CONTECH®
ENGINEERED SOLUTIONS

MULTI-PLATE®

Aluminum Structural Plate

Aluminum Box Culvert

SUPER-SPAN™ & SUPER-PLATE®

BridgeCor®

Structural Plate Design Guidelines

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Steel and Aluminum Structural Plate design manual.

This design manual 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 guideline, standard CAD details which can be used by any designer to aid with plan preparation are available. Hydraulic nomographs or FHWA HY-8 support is available from your local Contech representative.

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 should contact the local Contech representative or call 800-338-1122 for the telephone number of the local Contech representative.

Design Sequence and References

1. General Structure Selection
   - Guidelines for selection of Hydraulic, Traffic/ Pedestrian passage, 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
   - Performing Structural Checks
   - Design Methods outline
   - American Association of State Highway and Transportation Officials (AASHTO covered herein) **
   - American Iron and Steel Institute
   - 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.

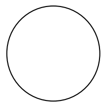
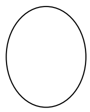
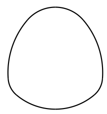
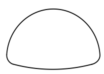
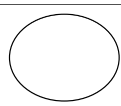
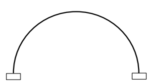
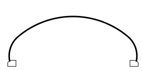
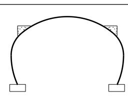
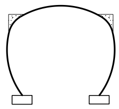
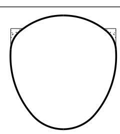
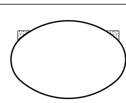
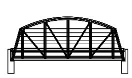
** An NCSPA Corrugated Steel Pipe Design Manual is available from your local Contech representative.

*** 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
   - Toe-walls and cutoff walls
8. Specify Structure Installation Procedure
   - AASHTO Section 26
   - ASTM A807 for steel structures, ASTM B879 for Aluminum Structural Plate
9. Material, Design, and Installation Specifications
   - AASHTO MULTI-PLATE, SUPER-SPAN, Aluminum Structural Plate, Box Culvert and BridgeCor – Material Design and Installation
   - Typical Specifications
10. CAD Drawings
    - Structure Shape and detail drawings are available to the designer upon request.

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

More specific information on each step or topic is available from Contech Engineered Solutions.

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*		20′-1″ x 7′-6″ 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		MULTI-PLATE
					x	Aluminum Structure 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
Pear- Arch		23′-11″ x 23′-4″ to 30'-4" x 25'-10"	Railroad underpasses or large clearance areas.	x		SUPER-SPAN
Pear		23′-8″ x 25′-5″ to 29'-11" x 31'-3"	Railroad underpasses or large clearance areas.	x		SUPER-SPAN
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
Box Culvert		8′-9″ x 2′-6″ to 35′-3″ x 13′-7″	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® (concrete)
H 20 Bridge ** Pedestrian **		spans up to 300′ spans up to 300′	County, city, parks, industrial complexes. Recreational, overpasses, industrial conveyor, pipe support.	x		U.S. Bridge® Vehicular Truss Continental® Pedestrian Truss

* Larger steel sizes are available up through 65-foot spans with our BridgeCor® product line. Call your local Contech representative for more information.
** The design process for these bridge structures is not covered by this document. Call your local Contech representative for more information.

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 the prior page 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 fit. 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 round structure is not large enough, consider a SUPER-SPAN 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′. 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 30′ should warrant the consideration of Keyhole 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 over an arch because of the elimination of concrete footings. However, many regulations prefer 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 preferably, a paved invert.

• Corrosive Soils

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

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 Hydraulics Engineering Circular HEC 18 outlines the design for scour. FHWA Hydraulics Engineering Circular 23 outlines the design procedures for scour counter measures.

Protect footings from scour

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 shape 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®, Aluminum Structure 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.

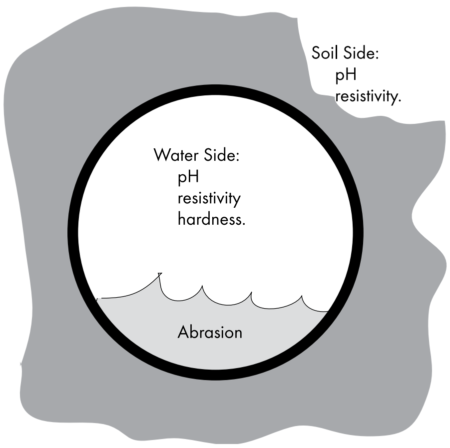
While arch structures often appear to be the best choice for many applications, the same shape in a round or elliptical shape may be more economical due to the elimination of footings. For example, a round structure or horizontal ellipse with the invert buried and paved are often used in lieu of an arch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

Horizontal ellipse SUPER-SPAN at Lowes Motor Speedway

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.

Prediction of Structure Life Limited by Corrosion

Galvanized steel structure plate has been used in the United States since 1931. Aluminum Structure 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 Corp 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 galvanized steel MULTI-PLATE, this brochure will follow the guidelines set forth by the A.I.S.I. The A.I.S.I. design method grew out of a California Department of Transportation (CALTRANS) study which preformed an inspection of over 7,000 galvanized steel drainage structures in the state of California for the purposes of developing a reliable method for the prediction of the life of corrugated galvanized steel structures. The data collected reflected the combined effects of corrosion and a wide range of abrasive levels. CALTRANS defined the end of the structure life to be coincident with the first perforation of approximately 12% metal loss in the invert.

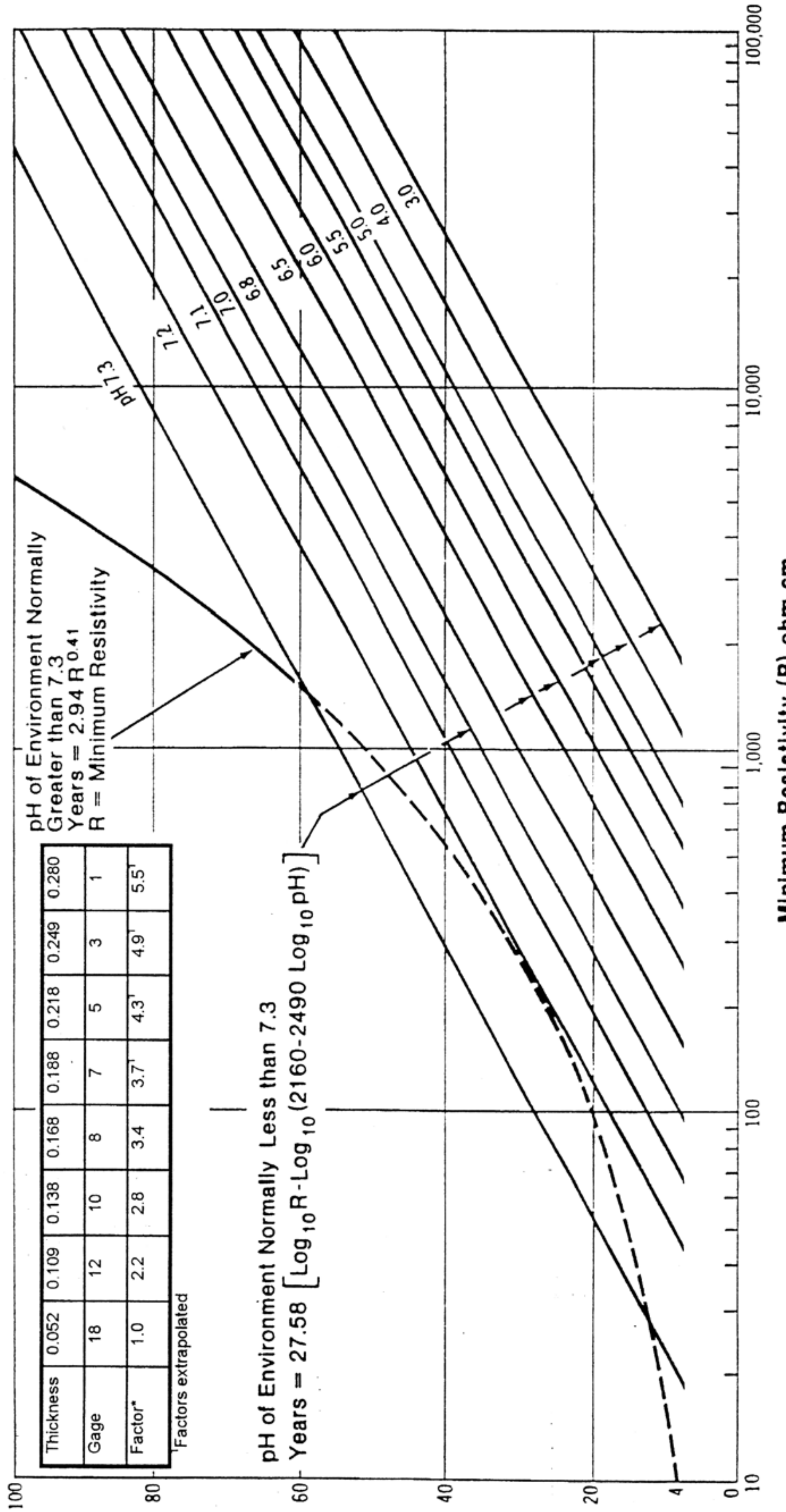
Many state DOT's found the CALTRANS method to be overly conservative in that it underestimated the average observed service life of galvanized steel structures in service in their states. This was primarily due to the fact that a gravity flow drainage structure of any kind functions properly well beyond the occurrence of the first perforation.

In addition, many of the structures surveyed in California were in mountainous areas and, therefore, were affected by above average abrasion. R.F. Stratful, based upon research by the U.S. Dept. of Weights and Measures upon corrosion rates, refined the method developed by CALTRANS and produced a reliable means of predicting the average effective invert service life of a galvanized steel drainage structure – the end of average effective service life being determined by approximately 25% metal loss in the invert. The basis for this being that if the in-service time that it takes for a 12% metal loss produces the first perforation, then the structure should function properly for at least twice that period. Also, a 25% metal loss still provides for remediation such as invert paving.

An important factor when choosing a design method, either CALTRANS or A.I.S.I., 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 A.I.S.I. method would be more appropriate. Recent inspections of 30-year-old SUPER-SPANs have revealed little, if any metal loss. Even the A.I.S.I. method would predict some metal loss. Because of this, the remainder of this discussion will focus upon the A.I.S.I. design method.

The A.I.S.I. chart for estimating average invert life is shown on the following page.

Average Invert Life–Years 0.052 Inch Galvanized Steel Sheet



Thickness	0.052	0.109	0.138	0.168	0.188	0.218	0.249	0.280
Gage	18	12	10	8	7	5	3	1
Factor*	1.0	2.2	2.8	3.4	3.7*	4.3*	4.9*	5.5*

*Factors extrapolated

Figure 1

Chart For Estimating Average Invert Life For Plain Galvanized Culverts

To further validate the use of the A.I.S.I. design method, galvanized steel plate structures feature a 3 oz. per square foot galvanized coating versus the 2 oz. coating found on the structures inspected in the original CALTRANS study. In addition, larger plate structures usually experience lower velocity flows and, hence, less potential for abrasion than the smaller culvert structures from the CALTRANS study.

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
$6 \le pH \le 10$		$6 \le pH \le 10$

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

* 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.

Steel Structural Plate
Installed in 1946
Inspected in 1998

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 prediction.

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.

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

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

Note: 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.

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, a layer of impermeable clay over the structure or a polymeric membrane over the structure. Details for each of these solutions are presented on the following pages.

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 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 1.5 meters per second (5 feet per second) or less.
- **Level 3 moderate abrasive** conditions exist in areas of moderate bed loads of sand and gravel and velocities between 1.5 m/s and 4.5 m/s (5 and 15 fps).
- **Level 4 severe abrasive** conditions exist in areas of heavy bed loads of sand, gravel, and rock and velocities exceeding 4.5 m/s (15 fps).

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

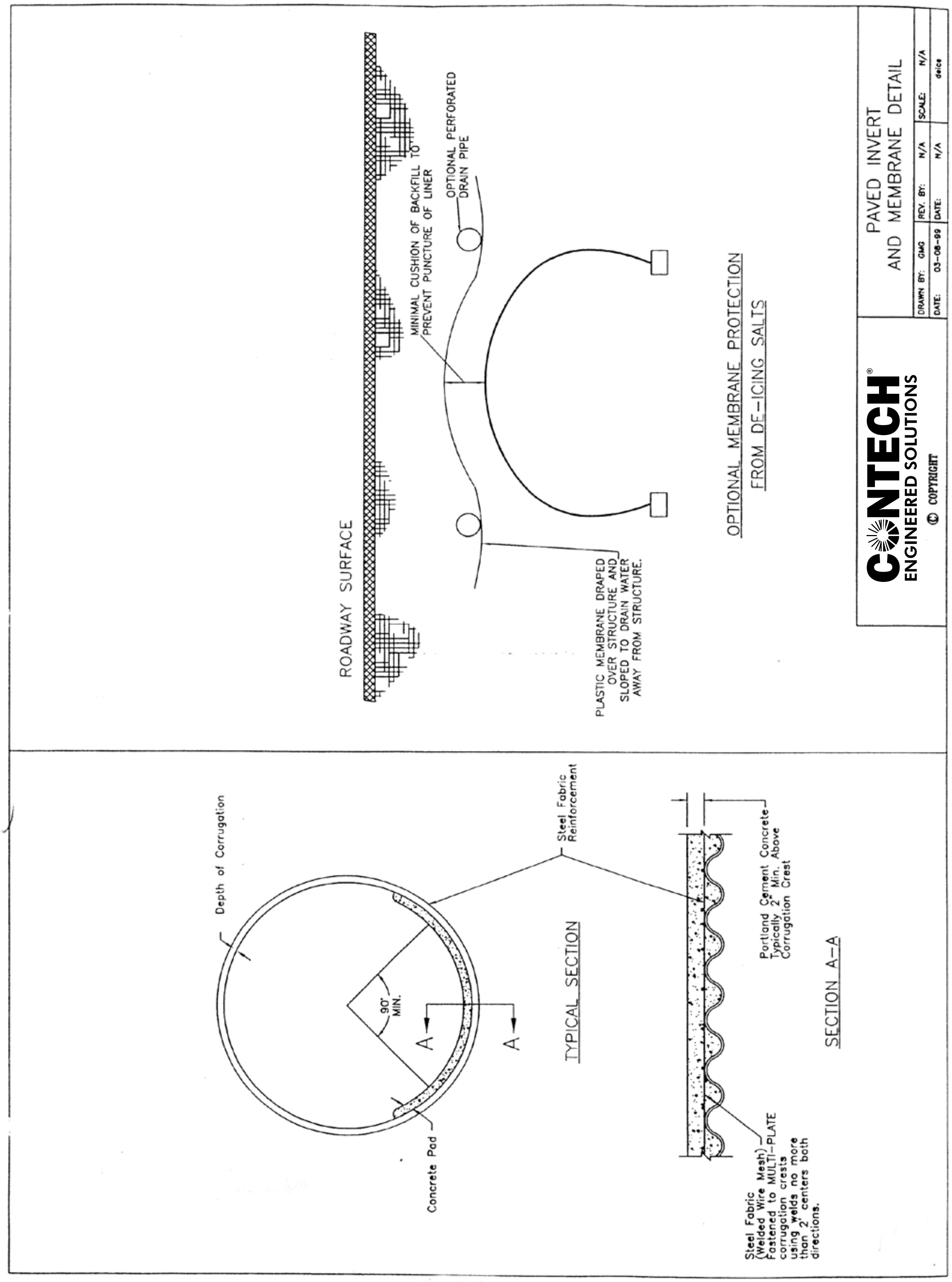
Once the minimum structural gage is selected and service life requirement checked on "The AISI Chart for Estimating Average Invert Life" on page 8, adjustments should be made based on the abrasion potential of the site.

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.



Paved Invert and Membrane Detail

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 uncomplicated, conservative procedures. Current AASHTO design procedures also address foundation, backfill and end treatment. (See page 29 for listing of all design specifications.)

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

1. Determine the backfill soil density by the soil 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.

Quantifying Live and Dead Loads Applied to the Structure

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. This manual typically considers H20, H25, HS 20, and HS 25 highway loads. Cooper railroad loads (E-80) are addressed in the American Railroad Engineering and Maintenance of Way Association (AREMA) specification which is analogous to the procedure herein. Airport loading and off-highway loads such as mining equipment are special. Contech is available to assist the designer in the evaluation of these special loads on the structure.

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 assumed to increase at a one-to-one ratio with depth.

Dead Load (DL) = w x H

Where: w = unit weight of soil (lb/ft^3)

H = Height of fill over structure (ft)

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

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.

NCSPA – Drainage Technology Bulletin November 1991

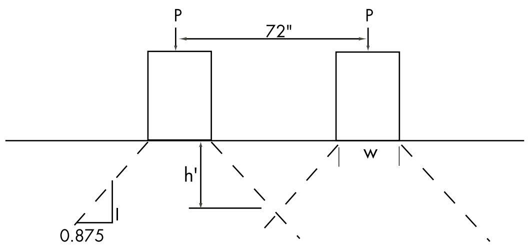
Section 3.3 of AASHTO specifications assume a rectangular tire contact pattern with an area (A, square inches) equal to 1 percent of the wheel load (P, pounds).
P is 1/2 of the axle load and should include any impact. The contact area is assumed to have a width (w) equal to 2.5 times its length (L) in the direction of traffic. Section 3.8.2.3 provides impact loads (I) for culverts with cover (H) less than 3 feet according to the following schedule:

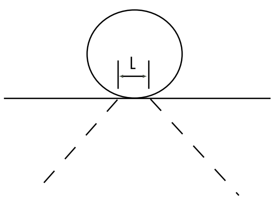
H<1'-0" I = 30%
1'-1" < H<2'-0" I = 20%
2'-1"<H<2'-11" I = 10%

Section 6.4 of AASHTO provides for the dissipation of the live load pressure depth assuming that the load is distributed over the base of a truncated prism with side slopes of 1 vertical to 0.875 horizontal (as seen on the next page).

**TABLE 1.
LIVE LOAD PRESSURES FOR DESIGN
AASHTO**

Height of Cover (ft)	H20 Loading (psf)	H25 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





AASHTO

- Tire contact area, A (sq. in.), is related to the wheel load, P (lbs, including impact), By
  A = 0.01 P
- Values of P are: (H = Height of Cover)

H < 1′ = 0″	H20 = 1.3 x 16000 = 20,800	
	H25 = 1.3 x 20000 = 26,000	
1′-1″< H < 2′ -0″	H20 = 1.2 x 16000 =19,200	
	H25 = 1.2 x 20000 = 24,000	
2′-1″< H < 2′ -11″	H20 = 1.1 x 16000 =17,600	
	H25 = 1.1 x 20000 = 22,000	
H > 2′-11″	H20 = 16,000	
	H25 = 20,000	

- Length, L (inches) and Width, w (inches), of the contact area are related by
  A = Lw
  w = 2.5L

  Therefore,

  $$w = \sqrt{0.025\,P}$$

- Depth, h′ (inches), to intersection of pressure zones under the two wheels is:
  h′ = (72″ – w)/1.75
- Pressure, p (psf), at the top of pipe for a height of cover, h (inches) is:

  p = 144 P/((1.75h + w)(1.75h + L))
  When h<h′
- For covers greater than h′, the pressure zones overlap and the pressure is:

  p = 288P / ((1.75h + w+72)(1.75h + L))
  When h>h′

Table 1 summarizes these live load calculations for varying Heights of Cover. (See page 13.)

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 x s/2
  T_s = wall thrust (lb/ft)
  s = dsiameter or span (ft)
- Wall area
  $A = T_s/f_a$
  T_s = wall thrust (lb/ft)
  f_a = allowable stress (min. yield point f.s. = 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 span (inches)
E_M = modulus of elasticity of metal (psi)

- Seam Strength
  ss = T_s x S.F.
  Safety factor = 3
  ss = seam strength = lb/ft

- **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

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

"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

Should it be found through analysis that the seam strength of a structure is the limiting factor, which can occur when fill heights become great, the structure gage may be forced to undesirable levels to provide greater seam strength. In some cases, the seam strength provided by the standard four bolt per foot seam may not be sufficient to handle the load. In these cases, the designer may wish to consider the use of six or eight bolts per foot.

The following table provides seam strengths 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

Specified Thickness in.	6" x 2" Corrugation		
	4 Bolts Per Ft.	6 Bolts Per Ft.	8 Bolts Per Ft.
0.111	42,000		
0.140	62,000		
0.170	81,000		
0.188	93,000		
0.218	112,000		
0.249	132,000		
0.280	144,000	180,000	194,000
0.318			235,000
0.375			285,000

Notes:
1. Bolts used are 3/4" diameter – high strength bolts, meeting ASTM A 449.
2. Bolts and nuts also used for connecting arch plates to receiving angles and structural reinforcement to structural plates.
3. 7/8" diameter bolts may be required with thicker plates.

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 A304

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

Keyhole 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 by use of a special bolted seam that yields or slips under load. (See diagram below).

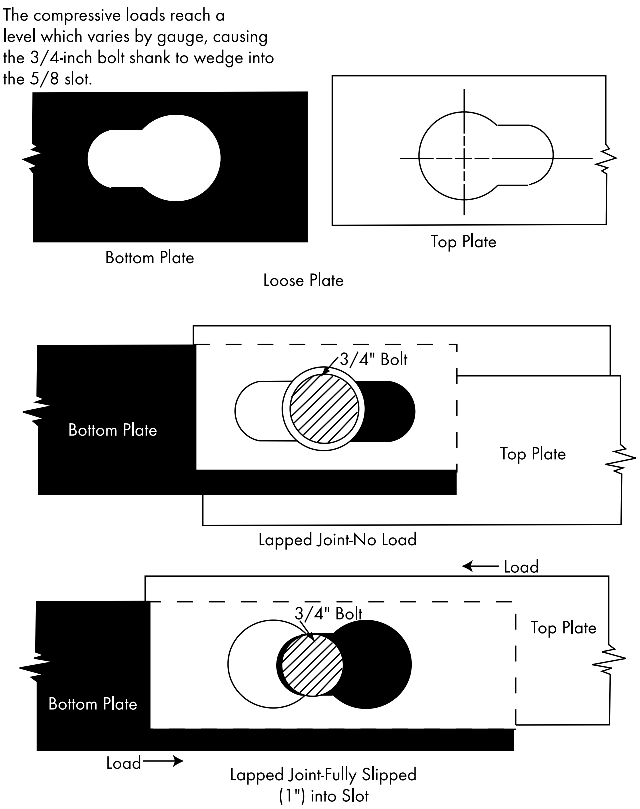


Figure 2—Key-hole slot MULTI-PLATE® at work

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 backfill per AASHTO M-145 is desired as backfill for any pipe or flexible structures and to gain the load carrying capacity for rigid 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 easy with Key-Hole Slot MULTI-PLATE®

Section Properties

TABLE 4.
STEEL CONDUITS

Gage	Thickness (inches)	6" x 2" Corrugations A_s (sq. in/ft)	r (inches)	I x 10^{-3} (in.^{4}/in.)
12	0.111	1.556	0.682	60.411
10	0.140	2.003	0.684	78.175
8	0.170	2.449	0.686	96.163
7	0.188	2.739	0.688	108.000
5	0.218	3.199	0.690	126.922
3	0.249	3.650	0.692	146.172
1	0.280	4.119	0.695	165.836
5/16	0.318	4.671	0.698	190.000
3/8	0.375	5.613	0.704	232.000

TABLE 5.
ALUMINUM CONDUITS

Thickness (inches)	9" x 2 1/2" Corrugations A_s (sq. in/ft)	r (inches)	I x 10^{-3} (in.^{4}/in.)
0.100	1.404	0.8438	83.065
0.125	1.750	0.8444	103.991
0.150	2.100	0.8449	124.883
0.175	2.449	0.8454	145.895
0.200	2.799	0.8460	166.959
0.225	3.149	0.8468	188.179
0.250	3.501	0.8473	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'
Live load, LL = H20
Backfill = Compacted 90% AASHTO T-99
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 soil unit weight (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, $f_{cr}/SF < f_a$

then area must be rechecked using f_{cr}/SF 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 (SF)
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 = H20
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 = H20
Weight of soil W = 120 lb/ft^3

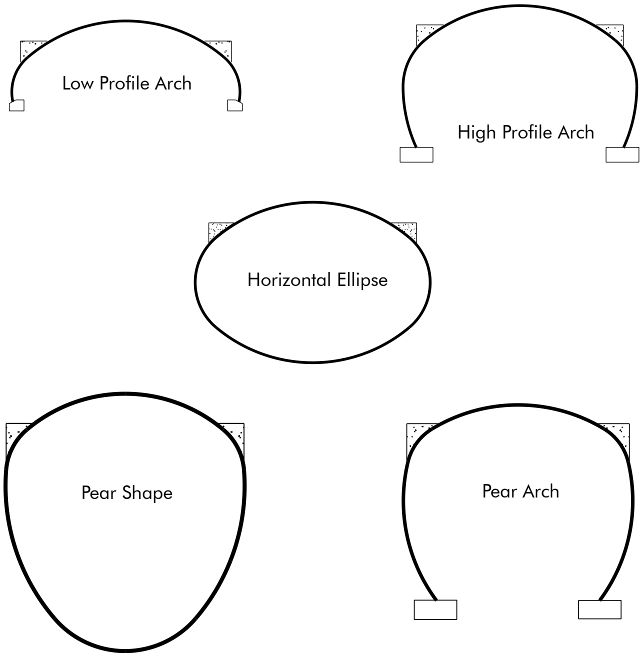
By following the steps in examples 1 and 2, this structure can be built using 8 gage (0.170″)

Note: 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 has supplied design height-of-cover tables that provide the optimum rib and shell thickness combination.

SUPER-SPAN™ and SUPER-PLATE® Design

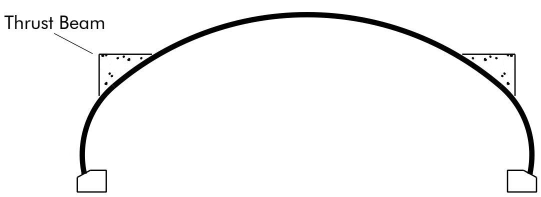
Design of SUPER-SPAN and SUPER-PLATE (Long Span) structures follow AASHTO Section 12.7.

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 Hamilton, Ohio

The designer should consult with Contech Engineered Solutions LLC regarding these special features. Dimensions for longitudinal thrust beams are also available as are recommendations on the suitability of a particular backfill type.

Gage or thickness for SUPER-SPAN is a function of the structure's top radius and the live and dead loads. Table 8 shown provides the recommended gages for SUPER-SPAN. The designer should also note that Contech Engineered Solutions provides a "shape control monitor" as a condition of the sale of a SUPER-SPAN or SUPER-PLATE. The shape control monitor will be on-site during the entire backfilling process to ensure proper finished structure shape.

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

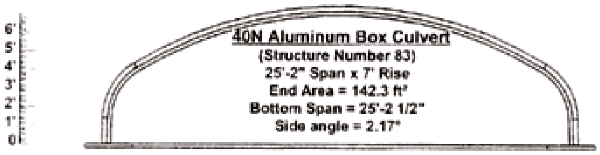
Further information is available in the SUPER-SPAN and SUPER-PLATE section of this catalogue and technical guidelines contained in this brochure.

TABLE 8.
MINIMUM THICKNESS – MINIMUM COVER TABLE, FT. H 20 LIVE LOAD

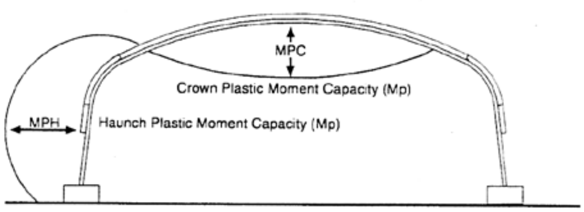
	Wall Thickness, Inches					
Top Radius R_T Ft.	**0.111"**	**0.140"**	**0.170" or 0.188"**	**0.218"**	**0.249"**	**0.280"**
15'	2.5'	2.'5	2.5'	2.0'	2.0'	2.0'
15'-17'		3.0'	3.0'	2.5'	2.0'	2.0'
17'-20'			3.0'	2.5'	2.5'	2.5'
20'-23'				3.0'	3.0'	3.0'
23'-25'					4.0'	4.0'

Contact a Contech representative for Pear and Pear-Arch shapes.

Aluminum Box Culvert Design



The structural design of Aluminum Box Culvert does not follow the aforementioned processes. Due to the shape of the box culvert, the "ring compression" method used to quantify design pressures does not apply. The relatively flat radius crowns are subject to large 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 and HS-25 live loads that supply the plate gages and reinforcing ribs necessary for a given height of cover. These tabled values are contained in the Aluminum Box Culvert section of this manual.

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. Cover over 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 cover heights as part of height of cover tables contained in each following section. Minimum cover heights have been established based primarily upon extensive experience. When HS-20 or 25 highway type loads are expected, minimum cover height over steel or aluminum structural plate (excluding SUPER-SPAN or 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 concrete load-relieving slab may be used when minimum cover is not achievable.

Being a more rigid structure, minimum cover over Aluminum Box Culverts is often much lower than those for standard plate structures. In all cases, the minimum cover over these structures is 1.4 feet given 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.

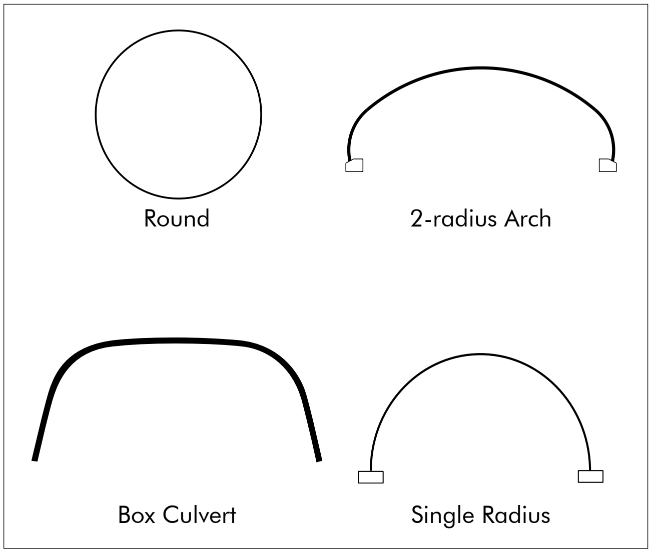
Minimum cover is measured from the top of the structure to the bottom of a flexible pavement and to the top of a rigid pavement. Particular attention should be given to the height of cover near roadway shoulders as they slope away from the road crown. Minimum cover heights must be maintained throughout 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. The following information supplies guidance for necessary minimum cover. Other 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.

These shapes include:



Structures designed under this specification shall be analyzed by accepted finite element analysis. This analysis must consider the strength and stiffness properties of the structural plate and the soil. 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.

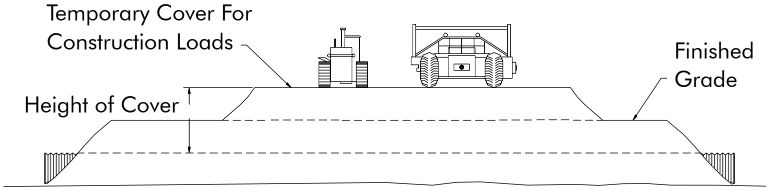
BridgeCor Monitoring

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. See your local Contech representative for additional information.

BridgeCor box culvert in Puerto Rico

General Guidelines for Minimum Cover Required for Heavy Off-Road Construction Equipment

For temporary construction vehicle loads, an extra amount of compacted cover may be required over the top of the pipe. The height of cover must meet the minimum requirements shown. The use of heavy construction equipment necessitates greater protection for the pipe than finished grade cover minimums for normal highway traffic.



Minimum Cover May Vary, Depending On Local Conditions. The Contractor Must Provide The Additional Cover Required To Avoid Damage To The Structure. Minimum Cover Is Measured From The Top Of The Structure To The Top Of The Maintained Construction Roadway Surface.

TABLE 9. HEAVY WHEEL LOAD (STEEL)
MIN. COVER FOR OFF HIGHWAY VEHICLES UP TO 450T GVW

DIAMETER (OR SPAN) IN FEET	WALL THICKNESS, IN INCHES						
	0.111" (12 GA.)	0.140" (10 GA.)	0.170" (8 GA.)	0.188" (7 GA.)	0.218" (5 GA.)	0.249" (3 GA.)	0.280" (1 GA.)
5' TO 10'	2.5'	2.5'	2.5'	2.5'	2.5'	2.5'	2.5'
11' TO 12'	3.0'	3.0'	3.0'	3.0'	3.0'	3.0'	3.0'
13' TO 14'	3.5'	3.5'	3.5'	3.5'	3.5'	3.5'	3.5'
15' TO 16'	4.0'	4.0'	4.0'	4.0'	4.0'	4.0'	4.0'
17' TO 18'	-	4.5'	4.5'	4.5'	4.5'	4.5'	4.5'
19' TO 20'	-	-	5.0'	5.0'	5.0'	5.0'	5.0'

Notes:
1. Follow AASHTO or NCSPA Guidelines for spans greater than 20'
2. Backfill shall be excellent quality material compacted to 90% proctor AASHTO T-99
3. Add 2' for rutting in un-maintained areas

TABLE 10. HEAVY WHEEL LOAD (ALUMINUM)
MIN. COVER FOR OFF HIGHWAY VEHICLES UP TO 175T GVW

DIAMETER (OR SPAN) IN FEET	WALL THICKNESS, IN INCHES					
	0.125"	0.150"	0.175"	0.200"	0.225"	0.250"
5' T0 9'	3.0'	3.0'	2.5'	2.5'	2.5'	2.5'
10' TO 12'	--	4.0'	4.0'	4.0'	3.5'	3.0'
13' TO 15'	--	5.0'	4.5'	4.5'	4.0'	4.0'
16' TO 18'	--	5.0'	5.5'	5.0'	5.0'	4.5'
19' TO 20'	--	6.0'	6.5'	6.0'	5.5'	5.5'
19' TO 20'	-	-	5.0'	5.0'	5.0'	5.0'

Notes:
1. Backfill shall be of excellent quality material compacted to 90% proctor AASHTO T-99
2. Add 2' for rutting in un-maintained areas
3. The use of crown ribs may enable crossing of construction equipment with less cover than indicated in the table above or permit the crossing of equipment greater than 175 tons GVW.
4. The use of crown ribs may accommodate spans greater than 20'. contact Contech for more information related to specific applications.

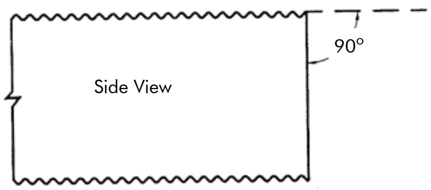
Grade Separation Structure

For minimum cover requirements for construction loads on structures with spans greater than 20'-0", contact your local Contech representative.

Structure End Treatments

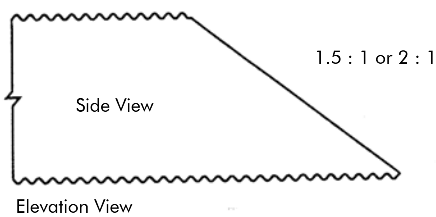
Once the designer has selected a structure and has determined the structural requirements, attention should be turned to protecting the ends of the structure. Hydraulic efficiency, protection of the structure backfill, and structure alignment may dictate the usage of modified structure ends (bevels and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

Square ended

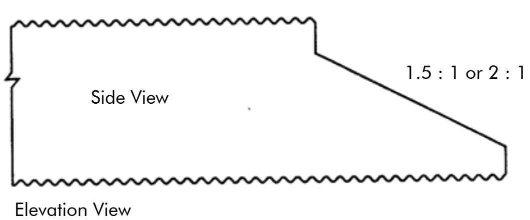


Beveled

(structure cut at an angle relative to horizontal plane)

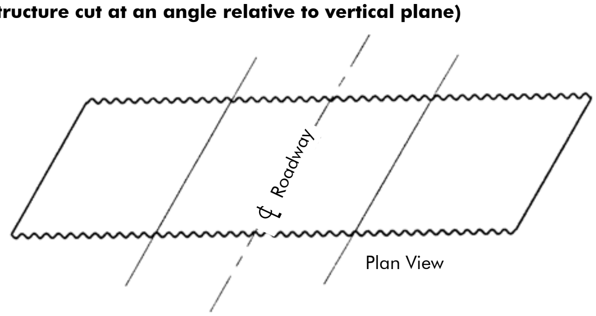


Step-beveled end

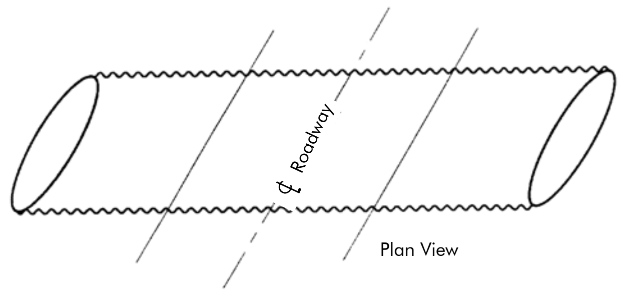


Skewed

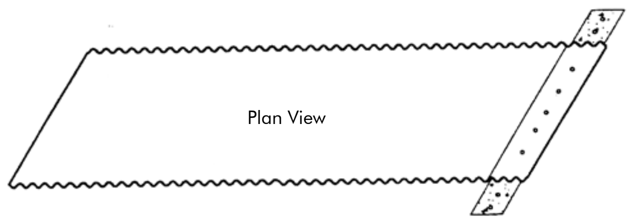
(structure cut at an angle relative to vertical plane)

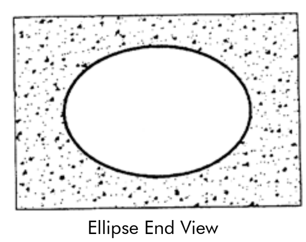


Beveled and skewed



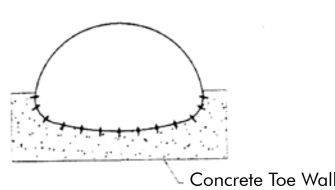
Skewed with concrete headwall





Beveled with concrete slope collar

Any of the above with concrete or sheet pile toe wall



Square ended 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 toe wall to anchor the leading edge of the invert, thus precluding 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. Skew angles without a concrete headwall should be a maximum of 15 degrees.

