

## B421 - PIPE CULVERTS - OPSS 421

### 421.1 GENERAL

Pipe culverts are installations designed to provide for the conveyance of surface water, pedestrians or livestock using preformed or pre-cast pipe sections, circular or non-circular in cross-section, laid end to end using suitable joint materials.

All design assumptions and calculations required to design a pipe culvert shall be retained as part of the design documentation.

### 421.2 REFERENCES

- Canadian Highway Bridge Design Code (CHBDC)
- MTO Drainage Management Manual
- MTO Gravity Pipe Design Guidelines (2014)
- MTO Guide for Preparing Hydrology Reports for Water Crossings
- MTO Highway Drainage Design Standards
- MTO Roadside Safety Manual
- MTO Structural Manual
- OPSS 100, MTO General Conditions of Contract
- OPSS 209, Embankments Over Swamps and Compressible Soils
- OPSS 401, Trenching, Backfilling, and Compacting
- OPSS 403, Rock Excavation for Pipelines, Utilities, and Associated Structures In Open Cut
- OPSS 492, Site Restoration Following Installation of Pipelines, Utilities, and Associated Structures
- OPSS 517, Dewatering
- OPSS 902, Excavating and Backfilling - Structures
- OPSS 904, Concrete Structures
- SSP 499S04, Requirements for Post Installation Inspection

The designer shall also reference other design manuals (i.e., MTO Roadside Safety Manual) as required for design assistance of other roadside features associated with the pipe culvert design.

### 421.3 TENDER ITEMS

| Item Code | Title               | Col Type  | U.O.M. | PQP |
|-----------|---------------------|-----------|--------|-----|
| 0421-0105 | 100 mm Pipe Culvert | Variation | m      | Y   |
| 0421-0205 | 200 mm Pipe Culvert | Variation | m      | Y   |
| 0421-0305 | 300 mm Pipe Culvert | Variation | m      | Y   |
| 0421-0405 | 400 mm Pipe Culvert | Variation | m      | Y   |

| Item Code | Title                                      | Col Type  | U.O.M. | PQP |
|-----------|--|-----------|--------|-----|
| 0421-0505 | 500 mm Pipe Culvert                        | Variation | m      | Y   |
| 0421-0605 | 600 mm Pipe Culvert                        | Variation | m      | Y   |
| 0421-0705 | 700 mm Pipe Culvert                        | Variation | m      | Y   |
| 0421-0805 | 800 mm Pipe Culvert                        | Variation | m      | Y   |
| 0421-0905 | 900 mm Pipe Culvert                        | Variation | m      | Y   |
| 0421-1005 | 1000 mm Pipe Culvert                       | Variation | m      | Y   |
| 0421-1205 | 1200 mm Pipe Culvert                       | Variation | m      | Y   |
| 0421-1305 | 1300 mm Pipe Culvert                       | Variation | m      | Y   |
| 0421-1405 | 1400 mm Pipe Culvert                       | Variation | m      | Y   |
| 0421-1505 | 1500 mm Pipe Culvert                       | Variation | m      | Y   |
| 0421-1605 | 1600 mm Pipe Culvert                       | Variation | m      | Y   |
| 0421-1805 | 1800 mm Pipe Culvert                       | Variation | m      | Y   |
| 0421-1905 | 1900 mm Pipe Culvert                       | Variation | m      | Y   |
| 0421-2005 | 2000 mm Pipe Culvert                       | Variation | m      | Y   |
| 0421-2105 | 2100 mm Pipe Culvert                       | Variation | m      | Y   |
| 0421-2205 | 2200 mm Pipe Culvert                       | Variation | m      | Y   |
| 0421-2405 | 2400 mm Pipe Culvert                       | Variation | m      | Y   |
| 0421-2505 | 2500 mm Pipe Culvert                       | Variation | m      | Y   |
| 0421-2605 | 2600 mm Pipe Culvert                       | Variation | m      | Y   |
| 0421-2705 | 2700 mm Pipe Culvert                       | Variation | m      | Y   |
| 0421-3005 | 3000 mm Pipe Culvert                       | Variation | m      | Y   |
| 0421-6205 | 1400 mm Pipe Culvert Extension             | Variation | m      | Y   |
| 0421-6206 | 1600 mm Pipe Culvert Extension             | Variation | m      | Y   |
| 0421-6207 | 1800 mm Pipe Culvert Extension             | Variation | m      | Y   |
| 0421-6211 | 400 mm Pipe Culvert Extension              | Variation | m      | Y   |
| 0421-6212 | 500 mm Pipe Culvert Extension              | Variation | m      | Y   |
| 0421-6213 | 600 mm Pipe Culvert Extension              | Variation | m      | Y   |
| 0421-6214 | 700 mm Pipe Culvert Extension              | Variation | m      | Y   |
| 0421-6215 | 800 mm Pipe Culvert Extension              | Variation | m      | Y   |
| 0421-6216 | 900 mm Pipe Culvert Extension              | Variation | m      | Y   |
| 0421-6217 | 1000 mm Pipe Culvert Extension             | Variation | m      | Y   |
| 0421-6219 | 1200 mm Pipe Culvert Extension             | Variation | m      | Y   |
| 0421-6222 | 500 mm Non-Circular Pipe Culvert Extension | Variation | m      | Y   |
| 0421-6223 | 600 mm Non-Circular Pipe Culvert Extension | Variation | m      | Y   |
| 0421-6224 | 700 mm Non-Circular Pipe Culvert Extension | Variation | m      | Y   |
| 0421-6225 | 800 mm Non-Circular Pipe Culvert Extension | Variation | m      | Y   |
| 0421-6226 | 900 mm Non-Circular Pipe Culvert Extension | Variation | m      | Y   |

| Item Code | Title                                       | Col Type  | U.O.M.   | PQP |
|-----------|---|-----------|----------|-----|
| 0421-6227 | 1000 mm Non-Circular Pipe Culvert Extension | Variation | m        | Y   |
| 0421-6229 | 1200 mm Non-Circular Pipe Culvert Extension | Variation | m        | Y   |
| 0421-6400 | Clay Seal                                   | Normal    | Lump Sum | N   |
| 0421-6500 | Concrete Appurtenances (for Pipe Culverts)  | Normal    | m3       | Y   |
| 0421-7040 | 400 mm Non-Circular Pipe Culvert            | Variation | m        | Y   |
| 0421-7050 | 500 mm Non-Circular Pipe Culvert            | Variation | m        | Y   |
| 0421-7060 | 600 mm Non-Circular Pipe Culvert            | Variation | m        | Y   |
| 0421-7070 | 700 mm Non-Circular Pipe Culvert            | Variation | m        | Y   |
| 0421-7080 | 800 mm Non-Circular Pipe Culvert            | Variation | m        | Y   |
| 0421-7090 | 900 mm Non-Circular Pipe Culvert            | Variation | m        | Y   |
| 0421-7100 | 1000 mm Non-Circular Pipe Culvert           | Variation | m        | Y   |
| 0421-7110 | 1100 mm Non-Circular Pipe Culvert           | Variation | m        | Y   |
| 0421-7120 | 1200 mm Non-Circular Pipe Culvert           | Variation | m        | Y   |
| 0421-7130 | 1300 mm Non-Circular Pipe Culvert           | Variation | m        | Y   |
| 0421-7140 | 1400 mm Non-Circular Pipe Culvert           | Variation | m        | Y   |
| 0421-7150 | 1500 mm Non-Circular Pipe Culvert           | Variation | m        | Y   |
| 0421-7160 | 1600 mm Non-Circular Pipe Culvert           | Variation | m        | Y   |
| 0421-7170 | 1700 mm Non-Circular Pipe Culvert           | Variation | m        | Y   |
| 0421-7180 | 1800 mm Non-Circular Pipe Culvert           | Variation | m        | Y   |
| 0421-7190 | 1900 mm Non-Circular Pipe Culvert           | Variation | m        | Y   |
| 0421-7200 | 2000 mm Non-Circular Pipe Culvert           | Variation | m        | Y   |
| 0421-7210 | 2100 mm Non-Circular Pipe Culvert           | Variation | m        | Y   |
| 0421-7220 | 2200 mm Non-Circular Pipe Culvert           | Variation | m        | Y   |
| 0421-7240 | 2400 mm Non-Circular Pipe Culvert           | Variation | m        | Y   |
| 0421-7250 | 2500 mm Non-Circular Pipe Culvert           | Variation | m        | Y   |

#### 421.4 SPECIFICATIONS

The requirements for the pipe culvert, non-circular pipe culvert, pipe culvert extension, non-circular pipe culvert extension and concrete appurtenance tender items are contained in OPSS 421. Trenching, backfilling and compaction requirements are specified in OPSS 401, and rock excavation requirements are specified in OPSS 403. The designer shall also reference or note other OPSS documents for construction and materials as identified or required when packaging a Contract.

##### 421.4.1 Appendices

Appendix A - describes the pipe culvert tender item variations to be entered by the designer for "size, type, class" on the "Quantities - Pipe Culverts" sheets for all ministry Contracts.

Appendix B - describes additional pipe culvert design components and is to be used by the designer to accurately identify the pipe culvert installation work in the "Quantities - Pipe Culverts" or other quantity sheets for all ministry Contracts, as appropriate.

