SECTION 550 Pipe Culverts

550.1 Culvert Pipe List

Standard spec 520.3.1 provides that, unless otherwise authorized by the project engineer in writing, the contractor must not order and deliver the pipe culverts required for the project until a corrected list of sizes and lengths is furnished by the project engineer. This provides the project engineer an opportunity for checking the designated plan length in the field, making any necessary adjustment in length, and assuring the correct length of culvert pipe required at a designated location to satisfy field conditions is ordered.

At the earliest opportunity, the project engineer should prepare and furnish to the contractor the corrected list of sizes and lengths of culvert pipe, so the contractor may place the order with the supplier at an early date, avoiding a late delivery and delay in the progress of the work. This list should be in writing and a duplicate copy should be retained in the project engineer's files. The ordered length of a culvert should be in agreement with the length staked in the field and should be in accordance with the provisions below.

If the staking of culverts is not completed before the start of construction operations, the furnishing of the pipe lists should coincide with the contractor's plan of operations. Should the contractor have the pipe delivered at intervals, it will provide a more favorable opportunity to WisDOT for determining and furnishing the lists of required lengths. However, it is important the list be furnished as soon as practicable.

Section CMM 735 describes in detail the conditions necessary for restoration or construction of private entrances and the standards to which entrances must be restored or constructed. The sizes and lengths of culvert pipes required for private entrances, as determined in accordance with CMM 735, will be compiled by WisDOT and included with the corrected list of sizes and lengths of culvert pipe to be furnished to the contractor. The list of culvert pipe for private entrances will not include culvert pipe to be furnished and placed by the owner for those allowed entrances to be constructed at the owner's expense.

550.2 Ordered Lengths of Culvert Pipe

550.2.1 Corrugated Steel and Aluminum

It is standard industry practice to manufacture corrugated steel culvert pipe and corrugated aluminum culvert pipe in lengths of two-foot multiples in individual lengths from 16' to 30'. The maximum fabricated length normally shipped is 30'. Typically, the supplier will furnish the pipe for a culvert in a minimum number of fabricated lengths. In this respect, culverts from 32' to 60' total length would be furnished in 2 fabricated lengths and culverts from 62' to 90' total length would be furnished in 3 lengths. However, this is not a fixed criterion and suppliers may often furnish pipe for culverts in more than the minimum number of fabricated lengths.

550.2.2 Reinforced Concrete

The practice of most of the suppliers of reinforced concrete culvert pipe is to manufacture the various sizes of pipe in length increments of either 4' and 6'; 6' and 8'; or 4', 6', and 8'. By using a combination of 4' and 6' lengths or 6' and 8' lengths, reinforced concrete pipe may be supplied for culverts of any 2-foot multiple of length.

Some concrete pipe manufacturers may manufacture large diameter pipe in 7.5' lengths, or 7' 8" lengths rather than 8' lengths to preclude over-width loads when transporting pipe.

The required length of culvert as determined in the field to satisfy conditions at the site should be adjusted, except in the case of pipes with skewed or beveled ends, to the nearest 2-foot multiple of barrel length. In accordance with SDD 8F1, concrete apron endwalls are manufactured with a part of the endwall in the form of pipe. The pipe-shaped part of the concrete endwall will vary from 19 3/4" to 48 7/8" in length, as shown in SDD 8F1 for the various sizes.

Where concrete apron endwalls are called for, the required length as determined to satisfy site conditions should first be corrected to accommodate any barrel portions of the endwalls. This corrected length is then adjusted to the appropriate 2-foot multiple of length. This adjusted length of culvert will be the ordered length. Adjustment in the required length of a pipe having skewed or beveled ends must take into account the method of measuring the end sections, as described below in this chapter.

550.2.3 Polyethylene and Polypropylene

Polyethylene and polypropylene culvert pipe is generally manufactured and supplied in 20-foot lengths. Individual manufacturers may offer one or more options for smaller lengths. Pipe is often field cut to match jobsite conditions. When apron endwalls are called for, standard steel apron endwalls or steel endwalls sloped for cross or side drains conforming to standard spec 521.2 are required. Polyethylene and polypropylene endwalls are not allowed. Where corrosive conditions exist, aluminum endwalls conforming to standard spec 525 may be specified.

550.3 Inspection

Each load of delivered pipe must be accompanied by a loading document. The pipe must be installed only after the documentation is received. Pipe should also be inspected as soon as possible after delivery to the job. The inspection should cover dimensions, soundness, markings, damage incurred during shipment or unloading, and defects overlooked at the plant. Pertinent information concerning any rejected pipe should be recorded by the inspector in field notebooks. Refer to measurement of pipe culverts of this section for needed documentation. Refer to the Materials Testing and Acceptance Guide in CMM 850 for pipe acceptance conditions.

