Steel Structural Plate *Assembly Guide*

These instructions are intended to be a basic guide to the installation and assembly of plate structures. Job site specific conditions may require other procedures.

A Statement on Safety

The assembly procedure of structural plates can vary widely from one job site to another. Although there is no substitute for experience; safe practices should be of utmost importance on all projects. A review of project safety requirements, regulations and established construction safety practices must be completed before attempting to assemble. Lane Enterprises' attention to quality in manufacturing and design insures that the structural plates can be assembled in a manner that will not compromise the safety of workers on the project. However, all those involved MUST adhere to those safety procedures and methods as dictated by regulations and good construction practice.

Supervisors and workers should review and confirm the understanding of the safety procedures and regulations before attempting the assembly of Lane Structural Plate.

A. Suggested Tool List

The following list of tools are suggested for the assembly of Lane structural plate. Job site conditions and special structural considerations may require different or additional tools.

1. **Compressor:** Suggest an air compressor of 125 CFM at 100 psi as a minimum.
2. **Air Hose:** Universal quick-fit fittings as found on most compressors.
3. **Impact Wrench:** Air impact wrench with adequate capacity for the torque ranges required (up to 300 ft-lbs).
4. **Sockets for above 1'14' Diameter:** With tapered tip to fit down into the corrugation.
5. **Hand Tools:** Tapered aligning bars and drift pins for use in positioning the plates. The preferred material is tempered steel bar stock, 11/**s**" diameter. Lengths of alignment bars and drift pins should be from 18" to 42" depending on the type of plate being assembled.
6. **Band Cutters:** To cut bands that are used in packaging.
7. **Cables:** With safety hook or clevis for moving individual plates.
8. **Come-Along:** For pulling the plates together where needed with use of eyebolts.
9. **Scaffolding:** Used for larger structures where needed.
10. **Electric Extension Cords:** Of adequate gage with proper ground.
11. **Lifting Equipment:** A crane, backhoe or boom truck of needed capacity and size will be required for lifting plates into place. Requirements can vary greatly depending on the weight of plates, size of structure and available access. The erector should review these factors with the site contractor and the manufacturer of the material for the needed information before acquiring this equipment.

B. Pipe Arch Structures Preparation of Foundation

The earth foundation upon which a pipe arch structure is to rest should be free from projecting stones, roots and inequalities in the bedding surface which will prevent the structure from having a firm, uniform bearing.

Where rock in either ledge or boulder formation is encountered, it should be removed to a depth as recommended by the engineer in charge. This additional excavation should be backfilled with suitable materials in such manner as to insure a uniform bearing for the entire length of the structure.

If, in the opinion of the engineer, the natural material exposed at the grade established for the bottom of a plate structure appears unstable and is of such a character as to invite unequal settlement along the length of the structure the engineer should instruct correction of this condition.

The foundation on which a plate structure is to rest should either be shaped to conform to the bottom of the structure or as otherwise approved by the engineer.

C. Description of Materials

1. Plates

Before starting the erection of a plate structure, study the assembly drawing (shop drawing) to acquaint yourself with the plate arrangement and to check the material on hand. The assembly diagram will show the plate width (N) for each plate in the structure. It will also show the length of each plate. If the structure ends are sloped or skewed, the cut plates forming the cut end are numbered and correspondingly marked on the assembly drawing for proper positioning.

Plates are made in standard 12’ and 10’ nominal lengths to permit staggering of the circumferential joints. Various combinations of these plate lengths result in structure lengths, typically in multiples of 2’.

Overall widths range from 34” (3-N) to 92” (9-N), in 9⅝’’ (I-N) increments. They are designated on the drawing as 3N, 5N, 6N, 7N, 8N and 9N.

Each standard plate is identified by a stencil which gives the N number (width), length and gage. Plates specially fabricated to assemble sloped, skewed or sloped and skewed ends or deflections (elbows) are marked with a welded numeral on the concave side of the plate (inside of structure) to correspond with the numbers shown on the drawing.