Appendix C - lists the available sizes of circular and non-circular pipe culvert and pipe culvert extensions tender items.

## **421.5 SPECIAL PROVISIONS**

Post installation inspection work is a separate tender item detailed in SSP 499S04.

## **421.6 STANDARD DRAWINGS**

Standard Drawings means both OPSD and MTOD. Applicable Standard Drawings are contained in the 800 series of the Standard Drawings.; however, other series may also apply.

## **421.7 DESIGN**

### **421.7.1 Pipe Culvert**

The general alignment, size, type and class of a pipe culvert are established, based on acceptable drainage theory, by the designer. The designer shall use accepted drainage design methods by which to establish the pipe culvert design that satisfies required drainage standards or criteria for the highway project.

As a general rule, pipe culverts, if embedment depths have not been defined through the design process, other than entrance pipe culverts should be embedded to a depth equal to one tenth of the height or diameter of the pipe culvert below the bottom of ditch, unless there are reasons for deviating from this rule.

Gravity pipe drainage standards are available in the MTO Highway Drainage Design Standards. Gravity pipe design requirements, analysis methods and other information are available in the MTO Gravity Pipe Design Guidelines, the MTO Drainage Management Manual and the MTO Guide for Preparing Hydrology Reports for Water Crossings.

#### **421.7.1.1 Size**

The design of a pipe culvert involves determining the size of a pipe, in conjunction with pipe type and class availability that will permit the pipe culvert to function within set design requirements and standards. The designer will also determine the maximum increase or tolerance range in pipe culvert size, of like pipe type and class availability that will still permit the pipe culvert to function within the design parameters set.

For crossings where multiple pipe culverts are required, refer to Appendix B - Additional Pipe Culvert Design Factors for additional information on how to determine spacing and other requirements.

### **421.7.1.2 Type**

Pipe type refers to a pipe's inside wall design, which can be smooth or corrugated. A separate hydraulic analysis of each pipe type to determine hydraulic acceptability is required to determine if both pipe types should be specified in a Contract as alternative pipe type choices. The designer will use hydraulic flow parameters, characteristic of each pipe type, during the hydraulic analysis work. For some sites, only one pipe type may be appropriate for the site conditions.

The designer will analyze a pipe culvert for hydraulic acceptance based on one pipe type for the entire pipe culvert length. Two separate hydraulic design analysis runs are required to determine if both pipe types are hydraulically acceptable.

Only where site circumstances are found to be pipe type sensitive, will it not be necessary for a designer to perform the hydraulic analysis separately for both pipe types.

Circular or non-circular pipe culverts greater than 3000 mm in diameter or span are designed from first principles in conjunction with structural engineers following the requirements of the Canadian Highway Bridge Design Code and the MTO Structural manual.

### **421.7.1.3 Class**

Pipe class refers to the material specifications of the pipe products. These specifications include load and pressure ratings, pipe wall thickness, protective coatings, corrugations and reinforcement. Acceptable material specifications of a pipe culvert are established, based on structural loading and material durability requirements, by the designer. The designer shall use accepted structural and durability assessment methods to establish the pipe class that satisfies both structural and material durability criteria.

#### **A. Structural Assessment**

Pipe culverts, since they are installed underground, are subject to 'dead' and 'live' loads. The loading requirements are addressed through placement of fill material below, around and on top of the pipe culvert. Bedding, cover, embedment in the case of flexible pipes, backfill, subgrade, and pavement are to be considered in the structural loading assessment. The height of fill available will define acceptable pipe sizes, types and classes in terms of structural strength.

#### **B. Durability Assessment**

Pipe culverts, for the different functional highway classifications, must be designed to the specified Design Service Life (DSL) criteria. Every pipe material has an Estimated Material Service Life (EMSL) based on its material properties and the site environment. Acceptable pipe materials are those that have an EMSL greater than or equal to the DSL criteria, unless otherwise determined during the design criteria setting for the project.

Pipe materials with an EMSL less than the DSL criteria may only be considered in a strategic pipe replacement context. A Life Cycle Cost Analysis (LCCA) must be performed to support any pipe replacement design. Standards and Contracts Branch approvals are required to use a pipe replacement design approach as per GPDG.

#### **421.7.1.4 Joints**

The designer, through hydraulic analysis of surface flow or through subsurface information as provided in a foundations or geotechnical report, shall assess the type of pipe joints required for the pipe culvert.

The designer shall refer to the MTO Gravity Pipe Design Guidelines for further information on pipe joint selection requirements.

#### **421.7.1.5 End Finish and Safety**

The use of bevels, end finishes or safety grates on a pipe culvert is determined by the designer based on hydraulic analysis and the final embankment slopes. When corrugated steel pipe is used for a pipe culvert, the protruding end may be cut to blend with the surrounding slopes more aesthetically.

Where traffic safety is an issue, the designer may also consider a safety end treatment on the pipe culvert ends. The designer shall refer to relevant design manuals and any associated Standard Drawings for information on warrants and design of safety end treatments.

#### **421.7.1.6 Treatment**

Frost treatment is required if the frostline falls below the top of the pipe culvert, within the bedding layer or below the bedding layer. Foundations or geotechnical reports shall contain information regarding recommended pipe fill materials and the configuration and extent of frost taper excavations.

Frost tapers are not required when the frostline falls above the pipe culvert. In rock or granular fills, frost tapers are not required.

Pipe culverts being placed on sideroads and entrances that are paved or will be paved, either under the current project or in the foreseeable future, must be provided with frost tapers, where required, regardless of the length of paving (pipe culvert within the limits of paving or future paving).

Information on future sideroad requirements should be obtained from municipalities.

On gravel roads, pipe culverts should not be provided with frost tapers unless specifically identified in a foundations or geotechnical report or requested by the municipality.

Flow sources carrying sediment loads under certain velocity conditions may require lining the pipe culvert invert to prevent abrasion of the pipe material. Lining the pipe culvert invert can be done with concrete or shotcrete material. Bituminous products shall not be used to line the invert of the pipe culvert.

In lieu of a lined invert, the designer may also consider pipe products with thicker walls and/or protective coatings to provide the required protection against abrasive forces.

Fish bearing streams may require channel substrate or baffles to provide suitable conditions for fish to travel through the pipe culvert. The pipe culvert size may need to be larger to properly embed the pipe culvert and provide suitable substrate depth in which to form the low flow channel for fish passage or to accommodate baffle block heights and provide suitable resting zone water depths

and lengths. Baffle configurations and heights may also dictate a larger pipe size to maintain the flow capacity requirements for larger storm events.

The designer shall also refer to the MTO Drainage Management Manual for further information on design of low flow channels and baffles.

#### **421.7.1.7 Concrete Appurtenances**

The flow through a pipe culvert may need to be controlled to prevent erosion damage to the area around it or to the pipe structure itself. Concrete appurtenances such as headwalls, wingwalls, energy dissipators, aprons, collars or other such types of structures are used to direct flow, slow velocities to prevent erosion, offset buoyancy forces, etc. Concrete structures covered by OPSS 904 do not include the aforementioned concrete appurtenances.

Culvert inlet grates shall be considered for each culvert site to prevent debris entering the culvert. The designer shall refer to OPSD 804.050 for design details.

#### **421.7.2 Trench**

##### **421.7.2.1 Excavation**

Excavated earth material may be used for embankment construction or used as native backfill to the excavated pipe culvert trench as determined by the designer based on foundation or geotechnical reports. Surplus or unsuitable excavation material should be managed as outlined in B206 of this manual.

In view of the high unit cost of rock excavation, the designer shall endeavour to reduce the volume of excavation by relocating, pipe skewing, etc., wherever possible. Excavation in rock for placing pipe culverts is also done according to Standard Drawings.

##### **421.7.2.2 Tunnelling, Jacking and Boring Pipe Culverts**

In addition to the open-cut method of installing pipes, there are trenchless methods employed where trenching is not cost-effective:

- a) Open cut installation;
- b) Sliplining;
- c) Diameter reduction sliplining;
- d) Fold and form sliplining;
- e) Cured-in-place pipe (CIPP);
- f) Pipe bursting;
- g) Horizontal drilling (a.k.a., horizontal directional drilling);
- h) Internal joint seals;
- i) Panel and section insert linings;
- j) Chemical grouting;
- k) Full tunnelling and micro-tunnelling;
- l) Auger boring; and
- m) Pipe eating.

### **421.7.2.3 Dewatering**

Dewatering refers to pumping, bailing, groundwater lowering, temporary ditching or vacuum removal of uncontaminated groundwater, rain water, melt water, surface runoff, water pipe leakage from excavations and trenches or within sheeted coffer dams to improve the soil stability or for other construction purposes.

Where dewatering is required for the installation of a pipe culvert, the details shall be according to OPSS 517 or OPSS 902 when specified.

Although the Contractor is responsible for a dewatering plan, the designer shall note any recommendations included in the foundation investigation and design report.

The designer shall also refer to OPSS 100, General Conditions of Contract, Subsection GC 7.10, Approvals and Permits, for additional requirements that may need to be specified in the Contract.