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 number 1008534B on page 28).

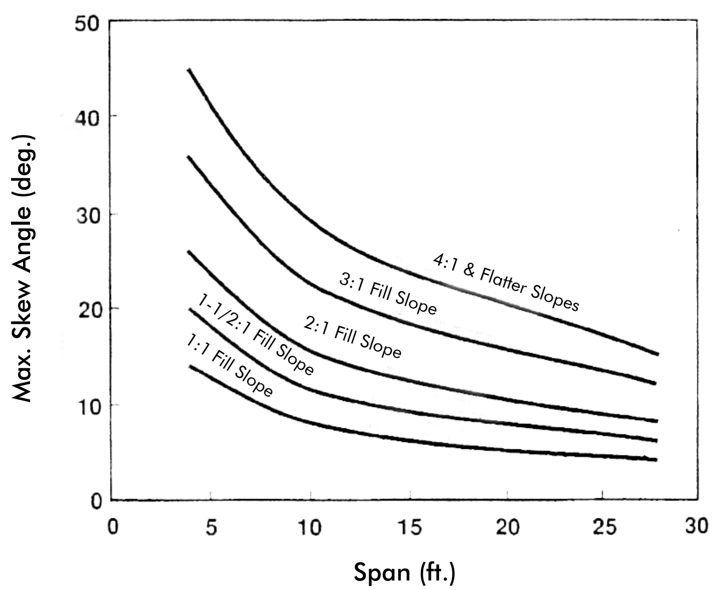


Figure 3. Suggested limits for skews to embankments unless the embankment is warped for support or full head walls are provided.

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.

C.I.P. Concrete Cut-off or Toe-walls 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. The structure should be well anchored to the wall with anchor bolts. Interlocking sheet piling may be driven below the wall to minimize the use of the concrete. Slope protection is also advised to preclude water entering the structure backfill.

Modular Block Headwalls can be utilized to provide an aesthetically pleasing headwall. 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.

BridgeCor, SUPER-SPAN and SUPER-PLATE End Treatment

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

Aluminum Box Culvert End Treatment

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 allowed on Aluminum Box Culverts.

Skewed ends are allowed only with a concrete headwall.

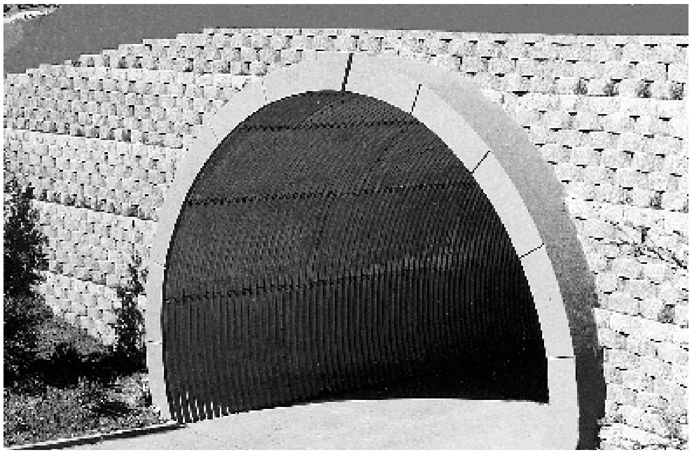
C.I.P. concrete headwalls may be used and are required if the structure is to be skew cut. The structure may be anchored to the C.I.P. headwall in the same fashion as with steel structures discussed earlier. C.I.P. headwall standard designs are available from your Contech representative.

As with all corrugated metal structures with full inverts, a cut-off wall is a necessity on hydraulic structures. Aluminum Box Culverts with full inverts are provided with a bolt-on 26” deep toe wall plate. The designer should determine the depth to which the toe-wall should extend.

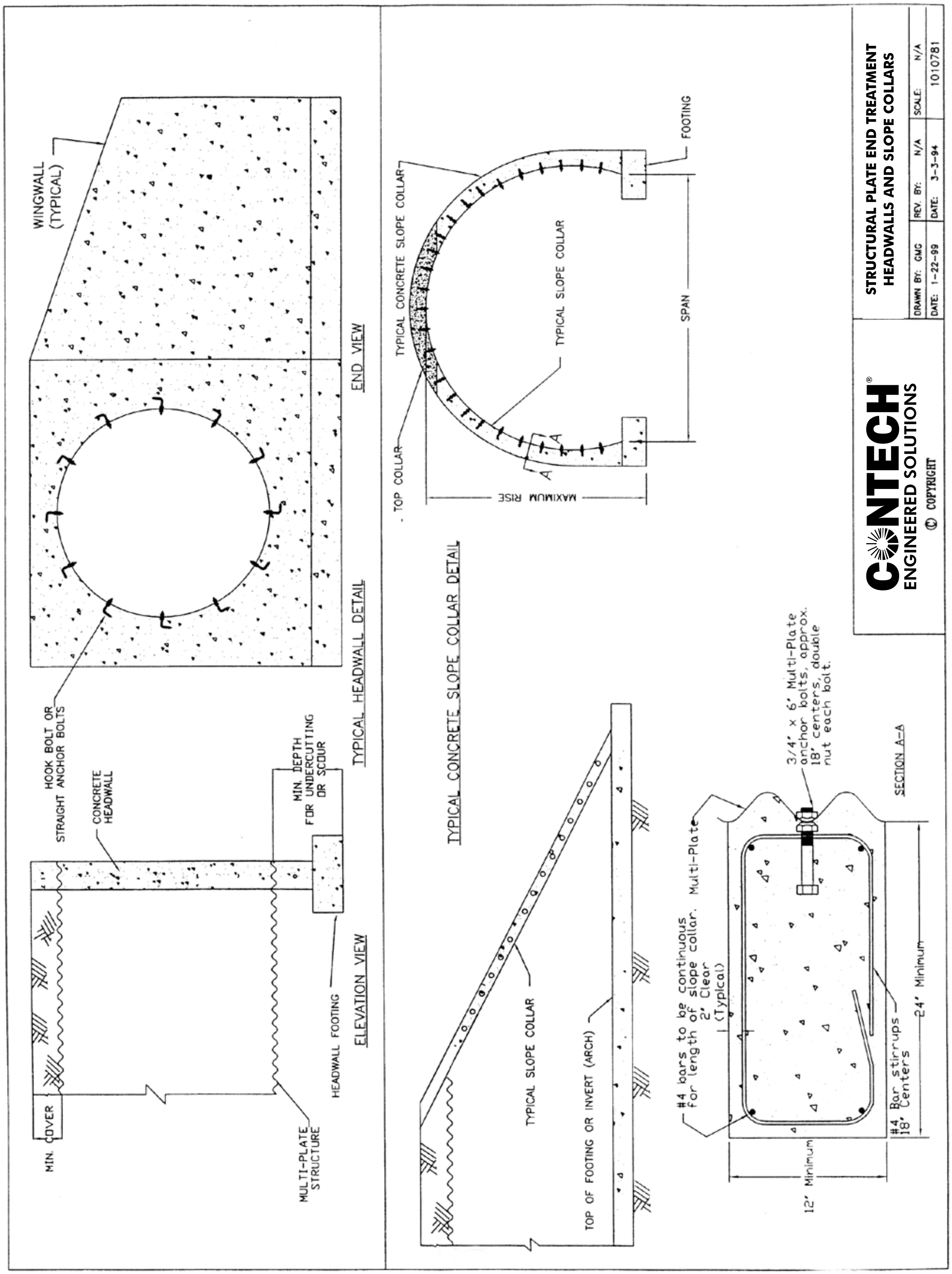
Contech Engineered Solutions advises the designer to take all necessary precautions to protect the ends of corrugated metal hydraulic structures. Damage to the structure ends may result in inlet blockage. The designer is also advised that whenever heavy debris flow is expected, the use of a large single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

As with all contents of this manual, Contech Engineered Solutions cannot foresee all possible situations or events relating to the end treatment of structures. Therefore, this manual cannot be expected to serve as the sole reference on the subject and the designer should consult documents such as those published by FHWA or a local Department of Transportation for more complete information.

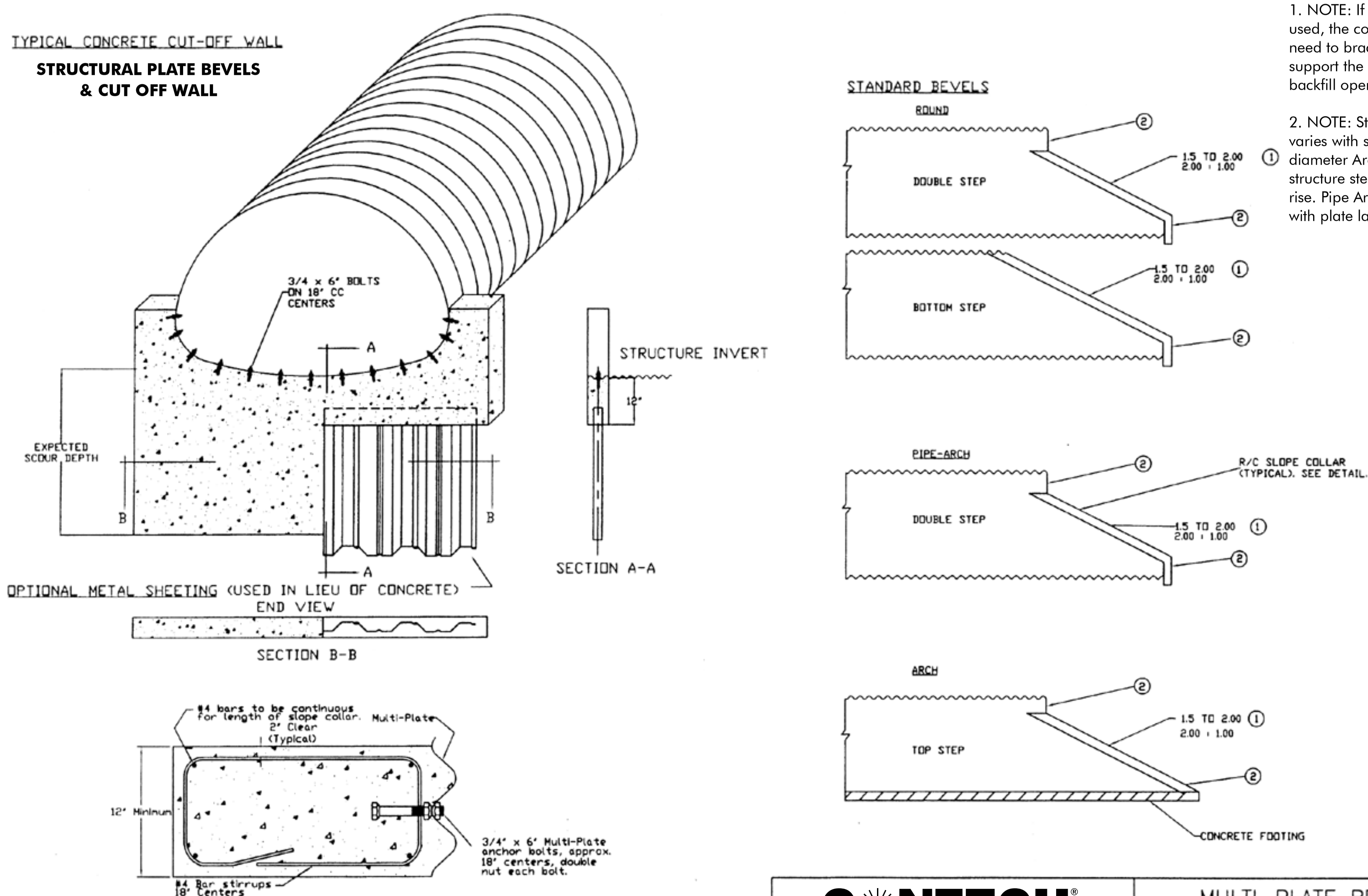
Appropriate end treatment design is beyond the scope of this catalog. Additional information can be obtained from the local D.O.T. guidelines, the FHWA Circular Memo, “Plans for Culvert Inlet and Outlet Structures”, Sheets G-39-66 to G-42-66, 1996, and chapters within the AISI Handbook of Steel Drainage & Highway Construction Products.



KeyStone Modular Block Headwall with MULTI-PLATE underpass



Typical End Treatments



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. a 25% rise. Pipe Arch steps coincide with plate laps.

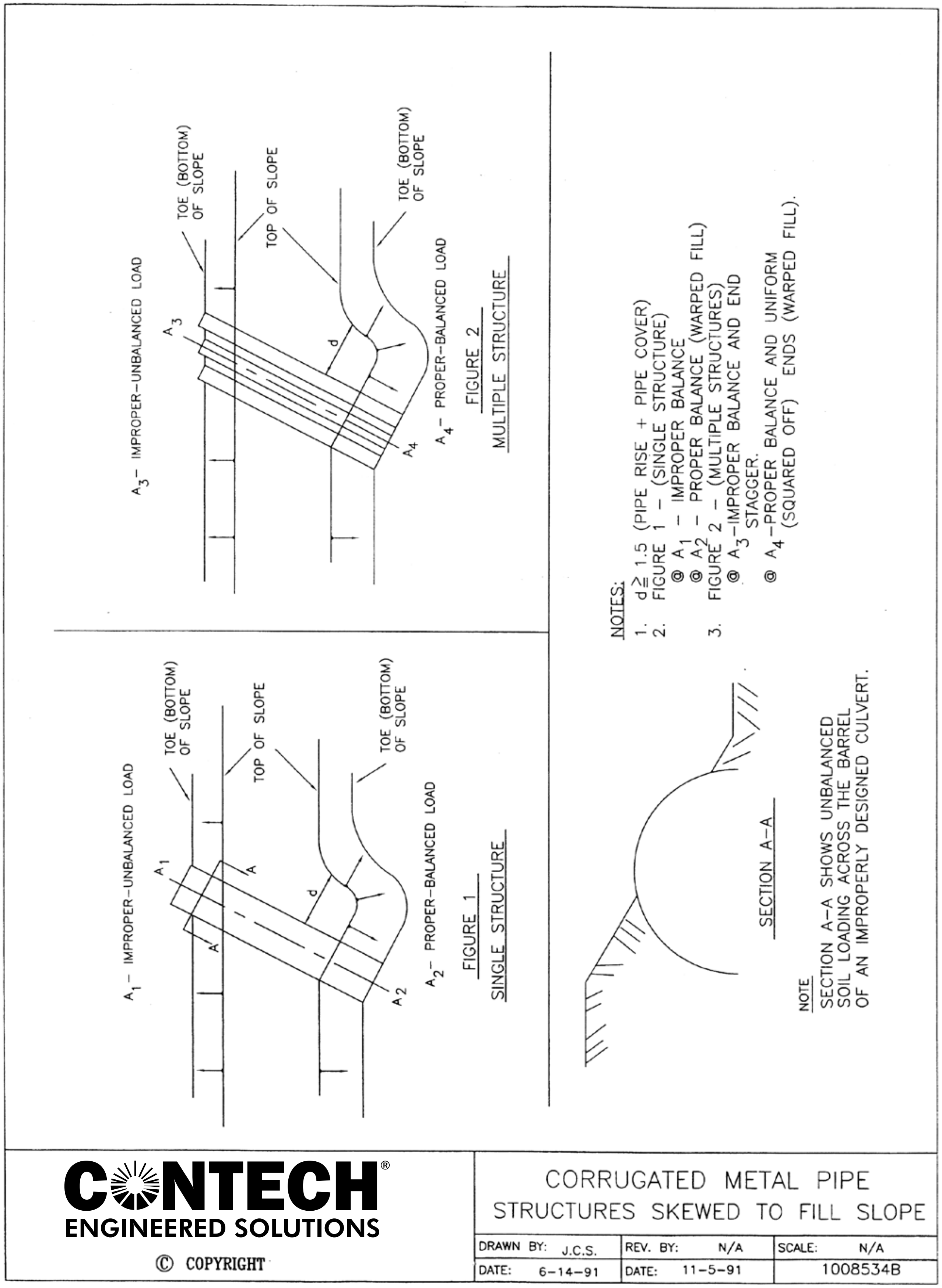
This detail shows minimum dimensions recommended for structural soundness.
Certain hydraulic conditions may require a larger slope collar or other end treatment.

CONTECH® ENGINEERED SOLUTIONS

MULTI-PLATE BEVELS & CUT OFF WALL

DRAWN BY: GMG	REV. BY: N/A	SCALE: N/A
DATE: 12-14-99	DATE: N/A	TREATMENT

Cut Off Wall & Beveled End Treatments



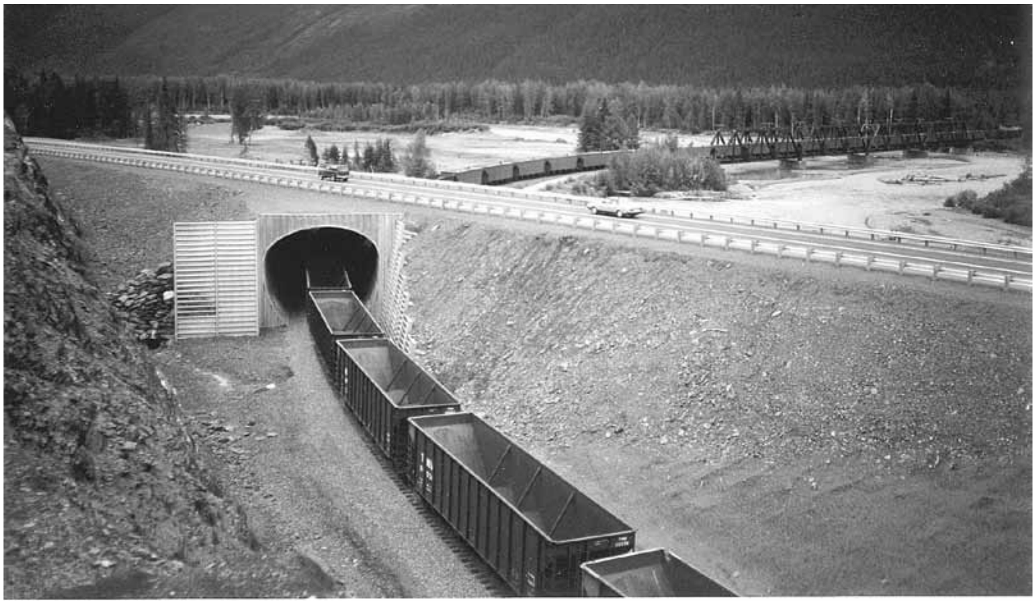
Skews To Fill Slope

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	A-761
Installation	Refer to AASHTO Standard Specifications for Highway Bridges (Sec. 26)	A-807
Design	Refer to AASHTO Standard Specifications for Highway Bridges (Sec. 12)	A-796
Aluminum Structural Plate		
Material	M-219	B-746
Installation	M-219 – Refer to AASHTO Standard Specifications for Highway Bridges (Sec. 26.5)	B-789
Design	Refer to AASHTO Standard Specifications for Highway Bridges (Sec. 12.6)	B-790
Aluminum Box Culverts		
Material	M-219	B-864
Installation	Refer to AASHTO Standard Specifications for Highway Bridges (Sec. 12.8)	N/A
Design	Refer to AASHTO Standard Specifications for Highway Bridges (Sec. 12.8)	N/A
SUPER-SPAN & SUPER-PLATE		
Material	M-167 (steel) and M-219 (Aluminum)	A-761
Installation	Refer to AASHTO Standard Specifications for Highway Bridges (Sec. 12 and Sec. 26)	A-761
Design	Refer to AASHTO Standard Specifications for Highway Bridges (Sec. 12.7)	N/A
BridgeCor		
Material	M-167	A-761
Installation	Refer to AASHTO Standard Specifications for Highway Bridges (Sec. 26)	N/A
Design	Refer to AASHTO Standard Specifications for Highway Bridges (Sec. 12.8.9)	N/A

Excerpts of these specifications are available from Contech Engineered Solutions LLC.



SUPER-SPAN grade separation structure with Bin-Wall 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, box culvert, 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 capable of providing a service life of 75 years or longer. More information is covered on 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 a MULTI-PLATE specialty.

Easier, faster 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, box culverts, 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 0.375 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.

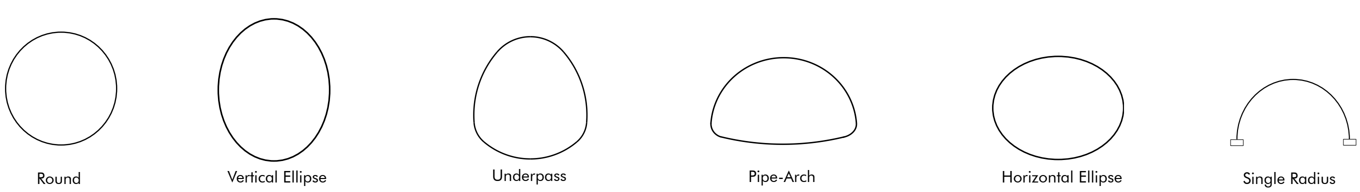
The "Pi" nomenclature translated circumference directly into nominal diameter in inches. For example, four 15-Pi plates give a diameter of 60 inches; four 21-Pi plates provide an 84-inch diameter, etc. Various plate widths may be combined to obtain almost any diameter.

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.

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 0.375-inch thick material.

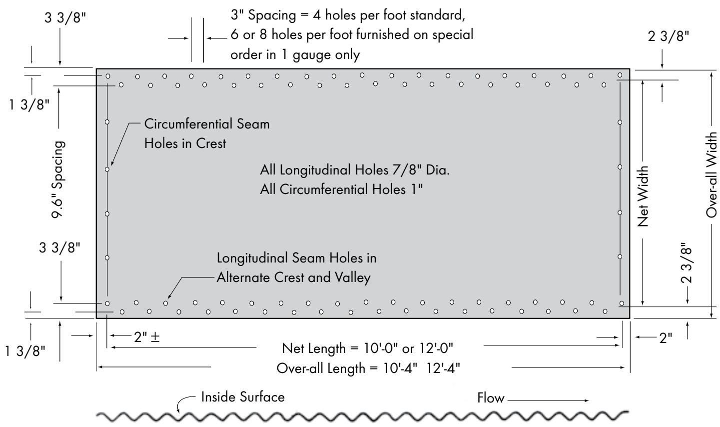
The inside crests of the end corrugations are punched with 1-inch-diameter holes for circumferential seams on centers of 9.6 inches or 9 $^{19/32}$ inches (equals 3-Pi).

Single Radius Arch



Standard Shapes

Bolt Hole Spacing

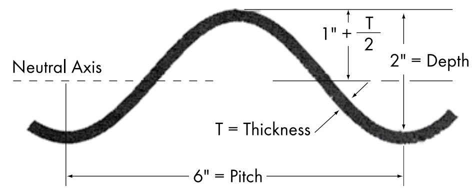


For square end structures on which headwalls are to be built, design should allow for a 2" lip at each end.

TABLE 11. DETAILS OF UNCURVED MULTI-PLATE® SECTIONS

	Net Width, Inches Nominal	Net Width, Inches 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



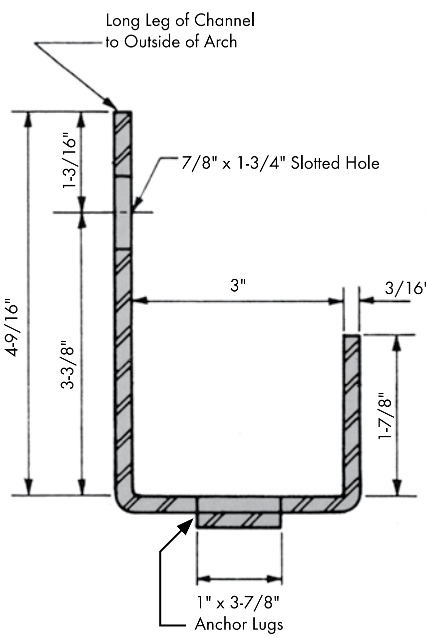
Standard 6" x 2" Corrugation

TABLE 12. APPROXIMATE WEIGHT OF MULTI-PLATE SECTIONS

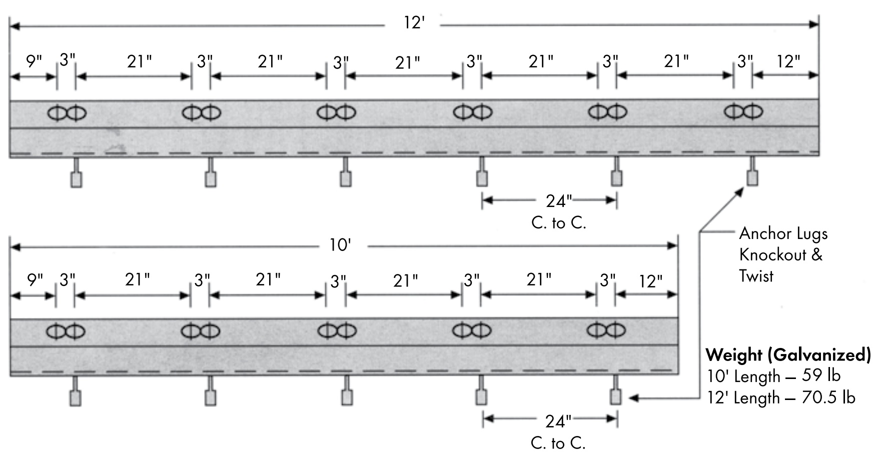
Galvanized, in Pounds, without Bolts (1)(2) — Specified Thickness, Inches (3)

Pi	Net Length (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 In.)	0.375 (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	1130	1340
24	12	473	603	732	797	927	1060	1190	1351	1602

(1) Weights are based on a zinc coating of 3 Oz./sq. ft. of double exposed surface.
(2) All weights are subject to manufacturing tolerances.
(3) Specified thickness is a nominal galvanized thickness. Reference AASHTO M 167.



Unbalanced Channel Cross Section



Unbalanced Channel for MULTI-PLATE® Arch

TABLE 13. NORMAL BOLT 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 7/8″ diameter bolts.
Note: The longer bolts are used in 3 plate lap seams.

TABLE 14. PHYSICAL PROPERTIES OF MULTI-PLATE®

Gage	Specified Thickness, Inches	Uncoated Thickness T (Inches)	Moment of Inertia I ($In.^4/In.$)	Section Modulus S ($In.^3/In.$)	Radius of Gyration r (Inches)	Area of Section ($In.^2/Ft.$)
12	0.111	0.1046	0.0604	0.0574	0.682	1.556
10	0.140	0.1345	0.0782	0.0733	0.684	2.003
8	0.170	0.1644	0.0962	0.0888	0.686	2.449
7	0.188	0.1838	0.108	0.0989	0.688	2.739
5	0.218	0.2145	0.1269	0.1147	0.690	3.199
3	0.249	0.2451	0.1462	0.1302	0.692	3.658
1	0.280	0.2758	0.1658	0.1458	0.695	4.119
5/16	0.318	0.3125	0.190	0.164	0.698	4.671
3/8	0.380	0.375	0.232	0.195	0.704	5.613

TABLE 15. MULTI-PLATE ROUND PIPE

Pipe Diameter		End Area, Sq. Ft.	Pipe Diameter		End Area, Sq. Ft.
(Feet)	(Inches)		(Feet)	(Inches)	
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	1467.5	25.5	306	523.1
15.0	180	179.4	26.0	312	543.9
15.5	186	191.7			

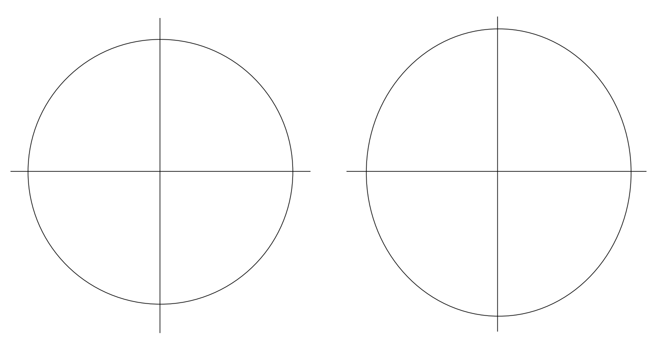
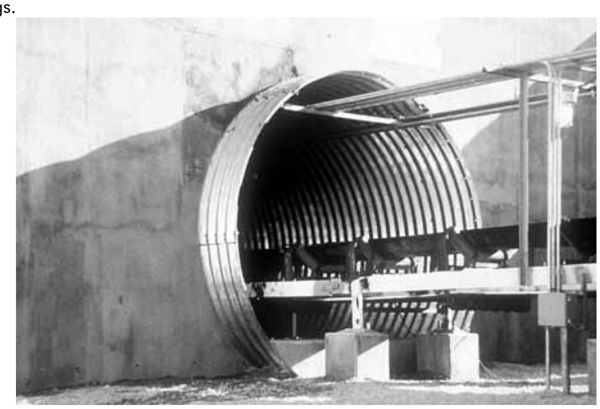


Figure 4. Round and 5% Vertical Ellipse Pipe

Pipe Diameter (inches)	Number of Plates Per Ring 12 through 1 Gage: Pi 15	18	21	24	Total Plates	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.)	with 7/8" fasteners 5/16	3/8
60	4				4	105	132	160	178	205	233	260	320	373
66	2	2			4	116	145	176	195	226	256	286	346	405
72		4			4	126	158	192	213	246	279	312	372	436
78		2	2		4	137	172	207	231	267	303	339	399	467
84			4		4	147	185	223	249	287	326	365	426	499
90			2	2	4	158	198	239	266	308	349	391	479	560
96				4	4	168	211	255	284	328	372	417	506	591
102	2	4			6	179	224	271	302	349	396	443	532	623
108		6			6	189	238	287	320	369	419	469	559	654
114		4	2		6	200	251	303	337	390	442	495	585	685
120		2	4		6	210	264	319	355	410	466	521	612	717
126			6		6	221	277	335	373	431	489	547	638	748
132			4	2	6	231	290	351	391	451	512	573	692	809
138			2	4	6	242	304	367	408	472	535	599	718	841
144				6	6	252	317	383	426	492	559	625	745	872
150		6	2		8	263	330	399	444	513	582	651	771	903
156		4	4		8	273	343	415	462	534	605	677	798	935
162		2	6		8	284	356	431	480	554	629	703	825	966
168			8		8	294	370	447	497	575	652	729	851	998
174			6	2	8	305	383	463	515	595	675	755	905	1,059
180			4	4	8	315	396	479	533	616	698	781	931	1,090
186			2	6	8	326	409	495	551	636	722	807	958	1,121
192				8	8	336	422	511	568	657	745	833	984	1,153
198		4	6		10		436	527	586	677	768	859	1,011	1,184
204		2	8		10		449	543	604	698	792	885	1,037	1,216
210			10		10		462	559	622	718	815	911	1,064	1,247
216			8	2	10		475	575	639	739	838	937	1,117	1,308
222			6	4	10			591	657	759	861	963	1,144	1,339
228			4	6	10			606	675	780	885	990	1,170	1,371
234			2	8	10			622	693	800	908	1016	1,197	1,402
240				10	10			638	710	821	931	1042	1,224	1,434
246		2	10		12				728	841	954	1068	1,250	1,465
252			12		12				746	862	978	1094	1,277	1,496
258			10	2	12					882	1001	1120	1,330	1,557
264			8	4	12					903	1024	1146	1,357	1,589
270			6	6	12					923	1048	1172	1,383	1,620
276			4	8	12					944	1071	1198	1,410	1,652
282			2	10	12						1094	1224	1,436	1,683
288				12	12						1117	1250	1,463	1,714
294				14	14						1141	1276	1,490	1,746
300			12	2	14						1164	1302	1,543	1,807
306			10	4	14						1187	1328	1,569	1,838
312			8	6	14						1211	1354	1,596	1,870

Table 16. Plate Arrangement and Approximate Weight per Foot for Multi-Plate Round Pipe

Note:
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. Galvanized, with bolts and nuts.
4. Specified thickness is a nominal galvanized thickness.



Aggregate Tunnel

MULTI-PLATE® Height of Cover Tables

Height-of-Cover Tables 18, 21, 24, 26 and 29 A are presented for the designer's convenience for use in routine applications. They are based on the design procedures presented herein, 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 99
Yield point of steel – 33,000 psi

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)**	**0.375 (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					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 off highway construction loads must be checked.
5. All covers are calculated using (4) 3/4" A449 bolts/ft. except .318 and .375 which uses (8) 7/8" A449 bolts/ft. 6 and 8 bolts/ft. are available for structures using 3/4" A449 bolts.

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

Nominal Pipe Diameter Pi[1]	5% Vertical Ellipse [1]		Area	Number of Plates Per Ring [2]					Approximate Weight Per Foot of Structure, Lbs. [3] Specified Thickness, Inches [4]						
	Horizontal Inches	Vertical Inches	Sq. Ft.	15 Pi	18 Pi	21 Pi	24 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.)
60	56	62	19	4				4	105	132	160	178	205	233	260
66	62	68	23	2	2			4	116	145	176	195	226	256	286
72	67	75	28		4			4	126	158	192	213	246	279	312
78	73	81	32		2	2		4	137	172	207	231	267	303	339
84	79	88	38			4		4	147	185	223	249	287	326	365
90	85	94	43			2	2	4	158	198	239	266	308	349	391
96	91	101	50				4	4	168	211	255	284	328	372	417
102	97	107	55	2	4			6	179	224	271	302	349	396	443
108	103	114	62		6			6	189	238	287	320	369	419	469
114	109	120	70		4	2		6	200	251	303	337	390	442	495
120	115	127	77		2	4		6	210	264	319	355	410	466	521
126	120	133	85			6		6	221	277	335	373	431	489	547
132	126	139	94			4	2	6	231	290	351	391	451	512	573
138	132	146	102			2	4	6	242	304	367	408	472	535	599
144	138	152	112				6	6	252	317	383	426	492	559	625
150	142	157	124		6	2		8	263	330	399	444	513	582	651
156	148	164	134		4	4		8	273	343	415	462	534	605	677
162	154	170	144		2	6		8	284	356	431	480	554	629	703
168	159	176	155			8		8	294	370	447	497	575	652	729
174	165	183	167			6	2	8	305	383	463	515	595	675	755
180	171	189	178			4	4	8	315	396	479	533	616	698	781
186	177	195	191			2	6	8	326	409	495	551	636	722	807
192	182	202	203				8	8	336	422	511	568	657	745	833
198	189	209	216		4	6		10		436	527	586	677	768	859
204	195	216	230		2	8		10		449	543	604	698	792	885
210	201	222	244			10		10		462	559	622	718	815	911
216	207	228	258			8	2	10		475	575	639	739	838	937
222	212	235	272			6	4	10			591	657	759	861	963
228	217	241	287			4	6	10			606	675	780	885	990
234	224	247	302			2	8	10			622	693	800	908	1016
240	229	254	318				10	10			638	710	821	931	1042
246	236	261	336		2	10		12				728	841	954	1068
252	241	267	352			12		12				746	862	978	1094
258	247	274	370			10	2	12					882	1001	1120
264	253	280	387			8	4	12					903	1024	1146
270	259	287	405			6	6	12					923	1048	1172
276	264	291	423			4	8	12					944	1071	1198
282	271	299	442			2	10	12						1094	1224
288	275	304	461				12	12						1117	1250
294	283	312	480			14		14						1141	1276
300	289	319	496			12	2	14						1164	1302
306	294	325	516			10	4	14						1187	1328
312	300	332	536			8	6	14						1211	1354

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. Galvanized, with bolts and nuts.
4. Specified thickness is a nominal galvanized thickness.

