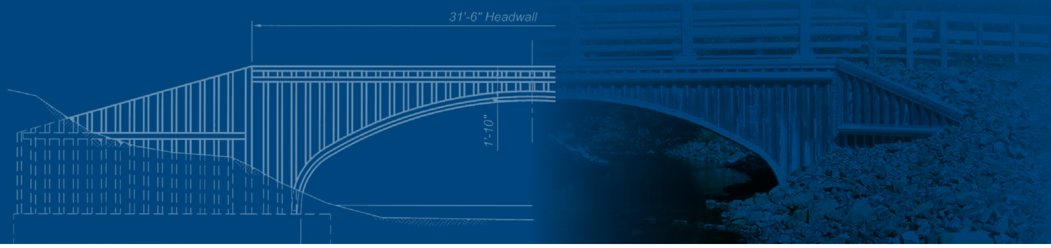

END TREATMENT

The exposed ends of structural plate spans are typically subjected to hydraulic forces resulting in potential erosion of the backfill material that supports the structure. Headwalls, collars, slope pavement, gabion baskets and other systems are commonly used as protective end treatments. Balanced backfill loads must be provided. Adequate support from a headwall or similar construction provides needed stability for skewed applications.

Structure Square to the Embankment

Square (un-cut) Ends with complete rings of structural plate are preferred. Generally, square ended structures have a headwall for either aesthetic or hydraulic reasons. The headwall can be constructed with cast-in-place concrete or modular block systems. Shorter headwalls (less than 14 feet from top of footing to top of wall) can be designed using un-curved aluminum structural plate or steel sheet pile along with suitable wale beams and anchor ties. Precast concrete headwalls are possible for low single radius arches and aluminum box culverts with spans less than 20 feet.

Step-Bevel Cut Ends use bevel cut side plates while leaving the top and invert (if any) plates uncut. For this widely used end treatment, a concrete slope collar is recommended to support the bevel cut plates and to protect against backfill erosion. Bevel slopes should be no flatter than 2:1 and the top (and bottom) steps should be approximately 25% of the total rise. Smaller steel shapes less than 14 feet span and aluminum shapes less than 12 feet span can have bevel slopes that are flatter than 2:1 and should be evaluated on a case-by-case basis.

Full Bevel Cut Ends should not be used on long-span structural plate and should be avoided for any shape with a span over 12 to 14 feet. Structures with inverts should not have cut invert plates as this makes the structure prone to flow forces and hydraulic uplift.

Many State DOTs have standard drawings that address either step-bevel or full bevel cuts up to 4:1. Readers are advised to refer to governing State standards for guidance. As the severity of the end cut increases (relatively large amount of structural plate material removed to accommodate the end treatment geometry) the need for temporary bracing during backfill and concrete placement should be considered. Cross bracing or shoring the ends of the structure is recommended.

Aluminum box culverts are not bevel cut.

Structure Skewed to the Roadway

Skew Cut Ends are fabricated by cutting the end of the plate structure diagonally across the centerline. These cut ends allow the structure to be skewed to the centerline of the roadway while minimizing the amount of right-of-way. All skew cut ends require a cast-in-place concrete headwall to anchor and support the entire cut plane. Ring compression theory requires the thrust developed circumferentially in the corrugated plate to be resisted by the headwall. Skew cuts up to 30 degrees are readily addressed.

Skew-Bevel Cut Ends are normally used on smaller round and pipe arch shapes to accommodate both structure skew and embankment slope. Concrete collars are used to protect the backfill. Structures with a span larger than 12 to 14 feet are generally not skew-bevel cut.

Structure Skewed to the Embankment

Square or Step-Bevel Cut Ends can be used if the right-of way will allow a longer structure. This method requires a warped backfill. A warped backfill is an adjustment of the grading contours which provides balanced backfill loads and support on the structural plate. By creating a "plateau" over the otherwise exposed side of the structure, balanced backfill is achieved. ***See Figure 1*** for isometric schematic. The plateau should extend approximately 1.5(Total Rise + Cover) + Span/2 from the centerline of the structure. ***See Figure 2*** for details. This method can eliminate the need for headwalls as described above. If the structure is step-beveled or there are hydraulic forces present a concrete collar should be considered.

