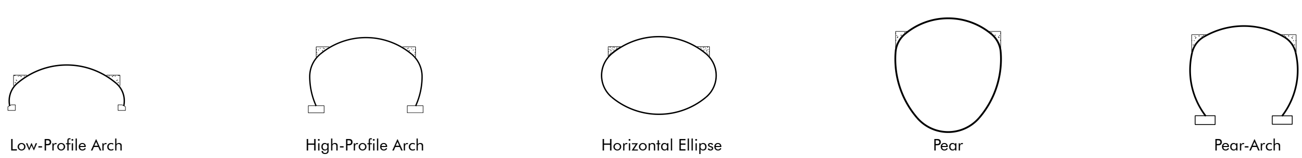
Many state and federal agencies recognize the excellent performance and economy of SUPER-SPAN corrugated structures. In a 1979 memorandum, the chief of FHWA's Bridge Division noted that in the previous 15 years, several hundred Contech SUPER-SPAN Culverts had been erected in the United States and Canada and their performance had been excellent.

In a 1983 report to the Secretary of Transportation, the General Accounting Office stated, *"Some innovations, such as using certain long-span culverts rather than building conventional bridges, have substantially lowered bridge costs."*

Aluminum Long-Span Structures (SUPER-PLATE)

SUPER-PLATE structures add both longitudinal stiffeners (thrust beams) and circumferential stiffeners (reinforcing ribs) to conventional Aluminum Structural Plate to achieve larger sizes. Clear spans in excess of 30 feet and clear areas over 435 square feet are achievable with SUPER-PLATE. Available shapes include low-profile and high-profile arch (as seen below) and horizontal ellipse. Contact your local a Contech representative for additional information.

High-profile arch SUPER-SPAN in Puerto Rico to span a wetland and to provide a wildlife crossing



Standard Shapes

General design and installation characteristics

As conventional round structures increase in diameter beyond 16-18 feet, they become more flexible which requires more attention during the installation. It becomes increasingly difficult to both control the shape and to achieve good backfill support. Contech's SUPER-SPAN and SUPER-PLATE help overcome these problems through the use of both special shapes and concrete thrust beams.

SUPER-SPAN/SUPER-PLATE Solves the Problem

The horizontal ellipse, low-profile and high-profile arch shapes are wide-span, reduced-rise structures. They provide large open areas with less rise than comparable circular shapes. Sidewalls are compact with a modest radius to provide a more rigid pipe wall to compact against. At the same time, the large radius top arc of these structures is flatter and, therefore, has less tendency to peak as it supports the sides (see Figure 9).

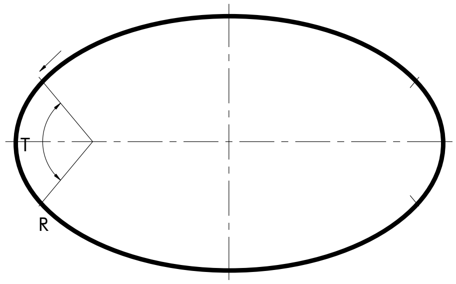


Figure 9

By contrast, Pear and Pear-Arch shapes provide relatively high-rise structures. These shapes orient their sides at the derivable angle to the soil pressures (see Figure 10). Their smaller radius crowns are typically heavy gage to provide the necessary restraint at the top.

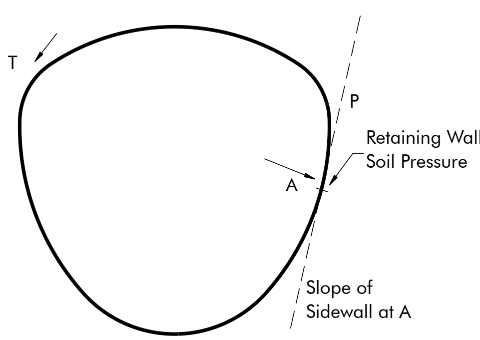
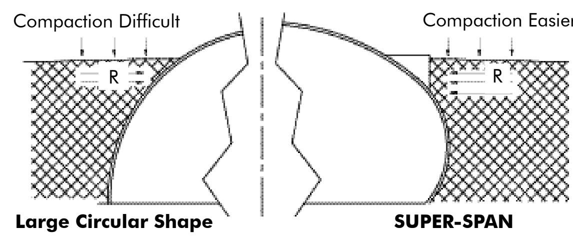


Figure 10

The thrust beam is the key element to SUPER-SPAN and SUPER-PLATE success. Besides providing perfect backfill in the important area above the spring line, it acts as a floating footing for the critical large radius top arch of the structure. It fixes the end of the arch, stiffening it and reducing deflection as backfill goes over the top.

The thrust beam also provides a solid vertical surface that is easy to backfill against to obtain excellent compaction*. After installation, the beam effectively controls possible horizontal spreading of the top arch.

Thrust Beam Function



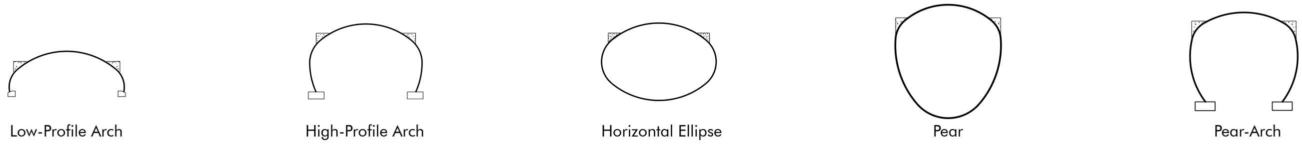
With the shape on the left, it is difficult to obtain adequate compaction of the backfill at the critical 3/4 rise point.

Compare it to the SUPER-SPAN on the right. Excellent compaction* and a high restraining force (R) is readily obtained against the vertical surface of the thrust beam. Force (R) acts on the vertical surface to prevent significant horizontal movement on the pipe wall at the 3/4 rise point under dead and live loads.

*See Backfilling and Backfill material on page 84.

SUPER-SPAN and SUPER-PLATE structures, by means of their shape and thrust beams (which reduce the central angle of the effective top arch to 80 degrees) have added stability against deflection and snap-through buckling. They can be economically designed and installed within recognized AASHTO /AISI critical stresses and seam strength limits.

Horizontal reinforcement bars are tied to Contech bent and threaded rods to provide reinforcement for the concrete thrust beam



Standard Shapes

Structural Design

TABLE 53 MINIMUM THICKNESS — MININUM COVER TABLE, FT. H-20, HS-20, H-25, HS-25 LIVE LOAD						
	Wall Thickness, Inches					
Top Radius	**0.111**	**0.140**	**0.170 or 0.188**	**0.218**	**0.249**	**0.280**
R_T Ft.	**(12 Ga.)**	**(10 Ga.)**	**(8 or 7 Ga.)**	**(5 Ga.)**	**(3 Ga.)**	**(1 Ga.)**
15′	2.5′	2.5′	2.5′	2.0′	2.0′	2.0′
15′-17′		3.0′	3.0′	2.5′	2.0′	2.0′
17′-20′			3.0′	2.5′	2.5′	2.5′
20′-23′				3.0′	3.0′	3.0′
23′-25′					4.0′	4.0′

Notes:
1. Designs listed are for steel 6″ x 2″ corrugation only. For aluminum 9″ x $2^1/_2$″ corrugation design, please contact your local Contech representative.
2. Heights of cover for highway live loads given are to top of concrete pavement or bottom of flexible pavement.
3. Minimum covers for E 80 live loads are approximately twice those for HS-20. However, E 80 minimums must be established for individual applications.
4. Minimum covers for construction loads and similar heavy wheel loads must be established for individual applications.
5. The table assumes a granular backfill over the crown of the structure to the full minimum cover depth (height) compacted to not less than 90 percent AASHTO T 180 density.
6. Pear and Pear-Arch shape gages are determined on an "as-needed" basis.

A SUPER-SPAN or SUPER-PLATE structure is essentially an engineering combination of steel and soil. Maximum fill heights are calculated on the basis of AASHTO/AISI design methods using top radius to calculate ring compression (thrust=pressure x R_T) with allowable wall stress of 16,500 psi. In the design method, AISI requires a seam strength safety factor of two, while AASHTO requires a seam strength safety factor of three.

In accordance with AASHTO, buckling and flexibility factors are not calculated. These factors are covered by the minimum thickness/minimum cover table on this page and special geometry limitations spelled out by AASHTO.

Shallow Fill

Minimum designs are shown in Table 53. Ordinarily, shallow cover structures will be at the minimum (shown in the tables) thickness required for installation and to prevent against buckling. Wall stresses can be checked in deep cover applications by adding the soil load to the appropriate live load.

When adding the total live load over the structure, it is necessary to distribute it over an appropriate area of the structure which varies with the fill height.

Special Designs

Structure sizes shown in Tables 54 through 60 are standard shapes. Intermediate or larger sizes are available. These special sizes also are designed in accordance with the AASHTO design method.

Minimum covers shown in Table 53 are based on standard construction. Somewhat lower covers are possible with special measures such as using concrete relieving slabs. Special designs are also available for fill heights exceeding the normal limitations of standard structures. Contact your local Contech representative for additional information on special requirements.

Foundation

The foundation under the structure and sidefill zones must be evaluated by the design engineer to ensure adequate bearing capacity. Differential settlement between the structure and side fill must be minimal.

Hydraulic Design

The most commonly used SUPER-SPAN and SUPER-PLATE hydraulic shapes are the horizontal ellipse, the low-profile arch, and the high-profile arch. Hydraulic data for these shapes are presented in tabular and graphical form in the current edition of the NCSPA CSP Design Manual. Standard procedures are presented in the Hydraulics chapter of the design manual to determine the headwater depth required for a given flow through these structures under both inlet and outlet control conditions.

In addition, the hydraulic design series of publications from FHWA offers guidance regarding hydraulic capacity of these structures.

Installation Precautions

During the installation and prior to the construction of permanent erosion control and end-treatment protection, special precautions may be necessary. The structure must be protected from unbalanced loads and from any structural loads or hydraulic forces that might bend or distort the unsupported ends of the structure. Base channels for arches must be square to the centerline on arch structures. Erosion wash out of previously placed soil support must be prevented to ensure that the structure maintains its load capacity.

Contech SUPER-SPAN structures have proven both practical and economical to construct in a wide range of applications and conditions. Nevertheless, there are basic rules of installation that must be obeyed to ensure acceptable performance.

Comprehensive installation and inspection standards are furnished with every SUPER-SPAN installation. These documents should be studied thoroughly by the contractor and engineer prior to beginning construction. The following material highlights the key elements involved in the proper construction of a Contech SUPER-SPAN.

Foundation and Bedding

There must be adequate distance between the SUPER-SPAN and questionable in-situ soils. Proper bedding preparation is critical to both structure performance and service life. The bedding should be constructed to a uniform line and grade to avoid distortions that may create undesirable stresses in the structure and/or rapid deterioration of the roadway. It should be free of rock formations, protruding stones, and frozen matter that may cause unequal settlement.

It is recommended that the bedding be a relatively loose granular material that is roughly shaped to fit the bottom of the structure, be a minimum of twice the corrugation depth in thickness and have a maximum particle size of one half the corrugation depth.

It should be noted that the bedding depth can vary based on the amount of cover and the shape of the structure's invert. The bedding should be shaped to match structures with flatter inverts.

Assembly

Plates can be placed either one at a time or in preassembled units of two or more plates in a ring.

All bolts in a newly hung plate or assembly should be tightened before adding the next unit above it. This should be done only with the plates in proper relation to each other for correct curvature and alignment in the structure. It may be necessary to use cables, props, or jigs to keep the plates in position during tightening.

The structure cross-section must be checked regularly during assembly. Its shape must be symmetrical, with the plates forming smooth, continuous curves. Longitudinal seams should be tight and plate ends should be parallel to each other.

Backfilling

SUPER-SPANs are flexible structures, therefore care is required during the placement and compaction of backfill. An effective system to monitor the structure during the backfilling process must be established.

Select an approved structure backfill material for the zone around the SUPER-SPAN. Establish soil density curves and determine proper frequencies and procedures for testing. The equipment used to place and compact fill around and over the structure should be selected based on the quality of the backfill and the shape of the SUPER-SPAN. Such plans should be verified in the initial backfilling stages. Compaction needs to be achieved under the haunches by carefully tamping a granular or select material.

Use only backfilling methods and equipment that obtain specified density without excessive movement or deformation of the structure.

Backfill Material

Contech's specification for backfill material contains the following as listed in the AASHTO Bridge Specification:

1. Granular type soils shall be used as structure backfill (the envelope next to the metal structure). Well graded sand and gravel that is sharp, rough, and angular is preferred.
2. Approved stabilized soil shall be used only under direct supervision of a competent, experienced soils engineer. Plastic or cohesive soils should not be used.
3. The structure backfill material shall conform to one of the following soil classifications from AASHTO Specification M 145, Table 62 . Structure backfill shall be placed and compacted to not less than 90 percent density, per AASHTO T 180.
4. The extent of the select structural backfill outside the maximum span is dependent on the quality of the adjacent embankment, loading and shape of the structure. It may be necessary to excavate native soil at the sides to provide an adequate width needed for compaction. For ordinary installations with a good quality, well-compacted embankment or in situ soil adjacent to the structure backfill, a minimum width of structural backfill six feet beyond the structure is usually required. The engineer must evaluate the in situ conditions to ensure adequate bearing capacity. The structure backfill shall extend to the minimum cover elevation (Table 53—page 83) above the structure.

Monitoring Backfill

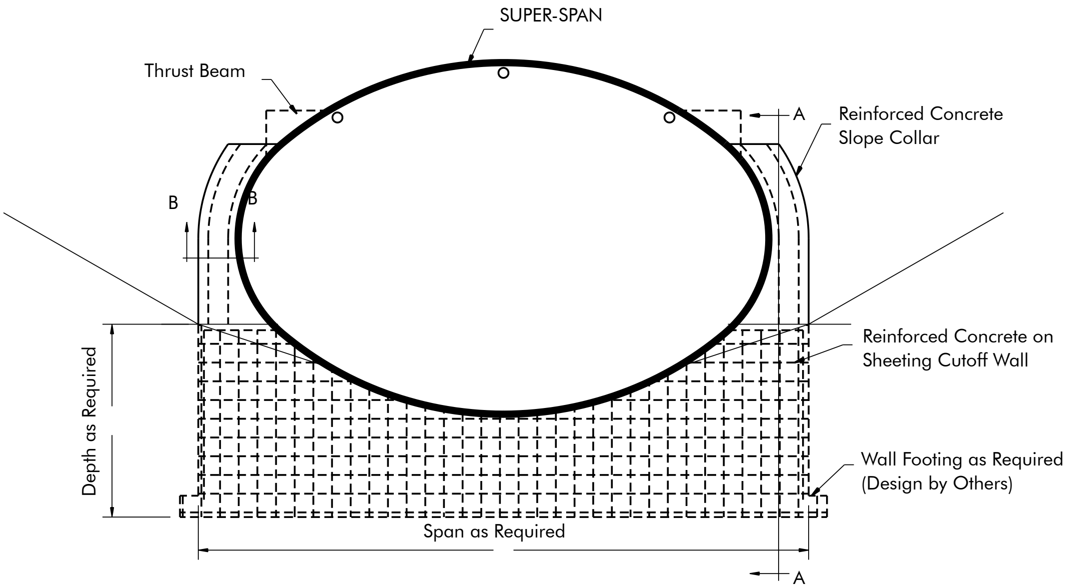
Regular monitoring is required during backfilling to ensure a structure with a proper shape and that compaction levels are achieved. A Shape Control Technician will confirm the structure's shape before backfilling, then monitor the shape and verify compaction readings until the backfill reaches the minimum cover level.

Special Requirements

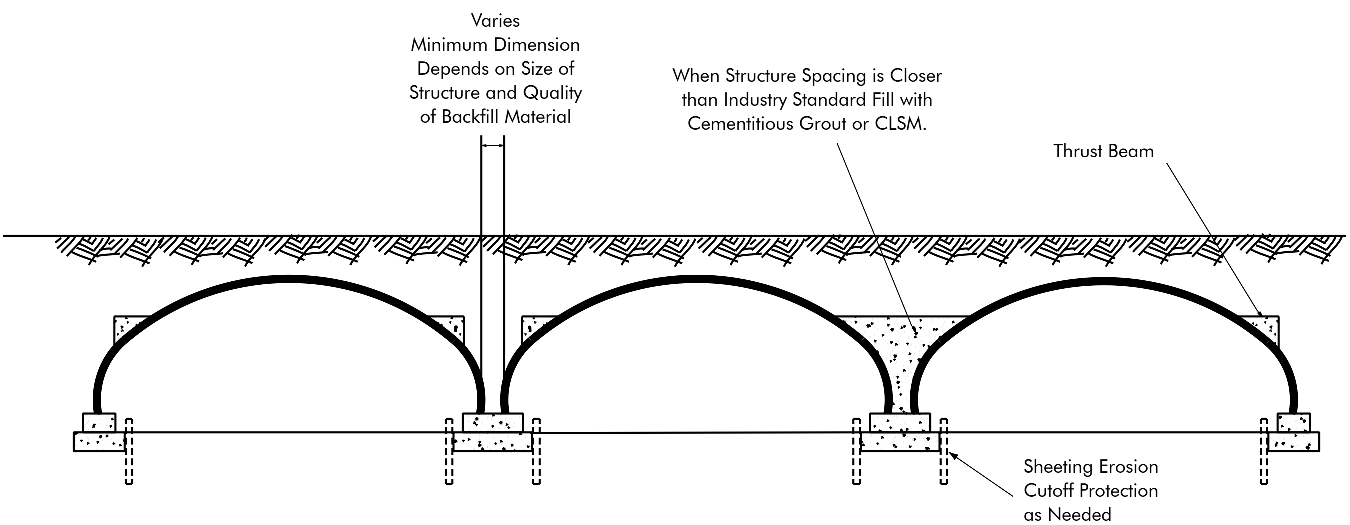
Very large or high structures sometimes call for additional special provisions for shape control during backfilling.