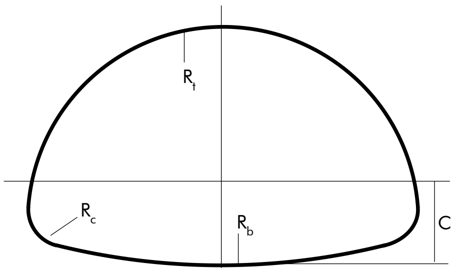


Figure 5. Pipe-Arch

TABLE 19. MULTI-PLATE® PIPE-ARCH [1]

	Span, Ft.-In.	Rise, Ft.-In.	Area, Sq. Ft.	R_t Inches	R_b Inches	C Inches[2]
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	83	29
	7-0	5-1	29	42	104	27
	7-3	5-3	31	44	137	25
	7-8	5-5	33	46	109	28
	7-11	5-7	36	48	138	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	57	229	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	223	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

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

Span, Ft.-In.[1]	Rise, Ft.-In.[1]	Pi	Total Plates	Number of Plates Per Ring[2] 9 Pi C	9 Pi B	15 Pi C	15 Pi B	15 Pi T	18 Pi B	18 Pi T	21 Pi B	21 Pi T	24 Pi B	24 Pi T	Approximate Weight Per Foot of Structure, Pounds[3] — 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.)
6-1	4-7	66	5	2			1	1		1					116	145	176	195	226	256	286
6-4	4-9	69	5	2			1			2					124	152	184	204	236	268	299
6-9	4-11	72	5	2					1	2					126	158	192	213	246	279	312
7-0	5-1	75	5	2					1	1		1			131	165	200	222	257	291	326
7-3	5-3	78	5	2					1			2			137	172	207	231	267	303	339
7-8	5-5	81	5	2							1	2			142	178	215	240	277	314	352
7-11	5-7	84	5	2							1	1		1	147	185	223	249	287	326	365
8-2	5-9	87	5	2							1			2	152	191	231	258	298	338	378
8-7	5-11	90	5	2									1	2	158	198	239	266	308	349	391
8-10	6-1	93	6	2				1		2			1		163	205	247	275	318	361	404
9-4	6-3	96	7	2	1			1	1	2					168	211	255	284	328	372	417
9-6	6-5	99	7	2	1				1	3					173	218	263	293	339	384	430
9-9	6-7	102	7	2	1				1	2		1			179	224	271	302	349	396	443
10-3	6-9	105	7	2			2			2		1			184	231	279	311	359	407	456
10-8	6-11	108	7	2			1		1	2		1			189	238	287	320	369	419	469
10-11	7-1	111	7	2			1		1	1		2			194	244	295	329	380	431	482
11-5	7-3	114	7	2					2	1		2			200	251	303	337	390	442	495
11-7	7-5	117	7	2					2			3			205	257	311	346	400	454	508
11-10	7-7	120	7	2					2			2		1	210	264	319	355	410	466	521
12-4	7-9	123	7	2					1		1	2		1	215	271	327	364	421	477	534
12-6	7-11	126	7	2					1		1	1		2	221	277	335	373	431	489	547
12-8	8-1	129	7	2					1		1			3	226	284	343	382	441	501	560
12-10	8-4	132	8	2					1	3	1	1			231	290	351	391	451	512	573
13-3	9-4	138	7			2			2					3	242	304	367	408	472	535	599
13-6	9-6	141	8			2			2	3		1			247	310	375	417	482	547	612
14-0	9-8	144	8			2			1	3	1	1			252	317	383	426	492	559	625
14-2	9-10	147	8			2			1	2	1	2			257	323	391	435	503	570	638
14-5	10-0	150	8			2			1	1	1	3			263	330	399	444	513	582	651
14-11	10-2	153	8			2				1	2	3			268	337	407	453	523	594	664
15-4	10-4	156	8			2				1	1	3	1		273	343	415	462	534	605	677
15-7	10-6	159	8			2					1	4	1		278	350	423	471	544	617	690
15-10	10-8	162	8			2					1	3	1	1	284	356	431	480	554	629	703
16-3	10-10	165	8			2						3	2	1	289	363	439	488	564	640	716
16-6	11-0	168	8			2						2	2	2	294	370	447	497	575	652	729
17-0	11-2	171	9			2	1		2			2		2	299	376	455	506	585	663	742
17-2	11-4	174	9			2	1		2			1		3	305	383	463	515	595	675	755
17-5	11-6	177	9			2	1		2					4	310	389	471	524	605	687	768
17-11	11-8	180	9			2			3					4	315	396	479	533	616	698	781
18-1	11-10	183	10			2			3	2		3			320	403	487	542	626	710	794
18-7	12-0	186	10			2			2	2	1	3			326	409	495	551	636	722	807
18-9	12-2	189	10			2			2	1	1	4			331	416	503	559	646	733	820
19-3	12-4	192	10			2			1	1	2	4			336	422	511	568	657	745	833
19-6	12-6	195	10			2			1		2	5			341	429	519	577	667	757	846
19-8	12-8	198	10			2			1		2	4		1		436	527	586	677	768	859
19-11	12-10	201	10			2			1		2	3		2		442	535	595	687	780	872
20-5	13-0	204	10			2					3	3		2		449	543	604	698	792	885
20-7	13-2	207	10			2					3	2		3		455	551	613	708	803	898

C = Corner B = Bottom T = Top

(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) Galvanized, with bolts and nuts.

Some pipe-arch sizes with 18-inch corner radius are not shown. Those not shown are almost duplicate sizes of pipe-arches shown with 31-inch corner radius. The 31-inch corner radius structures have a much lower R_t/R_c ratio resulting in lower corner pressures. See design pages. Some pipe-arch structures are furnished with double curved plates.

MULTI-PLATE®

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 Diameter (Ft.-In.)	Rise (Ft.-In.)	Minimum Cover (Inches)	Corner Radius (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.)
				(Maximum Cover Heights Shown in Feet)						
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
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	N/A	8	8	8	8	8	8
19-6	12-6	30	31	N/A	8	8	8	8	8	8
19-8	12-8	30	31	N/A	8	8	8	8	8	8
19-11	12-10	30	31	N/A	8	8	8	8	8	8
20-5	13-0	36	31	N/A	8	8	8	8	8	8
20-7	13-2	36	31	N/A	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 off highway construction loads 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. PLATE ARRANGEMENT AND APPROXIMATE WEIGHT PER FOOT FOR SINGLE RADIUS MULTI-PLATE® ARCH

Arch Arc Length	Number of Plates Per Ring[(2)]						Approximate Weight Per Foot of Structure, Pounds[(2)] – Specified Thickness, Inches						
Pi[(1)]	9 Pi	15 Pi	18 Pi	21 Pi	24 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.)
24					1	1	42	53	64	71	82	93	104
27	1		1			2	47	59	72	80	92	105	117
30		2				2	53	66	80	89	103	116	130
33		1	1			2	58	73	88	98	113	128	143
36		1		1		2	63	79	96	107	123	140	156
39			1	1		2	68	86	104	115	133	151	169
42			1		1	2	74	92	112	124	144	163	182
45				1	1	2	79	99	120	133	154	175	195
48					2	2	84	106	128	142	164	186	208
51		1	2			3	89	112	136	151	174	198	221
54			3			3	95	119	144	160	185	210	234
57			2	1		3	100	125	152	169	195	221	247
60			1	2		3	105	132	160	178	205	233	260
63				3		3	110	139	168	186	215	244	273
66				2	1	3	116	145	176	195	226	256	286
69				1	2	3	121	152	184	204	236	268	299
72					3	3	126	158	192	213	246	279	312
75			3	1		4	131	165	200	222	257	291	326
78			2	2		4	137	172	207	231	267	303	339
81			1	3		4	142	178	215	240	277	314	352
84			2		2	4	147	185	223	249	287	326	365
87				3	1	4	152	191	231	258	298	338	378
90				2	2	4	158	198	239	266	308	349	391
93				1	3	4	163	205	247	275	318	361	404
96			3	2		5	168	211	255	284	328	372	417
99			2	3		5	173	218	263	293	339	384	430
102			1	4		5	179	224	271	302	349	396	443
105				5		5	184	231	279	311	359	407	456
108				4	1	5		238	287	320	369	419	469
111				3	2	5		244	295	329	380	431	482
114				2	3	5		251	303	337	390	442	495
117				1	4	5		257	311	346	400	454	508
120					5	5		264	319	355	410	466	521
123			1	5		6			327	364	421	477	534
126			3		3	6			335	373	431	489	547
129				5	1	6			343	382	441	501	560
132				4	2	6				391	451	512	573
135				3	3	6				400	462	524	586
138				2	4	6				408	472	535	599
141				1	5	6				417	482	547	612
144			1	6		7					492	559	625
147				7		7					503	570	638

(1) Dimensions are to inside crests of corrugations and are subject to manufacturing tolerances. See Table 23 for structure Pi
(2) These plate arrangements will be furnished unless noted otherwise on assembly drawings.
(3) Galvanized, with bolts and nuts.

TABLE 23. MULTI-PLATE® ARCHES (1)

Dimensions					Nominal Arc Length
Span, Feet	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

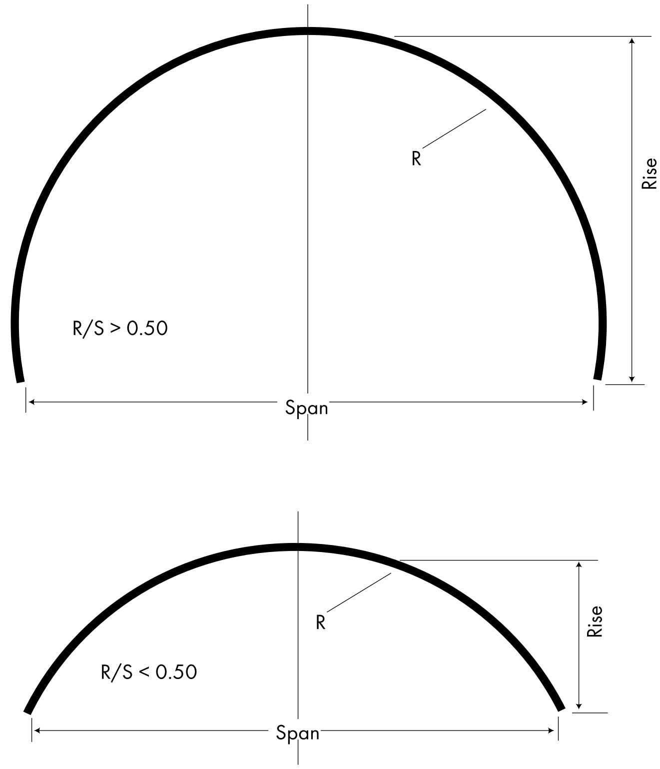


Figure 6. Arch

MULTI-PLATE Arch Pedestrian Underpass

1) Dimensions are to inside crests of corrugations are are subject to manufacturing tolerances.

To determine proper gage, use Table 24 and design information found on Pages 13-18.

For additional arch sizes, see your Contech® representative.

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)								
			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)	0.375 (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	26	38	50	57	69	81	88	142	172
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 off highway construction loads must be checked.
5. Footing reactions provided by supplier.

TABLE 25. MULTI-PLATE® HORIZONTAL ELLIPSE[1]

Structure Number[2]	Span, Ft.-In.	Rise, Ft.-In.	Area, Sq. Ft.	R_t Inches	R_s Inches	Total Pi
24E15	7-4	5-6	31.6	54	27	78
27E15	8-1	5-9	36.4	61	27	84
30E15	8-10	6-0	41.4	68	27	90
30E18	9-2	6-9	48.2	68	32	96
33E15	9-7	6-4	46.7	75	27	96
33E18	9-11	7-0	54.0	75	32	102
36E15	10-4	6-7	52.2	82	27	102
36E18	10-8	7-3	60.1	82	32	108
36E21	11-0	8-0	68.2	82	38	114
39E15	11-1	6-10	58.1	88	27	108
39E18	11-4	7-6	66.4	88	32	114
39E21	11-8	8-3	75.1	88	38	120
39E24	12-0	8-11	84.1	88	43	126
42E15	11-9	7-1	64.2	95	27	114
42E18	12-1	7-10	73.0	95	32	120
42E21	12-5	8-6	82.2	95	38	126
42E24	12-9	9-2	91.7	95	43	132
45E15	12-6	7-4	70.5	102	27	120
45E18	12-10	8-1	79.9	102	32	126
45E21	13-2	8-9	89.6	102	38	132
45E24	13-6	9-6	99.6	102	43	138
48E18	13-7	8-4	87.1	109	32	132
48E21	13-11	9-0	97.3	109	38	138
48E24	14-3	9-9	107.8	109	43	144
48E27	14-7	10-5	118.7	109	49	150
48E30	14-11	11-2	129.9	109	54	156

(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., 45E21 has a 24pi and 21pi plate in the top and bottom (24pi + 21pi = 45pi) and a 21pi plate in each side.

Note:
Horizontal ellipse shapes are intended for use in low cover applications where a relatively wide, low centered flow area is required. Because of their relatively large top radii, special attention must be directed to providing proper backfill support to maintain shape.

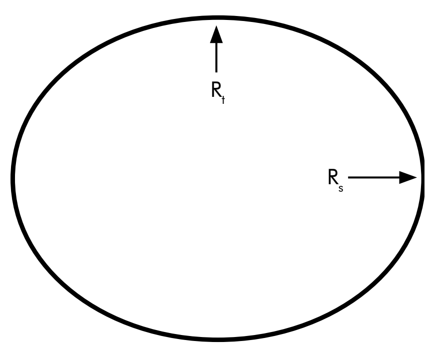


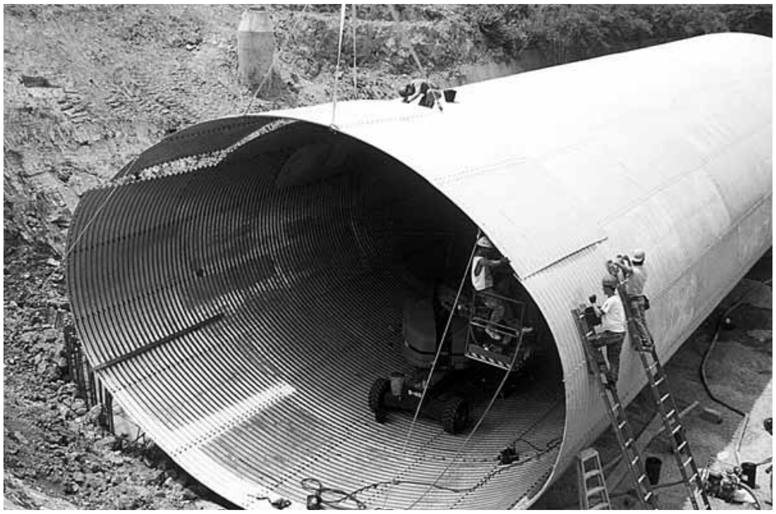
Figure 7. Horizontal Ellipse

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: Span Ft.-In.	Size: Rise, Ft.-In.	All Structures are 12 Gage [1]: Minimum Cover (Inches)	All Structures are 12 Gage [1]: Maximum Cover (In Feet) Over Horizontal Ellipse For Corner Bearing Pressure of 2 Tons per Ft. [2]
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

(1) Heavier gages may be supplied.

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 off highway construction loads must be checked.



Horizontal Ellipse Assembly

TABLE 27. MULTI-PLATE® UNDERPASS [1]

Span, Ft.-In.	Rise, Ft.-In.	Area, Sq. Ft.	R_t Inches	R_s Inches	R_c Inches	R_b Inches
12-2	11-0	107	67	93	38	134
12-11	22-3	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	17-9	295	113	156	47	314

(1) To nearest whole number. Dimensions are to inside crests and are subject to manufacturing tolerances. Smaller (junior) underpasses are also available.

MULTI-PLATE Underpass

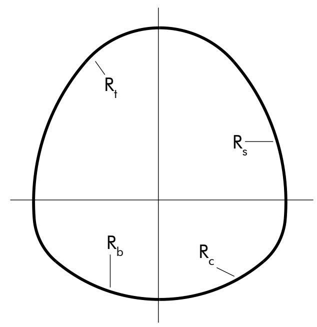


Figure 8. Underpass

(1) Dimensions are to inside crests of corrugations and are subject to manufacturing tolerances.

TABLE 28. PLATE ARRANGEMENT FOR MULTI-PLATE® UNDERPASS

Span, Ft.-In.[1]	Rise, Ft.-In. [1]	Total Pi	Numbers of Nominal Pi Width Plates [2]															Total Plates Per Ring
			Top				Sides					Corners		Bottom				
			15	18	21	24	9	15	18	21	24	15	18	15	18	21	24	
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	18	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	17-9	234			2	1			2	2			2		3			12

(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) Smaller (junior) underpasses are also available.

TABLE 29. APPROXIMATE WEIGHT PER FOOT FOR MULTI-PLATE® UNDERPASS									
Span, Ft.-In.[1]	Rise, Ft.-In. [1]	Approximate Weight Per Foot of Structure, Pounds [2]							
		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.)	Area Sq. Ft.
12-2	11-0	247	310	375	417	482	547	612	107
12-11	11-3	257	323	391	435	503	570	638	116
13-2	11-11	268	337	407	453	523	594	664	126
13-10	12-3	278	350	423	471	544	617	690	136
14-1	12-10	289	363	439	488	564	640	716	147
14-6	13-5	299	376	455	506	585	663	742	158
14-10	14-0	310	389	471	524	605	687	768	169
15-6	14-4	320	403	487	542	626	710	794	180
15-9	15-1	331	416	503	559	646	733	820	192
16-4	15-5		429	519	577	667	757	846	204
16-5	16-1		442	535	595	687	780	872	217
16-9	16-3		449	543	604	698	792	885	224
17-3	17-0		462	559	622	718	815	911	239
18-4	16-11			575	639	739	838	937	252
19-2	17-2			591	657	759	861	963	266
19-6	17-7			606	675	780	885	990	280
20-4	17-9			622	693	800	908	1016	298

[1] Dimensions are to inside crests of corrugations and are subject to manufacturing tolerances.
[2] Galvanized, with bolts and nuts.

TABLE 29 A. MULTI-PLATE® UNDERPASS H-20, HS-20, H-25, HS-25 LIVE LOADS MAXIMUM					
Size [1] Bearing Span, Ft.-In	Rise, Ft.-In.	Radius, Inches R_c Corner	Minimum Specified Thickness Required, Inches	Cover, Inches	Maximum Height of Cover Over Underpass for Corner Pressures of 2 Tons per Sq. Ft.
12-2	11-0	38	0.111	24	22
12-11	11-3	38			20
13-2	11-11	38			20
13-10	12-3	38			19
14-1	12-10	38			19
14-6	13-5	38			19
14-10	14-0	38			19
15-6	14-4	38			15
15-9	15-1	38	0.111	24	15
16-4	15-5	38	0.140	36	15
16-5	16-1	38			14
19-9	16-3	38			14
17-3	17-0	47	0.140		17
18-4	16-11	47	0.170		16
192	17-2	47	0.170		15
19-6	17-7	47	0.170		15
20-4	17-9	47	0.188	36	14

[1] Smaller (junior) underpasses are also available.

Golf Cart Underpass

Galvanized Steel Structural Plate Specification

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

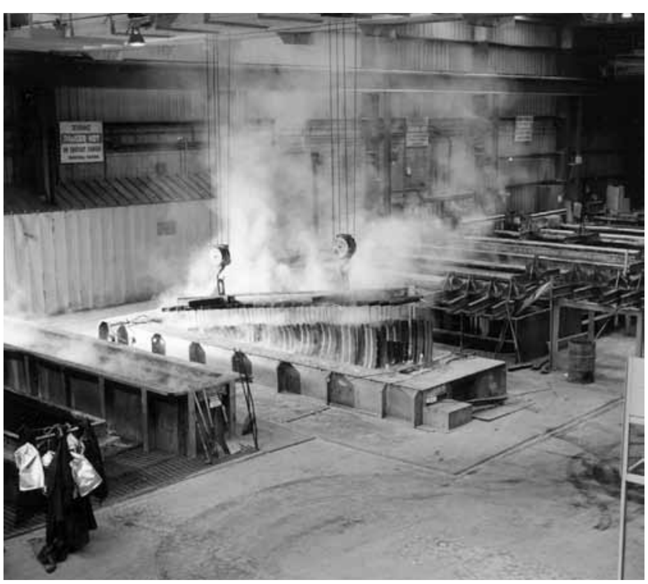
Material: The galvanized steel structural plate structure shall consist of plate and appurtenant items as shown on the plans and shall confirm to the requirements of AASHTO M 167 /ASTM A 761. All manufacturing processes, including corrugating, punching, curving and galvanizing, shall be performed within the United States using raw materials made in the United States.

Assembly bolts and nuts shall be galvanized and meet the provisions of ASTM A 449, Type 1 and ASTM A-563, 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 (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 or A-3. Backfill must be placed symmetrically on each side of the structure in 6 to 8-inch lifts. Each lift shall be compacted to a minimum of 90 percent density per AASHTO T 99.



Hot-Dip Galvanizing Process

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

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 A 449, Type 1 and ASTM A-563, 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 (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. Backfill must be placed symmetrically on each side of the structure in 6- to 8-inch 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 Reference ASTM D 1557.

Note: 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, and backfill.

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.

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

It is recommended that the bedding be stable, *well graded* granular material. Placing the structure on the bedding surface is generally accomplished by one of the two following methods:

- Shaping the bedding surface to conform to the lower section of the structure
- Carefully tamping a granular or select material beneath the haunches to achieve a well-compacted condition

Using one of these two methods ensures satisfactory compaction beneath the haunches.

Backfill
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, 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 99.

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 (D-4 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 D-4).

For more information, refer to ASTM A 807 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.

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 weighs 1/50 as much as 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.

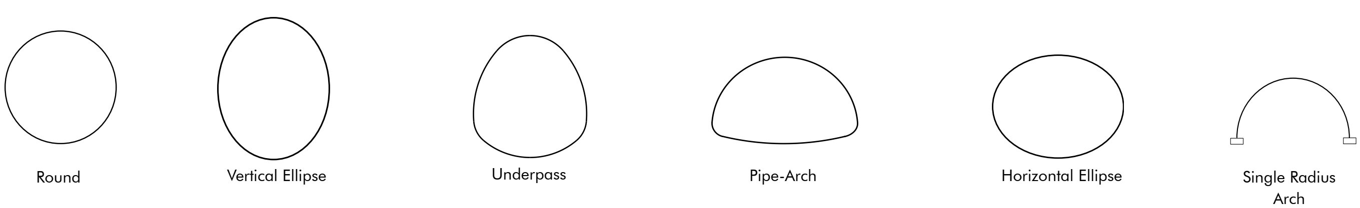
Aluminum Structural Plate can be manufactured into large sections with up to three different radii in the same plate. This reduces the number of joint connections, lowering assembly costs. Off-site assembly is an added feature of lightweight aluminum, with obvious cost-saving benefits.

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

National Specification

Contech's Aluminum Structural Plate design meets or exceeds AASHTO Standard Specifications for Highway Bridges (Sec. 12.6) and ASTM B 790. Material meets or exceeds AASHTO M 219 or ASTM B 746. Installation is covered by AASHTO Standard Specifications for Highway Bridges (Sec. 26.5) and ASTM B 789.

Lifting of 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 at right angles 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.)

Lengths. Individual circumferential plate lengths are noted in terms of N (N = 9.625" or 9-5/8 or 3pi). Standard plates are fabricated in net covering lengths in one "N" increments from:

8N (77.00"), through 20N (192.52").

The N nomenclature translated 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.

Widths. All standard plates have a net width of 4'-6".

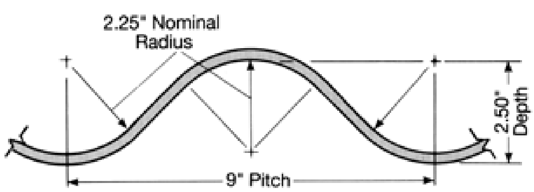
Longitudinal bolt holes at 4-$^{1}/_{2}$" centers provide a standard 5.33 bolts per foot of longitudinal seams in two parallel rows at 1- $^{3}/_{4}$" centers. The outside crests of the end corrugations are punched for circumferential seam holes on center of 9.625" (or 3 pi).

Materials. Plates are fabricated from an aluminum alloy with material properties that conform to AASHTO M 219 and ASTM B 209 specifications.

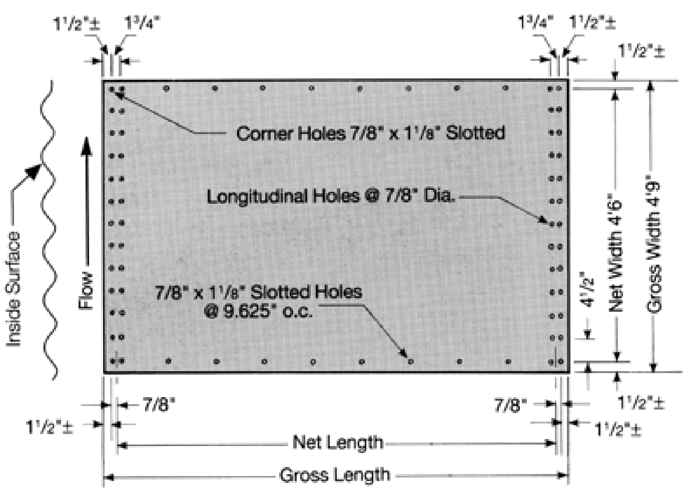
Bolts and nuts

Hot-dipped galvanized, specially heat-treated $^{3}/_{4}$"-diameter steel bolts, meeting ASTM A 307 specifications, are used to assemble structural plate sections. The underside of the bolt head is uniformly rounded and does not require special positioning.

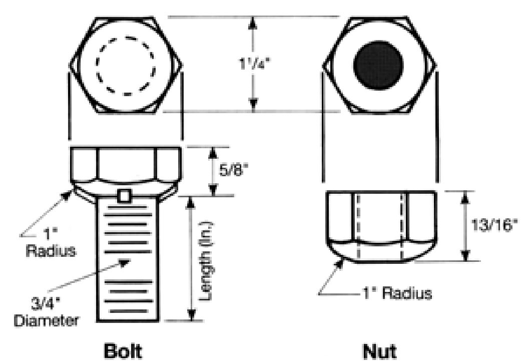
In addition, the underside of the bolt head is ribbed to prevent bolt head rotation while tightening. Unlike conventional bolts, once the nut is finger tight, final tightening can usually be accomplished by one worker.



9" x 2 1/2" Corrugation



Standard Plate Detail



Bolt and Nut

TABLE 30. SECTION PROPERTIES OF PLATES ONLY[1]
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[2]	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

[1] Design Yield Stress is 24 ksi.

[2] 0.100" Thickness can not be curved.

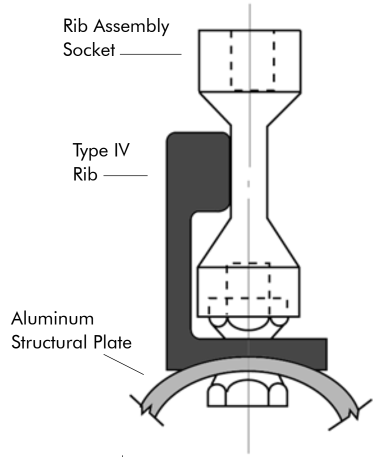
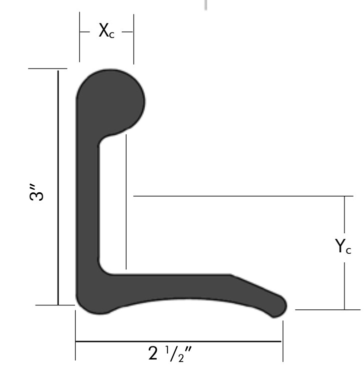
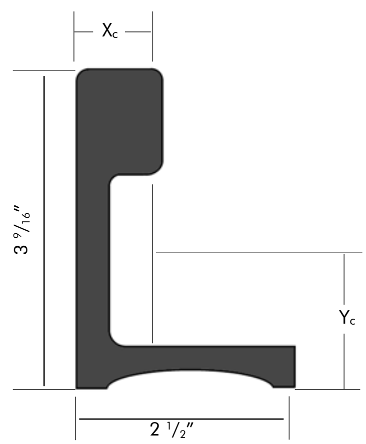


TABLE 31. PLATE & RIB COMPOSITE SECTION PROPERTIES

Rib Type		Metal Thickness, Inches 0.125	0.150	0.175	0.200	0.225	0.250
		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



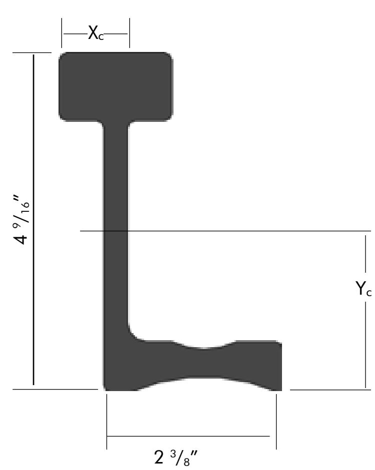
Type II Rib



Type IV 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 VI Rib

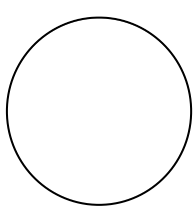
Height of Cover and Details Tables – HS-20 Loading

Round, Vertical Ellipse

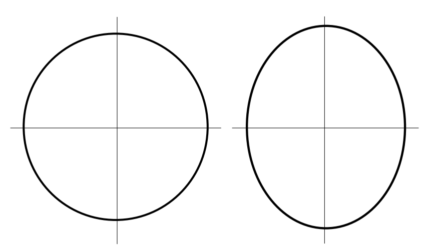
TABLE 33. ROUND STRUCTURES (H-20, HS-20 LIVE LOAD)									TABLE 34. ROUND, ELLIPSE DETAILS				
Metal Thickness (Inches) — Reinforcing Rib Type-Rib Spacing (Inches) (Maximum Cover — Ft.)									Ellipse Dimensions (inches)		Total N		
		Approx.										Rib	
Diameter	Round	Area	Minimum Height-of-Cover (Feet)						Span	Rise	Structure	Round	Ellipse
(ft.-In.)	(inches)	(sq. ft.)	1.25	1.50	2.00	2.50	3.00	3.50					
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	18/3	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. (Call your local Contech representative for H-25 and 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 off highway construction loads must be checked.
5. Greater cover heights possible with heavier gage and rib combinations.
6. Plate and rib combinations shown meet or exceed AASHTO Sec. 12.6 Standard Specifications for Highway Bridges.
7. Minimum cover heights < span/8 determined by moment capacity analysis.
8. Contact your local Contech representative for information regarding vertical ellipse shapes.

Notes:
1. N = 9.625″ (9 5/8″).
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



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

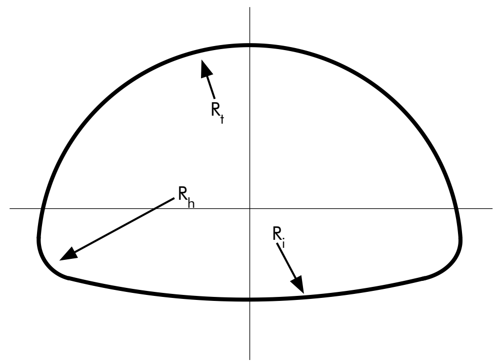


* Greater max. cover heights are available for each diameter by use of heavier gages.

Pipe-Arch

TABLE 35. PIPE-ARCH DETAILS (1,2,3,5,6)										
		Approx.	Inside Radius (Inches)		Arc Length N(4)			Total N		
Span (Ft.-In.)	Rise (Ft.-In.)	Area (Sq. Ft.)	Crown (R_t)	(R_i)	Crown	Haunch	Invert	Structure	Rib(6) (Min)
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	
8-10	6-4	44.5	63.3	93.0	10	7	7	31	11
9-3	6-5	47.1	64.4	112.6	11	7	7	32	10
9-7	6-6	49.9	65.4	141.6	12	7	7	33	11
9-11	6-8	52.7	66.4	188.7	13	7	7	34	10
10-3	6-9	55.5	67.4	278.8	14	7	7	35	11
10-9	6-10	58.4	77.5	139.6	13	7	9	36	12
11-1	7-0	61.4	77.8	172.0	14	7	9	37	11
11-5	7-1	64.4	78.2	222.0	15	7	9	38	12
11-9	7-2	67.5	78.7	309.5	16	7	9	39	13
12-3	7-3	70.5	90.8	165.2	15	7	11	40	14
12-7	7-5	73.7	90.5	200.0	16	7	11	41	13
12-11	7-6	77.0	90.4	251.7	17	7	11	42	14
13-1	8-2	83.0	88.8	143.6	18	6	13	43	13
13-1	8-4	86.8	81.7	300.8	21	6	11	44	14
13-11	8-5	90.3	100.4	132.0	18	6	15	45	13
14-0	8-7	94.2	90.3	215.7	21	6	13	46	14
13-11	9-5	101.5	86.2	159.3	23	5	14	47	14
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	13
14-11	9-10	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	14
15-7	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	15
16-4	10-6	132.3	101.0	196.1	27	5	17	54	14
16-9	10-8	136.9	105.0	186.5	27	5	18	55	16
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	17
17-9	11-2	151.6	110.4	208.9	29	5	19	58	16
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	17
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	18
19-5	11-11	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	19
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	18
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	19
21-6	12-11	211.2	134.8	257.3	35	5	24	69	20
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
21-5	14-7	241.5	133.0	238.6	36	7	22	72	19
21-11	14-11	254.7	135.0	270.0	38	7	22	74	19

Notes
1. N = 9.625″ (9-5/8″).
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.
5. Haunch Radius (R_h) = 31.75″ except for the last four structures shown, which have a haunch radius (R_h) = 47.0″
6. Minimum reinforcing rib length, if required.



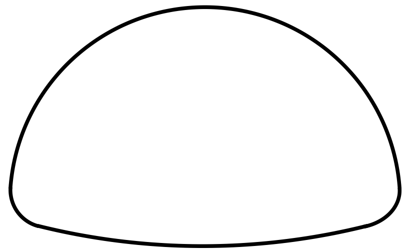


TABLE 36. PIPE-ARCH STRUCTURES (H-20, HS-20 LIVE LOAD)								
Metal Thickness (Inches) — Reinforcing Rib Type — Rib Spacing (Inches) (Maximum Cover-Ft.)								
Span	Rise	Approx. Area	Minimum Height-of-Cover (Feet)					
(Ft.-In.)	(Ft.-In.)	(Sq. Ft.)	1.25	1.50	2.00	2.50	3.00	3.50
6-7	5-8	29.6	.175	.125	.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						
13-11	8-5	90.3			.125-II-18	.125-II-27	.125	.125
14-0	8-7	94.2			(10)	(10)	(10)	(10)
13-11	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	9-10	114.2						
15-4	10-0	118.6			.125-II-9	.125-II-27	.150	.125
15-7	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-18	.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	11-11	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			(11)	(11)	(11)	(11)
21-5	14-7	241.5						
21-11	14-11	254.7						

Notes:
1. Tables based upon AASHTO Sec. 12 Standard Specifications for Highway Bridges.
2. H-20, HS-20 Live Loads. (Call your Contech representative for HS-25 and H-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 off highway construction 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.

Single Radius Arch

TABLE 37. ARCH DETAILS (1,2,3,6)						
Span (Ft.-In.)	Rise (Ft.-In.)	Approx Area (Sq. Ft.)	Radius (Inches)	Rise/ Span Ratio	Total N Structure	Total N Rib(4)
5-0	1-9	6.5	31.75	.36	8	
	2-3	8.5	30.25	.44	9	
	2-7	10.4	30.00	.52	10	
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
	5-8	49.8	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” (9-5/8”).
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. Reinforcing rib length, if required.
5. The aluminum receiving angle is a separate item.
6. Arch shapes shown are single radius with a rise/span ratio of 0.30 or greater.

