

BACKFILL REQUIREMENTS

Supporting Flexible Structures

All flexible structures depend on the envelope of soil around them for a majority of their design strength as well as providing the necessary support to maintain shape. After the structure is supported on a competent foundation, the soil envelope becomes the primary strength consideration.

Soil envelope considerations include the structural backfill material, the extents of the structural backfill zone and the procedures used to place and compact the backfill.

Structural Backfill Material

In general, well graded, granular material is used within the structural backfill zone (sometimes called the critical backfill zone). Appropriate granular materials are selected based on structure shape, live load, cover and other site conditions. Granular materials that meet the AASHTO M-145 Classification for Soil-Aggregate Mixtures for Highway Construction are normally acceptable. These materials can be processed quarry stone or on-site borrow approved by the Engineer of Record and meeting the requirements herein.

Table 1 lists the generally accepted materials used as structural backfill with Structural Plate shapes including round, pipe arch, single radius arch, horizontal ellipse, aluminum box culverts and other basic shapes. **Table 2** lists the generally accepted materials used for structural backfill with Structural

Plate shapes including long-span and large aluminum box culverts.

Other materials such as lean concrete, cemented sand mixtures, grout, CLSM or flowable fill may be used as allowed by local construction practice and as directed by the Geotechnical Engineer.

As a flexible soil-interaction structure, the backfill beside and over a structural plate provides a major portion of the strength and stability. Backfill material type, gradation, compaction and moisture are all factors that should be considered by the Engineer of Record.

Backfill material requirements vary with application, finished cover height and structure shape and gauge. CONTECH can provide site specific guidance in selecting and specifying backfill material.

Minimum Structural Backfill Requirements

In all cases, balanced lifts should be placed on either side of the structure according to AASHTO Section 26. It is common to place 6 to 8 inches of loose material then compact using light roller or walk-behind equipment.

GROUP CLASSIFICATION	A-1	A-2	A-3**
Sieve Analysis, Percent Passing:			
No. 10 (2.00 mm)	---	---	---
No. 40 (0.425 mm)	50 Max.	---	51 Max.
No. 200 (0.075 mm)	25 Max.	35 Max.	10 Max.
Characteristics of Fraction			
Passing No. 40 (0.425 mm)			
Liquid Limit	---	*	---
Plasticity Index	6 Max.	*	Non Plastic
Usual Types of Significant Constituent Materials	Stone Fragments, Gravel and Sand	Gravel or Sand with Silt or Clay	Sand
Adapted from AASHTO M-145			
* See Table 2 for values.			
** See note Table 2.			

Table 1. AASHTO M-145 – Materials for Round, Pipe Arch, Single Radius Arch, Horizontal Ellipse, Underpass, Aluminum Box Culverts and other basic structures.

STRUCTURAL PLATE

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		Gravel or Sand with Silt or Clay	
Adapted from AASHTO M-145				
* Modified to provide primarily granular, non-plastic materials				
Additional Requirements:				
Materials must be dense graded. Open graded or gap graded materials are not allowed.				
Fine beach sands, windblown sands, stream deposited sands, etc., exhibiting fine, rounded particles and typically classified by AASHTO M-145 as A-3 materials are not allowed for long span structures.				
NOTE: On-site mixing or blending to achieve specified gradation is not allowed unless these materials are regularly tested and certified by a geotechnical firm as meeting the specified gradation.				
CONTECH recommends specifying A-1-a backfill material for large structures that are not listed in the SPDG				

Table 2. AASHTO M-145 (Modified for Long-Span and Large Aluminum Box Culverts)

- For structures using materials listed in **Table 1**, the backfill should be compacted to 90% density using the Standard Proctor method (AASHTO T-99). For structures using materials listed in **Table 2**, the backfill density should be 90% using the Modified Proctor method (AASHTO T-180). Some special cases will require 95% Modified Proctor.
- Maximum particle size shall not exceed 3 inches. For A-2 materials the moisture content should be between -3% and +2% of optimum using AASHTO T-180.

Extents of the Structural Backfill Zone

The overall backfill zone includes the structural backfill zone and extends beyond the spring-line to a total horizontal distance "H" shown in **Figure 1**. The distance is equal to the total structure rise plus the total cover over the structure.

The stability of this material and the bearing strength are important to the performance of the Structural Plate. Any settlement of materials in this zone may impart down-drag

forces on the structure as well as contribute to a loss of side support. As the top radius, R_t (and resulting span) of the structure increases, the horizontal compression of the backfill by the side plates increases.