The minimum stiffness requirements for some structures shown in Table 53 on Page 83 may need to be augmented by increased design stiffness or mandatory top loading. Top loading requires the placement of a modest blanket of soil on the crown when backfill is approximately at the springline height.

Conceptual Drawings



End Elevation Typical Step-Beveled End with Cutoff Wall and Slope Collar



Typical Multiple Span Low Profile Arches

Notes:
1. Many of the details shown are conceptual. The designer should work with the Contech representative on each particular application.
2. Sections A-A and B-B are located on page 92.

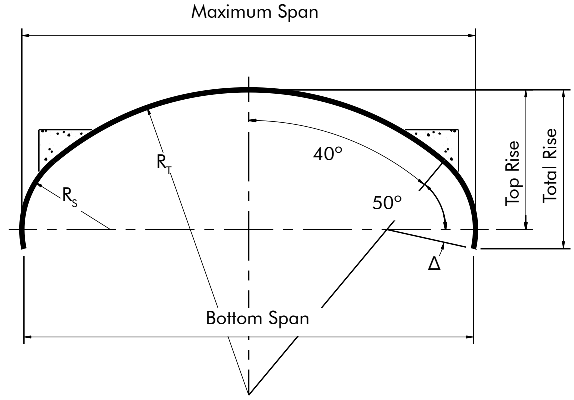
Galvanized Steel 6" x 2" Corrugation

SUPER-SPAN

TABLE 54. TYPICAL LOW PROFILE ARCH SHAPES
(ALL DIMENSIONS TO INSIDE CRESTS)

Structure Number	Maximum Span Ft.-In.	Bottom Span Ft.-In.	Total Rise Ft.-In.	Top Rise Ft.-In.	Top Radius R_T Ft.-In.	Side Radius R_S Ft.-In.	Angle Below Horizontal Δ	Approx. Area Sq. Ft.	Shape Factor R_T/R_S
69A15	19-5	19-2	6-9	5-10	13-1	3-7	15°-36′	105	3.60
69A18	20-1	19-10	7-6	6-6	13-1	4-6	12°-28′	120	2.91
75A18	21-6	21-4	7-9	6-9	14-3	4-6	12°-28′	133	3.13
78A18	22-3	22-1	7-11	6-11	14-10	4-6	12°-28′	140	3.25
81A18	23-0	22-9	8-0	7-1	15-5	4-6	12°-28′	147	3.38
84A18	23-9	23-6	8-2	7-2	16-0	4-6	12°-28′	154	3.50
87A18	24-6	24-3	8-3	7-4	16-6	4-6	12°-28′	161	3.63
90A18	25-2	25-0	8-5	7-5	17-1	4-6	12°-28′	168	3.75
93A18	25-11	25-9	8-7	7-7	17-8	4-6	12°-28′	176	3.88
93A24	27-3	27-1	10-0	9-0	17-8	6-4	8°-55′	217	2.77
99A21	28-1	27-11	9-6	8-7	1810	5-5	10°-24′	212	3.48
99A24	28-9	28-7	10-3	9-3	18-10	6-4	8°-55′	234	2.95
102A21	28-10	28-8	9-8	8-8	19-5	5-5	10°-24′	220	3.54
108A21	30-3	30-1	9-11	8-11	20-7	5-5	10°-24′	237	3.76
108A24	30-11	30-9	10-8	9-8	20-7	6-4	8°-55′	261	3.22
108A30	31-7	31-2	12-1	10-4	20-7	7-3	14°-03′	309	2.82
111A21	31-0	30-10	10-1	9-1	21-1	5-5	10°-24′	246	3.85
111A30	32-4	31-11	12-3	10-6	21-1	7-3	14°-03′	319	2.89
114A21	31-9	31-7	10-2	9-3	21-8	5-5	10°-24′	255	3.96
114A30	33-1	32-8	12-5	10-8	21-8	7-3	14°-03′	330	2.97
117A24	33-2	33-0	11-0	10-1	22-3	6-4	8°-55′	289	3.49
117A33	34-5	34-1	13-3	11-6	22-3	8-2	12°-29′	367	2.71
123A24	34-7	34-6	11-4	10-4	23-5	6-4	8°-55′	308	3.67
123A42	37-11	37-7	15-7	13-10	23-5	10-11	9°-22′	477	2.14
126A24	35-4	35-2	11-5	10-6	24-0	6-4	8°-55′	318	3.76
126A42	38-8	38-4	15-9	14-0	24-0	10-11	9°-22′	490	2.28
129A30	37-10	37-9	12-11	12-5	24-7	8-9	3°-10′	383	2.81
129A36	39-4	39-4	14-4	14-1	24-7	10-10	1°-25′	441	2.27
*138A30	*39-8	39-7	13-5	12-6	26-3	8-3	6°-22′	418	3.18
*138A39	*42-3	42-3	15-5	15-3	26-3	11-11	0°-36′	510	2.20
*144A51	*45-0	44-9	18-8	16-11	27-5	13-8	7°-30′	675	2.00

Notes:
Other sizes are available for special designs.
* Structures require ring beams on the crown plates per AASHTO Section 12.



Low Profile Arch

SUPER-SPAN/SUPER-PLATE

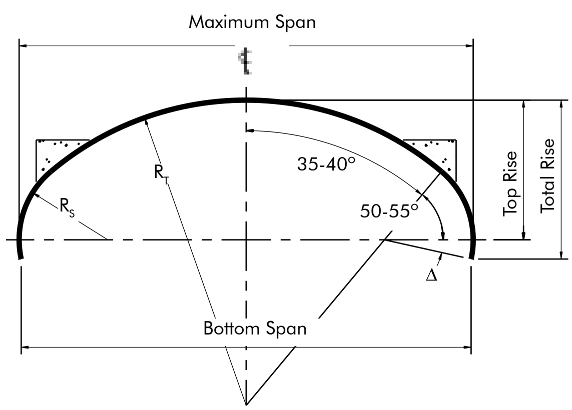
Galvanized Steel 6” x 2” Corrugation

SUPER-SPAN

TABLE 55. SPECIAL LOW-RISE SHAPES
(ALL DIMENSIONS TO INSIDE CRESTS)

Structure Number	Maximum Span	Bottom Span	Total Rise	Top Rise	Top Radius R_T	Side Radius R_S	Angle Below Horizontal	Approx. Area	Shape Factor
	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.	Ft.-In.	Δ	Sq. Ft.	R_T/R_S
69A15-NS	20-8	20-8	6-3	6-1.5	14-10	4-2	1°-56′	99	3.56
78A15-NS	22-8	22-8	6-6	6-3.5	16-8	3-11	5°-43′	112	4.26
84A15-NS	24-5	24-5	6-10	6-9	18-0	4-2	2°-05′	127	4.32
87A15-S	24-6	24-6	7-6	7-4.5	16-6	4-7	1°-32′	139	3.61
93A15-S	26-0	26-0	7-9	7-7.5	17-8	4-7	1°-32′	153	3.86
99A15-S	27-6	27-6	8-0	7-11	18-10	4-7	1°-32′	166	4.11
108A15-S	29-9	29-9	8-5	8-4	20-7	4-8	0°-38′	190	4.4
105A21-NS	30-10	30-10	8-10	8-7	22-9	5-5	5°-32′	207	4.2
111A18-S	31-1	31-1	9-3	9-1.5	21-1	5-6	1°-17′	218	3.84
117A18-S	32-7	32-7	9-6	9-5	22-3	5-6	1°-17′	235	4.05
123A18-S	34-0	34-0	9-9	9-8	23-5	5-6	1°-17′	255	4.26
129A18-S	35-7	35-7	10-1	10-0	24-7	5-7	0°-32′	271	4.4
129A21S	36-2	36-2	10-9	10-8	24-7	6-5	1°-07′	296	3.83

Notes:
1. Due to their high shape factor, cover heights are generally limited to 8' or less. Backfill material typically must meet AASHTO M 145 requirements for A-1 materials or consist of cementitious grout, CLSM, or cement stabilized sand. Other backfill materials may be acceptable, depending upon the structure selected and the actual cover height.
2. Other sizes are available for special designs.



Special Low Profile Arch

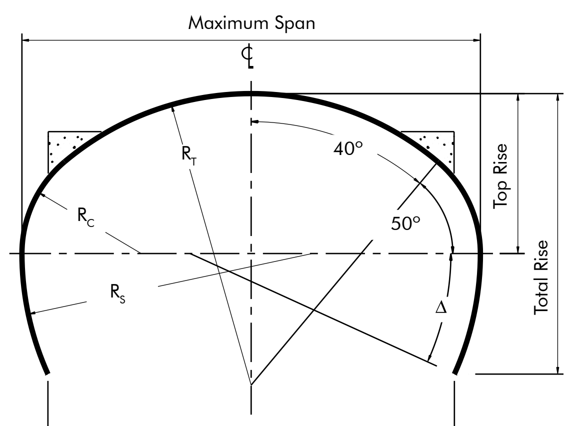
Galvanized Steel 6” x 2” Corrugation

SUPER-SPAN

TABLE 57. TYPICAL HIGH PROFILE ARCH SHAPES
(ALL DIMENSIONS TO INSIDE CRESTS)

Structure Number	Maximum Span Ft.-In.	Bottom Span Ft.-In.	Total Rise Ft.-In.	Top Rise Ft.-In.	Top Radius R_T Ft.-In.	Upper Side Radius R_C in.-Ft.	Lower Side Radius R_S	Angle Below Horizontal Δ	Approx. Area Sq. Ft.	Shape Factor R_T/R_C
69A15-9	20-1	19-6	9-1	6-6	13-1	4-6	13-1	11°-18′	152	2.91
69A18-18	208	18-10	12-1	7-3	13-1	5-5	13-1	21°-44′	214	2.42
75A15-18	21-6	19-10	11-8	6-9	14-3	4-6	14-3	20°-0′	215	3.16
75A21-24	22-10	1910	14-6	8-2	14-3	6-4	14-3	26°-24′	284	2.25
78A15-18	22-3	20-7	11-9	6-11	14-10	4-6	14-10	19°-13′	224	3.27
78A18-15	22-11	21-9	11-9	7-8	14-10	5-5	14-10	16°-09′	228	2.73
78A18-24	22-11	20-1	14-0	7-7	14-10	5-5	14-10	25°-23′	275	2.73
81A15-18	23-0	21-5	11-11	7-1	15-5	4-6	15-5	18°-31′	234	3.42
81A18-15	23-8	22-6	11-10	7-9	15-5	5-5	15-5	15°-33′	238	2.84
81A21-24	24-4	21-7	14-10	8-5	15-5	6-4	15-5	24°-26′	309	2.43
84A15-18	23-9	22-2	12-1	7-2	16-0	4-6	16-0	17°-51′	244	3.55
84A18-15	24-5	23-4	12-0	7-11	16-0	5-5	16-0	14°-57′	248	2.95
87A15-24	24-6	21-11	13-8	7-4	16-6	4-6	16-6	22°-45′	288	3.67
87A21-15	25-9	24-9	12-10	8-9	16-6	6-4	16-6	14°-29′	280	2.61
87A21-24	25-9	23-2	15-1	8-9	16-6	6-4	16-6	22°-45′	334	2.61
90A15-21	25-2	23-3	13-1	7-5	17-1	4-6	17-1	19°-20′	283	3.80
90A21-15	26-6	25-6	13-0	8-10	17-1	6-4	17-1	13°-59′	290	2.70
90A21-24	26-6	24-0	15-3	8-10	17-1	6-4	17-1	22°-0′	347	2.70
93A15-21	25-11	24-1	13-3	7-7	17-8	4-6	17-8	18°-42′	294	3.93
93A21-15	27-3	26-3	13-2	9-0	17-8	6-4	17-8	13°-32′	301	2.79
93A21-24	27-3	24-10	15-5	9-0	17-8	6-4	17-8	21°-17′	360	2.79
99A15-21	27-5	25-8	13-6	7-10	18-10	4-6	18-10	17°-34′	317	4.18
99A21-15	28-9	27-10	13-5	9-3	18-10	6-4	18-10	12°-43′	323	2.97
99A24-24	29-5	27-1	16-5	9-11	18-10	7-3	18-10	20°-0′	412	2.60

Notes:
Other sizes are available for special designs.



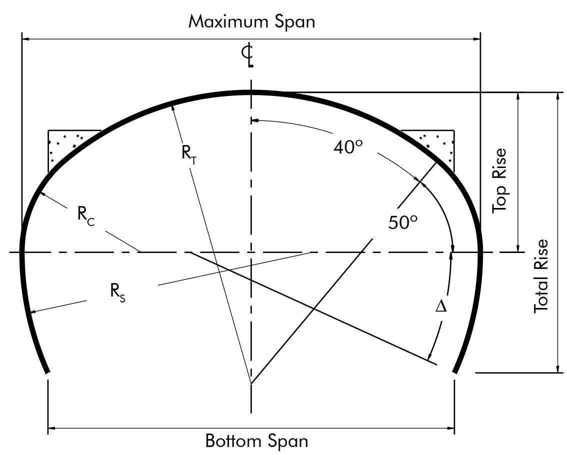
High Profile Arch

Galvanized Steel 6" x 2" Corrugation

SUPER-SPAN

TABLE 57. TYPICAL HIGH PROFILE ARCH SHAPES (ALL DIMENSIONS TO INSIDE CRESTS)										
Structure Number	Maximum Span Ft.-In.	Bottom Span Ft.-In.	Total Rise Ft.-In.	Top Rise Ft.-In.	Top Radius R_T Ft.-In.	Upper Side Radius R_C Ft.-In.	Lower Side Radius R_S Ft.-In.	Angle Below Horizontal Δ	Approx. Area Sq. Ft.	Shape Factor R_T/R_C
102A15-24	28-2	25-11	14-5	8-0	19-5	4-6	19-5	19°-24′	348	4.25
102A24-15	30-1	29-3	14-3	10-1	19-5	7-3	19-5	12°-21′	360	2.68
102A24-30	30-1	26-9	18-0	10-1	19-5	7-3	19-5	24°-07′	466	2.66
108A18-24	30-3	28-2	15-5	8-11	20-7	5-5	20-7	18°-20′	399	3.75
108A24-18	31-7	30-5	15-3	10-4	20-7	7-3	20-7	13°-51′	407	2.83
108A24-30	31-7	28-5	18-4	10-4	20-7	7-3	20-7	22°-46′	496	2.82
111A18-24	31-0	29-0	15-7	9-1	21-1	5-5	21-1	17°-50′	412	3.85
111A21-30	31-8	28-7	17-9	9-10	21-1	6-4	21-1	22°-09′	483	3.31
111A24-18	32-4	31-2	15-5	10-6	21-1	7-3	21-1	13°-31′	420	2.91
114A18-30	31-9	28-9	17-2	9-3	21-8	5-5	21-8	21°-34′	469	3.96
114A30-18	34-4	33-3	17-0	12-0	21-8	9-1	21-8	13°-09′	490	2.39
117A18-30	32-6	29-6	17-4	9-4	22-3	5-5	22-3	21°-01′	484	4.06
117A30-18	35-1	34-0	17-1	12-2	22-3	9-1	22-3	12°-49′	504	2.45
123A18-30	34-0	31-2	17-8	9-8	23-5	5-5	23-5	20°-0′	513	4.27
123A30-18	36-7	35-6	17-5	12-5	23-5	9-1	23-5	12°-11′	533	2.58
126A18-30	34-8	31-11	17-9	9-9	24-0	5-5	24-0	19°-31′	528	4.38
126A30-18	37-4	36-3	17-6	12-7	24-0	9-1	24-0	11°-54′	547	2.64

Notes:
Other sizes are available for special designs.