### **421.7.2.4 Fill Material**

Pipe fill material for rigid pipe installations is placed in distinct bedding, cover, and backfill layers. Flexible pipe installations require pipe fill material to be placed as distinct embedment, which is from the bottom of the bedding layer to the bottom of the backfill layer.

Applicable minimum or maximum height of pipe fill material limits are placed in accordance with Standard Drawings Height of Fill tables for the pipe materials identified. The minimum depth of cover for entrance pipe culverts is 300 mm. In rock cuts, this may require lowering of the ditch grade, using pipe arches, or excavating the shatter below the ditch bottom.

A foundation or geotechnical report will include recommendations for the supply, placement, and specifications of pipe fill material or any special conditions for bedding, cover, embedment in the case of flexible pipes, and backfill layers. In addition, special consideration for scour protection at the pipe culvert inlet or outlet may be required.

The designer shall, based on the recommendations of the foundation or geotechnical report, specify the pipe fill materials required for the installation. The designer should be familiar with the various installation methods available as referenced in the 800 series of the Standard Drawings for the pipe culvert installation so that the pipe fill materials recommended are appropriately specified.

The Contractor, not the designer, is responsible for selecting the appropriate pipe culvert installation method, including excavation geometry, at the time of installation based on the soil types found on the construction site in accordance with the Occupational Health and Safety Act and Regulations for Construction Projects.

### **421.7.2.5 Reinstatement**

Where existing driving lanes must be excavated to allow the construction of the pipe culvert crossing, the affected roadbed must be rebuilt to acceptable standards to maintain the continuity of the pavement. This is particularly important where there is to be no resurfacing of the highway. The designer shall determine and specify bedding, cover, embedment in the case of flexible pipe, and backfill depths and materials up to subgrade. Above subgrade, the designer shall determine the types and depths of granular and pavement courses necessary to achieve roadbed integrity.



#### **421.7.2.6 Protection Systems**

These systems will be applicable where the stability, safety or function of an existing roadway, railway, etc., may be threatened or impaired due to the construction of a pipe culvert or in cases where the pipe culvert will be installed at a depth where protection schemes are required.

The design, installation, monitoring of protection systems is the Contractor's responsibility, and the Contractor should base his plan on information as found in foundation reports. Problematic soils, high groundwater tables or other installation issues, if identified, will give rise to recommendations regarding the design, installation and removal and would also be provided in this report. Recommendations for performance levels can also be found in foundation investigation and design reports.

Requirements for field investigation, laboratory testing and engineering recommendations for protection systems are to be specified in the foundation engineering terms of reference for any specific project such that appropriate information for the Contractor is provided.

#### **421.7.2.7 Clay Seals**

Warrants for clay seals to be installed on pipe culverts can be found in the MTO Gravity Pipe Design Guidelines (GPDG). Other physical flow control barrier options are in the GPDG. Recommendations may also be found in a foundation or geotechnical investigation and design report.

#### **421.7.2.8 Camber**

A foundations or geotechnical report will contain information and design requirements for the camber depths needed for flexible pipe installations. Also refer to Appendix B - Additional Pipe Culvert Design Factors for additional information on how to determine the amount of camber depth is required.

### **421.8 COMPUTATION**

#### **421.8.1 Item Payment Basis**

Pipe Culvert, Pipe Culvert Extension, Non-Circular Pipe Culvert, Non-Circular Pipe Culvert Extension, and Concrete Appurtenances tender items are Plan Quantity Payment items.

"Post Installation Inspection" is not a Plan Quantity Payment item.

The CCTV inspection is included in with the following items:

Post Installation Inspection – Item (OPSS PROV 410/421)

#### **421.8.2 Sources of Information**

The main sources of information for pipe culvert items are:

- a) Survey notes and plans that provide profiles along the drainage course at both existing and new pipe culvert locations and drainage courses in addition to drainage areas, mosaic studies, soil types, etc, that provide information to assist in the calculation of pipe culvert sizes.

- b) The MTO Highway Drainage Design Standards provides the overall design criteria requirements of pipe culvert installations.
- c) The GPDG provides DSL criteria, water chemistry testing and pipe material selection procedures and requirements.
- d) The MTO Guide for Preparing Hydrology Reports for Water Crossings provides an overview to the design issues associated with culverts on water crossings.
- e) The MTO Drainage Management Manual provides the overall guidance on the design of pipe culverts and other storm drainage systems.
- f) Foundation or geotechnical reports provide guidance and recommendations on subsurface and groundwater conditions, backfilling requirements, special foundation treatments, camber, articulation, scour protection at the culvert inlets/outlets and the need for placing clay seals. The foundation or geotechnical reports should also provide recommendations regarding dewatering requirements.

### **421.8.3 Methods of Calculation**

The unit of measurement for circular and non-circular pipe culverts is the metre. The price per metre for placing pipe culverts includes the following operations:

- a) Supplying, placing and joining pipe lengths;
- b) Earth excavations for trenches, frost tapers, etc., for pipes, culvert treatments, end finishes and concrete appurtenances;
- c) Supplying, placing and compacting all bedding, cover, embedment in the case of flexible pipes, and backfill materials for pipe culverts;
- d) Dewatering operations, unless otherwise specified;
- e) Design, installation and removal of protection systems, unless otherwise specified;
- f) Reinstating or constructing any highway ancillary elements, not covered under other required works in the Contract, as part of the pipe culvert installation; and
- g) Disposing of all surplus excavated materials.

#### **421.8.3.1 Post Installation Inspection**

The "Post Installation Inspection" tender item is measured based on the linear metres of pipe culverts that are inspected by Closed-Circuit Television (CCTV) Inspection. Post Installation Inspection shall be based on random sampling and to include 25% of the total pipe culvert installations on the Contract.

**421.8.4 Pipe Culvert****421.8.4.1 Length**

The design length (L) of pipe culverts is the distance between the toes of embankment slopes where they meet the streambed profile measured to the nearest full metre. When the space is restricted or short lengths are required, the metric design length of pipe culverts may be determined as the next larger 0.1 metre.

Where pipe culvert end treatment sections are used the length of the end treatment sections added.

While the standard rock slope is 1¼:1, the length of pipe culvert should be based on a rock slope of 1½:1.

Slope flattening should also be considered when calculating the length of pipe culverts.

The length of a pipe culvert is measured horizontally, except when the pipe grade is 10% or steeper, in which case the length is measured along the slope.

**421.8.4.2 Joints**

Pipe joints are inclusive with the work to be done when installing a pipe culvert.

**421.8.4.3 Concrete Appurtenances**

The unit of measurement for concrete appurtenances is the cubic metre. The volume of each appurtenance is computed and the payment in cubic metre covers the cost of supplying and placing both concrete and reinforcing steel. Payment for excavation and backfilling, including the supply of granular material, is included with the associated pipe culvert tender item.

**421.8.5 Trench****421.8.5.1 Excavation**

Earth excavation required to place pipe culverts is part of the cost for placing the pipe culvert. Excavation in earth for placing pipe culverts is done according to Standard Drawings.

Unlike earth excavation, which is included in the bid price of the pipe, rock excavation is tendered as a separate item. Rock excavation uses information for the computation of rock excavation quantities from the foundations or geotechnical reports and soils profiles and field survey notes. The unit of measurement for this tender item is the cubic metre. Rock excavation operations shall be according to OPSS 403 when specified.

Usually, the field survey drainage information contains a profile along the centreline of the pipe culvert, which is used to compute both pipe culvert length and volume of excavation.

When the only information available is a profile along the centreline of the pipe culvert, the excavation is computed as shown in Figure B421-4, which can be found in Appendix B. However, when cross-sections are taken normal to the axis of the projected pipe culvert location, a more accurate computation of the quantity of excavation is obtained.

Where a pipe culvert is installed in a rock cut, the volume of excavation is measured from the top of the shatter.

#### **421.8.5.2 Swamp Excavations**

In swamp areas where existing embankments are being widened, excavate existing embankment and swamp as per OPSS 209 and apply swamp excavation quantities to Earth Excavation (Grading) or Rental of Swamp Excavation Equipment.

#### **421.8.5.3 Dewatering**

Dewatering operations are according to OPSS 517 or OPSS 902 when specified. The designer shall ensure the requirements of OPSS 100, General Conditions of Contract, Subsection GC 7.10, Approvals and Permits, are accounted for.

Should a rare situation occur where it would be unfair to the Contractor to include an expensive dewatering or unwatering operation in his pipe bid price, consideration shall be given to using a separate non-standard tender item for the dewatering. Consultation with the ministry's foundation or geotechnical staff is required prior to use of the non-standard dewatering item.

#### **421.8.5.4 Fill Material**

Granular volumes for frost tapers, bedding, cover, embedment in the case of flexible pipes, and backfill material for pipe culverts are computed as shown in Standard Drawings or from detail drawings when applicable.

Granular materials for concrete appurtenances are included in the pipe culvert granular quantities.

The total granular requirement for each pipe culvert location is computed in cubic metres and may be converted to tonnes using the conversion factor according to CDED B314.8.3 of this manual. This quantity is used for Geotechnical MTO Aggregate Source List purposes only.

### **421.9 DOCUMENTATION**

#### **421.9.1 Drawings**

##### **421.9.1.1 Pipe Culvert**

###### **421.9.1.1.1 Location**

New pipe culverts, and existing pipe culverts requiring extensions or end-sections, are shown on the Contract Drawings, numbered sequentially in the direction of chainage.