2. Bolts

The high strength bolls and nuts for plate structures conform to the requirements of ASTM A-449 and ASTM A-563 Grade C respectively and are galvanized. The bolts are 3/4” diameter and are 1¼”, 1½”, 1¾”, 2” and 3½” long. The appropriate length of bolt is provided for a structure according to the gage of plate and number of plate layers in the lap.

The hexagonal bolt head is uniformly rounded on the underside and may be placed either in the valley or on the crest of the corrugation without special positioning.

The hexagonal nuts are American Standard Heavy across the flats with a round top to conform to the valley of the corrugation and permit tightening in that position.

The bolt threads are Unified National Coarse, Class 2 fit before galvanizing, and the nuts are tapped oversize after galvanizing to fit the coated bolts.

Usual practice is to insert the bolts so the head is in the valley and the nut is on the crest of the corrugation. It is acceptable to place the bolts so the head is either on a crest or in a valley. Reference TABLE 1, which indicates the proper usage of the various lengths furnished.

If the structure is composed of plates of different gages, for instance a pipe with a heavier invert the bolts supplied will be in accordance with the combination of gages. Bolts furnished with asphalt coated pipe will be ¼” longer than those indicated in TABLE 1.

Table 1: Recommended Gage/Bolt Lengths

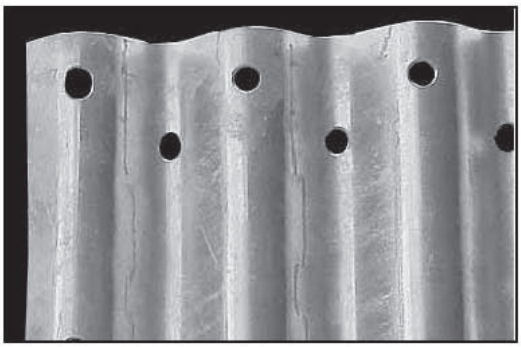
Gage	12	10	8	7	5	3	1
2 pl. lap	1¼”	1¼”	1¼”	1¼”	1½”	1½”	1¾”
3 pl. lap	1¼”	1½”	1½”	1¾”	1¾”	1¾”	2”
3½” lap	Used in base channel to plate connection						

Care should be exercised to keep the bolts segregated. The workmen should be instructed where to use each length bolt, otherwise there will be insufficient long bolts to use where required.

3. Invert Plates

After the foundation has been prepared, and starting at the downstream end, start assembly by setting the first invert plate in position. The first plate laid should be oriented in the direction as shown on the assembly drawing. Pay close attention to the bolt pattern. **Figure 1** shows the typical orientation when viewed from inside the structure. Flow direction is from right to left. This picture is consistent with the typical plate detail on the assembly drawing.

Figure 1

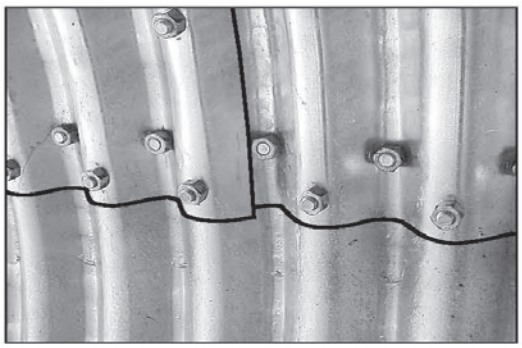


When the invert is composed of two or more plates, the additional plates overlap the adjacent plate. Place each succeeding plate in the longitudinal row, so as to lap it one corrugation on top of the preceding one. Circumferential seams are staggered 2', 4', 6', 8' or 10' as shown in **Figure 3 on page 4**. Insert the bolts in both the transverse and longitudinal seams, carefully align the plates and tighten all nuts. The end plate can be held up with a crane, or blocks can be used to gain access to these seams. Proceed in this manner until all invert plates are laid and all nuts tightened.