High Profile Arch

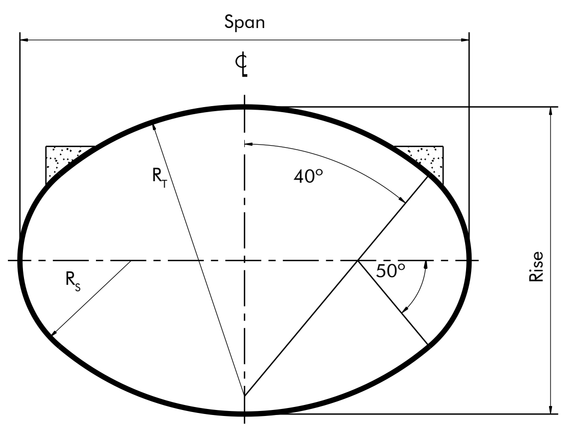
Galvanized Steel 6" x 2" Corrugation

SUPER-SPAN

TABLE 58 TYPICAL HORIZONTAL ELLIPSE SHAPES
(ALL DIMENSIONS TO INSIDE CRESTS)

Structure Number	Maximum Span Ft.-In.	Total Rise Ft.-In.	Top Radius R_T Ft.-In.	Side Radius R_S Ft.-In.	Approx. Area Sq. Ft.	Shape Factor R_T R_S
66E30	19-4	12-9	12-6	4-6	191	2.78
69E30	20-1	13-0	13-1	4-6	202	2.91
72E24	20-2	11-11	13-8	3-7	183	3.81
75E24	20-10	12-2	14-3	3-7	194	3.97
69E39	21-0	15-2	13-1	5-11	248	2.23
78E27	21-11	13-1	14-10	4-1	221	3.66
75E39	22-6	15-8	14-3	5-11	274	2.42
81E30	23-0	14-1	15-5	4-6	249	3.42
78E39	23-3	15-11	14-10	5-11	288	2.52
81E42	24-4	16-11	15-5	6-4	320	2.43
87E30	24-6	14-8	16-6	4-6	274	3.67
90E30	25-2	14-11	17-1	4-6	287	3.80
87E39	25-5	16-9	16-6	5-11	330	2.81
87E45	26-1	18-2	16-6	6-10	369	2.43
93E33	26-3	15-10	17-8	5-0	320	3.57
96E33	27-0	16-2	18-3	5-0	334	3.68
90E48	27-2	19-1	17-1	7-3	405	2.36
93E48	27-11	19-5	17-8	7-3	421	2.44
99E36	28-1	17-1	18-10	5-5	369	3.47
102E36	28-10	17-5	19-5	5-5	384	3.58
99E48	29-5	19-11	18-10	7-3	455	2.60
102E48	30-1	20-2	19-5	7-3	472	2.68
108E36	30-3	17-11	20-7	5-5	415	3.79
105E51	31-2	21-2	20-0	7-9	513	2.59
111E39	31-4	18-11	21-1	5-11	454	3.59
114E39	32-1	19-2	21-8	5-11	471	3.69
108E54	32-3	22-2	20-7	8-2	555	2.52
111E54	33-0	22-5	21-1	8-2	574	2.59
117E42	33-2	20-1	22-3	6-4	512	3.51
114E57	34-1	23-4	21-8	8-8	619	2.51
123E42	34-7	20-8	23-5	6-4	548	3.70
123E45	34-11	21-4	23-5	6-10	574	3.45
126E48	36-0	22-4	24-0	7-3	619	3.31

Notes:
Other sizes are available for special designs.



Horizontal Ellipse

Galvanized Steel 6" x 2" Corrugation

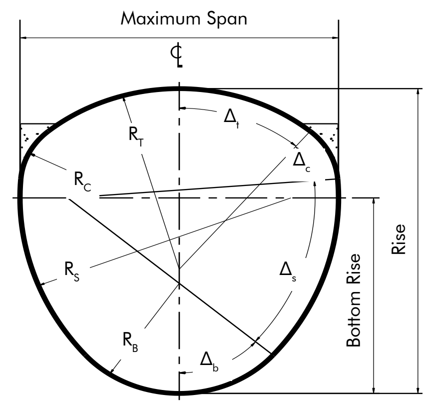
SUPER-SPAN

TABLE 59. TYPICAL PEAR SHAPES (ALL DIMENSIONS TO INSIDE CRESTS)

Structure Number	Maximum Span Ft-In.	Total Rise Ft.-In.	Bottom Rise Ft.-In.	Top Radius R_T Ft.In.	Δ_t	Corner Radius R_C	Δ_c	Side Radius R_S	Δ_s	Bottom Radius Ft.-In.	Δ_b	Approx. Area Sq. Ft.
75P15-72-45	23-8	25-5	14-10	14-11	38°-25′	6-1	37°-10′	16-6	66°-23′	9-0	38°-02′	477
66P21-66-60	24-0	25-10	15-1	16-2	31°-02′	7-0	45°-18′	17-4	57°-49′	9-11	45°-51′	497
81P21-60-63	25-2	26-1	16-1	15-10	38°-16′	6-11	45°-50′	18-9	48°-38′	10-3	46°-39′	517
81P15-75-54	24-10	27-8	16-9	15-11	38°-41′	5-9	39°-17′	19-9	57°-45′	9-3	44°-17′	544
*84P15-90-36	26-7	28-4	18-1	20-11	30°-34′	4-9	47°-25′	20-2	67°-46′	7-11	34°-15′	593
90P18-78-48	27-6	27-8	18-0	19-11	34°-22′	5-6	49°-16′	20-3	58°-32′	9-7	37°-00′	596
81P24-66-75	28-1	27-10	16-9	20-5	30°-11′	7-3	50°-0′	18-10	53°-16′	12-3	46°-33′	624
96P21-72-72	28-6	30-8	19-8	18-2	40°-11′	7-0	45°-18′	24-3	45°-13′	11-1	49°-18′	689
96P24-69-75	30-0	29-8	20-1	21-10	33°-28′	6-7	55°-0′	24-2	43°-29′	11-10	48°-03′	698
**102P21-72-78	29-11	31-3	20-0	19-3	40°-18′	7-0	45°-18′	24-4	45°-05′	12-0	49°-19′	738

*Meets AREMA clearances for bridges and turntables.
**Meets AREMA clearances for single track tunnel.

Notes:
1. Other sizes are available for special designs.



Pear

Galvanized Steel 6" x 2" Corrugation

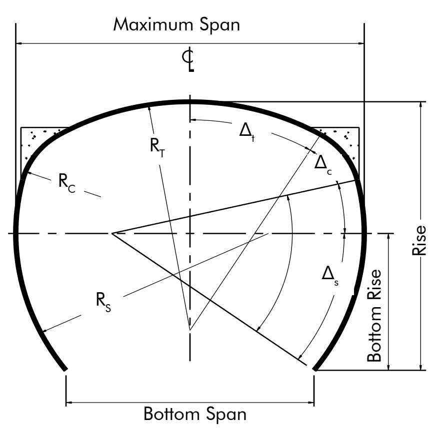
SUPER-SPAN

TABLE 60. TYPICAL PEAR-ARCH SHAPES (ALL DIMENSIONS TO INSIDE CRESTS)

Structure Number	Maximum Span Ft.-In.	Bottom Span Ft.-In.	Total Rise Ft.-In.	Bottom Rise Ft.-In.	Top Radius R_T Ft.-In.	Δ_t	Corner Radius R_C Ft.-In.	Δ_c	Side Radius R_S Ft.-In.	Δ_s	Approx. Area Sq. Ft.
75PA15-66	23-11	16-2	23-4	11-10	14-10	38°-25′	6-1	37°-10′	20-0	50°-47′	480
78PA21-66	26-4	18-5	24-9	11-11	15-5	38°-27′	8-6	37°-23′	20-0	50°-47′	559
*81PA18-75	27-3	17-9	25-6	13-8	20-0	30°-49′	6-0	45°-13′	22-0	52°-24′	603
87PA21-69	29-7	21-6	24-11	12-9	22-0	30°-6′	6-9	46°-57′	22-0	48°-15′	645
**90PA21-72	30-4	21-7	25-10	13-2	22-0	31°-8′	7-0	45°-18′	22-0	50°-20′	683

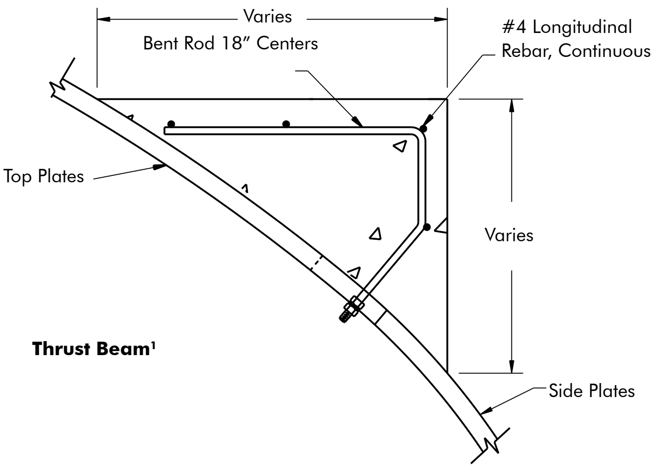
*Meets AREMA clearances for bridges and turntables.
**Meets AREMA clearances for single track tunnel.

Notes:
1. Other sizes are available for special designs.

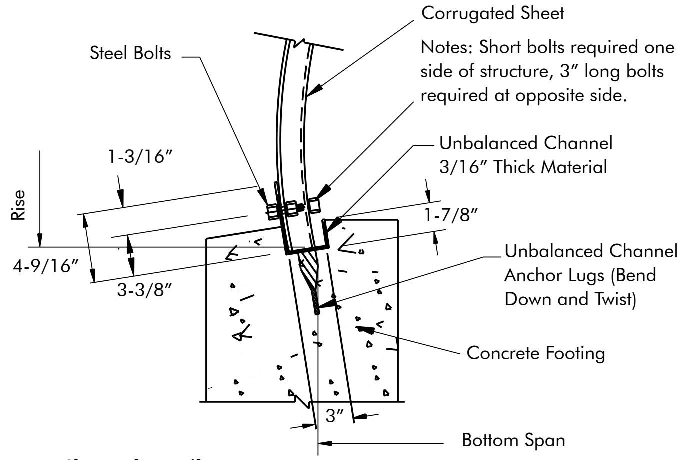


Pear Arch

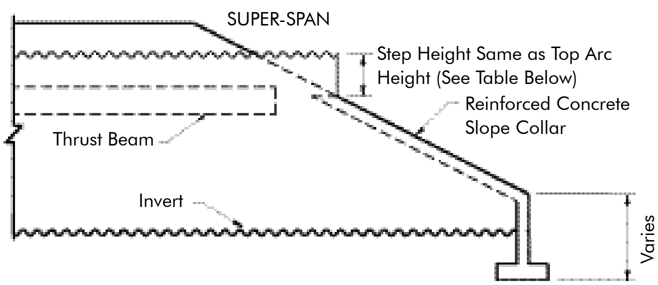
Conceptual Drawings



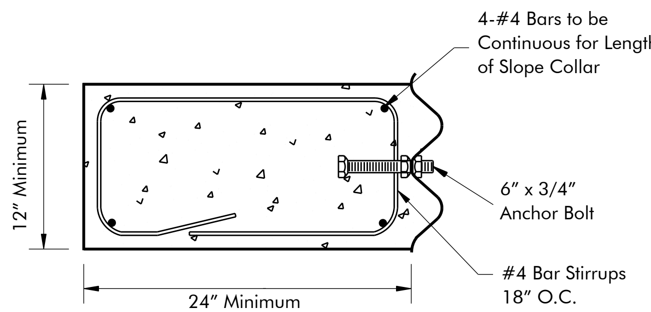
Thrust Beam[1]



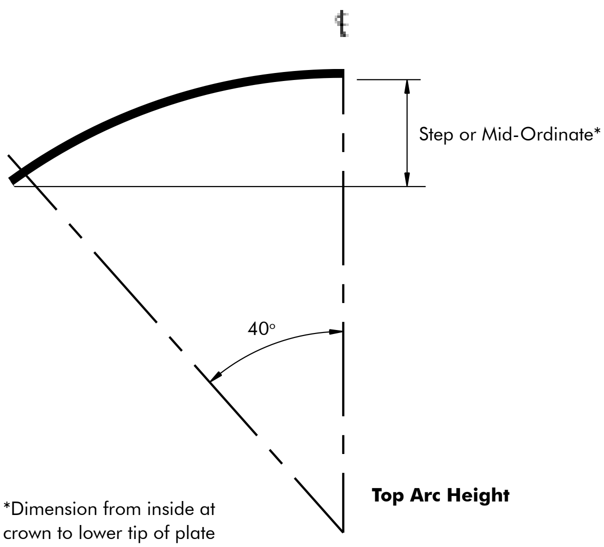
Base Channel Detail



Section A-A (see elev. p. 85)



Section B-B
Typical Slope Collar[1] (see elev. p. 85)



Top Arc Height

*Dimension from inside at crown to lower tip of plate as shown

Notes:
1. Many of the details are conceptual. The designer should work with the Contech representative on each particular application.

TABLE 61. TYPICAL TOP STEP DIMENSIONS

Top or Bottom Arc. in Pi	Step or Mid-Ordinate Ft.-In.
60	2-10
63	2-11
66	3-1
69	3-3
72	3-4
75	3-6
78	3-7
81	3-9
84	3-11
87	4-0
90	4-2
93	4-3
96	4-5
99	4-7
102	4-8
105	4-10
108	4-11
111	5-1
114	5-3
117	5-4
120	5-6
123	5-8
126	5-9
129	5-11
132	6-0

(applies only to structures with 80° top arc)

Notes:
1. Top and bottom steps are the same for ellipse shapes.

SUPER-SPAN

Galvanized Steel Long Span Structures — 6" x 2" Corrugation Specification

General Description

The long span steel structural plate structure, conforming to the dimensions shown on the plans and specifications, shall be installed at the location designated. The design and installation shall conform to AASHTO Standard Specifications for Highway Bridges, Division I, "Soil-Corrugated Metal Structure Interaction Systems", Section 12.7, "Long Span Structural Plate Structures", and Division II, Section 26, "Metal Culverts" and Division II, Section 8, "Concrete Structures."

Materials

The galvanized steel structural plate shall have 6" x 2" corrugations and shall be of the gage as shown on the plans. The plates shall be manufactured in conformance with AASHTO Specification M 167. Bolts and nuts shall meet the provisions of ASTM A449, Type 1 and ASTM A563, Grade C. The steel anchor bolts shall conform to ASTM A307, Grade A.

Longitudinal Structural Stiffeners (Thrust Beams)

Longitudinal stiffeners shall be located at the radius transition at the ends of the top arc. The thrust beams shall consist of reinforced concrete conforming to AASHTO Standard Specifications for Highway Bridges having a minimum compression strength of 2400 psi. Reinforcing steel shall conform to ASTM A615, Grade 40, having a minimum yield strength of 40,000 psi. Thrust beams shall be formed and poured conforming to the plan dimensions when the backfill reaches the bottom elevation of the thrust beams.

Design

The long span structure shall be designed in accordance with the latest AASHTO design criteria and shall be required to incorporate the use of continuous longitudinal structural stiffeners (concrete thrust beams).

Structure Assembly

The structure shall be assembled in strict accordance with the manufacturer's instructions and to the design shape shown on the plans. Plates shall be assembled according to plate assembly drawings supplied by the manufacturer.

Structural Backfill

Material

A granular type of material shall be used around and over the structure. This select structural backfill material shall conform to one of the following classifications of soil from AASHTO Specification M 145, as modified in the following table for A-1, A-2-4 or A-2-5.

TABLE 62. - AASHTO M 145

	A-1		A-2(Modified)	
GROUP CLASSIFICATION	A-1-a	A-1-b	A-2-4	A-2-5
Sieve Analysis, Percent Passing:				
No.10 (2.00 mm)	50 Max.	——	——	——
No. 40 (0.425 mm)	30 Max.	50 Max.	——	——
No. 100 (0.150 mm)	——	——	50 Max.	50 Max.
No. 200 (0.075 mm)	15 Max.	25 Max.	20 Max.	20 Max.
Characteristics of Fraction Passing No. 40 (0.425 mm)				
Liquid Limit	—		40 Max.	41 Min.
Plasticity Index	6 Max.		10 Max.	10 Max.
Usual Types of Significant Constituent Materials	Stone Fragments Gravel and Sand		Silty or Clayey Gravel and Sand	

* Modified to be more select than M 145.

Additional Requirements

- Materials must be dense graded (open graded or gap graded materials are not allowed).
- Fine beach sands, windblown sands, and stream deposited sands all of which exhibit fine, rounded particles and typically are classified by AASHTO M 145 as A-3 materials are not allowed.
- On site mixing or blending to achieve specified gradation is not allowed.

Maximum particle size shall not exceed 3 inches. For the A-2 materials, moisture content must be between -3% and +2% optimum as defined by AASHTO T 180. All soil classifications are limited to the following height of cover limits and structure shape applications:

- A-1-a material is suitable for all long span shapes, sizes and fill heights.
- A-1-b material is suitable only for use with high profile arch and pear shape structures to a 12' maximum fill height and for use with elliptical and low profile arch structures to a 20' maximum fill height.
- A-2-4 and A-2-5 materials are restricted to maximum heights of cover of 12'. These materials are not allowed for use with pear, pear arch or high profile arches with more than 30 Pi in the side arc.

Other backfill materials which provide equivalent structural properties, longterm, in the environmental conditions expected (saturation, freeze-thaw, etc.) may be used. Such materials shall be approved only after thorough investigation and testing by a soils engineer familiar with the requirements for structural backfill of long span structures.

Backfill Envelope Limits

The backfill envelope limits are as detailed on the plans.

Backfill Placement

Before backfilling, the erected structure shall meet the tolerance and symmetry requirements of AASHTO and the manufacturer.

Approved backfill material shall be placed in horizontal, uniform layers not exceeding 8" in thickness, before compaction, and shall be brought up uniformly on both sides of the structure. Each layer of backfill shall be compacted to a relative density of not less than 90%, modified proctor per AASHTO T 180. Field density tests of compacted backfill will be made at regular intervals during backfill.

Long span structures, due to their size and shape, are sensitive to the types and weights of equipment used to place and compact the select backfill material. This is especially critical in the areas immediately adjacent to and above the structure. Therefore, equipment types will be restricted in those critical zones. Compaction equipment or methods that produce horizontal or vertical earth pressures which cause excessive distortion or damage to structures shall not be used.

Contractors should plan to have a D4 (approximately 20,000 lbs.) or similar weight tracked dozer to place and grade backfill immediately alongside and radially above the structure until minimum cover level is reached. Lightweight vibratory plate or roller type compaction equipment must be used to compact the backfill in these zones. Use of heavier equipment and/or rubber tired equipment such as scrapers, graders, and front end loaders will likely be prohibited inside the select fill envelope zone until appropriate minimum cover height has been obtained.