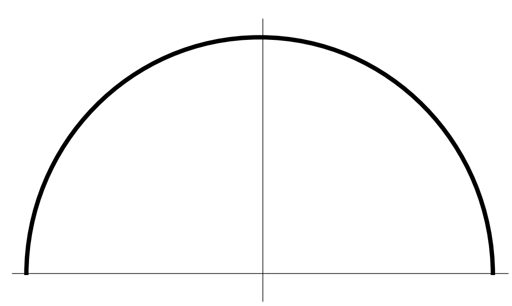
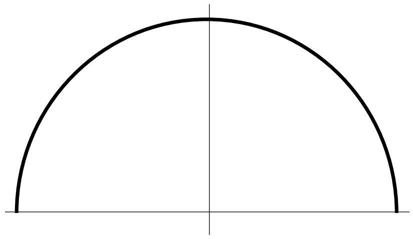


TABLE 38. ARCH STRUCTURES (H-20, HS-20 LIVE LOAD)

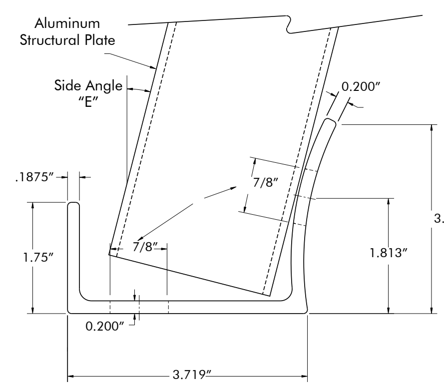
Span	Rise	Approx. Area	Metal Thickness (Inches) — Reinforcing Rib Type-Rib Spacing (Inches) (Maximum Cover-Ft.) Minimum Height of Cover (feet)					
(Ft.-In.)	(Ft.-In.)	(Sq. Ft.)	1.25	1.50	2.00	2.50	3.00	3.50
5-0	1-9	6.5	.125	.125	.125	.125	.125	.125
	2-3	8.5	(45)	(45)	(45)	(45)	(45)	(45)
	2-7	10.4						
6-0	1-10	7.8	0.13	.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)
	5-8	49.8						
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						



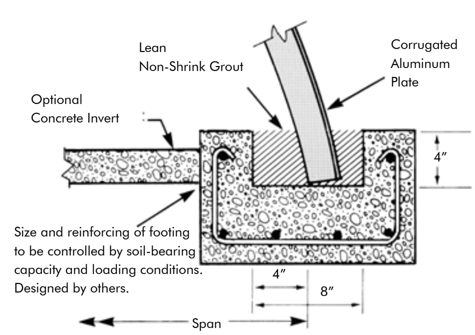
* Greater max. cover heights are available for each span by use of heavier gages.

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. (Call your local Contech representative for H-25 and 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 off highway construction 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. Greater cover heights possible with other plate thickness/rib combinations.
8. Arch footing reaction provided by supplier.



Aluminum Receiving Channel



Slotted Concrete Footing

Underpass

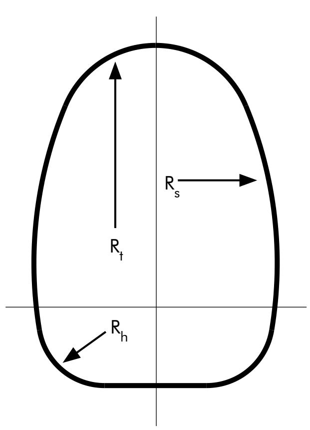
TABLE 39. PEDESTRIAN/ANIMAL UNDERPASS DETAILS (1,2,3,7)

Span (Ft.-In.)	Rise (Ft.-In.)	Approx. Area (Sq. Ft.)	Inside Radius (Inches)(5) Crown (R_t)	Side (R_s)	Haunch (R_h)	Arc Length (Inches)(4) Crown	Side	Haunch	Bottom	Total N Structure	Rib(6)
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	6-5	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	N/A
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	

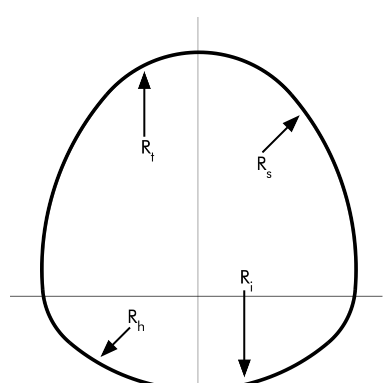
TABLE 40. VEHICULAR UNDERPASS DETAILS(1,2,3,7)

Span (Ft.-In.)	Rise (Ft.-In.)	Approx. Area (Sq. Ft.)	Inside Radius (Inches) Crown (R_t)	Side (R_s)	Haunch (R_h)	(R_i)	Arc Length N Crown	Side	Haunch	Invert Bottom	Total N Structure	Rib(6)
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" (9-5/8").
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. The bottoms of pedestrian/animal underpasses are nearly flat.
6. Mimimum reinforcing rib length, if required. (Ribs are not available for pedestrian underpass shapes.)
7. See sidefill and foundation design on Page 57.



Pedestrian Underpass



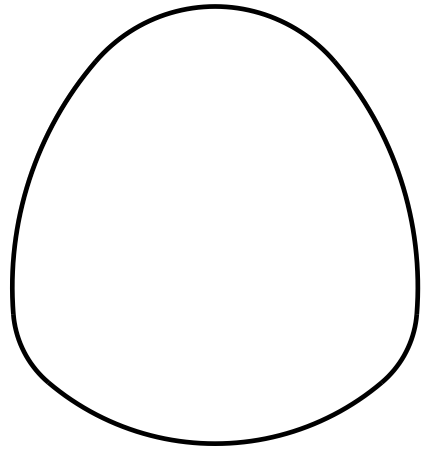
Vehicular Underpass

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	6-5	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		.150-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		.200-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		.250-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			.175-II-9	.175-II-27	.175-II-54	.175
18-5	16-11	252.0			(9)	(9)	(9)	(9)
19-0	17-3	266.0		.200-VI-9	.200-VI-18	.200-II-18	.200-II-54	.200
19-7	17-7	280.2		(13)	(13)	(13)	(13)	(13)
20-5	17-9	294.4						

Note
1. Maximum cover based on allowable corner bearing pressure of approximately 4,000 psf (2tsf).



Underpass Section

Notes for Tables 33, 36, 38, 41 and 43
1. 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 may possibly be used. Call your Contech representative.
2. 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. Minimum cover is measured at the lowest fill area subjected to possible wheel loads (typically at the roadway shoulder). Minimum cover must be maintained in unpaved areas. Maximum cover is measured at the highest fill and/or the highest pavement elevation.
3. To find the minimum material requirements for the aluminum structural plate structure:
   A. Locate the structure required.
   B. Select the cover in the top row that is equal to or less than that required for the project.
   C. The table selection shows metal thickness, rib type, rib spacing and maximum cover. Example: .150-11-27 = 0.150" – thick plate structure with Type II ribs at 27" on centers on the crown.
4. The tables are based on the following:
   A. Design specifications: Section 12 of AASHTO's Standard Specifications for Highway Bridges and ASTM B 790.
   B. Standard H-20, HS-20 wheel loads. Consult a Contech representative for special loading conditions.
   C. AASHTO M145 backfill materials classified as A-1, A-2, or A-3 compacted to 90% density per AASHTO T99. Unit weight of soil: 120 Lb./Cu. Ft.
   D. Yield point of aluminum: 24,000 psi for plate, 35,000 psi for reinforcing ribs.
   E. Allowable corner bearing pressure of approximately 4,000 psf (2 tsf) for horizontal ellipses, pipe-arches, and underpasses.

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 (Lb./Cu. Ft.)
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)

Aluminum Structural Plate

Ellipse

TABLE 42. HORIZONTAL ELLIPSE DETAILS[1,2,4]

Structure Number	Span Ft.-In.	Rise Ft.-In.	Area (Sq. Ft.)	R_t Inches	Approx. R_s Inches	Total N Structure	Total N Rib[3]
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" (9 5/8").
2. Dimensions are to inside corrugation crests and are subject to manufacturing tolerances.
3. Minimum reinforcing rib length, if required.

Installation of Aluminum Horizontal Ellipses

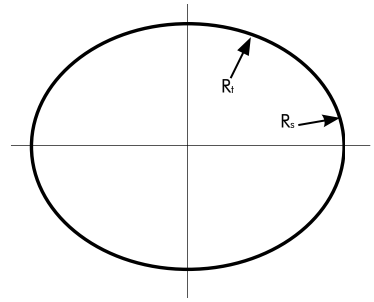


TABLE 43. HORIZONTAL ELLIPSE STRUCTURES (H-20, HS-20 LIVE LOAD)

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

Span (Ft.-In.)	Rise (Ft.-In.)	Area (Sq. Ft.)	Approx. Minimum Height-of-Cover (Feet) 1.25	1.50	2.00	2.50	3.00	3.50
9-2	6-8	48	.125-II-9 (14)	.125-II-18 (14)	.125 (14)	.125 (14)	.125 (14)	.125 (14)
9-11	7-0	54						
10-7	7-3	60	.150-II-9 (13)	.125-II-18 (13)	.225-II-27 (11)	.125 (13)	.125 (13)	.125 (13)
10-11	7-11	68						
11-4	7-6	66	.225-II-9 (11)	.225-II-9 (11)	.225-II-27 (11)	.125 (11)	.125 (11)	.125 (11)
11-8	8-3	75						
12-0	8-11	84						
12-1	7-9	73						
12-5	8-6	82		.150-II-9 (10)	.125-II-27 (10)	.150 (10)	.125 (10)	.125 (10)
12-9	9-2	92						
12-10	8-1	80						
13-2	8-9	89	.175-VI-18	.175-VI-18	.175-IV-27	125-II-27	.125	.125
13-6	9-6	99	(9)	(9)	(9)	(9)	(9)	(9)
13-7	8-4	87						
13-11	9-0	97						
14-3	9-9	108	.125-VI-9	.175-VI-18	.175-IV-27	125-II-27	.125	.125
14-7	10-5	119	(11)	(11)	(11)	(11)	(11)	(11)
14-11	11-2	130						

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. (Call 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 off highway construction 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.

TABLE 44. APPROXIMATE HANDLING WEIGHT OF STRUCTURE (POUNDS PER FOOT)

Total N	Nominal Thickness (Inches) .125	.150	.175	.200	.225	.250	Bolts per Foot of Structure	Plates per Ring in a Structure*
8	19	23	26	29	32	35	6.9	1
9	21	25	28	32	35	39	7.1	1
10	23	27	31	35	38	43	7.3	1
11	25	30	34	38	42	46	7.6	1
12	27	32	37	41	45	50	7.8	1
13	29	34	39	44	49	54	8.0	1
14	31	37	42	47	52	58	8.2	1
15	36	43	49	54	60	66	13.6	1
16	38	45	52	57	63	70	13.8	1
17	40	48	54	60	67	74	14.0	1
18	42	50	57	63	70	77	14.2	1
19	44	52	60	66	73	81	14.4	2
20	46	55	62	70	77	85	14.7	2
21	48	57	65	73	80	89	14.9	2
22	51	59	68	76	83	93	15.1	2
23	52	62	70	79	87	96	15.3	2
24	54	64	73	82	90	100	15.6	2
25	56	66	76	85	94	104	15.8	2
26	58	69	79	88	97	108	16.0	2
27	59	71	81	91	100	112	16.2	2
28	61	73	84	94	104	115	16.4	2
29	67	80	91	101	112	124	21.8	2
30	69	82	93	104	115	128	22.0	2
31	71	84	96	107	118	132	22.2	2
32	73	87	99	110	122	135	22.7	2
33	75	89	102	113	125	139	22.7	2
34	77	91	104	116	129	143	22.9	2
35	79	94	107	120	132	146	23.1	2
36	80	96	110	123	135	150	23.3	2
37	82	98	112	126	139	154	23.6	3
38	84	101	115	129	142	158	23.8	3
39	86	103	118	132	146	162	24.0	3
40	88	105	121	135	149	165	24.2	3
41	90	108	123	138	152	169	24.4	3
42	92	110	126	141	156	173	24.7	3
43	98	116	133	148	164	181	30.0	3
44	100	118	135	151	167	185	30.2	3
45	102	121	138	154	170	189	30.4	3
46	103	123	141	157	174	193	30.7	3
47	105	125	144	160	177	197	30.9	3
48	107	128	146	163	180	200	31.1	3
49	109	130	149	166	184	204	31.3	3
50	111	133	152	169	187	208	31.6	3
51	113	135	154	173	191	212	31.8	3
52	115	137	157	176	194	215	32.0	3
53	117	140	160	179	197	219	32.2	3
54	119	142	163	182	201	223	32.4	4
55	121	144	165	185	204	227	32.7	4
56	123	147	168	188	208	231	32.9	4
57	128	153	175	195	215	239	38.2	4
58	130	155	177	198	219	243	38.4	4
59	132	157	180	201	222	247	38.7	4
60	134	160	183	204	226	250	38.9	4
61	136	162	186	207	229	254	39.1	4
62	138	164	188	210	232	258	39.3	4
63	140	167	191	213	236	262	39.6	4
64	142	169	194	216	239	266	39.8	4
65	144	171	196	219	243	269	40.0	4
66	146	174	199	223	246	273	40.2	4
67	148	176	202	226	249	277	40.4	4
68	150	178	205	229	253	281	40.7	4
69	151	181	207	232	256	285	40.9	4
70	153	183	210	235	260	288	41.1	4
71	159	189	217	242	267	297	46.4	4
72	161	192	219	245	271	300	46.7	4
73	163	194	222	248	274	304	46.9	4
74	165	196	225	251	278	308	47.1	4
75	167	199	228	254	281	312	47.3	5
76	169	201	230	257	284	316	47.6	5
77	170	203	233	260	288	319	47.8	5
78	172	206	236	263	291	323	48.0	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 of Structure."
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" will be furnished unless noted otherwise on the assembly drawings.

* Round or arch only

Reinforcing Rib Design

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 at spacings of 9", 18", 27" or 54" centers.

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

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

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

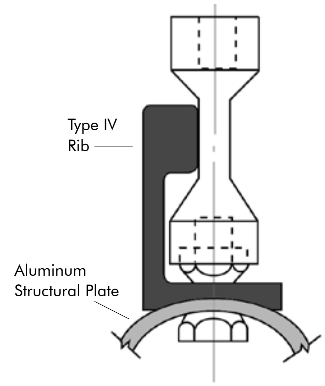
Total N of Rib	9" o.c.		18" o.c.		27" o.c.		54" o.c.	
	Wt/ft	Bolts/ft	Wt/ft	Bolts/ft	Wt/ft	Bolts/ft	Wt/ft	Bolts/ft
5	20.0	7.3	9.8	3.3	6.4	2.0	3.0	0.7
6	23.7	8.6	11.6	3.9	7.6	2.3	3.6	0.8
7	27.4	9.8	13.4	4.4	8.8	2.7	4.2	0.9
8	31.0	11.0	15.2	5.0	10.0	3.0	4.7	1.0
9	34.7	12.2	17.1	5.6	11.2	3.3	5.3	1.1
10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

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

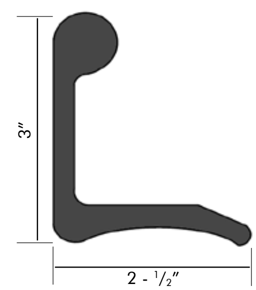
Total N of Rib	9" o.c.		18" o.c.		27" o.c.		54" o.c.	
	Wt/ft	Bolts/ft	Wt/ft	Bolts/ft	Wt/ft	Bolts/ft	Wt/ft	Bolts/ft
5	28.8	7.3	14.2	3.3	9.4	2.0	4.5	0.7
6	34.1	8.6	16.9	3.9	11.1	2.3	5.3	0.8
7	39.4	9.8	19.5	4.4	12.8	2.7	6.2	0.9
8	44.8	11.0	22.1	5.0	14.6	3.0	7.0	1.0
9	50.1	12.2	24.7	5.6	16.3	3.3	7.8	1.1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

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.

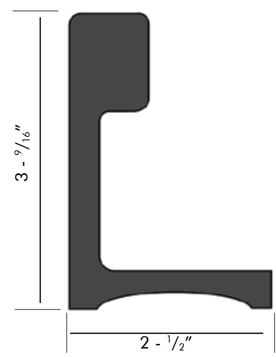
Rib Assembly Socket



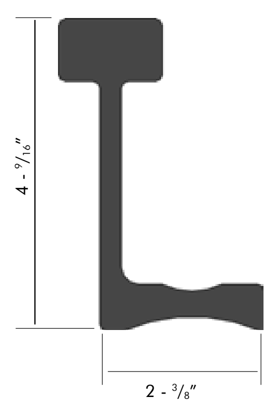
Type II Rib



Type IV Rib



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 219 and ASTM B 746. 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 of between 90 and 135 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 (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 or A3. Backfill must be placed symmetrically on each side of the structure in 6 to 8 inch lifts. Each lift shall be compacted to a minimum of 90 percent density per AASHTO T 99.

Note: 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 problems 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 bed should be constructed to avoid distortions that may create undesirable stresses in the structure and/or rapid deterioration of the roadway. The bed should be free of rock formations, protruding stones and frozen matter that may cause unequal settlement.

It is recommended that the bedding be stable, *well graded* granular material. Placing the structure on the bedding surface is generally accomplished by one of the two following methods:

- Shaping the bedding surface to conform to the lower section of the structure
- Carefully tamping a granular or select material beneath the haunches to achieve a well-compacted condition

Using one of these two methods ensures satisfactory compaction beneath the haunches.

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.

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 six-inch loose lifts. Each lift is to be compacted to a minimum of 90 percent density per AASHTO T 99.

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 (D-4 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 D-4).

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.

Pavement

For minimum cover applications, Contech recommends that a properly designed flexible or rigid pavement be provided above the structure to distribute live loads and maintain cover.

Precautions

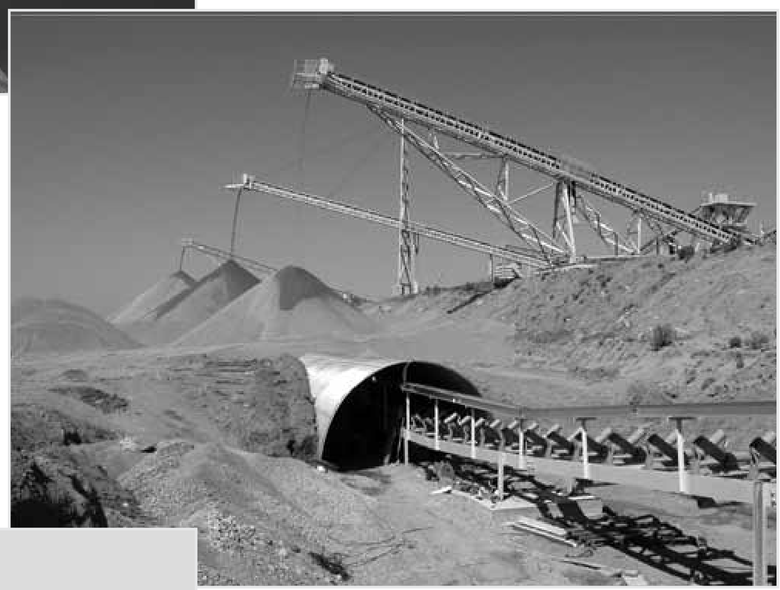
During installation and prior to the construction of permanent erosion control and end treatment protection, special precautions may be necessary.

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.

SUPER-SPAN Structure for Access Roads

MULTI-PLATE Conveyor Covers



Single Radius Arch for Residential Development

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 of only 17 inches for all spans, handling HS-20 or HS-25 live loads.

Faster Installation Means Lower Installed Cost

Closing roads for bridge replacement causes extensive traffic detours, so minimizing installation time is critical. Aluminum Box Culverts may be quickly erected in place and are usually ready to be backfilled in a matter of hours. For faster installation, Aluminum Box Culverts can be completely assembled nearby while the site is being prepared. Light equipment can then be used to set them in place.

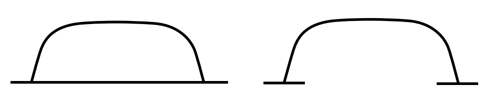
National Specification

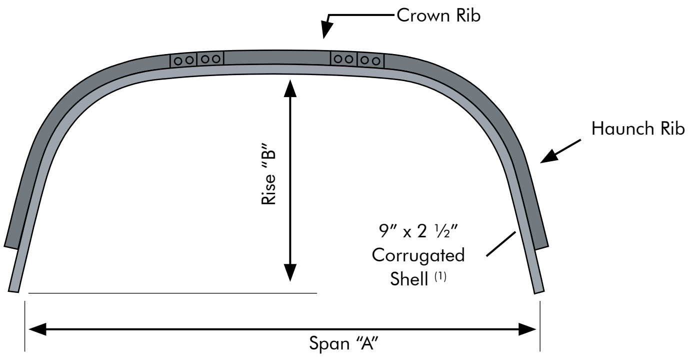
Contech Aluminum Box Culvert design and installation is covered by AASHTO Standard Specifications for Highway Bridges (Sec 12.8). The material is covered by AASHTO M 219 and ASTM B 864.

Lifting of Aluminum Box Culvert

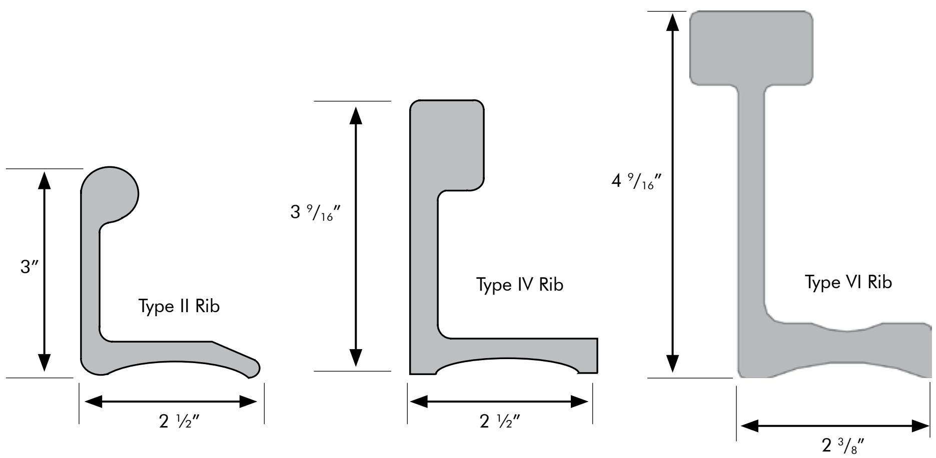
Installation of Ribs

Corrugated Aluminum Headwall Package





Box Culvert Shell Cross Section



Box Culvert Rib Geometry

Notes (refer to pages 66-67)

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 48 & 49, 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. See Table 48B for HS-25 loading design information. Call a 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)[9]	A6 Max. (Feet)[9]	B6 HG\CG (Gage)	B6 HRS/CRS (Inches)	B6 Min. (Feet)[9]	B6 Max. (Feet)[9]	C6 HG\CG (Gage)	C6 HRS/CRS (Inches)	C6 Min. (Feet)[9]	C6 Max. (Feet)[9]	Max. 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									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	1.4	5.0									54
4	10-0	4-10	40.2	2\2	54/18	1.4	5.0									58
5	10-6	5-7	48.1	2\2	54/18	1.7	5.0	3\3	54/18	1.4	5.0					71
6	10-11	6-4	56.4	2\2	54/18	2.0	5.0	2\2	27/18	1.4	5.0					74
7	11-4	7-2	65.0	2\2	54/18	2.5	5.0	2\2	54/9	1.4	5.0					79
8	10-2	2-8	23.0	2\2	54/18	1.7	5.0	3\3	54/18	1.4	5.0					60
9	10-7	3-5	31.1	2\2	54/18	2.0	5.0	3\3	54/18	1.4	5.0					65
10	10-11	4-3	39.5	2\2	54/18	2.0	5.0	3\3	54/18	1.4	5.0					70
11	11-4	5-0	48.2	2\2	54/18	2.5	5.0	3\3	54/18	1.7	5.0	2\2	54/9	1.4	5.0	79
12	11-8	5-9	57.2	2\2	54/18	2.5	5.0	3\3	54/18	1.7	5.0	2\2	54/9	1.4	5.0	83
13	12-1	6-7	66.4	2\2	54/18	3.0	5.0	2\2	27/18	2.0	5.0	2\2	54/9	1.4	5.0	86
14	12-5	7-4	76.0	2\2	54/18	3.0	5.0	2\2	27/18	2.5	5.0	2\2	27/9	1.4	5.0	98
15	11-7	2-10	28.1	2\2	54/18	2.5	5.0	3\3	54/18	1.7	5.0	3\3	27/18	1.4	5.0	75
16	11-11	3-7	37.4	2\2	54/18	2.5	5.0	3\3	54/18	2.0	5.0	4\4	54/18	1.4	5.0	81
17	12-3	4-5	46.9	2\2	54/18	3.0	5.0	3\3	54/18	2.0	5.0	3\3	27/18	1.4	5.0	87
18	12-7	5-2	56.6	2\2	54/18	3.0	5.0	2\2	27/18	2.5	5.0	2\2	27/9	1.4	5.0	98
19	12-11	6-0	66.6	2\2	54/18	3.0	5.0	2\2	27/18	2.5	5.0	2\2	27/9	1.4	5.0	102
20	13-3	6-9	76.9	3\3	54/18	2.5	5.0	3\3	27/18	2.0	5.0	2\2	27/9	1.4	5.0	105
21	13-0	3-0	33.8	3\3	54/18	2.5	5.0	4\4	54/18	2.0	5.0	4\4	27/18	1.4	5.0	91
22	13-4	3-10	44.2	3\3	54/18	3.0	5.0	3\3	27/18	2.0	5.0	3\3	54/9	1.4	5.0	102
23	13-7	4-7	54.8	3\3	54/18	3.0	5.0	3\3	27/18	2.5	5.0	3\3	54/9	1.4	5.0	107
24	13-10	5-5	65.6	2\2	27/18	3.0	5.0	3\3	27/18	2.5	5.0	3\3	54/9	1.4	5.0	112
25	14-1	6-2	76.6	3\3	54/18	3.0	5.0	3\3	27/18	2.5	5.0	2\2	18/9	1.4	5.0	121
26	14-5	3-3	40.0	3\3	27/18	3.0	5.0	4\4	27/18	2.5	5.0	5\5	18/18	1.4	5.0	114
STRUCTURES 27 THROUGH 39 HAVE TYPE II HAUNCH AND TYPE VI CROWN RIBS[10]																
27	14-8	4-1	51.5	2\2	27/18	1.4	5.0									100
28	14-10	4-10	63.2	2\2	27/18	1.4	5.0									112
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	3\2	18/18	1.4	5.0					138
33	15-10	3-6	46.8	2\2	27/18	2.1	5.0	3\2	18/18	1.4	5.0					115
34	16-0	4-3	59.5	2\2	27/18	2.3	5.0	3\2	18/18	1.4	5.0					122
35	16-2	5-1	72.3	2\2	27/18	2.4	4.9	3\2	18/18	1.4	5.0					129
36	16-4	5-11	85.2	2\2	27/18	2.6	4.5	3\2	18/18	1.4	5.0					133
37	16-6	6-8	98.3	3\2	27/18	1.8	5.0	4\2	18/18	1.4	5.0					146
38	16-8	7-6	111.5	3\2	27/18	1.9	5.0	4\2	18/18	1.4	5.0					151
39	16-10	8-3	124.8	3\2	27/18	2.0	5.0	4\2	18/18	1.4	5.0					165
STRUCTURES 40 THROUGH 87 USE ALL TYPE VI RIBS[10]																
40	17-9	3-10	54.4	2\2	54/18	2.0	5.0	2\2	27/18	1.4	5.0					124
41	18-2	4-7	68.3	2\2	54/18	2.2	5.0	2\2	27/18	1.4	5.0					131
42	18-7	5-4	82.5	2\2	54/18	2.4	5.0	2\2	27/18	1.4	5.0					138
43	19-0	6-1	97.1	2\2	54/18	2.6	5.0	2\2	27/18	1.4	5.0					142
44	19-5	6-11	111.9	2\2	54/18	2.8	5.0	2\2	18/18	1.4	5.0					154
45	19-10	7-8	127.1	2\2	54/18	2.9	5.0	2\2	18/18	1.4	5.0					164
46	20-3	8-5	142.6	2\2	27/18	1.9	5.0	2\2	18/18	1.4	5.0					167
47	19-1	4-2	63.3	2\2	54/18	2.6	5.0	2\2	18/18	1.4	5.0					133
48	19-5	4-11	78.3	2\2	54/18	2.8	5.0	2\2	18/18	1.4	5.0					153
49	19-9	5-8	93.6	2\2	54/18	2.9	4.8	2\2	18/18	1.4	5.0					162
50	20-1	6-6	109.2	2\2	27/18	1.9	5.0	2\2	18/18	1.4	5.0					165
51	20-6	7-3	125	2\2	27/18	2.0	5.0	2\2	18/18	1.4	5.0					169
52	20-10	8-1	141.2	2\2	27/18	2.1	5.0	2\2	18/18	1.4	5.0					173
53	21-2	8-10	157.6	2\2	27/18	2.2	5.0	2\2	18/18	1.4	5.0					176
54	20-4	4-6	73.1	2\2	27/18	2.0	5.0	2\2	18/18	1.4	5.0					153
55	20-7	5-3	89.2	2\2	27/18	2.1	5.0	2\2	18/18	1.4	5.0					162
56	20-11	6-1	105.5	2\2	27/18	2.2	5.0	2\2	18/18	1.4	5.0					171
57	21-3	6-10	122.1	2\2	27/18	2.3	5.0	2\2	18/18	1.4	5.0					174
58	21-6	7-8	139.0	2\2	27/18	2.3	5.0	2\2	18/18	1.4	5.0					178
59	21-10	8-5	156.0	2\2	27/18	2.5	5.0	2\2	18/18	1.4	5.0					182
60	22-1	9-3	173.3	2\2	27/18	2.5	4.8	2\3	18/18	1.4	5.0					190
61	21-7	4-11	83.8	2\2	27/18	2.4	5.0	2\2	18/18	1.4	5.0					162
62	21-10	5-8	101	2\2	27/18	2.5	5.0	2\2	18/18	1.4	5.0					171
63	22-1	6-6	118.4	2\2	27/18	2.5	4.8	2\3	18/18	1.4	5.0					185
64	22-3	7-3	135.9	2\2	27/18	2.6	4.6	2\3	18/18	1.4	5.0					188
65	22-6	8-1	153.7	2\2	27/18	2.7	4.4	2\3	18/18	1.4	5.0					192
66	22-9	8-10	171.6	2\2	27/18	2.8	4.2	2\4	18/18	1.4	5.0					191
67	23-0	9-8	189.8	2\2	27/18	2.8	4.0	2\4	18/18	1.4	5.0					204
68	22-9	5-4	95.5	2\2	27/18	2.8	4.2	2\4	18/18	1.4	5.0					181
69	23-0	6-1	113.7	2\2	27/18	2.8	4.0	2\4	18/18	1.4	5.0					190
70	23-2	6-11	132.1	3\3	27/18	2.6	4.4	2\5	18/18	1.4	5.0					203
71	23-4	7-8	150.6	3\3	27/18	2.6	4.3	2\5	18/18	1.4	5.0					207
72	23-6	8-6	169.3	3\3	27/18	2.7	4.2	2\5	18/18	1.4	5.0					211
73	23-8	9-3	188.1	3\3	27/18	2.7	4.0	2\5	18/18	1.4	5.0					214
74	23-10	10-1	207.0	3\3	27/18	2.8	3.9	2\5	18/18	1.4	5.0					213
75	24-0	5-9	108.2	2\2	18/18	1.7	5.0	2\5	18/18	1.4	5.0					196
76	24-1	6-6	127.5	2\2	18/18	1.7	5.0	2\6	18/18	1.4	5.0					211
77	24-3	7-4	146.8	2\2	18/18	1.8	5.0	2\6	18/18	1.4	5.0					220
78	24-4	8-2	166.2	2\2	18/18	1.8	5.0	2\6	18/18	1.4	5.0					224
79	24-5	8-11	185.7	2\2	18/18	1.8	5.0	2\6	18/18	1.4	5.0					227
80	24-7	9-9	205.3	2\2	18/18	1.8	5.0	2\6	18/18	1.4	5.0					231
81	24-8	10-6	225	2\2	18/18	1.8	5.0	2\6	18/18	1.4	5.0					234
82	25-2	6-2	122.0	2\2	18/18	1.9	4.9	2\6	18/18	1.4	5.0					214
83	25-2	7-0	142.2	2\2	18/18	1.9	4.9	2\7	18/18	1.4	5.0					226
84	25-3	7-9	162.4	2\2	18/18	1.9	4.9	2\7	18/18	1.4	5.0					235
85	25-4	8-7	182.6	2\2	18/18	1.9	4.8	2\7	18/18	1.4	5.0					238
86	25-4	9-5	202.9	2\2	18/18	1.9	4.8	2\7	18/18	1.4	5.0					242
87	25-5	10-2	223.3	2\2	18/18	2.0	4.5	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)[9]	D6 Max. (Feet)[9]	E6 HG\CG (Gage)	E6 HRS/CRS (Inches)	E6 Min. (Feet)[9]	E6 Max. (Feet)[9]	F6 HG\CG (Gage)	F6 HRS/CRS (Inches)	F6 Min. (Feet)[9]	F6 Max. (Feet)[9]	Max. 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	3\3	54/18	1.4	5.0					49
2	9-2	3-3	25.4	2\2	54/18	2.0	5.0	3\3	54/18	1.4	5.0					57
3	9-7	4-1	32.6	2\2	54/18	2.0	5.0	3\3	54/18	1.4	5.0					62
4	10-0	4-10	40.2	2\2	54/18	2.5	5.0	2\2	54/9	1.4	5.0					67
5	10-6	5-7	48.1	2\2	54/18	2.5	5.0	2\2	54/9	1.4	5.0					71
6	10-11	6-4	56.4	2\2	54/18	3.0	5.0	2\2	54/9	2.0	5.0	3\3	54/9	1.4	5.0	85
7	11-4	7-2	65.0	2\2	54/18	3.0	5.0	2\2	27/18	2.5	5.0	3\3	54/9	1.4	5.0	90
8	10-2	2-8	23.0	2\2	54/18	2.5	5.0	3\3	54/18	1.7	5.0	4\4	54/18	1.4	5.0	66
9	10-7	3-5	31.1	2\2	54/18	3.0	5.0	3\3	54/18	2.0	5.0	3\3	27/18	1.4	5.0	73
10	10-11	4-3	39.5	2\2	54/18	3.0	5.0	3\3	54/18	2.5	5.0	3\3	54/9	1.4	5.0	84
11	11-4	5-0	48.2	2\2	54/18	3.0	5.0	3\3	54/18	2.5	5.0	3\3	54/9	1.4	5.0	88
12	11-8	5-9	57.2	2\2	54/18	3.0	5.0	3\3	54/18	2.5	5.0	3\3	54/9	1.4	5.0	93
13	12-1	6-7	66.4	3\3	54/18	3.0	5.0	3\3	27/18	2.5	5.0	3\3	27/9	1.4	5.0	105
14	12-5	7-4	76.0	2\2	27/18	3.0	5.0	2\2	27/9	2.0	5.0	3\3	27/9	1.4	5.0	110
15	11-7	2-10	28.1	2\2	54/18	3.0	5.0	3\3	54/18	2.5	5.0	3\3	54/9	1.4	5.0	85
16	11-11	3-7	37.4	3\3	54/18	3.0	5.0	3\3	27/18	2.5	5.0	3\3	54/9	1.4	5.0	90
17	12-3	4-5	46.9	3\3	54/18	3.0	5.0	4\4	54/18	2.5	5.0	4\4	54/9	1.4	5.0	104
18	12-7	5-2	56.6	3\3	54/18	3.0	5.0	3\3	27/18	2.5	5.0	4\4	54/9	1.4	5.0	109
19	12-11	6-0	66.6	3\3	27/18	3.0	5.0	2\2	27/9	2.0	5.0	4\4	27/9	1.4	5.0	123
20	13-3	6-9	76.9	2\2	18/18	3.0	5.0	2\2	27/9	2.5	5.0	3\3	18/9	1.4	5.0	125
STRUCTURES 21 THROUGH 39 HAVE TYPE II HAUNCH AND TYPE VI CROWN RIBS [10]																
21	13-0	3-0	33.8	3\3	54/18	2.3	5.0	2\2	27/18	1.6	5.0	3\3	27/18	1.4	5.0	100
22	13-4	3-10	44.2	3\3	54/18	2.5	5.0	2\2	27/18	1.7	5.0	4\4	27/18	1.4	5.0	114
23	13-7	4-7	54.8	3\3	54/18	2.7	5.0	2\2	27/18	1.9	5.0	3\3	18/18	1.4	5.0	118
24	13-10	5-5	65.6	3\3	54/18	2.9	5.0	2\2	27/18	2.0	5.0	3\3	18/18	1.4	5.0	122
25	14-1	6-2	76.6	2\2	27/18	2.3	5.0	2\2	18/18	1.7	5.0	3\3	18/18	1.4	5.0	126
26	14-5	3-3	40.0	2\2	27/18	2.5	5.0	2\2	18/18	1.8	5.0	4\4	18/18	1.4	5.0	121
27	14-8	4-1	51.5	2\2	27/18	2.8	5.0	2\2	18/18	2.0	5.0	4\5	18/18	1.4	5.0	140
28	14-10	4-10	63.2	2\2	27/18	2.8	5.0	2\2	18/18	2.0	5.0	4\6	18/18	1.4	5.0	137
29	15-1	5-8	75.1	2\2	27/18	3.0	5.0	2\2	18/18	2.1	5.0	4\7	18/18	1.4	5.0	145
30	15-4	6-5	87.2	3\3	27/18	2.6	5.0	2\2	18/18	2.3	5.0	5\7	18/18	1.4	5.0	157
31	15-6	7-3	99.4	3\3	27/18	2.6	5.0	2\2	18/18	2.3	5.0	5\7	18/18	1.4	5.0	163
32	15-9	8-0	111.8	3\3	27/18	2.6	5.0	2\2	18/18	2.5	5.0	5\7	18/18	1.4	5.0	169
33	15-10	3-6	46.8	2\2	18/18	2.4	5.0	6\2	18/18	1.7	5.0	7\5	18/18	1.4	5.0	149
34	16-0	4-3	59.5	2\2	18/18	2.5	5.0	6\2	18/18	1.8	5.0	7\6	18/18	1.4	5.0	159
35	16-2	5-1	72.3	2\2	18/18	2.5	5.0	6\2	18/18	1.8	5.0	7\7	18/18	1.4	5.0	170
36	16-4	5-11	85.2	2\2	18/18	2.6	5.0	6\2	18/18	1.9	5.0	7\7	18/18	1.4	5.0	176
37	16-6	6-8	98.3	2\2	18/18	2.6	5.0	6\2	18/18	2.0	5.0	4\5	9/18	1.4	5.0	178
38	16-8	7-6	111.5	2\2	18/18	2.7	5.0	6\2	18/18	2.0	5.0	4\7	9/18	1.4	5.0	197
39	16-10	8-3	124.8	2\2	18/18	2.8	5.0	6\2	18/18	2.1	5.0	4\7	9/18	1.4	5.0	202
STRUCTURES 40 THROUGH 87 USE ALL TYPE VI RIBS [10]																
40	17-9	3-10	54.4	2\2	54/18	2.8	5.0	2\2	27/18	2.0	5.0	2\2	18/18	1.4	5.0	135
41	18-2	4-7	68.3	2\2	27/18	2.2	5.0	2\2	18/18	1.5	5.0	2\3	18/18	1.4	5.0	147
42	18-7	5-4	82.5	2\2	27/18	2.3	5.0	2\2	18/18	1.6	5.0	2\5	18/18	1.4	5.0	163
43	19-0	6-1	97.1	2\2	27/18	2.4	5.0	2\2	18/18	1.8	5.0	2\6	18/18	1.4	5.0	174
44	19-5	6-11	111.9	2\2	27/18	2.6	5.0	2\2	18/18	1.8	5.0	2\7	18/18	1.4	5.0	186
45	19-10	7-8	127.1	2\2	27/18	2.7	5.0	2\2	18/18	1.9	5.0	2\7	18/18	1.4	5.0	181
46	20-3	8-5	142.6	2\2	27/18	2.9	5.0	2\2	18/18	2.0	5.0	2\2	18/9	1.4	5.0	214
47	19-1	4-2	63.3	2\2	27/18	2.6	5.0	2\2	18/18	1.8	5.0	2\2	18/9	1.4	5.0	194
48	19-5	4-11	78.3	2\2	27/18	2.6	5.0	2\2	18/18	1.8	5.0	2\2	18/9	1.4	5.0	203
49	19-9	5-8	93.6	2\2	27/18	2.7	5.0	2\2	18/18	1.9	5.0	2\2	18/9	1.4	5.0	211
50	20-1	6-6	109.2	2\2	27/18	2.9	5.0	2\2	18/18	1.9	5.0	2\2	18/9	1.4	5.0	218
51	20-6	7-3	125	2\2	27/18	3.0	5.0	2\2	18/18	2.0	5.0	2\2	18/9	1.4	5.0	222
52	20-10	8-1	141.2	2\2	27/18	3.2	4.5	2\2	18/18	2.0	5.0	2\2	18/9	1.4	5.0	225
53	21-2	8-10	157.6	2\2	18/18	2.1	5.0	2\7	18/18	1.7	5.0	2\2	18/9	1.4	5.0	229
54	20-4	4-6	73.1	2\2	27/18	3.0	5.0	2\2	18/18	2.0	5.0	2\2	18/9	1.4	5.0	211
55	20-7	5-3	89.2	2\2	27/18	3.1	4.9	2\2	18/18	2.0	5.0	2\2	18/9	1.4	5.0	220
56	20-11	6-1	105.5	2\2	27/18	3.2	4.3	2\2	18/18	2.0	5.0	2\2	18/9	1.4	5.0	229
57	21-3	6-10	122.1	2\2	18/18	2.1	5.0	2\7	18/18	1.7	5.0	2\2	18/9	1.4	5.0	233
58	21-6	7-8	139.0	2\2	18/18	2.2	5.0	2\7	18/18	1.8	5.0	2\2	18/9	1.4	5.0	236
59	21-10	8-5	156.0	2\2	18/18	2.2	5.0	2\7	18/18	1.9	5.0	2\2	18/9	1.4	5.0	240
60	22-1	9-3	173.3	2\2	18/18	2.3	5.0	2\7	18/18	2.0	5.0	2\2	18/9	1.4	5.0	243
61	21-7	4-11	83.8	2\2	18/18	2.2	5.0	2\7	18/18	1.8	5.0	2\2	18/9	1.4	5.0	225
62	21-10	5-8	101	2\2	18/18	2.2	5.0	2\7	18/18	1.9	5.0	2\2	18/9	1.4	5.0	234
63	22-1	6-6	118.4	2\2	18/18	2.3	5.0	2\7	18/18	2.0	5.0	2\2	18/9	1.4	5.0	243
64	22-3	7-3	135.9	2\2	18/18	2.4	5.0	2\7	18/18	2.0	5.0	2\2	18/9	1.4	5.0	247
65	22-6	8-1	153.7	2\2	18/18	2.5	5.0	2\7	18/18	2.0	5.0	2\2	18/9	1.4	5.0	251
66	22-9	8-10	171.6	2\2	18/18	2.6	5.0	2\7	18/18	2.0	5.0	2\2	18/9	1.4	5.0	254
67	23-0	9-8	189.8	2\2	18/18	2.6	5.0	2\7	18/18	2.2	5.0	2\2	18/9	1.4	5.0	258
68	22-9	5-4	95.5	2\2	18/18	2.4	5.0	2\7	18/18	2.1	5.0	2\2	18/9	1.4	5.0	240
69	23-0	6-1	113.7	2\2	18/18	2.5	5.0	2\7	18/18	2.1	5.0	2\2	18/9	1.4	5.0	249
70	23-2	6-11	132.1	2\2	18/18	2.5	5.0	2\7	18/18	2.2	5.0	2\2	18/9	1.4	5.0	258
71	23-4	7-8	150.6	2\2	18/18	2.6	5.0	2\7	18/18	2.2	5.0	2\2	18/9	1.4	5.0	262
72	23-6	8-6	169.3	2\2	18/18	2.6	5.0	2\7	18/18	2.2	5.0	2\2	18/9	1.4	5.0	265
73	23-8	9-3	188.1	2\2	18/18	2.7	4.9	2\7	18/18	2.3	5.0	2\2	18/9	1.4	5.0	269
74	23-10	10-1	207.0	2\2	18/18	2.7	4.8	2\7	18/18	2.3	5.0	2\2	18/9	1.4	5.0	272
75	24-0	5-9	108.2	2\2	18/18	2.7	4.6	2\7	18/18	2.4	5.0	2\2	18/9	1.4	5.0	254
76	24-1	6-6	127.5	2\2	18/18	2.7	4.6	2\7	18/18	2.4	5.0	2\2	18/9	1.4	5.0	263
77	24-3	7-4	146.8	2\2	18/18	2.8	4.4	2\7	18/18	2.4	5.0	2\2	18/9	1.4	5.0	272
78	24-4	8-2	166.2	2\2	18/18	2.8	4.3	2\7	18/18	2.4	5.0	2\2	18/9	1.4	5.0	276
79	24-5	8-11	185.7	2\2	18/18	2.9	4.2	2\7	18/18	2.4	5.0	2\2	18/9	1.4	5.0	280
80	24-7	9-9	205.3	2\2	18/18	2.9	4.1	2\7	18/18	2.4	5.0	2\2	18/9	1.4	5.0	283
81	24-8	10-6	225	2\2	18/18	3.0	4.0	2\7	18/18	2.5	5.0	2\2	18/9	1.4	5.0	287
82	25-2	6-2	122.0	3\5	18/18	2.7	4.3	2\2	18/9	1.4	5.0					272
83	25-2	7-0	142.2	3\5	18/18	2.7	4.3	2\2	18/9	1.4	5.0					278
84	25-3	7-9	162.4	3\5	18/18	2.7	4.3	2\2	18/9	1.4	5.0					287
85	25-4	8-7	182.6	3\5	18/18	2.7	4.2	2\2	18/9	1.4	5.0					291
86	25-4	9-5	202.9	3\5	18/18	2.7	4.2	2\2	18/9	1.4	5.0					294
87	25-5	10-2	223.3	3\5	18/18	2.8	4.2	2\2	18/9	1.4	5.0					298