Pipe culverts to be removed are not numbered, however details regarding elevation and length of existing pipe culverts are shown crossed out on the drawings.

###### **421.9.1.1.2 End Finishes and Safety End Treatments**

The applicable drawing for such end finishes is shown in the Standard Drawings.

The types of safety slope end treatments are listed in the CPS Master Item list and will be listed as separate tender item in a column on the “Quantities - Pipe Culverts” sheets.

#### **421.9.1.1.3 Concrete Appurtenances**

Concrete Appurtenances are identified on the Contract Plans by means of an arrowed note (e.g., - Concrete Collar), and specifying the Standard Drawings number, or a special drawing, if required, showing the layout.

#### **421.9.1.1.4 Treatment**

Typical cross section drawings must be included in the Contract Drawings giving dimensions and shape of channel substrate materials or fish baffles. Locations of baffles must be shown on a typical profile drawing.

#### **421.9.1.2 Trench**

##### **421.9.1.2.1 Fill Material**

Standard Drawings in the 800 series depict dimensions, classes or types of bedding requirements for circular and non-circular pipes, of which the pipe can be either flexible or rigid.

Typical cross-sections must be included in the Contract Drawings, giving dimensions of frost depth, slope of frost tapers and depth of fill material layers. Because of the variety of possible treatments, Standard Drawings are not considered appropriate.

If special conditions for bedding, cover, embedment in the case of flexible pipes, or backfill materials are required, the appropriate dimensions must be shown on applicable Ontario Provincial Standard Drawings or on detail drawings when applicable.

##### **421.9.1.2.2 Reinstatement**

A typical section, traditionally known as “trench reinstatement,” must be shown on the Contract Plans. The drawing should refer to the applicable Standard Drawing numbers for bedding, cover, embedment in the case of flexible pipe, and backfill up to subgrade specifying the types and depths of pipe fill material necessary to achieve roadbed integrity. Above subgrade, the drawing should specify the types and depths of granular and pavement courses necessary to achieve roadbed integrity. These types and depths may be shown in table format adjacent to the trench reinstatement typical section.

When the Contract is for standalone pipe culvert replacements (i.e., no other pavement rehabilitation or resurfacing work), all of the work to reinstate the roadway, including granular and pavement layers above subgrade, may be included with the pipe culvert item, as per OPSS 492. In this case, the required attributes of the pavement and granular layers (e.g., Superpave traffic category, PGAC grade) shall be shown with the trench reinstatement typical section.

##### **421.9.1.2.3 Special Foundation Treatment**

A detailed typical drawing and/or a modified Standard Drawing will be necessary to show the depth of bedding and location if any special foundation treatment such as cambering, articulation, soil mixing, ground improvement, etc is included in the foundation investigation and design report.

#### 421.9.1.2.4 Protection Systems

Where a separate item for protection systems is required, as recommended by the foundation engineer, the line of protection or a protection system shall be shown on the Contract Drawings depending on the magnitude of the protection required. Performance levels shall be included on the Contract Drawings. These are only approximate lengths or locations, and it is up to the Contractor to design, install, and remove with actual lengths and locations defined.

#### 421.9.1.2.5 Clay Seal

A detailed dimensioned sketch must be shown on the Contract Drawings for each location, based on information from foundations or geotechnical report.

### 421.9.2 Quantities Sheet

The "Quantities - Pipe Culverts" sheet shall show details such as:

1. Culvert Number: numerical identifier of pipe culverts in the Contract Documents.
2. Station: chainage measurement on the Contract Documents.
3. Location: For cross culverts, the relevant alignment control line (e.g., highway centreline) at the identified station with offset positions of pipe culvert upstream and downstream ends designated as the distance in metres left (LT) and right (RT) from the alignment control line (e.g., C/L 31.5 LT - 83.5 RT). For non-cross culverts, the relevant alignment control line at the identified station coincident with the culvert midpoint by length with offset position of pipe culvert upstream and downstream ends designated as the distance in metres left (LT) and/or right (RT) as applicable from the alignment control line (e.g., EB Alignment 25.8 LT - 27.8 LT).
4. Extension: identifies placement of pipe culvert extensions by entering the length of the extension into the appropriate right or left extension column of the "Quantities - Pipe Culverts" sheet. The total length of the extension must also be entered into the appropriate Pipe Culvert Extension tender item column of the "Quantities - Pipe Culverts" sheet.

If an existing culvert is to have both a left and right extension added, each extension is to be entered as a separate record entry with reference to the same culvert number.

5. Skew number: Refer to Appendix B - Pipe Culvert Design Factors for information on how to determine skew number.
6. End Finish: type of end finish to be applied to the pipe culvert which can be square or protruding ends which are applicable to any accepted pipe material. When corrugated steel structural plate pipe is used the protruding end may be cut or bevelled to blend with the surrounding slopes more aesthetically. Steel toe sections may be attached to the end of a smooth or corrugated steel pipe, if required. Refer to relevant Standard Drawings for available end finish options for pipe culverts.
7. Depth to Pipe: from the surface downward to top of base pipe opening at the midpoint by length of the culvert.

8. Pipe Fill Material: Where there are no recommendations from a foundations or geotechnical report to specify any particular pipe fill material, the pipe fill materials will be specified, by default, as “G” for bedding and by extension embedment, and “N” for backfill and cover. The designer does not have to enter any material specifications in the columns to have the default material specifications apply.

However, specific pipe fill material for bedding, cover, embedment in the case of flexible pipes, or backfill, if recommended in a foundations or geotechnical report, shall be specified in the appropriate pipe fill material column. Pipe fill materials shall be specified as follows:

- N - native material, which applies to cover and backfill layers only, and permits Granular B Type I, II or III, or Granular A to be used;
- G - only Granular B Type I, II or III, or Granular A may be used;
- B - only Granular B Type II or Granular A may be used;
- A - only Granular A may be used; and
- C - Unshrinkable Fill (Concrete).

A single letter code is used to indicate the same pipe fill material for a pipe fill layer is suitable for both rigid and flexible pipe options. If using the same pipe fill material is not suitable, two letter codes are used such that the first letter specifies the pipe fill material for rigid pipes while the second letter specifies the pipe fill material for flexible pipes for a pipe fill layer.

The pipe fill material codes are structured in an ascending order of quality. All higher-level codes above the code that is selected are deemed to be satisfactory for the installation. In cases where the higher-level pipe fill materials are not suitable (i.e., different frost susceptibility characteristics), a designer shall insert a contract note to alert the Contractor that only the specified pipe fill material is acceptable.

Embedment for flexible pipes is from the bottom of bedding layer to bottom of backfill layer and is specified in the bedding material column. When only flexible pipes are specified, the pipe fill material cover column is not applicable.

Clear stone may be used as bedding or embedment fill material if groundwater conditions warrant the need. Refer to the MTO Gravity Pipe Design Guidelines for details.

9. Pipe Joints: Types of joints required are to be specified in the appropriately labelled column on the “Quantities - Pipe Culverts” sheet. “S” denotes a joint that is soil tight while “F” denotes a joint that is silt or fines tight and “L” denotes a joint that is watertight. Pipe joints are specified by default as “S” regardless of whether or not the “S” code is entered into the “Pipe Joints” column.

Joint classification is hierarchal in nature so that if an “S” joint is specified, the “F” and “L” joints are also acceptable, unless otherwise stated.

10. Treatment: Type or types of treatment that a pipe culvert will require are to be specified in the appropriately labelled column on the “Quantities - Pipe Culverts” sheet where “F” specifies frost treatment, “P” specifies paved invert, “S” specifies channel substrate placement and “B” specifies baffle placements. All appropriate treatment letters shall be entered in the column.

Up to two letters may be specified in the column of the “Quantities - Pipe Culverts” sheet. Should a third treatment letter be required, a contract note is to be used.

- 11. Upstream and downstream inverts: elevation entries of pipe culvert invert at the upstream and downstream locations. Refer to Appendix B - Pipe Culvert Design Factors for information on how to determine grades and elevations.
- 12. Pipe Culvert Tender Items: Pipe culverts are shown on the “Quantities - Pipe Culverts” sheet using a separate column for each pipe culvert tender item. Each pipe culvert tender item is formatted as shown below:

Circular Pipe Culverts

Size mm Pipe Culverts  
 Size + mm range S xxxxxx  
 Size + mm range C xxxxxx

Pipe Culvert Extensions

Size mm Pipe Culvert Extensions  
 Size S xxxxxx  
 Size C xxxxxx

Non-circular Pipe Culverts

Size mm Non-Circular Pipe Culverts  
 Size + mm S xxxxxx  
 Size + mm C xxxxxx

Non-Circular Pipe Culvert Extensions

Size mm Non-Circular Pipe Culvert Extensions  
 Size S xxxxxx  
 Size C xxxxxx

Different pipe culvert, non-circular pipe culvert, pipe culvert extension and non-circular pipe culvert extension sizes will necessitate entry of separate tender items. Same pipe culvert, non-circular pipe culvert, pipe culvert extension and non-circular pipe culvert extension sizes but with different size tolerance ranges and pipe material codes for different locations will necessitate entry as a composite pipe culvert tender item (e.g., more than one column is required to specify the pipe culvert tender item).