Shape Control Monitoring

Contech shall provide a Shape Control Technician who is a qualified representative of a professional soils engineering firm, or other qualified organization, to ensure a properly shaped structure. The Shape Control Technician shall take initial measurements of the erected structure before backfilling, observe all backfill materials and their placement, and record compaction densities. The Technician shall record all density readings and ensure they meet the requirements of the plans and specifications. However, in no case shall the relative densities be less than 90% per AASHTO T 180. The Shape Control Technician shall monitor the structure shape during the placement of structural backfill to the minimum cover height over the structure. **No structural backfill shall be placed without the Shape Control Technician on site**.

The Shape Control Technician Shall:

- Monitor the structure's shape throughout the backfilling operation and report shape change rates to the contractor.
- Contact the Contech representative immediately if there are problems in meeting the established tolerances.
- Have full authority to stop backfill work if necessary.

Preconstruction Conference

Prior to construction, a meeting will be held to review the construction procedures. A qualified representative of the manufacturer of the structure will be present to discuss methods and responsibility for shape monitoring and control, backfill material selection, testing and placement, and compaction methods and testing. A representative of the Engineer, Prime Contractor, and any involved sub-contractors must be present.

Alternate Structures

The Contractor may furnish an alternate structure to the long span shown on the plans and these specifications but the following conditions must be met:

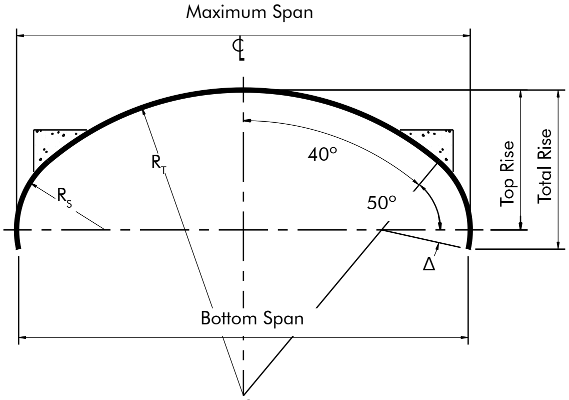
1. The structure must be designed using the AASHTO Long Span criteria and these plans and specifications. Steel structural plate shall conform to the requirements of AASHTO M 167.
2. The corrugated metal plate thickness specified is considered the minimum acceptable for the structure(s) on this project based on structural and durability requirements. Any other structure, regardless of "special features", must be of the same thickness or greater.
3. "Special Features", such as hot rolled structural steel ribs, shall be hot-dip galvanized after fabrication per ASTM A123. Ribs shall be placed across the top 180°, i.e., to the springline of all structures. Maximum rib spacing shall be two (2) feet. Ribs shall be placed over the same length of structure that the thrust beams would apply. No allowance for composite action between the rib and plate will be allowed. The combined moment of inertia of both plate and rib must satisfy the normal flexibility factor as shown in AASHTO Division I, Section 12.6.1.4. The span in the formula for the flexibility factor shall be replaced by twice the top arc radius.
4. Alternate structures meeting the above criteria will only be considered for use if pre-approved in writing by the Engineer prior to the bid date. To qualify for pre-approval, an alternate submittal package must be submitted to the Engineer a minimum of 15 days prior to the bid date.
5. The material supplier shall be a qualified manufacturer of steel structural plate and long span structures with a minimum of 50 successful installations. The foundation, structural backfill and end treatment shall be as required herein and detailed on the plans.

Aluminum 9″ x 2-1/2″ Corrugation

SUPER-PLATE

TABLE 63. TYPICAL LOW PROFILE ARCH SHAPES (ALL DIMENSIONS TO INSIDE CRESTS)									
Structure Number	Maximum Span Ft.-In.	Bottom Span Ft.-In.	Total Rise Ft.-In.	Top Rise Ft.-In.	Top Radius R_T Ft.-In.	Side Radius R_S Ft.-In.	Angle Below Horizontal Δ	Approx. Area Sq. Ft.	Shape Factor R_T/R_S
23A5	19-5	19-2	6-9	5-10	13-1	3-7	15°-23′	105	3.66
23A6	20-1	19-10	7-6	6-6	13-1	4-6	12°-21′	120	2.91
25A6	21-7	21-4	7-9	6-9	14-3	4-6	12°-21′	133	3.17
26A6	22-3	22-1	7-11	6-11	14-10	4-6	12°-21′	140	3.30
27A6	23-0	22-10	8-0	7-1	15-5	4-6	12°-21′	147	3.42
28A6	23-9	23-7	8-2	7-2	16-0	4-6	12°-21′	154	3.55
29A6	24-6	24-3	8-3	7-4	16-7	4-6	12°-21′	161	3.68
30A6	25-3	25-0	8-5	7-5	17-2	4-6	12°-21′	168	3.81
31A6	26-0	25-9	8-7	7-7	17-8	4-6	12°-21′	176	3.93
31A8	27-3	27-2	10-0	9-0	17-8	6-4	8°-52′	217	2.80
33A7	28-1	27-11	9-6	8-7	18-10	5-5	10°-19′	212	3.48
33A8	28-9	28-7	10-3	9-3	18-10	6-4	8°-52′	234	2.98
34A7	28-10	28-8	9-8	8-8	19-5	5-5	10°-19′	220	3.59
36A7	30-4	30-2	9-11	9-0	20-7	5-5	10°-19′	237	3.80
36A8	31-0	30-10	10-8	9-8	20-7	6-4	8°-52′	261	3.25
36A10	31-8	31-2	12-2	10-4	20-7	7-3	14°-02′	309	2.84
37A7	31-1	3011	10-1	9-1	21-2	5-5	10°-19′	246	3.90
37A10	32-4	31-11	12-3	10-6	21-2	7-3	14°-02′	320	2.92
38A7	31-10	31-7	10-2	9-3	21-9	5-5	10°-19′	255	4.01
38A10	33-1	32-8	12-5	10-8	21-9	7-3	14°-02′	330	3.00
39A8	33-2	33-0	11-1	10-1	22-4	6-4	8°-52′	289	3.52
39A11	34-6	34-1	13-3	11-6	22-4	8-2	12°-29′	368	2.73
41A8	34-8	34-6	11-4	10-4	23-5	6-4	8°-52′	308	3.70
41A14	37-11	37-8	15-8	13-10	23-5	10-11	9°-24′	478	2.15
42A8	35-5	35-3	11-5	10-6	24-0	6-4	8°-52′	318	3.79
42A14	38-8	38-5	15-9	14-0	24-0	10-11	9°-24′	491	2.20

Notes:
1. Other sizes are available for special designs.
2. The design table on page 83 of the catalog is for steel 6″ x 2″ corrugation only, for aluminum 9″ x 2-1/2″ corrugation design, please call your local Contech representative.
Reinforcing ribs may be required. Rib length will be determined.



Low Profile Arch

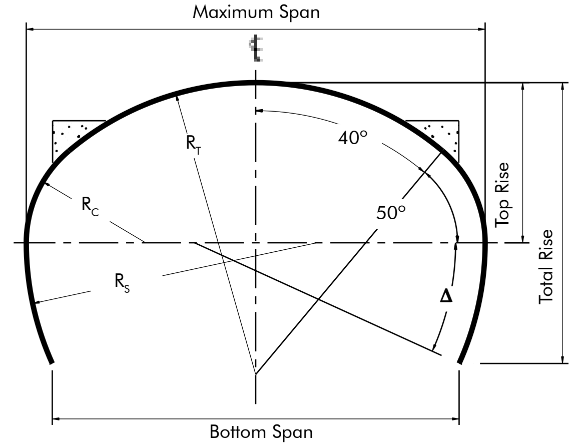
Aluminum 9" x 2-1/2" Corrugation

SUPER-PLATE

TABLE 64. TYPICAL HIGH PROFILE ARCH SHAPES
(ALL DIMENSIONS TO INSIDE CRESTS)

Structure Number	Maximum Span Ft.-In.	Bottom Span Ft.-In.	Total Rise Ft.-In.	Top Rise Ft.-In.	Top Radius R_T Ft.-In.	Upper Side Radius R_c Ft.-In.	Lower Side Radius R_s Ft.-In.	Angle Below Horizontal Δ	Approx. Area Sq. Ft.	Shape Factor R_T/R_C
23A5-3	20-1	19-7	9-1	6-6	13-1	4-6	13-1	11°-18′	152	2.91
23A6-6	209	18-10	12-1	7-3	13-1	5-5	13-1	21°-44′	214	2.42
25A5-6	21-6	19-10	11-8	6-9	14-3	4-6	14-3	20°-0′	215	3.17
25A7-8	22-10	1910	14-6	8-2	14-3	6-4	14-3	26°-23′	285	2.25
26A5-6	22-3	20-7	11-10	6-11	14-10	4-6	14-10	19°-13′	225	3.30
26A6-8	22-11	20-1	14-0	7-7	14-10	5-5	14-10	25°-22′	275	2.74
27A5-6	23-0	21-5	11-11	7-1	15-5	4-6	15-5	18°-31′	235	3.43
27A7-8	24-4	21-7	14-10	8-5	15-5	6-4	15-5	24°-27′	309	2.43
28A5-6	23-9	22-3	12-1	7-2	16-0	4-6	16-0	17°-51′	245	3.56
29A5-8	24-6	21-11	13-9	7-4	16-7	4-6	16-7	22°-45′	289	3.69
29A7-8	25-10	23-3	15-1	8-9	16-7	6-4	16-7	22°-45′	335	2.62
30A5-7	25-3	23-4	13-1	7-5	17-2	4-6	17-2	19°-20′	283	3.81
30A7-8	26-7	24-1	15-3	8-10	17-2	6-4	17-2	22°-0′	347	2.71
31A5-7	26-0	24-1	13-3	7-7	17-8	4-6	17-8	18°-43′	294	3.94
31A7-8	27-3	24-10	15-5	9-0	17-8	6-4	17-8	21°-17′	360	2.80
33A5-7	27-5	25-8	13-7	7-10	18-10	4-6	18-10	17°-35′	317	4.20
33A8-8	29-5	27-2	16-5	10-0	18-10	7-3	18-10	20°-0′	412	2.60
34A5-8	28-2	25-11	14-5	8-0	19-5	4-6	19-5	19°-25′	348	4.33
34A8-10	30-2	26-9	18-0	10-1	19-5	7-3	19-5	24°-07′	466	2.68
36A6-8	30-4	28-3	15-5	9-0	20-7	5-5	20-7	18°-20′	400	3.80
36A8-10	31-8	28-5	18-4	10-4	20-7	7-3	20-7	22°-47′	497	2.84
37A6-8	31-1	29-0	15-7	9-1	21-2	5-5	21-2	17°-50′	413	3.91
37A7-10	31-9	28-7	17-9	9-10	21-2	6-4	21-2	22°-10′	484	3.34
38A6-10	31-10	28-9	17-3	9-3	21-9	5-5	21-9	21°-35′	470	4.02
39A6-10	32-6	29-7	17-4	9-4	22-4	5-5	22-4	21°-02′	485	4.12

Notes:
1. Other sizes are available for special designs.
2 The design table on page 83 of the catalog is for steel 6" x 2" corrugation only. For aluminum 9" x 2-1/2" corrugation design, please call your local Contech representative.
Reinforcing ribs may be required. Rib length will be determined.



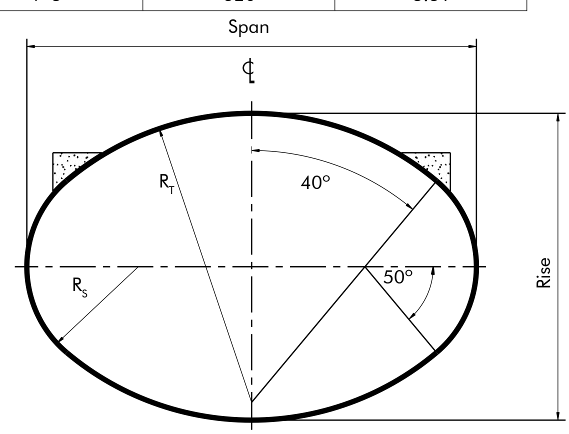
High Profile Arch

Aluminum 9" x 2-1/2" Corrugation

SUPER-PLATE

TABLE 65. TYPICAL HORIZONTAL ELLIPSE SHAPES (ALL DIMENSIONS TO INSIDE CRESTS)						
Structure Number	**Maximum Span Ft.-In.**	**Total Rise Ft.-In.**	**Top Radius R_T Ft.-In.**	**Side Radius R_S Ft.-In.**	**Approx. Area Sq. Ft.**	**Shape Factor R_T R_S**
22E10	19-4	12-9	12-6	4-6	191	2.79
23E10	20-1	13-0	13-1	4-6	202	2.92
24E8	20-2	11-11	13-8	3-7	183	3.83
25E8	20-11	12-2	14-3	3-7	194	3.99
23E13	21-1	15-2	13-1	5-10	248	2.23
26E9	21-11	13-1	14-10	4-0	221	3.68
25E13	22-6	15-8	14-3	5-10	275	2.43
27E10	23-0	14-1	15-5	4-6	249	3.43
26E13	23-3	15-11	14-10	5-10	288	2.53
27E14	24-4	16-11	15-5	6-4	320	2.43
29E10	24-6	14-8	16-7	4-6	275	3.69
30E10	25-3	14-11	17-2	4-6	288	3.81
29E13	25-6	16-9	16-7	5-10	330	2.82
29E15	26-2	18-2	16-7	6-9	369	2.44
31E11	26-4	15-10	17-8	4-11	320	3.58
32E11	27-0	16-2	18-3	4-11	334	3.69
30E16	27-2	19-1	17-2	7-3	405	2.36
31E16	27-11	19-5	17-8	7-3	422	2.44
33E12	28-1	17-1	18-10	5-5	369	3.48
34E12	28-10	17-5	19-5	5-5	385	3.59
33E16	29-5	19-11	18-10	7-3	455	2.60
34E16	30-2	20-2	19-5	7-3	473	2.68
36E12	30-4	17-11	20-7	5-5	416	3.80
35E17	31-3	21-2	20-0	7-9	513	2.59
37E13	31-5	18-11	21-2	5-10	455	3.60
38E13	32-1	19-2	21-9	5-10	472	3.70
36E18	32-3	22-2	20-7	8-2	556	2.52
37E18	33-0	22-5	21-2	8-2	575	2.59
38E14	32-5	19-10	21-9	6-4	496	3.43
38E19	34-1	23-5	21-9	8-8	620	2.52
41E14	34-8	20-8	23-5	6-4	549	3.70
41E15	35-0	21-4	23-5	6-9	575	3.45
42E16	36-1	22-4	24-0	7-3	620	3.31

Notes:
1. The design table on page 83 of the catalog is for steel 6" x 2" corrugation only. For aluminum 9" x 2-1/2" corrugation design, please call your local Contech representative. Reinforcing ribs may be required. Rib length will be determined.



Horizontal Ellipse

SUPER-PLATE®

Aluminum Long Span Structures — 9" x 2-1/2" Corrugation Specification

General Description

The long span aluminum structural plate structure, conforming to the dimensions shown on the plans and specifications, shall be installed at the location designated. The design and installation shall conform to AASHTO Standard Specifications for Highway Bridges, Division I, “Soil-Corrugated Metal Structure Interaction Systems”, Section 12.7, “Long Span Structural Plate Structures”, and Division II, Section 26, “Metal Culverts” and Division II, Section 8, “Concrete Structures”.

Materials

The aluminum structural plate shall have 9” x 2-1/2” corrugations and shall be of the gage as shown on the plans. The plates shall be manufactured in conformance with AASHTO Specification M 219 and ASTM B209. Bolts and nuts shall meet the provisions of ASTM A307/A449 and ASTM A563, and shall be galvanized in accordance with the requirements of ASTM A153 or B695. Steel anchor bolts shall conform to ASTM A307.

Required stiffening ribs for the crown portion shall be extruded bulb angles produced from 6061-T6 alloy providing a minimum 35 ksi yield strength.

Long Span Special Features

Aluminum Long Span Structures will require transverse stiffening ribs as well as longitudinal stiffeners.

Transverse Stiffeners

Transverse stiffeners will be bolted to the crown portion of the structure on 1 N (9.625”) maximum circumferential centers. Their size and longitudinal spacing must adequately stiffen the top portion of the crown over a minimum 55 degree arc.

Longitudinal Structural Stiffeners (Thrust Beams)

Longitudinal stiffeners shall be located at the radius transition at the ends of the top arc. The thrust beams shall consist of reinforced concrete conforming to AASHTO Standard Specifications for Highway Bridges having a minimum compression strength of 2400 psi. Reinforcing steel shall conform to ASTM A615, Grade 40, having a minimum yield strength of 40,000 psi. Black reinforcing steel shall in no instance come in contact with the Aluminum Structural Plate. Thrust beams shall be formed and poured conforming to the plan dimensions when the backfill reaches the bottom elevation of the thrust beams.

Design

The long span structure shall be designed in accordance with the latest AASHTO design criteria and shall be required to incorporate the use of continuous longitudinal structural stiffeners (concrete thrust beams). The material supplier shall be a qualified manufacturer of aluminum structural plate and long span structures with a minimum of 50 successful installations. The foundation, structural backfill, and end treatment shall be as required herein and detailed on the plans.

Structure Assembly

The structure shall be assembled in strict accordance with the manufacturer’s instructions and to the design shape shown on the plans. Plates shall be assembled according to plate assembly drawings supplied by the manufacturer.