550.4 Storage and Handling of Pipe

Pipe delivered to the project site should be handled, and if not immediately installed, stored in a manner to prevent potential damage. Staging and storage areas should be flat, free of large rocks, rough surfaces, and debris. Storage areas should also be out of the way of construction traffic. Palletized pipe should remain on the pallet for jobsite storage. Consult manufacturer data for recommendations or prohibitions regarding stacking of loose pipe. Pipe gaskets, if provided should be protected from harmful substances such as dust and grit, solvents, and petroleum-based greases and oils. Some gaskets may need to be protected from sunlight (consult the manufacturer). Although often treated with black carbon and potentially other UV stabilizers, long term uncovered storage of polyethylene and polypropylene pipes on the jobsite may warrant reconsideration.

Polyethylene and polypropylene pipes should not be handled with chains. Individual lengths of pipe can typically be handled using a nylon sling or cushioned cable secured around the third points of the pipe.

Consult the manufacturer data for specific handling and storage requirements or additional information.

550.5 Preparing Foundation

Success in the construction of pipe culverts against detrimental settlement depends largely upon proper preparation of the foundation for support of the pipe. Embankments are required to be constructed to at least one foot above the top of the proposed pipe (see figure 550-1) before excavating the trench and laying the pipe, to provide a firmly and uniformly consolidated support for the superimposed embankment, and to ensure against an overload bearing on the pipe due to settlement of the embankment or its foundation. To ensure uniformity in compaction of the fill above the pipe, embankments should not be built to a height in excess of two feet above the pipe before the pipe is laid.

Preparation of the foundation for support of the culvert pipe is performed during the preparation of the embankment foundation. During preparation, inspections should be made to ensure the foundation at the pipe site and for a distance on each side of the pipe of at least the height of the proposed embankment is uniformly and thoroughly consolidated. Any foundation materials of poor supporting value should be removed and replaced with suitable materials. Where flowing water is a problem, it may often be carried in a ditch cut around the culvert site until the pipe is in place, or pumps may be used to maintain a dry foundation.

On occasion culvert foundations may be on compressible soils that are so deep that full excavation is impossible or impractical. Using a modest strength geotextile beneath foundation backfill is of considerable benefit in providing a stable base for construction, and to reduce abrupt changes in settlement.

Before embankment construction, the contractor should remove detrimental rock materials located near the natural ground surface that may interfere with later culvert foundation preparations. Backfill of these areas should consist of acceptable materials similar to the proposed embankment soils.

Loads acting upon a pipe increase with the width of the trench as well as with the height of fill above the top of the pipe. To ensure against the occurrence of a greater load upon the pipe than the design load for the pipe, trench width and trench wall limitations are necessary.

Trenches should be wide enough to provide free working space on each side of the pipe. Typically, this space must not exceed 1/2 the nominal diameter of the pipe, and never be less than 6 inches. The required working space depends upon the size of the pipe and the character of the material in the excavation. For steel or concrete pipe, the trench width should be enough to allow for preparing the foundation, laying the pipe, and placing and compacting backfill, but not exceed the pipe's outside diameter by more than 36 inches. For polyethylene and polypropylene pipe ensure minimum trench width is not less than the greater of either the pipe outside diameter plus 16 inches or the pipe outside diameter times 1.25, plus 12 inches. ASTM D2321 and AASHTO LRFD Bridge Construction Specifications Section 30 provide additional guidance on the installation of polyethylene and polypropylene pipe.