The Engineer of Record will determine the required width of the structural backfill and overall backfill envelope as these are site specific determinations and should consider an evaluation of the embankment or in-situ soils.

Normally, the following minimum structural backfill widths are used:

- aluminum box culverts less than 26 ft span – 3 feet
- aluminum box culverts greater than 26 ft span – 6 feet
- round, pipe arch, single radius arch, horizontal ellipse, underpass and other basic shapes less than 14 ft span – 4 feet
- round, pipe arch, single radius arch, horizontal ellipse, underpass and other basic shapes greater than 14 ft span – 6 feet
- long-span structures of any length span – 6 feet

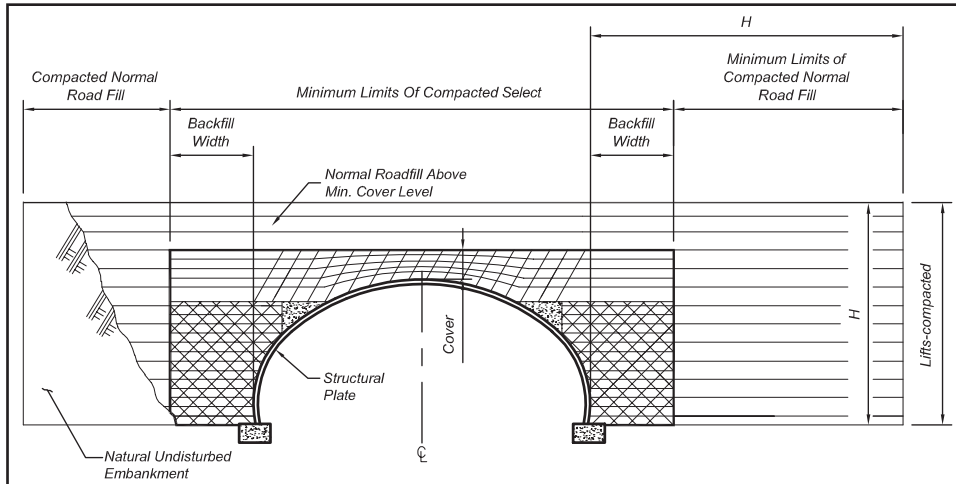


Figure 1 – Structural backfill zone for arches

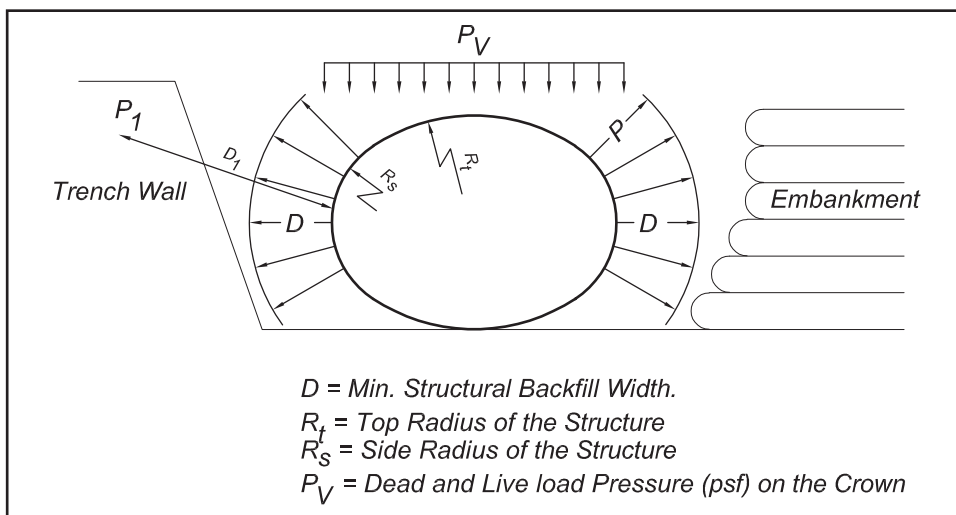


Figure 2 – Min backfill width

The height of the structural backfill zone normally coincides with the minimum cover based on the design live load and is a function of the structure top radius, R_t or R_s .

Many state DOT standard specifications and standard drawings prescribe the minimum width of the structural backfill zone.