Structural Backfill

Material

A granular type of material shall be used around and over the structure. This select structural backfill material shall conform to one of the following classifications of soil from AASHTO Specification M 145, as modified in the following table for A-1, A-2-4 or A-2-5.

TABLE 66. - AASHTO M 145				
	A-1		A-2 (Modified)	
GROUP CLASSIFICATION	**A-1-a**	**A-1-b**	**A-2-4**	**A-2-5**
Sieve Analysis, Percent Passing:				
No.10 (2.00 mm)	50 Max.	——	——	——
No. 40 (0.425 mm)	30 Max.	50 Max.	——	——
No. 100 (0.150 mm)	——	——	50 Max.	50 Max.
No. 200 (0.075 mm)	15 Max.	25 Max.	20 Max.	20 Max.
Characteristics of Fraction Passing No. 40 (0.425 mm)				
Liquid Limit	—		40 Max.	41 Min.
Plasticity Index	6 Max.		10 Max.	10 Max.
Usual Types of Significant Constituent Materials	Stone Fragments Gravel and Sand		Silty or Clayey Gravel and Sand	

* Modified to be more select than M 145.

Additional Requirements

1. Materials must be dense graded (open graded or gap graded materials are not allowed).
2. Fine beach sands, windblown sands, and stream deposited sands, all of which exhibit fine, rounded particles and typically are classified by AASHTO M 145 as A-3 materials, are not allowed.
3. On site mixing or blending to achieve specified gradation is not allowed.

Maximum particle size shall not exceed 3 inches. For the A-2 materials, moisture content must be between -3% and +2% optimum as defined by AASHTO specification T 180. All soil classifications are limited to the following height of cover limits and structure shape applications:

- A-1-a material is suitable for all long span shapes, sizes and fill heights.
- A-1-b material is suitable only for use with high profile arch structures to a 12′ maximum fill height and for use with elliptical and low profile arch structures to a 20′ maximum fill height.
- A-2-4 and A-2-5 materials are restricted to maximum heights of cover of 12′.

Other backfill materials, which provide equivalent structural properties, long-term, in the environmental conditions expected (saturation, freeze-thaw, etc.), may be used. Such materials shall be approved only after thorough investigation and testing by a soils engineer familiar with the requirements for structural backfill of long span structures.

Backfill Envelope Limits

The backfill envelope limits are as detailed on the plans.

Backfill Placement

Before backfilling, the erected structure shall meet the tolerance and symmetry requirements of AASHTO and the manufacturer.

Approved backfill material shall be placed in horizontal, uniform layers not exceeding 8″ in thickness, before compaction, and shall be brought up uniformly on both sides of the structure. Each layer of backfill shall be compacted to a relative density of not less than 90%, modified proctor per AASHTO T 180. Field density tests of compacted backfill will be made at regular intervals during backfill.

Long span structures, due to their size and shape, are sensitive to the types and weights of equipment used to place and compact the select backfill material. This is especially critical in the areas immediately adjacent to and above the structure. Therefore, equipment types will be restricted in those critical zones. Compaction equipment or methods that produce horizontal or vertical earth pressures which cause excessive distortion or damage to structures shall not be used.

Contractors should plan to have a D4 (approximately 20,000 lbs.) or similar weight tracked dozer to place and grade backfill immediately alongside and radially above the structure until minimum cover level is reached. Lightweight vibratory plate or roller type compaction equipment must be used to compact the backfill in these zones. Use of heavier equipment and/or rubber tired equipment such as scrapers, graders, and front end loaders will likely be prohibited inside the select fill envelope zone until appropriate minimum cover height has been obtained.

Shape Control Monitoring

The material supplier or the manufacturer shall provide a Shape Control Technician who is a qualified representative of a professional soils engineering firm, or other qualified organization, to ensure properly shaped structure. The Shape Control Technician shall take initial measurements of the erected structure before backfilling, observe all backfill materials and their placement, and record compaction densities. The Technician shall record all density readings and ensure they meet the requirements of the plans and specifications. However, in no case shall the relative densities be less than 90% per AASHTO T 180. The Shape Control Technician shall monitor the structure shape during the placement of structural backfill to the minimum cover height over the structure. **No structural backfill shall be placed without the Shape Control Technician on site**.

The Shape Control Technician shall:

- Monitor the structure's shape throughout the backfilling operation and report shape change rates to the contractor.
- Contact the material supplier or the manufacturer immediately if there are problems in meeting the established tolerances.
- Have full authority to stop backfill work if necessary.

Preconstruction Meeting

Prior to construction, a meeting will be held to review the construction procedures. A qualified representative of the manufacturer of the structure will be present to discuss methods and responsibility for shape monitoring and control, backfill material selection, testing and placement, and compaction methods and testing. A representative of the Engineer, Prime Contractor and any involved sub-contractors must be present.

Alternate Structures

The Contractor may furnish an alternate structure to the long span shown on the plans and these specifications but the following conditions must be met:

1. The structure must be designed using the AASHTO Long Span criteria and these plans and specifications. Aluminum alloy structural plate shall conform to the requirements of AASHTO M 219.
2. The corrugated metal plate thickness specified is considered the minimum acceptable for the structure(s) on this project, based on structural and durability requirements. Any other structure, regardless of "special features", must be of the same thickness or greater.
3. When longitudinal reinforcements are not used, the "Special Features", such as aluminum structural ribs, shall be aluminum alloy 6061-T6. Ribs shall be placed over the same length of structure that the thrust beams would apply.
4. Alternate structures meeting the above criteria will only be considered for use if pre-approved in writing by the Engineer prior to the bid date. To qualify for pre-approval, an alternate submittal package must be submitted to the Engineer a minimum of 15 days prior to the bid date.

Aluminum Structural Plate Single Radius Arch with Keystone Headwalls for Wetland Crossings

BridgeCor®
Deep Corrugation Expands Structural Plate

Structural plate has a long history of strength, durability and economy and has been a buried bridge standard for the past 80 years. BridgeCor, a deep corrugation pattern, provides designers of bridge systems the option to use structural plate bridges with wider spans and taller rises. BridgeCor is manufactured in a 15” X 5.5” corrugation pattern and Contech has improved on the manufacturing process to provide a three corrugation plate. A wider laying length (nominal 45 inch) can reduce the number of plates on a project reducing the overall installed cost.

BridgeCor structures are made from sturdy, heavy gage, corrugated steel plates that are pre-formed to various shapes and sizes, then galvanized for long-term protection and performance. The plates are delivered to the job site and bolted together to form a BridgeCor structure specifically chosen for the project.

BridgeCor is available in Round, Single and 2-Radius Arches and Box Culverts - all in a wide range of sizes. Custom shapes are also an option. The product is accepted by AASHTO and has been installed around the world.

Superior Durability

BridgeCor is similar to MULTI-PLATE and is manufactured from heavy gage steel using an industry standard of 3 ounce per square foot galvanized coating. The long history of structural plate installations have shown these designs can provide a service life of 75 years or longer.

When selecting the proper material for an application, designers need to evaluate the soil side of the structure along with the corrosive and abrasive action due to the flow at the invert of the structure. The use of structural plate gives designers more structure shape options to help minimize the impact of abrasion on the invert of the structure.

High Load-Carrying Capacity

As a steel-soil interaction system, BridgeCor is designed to carry high combined live and dead loads. High traffic loads and deep cover applications are a structural plate specialty.

More Efficient Installation Process

Prefabricated plates are assembled in the field, translating into finished construction in days instead of weeks as with most cast-in-place concrete structures.

Versatility

BridgeCor structures remove all of the shape, size and installation restrictions of precast or cast-in-place concrete.

Descriptions of Plates

BridgeCor plates are field assembled into pipe, arches, and box culverts. Corrugations of 15-inch pitch and 5.5-inch depth are perpendicular to the length of each plate. Each plate has a laying length of 45 inches.

Thickness. Standard specified thickness of the galvanized plates vary from 0.170 to 0.380 inches.

Widths. Standard plates come in multiples of 16 inches (S=16 inches or 5*3.2) and are fabricated in six net covering widths, 4 S - 64 inches, 5 S - 80 inches, 6 S - 96 inches, 7 S - 112 inches, 8 S - 128 inches, and 9 S - 144 inches, See Table 67.

The “S” nomenclature translates circumference directly into nominal diameter in inches.

The following calculations demonstrate how to convert "S" into pi.

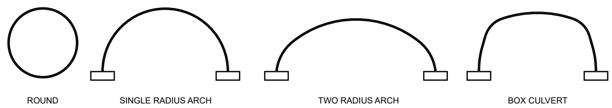
For example, a 54 S round structures uses six - 9 S plates (S=16 inches or 5 * 3.2)

54 S = 54 * (5 * 3.2)
= 270 * 3.2
= 270 pi

(Actual plate widths in a structure may vary to obtain the optimum plate layout)

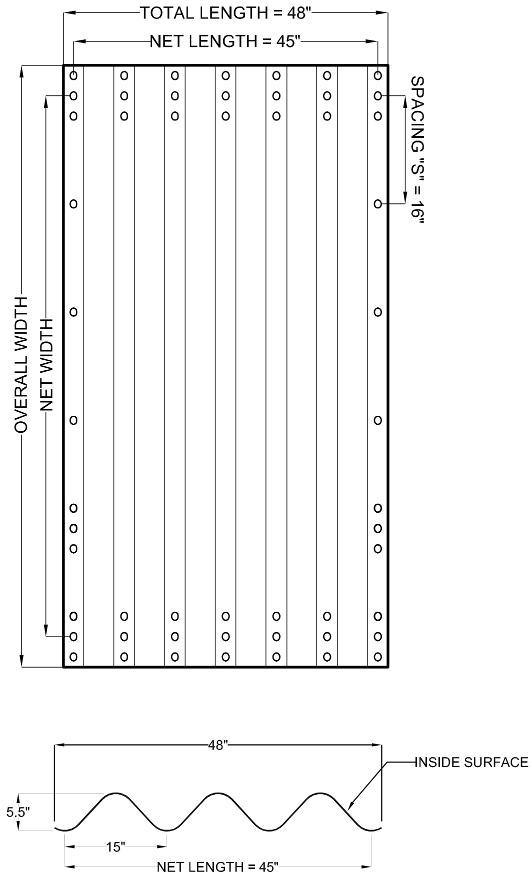
Lengths. BridgeCor plates are furnished in 3.75 foot nominal lengths. Actual length of the square-end structure is about three inches longer than its nominal length because a 1 ½-inch lip protrudes beyond each end of every plate for lapping purposes.

Bolt holes. BridgeCor plates are punched with 1 inch holes for 8 gage through 1 gage plates to accommodate a ¾ inch bolt. Circumferential holes are punched on 16 inch (1 S) centers. All BridgeCor requires a staggered longitudinal seam. These seams have a three-hole bolt pattern in the crest and valley of the corrugations along the length of structure to help provide additional seam strength. For heavier plate structures (0.318" and 0.380"), the holes are punched to 1.125 inch diameter along the seams to accommodate a ⅞ inch bolt. Bolt lengths will vary depending on the location of the bolt and the number of plates in a given location.



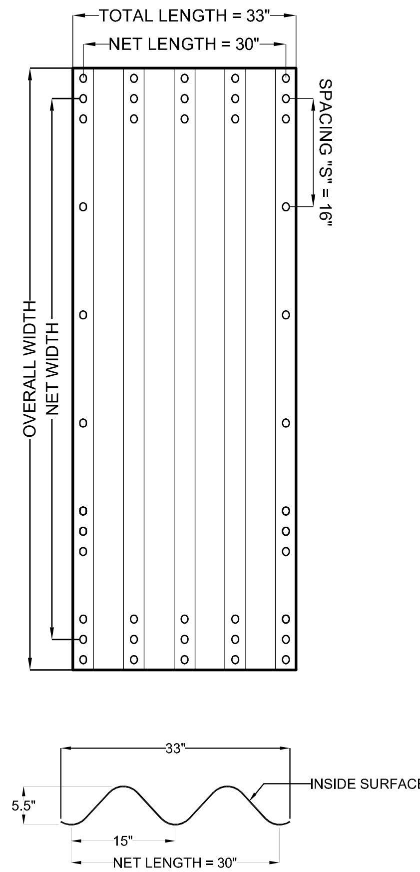
Standard Shapes

Standard Plate Details



Standard 15" x 5.5" Corrugation

Notes: 8 Ga. (0.170) thru 1 Ga. (0.280) plates shall be three corrugations.



Standard 15" x 5.5" Corrugation

Notes: 5/16 (.318) and 3/8 (.380) plate shall be two corrugations.

TABLE 67. DETAILS OF UNCURVED BRIDGECOR SECTIONS

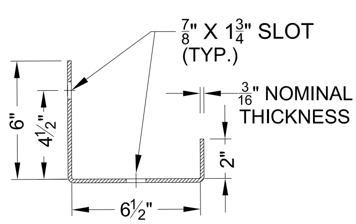
Nominal	Net Width (Inches)	Overall Width (Inches)	Spaces 16 in.	Number of Circumferential Bolt Holes
4 S	64	73	4	5
5 S	80	89	5	6
6 S	96	105	6	7
7 S	112	121	7	8
8 S	128	137	8	9
9 S	144	153	9	10

For BridgeCor, S = 16 inches.

TABLE 68. APPROXIMATE WEIGHT OF BRIDGECOR SECTIONS

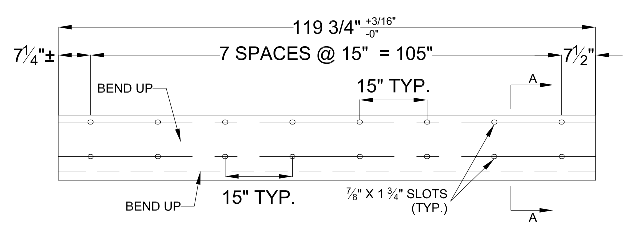
			Sheet weights, lbs. (without fasteners)						
Plate Width S	Overall Width (Feet)	Net Length	0.170 (8 Ga.)	0.188 (7 Ga.)	0.218 (5 Ga.)	0.249 (3 Ga.)	0.280 (1 Ga.)	0.318* (5/16)	0.380* (3/8)
4 S	6.1	3.75	219	242	280	321	361	285	339
5 S	7.4	3.75	267	295	342	391	440	347	414
6 S	8.8	3.75	315	348	404	461	519	409	489
7 S	10.1	3.75	363	401	465	531	598	471	563
8 S	11.4	3.75	411	454	527	602	677	534	638
9 S	12.8	3.75	459	507	588	672	756	596	712

1. Weights are based on a zinc coating of 3 oz/sf of double-exposed surface.
2. All weights are subject to manufacturing tolerances.
3. Specified thickness is a nominal galvanized thickness. Reference AASHTO M 167.
4. S = 16 inches
* For 5/16" or 3/8" the net length is 2.5' (30")



Unbalanced Channel Cross Section

Note: Weight is 10 lbs per foot per side.



Unbalanced Channel for BridgeCor® Arch "Unfolded View"

BridgeCor®
Galvanized Steel Specification

Scope: This specification covers the manufacture and installation of the galvanized steel BridgeCor structure as detailed in the plans.

I - GENERAL

1.0 STANDARDS AND DEFINITIONS

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

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

1.1.2 AASHTO LRFD Bridge Design Specification for Highway Bridges - Section 12.8.9.

1.1.3 AASHTO LRFD Bridge Construction Specification for Highway Bridges - Section 26.

1.2 DEFINITIONS

1.2.1 Owner - In these specifications the word "Owner" shall mean the site owner or the purchaser.

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

1.2.3 Manufacturer - In these specifications the word "Manufacturer" shall mean Contech Engineered Solutions LLC 800-338-1122.

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

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

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

2.0 GENERAL CONDITIONS

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

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

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

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

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

Any installation guidance provided herein shall be endorsed by the Engineer or superseded by the Engineer's plans and specifications.

II - Contech BridgeCor [Round, Single Radius Arch, 2-Radius Arch or Box]

1.0 GENERAL

1.1 Manufacturer shall fabricate the selected shape as shown on the plans. Fabrication shall conform to the requirements of ASTM A761 and shall consist of plates, fasteners, and appurtenant items.

Plate thickness, end treatment and type of invert and foundation shall be as indicated on the plans. All manufacturing processes including corrugating, punching, curving and required galvanizing shall be performed within the United States of America.

1.2 The contractor shall verify all field dimensions and conditions prior to ordering materials.

2.0 DIMENSIONS

2.1 The proposed structure shall be a Contech BridgeCor with the following dimensions:

Span: X’-Y” Rise: X’-Y” Gage: X “S” - X

2.2 All plan dimensions on the contract drawings are measured in a true horizontal plan unless otherwise noted.

3.0 ASSEMBLY AND INSTALLATION

3.1 Bolts and nuts shall conform to the requirements of ASTM A449. The Contech BridgeCor [insert shape] shall be assembled in accordance with the plate layout drawings provided by the manufacturer and per the manufacturer’s recommendations.

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

3.2 The [insert structure shape] shall be installed in accordance with the plans and specifications, the manufacturer’s recommendations, and AASHTO LRFD Bridge Construction Specification for Highway Bridges - Section 26.

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

3.4 The bedding should be constructed to a uniform line and grade to avoid distortions that may create undesirable stresses in the structure and/or rapid deterioration of the roadway. It should be free of rock formations, protruding stones, and frozen matter that may cause unequal settlement.