Refer to Appendix A - Pipe Culvert Tender Item for information and guidance of how to define pipe culvert, non-circular pipe culvert, pipe culvert extension and non-circular pipe culvert extension tender items for entry into the “Quantities - Pipe Culverts” sheets.

Refer to Appendix C - CPS Master List of Pipe Culvert Tender Items for a complete list of all pipe culvert, non-circular pipe culvert, pipe culvert extension and non-circular pipe culvert extension tender items to be used in MTO Contracts.

- 13. Pipe Culvert length: The pipe length for each pipe culvert tender item must be entered in the appropriate columns at each pipe culvert location.
- 14. Frost penetration depth must be entered on the “Quantities - Pipe Culverts” sheet.
- 15. Notes that may be required on the “Quantities - Pipe Culverts” sheet

A contract note can be a tender item note, which makes the note applicable to all culvert locations of that pipe size category or can be a quantity item note if it is only applicable to certain culvert locations.

- a) Identified locations where the non-reinforced concrete pipe material is acceptable must be noted.



- b) When corrugated steel pipes are specified and there are two different products permitted, the product with the greater material specifications must be noted at the locations where permitted since minimum material specifications have been identified in the pipe culvert tender item.
- c) All culverts, other than entrance culverts, shall have the non-designed embedment depth equal to one tenth of the height or diameter of the pipe culvert specified through an attached tender item note. Any culvert embedment depths, as determined through design, require a note specifying the embedment depth requirement.
- d) When special culvert end treatments are required, a note shall be provided indicating the culvert end treatment requirement.
- e) The locations of clay seals or other types of physical flow control barriers are to be indicated through a note.
- f) If frost treatment is different than standard 10 (k-d), a note shall be provided indicating the different treatment requirements.
- g) Where camber is required, the pipe culvert number and camber distances must be noted.
- h) When more than two culvert treatments are required, the additional treatments require a note indicating the treatment requirement.
- i) When higher level pipe fill materials are not acceptable, a note shall be provided indicating that only the specified pipe material is acceptable.

#### 16. Other Associated Pipe Culvert quantity items.

To specify other pipe culvert quantity items as discussed below, the designer shall use CPS functional capabilities to enter the requirements into the Contract package. Options may include creation of appropriate tender item columns on specific identified Contract quantity sheets, attachment of standard or non-standard special provisions, or other suitable Contract documentation methods.

- a) Where the installation of a pipe culvert is in a Contract that includes other highway work (i.e., asphalt pavement removal, sidewalk removal, earth excavation, granular and pavement placement), the works above subgrade required in the pipe culvert installation area is included in the tender item for the other highway work. If the Contract has no other highway work, that above subgrade work may be included in the pipe culvert item.
- b) Swamp excavation is included in either "Earth Excavation (Grading)" or "Rental of Swamp Excavation Equipment".
- c) Rock excavation for trenches and associated structures requires a separate entry for each pipe culvert in rock to be shown in the Rock Excavation column of the "Quantities - Pipe Culverts" sheet, and the total quantity transferred to the Tender document. Rock material from trenches and associated structures excavations is shown as "Material Available for Fill" on the "Quantities - Grading" sheet. Rock shatter that must be excavated to place pipe culvert bedding is quantified for payment under this item.  
Rock excavation for pipe sewers is a tender item under OPSS 403:

## 0403-0010 - Rock Excavation for Trenches and Associated Structures

- d) Granular and pavement to be supplied and placed for trench reinstatement would be included with the granular and pavement materials as part of the highway works.
- e) When concrete appurtenances are to be placed on pipe culverts, they are treated as a separate item of work. Concrete appurtenances must be listed for each individual location on the "Quantities - Miscellaneous 1" sheet, or, if there are no other concrete items, they should be listed on the "Quantities - Pipe Culverts" sheet.
- f) Clay Seal is a lump sum item and is identified as a separate tender item without quantity on the "Quantities - Pipe Culverts" sheet. The designation of 100% is recorded for each location and is entered in the tender totals column while the designation LS is entered into the unit column of the quantity sheet.
- g) If dewatering is tendered as a separate item, it shall be entered as a lump sum in the Contract. Ensure that any requirements as specified by OPSS 100, General Conditions of Contract, Subsection GC 7.10, Approvals and Permits, are accounted for in the Contract.
- h) Where recommended by the foundation Engineer, protection systems require separate tender items.
- i) Safety slope end treatments shall be entered into a separate column, if required, on the "Quantities - Pipe Culverts" sheet.

## 17. Post Installation Inspections

Pipe culverts on ministry Contracts may be subject to post installation inspections by CCTV. The following criteria shall be applied to determine if the post installation inspection shall be included in the Contract:

- a) The total combined pipe culvert length of all pipe culvert tender items for a given project, excluding entrance culverts, is greater than or equal to 400 m.
- b) Pipe culvert or a section of one is in difficult to access or environmentally sensitive areas.
- c) When recommended by a project manager or regional contract Engineer.

Post installation inspection work is a separate tender item detailed in SSP 499S04.

When included in the Contract, the number of test segments per pipe sewer tender item shall account for a minimum of 25% of the total number of pipe culvert installations on the Contract.

The payment for post installation inspection item shall be per metre (LS/m).

**421.9.3 Documentation Accuracy**

Stations are recorded to the nearest metre except for unusual circumstances, when 0.1 m may be required. Offsets are usually recorded to the nearest metre, or 0.1 m where required.

Individual pipe design lengths are recorded in whole metres (except 0.1 m where space is restricted and when steel end-sections are used) and placed on the “Quantities - Pipe Culverts” sheet in suitably headed columns.

Pipe culvert extension size, type, and class, for both circular and non-circular, require separate columns based on individual pipe extension sizes, types and pipe material codes. Individual pipe extension design lengths are recorded in whole metres (except 0.1 m where space is restricted).

Invert elevations are recorded in 0.01 m.

Concrete Appurtenances should have concrete quantities and tender totals recorded to 0.1 m<sup>3</sup>.

Clay Seal is a lump sum tender unit of measurement.

## Appendix A - Pipe Culvert Tender Item Variations

### 1. Pipe Culverts

The pipe culvert item is a variation tender item to be entered into a Contract and for circular pipe has been structured to identify: a base pipe diameter; the minimum smooth inner wall diameter plus the upper size range tolerance in mm with associated pipe material code; and, if appropriate, the minimum corrugated inner wall diameter plus the upper size range tolerance in mm with associated pipe material code. This tender item format can fully specify the acceptable pipe products based on size, type and class. The tender item follows the descriptive format as noted below:

|                        |  |
|------------------------|--|
| Size mm Pipe Culvert   | base pipe diameter   |
| Size+mm range S xxxxxx | minimum smooth pipe diameter + tolerance range, type and material code     |
| Size+mm range C xxxxxx | minimum corrugated pipe diameter + tolerance range, type and material code |

The need to insert the pipe diameter for the circular pipe in the item description necessitates a separate tender item for each size of circular pipe culvert.

### 2. Non-Circular Pipe Culverts

Non-circular pipe culvert tender items have been structured to identify: the equivalent circular base pipe diameter to the span and rise dimensions required; the minimum circular equivalent smooth inner wall diameter plus the upper size range tolerance in mm with associated pipe material code; and, if appropriate, the minimum circular equivalent corrugated inner wall diameter plus the upper size range tolerance in mm with associated pipe material code. The designer uses the equivalent circular diameter to identify the appropriate non-circular pipe span and rise dimensions that the non-circular pipe culvert design requires.

This tender item format can fully specify the acceptable pipe products based on size, type, and class. The tender item follows the descriptive format as noted below:

|                                   |   |
|-----------------------------------|---|
| Size mm Non-Circular Pipe Culvert | base pipe span x rise   |
| Size + mm range S xxxxxx          | minimum smooth pipe diameter + tolerance range, type, and material code     |
| Size + mm range C xxxxxx          | minimum corrugated pipe diameter + tolerance range, type, and material code |

The need to insert the equivalent pipe diameter for the non-circular pipe in the item description necessitates a separate tender item for each size of non-circular pipe culvert.

### 3. Pipe Culvert Extensions

A pipe culvert extension is essentially a pipe, circular or non-circular, that is fitted onto the end of an existing culvert in order to lengthen the existing culvert to the desired length.

Circular pipe culvert extension tender items have been structured to identify diameter, type and the required material specifications. The tender item follows the descriptive format as noted below:

|                                |  |
|--------------------------------|--|
| Size mm Pipe Culvert Extension | base pipe diameter                               |
| Size S xxxxxx                  | diameter, smooth pipe type and material code     |
| Size C xxxxxx                  | diameter, corrugated pipe type and material code |

The need to insert the pipe diameter for pipe culvert extensions in the item description necessitates a separate tender item for each size of pipe culvert extension.