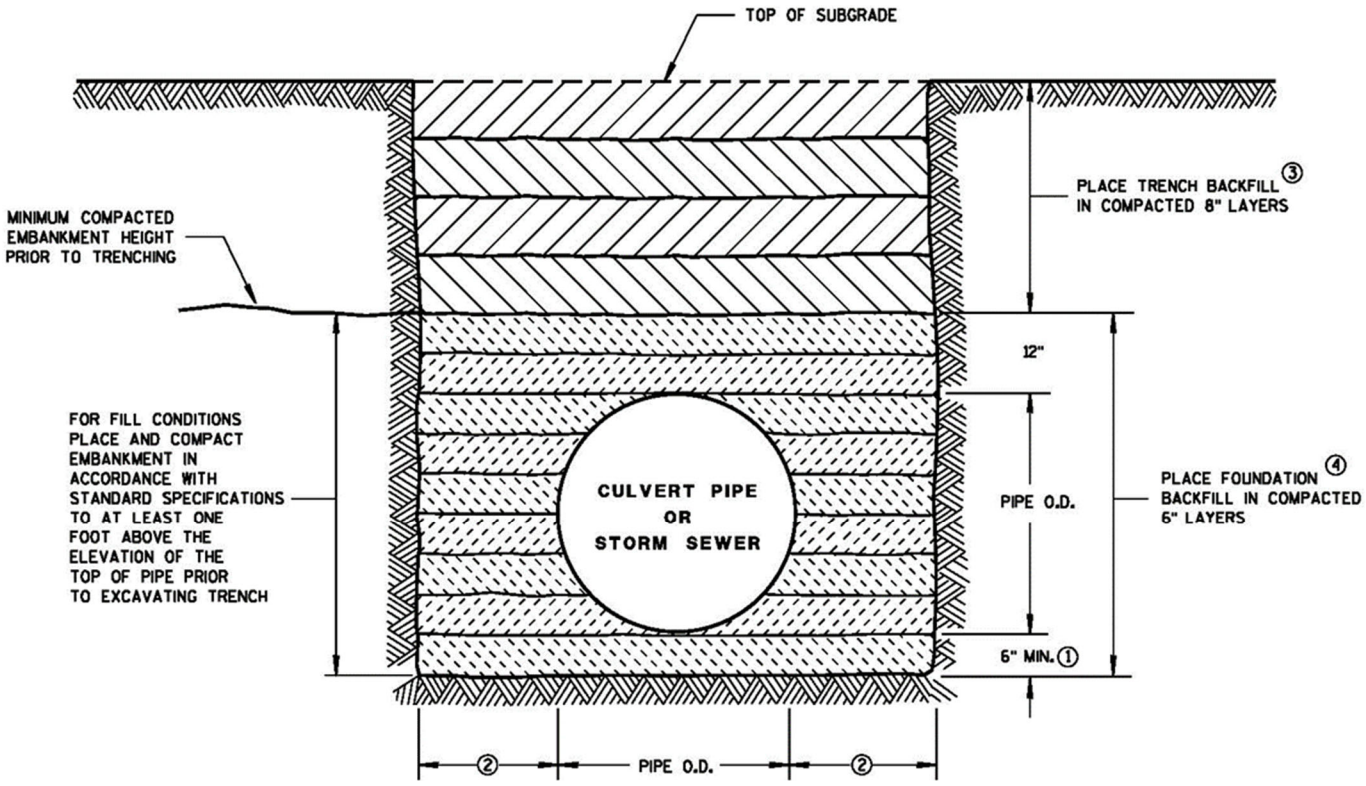
In addition to the trench width limitations stated above, the contractor should excavate the trench below the top of pipe as vertical as possible when the final height of the proposed fill above the top of the pipe will exceed 6 ft.

Pipe culverts placed under embankments support a greater load under the roadbed than at or near their ends and will settle more under the greater load. To compensate for this uneven anticipated settlement, a camber, may have been designated, to be built in the grade line of the culvert. When areas of unanticipated or unaddressed poor soils or a profile change creating higher fills, coordinate with the regional soils engineer, or the BTS Geotechnical Unit on the need for camber in areas of poor soils or high fills.

550.6 Excavating and Forming Bed for Pipe

Standard spec 520.3.2.1 specifies excavating and forming the foundation and bed for culvert pipes under public highways. Pipe foundation is the part of the terrain that supports the pipe and the forces of any loads superimposed upon the pipe. Pipe bedding or foundation backfill as depicted in figure 550-1, is the portion of the foundation in immediate contact with the pipe. The contractor must excavate for foundation backfill at least 6 inches below the elevation established for the bottom of the pipe unless the project engineer determines the existing foundation material for this depth conforms to standard spec 520.2.5.2. If rock, hardpan, or fragmented material exists, the trench is to be excavated the greater or 6 inches below the pipe or to a depth equal to 1/2 inch per foot of proposed embankment above the top of the pipe. Additional excavation may be needed for pipe bells. Figure 550-1 depicts trench width, foundation and backfill requirements for storm sewer and pipe culverts.

FIGURE 550-1 Trench, Foundation, and Backfill Details for Pipe Culverts and Storm Sewers



1. Excavate and place foundation backfill at least 6 inches below the bottom of the pipe. If rock, hardpan, or fragmented material exists, the depth is the greater or 6 inches below the pipe or to a depth equal to 1/2 inch per foot of proposed embankment above the top of the pipe.
2. 6 inches minimum. In general, this width not to exceed 1/2 the O.D. of the pipe.