It is recommended that the bedding be a relatively loose granular material that is roughly shaped to fit the bottom of the structure, be a minimum of twice the corrugation depth in thickness and have a maximum particle size of one half the corrugation depth. It should be noted that the bedding depth can vary based on the amount of cover and the shape of the structure’s invert. The bedding should be shaped to match structures with flatter inverts.

3.5 Adequate soil bearing capacity or strength shall be provided to the Engineer. Foundation details shall be provided by the Engineer.

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

When assembled on a cast in place spread footing, the structure shall be assembled in the footing starting at the upstream end. When assembled on a full invert, the invert shall be placed starting at the downstream end. The structure shell shall be assembled on the invert starting at the inlet end. Circumferential seams shall be installed with the plate laps shingled downstream as viewed from the inside of the structure.

The structure shall be backfilled using clean well graded granular material that meets the requirements of AASHTO M 145 for soil classifications A-1, A-2-4, A-2-5 or A-3 according to Table 69.

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

3.7 Construction loads that exceed highway load limits are not allowed to cross the structure without approval from the Engineer.

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

BridgeCor® Installation

A successful installation is dependent on these six critical components being followed:

1. Adequate foundation.
2. Proper structure assembly.
3. Use of select structural backfill.
4. 8" maximum thick lifts of backfill evenly placed on both sides of the structure.
5. Adequate compaction of backfill.
6. Adequate minimum cover over the structure.

Required Elements
Satisfactory site preparation, trench excavation and bedding and backfill operations are essential to develop the strength of any flexible conduit. In order to obtain proper strength while preventing settlement, it is necessary that the soil envelope around the structure be of good quality, well graded granular material, properly placed, and carefully compacted.

A qualified Engineer should be engaged to design a proper foundation, adequate bedding, and backfill.

Trench Excavation
If the adjacent embankment material is structurally adequate, the trench requires only a bottom clear width of the structure's span plus sufficient room for compaction equipment.

Bedding
The bedding should be constructed to a uniform line and grade to avoid distortions that may create undesirable stresses in the structure and/or rapid deterioration of the roadway. It should be free of rock formations, protruding stones, and frozen matter that may cause unequal settlement.

It is recommended that the bedding be a relatively loose granular material that is roughly shaped to fit the bottom of the structure, be a minimum of twice the corrugation depth in thickness and have a maximum particle size of one half the corrugation depth.

It should be noted that the bedding depth can vary based on the amount of cover and the shape of the structure's invert. The bedding should be shaped to match structures with flatter inverts.

Bolting
If the plates are well aligned, the torque applied with a power wrench need not be excessive. Bolts should be torque initially to a minimum 100 foot pounds and a maximum 300 foot pounds. A good plate fit is far better than high torque.

Complete detailed assembly instructions and drawings are provided with each structure.

Erosion Control
During installation and prior to the construction of permanent erosion control and end treatment protection, special precautions may be necessary. The structure must be protected from unbalanced loads and from any structural loads or hydraulic forces that may bend or distort the unsupported ends of the structure. Erosion or wash out of previously placed soil support must be prevented to ensure that the structure maintains its load capacity.

BridgeCor Plate Assembly

Backfill Material

Satisfactory backfill material, proper placement and compaction are key factors in obtaining maximum strength and stability.

The backfill material should be free of rocks, frozen lumps, and foreign material that can cause hard spots or decompose to create voids. Backfill material should be well graded granular material that meets the requirements of AASHTO M 145 for soil classifications A-1, A-2-4, A-2-5, or A-3 in Table 69. Backfill must be placed symmetrically on each side of the structure in eight-inch loose lifts. Typically, each lift shall be compacted to a minimum of 90 percent density per AASHTO T 180.

A high percentage of silt or fine sand in the native soils suggests the need for a well graded granular backfill material to prevent soil migration.

Contractors should plan to have a D4 (approximately 20,000 lbs.) or similar weight tracked dozer to place and grade backfill immediately alongside and radially above the structure until minimum cover level is reached. Lightweight vibratory plate or roller type compaction equipment must be used to compact the backfill in these zones. Use of heavier equipment and/or rubber tired equipment such as scrapers, graders, and front end loaders will likely be prohibited inside the select fill envelope zone until appropriate minimum cover height has been obtained.

The Engineer and Contractor are cautioned that the minimum cover may need to be increased to handle temporary construction vehicle loads (larger than D4).

For more information, refer to ASTM A807 and AASHTO LRFD Bridge Construction Specifications for Highway Bridges Div. II – Construction Section 26.

Typically, each lift shall be compacted to a minimum of 90 percent density per AASHTO T 180.

TABLE 69. STUCTURAL PLATE BACKFILL GROUP CLASSIFICATION, REFERENCE AASHTO M 145

Group Classification	A-1-a	A-1-b	A-2-4	A-2-5	A-3
Sieve Analysis Percent Passing					
No. 10 (2.000 mm)	50 max	----	----	----	----
No. 40 (0.425 mm)	30 max	50 max	----	----	51 max*
No. 200 (0.075 mm)	15 max	25 max	35 max	35 max	10 max
Atterberg Limits for Fraction Passing No. 40 (0.425 mm)					
Liquid Limits	----	----	40 max	41 max	----
Plasticity Index	6 max	6 max	10 max	10 max	Non-Plastic
Usual Materials	Stone Fragment, Gravel and Sand		Silty or Clayey Gravel and Sand		Coarse Sand
Most Probable Comparable Soil Groups In The Unified Soil Classification System Reference ASTM D2487	GW, GP	SW, SP, GM, SM	GM, SM	GM, SM	SP

* Modified from M 145
Fine Beach Sands, Windblown Sands, Stream Deposited Sands, etc., Exhibiting Fine, Rounded Particles And Typically Classified By AASHTO M 145 as A-3 Materials Should Not Be Used.

BridgeCor Backfill and Compaction

BridgeCor Box Culvert Assembly

Reline Old Stone Arch Bridges with BridgeCor

BridgeCor Assembly

TABLE 70. BRIDGECOR ROUND PIPE 15" X 5½"

LRFD HEIGHT OF COVER GUIDE (HL-93 LOADING)

Dimensions to Inside Corrugation				**Gage Thickness (Inches) Maximum Cover Height Shown in Feet**								
Diameter Ft.-In.	**Approx. Area Sq. Ft.**	**Min. Cover (Feet)**	**Total S**	**8 (0.170)**	**7 (0.188)**	**5 (0.218)**	**3 (0.249)**	**1 (0.280)**	**5/16 (0.318)**	**3/8 (0.380)**	**Select Fill Width (Feet)**	**Precon (Min. Level)**
19-11	311	2.5	48	21	25	30	35	40	45	50	8	1
20-9	339	2.5	50	20	23	28	33	38	43	48	8	1
21-7	367	2.5	52	18	21	26	31	36	41	46	8	1
22-6	396	2.5	54	17	19	25	29	33	38	43	8	1
23-4	427	2.5	56	16	19	24	28	32	37	42	8	1
24-2	459	2.5	58	15	18	23	27	30	35	40	8	1
25-0	491	2.5	60	14	17	22	26	29	34	39	8	1
25-10	525	2.5	62	14	17	22	25	28	32	37	8	1
26-8	560	2.5	64	13	16	21	24	27	31	35	8	1
27-7	596	2.5	66	13	15	21	24	26	30	34	8	1
28-5	634	2.5	68	12	15	20	23	25	29	33	8	1
29-3	672	2.5	70	12	15	20	22	24	28	32	8	1
30-1	712	2.5	72	12	14	19	21	23	26	30	8	1
30-11	752	2.5	74	11	14	18	20	22	25	29	8	2
31-10	794	3.0	76	11	14	18	20	22	25	28	8	2
32-8	837	3.0	78	11	13	17	19	21	24	27	8	2
33-6	881	3.0	80	10	13	17	19	20	23	26	8	2
34-4	926	3.0	82	10	13	17	18	20	23	26	8	2
35-2	973	3.0	84	9	13	16	18	19	22	25	8	2
36-0	1020	3.0	86		13	16	17	18	21	24	8	2
36-11	1069	3.0	88		12	15	17	18	21	24	8	3
37-9	1119	3.0	90			15	16	17	20	23	8	3
38-7	1170	3.0	92			15	16	17	20	22	8	3
39-5	1222	3.0	94			14	15	16	19	21	8	3
40-3	1275	3.0	96				15	16	19	21	8	3
41-2	1329	3.0	98				15	16	18	20	8	3
42-0	1384	3.0	100				14	15	17	19	8	4
42-10	1441	3.0	102				14	15	17	19	8	4
43-8	1499	3.0	104					14	16	18	8	4
44-6	1557	3.0	106					14	16	19	8	4
45-5	1617	3.0	108					13	15	16	8	4
46-3	1679	3.0	110					13	14	15	8	4
47-1	1741	3.0	112						15	16	8	4
47-11	1804	3.0	114						15	16	8	4
48-9	1868	3.0	116						14	15	8	4
49-7	1934	3.5	118						14	15	8	4
50-6	2001	3.5	120							15	8	4

Notes:
1. **Not for a specific structural design. Use for budget estimating only. Finite Element Analysis (CANDE) is required for final design and quotation.**
2. The above table is based upon the general requirements of the AASHTO LRFD Design Specification, Section 12, and:
   a. These tables are based upon a trench condition installation.
   b. Backfill material per AASHTO M 145. For estimating, assume A-1 material.
      With specific site information, alternate backfill materials may be allowed. Refer to Table 69 (pg. 106).
   c. Backfill 120 pcf in density and compacted to a minimum of 90% modified proctor.
   d. The minimum cover is per article 12.8.9.4
   e. The minimum select backfill width (six to eight feet) is measured from outside the maximum span on each side of the structure.
      This width only applies when the material adjacent to the select zone is determined to be competent, well consolidated material.
3. Select backfill width may increase for situations where lower strength fill exists in either the select fill zone or the adjacent embankment zone.
4. This estimate is for single barrel structures. For multiple barrels, more investigation is required.

TABLE 71. BRIDGECOR ROUND PIPE 15" X 5½"

WEIGHT TABLES

Inside Diameter		Gage Thickness (Inches) Weight Shown as per Foot of Structure							Plate Make-Up					
Diameter Ft.-In.	Total S	8 (0.170)	7 (0.188)	5 (0.218)	3 (0.249)	1 (0.280)	5/16 (0.318)	3/8 (0.380)	9 S	8 S	7 S	6 S	5 S	Total Plates
19-11	48	680	750	867	987	1107	1325	1574		6				6
20-9	50	706	779	900	1025	1149	1375	1635	2	4				6
21-7	52	731	808	933	1063	1191	1426	1696	4	2				6
22-6	54	757	837	966	1101	1234	1476	1757	6					6
23-4	56	793	875	1012	1152	1292	1546	1837		7				7
24-2	58	819	904	1045	1190	1334	1596	1898	2	5				7
25-0	60	845	933	1078	1227	1376	1646	1958	4	3				7
25-10	62	870	962	1111	1265	1418	1697	2019	6	1				7
26-8	64	907	1001	1156	1316	1476	1766	2099		8				8
27-7	66	932	1029	1189	1354	1518	1817	2160	2	6				8
28-5	68	958	1058	1222	1392	1561	1867	2221	4	4				8
29-3	70	983	1087	1255	1430	1603	1918	2282	6	2				8
30-1	72	1009	1116	1289	1468	1645	1968	2342	8					8
30-11	74	1046	1154	1334	1519	1703	2038	2422	2	7				9
31-10	76	1071	1183	1367	1557	1745	2088	2483	4	5				9
32-8	78	1097	1212	1400	1594	1787	2138	2544	6	3				9
33-6	80	1122	1241	1433	1632	1829	2189	2605	8	1				9
34-4	82	1159	1279	1478	1683	1887	2258	2685	2	8				10
35-2	84	1185	1308	1511	1721	1930	2309	2746	4	6				10
36-0	86		1337	1545	1759	1972	2359	2806	6	4				10
36-11	88		1366	1578	1797	2014	2410	2867	8	2				10
37-9	90			1611	1835	2056	2460	2928	10					10
38-7	92			1656	1886	2114	2530	3008	4	7				11
39-5	94			1689	1923	2156	2580	3069	6	5				11
40-3	96				1961	2198	2630	3130	8	3				11
41-2	98				1999	2241	2681	3190	10	1				11
42-0	100				2050	2299	2750	3270	4	8				12
42-10	102				2088	2341	2801	3331	6	6				12
43-8	104					2383	2851	3392	8	4				12
44-6	106					2425	2902	3453	10	2				12
45-5	108					2467	2952	3514	12					12
46-3	110					2525	3022	3594	6	7				13
47-1	112						3072	3654	8	5				13
47-11	114						3122	3715	10	3				13
48-9	116						3173	3776	12	1				13
49-7	118						3242	3856	6	8				14
50-6	120							3917	8	6				14

Notes:
1. Custom shapes and alternate sizes are available. Please contact your Contech representative.
2. Weights include 3/4” diameter fasteners for assembly. Inquire for cases utilizing 7/8” diameter fasteners.
3. Weights include a galvanized coating which is 3 ounces per square foot, total both sides.
4. Alternate plate make-ups may be supplied due to material availability, which may effect the structure weight.
5. Plates are 45” in net length except for 5/16 and 3/8 gages, which are 30” net length.
6. If Unbalanced Channels are supplied, add 20 pounds per foot to the structure length.

TABLE 72. BRIDGECOR SINGLE RADIUS ARCH 15" X 5½"														
LRFD HEIGHT OF COVER GUIDE (HL-93 LOADING)														
Dimensions to Inside Corrugation					**Gage Thickness (Inches) Maximum Height of Cover Shown in Feet**									
Bottom Span Ft.-In.	**Rise Ft.-In.**	**Approx. Area Sq. Ft.**	**Min Cover (Feet)**	**Total S**	**8 (0.170)**	**7 (0.188)**	**5 (0.218)**	**3 (0.249)**	**1 (0.280)**	**5/16 (0.318)**	**3/8 (0.380)**	**Select Fill Width (Feet)**	**Precon (min Level)**
19-7	9-9	150	2.0	23	20	24	29	34	39	44	49	8	1
19-10	5-0	66	2.0	17	19	23	28	32	36	41	46	8	1
20-5	10-2	164	2.0	24	19	22	27	32	37	42	47	8	1
21-3	10-7	177	2.0	25	18	21	26	31	36	40	45	8	1
22-1	11-0	192	2.0	26	17	20	25	30	34	39	44	8	1
22-10	11-6	207	2.0	27	17	20	25	29	33	37	42	8	1
23-10	11-11	222	2.0	28	16	19	24	28	32	36	40	8	1
24-8	12-4	238	2.0	29	15	18	23	27	30	34	38	8	1
24-8	6-0	103	2.0	21	15	17	21	25	28	31	34	8	1
25-6	12-9	255	2.0	30	14	17	21	25	29	33	37	8	1
26-4	13-2	272	2.0	31	14	17	21	25	28	31	35	8	1
27-2	13-7	290	2.0	32	13	16	20	24	27	30	34	8	2
28-0	14-0	309	2.0	33	12	15	19	23	26	29	33	8	2
28-10	7-5	149	2.0	25	11	13	16	20	24	27	30	8	2
28-10	14-5	328	2.0	34	12	14	18	21	25	28	32	8	2
29-8	14-10	347	2.0	35	11	14	17	21	24	28	31	8	2
30-6	15-3	367	2.0	36	11	13	16	19	23	26	29	8	2
31-6	15-9	388	2.0	37	11	13	16	19	22	25	28	8	2
32-4	16-1	409	2.0	38	10	12	15	18	21	24	27	8	2
33-2	16-7	431	2.0	39	10	11	14	17	20	23	26	8	2
34-0	17-0	453	2.0	40	10	11	14	17	19	23	25	8	2
34-1	9-2	219	2.0	30	10	11	14	17	19	21	23	8	2
35-8	17-10	500	2.0	42	9	11	13	16	18	20	22	8	2
37-0	18-9	548	2.0	44		11	13	15	17	19	21	8	2
38-11	10-2	278	2.0	34		10	12	14	16	18	20	8	2
39-0	19-6	599	2.0	46		10	12	14	16	18	19	8	2
40-8	20-4	653	2.0	48			12	13	15	16	17	8	3
42-6	21-3	708	2.0	50			12	13	14	15	16	8	3
44-2	22-1	766	2.0	52			11	12	13	14	15	8	3
45-10	22-11	826	2.0	54			10	11	12	13	14	8	3
46-0	11-9	380	2.0	40				12	12	13	14	8	3
49-2	24-7	953	2.5	58					11	13	14	8	3
51-0	25-6	1019	2.5	60					10	13	14	8	3
52-8	26-4	1088	3.0	62						12	13	8	3
54-4	27-2	1160	3.5	64						11	12	8	3

Notes:
1. **Not for a specific structural design. Use for budget estimating only. Finite Element Analysis (CANDE) is required for final design and quotation.**
2. The above table is based upon the general requirements of the AASHTO LRFD Design Specification, Section 12, and:
   a. These tables are based upon a trench condition installation.
   b. Backfill material per AASHTO M 145. For estimating, assume A-1 material.
      With specific site information, alternate backfill materials may be allowed. Refer to Table 69 (pg. 106).
   c. Backfill 120 pcf in density and compacted to a minimum of 90% modified proctor.
   d. The minimum cover is per article 12.8.9.4
   e. The minimum select backfill width (six to eight feet) is measured from outside the maximum span on each side of the structure.
      This width only applies when the material adjacent to the select zone is determined to be competent, well consolidated material.
3. Select backfill width may increase for situations where lower strength fill exists in either the select fill zone or the adjacent embankment zone.
4. This estimate is for single barrel structures. For multiple barrels, more investigation is required.