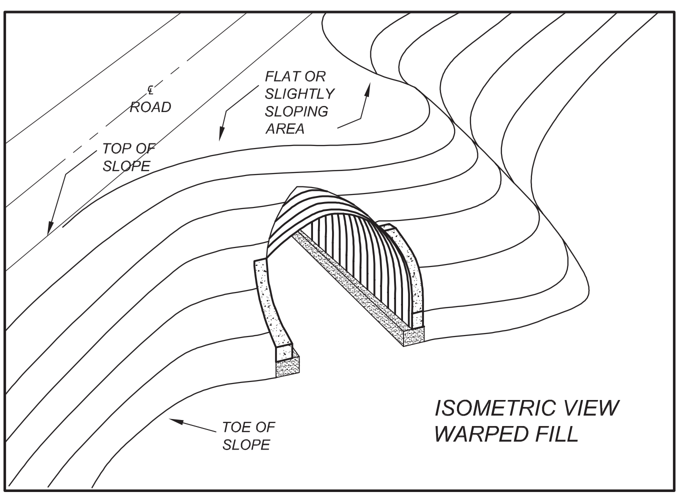

Figure 1 – Warped fill

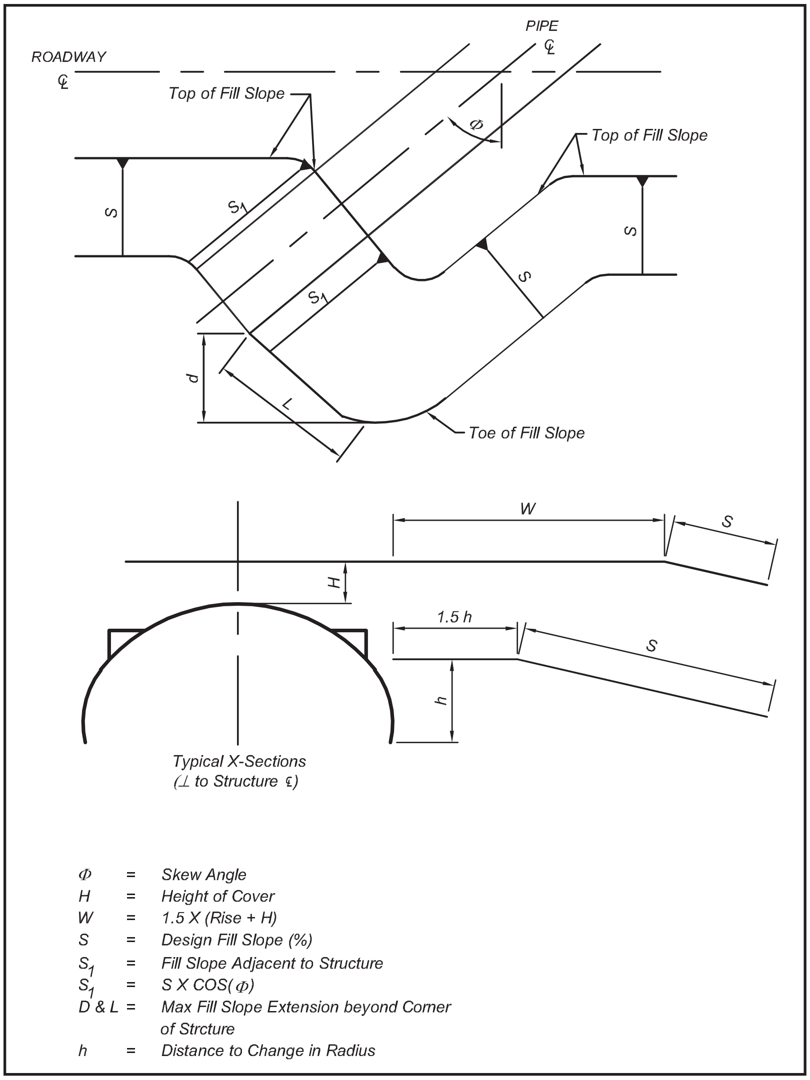

Figure 2 – warped fill details

Hydraulic Protection

Water flow and hydraulic force can erode backfill, damage the structure ends and inundate the bedding and backfill. Proper inlet design will provide necessary protection and improved hydraulic inlet conditions, if necessary.

Flow into the structure should be in a straight path or directed into the structure using wingwalls or other channeling system. Eddy currents and excessive turbulence can erode unprotected backfill slopes and ultimately damage structural plate. In hydraulic applications, the backfill material must be selected in accordance with Technical Bulletin #4 Backfill Requirements and provide adequate protection against degradation, migration, piping or loss of strength when saturated. Structural backfill should be protected from percolation and saturation caused by high headwater and tailwater elevations. Compacted clay caps at least 1 foot thick over the granular backfill, slope pavement and grouted rip-rap are effective means of protection.

Structures with inverts in hydraulic applications require full cut-off (toe) walls at the inlet and outlet. Prefabricated structural plate, sheeting and cast in place concrete are effective means to providing invert protection from undermining hydraulic forces.

Uplift Forces – Buoyancy

All structures with inverts are subject to uplift forces or buoyancy. Excessive hydrostatic forces can float the structure or buckle invert plates. While adequate cover can be provided to hold the structure in place, this does not eliminate buckling considerations for the invert plates. Proper design keeps water from permeating the foundation and backfill materials to an excessive depth. A properly graded, free-draining select backfill envelope and foundation are key factors to control differential water elevations.

As long as the flow depth in the structure is at least the depth of water saturation in the backfill, uplift forces are approximately balanced. When headwater or tailwater depths are relatively high for a significant period of time, then rapidly drop, the possibility for excessive uplift exists and further investigation is prudent. If the water level in the backfill or ground water level drops slower than the flow level in the structure, buoyancy and invert buckling should be considered in the design.

Increased invert plate thickness, paved inverts, free draining backfill, sub-drains, toe-walls with adequate depth, slopes with compacted clay caps at least 1 foot thick over the granular backfill, slope pavement and grouted rip-rap are effective in controlling backfill moisture content.

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.

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