4. Corner Plates

After the invert plates are assembled, again start at the downstream end and add the corner plates. These plates lap inside the invert plates. Insert enough bolts in each plate as it is placed to hold it securely, but do not tighten the nuts, thus leaving the plates free to move slightly to facilitate matching the remaining holes. Always place the bolts in the transverse seams and at the plate corners where three layers are lapped before proceeding to the next plate. Each succeeding corner plate laps over the previous plate by one corrugation. No more than three plates should lap at any one connection. A typical 'three plate lap" is shown in **Figure 2.**

Figure 2



5. Top Plates

When all of the corner plates are attached and while the bolts are still loose, the first row of top plates adjacent to the corner plates are placed beginning at the upstream end. *Refer to the assembly drawing section view to determine how to lap the corner plates* (**see Figure 3 on page 4**). Extend each row only far enough to support the next row of plates above, to a place where one final plate can be added to complete the ring.

The balance of the pipe arch is assembled, progressing downstream, with the top closing plate added as soon as lower plates are in place to support it. The transverse seams and the three plate laps are bolted in advance of the rest of the seam in the same manner as in the corner plates. After all plates are in position, insert the remaining bolts using structural wrenches and drift pins or pointed bars to align the holes. Next, tighten all nuts to between 100 and 300 ft-lbs of torque. Make several passes over each seam to catch any nuts that have loosened as a result of the plates being drawn together. On long structures it will be advantageous to have a bolting crew follow the erection crew by three or four plate lengths to complete the bolting. Power wrenches will speed up the final bolting but should not be used beyond the point where all the bolts have been inserted.

6. Special Configurations

The above instructions apply also to structures with ends cut to fit a slope, skew, or slope and skew combination. *Care should be taken to begin the invert row of plates with the numbered plate designated on the plan tor the downstream end, since the two ends on a pipe may not be designed to meet the same conditions.*

If the pipe arch has an elbow, tee, lateral, manhole or other special shop fabricated section which depends on the bolt pattern in the plates for its proper position in the structure, care must be exercised to properly position the first invert plate at the downstream end. If the structure has cut ends, the downstream invert will have a detail sketch, which will establish the bolt pattern. If the ends of the pipe arch are not cut, or if the cut does not include the invert plate, the bolt pattern for the index plate will be noted on the drawing. If assembly of the pipe arch is begun at a point other than where the index plate would be used, a numbered plate from the special section should be laid on the ground in its correct position at the starting point. The first invert plate can then be laid in a direction so that the bolt patterns correspond.

D. Longer Structures; Alternate Method of Assembly

An alternate method of assembly preferred for longer structures is a progressive system beginning at the downstream end, which allows the crane to complete its job as it moves upstream.

Beginning at the downstream end, 40’ or 50’ of the invert plates are placed. Insert both circumferential and longitudinal bolts. Carefully align the plates and tighten all nuts. Again, starting at the downstream end, add four corner plates on each side of the invert plate.

Insert the bolts in the corners and circumferential seams. Do not tighten the nuts.

Begin again at the downstream end and assemble the top plates.

If the pipe arch has two plates forming the top, one row above each corner plate will close the structure.

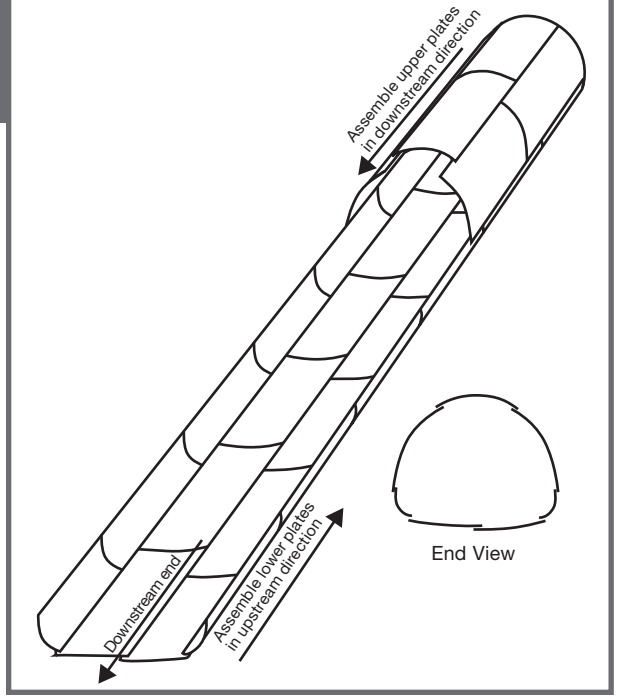
If the top is composed of three or more rows of plates, extend the first row of top plates on each side three plate lengths. This will allow the succeeding rows of plates to be assembled to a point where one top plate will complete the closing. Place only enough bolts to hold the plates securely. The nuts should not be tightened. After 30’ or 40’ of the top plates are in place, a bolting crew may start to place all bolts and complete the bolt tightening. It is important that the bolting crew does not approach the erection crew closer than 15’ or 20’, otherwise erection and placing of bolts will be greatly impeded.