TABLE 73. BRIDGECOR SINGLE RADIUS ARCH 15" X 5½"															
WEIGHT TABLES															
Dimensions to Inside Corrugation			Gage Thickness (Inches) Weight Shown as per Foot of Structure							Plate Make-Up					
Bottom Span Ft.-In.	Rise Ft.-In.	Total S	8 (0.170)	7 (0.188)	5 (0.218)	3 (0.249)	1 (0.280)	5/16 (0.318)	3/8 (0.380)	9 S	8 S	7 S	6 S	5 S	Total Plates
19-7	9-9	23	325	358	414	472	530	631	751		2	1			3
19-10	5-0	17	237	262	303	345	387	461	549	1	1				2
20-5	10-2	24	337	373	431	491	551	656	781	1	1	1			3
21-3	10-7	25	350	387	447	510	572	681	811	1	2				3
22-1	11-0	26	363	401	464	529	593	707	842	2	1				3
22-10	11-6	27	386	427	493	561	629	751	893			3	1		4
23-10	11-11	28	399	440	509	580	650	776	923		2	1		1	4
24-8	12-4	29	412	455	526	599	671	801	953		1	3			4
24-8	6-0	21	299	330	381	434	487	581	691		1	1	1		3
25-6	12-9	30	425	469	542	618	693	827	983		2	2			4
26-4	13-2	31	438	483	559	636	714	852	1013		3	1			4
27-2	13-7	32	451	498	575	655	735	877	1044	1	2	1			4
28-0	14-0	33	463	512	592	674	756	902	1074	1	3				4
28-10	14-5	34	476	526	608	693	778	927	1104	2	2				4
29-8	14-10	35	489	541	625	712	799	953	1135	3	1				4
28-10	7-5	25	350	387	447	510	572	681	811	1	2				3
30-6	15-3	36	513	566	654	744	835	997	1186		1	4			5
31-6	15-9	37	525	580	670	763	856	1022	1216		3	1	1		5
32-4	16-1	38	538	594	687	782	877	1047	1246		3	2			5
33-2	16-7	39	551	608	703	801	899	1073	1276		4	1			5
34-0	17-0	40	564	623	720	820	920	1098	1306	1	3	1			5
34-1	9-2	30	425	469	542	618	693	827	983		2	2			4
35-8	17-10	42	590	651	753	858	962	1148	1367	2	3				5
37-0	18-9	44		680	786	896	1004	1199	1427	4	1				5
38-11	10-2	34		526	608	693	778	927	1104	2	2				4
39-0	19-6	46		719	831	947	1062	1268	1508		4	2			6
40-8	20-4	48			864	984	1104	1319	1569	2	2	2			6
42-6	21-3	50			898	1022	1147	1369	1629	2	4				6
44-2	22-1	52			931	1060	1189	1419	1690	4	2				6
45-10	22-11	54			976	1111	1246	1489	1771		5	2			7
46-0	11-9	40				820	920	1098	1306	1	3	1			5
49-2	24-7	58					1331	1590	1891	2	5				7
51-0	25-6	60					1373	1640	1952	4	3				7
52-8	26-4	62							2013	6	1				7
54-4	27-2	64							2093	1	6	1			8

Notes:
1. Custom shapes and alternate sizes are available. Please contact your Contech representative.
2. Weights include 3/4" diameter fasteners for assembly. Inquire for cases utilizing 7/8" diameter fasteners.
3. Weights include a galvanized coating which is 3 ounces per square foot, total both sides.
4. Alternate plate make-ups may be supplied due to material availability, which may effect the structure weight.
5. Plates are 45" in net length except for 5/16 and 3/8 gages, which are 30" net length.
6. If Unbalanced Channels are supplied, add 20 pounds per foot to the structure length.

TABLE 74. BRIDGECOR 2-RADIUS ARCH 15 X 5½												
LRFD HEIGHT OF COVER GUIDE (HL-93 LOADING)												
Dimensions to Inside Corrugation				**Gage Thickness (Inches) - Height of Cover Shown in Feet Maximum Height of Cover (Minimum Height of Cover)**								
Maximum Span Ft.-In.	**Rise Ft.-In.**	**Approx. Area Sq. Ft.**	**Total S**	**8 (0.170)**	**7 (0.188)**	**5 (0.218)**	**3 (0.249)**	**1 (0.280)**	**5/16 (0.318)**	**3/8 (0.380)**	**Select Fill Width (Feet)**	**Precon (min Level)**
18-5	8-4	124	21	20 (2.0)	24 (2.0)	28 (1.5)	33 (1.5)	38 (1.5)	43 (1.5)	48 (1.5)	8	2
22-0	10-0	173	25	17 (2.0)	21 (2.0)	25 (1.5)	29 (1.5)	34 (1.5)	39 (1.5)	44 (1.5)	8	2
23-5	9-3	172	25	15 (2.0)	18 (2.0)	21 (1.5)	24 (1.5)	27 (1.5)	30 (1.5)	33 (1.5)	8	2
25-5	11-7	228	29	14 (2.0)	17 (2.0)	20 (2.0)	23 (2.0)	26 (2.0)	29 (2.0)	33 (2.0)	8	2
26-11	10-10	233	29	13 (2.5)	16 (2.0)	19 (2.0)	22 (2.0)	25 (2.0)	29 (2.0)	33 (2.0)	8	2
27-2	9-10	212	28	12 (2.5)	14 (2.5)	16 (2.0)	18 (2.0)	20 (2.0)	23 (2.0)	26 (2.0)	8	2
28-11	13-2	306	33	12 (2.0)	15 (2.0)	18 (2.0)	21 (2.0)	24 (2.0)	27 (2.0)	30 (2.0)	8	3
31-8	12-8	320	34	10 (2.5)	12 (2.0)	15 (2.0)	18 (2.0)	21 (2.0)	24 (2.0)	27 (2.0)	8	3
31-11	11-8	295	33	10 (2.5)	12 (2.5)	14 (2.0)	16 (2.0)	18 (2.0)	20 (2.0)	23 (2.0)	8	3
32-2	10-8	271	32	9 (2.0)	10 (2.0)	11 (2.0)	12 (2.0)	14 (2.0)	16 (2.0)	18 (2.0)	8	3
32-5	14-9	385	37	9 (2.0)	11 (2.0)	14 (2.0)	17 (2.0)	20 (2.0)	23 (2.0)	26 (2.0)	8	3
35-10	11-4	318	35	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	11 (2.0)	12 (2.0)	14 (2.0)	8	3
35-11	16-5	473	41	9 (2.0)	11 (2.0)	13 (2.0)	15 (2.0)	17 (2.0)	20 (2.0)	23 (2.0)	8	3
36-5	14-5	420	39	9 (2.0)	11 (2.0)	13 (2.0)	15 (2.0)	17 (2.0)	20 (2.0)	23 (2.0)	8	3
37-10	13-8	412	39	8 (2.5)	11 (2.0)	13 (2.0)	14 (2.0)	16 (2.0)	18 (2.0)	20 (2.0)	8	3
38-1	12-9	382	38	8 (2.0)	9 (2.0)	10 (2.0)	11 (2.0)	12 (2.0)	14 (2.5)	16 (2.0)	8	3
39-5	18-0	569	45		10 (2.0)	12 (2.0)	14 (2.0)	16 (2.0)	18 (2.0)	20 (2.0)	8	3
39-11	16-1	512	43		10 (2.0)	12 (2.0)	14 (2.0)	16 (2.0)	18 (2.0)	21 (2.0)	8	3
40-10	12-2	387	39			6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	8	4
42-7	15-6	525	44		9 (2.0)	11 (2.0)	13 (2.0)	15 (2.0)	17 (2.0)	19 (2.0)	8	4
42-11	19-7	675	49			12 (2.0)	14 (2.0)	15 (2.0)	17 (2.0)	18 (2.0)	8	4
43-1	13-7	458	42			8 (2.0)	9 (2.0)	10 (2.0)	11 (2.0)	12 (2.0)	8	4
44-1	14-9	513	44			9 (2.0)	10 (2.0)	11 (2.0)	12 (2.0)	13 (2.0)	8	4
44-7	17-10	637	48			11 (2.0)	13 (2.0)	14 (2.0)	16 (2.0)	18 (2.0)	8	4
46-5	21-2	790	53			10 (2.0)	12 (2.0)	13 (2.0)	14 (2.0)	16 (2.0)	8	4
47-4	17-4	652	49			10 (2.0)	11 (2.0)	12 (2.0)	14 (2.0)	16 (2.0)	8	4
48-0	14-5	539	46			5 (2.0)	6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	8	4
48-1	19-6	749	52			10 (2.0)	12 (2.0)	13 (2.0)	14 (2.0)	16 (2.0)	8	4
48-7	17-7	676	50			9 (2.0)	11 (2.0)	12 (2.0)	14 (2.0)	16 (2.0)	8	4
49-11	22-10	914	57				10 (2.0)	11 (2.0)	13 (2.0)	15 (2.0)	8	4
50-0	16-10	662	50				8 (2.5)	10 (2.5)	12 (2.5)	14 (2.0)	8	4
50-3	15-10	623	49				7 (2.5)	8 (2.5)	9 (2.5)	10 (2.0)	8	4
50-7	19-11	804	54				11 (2.5)	12 (2.5)	13 (2.5)	15 (2.0)	8	4

Notes:
1. **Not for a specific structural design. Use for budget estimating only. Finite Element Analysis (CANDE) is required for final design and quotation.**
2. The above table is based upon the general requirements of the AASHTO LRFD Design Specification, Section 12, and:
   a. These tables are based upon a trench condition installation.
   b. Backfill material per AASHTO M 145. For estimating, assume A-1 material.
   With specific site information, alternate backfill materials may be allowed. Refer to Table 69 (pg. 106).
   c. Backfill 120 pcf in density and compacted to a minimum of 90% modified proctor.
   d. The minimum cover is per article 12.8.9.4
   e. The minimum select backfill width (six to eight feet) is measured from outside the maximum span on each side of the structure.
   This width only applies when the material adjacent to the select zone is determined to be competent, well consolidated material.
3. Select backfill width may increase for situations where lower strength fill exists in either the select fill zone or the adjacent embankment zone.
4. This estimate is for single barrel structures. For multiple barrels, more investigation is required.

TABLE 75. BRIDGECOR 2-RADIUS ARCH 15" X 5½"

WEIGHT TABLES

Dimensions to Inside Corrugation			Gage Thickness (Inches) Weight Shown as per Foot of Structure							Plate Make-Up					
Maximum Span Ft.-In.	Rise Ft.-In.	Total S	8 (0.170)	7 (0.188)	5 (0.218)	3 (0.249)	1 (0.280)	5/16 (0.318)	3/8 (0.380)	9 S	8 S	7 S	6 S	5 S	Total Plates
18-5	8-4	21	299	330	381	434	487	581	691		1	1	1		3
22-0	10-0	25	350	387	447	510	572	681	811	1	2				3
23-5	9-3	25	350	387	447	510	572	681	811	1	2				3
25-5	11-7	29	412	455	526	599	672	801	954	1	1		2		4
26-11	10-10	29	412	455	526	599	672	801	954		1	3			4
27-2	9-10	28	399	441	509	580	650	776	923		1	2	1		4
28-11	13-2	33	474	523	604	687	771	921	1096			3	2		5
31-8	12-8	34	476	526	608	693	778	927	1104	2	2				4
31-11	11-8	33	463	512	592	674	756	902	1074	1	3				4
32-2	10-8	32	451	498	575	655	735	877	1044	1	2	1			4
32-5	14-9	37	525	580	670	763	856	1022	1216		3	1	1		5
35-10	11-4	35	489	541	625	712	799	953	1135	3	1				4
35-11	16-5	41	577	637	736	839	941	1123	1337	2	2	1			5
36-5	14-5	39	571	620	716	814	913	1092	1298			3	3		6
37-10	13-8	39	561	608	703	801	898	1072	1276	2	2			1	5
38-1	12-9	38	538	594	687	782	877	1047	1246		3	2			5
39-5	18-0	45		705	815	928	1040	1243	1478		3	3			6
39-11	16-1	43		676	782	890	998	1192	1418		3	2		1	6
40-10	12-2	39			703	801	899	1073	1276		4	1			5
42-7	15-6	44		702	811	922	1034	1237	1470			3	3	1	7
42-11	19-7	49			871	1003	1126	1344	1599	1	5				6
43-1	13-7	42			753	858	962	1148	1367	2	3				5
44-1	14-9	44			786	896	1004	1199	1427	4	1				5
44-7	17-10	48			864	984	1104	1319	1569	2	2	2			6
46-5	21-2	53			947	1079	1210	1445	1720	5	1				6
47-4	17-4	49			883	1016	1140	1363	1621		3	1	3		7
48-0	14-5	46			831	947	1062	1268	1508		4	2			6
48-1	19-6	52			931	1060	1189	1419	1690	4	2				6
48-7	17-7	50			910	1035	1162	1388	1651		3	2	2		7
49-11	22-10	57				1167	1310	1565	1861	1	6				7
50-0	16-10	50				1048	1176	1407	1673			2	6		8
50-3	15-10	49				1003	1126	1344	1599	1	5				6
50-7	19-11	54				1111	1246	1489	1771		5	2			7

Notes:
1. Custom shapes and alternate sizes are available. Please contact your Contech representative.
2. Weights include 3/4″ diameter fasteners for assembly. Inquire for cases utilizing 7/8″ diameter fasteners.
3. Weights include a galvanized coating which is 3 ounces per square foot, total both sides.
4. Alternate plate make-ups may be supplied due to material availability, which may effect the structure weight.
5. Plates are 45″ in net length except for 5/16 and 3/8 gages, which are 30″ net length.
6. If Unbalanced Channels are supplied, add 20 pounds per foot to the structure length.

TABLE 76. BRIDGECOR BOX CULVERT 15 X 5½												
LRFD HEIGHT OF COVER GUIDE (HL-93 LOADING)												
Dimensions to Inside Corrugation			**Gage Thickness (Inches) - Height of Cover Shown in Feet Maximum Height of Cover (Minimum Height of Cover)**									
Bottom Span Ft.-In.	**Rise Ft.-In.**	**Approx. Area Sq. Ft.**	**Total S**	**8 (0.170)**	**7 (0.188)**	**5 (0.218)**	**3 (0.249)**	**1 (0.280)**	**5/16 (0.318)**	**3/8 (0.380)**	**Select Fill Width (Feet)**	**Precon (min Level)**
19-7	5-10	93	19	8 (2.25)	9 (2.0)	11 (1.5)	13 (1.5)	15 (1.5)	17 (1.5)	21 (1.5)	8	1
20-0	7-1	119	21	9 (2.25)	10 (2.0)	12 (1.5)	14 (1.5)	15 (1.5)	18 (1.5)	21 (1.5)	8	1
20-4	8-5	145	23	9 (2.25)	10 (2.0)	12 (1.5)	14 (1.5)	15 (1.5)	18 (1.5)	21 (1.5)	8	1
20-6	9-9	172	25	9 (2.25)	10 (2.0)	12 (1.5)	14 (1.5)	15 (1.5)	18 (1.5)	21 (1.5)	8	1
20-7	6-1	102	20	7 (2.25)	8 (2.0)	10 (1.5)	12 (1.5)	13 (1.5)	15 (1.5)	19 (1.5)	8	1
21-0	7-5	130	22	7 (2.25)	8 (2.0)	10 (1.5)	12 (1.5)	13 (1.5)	15 (1.5)	18 (1.5)	8	1
21-3	8-9	157	24	7 (2.25)	8 (2.0)	10 (1.5)	12 (1.5)	13 (1.5)	15 (1.5)	18 (1.5)	8	1
21-4	10-0	186	26	8 (2.25)	9 (2.0)	11 (1.5)	12 (1.5)	14 (1.5)	15 (1.5)	18 (1.5)	8	1
21-10	6-4	112	21	7 (2.25)	8 (2.0)	10 (1.5)	12 (1.5)	13 (1.5)	15 (1.5)	18 (1.5)	8	1
22-3	7-8	141	23	6 (2.25)	7 (2.0)	9 (1.5)	11 (1.5)	12 (1.5)	14 (1.5)	17 (1.5)	8	1
22-7	8-11	171	25	7 (2.25)	8 (2.0)	10 (1.5)	11 (1.5)	13 (1.5)	14 (1.5)	17 (1.5)	8	1
22-9	10-3	200	27	7 (2.25)	8 (2.0)	10 (1.5)	11 (1.5)	13 (1.5)	14 (1.5)	17 (1.5)	8	1
23-0	6-7	123	22	6 (2.25)	7 (2.0)	9 (1.5)	10 (1.5)	12 (1.5)	13 (1.5)	16 (1.5)	8	1
23-5	7-11	153	24	6 (2.25)	7 (2.0)	9 (1.5)	10 (1.5)	12 (1.5)	13 (1.5)	16 (1.5)	8	1
23-8	9-3	184	26	6 (2.25)	7 (2.0)	9 (1.5)	10 (1.5)	12 (1.5)	13 (1.5)	16 (1.5)	8	1
23-10	10-7	215	28	6 (2.25)	7 (2.0)	9 (1.5)	10 (1.5)	12 (1.5)	13 (1.5)	16 (1.5)	8	1
24-2	6-11	133	23	6 (2.25	7 (2.0)	8 (1.5)	9 (1.5)	11 (1.5)	12 (1.5)	15 (1.5)	8	1
24-6	8-2	165	25	6 (2.25)	7 (2.0)	8 (1.5)	9 (1.5)	10 (1.5)	12 (1.5)	14 (1.5)	8	1
24-9	9-6	198	27	6 (2.25)	7 (2.0)	8 (1.5)	9 (1.5)	10 (1.5)	12 (1.5)	14 (1.5)	8	1
24-11	10-10	231	29	6 (2.25)	7 (2.0)	8 (1.5)	9 (1.5)	11 (1.5)	12 (1.5)	15 (1.5)	8	1
25-5	7-2	145	24	5 (2.25)	6 (2.0)	8 (2.0)	9 (2.0)	11 (2.0)	12 (2.0)	14 (2.0)	8	2
25-10	8-6	178	26	6 (2.25)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	12 (2.0)	14 (2.0)	8	2
26-1	9-9	212	28	6 (2.25)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	12 (2.0)	14 (2.0)	8	2
26-3	11-1	247	30	6 (2.25)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	12 (2.0)	14 (2.0)	8	2
26-5	7-6	157	25	5 (2.25)	6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	11 (2.0)	13 (2.0)	8	2
26-9	8-9	192	27	5 (2.25)	6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	11 (2.0)	13 (2.0)	8	2
27-0	10-1	227	29	6 (2.25)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	11 (2.0)	13 (2.0)	8	2
27-1	11-5	263	31	6 (2.25)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	11 (2.0)	13 (2.0)	8	2

Notes:
1. **Not for a specific structural design. Use for budget estimating only. Finite Element Analysis (CANDE) is required for final design and quotation.**
2. The above table is based upon the general requirements of the AASHTO LRFD Design Specification, Section 12, and:
   a. These tables are based upon a trench condition installation.
   b. Backfill material per AASHTO M 145. For estimating, assume A-1 material.
   With specific site information, alternate backfill materials may be allowed. Refer to Table 69 (pg. 106).
   c. Backfill 120 pcf in density and compacted to a minimum of 90% modified proctor.
   d. The minimum cover is per article 12.8.9.4
   e. The minimum select backfill width (six to eight feet) is measured from outside the maximum span on each side of the structure.
   This width only applies when the material adjacent to the select zone is determined to be competent, well consolidated material.
3. Select backfill width may increase for situations where lower strength fill exists in either the select fill zone or the adjacent embankment zone.
4. This estimate is for single barrel structures. For multiple barrels, more investigation is required.