See Notes page 65

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

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

Structure Number	Span (Ft.-In.)	Rise (Ft.-In.)	Area (Sq. Ft.)	L1					L2				
				HG\CG (Gage)	HRS/CRS (Inches)	Min (Feet)	Max (3) (Feet)	Shell Wt/Ft (Lbs.)	HG\CG (Gage)	HR/CRS (Inches)	Min. (Feet)	Max. (3) (Feet)	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					43
2	9-2	3-3	25.4	2\2	54/18	1.4	5.0	50					50
3	9-7	4-1	32.6	2\2	54/18	2.0	5.0	58	2\2	27/18	1.4	5.0	67
4	10-0	4-10	40.2	2\2	54/18	2.5	5.0	61	2\2	27/18	1.4	5.0	70
5	10-6	5-7	48.1	2\2	27/18	2.0	5.0	74	2\2	18/18	1.4	5.0	83
6	10-11	6-4	56.4	2\2	27/18	2.5	5.0	77	2\2	27/9	1.4	5.0	88
7	11-4	7-2	65.0	2\2	27/18	2.5	5.0	81	2\2	27/9	1.4	5.0	91
8	10-2	2-8	23.0	2\2	27/18	2.0	5.0	63	2\2	27/18	1.4	5.0	63
9	10-7	3-5	31.1	2\2	27/18	2.0	5.0	68	2\2	18/18	1.4	5.0	76
10	10-11	4-3	39.5	2\2	27/18	2.0	5.0	74	2\2	18/18	1.4	5.0	83
11	11-4	5-0	48.2	2\2	27/18	2.5	5.0	78	2\2	27/9	1.4	5.0	92
12	11-8	5-9	57.2	2\2	27/18	2.5	5.0	81	2\2	27/9	1.4	5.0	95
13	12-1	6-7	66.4	2\2	27/18	3.0	5.0	85	2\2	27/9	1.4	5.0	99
14	12-5	7-4	76.0	2\2	27/9	2.0	5.0	102	2\2	18/9	1.4	5.0	111
15	11-7	2-10	28.1	2\2	27/18	2.5	5.0	70	2\2	27/9	1.4	5.0	88
16	11-11	3-7	37.4	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	27/9	2.0	5.0	99	2\2	18/9	1.4	5.0	108
18	12-7	5-2	56.6	2\2	27/9	2.0	5.0	102	2\2	18/9	1.4	5.0	111
19	12-11	6-0	66.6	2\2	27/9	2.0	5.0	106	3\3	18/9	1.4	5.0	121
20	13-3	6-9	76.9	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	2\2	54/18	3.0	5.0	71	2\2	27/18	1.4	5.0	78
22	13-4	3-10	44.2	2\2	27/18	2.0	5.0	83	2\2	18/18	1.4	5.0	91
23	13-7	4-7	54.8	2\2	27/18	2.0	5.0	89	2\2	18/18	1.4	5.0	98
24	13-10	5-5	65.6	2\2	27/18	2.5	5.0	92	3\3	18/18	1.4	5.0	122
25	14-1	6-2	76.6	2\2	27/18	2.5	5.0	96	3\3	18/18	1.4	5.0	126
26	14-5	3-3	40.0	2\2	27/18	3.0	5.0	85	3\3	18/9	1.4	5.0	125
27	14-8	4-1	51.5	2\2	27/18	3.0	5.0	91	3\2	18/9	1.4	5.0	129
28	14-10	4-10	63.2	2\2	27/18	3.5	5.0	106	3\2	18/9	1.4	5.0	137
29	15-1	5-8	75.1	2\2	18/18	2.5	5.0	116	3\2	18/9	1.4	5.0	141
30	15-4	6-5	87.2	2\2	18/18	2.5	5.0	119	3\2	18/9	1.4	5.0	145
31	15-6	7-3	99.4	2\2	18/18	2.5	5.0	123	3\2	18/9	1.4	5.0	149
32	15-9	8-0	111.8	3\2	18/18	2.5	5.0	136	3\2	18/9	1.4	5.0	153
33	15-10	3-6	46.8	3\2	18/18	2.5	5.0	114	3\2	18/9	1.4	5.0	156
34	16-0	4-3	59.5	3\2	18/18	2.5	5.0	121	3\2	18/9	1.4	5.0	163
35	16-2	5-1	72.3	3\2	18/18	2.5	5.0	128	4\2	18/9	1.4	5.0	177
36	16-4	5-11	85.2	3\2	18/9	2.0	5.0	174	4\2	18/9	1.4	5.0	182
37	16-6	6-8	98.3	3\2	18/9	2.0	5.0	179	4\2	18/9	1.4	5.0	187
38	16-8	7-6	111.5	3\2	18/9	2.0	5.0	183	4\2	18/9	1.4	5.0	192
39	16-10	8-3	124.8	3\2	18/9	2.5	5.0	187	4\2	18/9	1.4	5.0	197
STRUCTURES 40 THROUGH 87 USE ALL TYPE VI RIBS													
40	17-9	3-10	54.4	2\2	27/18	2.5	5.0	124	2\2	27/9	1.4	5.0	170
41	18-2	4-7	68.3	2\2	27/18	2.5	5.0	131	2\2	27/9	1.4	5.0	178
42	18-7	5-4	82.5	2\2	27/18	3.0	5.0	139	2\2	27/9	1.4	5.0	185
43	19-0	6-1	97.1	2\2	27/9	2.0	5.0	188	2\2	18/9	1.4	5.0	203
44	19-5	6-11	111.9	2\2	27/9	2.0	5.0	192	2\2	18/9	1.4	5.0	207
45	19-10	7-8	127.1	2\2	27/9	2.0	5.0	195	2\2	18/9	1.4	5.0	210
46	20-3	8-5	142.6	2\2	27/9	3.0	5.0	199	2\2	18/9	1.4	5.0	214
47	19-1	4-2	63.3	2\2	27/9	2.0	5.0	185	2\2	18/9	1.4	5.0	194
48	19-5	4-11	78.3	2\2	27/9	2.0	5.0	192	2\2	18/9	1.4	5.0	203
49	19-9	5-8	93.6	2\2	27/9	2.0	5.0	199	2\2	18/9	1.4	5.0	211
50	20-1	6-6	109.2	2\2	18/18	2.5	5.0	165	2\2	18/9	1.4	5.0	218
51	20-6	7-3	125.0	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	2\2	18/18	3.0	5.0	172	2\2	18/9	1.4	5.0	225
53	21-2	8-10	157.6	2\2	18/18	3.0	5.0	175	2\2	18/9	1.4	5.0	229
54	20-4	4-6	73.1	2\2	18/18	2.5	5.0	152	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	2\2	18/9	1.4	5.0	220
56	20-11	6-1	105.5	2\2	18/18	3.0	5.0	170	2\2	18/9	1.4	5.0	229
57	21-3	6-10	122.1	2\2	18/18	3.0	5.0	174	2\2	18/9	1.4	5.0	233
58	21-6	7-8	139.0	2\2	18/9	2.0	5.0	235	3\3	18/9	1.4	5.0	249
59	21-10	8-5	156.0	2\2	18/9	2.0	5.0	239	3\3	18/9	1.4	5.0	253
60	22-1	9-3	173.3	2\2	18/9	2.0	5.0	243	3\3	18/9	1.4	5.0	257
61	21-7	4-11	83.8	2\2	18/9	2.0	5.0	225	3\3	18/9	1.4	5.0	236
62	21-10	5-8	101.0	2\2	18/9	2.0	5.0	234	3\3	18/9	1.4	5.0	246
63	22-1	6-6	118.4	2\2	18/9	2.0	5.0	243	3\3	18/9	1.4	5.0	256
64	22-3	7-3	135.9	2\2	18/9	2.0	5.0	246	4\4	18/9	1.4	5.0	273
65	22-6	8-1	153.7	2\2	18/9	2.0	5.0	250	4\4	18/9	1.4	5.0	278
66	22-9	8-10	171.6	2\2	18/9	2.0	5.0	253	5\5	18/9	1.4	5.0	297
67	23-0	9-8	189.8	2\2	18/9	2.0	5.0	257	5\5	18/9	1.4	5.0	303
68	22-9	5-4	95.5	2\2	18/9	2.0	5.0	239	4\4	18/9	1.4	5.0	263
69	23-0	6-1	113.7	2\2	18/9	2.0	5.0	248	5\5	18/9	1.4	5.0	286
70	23-2	6-11	132.1	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\2	18/9	2.5	5.0	270	5\5	18/9	1.4	5.0	303
72	23-6	8-6	169.3	2\2	18/9	2.5	5.0	274	5\5	18/9	1.4	5.0	308
73	23-8	9-3	188.1	2\2	18/9	2.5	5.0	278	5\5	18/9	1.4	5.0	314
74	23-10	10-1	207.0	2\2	18/9	2.5	5.0	283	5\5	18/9	1.4	5.0	319
75	24-0	5-9	108.2	2\2	18/9	2.5	5.0	254	6\6	18/9	1.4	5.0	304
76	24-1	6-6	127.5	2\2	18/9	2.5	5.0	263	6\6	18/9	1.4	5.0	316
77	24-3	7-4	146.8	2\2	18/9	2.5	5.0	272	6\6	18/9	1.4	5.0	327
78	24-4	8-2	166.2	2\2	18/9	2.5	5.0	275	6\6	18/9	1.4	5.0	334
79	24-5	8-11	185.7	2\2	18/9	2.5	5.0	279	6\6	18/9	1.4	5.0	340
80	24-7	9-9	205.3	2\2	18/9	2.5	5.0	283	6\6	18/9	1.4	5.0	346
81	24-8	10-6	225.0	2\2	18/9	2.5	5.0	286	7\7	18/9	1.4	5.0	369
82	25-2	6-2	122.0	2\2	18/9	2.5	5.0	268	7\7	18/9	1.4	5.0	334
83	25-2	7-0	142.2	2\2	18/9	2.5	5.0	277	7\7	18/9	1.4	5.0	347
84	25-3	7-9	162.4	2\2	18/9	2.5	5.0	286	7\7	18/9	1.4	5.0	359
85	25-4	8-7	182.6	2\2	18/9	2.5	5.0	290	7\7	18/9	1.4	5.0	366
86	25-4	9-5	202.9	2\2	18/9	2.5	5.0	293	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	7\7	18/9	1.4	5.0	380

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

TABLE 49B. ALBC SHELL DATA - LRFD HL93
PLATE AND RIB COMBINATIONS WITH ALLOWABLE HEIGHT OF COVER

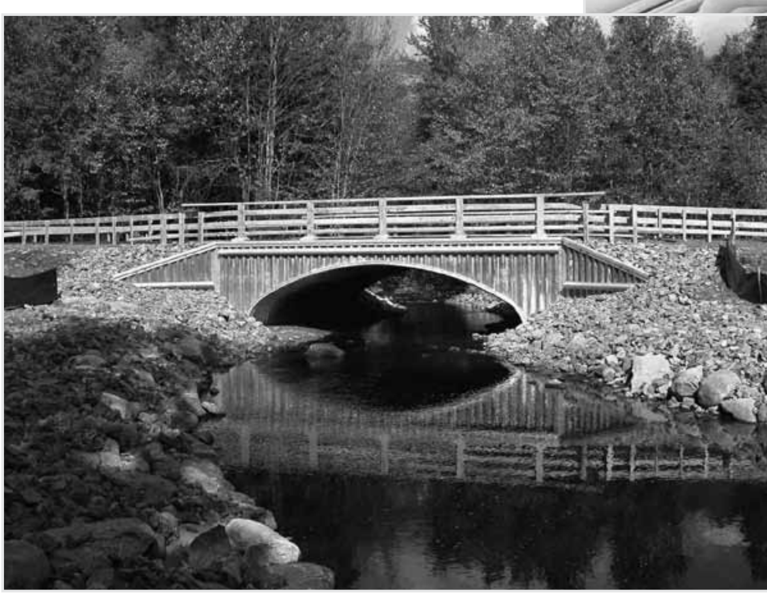
Structure Number	Span (Ft.-In.)	Rise (Ft.-In.)	Area (Sq. Ft.)	L1 HG\CG (Gage)	L1 HRS/CRS (Inches)	L1 Min. [3] (Feet)	L1 Max. (Feet)	L1 Shell Wt/Ft (Lbs.)	L2 HG\CG (Gage)	L2 HRS/CRS (Inches)	L2 Min. [3] (Feet)	L2 Max. (Feet)	L2 Shell Wt/Ft (Lbs.)
STRUCTURES 88 THROUGH 143 USE ALL TYPE VI RIBS													
88	26-7	5-5	111.6	3\3	9\9	2.9	5.0	314	7\7	9\9	2.0	5.0	367
89	27-0	6-3	132.4	3\3	9\9	2.9	5.0	329	7\7	9\9	2.0	5.0	384
90	27-5	7-0	153.4	3\3	9\9	2.9	5.0	344	7\7	9\9	2.0	5.0	402
91	27-10	7-9	174.8	3\3	9\9	2.9	5.0	360	7\7	9\9	2.0	5.0	420
92	28-3	8-7	196.5	3\3	9\9	2.9	5.0	364	7\7	9\9	2.0	5.0	427
93	28-8	9-4	218.6	3\3	9\9	2.9	5.0	368	7\7	9\9	2.0	5.0	434
94	29-1	10-1	241.0	3\3	9\9	2.9	5.0	372	7\7	9\9	2.0	5.0	441
95	27-10	5-10	125.4	3\3	9\9	2.9	5.0	329	7\7	9\9	2.0	5.0	384
96	28-3	6-8	147.3	3\3	9\9	2.9	5.0	344	7\7	9\9	2.0	5.0	402
97	28-7	7-5	169.4	3\3	9\9	2.9	5.0	360	7\7	9\9	2.0	5.0	420
98	29-0	8-3	191.8	3\3	9\9	2.9	5.0	375	7\7	9\9	2.0	5.0	438
99	29-4	9-0	214.6	3\3	9\9	2.9	5.0	379	7\7	9\9	2.0	5.0	445
100	29-8	9-9	237.6	3\3	9\9	2.9	5.0	383	7\7	9\9	2.0	5.0	452
101	30-1	10-7	260.9	3\3	9\9	2.9	5.0	387	7\7	9\9	2.0	5.0	459
102	29-1	6-4	140.2	3\3	9\9	2.9	5.0	344	7\7	9\9	2.0	5.0	402
103	29-5	7-1	163.2	3\3	9\9	2.9	5.0	360	7\7	9\9	2.0	5.0	420
104	29-8	7-11	186.4	3\3	9\9	2.9	5.0	375	7\7	9\9	2.0	5.0	438
105	30-0	8-8	209.8	3\3	9\9	2.9	5.0	390	7\7	9\9	2.0	5.0	456
106	30-4	9-5	233.6	3\3	9\9	2.9	5.0	394	7\7	9\9	2.0	5.0	463
107	30-8	10-3	257.5	3\3	9\9	2.9	5.0	398	7\7	9\9	2.0	5.0	470
108	31-0	11-0	281.8	3\3	9\9	2.9	5.0	403	7\7	9\9	2.0	5.0	477
109	31-3	6-9	156.1	3\3	9\9	2.9	5.0	360	7\7	9\9	2.0	5.0	420
110	30-6	7-7	180.1	3\3	9\9	2.9	5.0	375	7\7	9\9	2.0	5.0	438
111	30-10	8-4	204.4	3\3	9\9	2.9	5.0	390	7\7	9\9	2.0	5.0	456
112	31-1	9-2	228.8	3\3	9\9	2.9	5.0	405	7\7	9\9	2.0	5.0	474
113	31-4	9-11	253.5	3\3	9\9	2.9	5.0	409	7\7	9\9	2.0	5.0	481
114	31-8	10-9	278.4	3\3	9\9	2.9	5.0	414	7\7	9\9	2.0	5.0	487
115	31-11	11-6	303.5	3\3	9\9	2.9	5.0	418	7\7	9\9	2.0	5.0	494
116	31-5	7-3	173.1	3\3	9\9	2.9	5.0	375	7\7	9\9	2.0	5.0	438
117	31-8	8-0	198.2	3\3	9\9	2.9	5.0	390	7\7	9\9	2.0	5.0	456
118	31-10	8-10	223.4	3\3	9\9	2.9	5.0	405	7\7	9\9	2.0	5.0	474
119	32-1	9-8	248.8	3\3	9\9	2.9	5.0	420	7\7	9\9	2.0	5.0	491
120	32-4	10-4	274.4	3\3	9\9	2.9	5.0	424	7\7	9\9	2.0	5.0	498
121	32-7	11-3	300.1	3\3	9\9	2.9	5.0	429	7\7	9\9	2.0	5.0	505
122	32-9	12-0	326.1	3\3	9\9	2.9	5.0	433	7\7	9\9	2.0	5.0	512
123	32-7	7-9	191.3	3\3	9\9	2.9	5.0	390	7\7	9\9	2.0	5.0	456
124	32-9	8-6	217.3	3\3	9\9	2.9	5.0	405	7\7	9\9	2.0	5.0	474
125	32-11	9-4	243.4	3\3	9\9	2.9	5.0	420	7\7	9\9	2.0	5.0	491
126	33-1	10-2	269.7	3\3	9\9	2.9	5.0	435	7\7	9\9	2.0	5.0	509
127	33-3	10-11	296.4	3\3	9\9	2.9	5.0	440	7\7	9\9	2.0	5.0	516
128	33-5	11-9	322.8	3\3	9\9	2.9	5.0	444	7\7	9\9	2.0	5.0	523
129	33-8	12-6	349.5	3\3	9\9	2.9	5.0	448	7\7	9\9	2.0	5.0	530
130	33-8	8-3	210.5	3\3	9\9	2.9	5.0	405	7\7	9\9	2.0	5.0	474
131	33-9	9-1	237.5	3\3	9\9	2.9	5.0	420	7\7	9\9	2.0	5.0	491
132	33-11	9-10	264.5	3\3	9\9	2.9	5.0	435	7\7	9\9	2.0	5.0	509
133	34-0	10-8	291.7	3\3	9\9	2.9	5.0	451	7\7	9\9	2.0	5.0	527
134	34-2	11-5	319.0	3\3	9\9	2.9	5.0	455	7\7	9\9	2.0	5.0	534
135	34-3	12-3	346.4	3\3	9\9	2.9	5.0	459	7\7	9\9	2.0	5.0	541
136	34-5	13-1	373.8	3\3	9\9	2.9	5.0	463	7\7	9\9	2.0	5.0	548
137	34-9	8-9	230.9	3\3	9\9	2.9	5.0	420	7\7	9\9	2.0	5.0	491
138	34-10	9-7	258.1	3\3	9\9	2.9	5.0	435	7\7	9\9	2.0	5.0	509
139	34-11	10-4	286.7	3\3	9\9	2.9	5.0	451	7\7	9\9	2.0	5.0	527
140	35-0	11-2	314.6	3\3	9\9	2.9	5.0	466	7\7	9\9	2.0	5.0	545
141	35-2	12-0	342.7	3\3	9\9	2.9	5.0	470	7\7	9\9	2.0	5.0	552
142	35-2	12-9	370.8	3\3	9\9	2.9	5.0	474	7\7	9\9	2.0	5.0	559
143	35-3	13-7	399.0	3\3	9\9	2.9	5.0	476	7\7	9\9	2.0	5.0	563

Notes

1. The cover height is measured from the outside valley crown plate corrugation to the bottom of a flexible pavement, or to the top of a rigid pavement.
2. Plate thickness designations: 2 = .125", 3 = .150", 4 = .175", 5 = .200", 6 = .255", 7 = .250"
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 49A and 49B.
4. Check with your Contech representative to see if additional options are available.

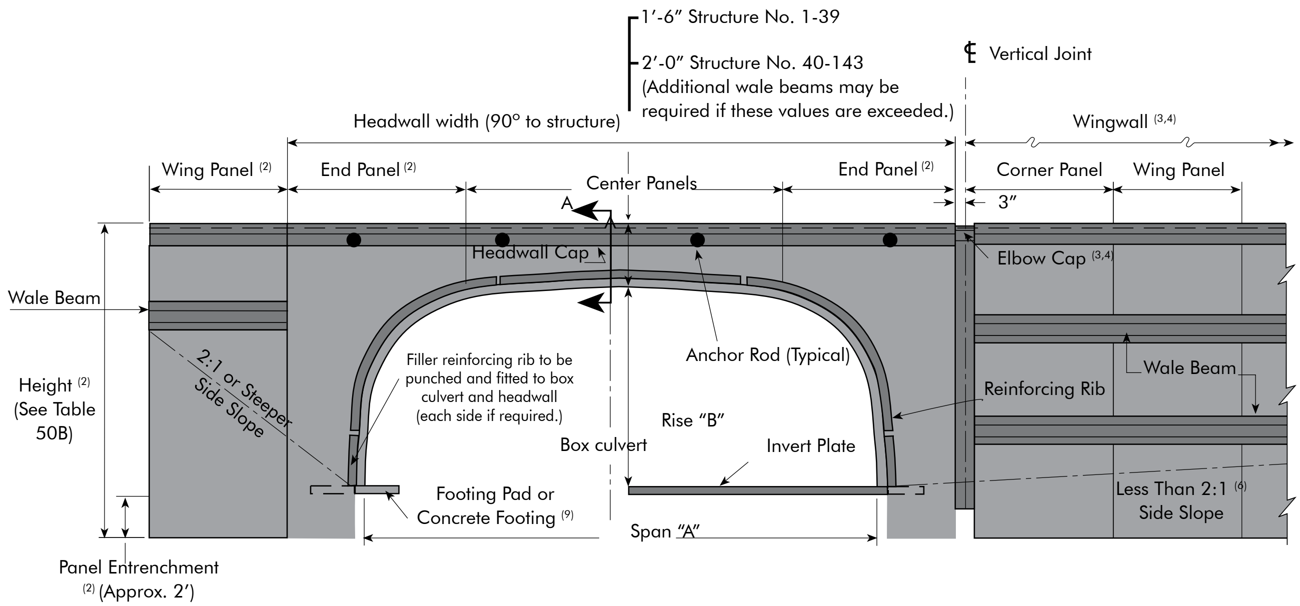
Aluminum Box Culvert Pedestrian Underpass

Access Road for Industrial Facilities

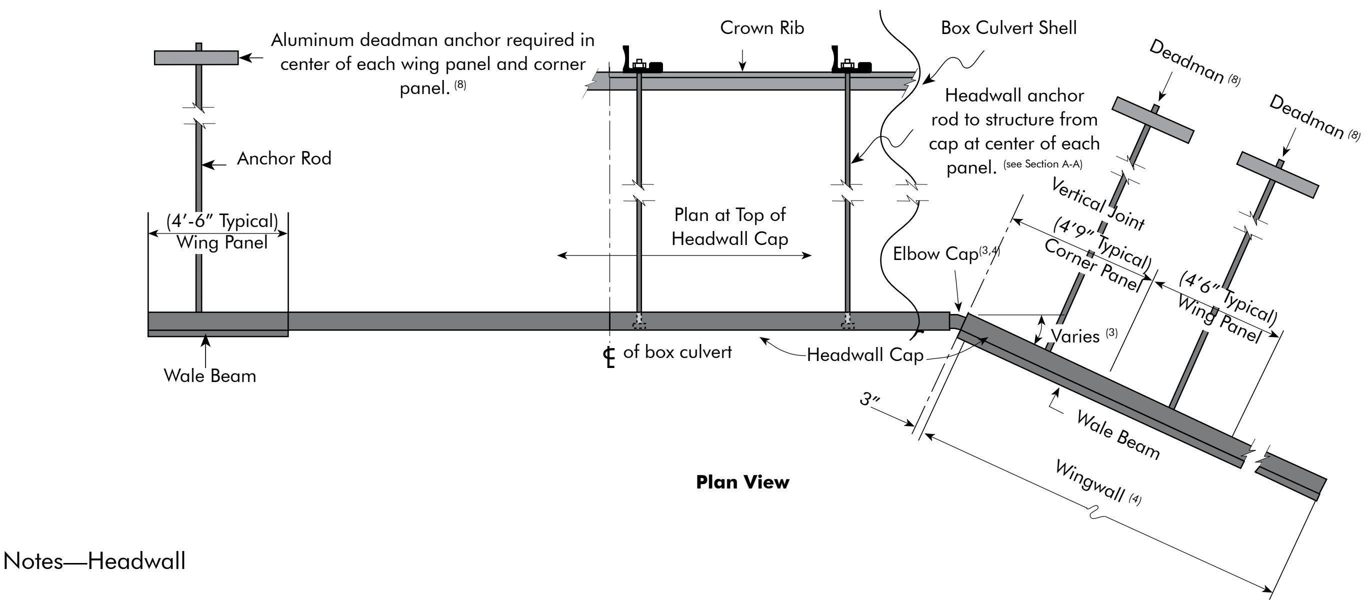


Stream Crossing for Environmentally Sensitive Areas

Headwall and Wingwall Details



Typical Headwall Elevation



Plan View

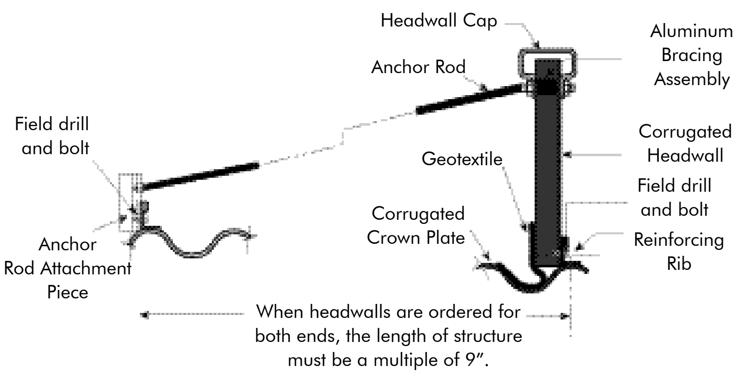
Notes—Headwall

1. All panels are fabricated from aluminum structural plate as specified in ASTM B 746.
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 is 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 and HS-25 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		Duel 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"

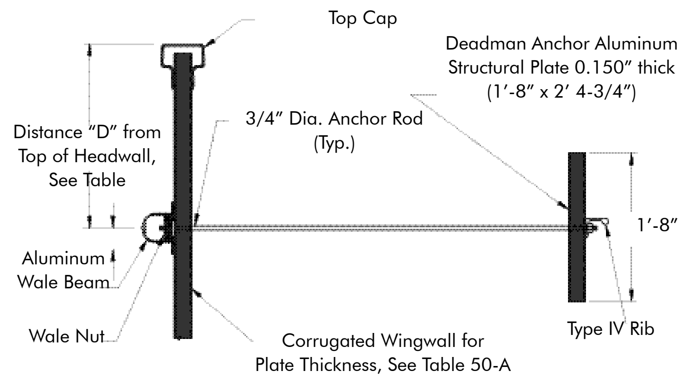
ANYTHING GREATER THAN 14'2": INQUIRE



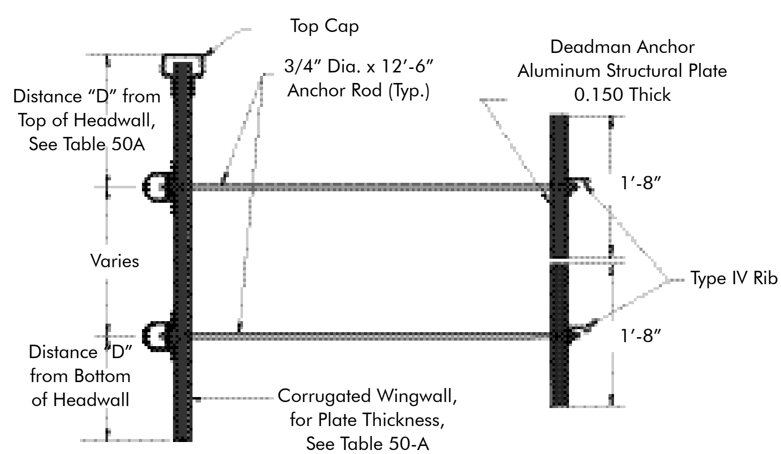
Section A-A (see page 69)