The invert plates should be laid well in advance of the corner and top plates while the seams in the invert plates are accessible.

E. Pipe Structures

Structural plate pipes are assembled in the same manner as pipe arch structures with the exception that there are no corner plates. The invert is usually considered to be 25% of the circumference. Sequence and direction of assembly is based on the pipe arch section of this document.

Figure 3



F. Plate Arch Structures

1. Concrete Footers

Unlike pipe and pipe arches, which rest directly on an earth foundation that will yield to some extent and conform to the shape which the structure assumes under load, an arch must be erected on a rigid foundation. This foundation is usually composed of concrete footers and in the case of a multiple span structure and intermediate shared footings.

Assuming that the footers are correctly designed for strength and stability, it is also imperative that they be properly located relative to the center line of the road. If the ends of the arch are skewed, the setback of the footers should conform to the skew angle of the arch and center line. If the arch is a half circle

the top of the footer will be level, but if the arch is less than a half circle the top should slope inward at an angle as shown by the "rise to run" pitch angle shown in the arch section view.

Just as with pipe arch structures as previously described, the erector should study the assembly drawing supplied by Lane to become acquainted with the required placement of plates and sequence of assembly.

2. Unbalanced Base Channels

Under most structural arches a metal bearing (unbalanced channel) surface is used. However, for a short span arch with a light load, the plates may bear directly on the concrete in a groove formed in the top of the abutment. Care should be taken in forming the footer to get the bottom of the groove smooth and at the correct angle (pitch) to receive the arch plates. When base channels are used for anchorage of the arch, care should be used to place the channels in the proper alignment and at the correct pitch, as shown on the assembly drawing.

3. Plates

The plates are of the same sizes as described in the pipe arch section. Bolting requirements are also the same as shown in **Table 1 on page 3.**

4. Assembly of the Structure

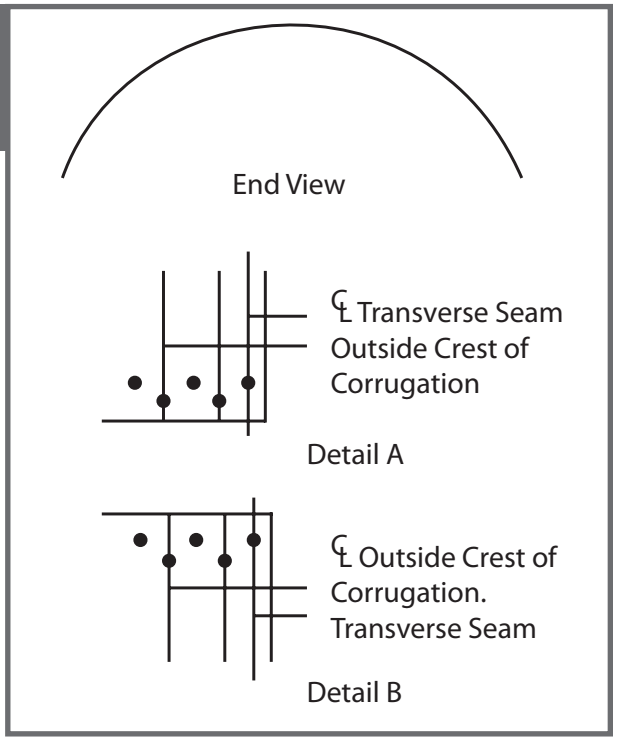
The groove or channel should be free of concrete splatters and other debris that may have entered during the concrete work. This is important so that no misalignment of the plates will occur.