### 4. Non-Circular Pipe Culvert Extensions

Non-circular pipe culvert extension tender items have been structured to identify the equivalent diameter, type and the required material specifications. The tender item follows the descriptive format as noted below:

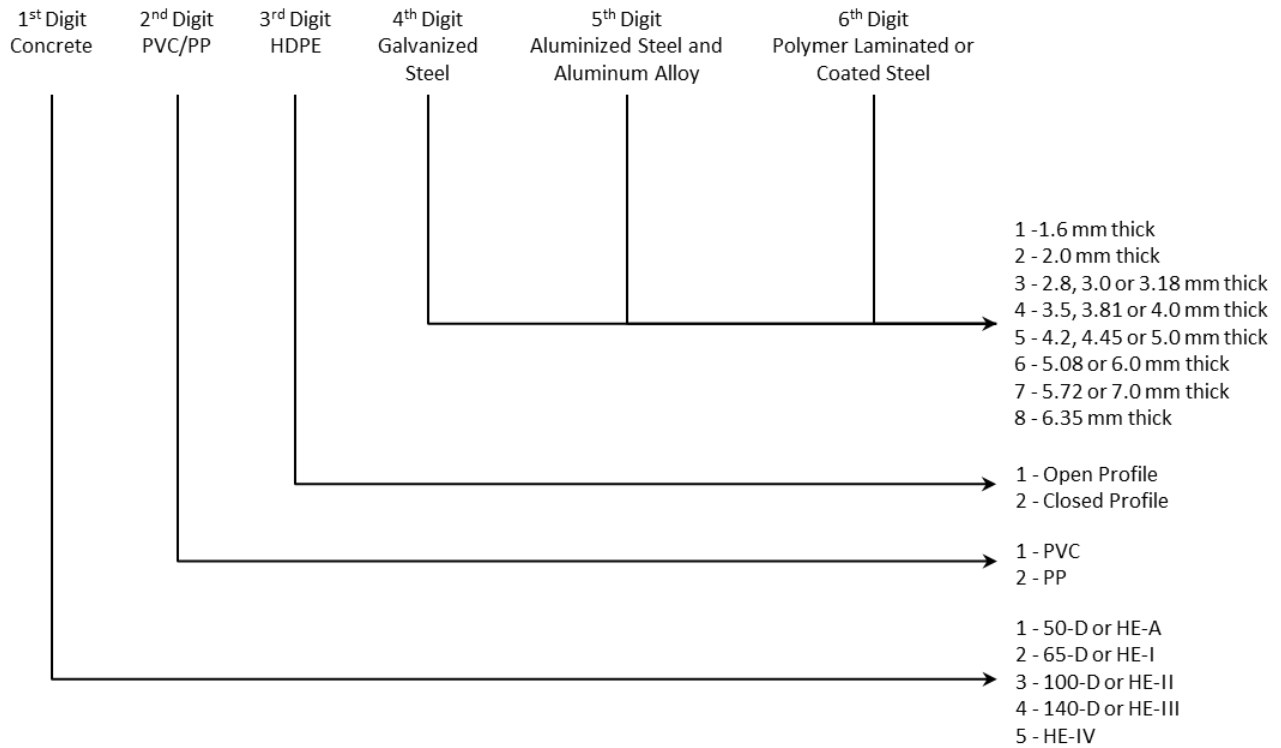
|   |   |
|---|---|
| Size mm Non-Circular Pipe Culvert Extension | base pipe diameter  |
| Size S xxxxxx                               | equivalent diameter, smooth pipe type and material code     |
| Size C xxxxxx                               | equivalent diameter, corrugated pipe type and material code |

The need to insert the equivalent pipe diameter for non-circular pipe culvert extensions in the item description necessitates a separate tender item for each size of non-circular pipe culvert extension.

The pipe culvert material code is a 6-digit code that specifies the minimum material specifications for all acceptable pipe materials identified through design. Each digit represents a pipe material and in turn each digit has different values that specify the material specifications of that pipe material.

### 5. Pipe Culvert Material Code

The Pipe Culvert Material Code is illustrated in Figure 1.0.



**Note:** '0' value for any digit means that the pipe material is not acceptable.  
 Higher pipe material code values are also acceptable, unless otherwise stated.  
 This pipe material code applies to all circular and non-circular pipe materials.

**Pipe Culvert Material Code**  
**Figure 1.0**

The Pipe Culvert Material Code is interpreted in the following manner:

- a) The 1<sup>st</sup> digit represents concrete pipe, both circular and non-circular. For circular concrete pipe, there are two product types for consideration. They are manufactured with reinforcing steel or without. To define the required reinforced concrete pipe, the designer will specify the appropriate values as:

| Specified Value for Circular Pipe | Specified Value for Non-Circular Concrete Pipe |
|-----------------------------------|--|
| 1 for Class 50 D-Load             | 1 for HE-A                                     |
| 2 for Class 65 D-Load             | 2 for HE-I                                     |
| 3 for Class 100 D-Load            | 3 for HE-II                                    |
| 4 for Class 140 D-Load            | 4 for HE-III                                   |
| -                                 | 5 for HE-IV                                    |

To define the required reinforced non-circular concrete pipe, the designer will specify the appropriate values as:

The final concrete pipe class selection shall be dependent on the bedding class that is appropriate for the type of soils encountered at the site.

When specifying any concrete pipe material, the designer should reference the pipe availability tables in Appendix C of the MTO Gravity Pipe Design Guidelines to ensure that the pipe products specified are indeed commercially available in size and load rating.

Exception: The designer shall note the acceptability of non-reinforced concrete pipe products on the "Quantities - Pipe Culverts" sheet in the Contract. This will be done as a note to the tender item to indicate the suitability of this pipe product in all locations or as a note to a quantity if the suitability of non-reinforced concrete pipe only applies to one pipe location.

- b) The 2<sup>nd</sup> digit represents PVC and PP (polypropylene) pipes. There are two PVC product types for consideration. They are manufactured with a smooth inside and a ribbed outside (profile) wall or with a smooth inside and outside (solid) wall.

To define the required PVC pipe, the designer will specify the appropriate value as 1 for all classes (Class 210 kpa (equivalent to SDR 41) or Class 320 kpa (equivalent to SDR 35)) which defines the strength requirement for either product type.

When one of the PVC pipe products is not suitable for a given site, the designer, through a contract note, shall restrict the use of the unsuitable PVC pipe product.

PP pipe product types are manufactured as dual (open profile) and triple wall (closed profile) pipes available in 320 kPa material specifications.

To define the required PP pipe, the designer will specify the appropriate value as 2 for both product types which define the strength requirements for either product type.

The designer should be aware that the 750 mm PP pipe is available in both an open and closed profile. If one of the PP pipe products is not suitable for a given site, the designer, through a contract note, shall restrict the use of the unsuitable PP pipe product.

PP pipe products are automatically specified when the 2<sup>nd</sup> digit pipe material code is 1. If this is not the case for a given site, then the designer, through a contract note, shall restrict the use of PP pipe at the site.

When specifying any PVC or PP pipe material, the designer should reference the pipe availability tables in Appendix C of the MTO Gravity Pipe Design Guidelines to ensure that the pipe products specified are indeed commercially available in size and pipe stiffness rating.

- c) The 3<sup>rd</sup> digit represents HDPE pipes. There are two product types for consideration. They are manufactured with a smooth inside and a corrugated outside wall (open profile) or with a smooth inside and outside wall with a corrugated inner wall (closed profile).

To define the required HDPE pipe, the designer will specify the appropriate value as 1 for open profile pipes and 2 for closed profile.

Closed profile HDPE pipe products are automatically specified when the 3<sup>rd</sup> digit pipe material code is 1. If this is not the case for a given site, then the designer, through a contract note, shall restrict the use of the closed profile HDPE pipe at the site.

When specifying any HDPE pipe material, the designer should reference the pipe availability tables in Appendix C of the MTO Gravity Pipe Design Guidelines to ensure that the pipe products specified are indeed commercially available in size and pipe stiffness.

- d) The 4<sup>th</sup>, 5<sup>th</sup> and 6<sup>th</sup> digits all represent steel and aluminum alloy pipe products. There are three pipe product lines for consideration. They are manufactured as spiral rib steel pipe (SRSP), corrugated steel pipe (CSP), and structural plate pipe (SPP). The SRSP is a smooth pipe while CSP and SPP are corrugated pipes.

SRSP and CSP pipe products come in three coatings; galvanized, aluminized type II and polymer laminated. Steel SPP is available with a galvanized coating and a polymer coating. The SPP is also manufactured from aluminum alloy materials.