TABLE 77. BRIDGECOR BOX CULVERT 15 X 5½												
LRFD HEIGHT OF COVER GUIDE (HL-93 LOADING)												
Dimensions to Inside Corrugation			**Gage Thickness (Inches) - Height of Cover Shown in Feet Maximum Height of Cover (Minimum Height of Cover)**									
Bottom Span Ft.-In.	**Rise Ft.-In.**	**Approx. Area Sq. Ft.**	**Total S**	**8 (0.170)**	**7 (0.188)**	**5 (0.218)**	**3 (0.249)**	**1 (0.280)**	**5/16 (0.318)**	**3/8 (0.380)**	**Select Fill Width (Feet)**	**Precon (Min Level)**
27-8	7-9	169	26	5 (2.25)	6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	12 (2.0)	8	2
28-0	9-1	206	28	5 (2.25)	6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	12 (2.0)	8	2
28-3	10-5	243	30	5 (2.25)	6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	12 (2.0)	8	2
28-5	11-8	280	32	6 (2.25)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	11 (2.0)	13 (2.0)	8	2
28-10	8-1	182	27	5 (2.25)	6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	12 (2.0)	8	2
29-3	9-4	220	29	5 (2.25)	6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	12 (2.0)	8	2
29-6	10-8	259	31	5 (2.25)	6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	12 (2.0)	8	2
29-8	12-0	298	33	6 (2.25)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	11 (2.0)	13 (2.0)	8	2
29-11	8-4	196	28	5 (2.25)	6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	12 (2.0)	8	2
30-4	9-8	236	30	5 (2.25)	6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	11 (2.0)	8	2
30-8	11-0	275	32	5 (2.25)	6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	11 (2.0)	8	2
30-10	12-4	316	34	5 (2.25)	6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	12 (2.0)	8	2
31-0	8-8	210	29		5 (2.0)	6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	11 (2.0)	8	2
31-4	10-0	251	31		5 (2.0)	6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	11 (2.0)	8	2
31-7	11-4	292	33		6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	12 (2.0)	8	2
31-8	12-8	334	35		6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	12 (2.0)	8	2
32-2	9-0	224	30		5 (2.0)	6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	11 (2.0)	8	2
32-7	10-4	267	32		6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	11 (2.0)	8	2
32-10	11-7	310	34		6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	12 (2.0)	8	2
32-11	12-11	353	36		7 (2.0)	8 (2.5)	9 (2.0)	10 (2.0)	11 (2.0)	12 (2.0)	8	2
33-3	9-4	240	31		5 (2.0)	6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	11 (2.0)	8	2
33-8	10-7	284	33		6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	11 (2.0)	8	2
33-11	11-11	328	35		6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	12 (2.0)	8	2
34-0	13-3	373	37		7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	11 (2.0)	12 (2.0)	8	2

Notes:
1. Custom shapes and alternate sizes are available. Please contact your Contech representative.
2. **Not for a specific structural design. Use for budget estimating only. Finite Element Analysis (CANDE) is required for final design and quotation.**
3. The above table is based upon the general requirements of the AASHTO LRFD Design Specification, Section 12, and:
   a. These tables are based upon a trench condition installation.
   b. Backfill material per AASHTO M 145. For estimating, assume A-1 material.
      With specific site information, alternate backfill materials may be allowed. Refer to Table 69 (pg. 106).
   c. Backfill 120 pcf in density and compacted to a minimum of 90% modified proctor.
   d. The minimum cover is per article 12.8.9.4
   e. The minimum select backfill width (six to eight feet) is measured from outside the maximum span on each side of the structure.
      This width only applies when the material adjacent to the select zone is determined to be competent, well consolidated material.
4. Select backfill width may increase for situations where lower strength fill exists in either the select fill zone or the adjacent embankment zone.
5. This estimate is for single barrel structures. For multiple barrels, more investigation is required.

TABLE 78. BRIDGECOR BOX CULVERT 15 X 5½												
LRFD HEIGHT OF COVER GUIDE (HL-93 LOADING)												
Dimensions to Inside Corrugation			**Gage Thickness (Inches) - Height of Cover Shown in Feet Maximum Height of Cover (Minimum Height of Cover)**									
Bottom Span Ft.-In.	**Rise Ft.-In.**	**Approx. Area Sq. Ft.**	**Total S**	**8 (0.170)**	**7 (0.188)**	**5 (0.218)**	**3 (0.249)**	**1 (0.280)**	**5/16 (0.318)**	**3/8 (0.380)**	**Select Fill Width (Feet)**	**Precon (Min Level)**
34-4	9-7	255	32		5 (2.0)	6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	8	3
34-9	10-11	301	34		5 (2.0)	6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	8	3
35-0	12-3	347	36		6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	12 (2.0)	8	3
35-1	13-7	393	38		6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	12 (2.0)	8	3
35-6	9-11	272	33		5 (2.0)	6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	8	3
35-10	11-3	318	35		5 (2.0)	6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	8	3
36-1	12-7	366	37		6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	11 (2.0)	8	3
36-2	13-11	414	39		6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	12 (2.0)	8	3
36-8	10-3	288	34		5 (2.0)	6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	8	3
37-0	11-7	337	36		5 (2.0)	6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	8	3
37-3	12-11	385	38		6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	12 (2.0)	8	3
37-5	14-3	435	40		7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	11 (2.0)	12 (2.0)	8	3
37-9	10-7	306	35		5 (2.0)	6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	8	3
38-1	11-11	355	37		5 (2.0)	6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	8	3
38-4	13-3	406	39		7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	11 (2.0)	12 (2.0)	8	3
38-6	14-7	456	41		7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	11 (2.0)	12 (2.0)	8	3
38-10	10-11	323	36		6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	11 (2.0)	8	3
39-3	12-3	375	38		6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	11 (2.0)	8	3
39-6	13-7	426	40		7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	11 (2.0)	12 (2.0)	8	3
39-8	14-10	479	42		7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	11 (2.0)	12 (2.0)	8	3
39-11	11-3	342	37		6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	11 (2.0)	8	4
40-4	12-7	394	39		6 (2.0)	7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	11 (2.0)	8	4
40-7	13-11	448	41		7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	11 (2.0)	12 (2.0)	8	4
40-9	15-2	501	43		7 (2.0)	8 (2.0)	9 (2.0)	10 (2.0)	11 (2.0)	12 (2.0)	8	4

Notes:
1. **Not for a specific structural design. Use for budget estimating only. Finite Element Analysis (CANDE) is required for final design and quotation.**
2. The above table is based upon the general requirements of the AASHTO LRFD Design Specification, Section 12, and:
   a. These tables are based upon a trench condition installation.
   b. Backfill material per AASHTO M 145. For estimating, assume A-1 material.
   With specific site information, alternate backfill materials may be allowed. Refer to Table 69 (pg. 106).
   c. Backfill 120 pcf in density and compacted to a minimum of 90% modified proctor.
   d. The minimum cover is per article 12.8.9.4
   e. The minimum select backfill width (six to eight feet) is measured from outside the maximum span on each side of the structure.
   This width only applies when the material adjacent to the select zone is determined to be competent, well consolidated material.
3. Select backfill width may increase for situations where lower strength fill exists in either the select fill zone or the adjacent embankment zone.
4. This estimate is for single barrel structures. For multiple barrels, more investigation is required.

TABLE 79. BRIDGECOR BOX CULVERT 15" X 5½"															
WEIGHT TABLES															
Dimensions to Inside Corrugation			**Gage Thickness (Inches) Weight Shown as per Foot of Structure**							**Plate Make-Up**					
Total S	**Bottom Span Ft.-In.**	**Rise Ft.-In.**	**8 (0.170)**	**7 (0.188)**	**5 (0.218)**	**3 (0.249)**	**1 (0.280)**	**5/16 (0.318)**	**3/8 (0.380)**	**9 S**	**8 S**	**7 S**	**6 S**	**5 S**	**Total Plates**
19	19-7	5-10	273	301	348	396	445	530	631			1	2		3
21	20-0	7-1	299	330	381	434	487	581	691		1	1	1		3
23	20-4	8-5	325	358	414	472	530	656	781	1	1		1		3
25	20-6	9-9	350	387	447	510	572	681	811	1	2				3
20	20-7	6-1	286	315	365	415	466	555	661			2	1		3
22	21-0	7-5	312	344	398	453	508	606	721		1	2			3
24	21-3	8-9	337	373	431	491	551	656	781	1	1	1			3
26	21-4	10-0	363	401	464	529	593	707	842	2	1				3
21	21-10	6-4	299	330	381	434	487	581	691		1	1	1		3
23	22-3	7-8	325	358	414	472	530	656	781		2	1			3
25	22-7	8-11	350	387	447	510	572	681	811	1	2				3
27	22-9	10-3	386	427	493	561	629	751	893	1	1			2	4
22	23-0	6-7	312	344	398	453	508	606	721	1		1	1		3
24	23-5	7-11	337	373	431	491	551	656	781	1	1	1			3
26	23-8	9-3	363	401	464	529	593	707	842	2	1				3
28	23-10	10-7	399	440	509	580	650	753	923	1	1		1	1	4
23	24-2	6-11	335	369	426	485	565	674	802			1	1	2	4
25	24-6	8-2	360	398	459	523	587	699	832		1	1		2	4
27	24-9	9-6	386	427	493	561	629	751	893	1	1			2	4
29	24-11	10-10	412	455	526	599	671	801	953	1	1		2		4
24	25-5	7-2	347	384	443	504	566	674	802			1	2	1	4
26	25-10	8-6	373	412	476	542	608	725	863		1	1	1	1	4
28	26-1	9-9	399	440	509	580	650	753	923	1	1		1	1	4
30	26-3	11-1	425	469	542	618	693	827	983	1	1	1	1		4
25	26-5	7-6	360	398	459	523	587	699	832			1	3		4
27	26-9	8-9	386	427	493	561	629	751	893		1	1	2		4
29	27-0	10-1	412	455	526	599	671	801	953	1	1		2		4
31	27-1	11-5	438	483	559	636	714	852	1013	1	1	2			4
26	27-8	7-9	373	412	476	542	608	725	863			2	2		4
28	28-0	9-1	399	440	509	580	650	753	923		1	2	1		4
30	28-3	10-5	425	469	542	618	693	827	983	1	1	1	1		4
32	28-5	11-8	451	498	575	655	735	877	1044	1	2	1			4
27	28-10	8-1	386	427	493	561	629	751	893			3	1		4
29	29-3	9-4	412	455	526	599	671	801	953		1	3			4
31	29-6	10-8	438	483	559	636	714	852	1013	1	1	2			4
33	29-8	12-0	466	512	592	674	756	902	1074	1	3				4

Notes:
1. Custom shapes and alternate sizes are available. Please contact your Contech representative.
2. Weights include 3/4" diameter fasteners for assembly. Inquire for cases utilizing 7/8" diameter fasteners.
3. Weights include a galvanized coating which is 3 ounces per square foot, total both sides.
4. Alternate plate make-ups may be supplied due to material availability, which may effect the structure weight.
5. Plates are 45" in net length except for 5/16 and 3/8 gages, which are 30" net length.
6. If Unbalanced Channels are supplied, add 20 pounds per foot to the structure length.

TABLE 80. BRIDGECOR BOX CULVERT 15" X 5½"																
WEIGHT TABLES																
Dimensions to Inside Corrugation			**Gage Thickness (Inches) Weight Shown as per Foot of Structure**							**Plate Make-Up**						
Total S	**Bottom Span Ft.-In.**	**Rise Ft.-In.**	**8 (0.170)**	**7 (0.188)**	**5 (0.218)**	**3 (0.249)**	**1 (0.280)**	**5/16 (0.318)**	**3/8 (0.380)**	**9 S**	**8 S**	**7 S**	**6 S**	**5 S**	**Total Plates**
28	29-11	8-4	399	440	509	580	650	753	923		1	2	1		4
30	30-4	9-8	425	469	542	618	693	827	983		2	2			4
32	30-8	11-0	451	498	575	655	735	877	1044	1	2	1			4
34	30-10	12-4	476	526	608	693	778	927	1104	2	2				4
29	31-0	8-8		455	526	599	671	801	953		2	1	1		4
31	31-4	10-0		483	559	636	714	852	1013		3	1			4
33	31-7	11-4		512	592	674	756	902	1074	1	3				4
35	31-8	12-8		666	769	876	983	1174	1397	3	1				4
30	32-2	9-0		469	542	618	693	827	983	1	1	1	1		4
32	32-7	10-4		498	575	655	735	877	1044	1	2	1			4
34	32-10	11-7		526	608	693	778	927	1104	2	2				4
36	32-11	12-11		569	654	744	834	997	1186	1	1	1	2		5
31	33-3	9-4		483	559	636	714	852	1013	2		1	1		4
33	33-8	10-7		512	592	674	756	902	1074	2	1	1			4
35	33-11	11-11		541	625	712	799	953	1135	3	1				4
37	34-0	13-3		591	682	776	871	1022	1216	1	2		2		5
32	34-4	9-7		509	587	668	750	895	1065			2	3		5
34	34-9	10-11		537	620	706	793	945	1125		1	2	2		5
36	35-0	12-3		569	654	744	834	997	1186	1	1	1	2		5
38	35-1	13-7		594	687	782	877	1048	1546	1	1	3			5
33	35-6	9-11		523	604	687	671	920	1095			3	2		5
35	35-10	11-3		552	637	725	814	971	1156		1	3	1		5
37	36-1	12-7		591	682	776	871	1022	1216	1	1	2	1		5
39	36-2	13-11		608	703	801	898	1197	1276	1	2	2			5
34	36-8	10-3		537	620	706	793	945	1125			4	1		5
36	37-0	11-7		569	654	744	834	997	1186		1	4			5
38	37-3	12-11		594	687	782	877	1048	1246	1	1	3			5
40	37-5	14-3		623	720	820	919	1098	1306	1	3	1			5
35	37-9	10-7		552	637	725	814	971	1156		1	3	1		5
37	38-1	11-11		591	682	776	871	1022	1216		2	3			5
39	38-4	13-3		608	703	801	898	1073	1276	1	2	2			5
41	38-6	14-7		637	736	839	941	1123	1336	1	4				5
36	38-10	10-11		569	654	744	834	997	1186		2	2	1		5
38	39-3	12-3		594	687	782	877	1065	1246		3	2			5
40	39-6	13-7		623	720	820	919	1098	1306	1	3	1			5
42	39-8	14-10		651	753	858	962	1148	1367	2	3				5
37	39-11	11-3		591	682	776	871	1040	1237		3	1	1		5
39	40-4	12-7		608	703	801	898	1073	1276		4	1			5
41	40-7	13-11		637	736	839	941	1123	1336	1	4				5
43	40-9	15-2		666	769	876	983	1174	1397	3	2				5

Notes:
1. Weights include 3/4″ diameter fasteners for assembly. Inquire for cases utilizing 7/8″ diameter fasteners.
2. Weights include a galvanized coating which is 3 ounces per square foot, total both sides.
3. Alternate plate make-ups may be supplied due to material availability, which may effect the structure weight.
4. Plates are 45″ in net length except for 5/16″ and 3/8″ gages, which are 30″ net length.
5. If Unbalanced Channels are supplied, add 20 pounds per foot to the structure length.

For more information, call Contech Engineered Solutions:

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