An evaluation of the foundation or bedding material under the structure and side fill must be made by the Engineer of Record to ascertain adequate bearing capacity to support the structure and soil envelope with minimal differential settlement. Proper footing and foundation design is the responsibility of the Engineer of Record. Considerations are reviewed in Technical Bulletins #2, "Foundation Bearing Strength and Settlement" and #3, "Footings for Arch Structures".

Backfill Placement

Before backfilling procedures begin, the assembled shape shall meet the tolerance and symmetry requirements set by AASHTO and CONTECH.

Approved structural backfill materials shall be placed in horizontal, uniform lifts not exceeding 8 inches before compaction and shall be brought up uniformly on both sides of the structure. Each layer shall be compacted to the density described above in **Minimum Structural Backfill Requirements**. Field density tests of the compacted backfill shall be made within regular intervals during the backfill placement.

Non-woven geotextile should be placed between layers of soil with significantly different gradations to prevent migration of fines.

CONTECH will provide a Shape Control Technician to monitor the shape and log the compaction of backfill around long-span structures. Long-span structures are more sensitive to the types and weights of equipment used to place and compact granular materials in the structural backfill zone. This is especially critical in the areas immediately adjacent to and above the structure. Compaction equipment

or methods that produce horizontal or vertical earth pressures which cause excessive shape distortion or movement shall not be used.

Contractors should plan to have a D4 or other track dozer weighing no more than 20,000 pounds to place and grade backfill immediately alongside and above structures until the minimum cover is reached. Lightweight vibratory plate or roller compaction equipment must be used to compact the backfill in these areas. Use of heavier equipment and rubber tired equipment such as articulated dump trucks, front end loaders, scrapers and graders will most likely be prohibited inside the structural backfill zone.

Maximum Cover for Long Span and Large Aluminum Box Culverts

Maximum cover is controlled by a number of factors including, structure shape, backfill quality, plate properties and soil allowable bearing strength. Table 3 provides guidance based on shape, plate material and soil classification. All high fill applications should be carefully checked to confirm anticipated backfill density and appropriate plate gage.

Structure Shape and Material	Permissible Soil Classification	Typical Maximum Height of Cover in Feet***
MP LPA	A-1-a, A-1-b, CLSM*	20
	A-2-4**, A-2-5**	12
MP LPA Special ("NS" or "S")	A-1-a, A-1-b, CLSM*	8
MP HPA	A-1-a, CLSM*	20
	A-1-b, A-2-4**, A-2-5**	12
MP HPA (with side plates greater than 30 Pi)	A-1-a	20
	A-1-b	12
MP Ellipse	A-1-a, A-1-b, CLSM*	20
	A-2-4**, A-2-5**	12
MP Pear and Pear Arch	A-1-a, A-1-b, CLSM*	12
MP Round, Pipe Arch, Ellipse, Single radius Arch, Underpass	A-1, A-2, A-3, CLSM*	See heights of cover tables CONTECH Structural Plate Design Guide
ALSP LPA	A-1-a, A-1-b, CLSM*	20
	A-2-4**, A-2-5**	12
ALSP LPA Special ("NS" or "SL")	A-1-a, A-1-b, CLSM*	Determined by the Engineer
ALSP HPA	A-1-a, CLSM*	20
	A-1-b, A-2-4**, A-2-5**	12
ALSP Ellipse	A-1-a, A-1-b, CLSM*	20
	A-2-4**, A-2-5**	12
ALBC	A-1, A-2, A-3, CLSM*	5
ALSP Round, Pipe Arch, Ellipse, Single Radius Arch, Underpass	A-1, A-2, A-3, CLSM*	See heights of cover tables CONTECH Structural Plate Design Guide
* CLSM includes Controlled Low Strength material, flowable fill, cementitious grout, lean concrete, or cement/lime stabilized sand. ** Modified per Table 2 *** The specified maximum HOC for a site specific project will be determined by the Engineer, based on fill unit weight, live load and other factors. Note: The specified maximum cover height may be restricted to lesser values than are listed in this table by design issues such as wall strength and seam strength, especially for ALSP shapes.		

Table 3. Typical Maximum Height of Cover (Structural Backfill over crown plus embankment fill)

This bulletin reviews some of the general engineering and design considerations applicable to CONTECH Structural Plate structures. This bulletin is not intended to address all considerations or to provide detailed design methods. Because projects differ, the considerations presented may or may not apply to a specific project. Additional considerations or an alteration of those discussed here may be necessary for a specific site, application or structure. Only the Engineer of Record can determine the suitability of these and other necessary considerations. CONTECH Structural Plate is a product of Contech Engineered Solutions.