   For CMP or concrete pipe, the trench width should not exceed the pipe's O.D. by more than 36 inches. For polyethylene and polypropylene pipe minimum trench width is not less than the greater of either the pipe outside diameter plus 16 inches or the pipe outside diameter times 1.25, plus 12 inches.
3. For culvert pipe, trench backfill is to conform to standard spec 520.2.5.3. For storm sewer, trench backfill is to conform to standard spec 209.2 or standard spec 520.2.5.2.
4. For culvert pipe, foundation backfill is to conform to standard spec 520.2.5.2.

   For culvert pipe and storm sewer, foundation backfill is to conform to standard spec 608.2.2.2.

Major foundation problems should be brought to the attention of the project engineer and region soils engineer for resolution.

550.7 Backfilling Culvert Pipe

The backfill material should have a moisture content suitable for acceptable consolidation with the compaction tools used. A rough check for suitable moisture content may be made by squeezing the soil in the hand. A firm cast should result without wetting the hand.

550.7.1 Foundation Backfill

In order that a pipe may successfully support the loading to which it may be subjected without excessive distortion or rupture of the pipe, and to preclude settlement problems, it is essential that adequate lateral support be provided for the pipe by thorough consolidation of the backfill between the pipe and the walls of the trench. To facilitate this, culvert pipes are to be embedded in compacted foundation backfill as defined by standard spec 520.2.5.2 from a minimum 6 inches or more below the bottom of the pipe to 12 inches above the top of pipe. Foundation backfill is virgin material consisting of either sand-sized particles or sand-sized particles mixed with gravel, crushed gravel, or crushed stone. The contractor may use material from the work site only if it meets specification.

Before pipe placement, the foundation backfill is mechanically compacted. After pipe placement, mechanically compacted lifts, not measuring more than 6 inches after compaction, are to be placed to an elevation 12 inches above the top of pipe. To ensure against disturbance of the pipe alignment, each layer of backfill material must be placed, compacted, and brought up uniformly on each side of the pipe.

While compaction is essential and required by specification throughout the foundation backfill zone, special emphasis has been placed on compacting material under the lower portion of the pipe. Backfill material placed in the area under the lower half of the pipe must be thoroughly compacted. In narrow trenches where access and working conditions may be difficult, there may be a tendency to slight this work, particularly in the haunch areas directly under the pipe. Hand work may be required to fill voids under the pipe. Shovel slicing, rodding and hand tamping have been shown to be an effective means of achieving proper support in the haunch zone. Adequate compaction of foundation backfill in the haunch zone is important for all pipe materials, but it is particularly important for polyethylene, polypropylene and composite pipes where the pipe and bedding interaction is critical to developing the strength to support vertical loads applied to the pipe.

550.7.2 Trench Backfill

Starting 12 inches above the top of the pipe, the remaining trench, if any, must be backfilled with compacted trench backfill. Trench backfill is placed to the top of the subgrade in layers no more than 8 inches thick after compaction. Backfilling details are shown above in figure 550-1. Trench backfill can consist of material from the excavation for the typical roadway section that is free of large lumps, clods, rocks and other perishable and deleterious matter. Unless specified differently in plan documents, the trench backfill material for cross culverts starting 12 inches above the top of the pipe should be like the adjacent soil materials. This is to minimize differential frost heaves due to non-uniform materials and/or differential compaction efforts.

Pipe should be protected from construction traffic after placement. If 2 or more feet of cover is not provided by foundation and trench backfill, it may be necessary to temporarily place a "cushion" of compacted earth embankment over the pipe for at least the trench width. The purpose of this cushion is to protect the pipe from construction equipment during subsequent operations until such time the roadway pavements can be placed.

550.8 Joint Ties for Culvert Pipes

Reinforced concrete pipe culverts are required to be tied at the joints with joint ties to prevent separation of adjacent pipe sections. This is required at the last 3 sections on the upstream and downstream ends of concrete culvert and concrete cattle pass installations. When using apron endwalls, the endwall and the last 2 sections are tied. No ties are required on culverts with masonry endwalls unless the plans show otherwise.

Joint ties are not required for thermoplastic pipe where a full (+/- 20 foot) pipe section is utilized from the infall and outfall to the first joint. Where a partial pipe section must be used at the infall or outfall end, it should be restrained with a manufacturer supplied external mechanical coupling, a mastic impregnated geotextile wrap with mechanical fastening bands, or a concrete collar. Apron endwalls must be secured to the pipe. No ties are required on pipes with masonry endwalls unless the plans show otherwise.