The 4th digit is used for specifying required galvanized SRSP, CSP and SPP products. To define the required product the designer shall specify the appropriate value for the applicable wall thickness as follows:

| Product         | Specified Value | Wall Thickness |
|-----------------|-----------------|----------------|
| Galvanized SRSP | 1               | 1.6 mm         |
|                 | 2               | 2.0 mm         |
|                 | 3               | 2.8 mm         |
| Galvanized CSP  | 1               | 1.6 mm         |
|                 | 2               | 2.0 mm         |
|                 | 3               | 2.8 mm         |
|                 | 4               | 3.5 mm         |
|                 | 5               | 4.2 mm         |
| Galvanized SPP  | 3               | 3.0 mm         |
|                 | 4               | 4.0 mm         |
|                 | 5               | 5.0 mm         |
|                 | 6               | 6.0 mm         |
|                 | 7               | 7.0 mm         |



The 5th digit is used for specifying aluminized type II SRSP and CSP pipe products and for specifying aluminum alloy SPP products. To define the required product the designer shall specify the appropriate value for the applicable wall thickness as follows:

| Product                 | Specified Value | Wall Thickness |
|-------------------------|-----------------|----------------|
| Aluminized Type II SRSP | 1               | 1.6 mm         |
|                         | 2               | 2.0 mm         |
|                         | 3               | 2.8 mm         |
| Aluminized Type II CSP  | 1               | 1.6 mm         |
|                         | 2               | 2.0 mm         |
|                         | 3               | 2.8 mm         |
|                         | 4               | 3.5 mm         |
|                         | 5               | 4.2 mm         |
| Aluminum Alloy SPP      | 3               | 3.18 mm        |
|                         | 4               | 3.81 mm        |
|                         | 5               | 4.45 mm        |
|                         | 6               | 5.08 mm        |
|                         | 7               | 5.72 mm        |
|                         | 8               | 6.35 mm        |

The 6th digit is used for specifying polymer laminated or coated SRSP, CSP and SPP products. To define the required product the designer shall specify the appropriate value for the applicable wall thickness as follows:

| Product                          | Specified Value | Wall Thickness |
|----------------------------------|-----------------|----------------|
| Polymer Laminated or Coated SRSP | 1               | 1.6 mm         |
|                                  | 2               | 2.0 mm         |
|                                  | 3               | 2.8 mm         |
| Polymer Laminated or Coated CSP  | 1               | 1.6 mm         |
|                                  | 2               | 2.0 mm         |
|                                  | 3               | 2.8 mm         |
|                                  | 4               | 3.5 mm         |
|                                  | 5               | 4.2 mm         |
| Polymer Laminated or Coated SPP  | 3               | 3.0 mm         |
|                                  | 4               | 4.0 mm         |
|                                  | 5               | 5.0 mm         |
|                                  | 6               | 6.0 mm         |
|                                  | 7               | 7.0 mm         |

When specifying any steel or aluminum alloy pipe materials, the designer should reference the pipe availability tables in Appendix C of the MTO Gravity Pipe Design Guidelines to ensure that the pipe products specified are indeed commercially available in size, protective coating, and wall thickness.

Non-circular steel pipe products shall have the material requirements specified in the same fashion as for circular steel pipe products.

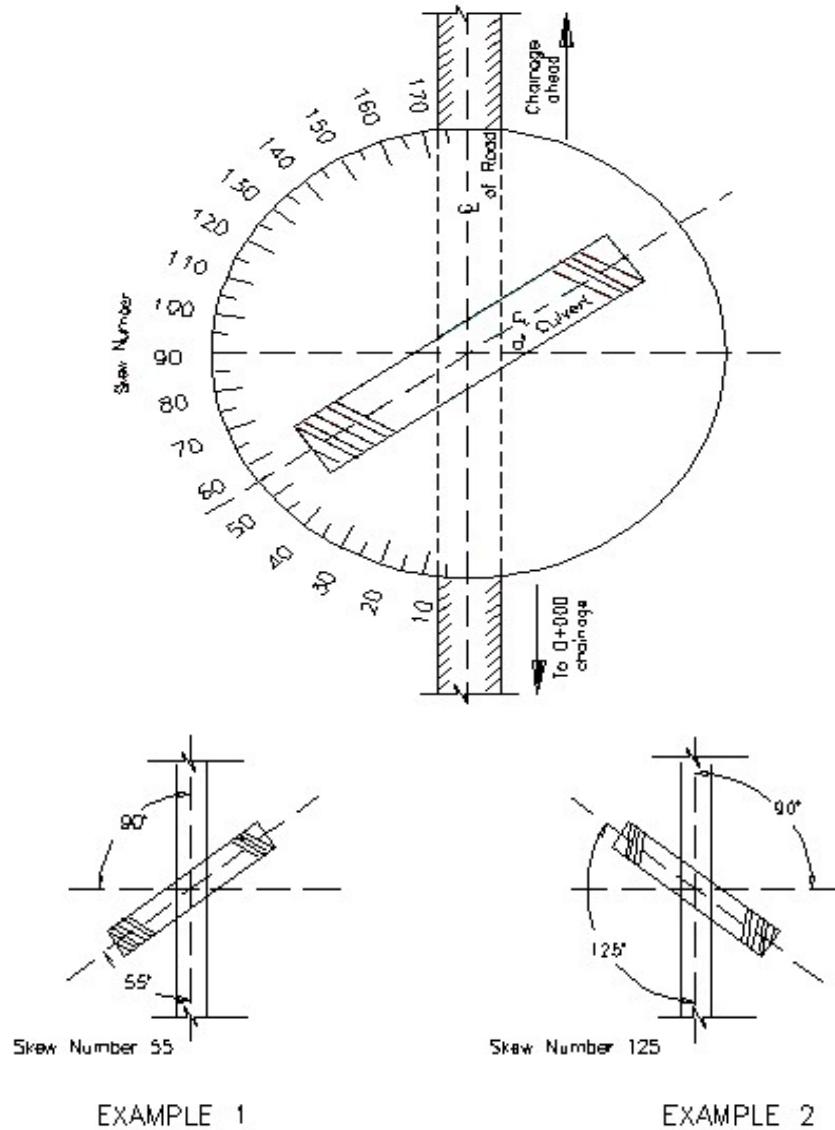
Exception: For some diameters, CSP is available with two corrugation profiles. The pipe material durability analysis may determine a single wall thickness for both CSP product lines, while the structural analysis of the pipe materials determines a different wall thickness for each CSP product lines.

The designer shall identify the minimum wall thickness through the Pipe Material Code and note the greater wall thickness requirement of the other pipe product on the "Quantities - Pipe Culverts" sheet in the Contract. This shall be done as a note to the tender item to indicate the greater wall thickness requirement of this pipe product in all locations on the Contract or as a note to a quantity if the greater wall thickness requirement of this pipe product only applies to one pipe location.

### Appendix B - Additional Pipe Culvert Design Factors

#### 1. Pipe Culvert Alignment

Pipe culvert location and alignment is discussed in detail in the MTO Drainage Management Manual. The crossing often is oblique to the highway centreline and is referred to as being skewed. Referring to Figure B421-1 “Skew Diagram for Pipe Culverts”, the designer will determine the angle of crossing and, from it, assign a “Skew Number”.

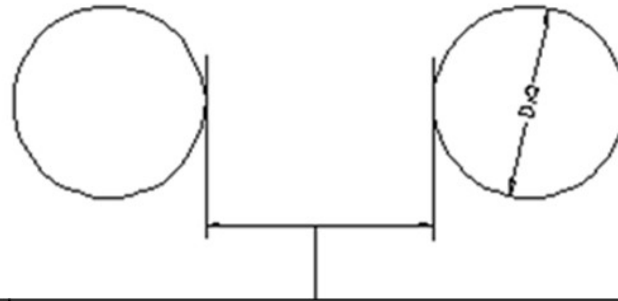


The SKEW NUMBER is obtained by measuring CLOCKWISE, to the nearest degree, the angle between the centreline of the highway and the centreline of the pipe culvert.

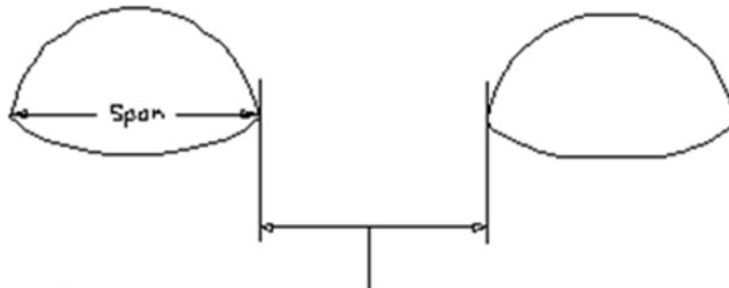
**Skew Diagram for Pipe Culverts  
Figure B421-1**

**2. Multiple Pipe Culvert Installations**

Figure B421-2 “Spacing for Multiple Pipe Culvert Installations” gives the minimum spacing allowed between pipe culverts when placing two or more circular or non-circular pipes in a multiple installation.



| Diameter             | Minimum Space Between Pipes |
|----------------------|-----------------------------|
| Less than 1200 mm    | 600 mm                      |
| 1200 to 2400 mm      | ½ pipe diameter             |
| Greater than 2400 mm | 1200 mm                     |

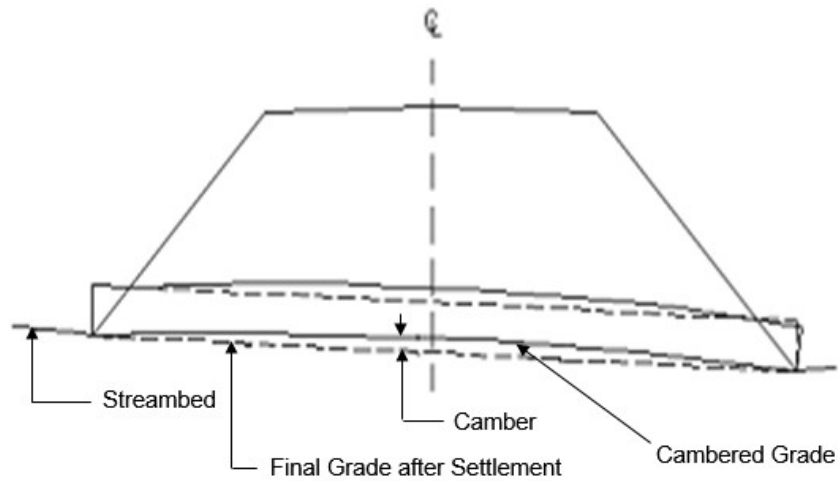


| Span                 | Minimum Space Between Pipe-Arches |
|----------------------|-----------------------------------|
| Less than 1800 mm    | 600 mm                            |
| 1800 to 5110 mm      | 1/3 span of pipe-arch             |
| Greater than 5110 mm | 1600 mm                           |