SINGLE ANCHOR DESIGN

Section A-A (see page 69)



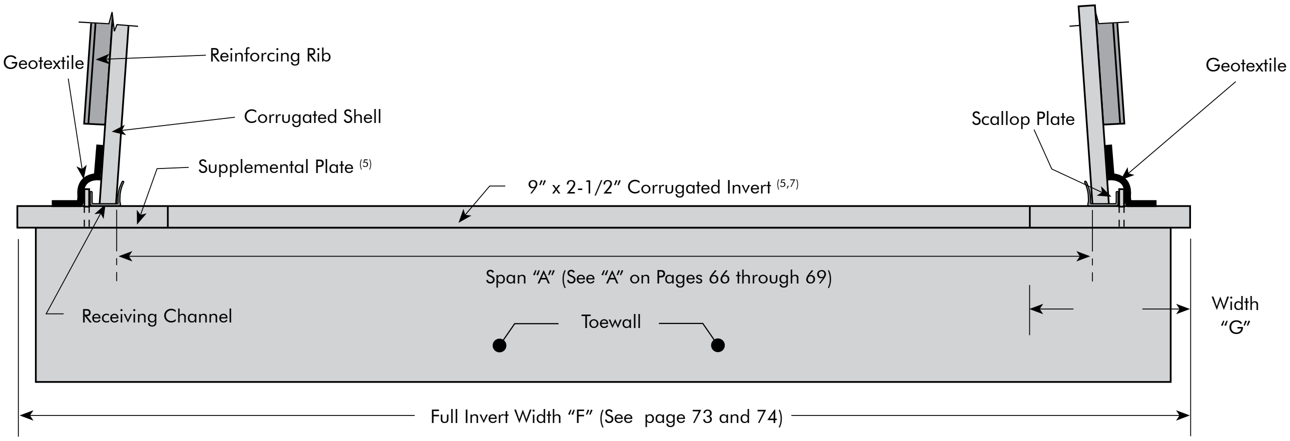
DUAL ANCHOR DESIGN



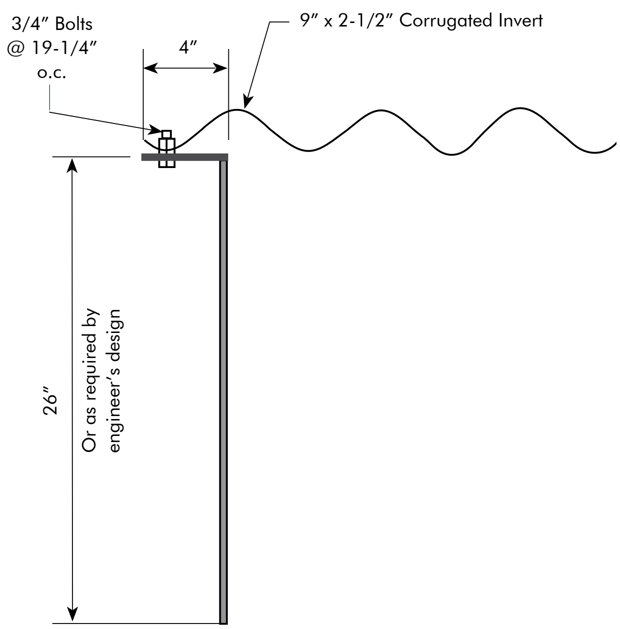
Headwall Dimensions for H-20, HS-20, H-25, HS-25 Loading

TABLE 50B. HEADWALL

No.	Width	Height	No. of Anchor Rods
1	13'-6"	6'-2"	3
2	13'-6"	6'11"	3
3	13'-6"	7'-9"	3
4	13'-6"	8'6"	3
5	13'-6"	9'-4"	3
6	13'-6"	10'-2"	3
7	13'-6"	10'11"	3
8	15'-0"	6'11"	3
9	15'-0"	7'-9"	3
10	15'-0"	8'6"	3
11	15'-0"	9'-4"	3
12	15'-0"	10'-2"	3
13	15'-0"	10'11"	3
14	15'-0"	11'-9"	3
15	16'-6"	6'11"	4
16	16'-6"	7'-9"	4
17	16'-6"	8'6"	4
18	16'-6"	9'-4"	4
19	16'-6"	10'-2"	4
20	16'-6"	10'11"	4
21	18'-0"	6'11"	4
22	18'-0"	7'-9"	4
23	18'-0"	8'6"	4
24	18'-0"	9'-4"	4
25	18'-0"	10'-2"	4
26	19'-6"	6'11"	4
27	19'-6"	7'-9"	4
28	19'-6"	8'6"	4
29	19'-6"	9'-4"	4
30	19'-6"	10'-2"	4
31	19'-6"	10'11"	4
32	19'-6"	11'-9"	4
33	21'-0"	7'-9"	5
34	21'-0"	8'6"	5
35	21'-0"	9'-4"	5
36	21'-0"	10'-2"	5
37	21'-0"	10'11"	5
38	21'-0"	11'-9"	5
39	21'-0"	12'-7"	5
40	22'-6"	7'-9"	5
41	22'-6"	8'6"	5
42	22'-6"	9'-4"	5
43	22'-6"	10'-2"	5
44	22'-6"	10'11"	5
45	22'-6"	11'-9"	5
46	22'-6"	12'-7"	5
47	24'-0"	8'6"	5
48	24'-0"	9'-4"	5
49	24'-0"	10'-2"	5
50	24'-0"	10'11"	5
51	24'-0"	11'-9"	5
52	24'-0"	12'-7"	5
53	24'-0"	13'-4"	5
54	25'-6"	8'6"	6
55	25'-6"	9'-4"	6
56	25'-6"	10'-2"	6
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
88	33'-0"	9'-4"	7
89	33'-0"	10'-2"	7
90	33'-0"	10'-11"	7
91	33'-0"	11'-9"	7
92	33'-0"	12'-7"	7
93	33'-0"	13'-4"	7
94	33'-0"	14'-2"	7
95	34'-6"	10'-2"	8
96	34'-6"	10'-11"	8
97	34'-6"	11'-9"	8
98	34'-6"	12'-7"	8
99	34'-6"	13'-4"	8
100	34'-6"	14'-2"	8
101	34'-6"	15'1"	8
102	36'-0"	10'-2"	8
103	36'-0"	10'-11"	8
104	36'-0"	11'-9"	8
105	36'-0"	12'-7"	8
106	36'-0"	13'-4"	8
107	36'-0"	14'-2"	8
108	36'-0"	15'1"	8
109	37'-6"	10'-11"	8
110	37'-6"	11'-9"	8
111	37'-6"	12'-7"	8
112	37'-6"	13'-4"	8
113	37'-6"	14'-2"	8
114	37'-6"	15'1"	8
115	37'-6"	15'11"	8
116	37'-6"	11'-9"	8
117	37'-6"	12'-7"	8
118	37'-6"	13'-4"	8
119	37'-6"	14'-2"	8
120	37'-6"	15'1"	8
121	37'-6"	15'11"	8
122	37'-6"	16'-8"	8
123	37'-6"	11'-9"	8
124	37'-6"	12'-7"	8
125	37'-6"	13'-4"	8
126	37'-6"	14'-2"	8
127	37'-6"	15'1"	8
128	37'-6"	15'11"	8
129	37'-6"	16'-8"	8
130	40'-6"	12'-7"	9
131	40'-6"	13'-4"	9
132	40'-6"	14'-2"	9
133	40'-6"	15'1"	9
134	40'-6"	15'11"	9
135	40'-6"	16'-8"	9
136	40'-6"	17'-5"	9
137	42'-0"	13'-4"	9
138	42'-0"	14'-2"	9
139	42'-0"	15'1"	9
140	42'-0"	15'11"	9
141	42'-0"	16'-8"	9
142	42'-0"	17'-5"	9
143	42'-0"	17'-5"	9



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



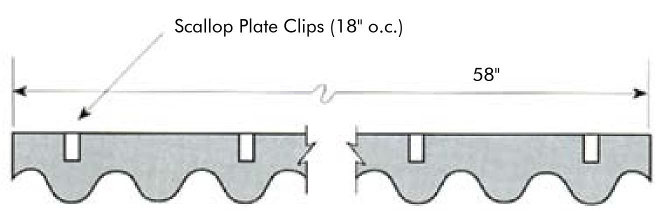
Aluminum Bent Sheet Toewall Detail

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 Table 48 or Table 49.
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)

Invert Details

TABLE 51A

FULL INVERT (H-20, HS-20)

Structure Number	Width "F" (N)	Supplemental Plate Thickness (inches)	Supplemental Plate Width "G" (N)	Weight/Ft. (Lbs.)	Bolts/Ft. (Each)
1	13	not required	2	26.1	5.78
2	14	not required	2	27.6	6.00
3	14	not required	2	27.6	6.00
4	15	not required	2	29.1	6.22
5	16	not required	2	30.5	6.44
6	16	not required	2	30.5	6.44
7	17	not required	2	32.0	6.67
8	15	not required	2	29.1	6.22
9	16	not required	2	30.5	6.44
10	16	not required	2	30.5	6.44
11	17	not required	2	32.0	6.67
12	17	not required	2	32.0	6.67
13	18	not required	2	33.5	6.89
14	18	not required	2	33.5	6.89
15	17	not required	2	32.0	6.67
16	17	not required	2	32.0	6.67
17	18	not required	2	33.5	6.89
18	18	not required	2	33.5	6.89
19	19	not required	2	35.0	7.11
20	19	not required	2	35.0	7.11
21	19	not required	2	35.0	7.11
22	19	not required	2	35.0	7.11
23	19	not required	2	35.0	7.11
24	20	not required	2	37.9	10.00
25	20	not required	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 (in)	Width "G" (N)	Weight/Ft. (Lbs.)	Bolts/Ft. (Each)
1	13	not required	2	26.1	5.78
2	14	not required	2	27.6	6.00
3	14	not required	2	27.6	6.00
4	15	not required	2	29.1	6.22
5	16	not required	2	30.5	6.44
6	16	not required	2	30.5	6.44
7	17	not required	2	33.0	6.67
8	15	not required	2	29.8	6.23
9	16	not required	2	30.5	6.44
10	16	not required	2	33.0	6.67
11	17	not required	2	33.0	6.67
12	17	not required	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	Invert Width (N)	Supplemental Plate Thickness	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

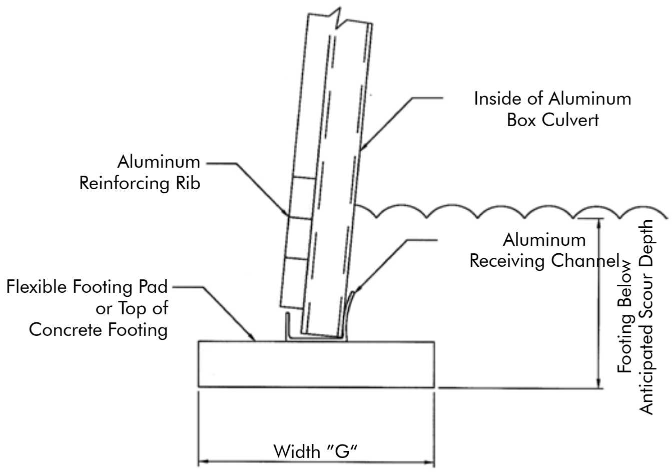
Assembly of Shell Plate onto Full Invert

TABLE 52A.[3] FOOTING PADS					
	H-20, HS-20 Loading		H-25, HS-25 Loading		
Structure No.	Plate Thickness (Inches)	Width "G"(N)	Plate Thickness (Inches)	Width "G" (N)	Weight/Ft.[4] (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

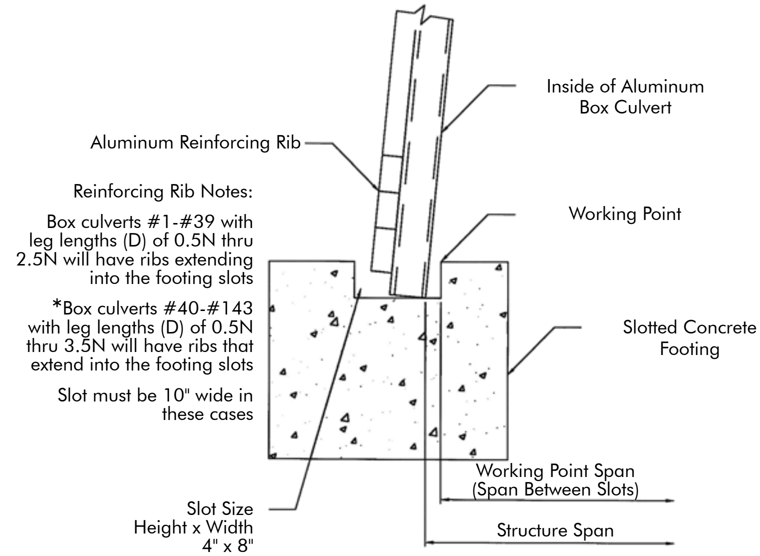
TABLE 52B. FOOTING PADS (HL-93)					
		Plate Thickness			
Structure No.	Total Thickness (Inches)	Quantity	(Inches)	Width "G" (N)	Weight/Foot (lbs)
88	0.500	2	0.250	4	53
89	0.500	2	0.250	4	53
90	0.500	2	0.250	4	53
91	0.500	2	0.250	4	53
92	0.500	2	0.250	4	53
93	0.500	2	0.250	4	53
94	0.500	2	0.250	4	53
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" or 9 5/8". 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. See Table 52.
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

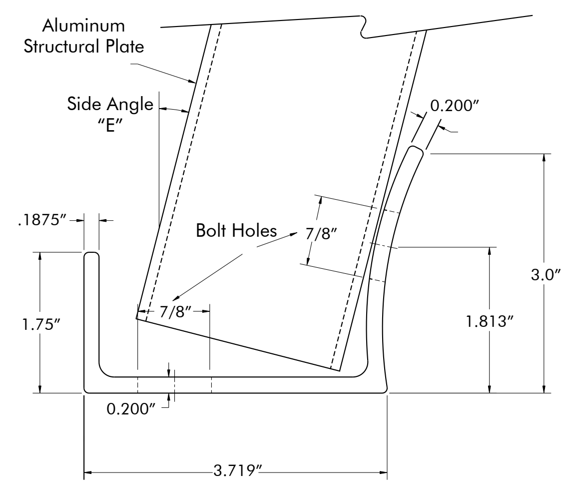
Scour Discussion

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, however, 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 chosen alternative should be designed by a competent professional experienced in the chosen field.

These counter measures include:

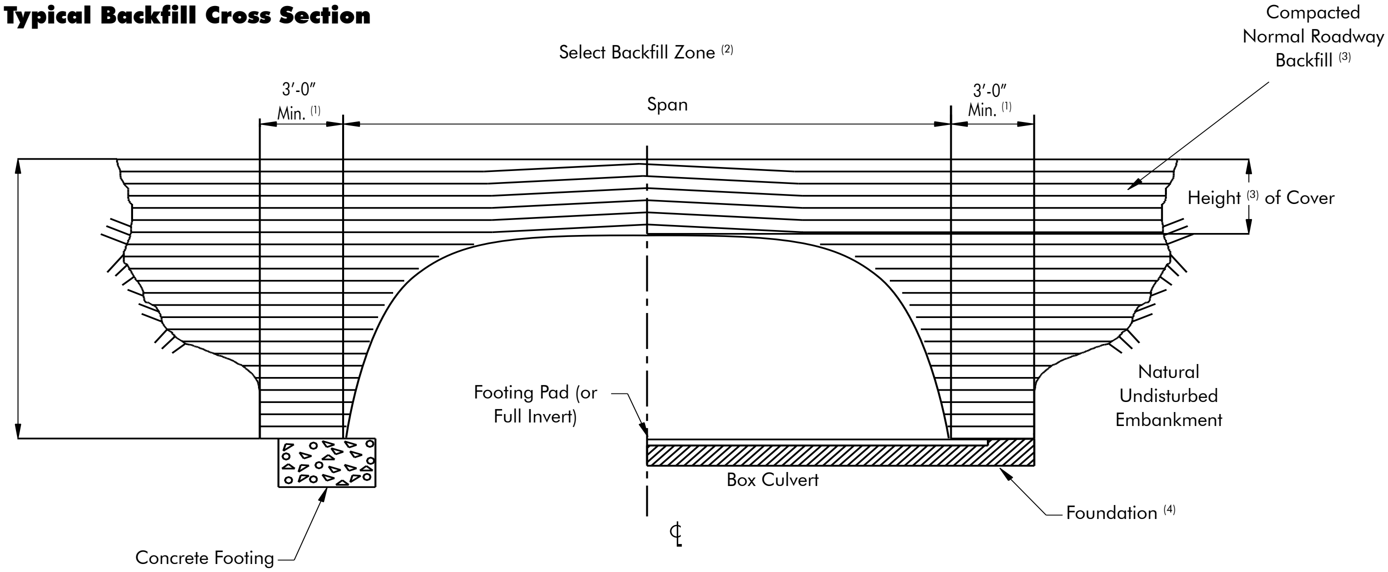
- Rip rap protection
- Concrete paving
- Lower footings below anticipated scour depth
- Bearing foundation on competent rock
- Undercut erodible soils and replace with non-erodible material
- Construction of guide banks including sheet piling
- Implementation of permanent erosion control mats where vegetation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

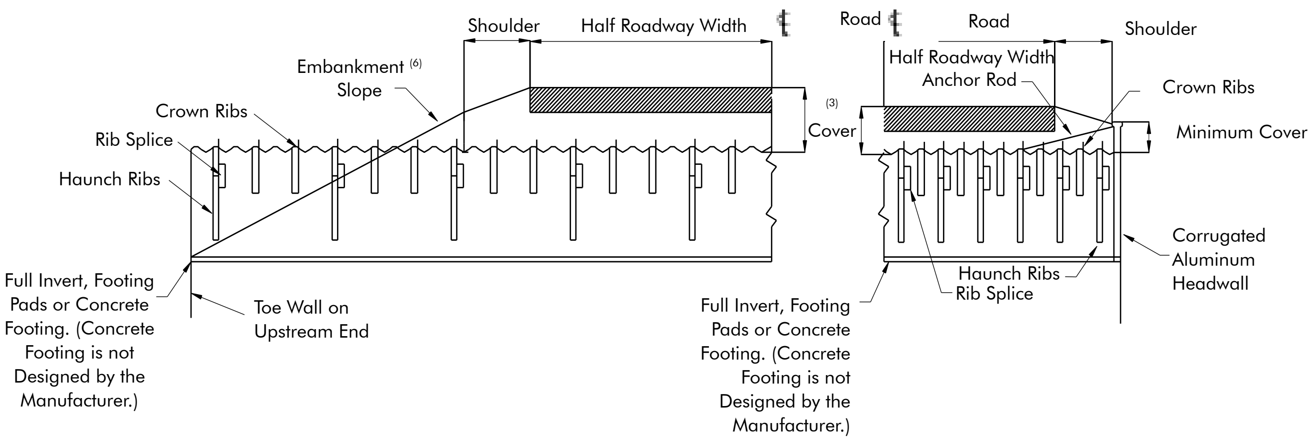
Please contact your Contech representative for more details and design guidance.



Aluminum Receiving Channel

Typical Backfill Cross Section





Typical Projecting End (6)

Notes - Installation

1. If less than 3' of space is available, concrete grout may be required.
2. Backfill to be well graded granular, A-1, A-3, A-2-4, or A-2-5, per AASHTO M145, placed in six- to eight-inch lifts symmetrically on each side compacted to minimum 90% density per AASHTO T180. D-4 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 T180.
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 headwalls shown are for vertical orientation only. Any design, other than vertical orientation, must be reviewed by the design engineer.
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. 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.
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 B 864 and AASHTO M219. 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 A 307 or ASTM A 449 and shall be galvanized in accordance with ASTM A 153.

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 of between 90 and 135 ft-lbs.

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 M145 for soil classifications A-1, A-3, A-2-4, or A-2-5. Backfill must be placed symmetrically on each side of the structure in 6-inch to 8-inch lifts. Each lift shall be compacted to a minimum of 90 percent density per AASHTO T180.

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 50 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 specification

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) 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 A 761. Installation is covered by AASHTO standard specification for highway bridges (Sec. 12) and ASTM A 761.

Acceptance

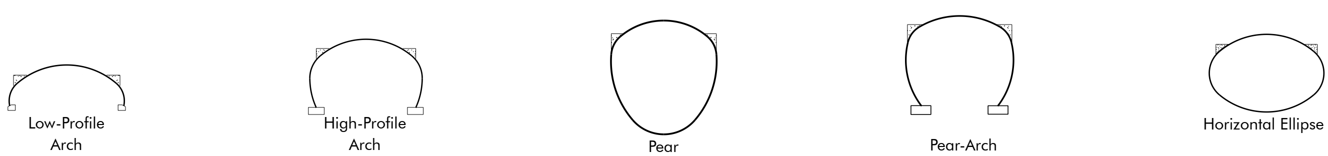
Many state and federal agencies recognize the excellent performance and economy of SUPER-SPAN corrugated structures. In a 1979 memorandum, the chief of FHWA's Bridge Division noted that in the previous 15 years, several hundred Contech SUPER-SPAN Culverts had been erected in the United States and Canada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

High-profile arch SUPER-SPAN (43'-3" span, 27' rise) in Hamilton, Ohio 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 difficult to install. 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).

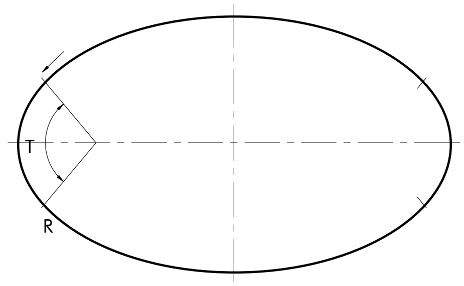


Figure 9

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.

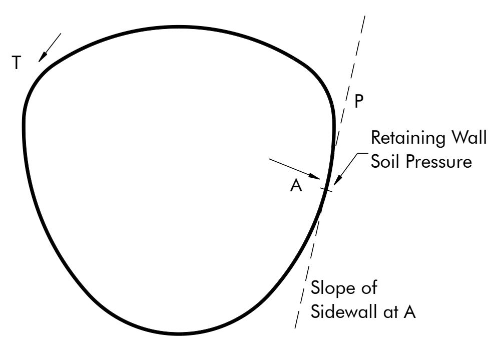
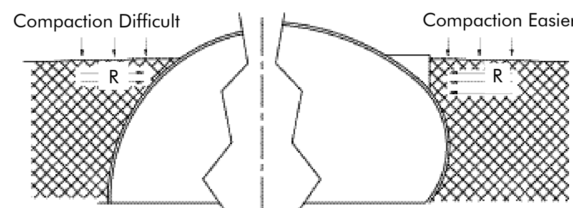


Figure 10

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



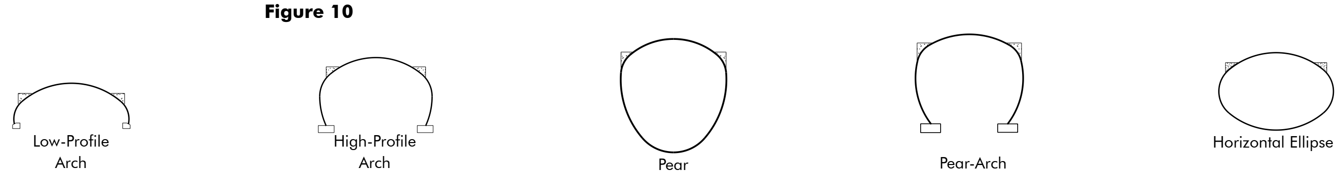
With the shape on the left, it is difficult to obtain adequate compaction of the backfill at the critical 3/4 rise point.

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 Design Details on page 85.

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 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′

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 T180 density.
6. Call a Contech representative for Pear and Pear-Arch shape gages.

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. Your Contech representative can provide 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 handbook 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. 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 purchase. These documents should be studied thoroughly by the contractor and engineer. The following material highlights the key elements involved in the proper construction of a Contech SUPER-SPAN.

Excavation, foundation and bedding

There must be adequate distance between the SUPER-SPAN and questionable native soils. Bedding must be preshaped for structures with inverts. A loose soil cushion should be provided for the bottom plates. Base channels for arches must be square to the centerline on arch structures.

Erection

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.

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.
   Approved stabilized soil shall be used only under direct supervision of a competent, experienced soils engineer. Plastic or cohesive soils should not be used.
2. The structure backfill material shall conform to one of the following soil classifications from AASHTO Specification M145, Table 2; for height of fill less than 12 feet, A-1, A-2-4 and A-2-5; for height of fill of 12 feet and more and all pear or pear-arch structures, A-1. Structure backfill shall be placed and compacted to not less than 90 percent density, per AASHTO T 180.
3. 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

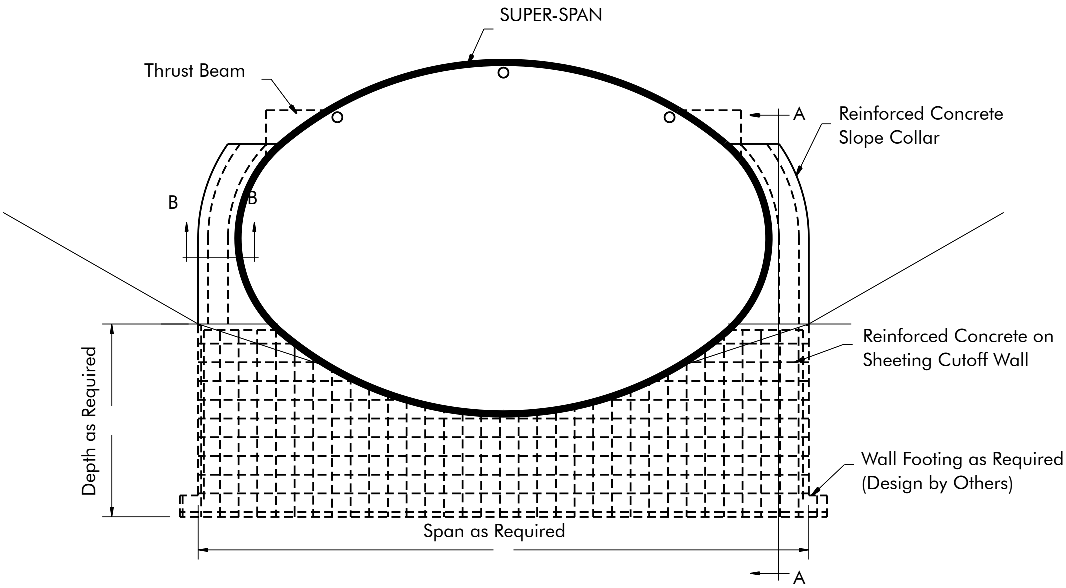
Regular monitoring is required during backfilling to ensure a structure with a proper shape and that compaction levels are achieved. A Contech technician will confirm the structure's shape before backfilling, then monitor the shape and verify compaction readings until the backfill reaches the minimum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

Special requirements

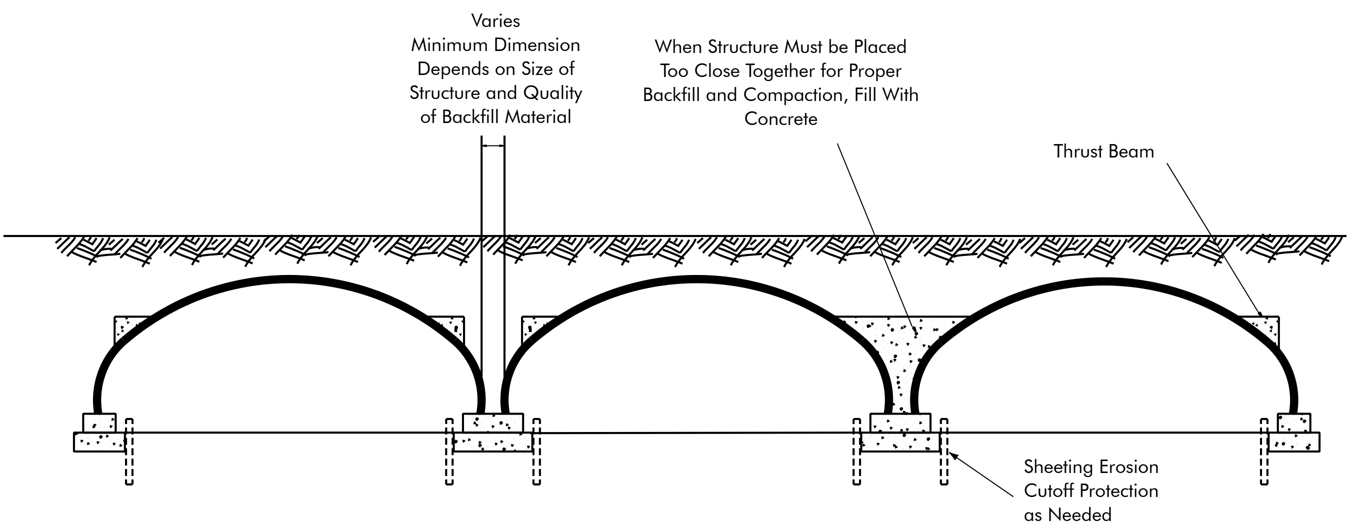
Very large or high structures sometimes call for additional special provisions for shape control during backfilling.

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[1]



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



Typical Multiple Span Low Profile Arches

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

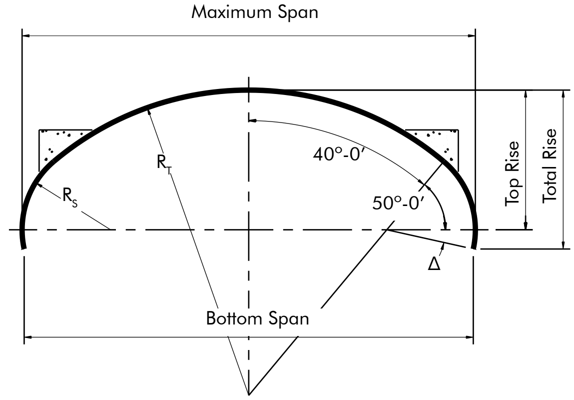
Galvanized Steel 6″ x 2″ Corrugation

SUPER-SPAN

TABLE 54. TYPICAL LOW PROFILE ARCH 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 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′-1″	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″	18′10″	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′-7″	12′-5″	10′-8″	21′-8″	7′-3″	14°-03′	330	2.97
117A24	33′-2″	33′-0″	11′-1″	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′	417	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.



End View – Low Profile Arch

Galvanized Steel 6" x 2" Corrugation

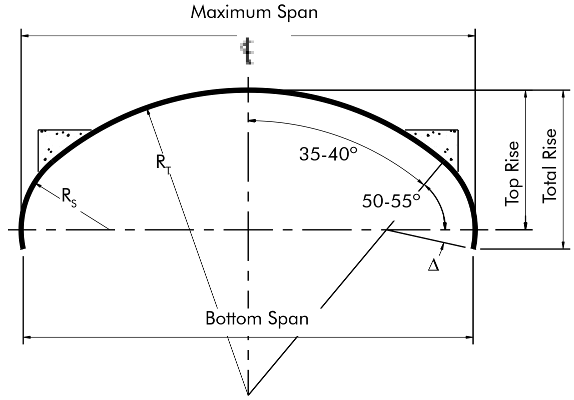
SUPER-SPAN

TABLE 55. SPECIAL LOW-RISE SHAPES[1]
(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 (Sq. Ft.)	Shape Factor R_T/R_S
69A15-NS	20′-8″	20′-8″	6′-3″	6′-1.5″	14′-10″	4′-2″	1°-56′	101	3.56
78A15-NS	22′-8″	22′-8″	6′-8″	6′-3.5″	16′-8″	3′-11″	5°-43′	119	4.26
84A15-NS	24′-5″	24′-5″	6′-11″	6′-9″	18′-0″	4′-2″	2°-05′	130	4.32
87A15-S	24′-6″	24′-6″	7′-6″	7′-4.5″	16′-6″	4′-7″	1°-32′	142	3.61
93A15-S	26′-0″	26′-0″	7′-9″	7′-7.5″	17′-8″	4′-7″	1°-32′	155	3.86
99A15-S	27′-6″	27′-6″	8′-0″	7′-11″	18′-10″	4′-7″	1°-32′	169	4.11
108A15-S	29′-9″	29′-9″	8′-5″	8′-4″	20′-7″	4′-8″	0°-38′	191	4.40
105A21-NS	30′-9″	30′-9″	9′-1″	8′-7″	22′-9″	5′-5″	5°-32′	220	4.20
111A18-S	31′-1″	31′-1″	9′-3″	9′-1.5″	21′-1″	5′-6″	1°-17′	221	3.84
117A18-S	32′-7″	32′-7″	9′-7″	9′-5″	22′-3″	5′-6″	1°-17′	238	4.05
123A18-S	34′-0″	34′-0″	9′-10″	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′	273	4.40
129A21S	36′-2″	36′-2″	10′-9″	10′-8″	24′-7″	6′-5″	1°-07′	299	3.83

[1]Due to their high shape factor, cover heights are generally limited to 8' or less. Backfill material typically must meet AASHTO M145 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.

Notes:
Other sizes are available for special designs.



End View – Special Low Profile Arch

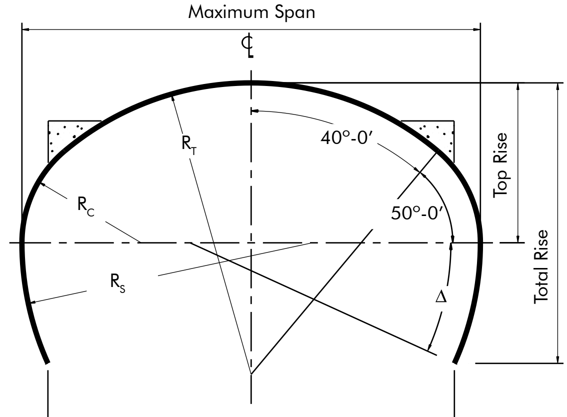
Galvanized Steel 6″ x 2″ Corrugation

SUPER-SPAN

TABLE 56. TYPICAL HIGH PROFILE ARCH SHAPES
(ALL DIMENSIONS TO INSIDE CRESTS)

Structure Number	Maximum Span	Bottom Span	Total Rise	Top Rise	Top Radius R_T	Upper Side Radius R_C	Lower Side Radius R_S	Angle Below Horizontal Δ	Approx. Area (Sq. Ft.)	Shape Factor R_T/R_C
69A15-9	20′-1″	19′-7″	9′-1″	6′-6″	13′-1″	4′-6″	13′-1″	11°-18′	152	2.91
69A18-18	20′8″	18′-10″	12′-1″	7′-3″	13′-1″	5′-5″	13′-1″	21°-44′	214	2.40
75A15-18	21′-6″	19′-10″	11′-8″	6′-9″	14′-3″	4′-6″	14′-3″	20°-0′	215	3.13
75A21-24	22′-10″	19′10″	14′-6″	8′-2″	14′-3″	6′-4″	14′-3″	26°-24′	284	2.24
78A15-18	22′-3″	20′-7″	11′-10″	6′-11″	14′-10″	4′-6″	14′-10″	19°-13′	224	3.25
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	2.71
81A15-18	23′-0″	21′-5″	11′-11″	7′-1″	15′-5″	4′-6″	15′-5″	18°-31′	234	3.38
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	2.41
84A15-18	23′-9″	22′-2″	12′-1″	7′-2″	16′-0″	4′-6″	16′-0″	17°-51′	244	3.50
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′-9″	7′-4″	16′-6″	4′-6″	16′-6″	22°-45′	288	3.63
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	2.59
90A15-21	25′-2″	23′-3″	13′-1″	7′-5″	17′-1″	4′-6″	17′-1″	19°-20′	283	3.75
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	2.68
93A15-21	25′-11″	24′-1″	13′-3″	7′-7″	17′-8″	4′-6″	17′-8″	18°-42′	294	3.88
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	2.77
99A15-21	27′-5″	25′-8″	13′-6″	7′-10″	18′-10″	4′-6″	18′-10″	17°-34′	317	4.13
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	2.58

Notes:
Other sizes are available for special designs.