Assembly of the arch is similar for each type of footer connection (groove or channel). Plate assembly should start at the upstream end. Bolt placement requirement is detailed in the section view. Longer bolts are used on the side of the arch where the bolt will pass through the full depth of the corrugation to reach the channel. On the other side of the arch, shorter bolts are used where the arch plate holes are against the channel. These bolts should be finger tightened. It is usually more convenient to place 2 to 3 plates in the channel before placing plates on the opposite side.

Much care should be taken to insure that the proper orientation of the bolt pattern is maintained from the start of placement of plates. **Figure 4** shows the proper orientation.

Additional plates are placed above the lower rows until a full ring is formed. Extend each row only far

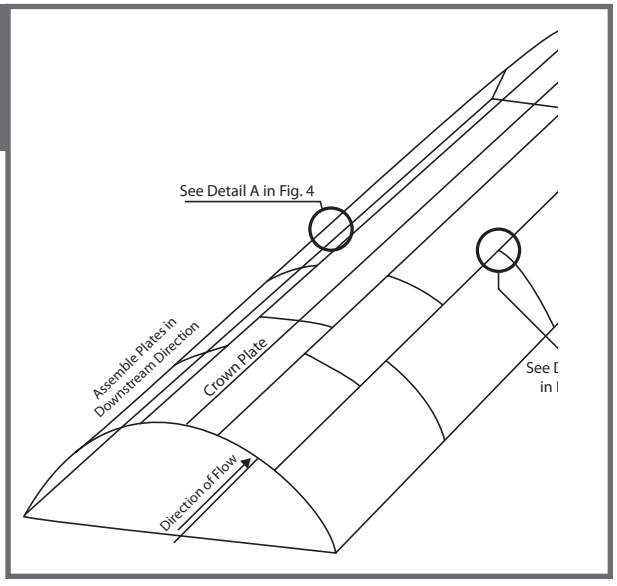
Figure 4



enough to support the next row of plates above to a place where one final plate will complete the ring. **Figure 5** shows a typical arch fully assembled. Temporary props should support each course of plates until the crown plate is in place.

The plates lap outside the lower plate shingle fashion and 4 bolts are placed finger tight in the longitudinal seam of each plate. The transverse seam and the 3 plate laps are bolted before additional bolts are inserted in the longitudinal seams.

Figure 5



The balance of the arch is assembled, progressing downstream, with the closing plate added at the crown as soon as the lower plates are in place to support it.

After all plates are in position, insert the remaining bolts. Next, tighten all nuts to between 150 and 300 ft-lbs of torque. Make several passes over each seam to catch any nuts that have loosened as a result of the plates being drawn together.

On long structures it will be advantageous to have a bolting crew follow the erection crew by 3 or 4 plate lengths to complete the bolting.

G. Low Profile Box Culverts

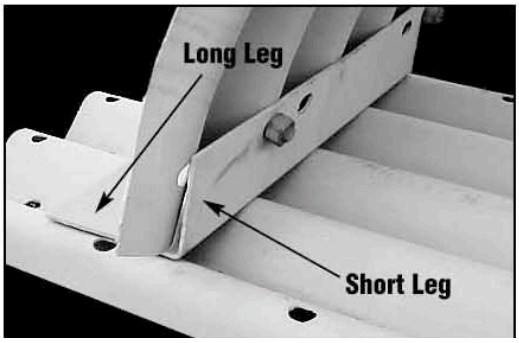
1. Preparation of Foundation

See sections on Pipe Arch and Arch.

2. Description of Material

Low profile box culverts (LPBC) are somewhat different from other types of structures described in this document. They are assembled in the same manner as the plate arch, but also have corrugated reinforcing stiffeners, commonly called “ribs,” bolted to the exterior and sometimes to the interior of the structure. Although they are typically set on concrete footings as are the plate arches, they can also be placed on a corrugated bottom, called the “invert.” The side plates of the LPBC are attached to the invert by means of “base angle.” This is a shop fabricated, galvanized steel angle of a specific geometry to fit the LPBC and invert. The connection of these components, the LPBC, base angle and invert is shown in **Figure 6.** The leading edge of the invert plate points to the ground.