550.9 Deflection Testing for Polyethylene and Polypropylene Pipe

Deflection testing is required for all polyethylene and polypropylene pipe culverts and storm sewers. Mandrels are used to test flexible pipes for variations in manufacturer tolerance, pipe roundness and deflection both from misaligned joints and backfill and construction loads.

Mandrels are typically manufactured from steel or aluminum and have nine legs (fins). Fins can be fixed or removable (figure 550-2). Mandrel kits with removable sets of fins can be used to test a variety of pipe sizes. Mandrels should be made available from the contractor, pipe supplier or manufacturer. The project engineer must approve the mandrel before testing. The mandrel must have nine fins or legs permanently marked to designate the nominal pipe diameter and mandrel diameter. Required mandrel size is shown in table 550-1.

FIGURE 550-2 Typical Fixed and Removable Fin Mandrels

The required mandrel is 92.5% of the nominal pipe diameter. This size mandrel accounts for 5% allowable deflection from installation plus allowable manufacturing tolerances. Unlike reinforced concrete pipe, polyethylene and polypropylene pipes are flexible and will deflect under load without compromising their integrity. The department required mandrel size accounts for these material specific conditions. Table 550-1 lists the minimum allowable mandrel size for testing polyethylene or polypropylene culvert or storm sewer. Mandrels labeled ASTM F679 or ASTM D3034 are intended for PVC gravity sewer and may be smaller than the minimum sizes in table 550-1 and, if so, should be rejected.

Acceptable mandrels should be permanently labeled, at a minimum, with the nominal pipe diameter and the mandrel diameter. As a spot check, or if the mandrel appears otherwise questionable, the size can be verified by measurement using the values in table 550-1 as a guide. Fixed fin mandrels could be verified by flexible tape or by proofing ring. Removable fin mandrels can be checked by measuring two removable fins laid adjacent to one another and adding a constant width representative of the fixed base. The mandrel manufacturer should be able to supply the fixed base constant width.

TABLE 550-1 Minimum Required Mandrel Size

Nominal Pipe Inside Diameter (inches)	Minimum Mandrel Outside Diameter (inches)[1]
12	11.10
15	13.88
18	16.65
21	19.43
24	22.20
27	24.98
30	27.75
36	33.30

[1] Values include both allowable manufacturing tolerances and allowable installed deflection.

The percentage of pipe that requires mandrel testing, based on size, is specified in standard spec 520.3.7 for culvert pipe and in standard spec 608.3.7 for storm sewer. Where less than 100% testing is required, the project engineer, not the contractor, designates where and how much pipe to test. The engineer should concentrate testing on larger diameter pipe, critical locations, areas of poor soils, and areas where contractor installation methods were questioned or not fully observed.

Pipe is tested after installation but before paving or finish grading. Waiting as long as practical, ideally 30 days when not in conflict with scheduled paving operations, to mandrel test is advised to allow deflection development in the pipe from embankment loading. The mandrel is pulled through the entire pipe section in one pass when pulled by hand without using excessive force. If the designated length of pipe fails, the project engineer may require additional testing in addition to the initial designation. Pipe that does not pass deflection testing needs to be re-laid or replaced and retested.

If deflection testing fails or significant construction issues occur with polyethylene and polypropylene pipe, the engineer should notify the statewide drainage engineer in the central office roadway standards development unit.

550.10 Measurement and Payment of Pipe Culverts

The standard specifications provide that the quantity measured for payment must be determined by measuring the linear foot acceptably completed, measured along the invert.

The corrected pipe list that was given to the contractor by the project engineer defines the lengths to be paid for, providing that the specified lengths are furnished and acceptably installed. Standard spec 520.5 provides that measurement will be made by the linear foot in place, which is interpreted as requiring that measurement for payment will be made only after the culvert pipe is in place and not upon delivery to the job site.

Joint ties or restraint use varies with pipe type and if endwalls are used, see standard spec 520.3.3. The ties or other restraints are incidental to item. If additional ties are required by the plans or the project engineer, they will have to be paid separately.

Foundation and trench backfill are incidental to the culvert or cattle pass items unless a special bedding or backfill material is called out in the plans or special provisions. The only other exceptions where foundation or trench backfill is paid are as follows

- For culvert installations where the where the project engineer determines that the material from the typical roadway section is not suitable for use as trench backfill. In that case the department will pay separately for additional trench backfill under other contract bid items.
- For pipe installations where the project engineer determines that proper bearing cannot be obtained 6 inches below the bottom of the pipe and directs additional excavation and subsequent backfill with foundation backfill. In this case the department will pay for excavating unsuitable material and backfilling as extra work.