End View – High Profile Arch

Galvanized Steel 6″ x 2″ Corrugation

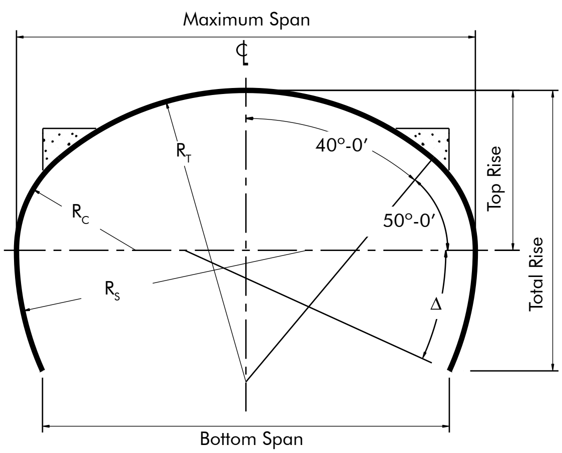
SUPER-SPAN

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

Structure Number	Maximum Span	Bottom Span	Total Rise	Top Rise	Top Radius R_T	Upper Side Radius R_C	Lower Side Radius R_S	Angle Below Horizontal	Approx. Area (Sq. Ft.) Δ	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′	408	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
†111A24-36	32′-4″	27′-11″	19′-11″	10′-6″	21′-1″	7′-3″	21′-1″	26°-29′	553	2.89
114A18-30	31′-9″	28′-8″	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
†114A24-36	33′-1″	28′-9″	20′-1″	10′-8″	21′-8″	7′-3″	21′-8″	25°-47′	570	2.97
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
†117A24-36	33′-10″	29′-7″	20′-3″	10′-9″	22′-3″	7′-3″	22′-3″	25°-07′	587	3.05
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′-4″	12′-5″	23′-5″	9′-1″	23′-5″	12°-11′	533	2.58
†123A21-36	34′-7″	30′-7″	19′-10″	10′-4″	23′-5″	6′-4″	23′-5″	23°-54′	590	3.67
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
†126A21-36	35′-4″	31′-5″	20′-0″	10′-6″	24′-0″	6′-4″	24′-0″	23°-20′	607	3.76

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

Note: Other sizes are available for special designs.



End View – High Profile Arch

Galvanized Steel 6″ x 2″ Corrugation

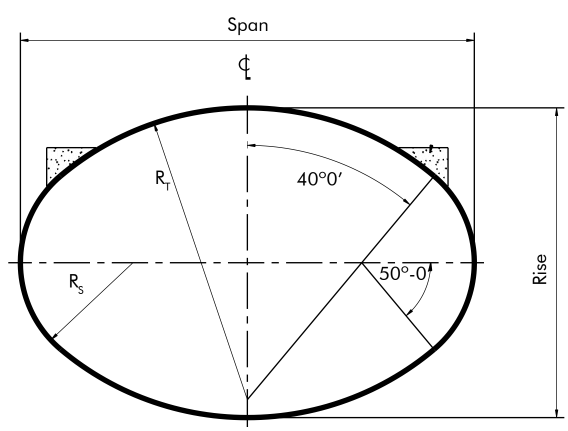
SUPER-SPAN

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

Structure Number	Maximum Span	Total Rise	Top Radius R_T	Side Radius R_S	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	2.90
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	2.21
78E27	21′-11″	13′-1″	14′-10″	4′-1″	221	3.63
75E39	22′-6″	15′-8″	14′-3″	5′-11″	274	2.40
81E30	23′-0″	14′-1″	15′-5″	4′-6″	249	3.42
78E39	23′-3″	15′-11″	14′-10″	5′-11″	288	2.50
81E42	24′-4″	16′-11″	15′-5″	6′-4″	320	2.43
87E30	24′-6″	14′-8″	16′-6″	4′-6″	274	3.66
90E30	25′-2″	14′-11″	17′-1″	4′-6″	287	3.79
87E39	25′-5″	16′-9″	16′-6″	5′-11″	330	2.79
87E45	26′-1″	18′-2″	16′-6″	6′-10″	369	2.42
93E33	26′-3″	15′-10″	17′-8″	5′-0″	320	3.53
96E33	27′-0″	16′-2″	18′-3″	5′-0″	334	3.65
90E48	27′-2″	19′-1″	17′-1″	7′-3″	405	2.35
93E48	27′-11″	19′-5″	17′-8″	7′-3″	421	2.43
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	2.59
102E48	30′-1″	20′-2″	19′-5″	7′-3″	472	2.67
108E36	30′-3″	17′-11″	20′-7″	5′-5″	415	3.75
105E51	31′-2″	21′-2″	20′-0″	7′-9″	513	2.58
111E39	31′-4″	18′-11″	21′-1″	5′-11″	454	3.56
114E39	32′-1″	19′-2″	21′-8″	5′-11″	471	3.66
108E54	32′-3″	22′-2″	20′-7″	8′-2″	555	2.52
111E54	33′-0″	22′-5″	21′-1″	8′-2″	574	2.58
117E42	33′-2″	20′-1″	22′-3″	6′-4″	512	3.51
114E57	34′-1″	23′-4″	21′-8″	8′-8″	619	2.50
123E42	34′-7″	20′-8″	23′-5″	6′-4″	548	3.69
123E45	34′-11″	21′-4″	23′-5″	6′-10″	574	3.42
†117E60	35′-1″	24′-4″	22′-3″	9′-1″	665	2.44
126E48	36′-0″	22′-4″	24′-0″	7′-3″	619	3.31
†132E45	37′-2″	22′-2″	25′-2″	6′-10″	631	3.68

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

Note:
Other sizes are available for special designs.



End View – Horizontal Ellipse

Galvanized Steel 6" x 2" Corrugation

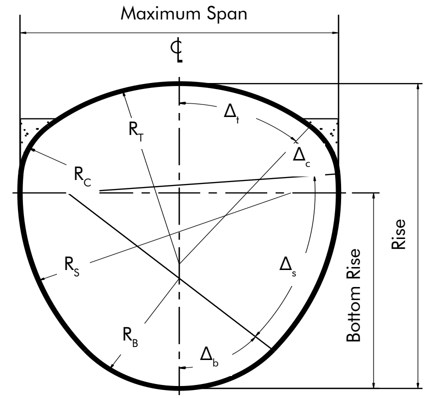
SUPER-SPAN

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

Structure Number	Maximum Span	Total Rise	Bottom Rise	Top Radius R_T	Δ_t	Corner Radius R_C	Δ_c	Side Radius R_S	Δ_s	Bottom Radius R_B	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.

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



End View – Pear

Galvanized Steel 6" x 2" Corrugation

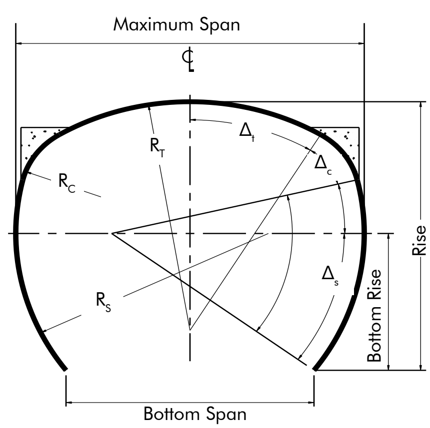
SUPER-SPAN

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

Structure Number	Maximum Span	Bottom Span	Total Rise	Bottom Rise	Top Radius R_T	Δ_t	Corner Radius R_C	Δ_c	Side Radius R_S	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

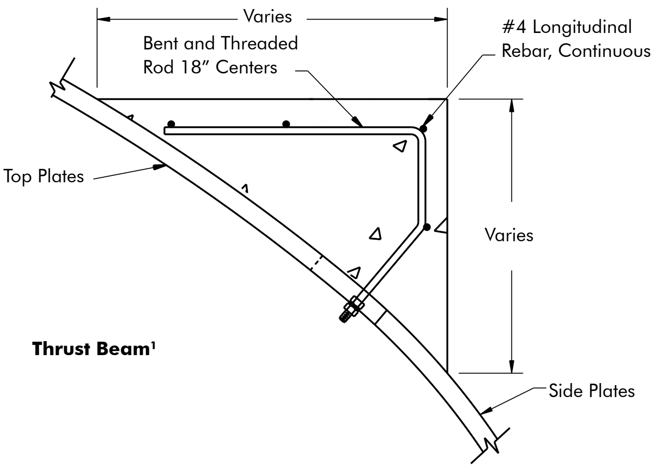
*Meets AREMA clearances for bridges and turntables.
**Meets AREMA clearances for single track tunnel.

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

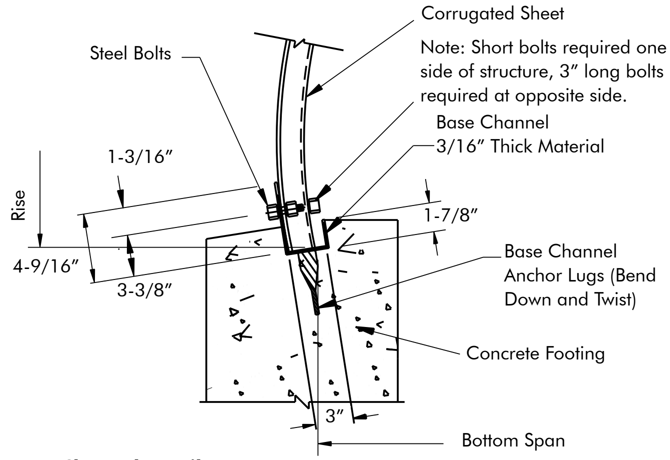


End View – Pear Arch

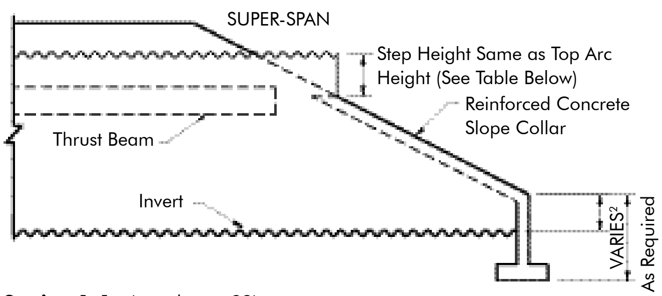
Conceptual drawings[1]



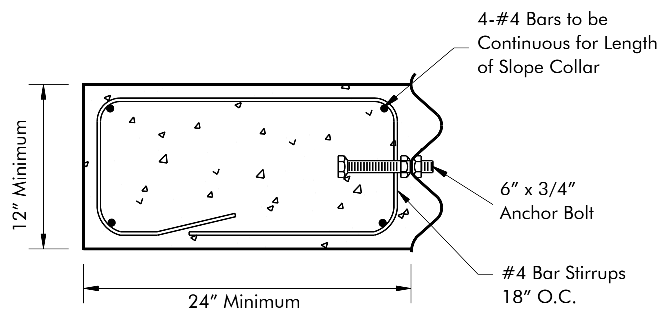
Thrust Beam[1]



Base Channel Detail

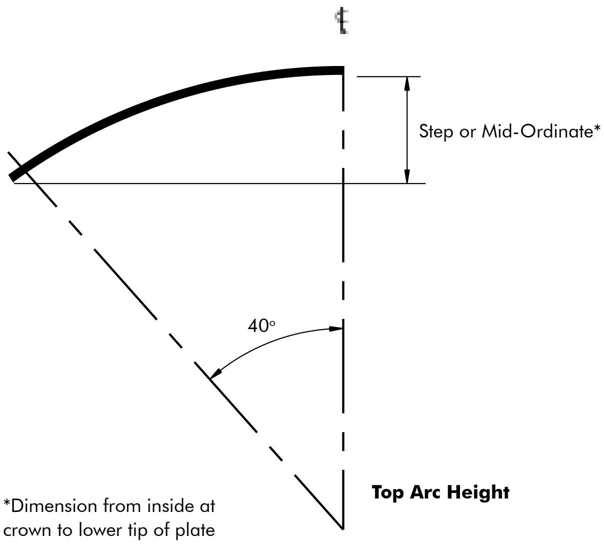


Section A-A (see elev. p. 83)



Section B-B

Typical Slope Collar[1] (see elev. p. 83)



Top Arc Height

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

TABLE 61. TYPICAL TOP STEP DIMENSIONS

Top or Bottom Arc. in Pi	Step or Mid-Ordinate
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. Many of the details are conceptual. The designer should work with the Contech representative on each particular application.
2. 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 A 449, Type 1 and ASTM A 563, Grade C, respectively. The steel anchor bolts shall conform to ASTM A-307, 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 Division II, Section 8, Class B of the AASHTO Standard Specifications for Highway Bridges having a minimum compression strength of 2400 psi. Reinforcing steel shall conform to ASTM A 615, 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

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 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 Test Method No. 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 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 M167. Aluminum alloy structural plate shall conform to the requirements of AASHTO M219.
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 A 123. 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

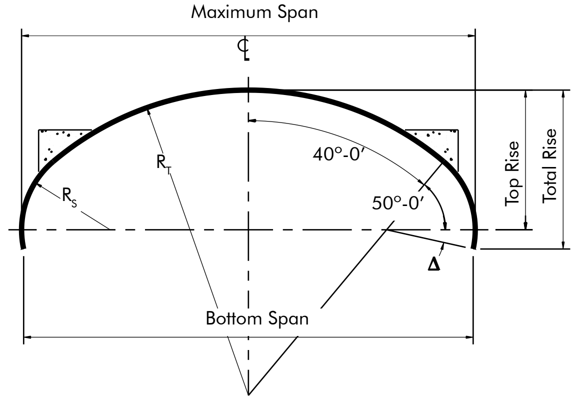
SUPER-PLATE

TABLE 63. TYPICAL LOW PROFILE ARCH SHAPES[1]
(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 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″	30′11″	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

Note: Other sizes are available for special designs.

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.



End View – Low Profile Arch

Aluminum 9" x 2-1/2" Corrugation

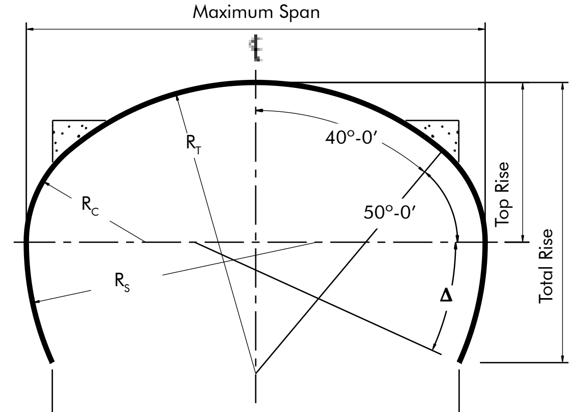
SUPER-PLATE

TABLE 64. TYPICAL HIGH PROFILE ARCH SHAPES[1]
(ALL DIMENSIONS TO INSIDE CRESTS)

Structure Number	Maximum Span	Bottom Span	Total Rise	Top Rise	Top Radius R_T	Upper Side Radius R_C	Lower Side Radius R_S	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	20′9″	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″	19′10″	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
†37A8-12	32′-4″	27′-11″	19′-11″	10′-6″	21′-2″	7′-3″	21′-2″	26°-29′	555	2.92
38A6-10	31′-10″	28′-9″	17′-3″	9′-3″	21′-9″	5′-5″	21′-9″	21°-35′	470	4.02
†38A8-12	33′-1″	28′-9″	20′-1″	10′-8″	21′-9″	7′-3″	21′-9″	25°-47′	572	3.00
39A6-10	32′-6″	29′-7″	17′-4″	9′-4″	22′-4″	5′-5″	22′-4″	21°-02′	485	4.12
†39A8-12	33′-10″	29′-8″	20′-3″	10′-9″	22′-4″	7′-3″	22′-4″	25°-08′	589	3.08
41A6-10	34′-0″	31′-2″	17′-8″	9′-8″	23′-5″	5′-5″	23′-5″	20°-0′	514	4.33
†41A7-12	34′-8″	30′-8″	19′-10″	10′-4″	23′-5″	6′-4″	23′-5″	23°-54′	591	3.70
42A6-10	34′-9″	32′-0″	17′-9″	9′-9″	24′-0″	5′-5″	24′-0″	19°-32′	529	4.44
†42A7-12	35′-5″	31′-6″	20′-0″	10′-6″	24′-0″	6′-4″	24′-0″	23°-20′	608	3.80

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

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.



End View – High Profile Arch

SUPER-SPAN/SUPER-PLATE

Aluminum 9″ x 2-1/2″ Corrugation

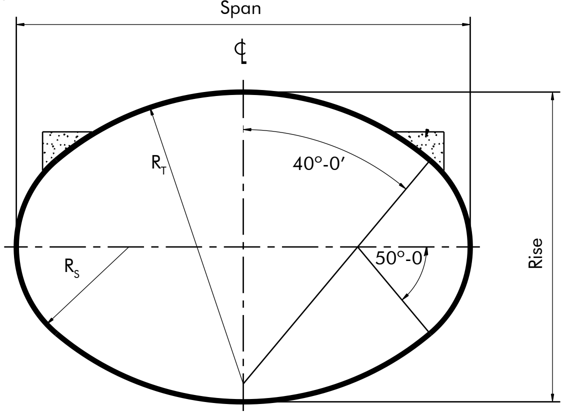
SUPER-PLATE

TABLE 65. TYPICAL HORIZONTAL ELLIPSE SHAPES[1]
(ALL DIMENSIONS TO INSIDE CRESTS)

Structure Number	Maximum Span	Total Rise	Top Radius R_T	Side Radius R_S	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	2.35
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″	495	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
†39E20	35′-2″	24′-4″	22′-4″	9′-1″	667	2.45
42E16	36′-1″	22′-4″	24′-0″	7′-3″	620	3.31
†44E15	37′-3″	22′-2″	25′-2″	6′-9″	632	3.71

† Very large or high structures sometimes call for additional special provisions for shape control during backfill.
Note: Other sizes are available for special designs.

Note:
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.



End View – 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 B 209. Bolts and nuts shall meet the provisions of ASTM A 307, Grade A and ASTM A 563, Grade A, respectively, and shall be galvanized in accordance with the requirements of ASTM A 153, Class C or B 695, Class 50. Steel anchor bolts shall conform to ASTM A 307, Grade A.

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 Division II, Section 8, Class B of the AASHTO Standard Specifications for Highway Bridges having a minimum compression strength of 2400 psi. Reinforcing steel shall conform to ASTM A 615, 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 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.

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

GROUP CLASSIFICATION	A-1		A-2(Modified)	
	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 Test Method specification 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 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 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 specification M167. Aluminum alloy structural plate shall conform to the requirements of AASHTO M219.
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. Now Contech has introduced BridgeCor, a deep corrugation pattern, providing 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 45 inch laying length 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 Full 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 0.140 to 0.380 inches.

Widths. Standard plates come in multiples of 16 inches (S=16 inches or 5*3.2) and are fabricated in five net covering widths, 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.

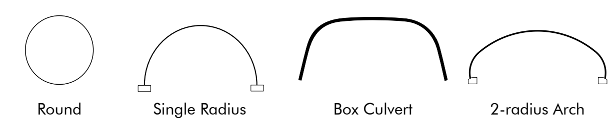
For example, a 54 S round structures uses six - 9 S plates (S=16 inches or 5*3.2)

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

Therefore, this calculates to a 270 inch (22'-6") diameter round pipe. Various plate widths may be combined to obtain almost any diameter.

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 10 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 0.375"), the holes are punched to 1-⅛ 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

Bolt Hole Spacing

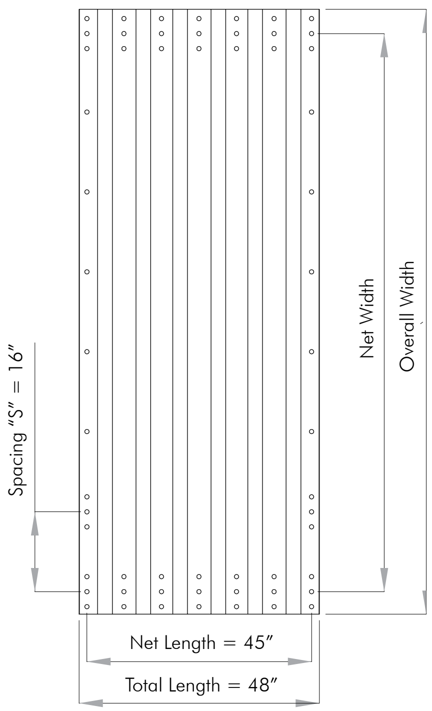
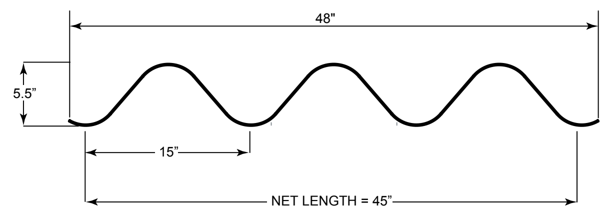


TABLE 67. DETAILS OF UNCURVED BRIDGECOR SECTIONS				
Nominal	Net Width, Inches	Overall Width, Inches	Spaces 16 inches	Number of Circumferential Bolt Holes
5 S	80	89	5	6
6 S	96	105	6	7
7 S	112	121	7	8
8 S	128	137	8	9
9 S	144	153	9	10

For BridgeCor, S = 16 inches.



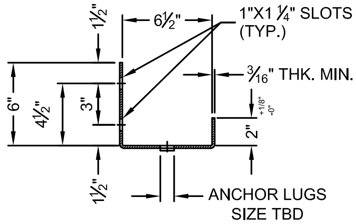
Standard 15" x 5.5" Corrugation

Note: 5/16" (.318) and 3/8" (.375) plate shall be two corrugations (30" net length)

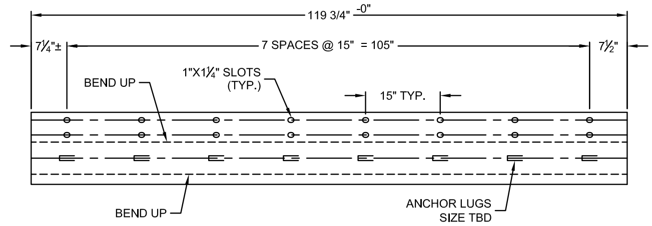
TABLE 68. APPROXIMATE WEIGHT OF BRIDGECOR SECTIONS

S	Net Length, Feet	Sheet weights, lbs. (with no fasteners)(1) (2)							
		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.)	0.375 (3/8 In.)
5 S	3.75	220	267	295	342	391	440	347	414
6 S	3.75	259	315	348	404	461	519	409	489
7 S	3.75	299	363	401	465	531	598	471	563
8 S	3.75	338	411	454	527	602	677	534	638
9 S	3.75	378	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



Unbalanced Channel Cross Section



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 A-761 "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 A-761 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 A-449. 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 Bedding preparation is critical to both structure performance and service life. The bed should be constructed to uniform line and grade to avoid distortions that may create undesirable stresses in the structure and/or rapid deterioration of the roadway. The bed should be free of rock formations, protruding stones, frozen lumps, roots and other foreign matter that may cause unequal settlement.

3.5 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 6 to 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 five critical components being followed:

1. Good foundation
2. Use of select structural backfill
3. 8″ maximum thick lifts of backfill evenly placed on both sides of the structure
4. Adequate compaction of backfill
5. 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.

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

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.

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

It is recommended that the bedding be stable, well graded granular material. Placing the structure on the bedding surface is generally accomplished by one of the two following methods:

- Shaping the bedding surface to conform to the lower section of the structure
- Carefully tamping a granular or select material beneath the haunches to achieve a well-compacted condition

Using one of these two methods ensures satisfactory compaction beneath the haunches.

Backfill
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, 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 (D-4 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 D-4).

For more information, refer to ASTM A 807 and AASHTO LRFD Bridge Construction 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.

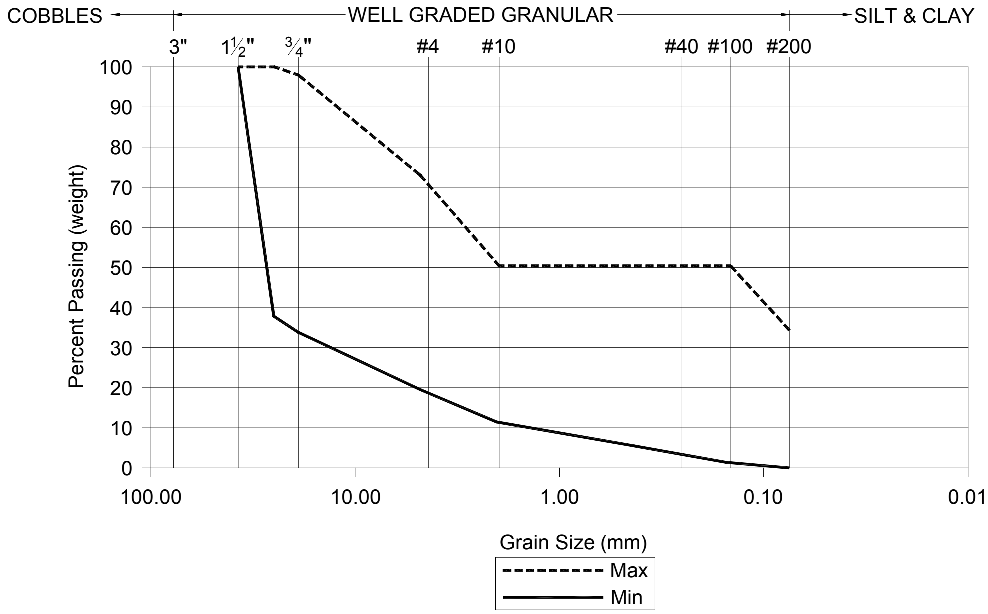


TABLE 69. BRIDGECOR GROUP CLASSIFICATION

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. 100 (0.150 mm)	----	----	50 max.	50 max.	----
No. 200 (0.075 mm)	15 max.	25 max.	20 max.	20 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

NOTE: Atterberg Limits are modified to provide material that are primarily granular

BridgeCor Plate Assembly

TABLE 70. BRIDGECOR BOX CULVERT 15" X 5½"

LRFD HEIGHT OF COVER GUIDE

Dimensions to Inside Corrugation				Gage Thickness (Inches) - Height of Cover Shown in Feet Maximum Height of Cover (Minimum Height of Cover)									
Shape	Bottom Span (Ft.-In.)	Rise (Ft.-In.)	Approx. Area (Sq. Ft.)	10 (0.140)	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 (ft.)	Precon (min Level)
1	17-6	6-10	98.9	11 (3.0)	13 (2.5)	14 (2.5)	16 (2.0)	17 (2.0)	19 (2.0)	21 (2.0)	25 (1.5)	8.0	1
2	17-7	8-2	122.2	11 (3.0)	13 (2.5)	14 (2.5)	15 (2.0)	17 (2.0)	19 (2.0)	21 (2.0)	24 (1.5)	8.0	1
3	17-9	9-6	145.7	11 (3.0)	13 (2.5)	14 (2.5)	15 (2.0)	17 (2.0)	19 (2.0)	21 (2.0)	24 (1.5)	8.0	1
4	17-10	10-10	169.4	11 (3.0)	13 (2.5)	13 (2.5)	15 (2.0)	17 (2.0)	18 (2.0)	21 (2.0)	24 (1.5)	8.0	1
5	18-10	7-0	108.4	10 (3.0)	11 (2.5)	12 (2.5)	14 (2.0)	15 (2.0)	17 (2.0)	19 (2.0)	22 (1.5)	8.0	1
6	18-11	8-4	133.5	10 (3.0)	11 (2.5)	12 (2.5)	14 (2.0)	15 (2.0)	17 (2.0)	19 (2.0)	22 (1.5)	8.0	1
7	19-1	9-8	158.8	10 (3.0)	11 (2.5)	12 (2.5)	14 (2.0)	15 (2.0)	17 (2.0)	18 (2.0)	22 (1.5)	8.0	1
8	19-3	11-0	184.4	10 (3.0)	11 (2.5)	12 (2.5)	13 (2.0)	15 (2.0)	16 (2.0)	18 (2.0)	21 (1.5)	8.0	1
9	20-4	8-6	145.1	9 (3.0)	10 (3.0)	11 (2.5)	12 (2.5)	14 (2.0)	15 (2.0)	17 (2.0)	19 (1.5)	8.0	1
10	20-5	9-10	172.2	9 (3.5)	10 (3.0)	11 (2.5)	12 (2.5)	13 (2.0)	15 (2.0)	16 (2.0)	19 (2.0)	8.0	1
11	20-7	11-1	199.5	8 (3.5)	10 (3.0)	11 (2.5)	12 (2.5)	13 (2.0)	15 (2.0)	16 (2.0)	19 (2.0)	8.0	1
12	21-6	7-3	128.2	8 (3.5)	9 (3.0)	10 (2.5)	11 (2.5)	12 (2.0)	13 (2.0)	15 (2.0)	17 (2.0)	8.0	1
13	21-8	8-7	156.9	8 (3.5)	9 (3.0)	10 (2.5)	11 (2.5)	12 (2.0)	13 (2.0)	15 (2.0)	17 (2.0)	8.0	1
14	21-10	9-11	185.8	8 (3.5)	9 (3.0)	9 (2.5)	11 (2.5)	12 (2.0)	13 (2.0)	15 (2.0)	17 (2.0)	8.0	1
15	22-5	11-3	214.9	8 (3.5)	9 (3.0)	9 (2.5)	10 (2.5)	12 (2.0)	13 (2.0)	14 (2.0)	17 (2.0)	8.0	1
16	22-9	7-5	138.5	7 (3.5)	8 (3.0)	9 (3.0)	10 (2.5)	11 (2.0)	12 (2.0)	13 (2.0)	15 (2.0)	8.0	1
17	22-11	8-9	168.9	7 (3.5)	8 (3.0)	9 (3.0)	10 (2.5)	11 (2.0)	12 (2.0)	13 (2.0)	15 (2.0)	8.0	1
18	23-2	10-1	199.5	7 (3.5)	8 (3.0)	8 (3.0)	9 (2.5)	11 (2.0)	12 (2.0)	13 (2.0)	15 (2.0)	8.0	1
19	23-4	11-5	230.5	7 (3.5)	8 (3.0)	8 (3.0)	9 (2.5)	10 (2.0)	11 (2.0)	13 (2.0)	15 (2.0)	8.0	1
20	24-1	7-7	149.1		7 (3.0)	8 (3.0)	9 (2.5)	10 (2.5)	11 (2.0)	12 (2.0)	14 (2.0)	8.0	2
21	24-3	8-7	167.7		7 (3.0)	8 (2.5)	9 (2.0)	9 (2.0)	10 (1.5)	12 (1.5)	14 (1.5)	8.0	2
22	24-3	8-11	181.3	7 (3.0)	9 (3.0)	9 (3.0)	10 (2.5)	11 (2.5)	12 (2.0)	14 (2.0)	16 (2.0)	8.0	2
23	24-5	9-11	200.1	7 (3.5)	8 (3.0)	9 (2.5)	10 (2.0)	11 (2.0)	12 (1.5)	14 (1.5)	16 (1.5)	8.0	2
24	24-5	10-3	213.7		7 (3.0)	8 (3.0)	8 (2.5)	9 (2.5)	10 (2.0)	11 (2.0)	13 (2.0)	8.0	2
25	24-6	11-3	232.7	7 (3.5)	8 (3.0)	9 (2.5)	10 (2.0)	11 (2.0)	12 (1.5)	14 (1.5)	16 (1.5)	8.0	2
26	24-8	11-7	246.3		7 (3.5)	7 (3.0)	8 (2.5)	9 (2.5)	10 (2.0)	11 (2.0)	13 (2.0)	8.0	2
27	24-8	12-7	265.4	7 (3.5)	8 (3.0)	9 (2.5)	10 (2.0)	11 (2.0)	12 (1.5)	13 (1.5)	16 (1.5)	8.0	2

Notes:
1. Not for a specific structural design. Use for budget estimating only. A CANDE analysis is required for final design and quotation.
2. The above table is based upon the minimum requirements of the AASHTO LRFD Design Specification, Section 12, and:
   a. Backfill material per AASHTO M145, class A-2-5 or better.
   b. Backfill 120 pcf in density and compacted to 90% modified proctor.
   c. The minimum cover is per article 12.8.9.4
   d. 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 BOX CULVERT 15" X 5½"

LRFD HEIGHT OF COVER GUIDE

Dimensions to Inside Corrugation				Gage Thickness (Inches) - Height of Cover Shown in Feet Maximum Height of Cover (Minimum Height of Cover)									
Shape	Bottom Span (Ft.-In.)	Rise (Ft.-In.)	Approx. Area (Sq. Ft.)	10 (0.140)	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 (Ft.)	Precon (Min Level)
28	24-11	8-0	162.4		7 (3.5)	7 (3.0)	8 (2.5)	9 (2.5)	10 (2.0)	11 (2.0)	13 (2.0)	8.0	2
29	25-7	9-1	193.8		6 (3.5)	7 (3.0)	8 (2.5)	8 (2.5)	9 (2.0)	10 (2.0)	12 (2.0)	6.0	2
30	25-8	8-8	179.3	7 (3.5)	8 (3.0)	8 (2.5)	9 (2.5)	10 (2.0)	11 (2.0)	12 (1.5)	14 (1.5)	8.0	2
31	25-10	10-0	213.7	7 (3.5)	8 (3.0)	8 (2.5)	9 (2.5)	10 (2.0)	11 (2.0)	12 (2.0)	14 (1.5)	8.0	2
32	26-0	11-4	258.2	7 (3.5)	8 (3.0)	8 (2.5)	9 (2.5)	10 (2.0)	11 (2.0)	12 (2.0)	14 (1.5)	8.0	2
33	26-2	12-8	283.0	7 (3.5)	7 (3.0)	8 (2.5)	9 (2.5)	10 (2.0)	11 (2.0)	12 (2.0)	14 (1.5)	8.0	2
34	26-4	9-6	208.7		6 (3.5)	6 (3.0)	7 (3.0)	8 (2.5)	9 (2.0)	10 (2.0)	11 (2.0)	6.0	2
35	26-5	10-10	243.8		6 (3.5)	6 (3.0)	7 (3.0)	8 (2.5)	9 (2.0)	10 (2.0)	11 (2.0)	6.0	2
36	26-6	12-2	278.2			6 (3.0)	7 (3.0)	8 (2.5)	9 (2.0)	10 (2.0)	11 (2.0)	6.0	2
37	27-1	8-10	191.3	6 (3.5)	7 (3.0)	7 (2.5)	8 (2.5)	9 (2.0)	10 (2.0)	11 (2.0)	13 (1.5)	8.0	2
38	27-3	10-2	226.7	6 (3.5)	7 (3.0)	7 (2.5)	8 (2.5)	9 (2.0)	10 (2.0)	11 (2.0)	13 (2.0)	8.0	2
39	27-5	11-6	263.0		7 (3.0)	7 (3.0)	8 (2.5)	9 (2.0)	10 (2.0)	11 (2.0)	13 (2.0)	8.0	2
40	27-6	8-4	185.3			6 (3.0)	7 (3.0)	7 (2.5)	8 (2.5)	9 (2.0)	10 (2.0)	6.0	3
41	27-7	12-10	299.6		8 (3.0)	8 (3.0)	9 (2.5)	10 (2.0)	10 (2.0)	11 (2.0)	13 (2.0)	8.0	2
42	27-9	11-0	259.0			6 (3.5)	6 (3.0)	7 (2.5)	8 (2.5)	9 (2.0)	10 (2.0)	6.0	3
43	27-11	12-4	296.0			6 (3.5)	6 (3.0)	7 (2.5)	8 (2.5)	8 (2.0)	10 (2.0)	6.0	3
44	28-2	9-5	219.8			6 (3.5)	6 (3.0)	7 (2.5)	8 (2.5)	8 (2.0)	10 (2.0)	6.0	3
45	28-6	9-0	203.4		6 (3.0)	7 (3.0)	7 (2.5)	8 (2.0)	9 (2.0)	10 (2.0)	12 (2.0)	8.0	2
46	28-8	10-4	241.4		6 (3.0)	7 (3.0)	7 (2.5)	8 (2.5)	9 (2.0)	10 (2.0)	11 (2.0)	8.0	2
47	28-10	8-6	197.2			5 (3.5)	6 (3.0)	7 (2.5)	7 (2.5)	8 (2.0)	9 (2.0)	6.0	3
48	28-11	11-8	279.7		6 (3.0)	7 (3.0)	7 (2.5)	8 (2.5)	9 (2.0)	10 (2.0)	11 (2.0)	8.0	2
49	29-1	11-2	274.4			5 (3.5)	6 (3.0)	6 (2.5)	7 (2.5)	8 (2.0)	9 (2.0)	6.0	3
50	29-1	13-0	318.3		6 (3.5)	6 (3.0)	7 (2.5)	8 (2.5)	9 (2.0)	10 (2.0)	11 (2.0)	8.0	2
51	29-3	12-6	313.2				6 (3.0)	6 (2.5)	7 (2.5)	8 (2.0)	9 (2.0)	6.0	3
52	29-6	9-7	233.2				6 (3.0)	6 (2.5)	7 (2.5)	8 (2.0)	9 (2.0)	8.0	3
53	29-10	9-1	215.8		6 (3.5)	6 (3.0)	7 (2.5)	8 (2.5)	8 (2.0)	9 (2.0)	11 (2.0)	8.0	2