Figure 6



Notice that the longer leg of the angle is placed onto the invert and the shorter leg is inside the side plate of the LPBC. The end of the angle should align with the crest of the corrugations of the invert and LPBC, not the actual end of those plates. A slight adjustment of the alignment might be necessary to line up the bolt holes of all components. The above photo is showing the inlet end, left side of the LPBC. Two lengths of bolts are used to attach the base angle to the side wall. 1¾” short bolts are used on the left side because the slotted holes of the base angle will align with the crests of corrugations as shown in this photo. On the right side of the LPBC, a 3½” long bolt will be used because the holes in the base angle will align with the valley of the corrugation.

3. Assembly of Invert

Begin the assembly of the invert at the downstream end. Orient the plates as shown on the shop drawing by observing the bolt pattern. Match the bolt pattern diagram. You may assemble the first length of invert on the bank and set the assembly as a unit, making sure to place and tighten all bolts and nuts to a torque of 100 to 300 ft-lbs before lifting into place. Assemble the next section as previously stated and connect the sections placing all bolts and nuts as you progress in the upstream direction with the assembly of sections.

The base angle can be attached as you proceed. Also, tighten the nuts as you go.

4. Assembly of LPBC

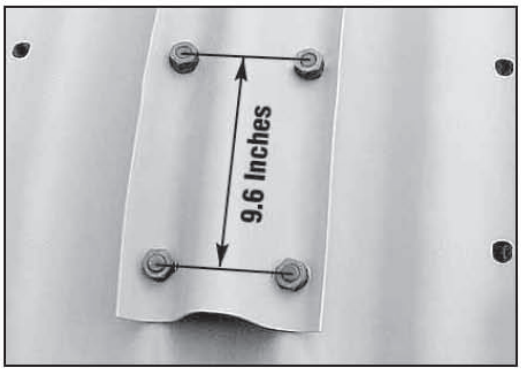
Start at the inlet end and place the side and haunch plates into the base angle as shown in the photo on the previous page. Orient the plates as shown in the bolt pattern diagram on the shop drawing. Only place enough bolts in the plates and base angles to hold them together. Then place the crown plates to complete a ring at the inlet end. Continue finishing rings, working from inlet to downstream end. Again, only placing as few bolts as needed to hold the plates together. After all plates are assembled, place all bolts and nuts and tighten to proper torque. Make sure not to place bolts in seam holes that are used by ribs or you will have to remove them when you attach the ribs.

5. Placement of Ribs

When the optional inside crown ribs are supplied, place these first. When these ribs are made of multiple segments, place the, top most piece first and work out toward the side of the LPBC.

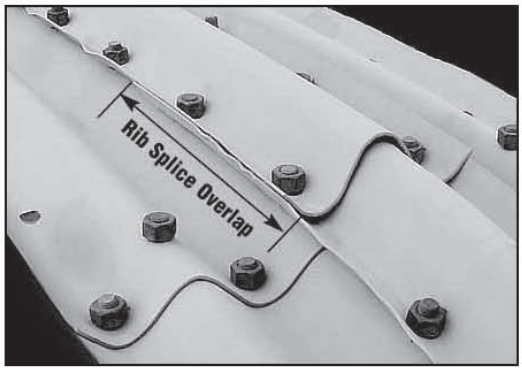
Place all bolts and nuts and tighten to the proper torque. Ribs are placed on the crests of the plate corrugations as shown in **Figure 7.**

Figure 7



Outside rib segments are placed, starting from the lowest side ribs and working up to the center of the crown. The ribs lap shingle fashion over top of each others' two pairs of holes (a distance of 1 N). This distance is shown in **Figure 7.** A typical lap splice is shown in **Figure 8.** When all the segments are placed for each rib, tighten all nuts to the proper torque.

Figure 8



6. Summary of LPBC Assembly Procedure

1. Assemble invert starting from downstream.
2. Attach base angles.
3. Assemble side and haunch plates starting from upstream.
4. Assemble crown plates.
5. Proceed downstream using steps 3 then 4.
6. Assemble inside crown ribs (if supplied).
7. Assemble outside ribs starting at sides.

H. Underpass Structures

Structural plate underpasses are considered to be the same as plate pipe arch in their assembly sequence. They also have invert, comer and top plates. See the section on pipe arch for assembly instructions on page 5.