Notes:
1. Not for a specific structural design. Use for budget estimating only. A CANDE analysis is required for final design and quotation.
2. The above table is based upon the minimum requirements of the AASHTO LRFD Design Specification, Section 12, and:
   a. Backfill material per AASHTO M145, class A-2-5 or better.
   b. Backfill 120 pcf in density and compacted to 90% modified proctor.
   c. The minimum cover is per article 12.8.9.4
   d. 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 72. BRIDGECOR BOX CULVERT 15" X 5½"

LRFD HEIGHT OF COVER GUIDE

Dimensions to Inside Corrugation				Gage Thickness (Inches) - Height of Cover Shown in Feet Maximum Height of Cover (Minimum Height of Cover)									
Shape	Bottom Span (Ft.-In.)	Rise (Ft.-In.)	Approx. Area (Sq. Ft.)	10 (0.140)	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 (ft.)	Precon (Min Level)
54	30-1	10-5	255.6		6 (3.5)	6 (3.0)	7 (2.5)	7 (2.5)	8 (2.0)	9 (2.0)	10 (2.0)	8.0	2
55	30-4	11-9	295.7		6 (3.5)	6 (3.0)	7 (2.5)	7 (2.5)	8 (2.0)	9 (2.0)	10 (2.0)	8.0	2
56	30-5	11-3	290.0				5 (3.0)	6 (2.5)	6 (2.5)	7 (2.0)	8 (2.0)	8.0	3
57	30-7	12-7	330.6		5 (3.5)	6 (3.0)	6 (3.0)	7 (2.5)	8 (2.5)	9 (2.0)	10 (2.0)	8.0	3
58	30-7	13-1	336.2				5 (3.0)	6 (2.5)	6 (2.0)	7 (2.0)	8 (2.0)	8.0	3
59	30-7	8-5	206.1				5 (3.0)	6 (2.5)	6 (2.5)	7 (2.0)	8 (2.0)	8.0	3
60	30-8	9-7	232.3		5 (3.5)	6 (3.0)	6 (3.0)	7 (2.5)	8 (2.0)	9 (2.0)	10 (2.0)	8.0	2
61	30-9	10-11	272.4		5 (3.5)	6 (3.0)	6 (3.0)	7 (2.5)	8 (2.0)	9 (2.0)	10 (2.0)	8.0	2
62	30-11	12-2	313.4			6 (3.0)	6 (3.0)	7 (2.5)	8 (2.0)	8 (2.0)	10 (2.0)	8.0	3
63	31-0	13-6	354.6			6 (3.0)	6 (3.0)	7 (2.5)	8 (2.0)	8 (2.0)	10 (2.0)	8.0	3
64	31-6	8-9	221.7				5 (3.0)	6 (3.0)	6 (2.5)	7 (2.0)	8 (2.0)	8.0	3
65	31-9	11-5	305.9				5 (3.0)	6 (3.0)	6 (2.5)	7 (2.0)	8 (2.0)	8.0	3
66	32-0	9-8	245.5			5 (3.5)	6 (3.0)	7 (2.5)	7 (2.5)	8 (2.0)	9 (2.0)	8.0	3
67	32-2	11-0	288.2			5 (3.5)	6 (3.0)	6 (2.5)	7 (2.5)	8 (2.0)	9 (2.0)	8.0	3
68	32-4	12-4	331.1			5 (3.5)	6 (3.0)	6 (3.0)	7 (2.5)	8 (2.0)	9 (2.0)	8.0	3
69	32-6	13-8	374.3			5 (3.5)	6 (3.0)	6 (3.0)	7 (2.5)	8 (2.0)	9 (2.0)	8.0	3
70	33-5	9-10	258.8				6 (3.0)	6 (3.0)	7 (2.5)	7 (2.0)	8 (2.0)	8.0	3
71	33-7	11-2	303.4				5 (3.0)	6 (3.0)	7 (2.5)	7 (2.5)	8 (2.0)	8.0	3
72	33-9	12-6	348.2				5 (3.0)	6 (3.0)	6 (2.5)	7 (2.5)	8 (2.0)	8.0	3
73	34-0	13-10	393.2				5 (3.0)	6 (3.0)	6 (2.5)	7 (2.5)	8 (2.0)	8.0	3
74	34-9	10-0	272.5				5 (3.0)	6 (3.0)	6 (2.5)	7 (2.5)	8 (2.0)	8.0	3
75	34-11	11-3	317.9				5 (3.0)	6 (3.0)	6 (2.5)	7 (2.5)	8 (2.0)	8.0	3
76	35-2	12-7	364.4				5 (3.0)	6 (3.0)	6 (2.5)	7 (2.5)	8 (2.0)	8.0	3
77	35-4	13-11	411.3				5 (3.0)	6 (3.0)	6 (2.5)	7 (2.5)	8 (2.0)	8.0	3
CUSTOM	UP TO 45'	VARIES		VARIES								INQUIRE	INQUIRE

Notes:
1. Not for a specific structural design. Use for budget estimating only. A CANDE analysis is required for final design and quotation.
2. The above table is based upon the minimum requirements of the AASHTO LRFD Design Specification, Section 12, and:
   a. Backfill material per AASHTO M145, class A-2-5 or better.
   b. Backfill 120 pcf in density and compacted to 90% modified proctor.
   c. The minimum cover is per article 12.8.9.4
   d. 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 BOX CULVERT 15" X 5½"

WEIGHT TABLES

Dimensions to Inside Corrugation				Gage Thickness (Inches) Weight Shown as per Foot of Structure								Plate Make-Up					
Structure Number	Total S	Bottom Span (Ft.-In.)	Rise (Ft.-In.)	10 (0.140)	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
1	19	17-6	6-10	226	273	301	348	396	445	530	631			1	2		3
2	21	17-7	8-2	247	299	330	381	434	487	581	691		1	1	1		3
3	23	17-9	9-6	269	325	358	414	472	530	631	751		2	1			3
4	25	17-10	10-10	290	350	387	447	510	572	681	811	1	2				3
5	20	18-10	7-0	237	286	315	365	415	466	555	661		1	1		1	3
6	22	18-11	8-4	258	312	344	398	453	508	606	721		1	2			3
7	24	19-1	9-8	279	337	373	431	491	551	656	781	1	1	1			3
8	26	19-3	11-0	301	363	401	464	529	593	707	842	2	1				3
9	23	20-4	8-6	269	325	358	414	472	530	631	751		2	1			3
10	25	20-5	9-10	290	350	387	447	510	572	681	811	1	2				3
11	27	20-7	11-1	319	386	427	493	561	629	751	893		2		1	1	4
12	22	21-6	7-3	258	312	344	398	453	508	606	721		1	2			3
13	24	21-8	8-7	279	337	373	431	491	551	656	781	1	1	1			3
14	26	21-10	9-11	301	363	401	464	529	593	707	842	2	1				3
15	28	22-5	11-3	331	399	440	509	580	650	776	923	1	1		1	1	4
16	23	22-9	7-5	269	325	358	414	472	530	631	751		2	1			3
17	25	22-11	8-9	290	350	387	447	510	572	681	811	1	2				3
18	27	23-2	10-1	319	386	427	493	561	629	751	893		1	1	2		4
19	29	23-4	11-5	341	412	455	526	599	671	801	953	1	1		2		4
20	24	24-1	7-7		337	373	431	491	551	656	781	1	1	1			3
21	26	24-3	8-7		299	330	381	434	487	581	691	1	2				3
22	25	24-3	8-11	290	350	387	447	510	572	681	811	2	1				3
23	27	24-5	9-11	319	380	427	493	561	629	751	893			3	1		4
24	28	24-5	10-3		399	440	509	580	650	776	923	1	1		1	1	4
25	29	24-6	11-3	341	412	455	526	599	671	801	953		1	3			4
26	30	24-8	11-10		425	469	542	618	693	827	983	2	1				3
27	31	24-8	12-7	363	438	483	559	636	714	852	1013	1	1	2			4
28	25	24-11	8-0		350	387	447	510	572	681	811	1	1	2			4
29	27	25-7	9-1		386	427	493	561	629	751	893			3	1		4
30	26	25-8	8-8	301	363	401	464	529	593	707	842	2	1				3
31	28	25-10	10-0	331	399	440	509	580	650	776	923		2	1			3
32	30	26-0	11-4	352	418	462	533	608	682	779	928		2	2			4
33	32	26-2	12-8	374	451	498	575	655	735	877	1044	1	2	1			4
34	28	26-4	9-6		399	440	509	580	650	776	923		2	1	1		4
35	30	26-5	10-10		425	469	542	618	693	827	983		2	2			4

Notes:
1. Weights include 3/4” diameter fasteners for assembly. Inquire for cases utilizing 7/8” diameter fasteners.
2. Weight 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 width.
5. If unbalanced channels are supplied, add 20 pounds per foot to the structure length.

TABLE 74. 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						
Structure Number	Total S	Bottom Span (Ft.-In.)	Rise (Ft.-In.)	10 (0.140)	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
36	32	26-6	12-2			498	575	655	735	877	1044	1	2	1			4
37	27	27-1	8-10	319	386	427	493	561	629	751	893			3	1		4
38	29	27-3	10-2	341	412	455	526	599	671	801	953		1	3			4
39	31	27-5	11-6		438	483	559	636	714	852	1013			3	1		4
40	27	27-6	8-4			427	493	561	629	751	893			3	1		4
41	33	27-7	12-10		463	512	592	674	756	902	1074	1	3				4
42	31	27-9	11-0			483	559	636	714	852	1013		3	1			4
43	33	27-11	12-4			512	592	674	756	902	1074	1	3				4
44	29	28-2	9-5			455	526	599	671	801	953		1	3			4
45	28	28-6	9-0		463	512	592	674	756	902	1074		2	1		1	4
46	28	28-8	10-4		399	440	509	580	650	776	923		2	2			4
47	28	28-10	8-6			440	509	580	650	776	923		2	1		1	4
48	34	29-1	13-0		476	526	608	693	778	927	1104	1	2	1			4
49	32	29-1	11-2			498	575	655	735	877	1044	1	2	1			4
50	34	29-1	13-0		476	526	608	693	778	927	1104	2	2				4
51	34	29-3	12-6				608	693	778	927	1104	2	2				4
52	30	29-3	9-7				542	618	693	827	983		2	2			4
53	29	29-10	9-1		412	455	526	599	671	801	953		1	3			4
54	31	30-1	10-5		438	483	559	636	714	852	1013		3	1			4
55	33	30-7	11-9		463	512	592	674	756	902	1074	1	3				4
56	33	30-5	11-3				592	674	756	902	1074	1	3				4
57	35	30-7	12-7		489	541	625	712	799	953	1135	3	1				4
58	35	30-7	13-1					712	799	953	1135	3	1				4
59	29	30-7	8-5					599	671	801	953		1	3			4
60	30	30-8	9-7		425	469	542	618	693	827	983		2	2			4
61	32	30-9	10-11		451	498	575	655	735	877	1044	1	2	1			4
62	34	30-11	12-2			526	608	693	778	927	1104	2	2				4
63	36	31-0	13-6			566	654	744	835	997	1186	2	1				3
64	30	31-6	8-9				542	618	693	827	983		2	2			4
65	34	31--9	11-5				608	693	778	927	1104	2	2				4
66	31	32-0	9-8			483	559	636	714	852	1013		3	1			4
67	33	32-2	11-0			512	592	674	756	902	1074	1	3				4
68	35	32-4	12-4			541	625	712	799	953	1135	3	1				4
69	37	32-6	13-8			580	670	763	856	1022	1216	2	1		1	1	4
70	32	33-5	9-10				575	655	735	877	1044	1	2	1			4
71	34	33-7	11-2				608	693	778	927	1104	2	2				4
72	36	33-9	12-6				654	744	835	997	1186		1	4			5
73	38	34-0	13-10				687	782	877	1047	1246	1	1	3			4
74	33	34-9	10-0				592	674	756	902	1074	1	3				4
75	35	34-11	11-3				625	712	799	953	1135	3	1				4
76	37	35-2	12-7				670	763	856	1022	1216		3	1	1		5
77	39	35-4	13-11				703	801	898	1197	1276	1	3		1		5
VARIES	UP TO 45'	VARIES		INQUIRE													

Notes:
1. Weights include 3/4" diameter fasteners for assembly. Inquire for cases utilizing 7/8" diameter fasteners.
2. Weight 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 width.
5. If Unbalanced Channels are supplied, add 20 pounds per foot to the structure length.

TABLE 75. BRIDGECOR ROUND PIPE 15" X 5½"

LRFD HEIGHT OF COVER GUIDE

Dimensions to Inside Corrugation				Gage Thickness (Inches) Maximum Cover Height Shown in Feet									
Diameter (Ft.-In.)	Approx. Area (Sq. Ft)	Min. Cover (Ft.)	Total S	10 (0.140)	8 (0.170)	7 (0.188)	5 (0.218)	3 (0.249)	1 (0.280)	5/16 (0.318)	3/8 (0.380)	Select Backfill Width (ft)	Precon (Min. Level)
19-11	311.4	2.5	48	23	28	31	36	41	46	52	63	8.0	1
20-9	338.5	2.5	50	22	26	29	34	39	44	51	61	8.0	1
21-7	366.8	2.5	52	20	25	28	33	38	43	49	59	8.0	1
22-6	396.3	2.5	54	19	24	27	32	36	41	47	57	8.0	1
23-4	426.8	2.5	56	18	23	26	30	35	40	46	55	8.0	1
24-2	458.5	2.5	58	17	22	25	29	34	38	44	54	8.0	1
25-0	490.9	2.5	60	16	21	23	28	32	37	43	52	8.0	1
25-10	524.9	2.5	62	15	20	22	27	31	36	41	50	8.0	1
26-8	560	2.5	64	14	19	21	26	30	34	40	49	8.0	1
27-7	596.2	2.5	66	13	18	20	24	29	33	38	47	8.0	2
28-5	633.5	2.5	68	13	17	19	23	28	32	37	45	8.0	2
29-3	672.0	2.5	70	12	16	18	22	27	31	36	44	8.0	2
30-1	711.6	3.0	72	11	15	18	21	26	30	34	42	8.0	2
30-11	752.3	3.0	74	11	14	17	21	24	28	33	41	8.0	2
31-10	794.2	3.0	76	10	14	16	20	24	27	32	40	8.0	2
32-8	837.3	3.0	78		13	15	19	23	26	31	38	8.0	2
33-6	880.9	3.0	80		12	14	18	22	25	30	37	8.0	2
34-4	926.2	3.0	82		12	14	17	21	24	29	36	8.0	2
35-2	972.6	3.0	84		11	13	17	20	23	28	35	8.0	2
36-0	1020.1	3.0	86			13	16	19	22	27	33	8.0	2
36-11	1069.0	3.0	88			12	15	18	22	26	32	8.0	2
37-9	1118.6	3.0	90				15	18	21	25	31	8.0	2
38-7	1169.6	3.0	92				14	17	20	24	30	8.0	2
39-5	1221.7	3.0	94				14	16	19	23	29	8.0	2
40-3	1274.9	3.0	96				13	16	19	22	28	8.0	3
41-2	1328.6	3.0	98					15	18	21	27	8.0	3
42-0	1384.1	3.0	100					15	17	21	26	8.0	3
42-10	1440.7	3.0	102					14	17	20	26	8.0	3
43-8	1498.5	3.0	104						16	19	25	8.0	3
44-6	1557.4	3.0	106						16	19	24	8.0	3
45-5	1617.4	3.0	108						15	18	23	8.0	3
46-3	1678.6	4.0	110						15	18	23	8.0	3
47-1	1740.9	4.0	112							17	22	8.0	4
47-11	1803.5	4.0	114							17	21	8.0	4
48-9	1868.1	4.0	116							16	21	8.0	4
49-7	1933.8	5.0	118							16	20	8.0	4
50-6	2000.6	5.0	120								20	8.0	4

Notes:
1. Not for a specific structural design. Use for budget estimating only. A CANDE analysis is required for final design and quotation.
2. The above table is based upon the minimum requirements of the AASHTO LRFD Design Specification, Section 12, and:
   a. Backfill material per AASHTO M145, class A-2-5 or better.
   b. Backfill 120 pcf in density and compacted to 90% modified proctor.
   c. The minimum cover is per article 12.8.9.4
   d. The minimum select backfill width (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 76. 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	10 (0.140)	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	6S	5S	Total Plates
19-11	48	565	680	750	867	987	1107	1325	1574		6				6
20-9	50	586	706	779	900	1025	1149	1375	1635	2	4				6
21-7	52	607	731	808	933	1063	1191	1426	1696	4	2				6
22-6	54	629	757	837	966	1101	1234	1476	1757	6					6
23-4	56	659	793	875	1012	1152	1292	1546	1837		7				7
24-2	58	680	819	904	1045	1190	1334	1596	1898	2	5				7
25-0	60	702	845	933	1078	1227	1376	1646	1958	4	3				7
25-10	62	723	870	962	1111	1265	1418	1697	2019	6	1				7
26-8	64	753	907	1001	1156	1316	1476	1766	2099		8				8
27-7	66	774	932	1029	1189	1354	1518	1817	2160	2	6				8
28-5	68	796	958	1058	1222	1392	1561	1867	2221	4	4				8
29-3	70	817	983	1087	1255	1430	1603	1918	2282	6	2				8
30-1	72	838	1009	1116	1289	1468	1645	1968	2342	8					8
30-11	74	869	1046	1154	1334	1519	1703	2038	2422	2	7				9
31-10	76	890	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				1722	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. Weights include 3/4" diameter fasteners for assembly. Inquire for applications requiring 7/8" diameter fasteners.
2. Weights include a 3 oz. per square foot galvanized coating on both sides.
3. An alternate plate make-up may be supplied due to material availability. This may affect the overall structure weight.
4. 10 ga. through 1ga. plate net lay length is 45" . 5/16" and 3/8" plate net lay length is 30 ".

TABLE 77. BRIDGECOR SINGLE RADIUS ARCH 15" X 5½"														
LRFD HEIGHT OF COVER GUIDE														
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 (Ft.)	Total S	10 (0.140)	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 (ft.)	Precon (min Level)
19-7	9-9	150.0	2.0	23	18	22	24	29	33	37	43	52	8.0	1
19-10	5-0	66.3	2.0	17	18	22	24	29	33	37	43	52	8.0	1
20-5	10-2	163.5	2.0	24	17	21	23	28	32	36	42	50	8.0	1
21-3	10-7	177.2	2.0	25	16	20	23	27	31	35	40	49	8.0	1
22-1	11-0	191.5	2.0	26	15	19	22	26	30	34	39	47	8.0	1
22-10	11-6	206.6	2.0	27	15	19	21	25	29	33	38	46	8.0	1
23-10	11-11	222.2	2.0	28	14	18	20	24	28	32	36	44	8.0	1
24-8	12-4	238.3	2.0	29	13	17	19	23	27	30	35	43	8.0	1
24-8	6-0	102.7	3.0	21	13	17	19	23	27	30	35	43	8.0	1
25-6	12-9	255.0	2.0	30	13	16	19	22	26	29	34	41	8.0	1
26-4	13-2	272.3	2.0	31	12	16	18	21	25	28	33	40	8.0	1
27-2	13-7	290.1	2.0	32	12	15	17	20	24	27	32	38	8.0	2
28-0	14-0	308.5	2.0	33	11	14	16	20	23	26	30	37	8.0	2
28-10	7-5	149.1	2.0	25	10	13	15	18	21	24	28	35	8.0	2
28-10	14-5	327.5	2.0	34	11	14	16	19	22	25	29	36	8.0	2
29-8	14-10	347.0	2.0	35	10	13	15	18	21	24	28	35	8.0	2
30-6	15-3	367.1	2.0	36	10	13	14	17	20	24	27	34	8.0	2
31-6	15-9	387.8	2.0	37	9	12	14	17	20	23	26	32	8.0	2
32-4	16-1	409.1	2.0	38	9	12	13	16	19	22	25	31	8.0	2
33-2	16-7	430.9	2.0	39	8	11	13	15	18	21	25	30	8.0	2
34-0	17-0	453.2	2.0	40	8	10	12	15	18	20	24	29	8.0	2
34-1	9-2	219.4	2.0	30	8	10	12	15	18	20	24	29	8.0	2
35-8	17-10	499.6	2.0	42	7	9	11	14	16	19	22	27	8.0	2
37-0	18-9	548.2	2.0	44	6	9	10	12	15	17	20	25	8.0	2
38-11	10-2	277.5	2.0	34	6	8	9	11	14	16	19	24	8.0	2
39-0	19-6	599.3	2.0	46	6	8	9	11	14	16	19	24	8.0	2
40-8	20-4	652.5	2.0	48	5	7	8	11	13	15	18	22	8.0	3
42-6	21-3	708.0	2.0	50	4	6	8	10	12	14	17	21	8.0	3
44-2	22-1	765.7	2.0	52	4	6	7	9	11	13	16	20	8.0	3
45-10	22-11	825.7	2.0	54	4	5	6	8	10	12	15	19	8.0	3
46-0	11-9	379.5	2.0	40	4	5	6	8	10	12	15	19	8.0	3
49-2	24-7	952.5	2.5	58		4	5	7	9	11	13	17	8.0	3
51-0	25-6	1019.4	2.5	60		4	5	7	9	10	13	16	8.0	3
52-8	26-4	1088.4	3.0	62			5	7	8	10	12	16	8.0	3
54-4	27-2	1159.7	3.0	64				6	8	10	12	16	8.0	3

Notes:
1. Not for a specific structural design. Use for budget estimating only. A CANDE analysis is required for final design and quotation.
2. The above table is based upon the minimum requirements of the AASHTO LRFD Design Specification, Section 12, and:
   a. Backfill material per AASHTO M145, class A-2-5 or better.
   b. Backfill 120 pcf in density and compacted to 90% modified proctor.
   c. The minimum cover is per article 12.8.9.4
   d. The minimum select backfill width (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 slect 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 78. 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	10 (0.140)	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	269	325	358	414	472	530	631	751		2	1			3
19-10	5-0	17	196	237	262	303	345	387	461	549	1	1				2
20-5	10-2	24	279	337	373	431	491	551	656	781	1	1	1			3
21-3	10-7	25	290	350	387	447	510	572	681	811	1	2				3
22-1	11-0	26	301	363	401	464	529	593	707	842	2	1				3
22-10	11-6	27	319	386	427	493	561	629	751	893			3	1		4
23-10	11-11	28	331	399	440	509	580	650	776	923		2	1		1	4
24-8	12-4	29	341	412	455	526	599	671	801	953		1	3			4
24-8	6-0	21	247	330	299	381	434	487	581	691		1	1	1		3
25-6	12-9	30	352	469	425	542	618	693	827	983		2	2			4
26-4	13-2	31	363	483	438	559	636	714	852	1013		3	1			4
27-2	13-7	32	374	498	451	575	655	735	877	1044	1	2	1			4
28-0	14-0	33	385	463	512	592	674	756	902	1074	1	3				4
28-10	14-5	34	395	476	526	608	693	778	927	1104	2	2				4
29-8	14-10	35	406	489	541	625	712	799	953	1135	3	1				4
28-10	7-5	25	290	350	387	447	510	572	681	811	1	2				3
30-6	15-3	36	424	513	566	654	744	835	997	1186		1	4			5
31-6	15-9	37	435	525	580	670	763	856	1022	1216		3	1	1		5
32-4	16-1	38	446	538	594	687	782	877	1047	1246		3	2			5
33-2	16-7	39	457	551	608	703	801	899	1073	1276		4	1			5
34-0	17-0	40	468	564	623	720	820	920	1098	1306	1	3	1			5
34-1	9-2	30	352	425	469	542	618	693	827	983		2	2			4
35-8	17-10	42	489	590	651	753	858	962	1148	1367	2	3				5
37-0	18-9	44	511	615	680	786	896	680	1199	1427	4	1				5
39-0	19-6	46	540	652	719	831	947	1062	1268	1508		4	2			6
38-11	10-2	34	395	476	526	608	693	778	927	1104	2	2				4
40-8	20-4	48	562	677	748	864	984	1104	1319	1569	2	2	2			6
42-6	21-3	50	583	703	776	898	1022	1147	1369	1629	2	4				6
44-2	22-1	52	605	729	805	931	1060	1189	1419	1690	4	2				6
45-10	22-11	54	634	765	844	976	1111	1246	1489	1771		5	2			7
46-0	11-9	40	468	564	623	720	820	920	1098	1306	1	3	1			5
49-2	24-7	58		816	902	1042	1187	1331	1590	1891	2	5				7
51-0	25-6	60		842	930	1075	1225	1373	1640	1952	4	3				7
52-8	26-4	62			959	1108	1263	1415	1691	2013	6	1				7
54-4	27-2	64				1154	1314	1473	1760	2093	1	6	1			8

Notes
1. Weights include 3/4" diameter fasteners for assembly. Inquire for applications requiring 7/8" diameter fasteners.
2. Weights include a 3 oz. per square foot galvanized coating on both sides.
3. An alternate plate make-up may be supplied due to material availability. This may affect the overall structure weight.
4. 10 ga. through 1ga. plate net lay length is 45" . 5/16" and 3/8" plate net lay length is 30 ".
5. If unbalanced channels are required, add 20 lbs./ foot times the total structure length.

TABLE 79. BRIDGECOR 2-RADIUS ARCH 15" X 5½"

LRFD HEIGHT OF COVER GUIDE

Dimensions to Inside Corrugation					Gage Thickness (Inches) - Height of Cover Shown in Feet Maximum Height of Cover (Minimum Height of Cover)									
Shape	Maximum Span (Ft.-In.)	Rise (Ft.-In.)	Approx. Area (Sq. Ft.)	Total S	10 (0.140)	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 (ft.)	Precon (min Level)
11A5	18-5	8-4	123.9	21	21 (2.0)	26 (2.0)	29 (1.5)	34 (1.5)	39 (1.5)	45 (1.5)	51 (1.5)	61 (1.5)	8.0	2
13A6	22-0	10-0	172.9	25	18 (2.5)	22 (2.0)	25 (2.0)	29 (1.5)	34 (1.5)	39 (1.5)	44 (1.5)	53 (1.5)	8.0	2
15A5	23-5	9-3	172.2	25	15 (2.5)	19 (2.0)	22 (2.0)	26 (1.5)	31 (1.5)	35 (1.5)	41 (1.5)	49 (1.5)	8.0	2
15A7	25-5	11-7	228.3	29	14 (2.5)	18 (2.0)	21 (2.0)	25 (2.0)	29 (2.0)	33 (2.0)	38 (2.0)	46 (2.0)	8.0	2
17A6	26-11	10-10	232.7	29	13 (2.5)	17 (2.5)	19 (2.0)	23 (2.0)	26 (2.0)	30 (2.0)	35 (2.0)	43 (2.0)	8.0	2
18A5	27-2	9-10	212.2	28	11 (3.0)	12 (2.5)	13 (2.5)	14 (2.0)	15 (2.0)	17 (2.0)	18 (2.0)	21 (2.0)	8.0	2
17A8	28-11	13-2	306.2	33	12 (2.5)	16 (2.0)	18 (2.0)	21 (2.0)	25 (2.0)	28 (2.0)	33 (2.0)	40 (2.0)	8.0	3
20A7	31-8	12-8	319.5	34	10 (2.5)	13 (2.5)	15 (2.0)	18 (2.0)	21 (2.0)	25 (2.0)	29 (2.0)	35 (2.0)	8.0	3
21A6	31-11	11-8	295.4	33	10 (3.0)	11 (2.5)	12 (2.5)	13 (2.0)	14 (2.0)	16 (2.0)	17 (2.0)	19 (2.0)	8.0	3
22A5	32-2	10-8	270.6	32		10 (2.5)	10 (2.5)	11 (2.0)	12 (2.0)	13 (2.0)	14 (2.0)	15 (2.0)	8.0	3
19A9	32-5	14-9	384.9	37	10 (2.5)	13 (2.0)	15 (2.0)	18 (2.0)	21 (2.0)	24 (2.0)	28 (2.0)	35 (2.0)	8.0	3
25A5	35-10	11-4	318.2	35			9 (2.5)	9 (2.5)	10 (2.5)	10 (2.0)	11 (2.0)	12 (2.0)	8.0	3
21A10	35-11	16-5	472.7	41	8 (2.5)	11 (2.0)	13 (2.0)	15 (2.0)	18 (2.0)	21 (2.0)	24 (2.0)	30 (2.0)	8.0	3
23A8	36-5	14-5	420.0	39	8 (3.0)	11 (2.5)	12 (2.0)	15 (2.0)	17 (2.0)	20 (2.0)	23 (2.0)	29 (2.0)	8.0	3
25A7	37-10	13-8	411.5	39		10 (2.5)	11 (2.5)	12 (2.0)	13 (2.0)	14 (2.0)	15 (2.0)	18 (2.0)	8.0	3
26A6	38-1	12-9	382.0	38		9 (2.5)	10 (2.5)	11 (2.5)	11 (2.5)	12 (2.5)	13 (2.5)	14 (2.0)	8.0	3
23A11	39-5	18-0	569.4	45		9 (2.0)	11 (2.0)	13 (2.0)	16 (2.0)	18 (2.0)	21 (2.0)	26 (2.0)	8.0	3
25A9	39-11	16-1	511.8	43		9 (2.5)	10 (2.0)	13 (2.0)	15 (2.0)	17 (2.0)	20 (2.0)	25 (2.0)	8.0	3
29A5	40-10	12-2	386.7	39					9 (2.5)	9 (2.5)	10 (2.5)	11 (2.0)	8.0	4
28A8	42-7	15-6	524.7	44			10 (2.5)	11 (2.0)	12 (2.0)	13 (2.0)	14 (2.0)	16 (2.0)	8.0	4
25A12	42-11	19-7	675.2	49		8 (2.0)	10 (2.0)	12 (2.0)	14 (2.0)	16 (2.0)	19 (2.0)	23 (2.0)	8.0	4
30A6	43-1	13-7	457.7	42				9 (2.5)	9 (2.5)	10 (2.5)	11 (2.5)	12 (2.0)	8.0	4
30A7	44-1	14-9	512.6	44			9 (2.5)	10 (2.5)	11 (2.5)	11 (2.5)	12 (2.5)	14 (2.0)	8.0	4
28A10	44-7	17-10	637.2	48		8 (2.5)	9 (2.0)	11 (2.0)	13 (2.0)	15 (2.0)	17 (2.0)	21 (2.0)	8.0	4
27A13	46-5	21-2	790.1	53			8 (2.0)	10 (2.0)	13 (2.0)	15 (2.0)	17 (2.0)	21 (2.0)	8.0	4
31A9	47-4	17-4	651.6	49				10 (2.0)	11 (2.0)	12 (2.0)	13 (2.0)	15 (2.0)	8.0	4
34A6	48-0	14-5	539.2	46					8 (2.5)	9 (2.5)	9 (2.5)	10 (2.0)	8.0	4
30A11	48-1	19-6	749.1	52			8 (2.0)	10 (2.0)	12 (2.0)	13 (2.0)	15 (2.0)	19 (2.0)	8.0	4
32A9	48-7	17-7	676.2	50				10 (2.0)	11 (2.0)	12 (2.0)	13 (2.0)	14 (2.0)	8.0	4
29A14	49-11	22-10	913.8	57				9 (2.0)	12 (2.0)	14 (2.0)	16 (2.0)	20 (2.0)	8.0	4
34A8	50-0	16-10	662.3	50				9 (2.5)	10 (2.5)	11 (2.5)	12 (2.5)	13 (2.0)	8.0	4
35A7	50-3	15-10	622.7	49				9 (2.5)	9 (2.5)	9 (2.5)	10 (2.5)	11 (2.0)	8.0	4
32A11	50-7	19-11	803.8	54				9 (2.0)	11 (2.0)	12 (2.0)	14 (2.0)	17 (2.0)	8.0	4
35A7	50-3	15-10	622.7	49				9 (2.5)	9 (2.5)	9 (2.5)	10 (2.5)	11 (2.0)	8.0	4
32A11	50-7	19-11	803.8	54				9 (2.0)	11 (2.0)	12 (2.0)	14 (2.0)	17 (2.0)	8.0	4
VARIES	UP TO 65'			VARIES	INQUIRE									

Notes:
1. Not for a specific structural design. Use for budget estimating only. A CANDE analysis is required for final design and quotation.
2. The above table is based upon the minimum requirements of the AASHTO LRFD Design Specification, Section 12, and:
   a. Backfill material per AASHTO M145, class A-2-5 or better.
   b. Backfill 120 pcf in density and compacted to 90% modified proctor.
   c. The minimum cover is per article 12.8.9.4
   d. The minimum select backfill width (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 80. 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						
Shape	Maximum Span (Ft.-In.)	Rise (Ft.-In.)	Total S	10 (0.140)	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
11A5	18-5	8-4	21	247	299	330	381	434	487	581	691		1	1	1		3
13A6	22-0	10-0	25	290	350	387	447	510	572	681	811	1	2				3
15A5	23-5	9-3	25	290	350	387	447	510	572	681	811	1	2				3
15A7	25-5	11-7	29	341	412	455	526	599	672	801	954	1	1		2		4
17A6	26-11	10-10	29	341	412	455	526	599	671	801	953		1	3			4
18A5	27-2	9-10	28	330	399	441	509	580	650	776	923		1	2	1		4
17A8	28-11	13-2	33	392	474	523	604	687	771	921	1096			3	2		5
20A7	31-8	12-8	34	395	476	526	608	693	778	927	1104	2	2				4
21A6	31-11	11-8	33	385	463	512	592	674	756	902	1074	1	3				4
22A5	32-2	10-8	32		451	498	575	655	735	877	1044	1	2	1			4
19A9	32-5	14-9	37	435	525	580	670	763	856	1022	1216		3	1	1		5
25A5	35-10	11-4	35			541	625	712	799	953	1135	3	1				4
21A10	35-11	16-5	41	478	577	637	736	839	941	1123	1337	2	2	1			5
23A8	36-5	14-5	39	457	561	620	716	814	913	1092	1298			3	3		6
25A7	37-10	13-8	39		551	608	703	801	898	1072	1276	2	2			1	5
26A6	38-1	12-9	38		538	594	687	782	877	1047	1246		3	2			5
23A11	39-5	18-0	45		639	705	815	928	1040	1243	1478		3	3			6
25A9	39-11	16-1	43		613	676	782	890	998	1192	1418		3	2		1	6
29A5	40-10	12-2	39					801	899	1073	1276		4	1			5
28A8	42-7	15-6	44			680	811	922	1034	1237	1470			3	3	1	7
25A12	42-11	19-7	49		690	762	811	1003	1126	1344	1599	1	5				6
30A6	43-1	13-7	42				753	858	962	1148	1367	2	3				5
30A7	44-1	14-9	44			680	786	896	1004	1199	1427	4	1				5
28A10	44-7	17-10	48		677	748	864	984	1104	1319	1569	2	2	2			6
27A13	46-5	21-2	53			820	947	1079	1210	1445	1720	5	1				6
31A9	47-4	17-4	49				881	1016	1140	1363	1621		3	1	3		7
34A6	48-0	14-5	46					947	1062	1268	1508		4	2			6
30A11	48-1	19-6	52			805	931	1060	1189	1419	1690	4	2				6
32A9	48-7	17-7	50				910	1035	1162	1388	1651		3	2	2		7
29A14	49-11	22-10	57				1026	1168	1310	1565	1861	1	6				7
34A8	50-0	16-10	50				910	1048	1176	1407	1673			2	6		8
35A7	50-3	15-10	49				881	1003	1126	1344	1599	1	5				6
32A11	50-7	19-11	54				976	1111	1246	1489	1771		5	2			7
VARIES	UP TO 65′		VARIES	INQUIRE													

Notes:
1. Weights include 3/4″ diameter fasteners for assembly. Inquire for applications requiring 7/8″ diameter fasteners.
2. Weights include a 3 oz. per square foot galvanized coating on both sides.
3. An alternate plate make-up may be supplied due to material availability. This may affect the overall structure weight.
4. 10 ga. through 1ga. plate net lay length is 45″ . 5/16″ and 3/8″ plate net lay length is 30 ″.
5. If unbalanced channels are required, add 20 lbs./ foot of the total structure length.

For more information, call Contech Engineered Solutions:

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