**Spacing for Multiple Culvert Installations  
Figure B421-2**

### 3. Pipe Culvert Camber

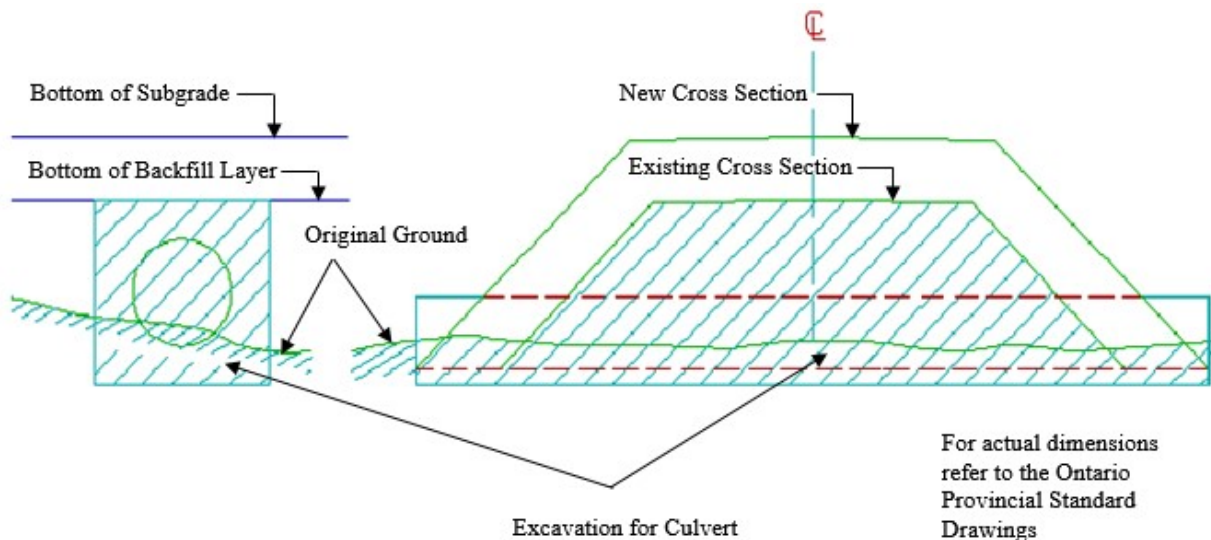
Flexible pipes on compressible soils, especially under high embankments, should be longitudinally cambered (Figure B421-3). This will counteract the effects of differential settlement, to avoid ponding inside the pipe culvert. A geotechnical report shall contain information and recommendations as to the amount of camber required.



**Steel / PVC / HDPE Pipe Camber**  
**Figure B421-3**

### 4. Rock Excavation for Trenches and Associated Structures

Calculations of rock removal are quantified based on the dimensional parameters shown in Figure B421-4.



**Placing of Culvert in Existing Roadbed Under a Reconstruction Project**  
**Figure B421-4**

## Appendix C - CPS Master List of Pipe Culvert Tender Items

The CPS master list contains the pipe culvert tender items and the sizes of pipe that each category represents. The list has been reproduced below for clarity to the designer.

### 1. Circular Pipe Culverts

The pipe size required is selected by the pipe culvert tender item category that it falls into. All circular pipe culvert tender items are selected in this fashion.

| Tender Item Code | CPS Pipe Culvert Tender Item | Culvert Pipe Size Range (mm) |
|------------------|------------------------------|------------------------------|
| 0421-0105        | 100 mm                       | ≥ 100 mm < 200 mm            |
| 0421-0205        | 200 mm                       | ≥ 200 mm < 300 mm            |
| 0421-0305        | 300 mm                       | ≥ 300 mm < 400 mm            |
| 0421-0405        | 400 mm                       | ≥ 400 mm < 500 mm            |
| 0421-0505        | 500 mm                       | ≥ 500 mm < 600 mm            |
| 0421-0605        | 600 mm                       | ≥ 600 mm < 700 mm            |
| 0421-0705        | 700 mm                       | ≥ 700 mm < 800 mm            |
| 0421-0805        | 800 mm                       | ≥ 800 mm < 900 mm            |
| 0421-0905        | 900 mm                       | ≥ 900 mm < 1000 mm           |
| 0421-1005        | 1000 mm                      | ≥ 1000 mm < 1200 mm          |
| 0421-1205        | 1200 mm                      | ≥ 1200 mm < 1300 mm          |
| 0421-1305        | 1300 mm                      | ≥ 1300 mm < 1400 mm          |
| 0421-1405        | 1400 mm                      | ≥ 1400 mm < 1500 mm          |
| 0421-1505        | 1500 mm                      | ≥ 1500 mm < 1600 mm          |
| 0421-1605        | 1600 mm                      | ≥ 1600 mm < 1800 mm          |
| 0421-1805        | 1800 mm                      | ≥ 1800 mm < 1900 mm          |
| 0421-1905        | 1900 mm                      | ≥ 1900 mm < 2000 mm          |
| 0421-2005        | 2000 mm                      | ≥ 2000 mm < 2100 mm          |
| 0421-2105        | 2100 mm                      | ≥ 2100 mm < 2200 mm          |
| 0421-2205        | 2200 mm                      | ≥ 2200 mm < 2400 mm          |
| 0421-2405        | 2400 mm                      | ≥ 2400 mm < 2500 mm          |
| 0421-2505        | 2500 mm                      | ≥ 2500 mm < 2600 mm          |
| 0421-2605        | 2600 mm                      | ≥ 2600 mm < 2700 mm          |
| 0421-2705        | 2700 mm                      | ≥ 2700 mm < 3000 mm          |
| 0421-3005        | 3000 mm                      | = 3000 mm                    |

## 2. Non-Circular Pipe Culverts

The pipe size required is selected by the pipe culvert tender item category that it falls into. All non-circular pipe culvert tender items are selected in this fashion.

| CPS Tender Item Code | CPS Non-Circular Pipe Culvert Tender Item Size | Actual Non-Circular Culvert Pipe Specified Span x Rise Dimensions |                |                |                                     |
|----------------------|--|---|----------------|----------------|-------------------------------------|
|                      |  | CSP Arch Pipe   | SRSP Arch Pipe | SSP Arch Pipe  | Horizontal Elliptical Concrete Pipe |
| 0421-7040            | 400 mm   | -   | 500 × 410 mm   | -              | -                                   |
| 0421-7050            | 500 mm   | 560 × 420 mm  | 580 × 490 mm   | -              | -                                   |
| 0421-7060            | 600 mm   | 680 × 500 mm  | 680 × 540 mm   | -              | -                                   |
| 0421-7070            | 700 mm   | 800 × 580 mm  | 830 × 660 mm   | -              | -                                   |
| 0421-7080            | 800 mm   | 910 × 660 mm  | -              | -              | -                                   |
| 0421-7090            | 900 mm   | 1030 × 740 mm   | 1010 × 790 mm  | -              | 1150 × 730 mm                       |
| 0421-7100            | 1000 mm  | 1150 × 820 mm   | 1160 × 920 mm  | -              | -                                   |
| 0421-7110            | 1100 mm  | -   | -              | -              | 1345 × 855 mm                       |
| 0421-7120            | 1200 mm  | 1390 × 970 mm<br>1330 × 1030 mm                                   | 1340 × 1050 mm | -              | 1535 × 975 mm                       |
| 0421-7130            | 1300 mm  | -   | 1520 × 1200 mm | -              | 1730 × 1095 mm                      |
| 0421-7140            | 1400 mm  | 1630 × 1120 mm<br>1550 × 1220 mm                                  | -              | -              | -                                   |
| 0421-7150            | 1500 mm  | -   | 1670 × 1300 mm | -              | 1920 × 1220 mm                      |
| 0421-7160            | 1600 mm  | 1880 × 1260 mm<br>1780 × 1360 mm                                  | 1850 × 1400 mm | -              | -                                   |
| 0421-7170            | 1700 mm  | -   | -              | -              | 2110 × 1340 mm                      |
| 0421-7180            | 1800 mm  | 2130 × 1400 mm<br>2010 × 1530 mm                                  | -              | 2080 × 1520 mm | 2305 × 1465 mm                      |
| 0421-7190            | 1900 mm  | -   | -              | 2240 × 1630 mm | 2495 × 1585 mm                      |
| 0421-7200            | 2000 mm  | 2230 × 1700 mm  | -              | -              | -                                   |
| 0421-7210            | 2100 mm  | -   | -              | 2440 × 1750 mm | 2690 × 1705 mm                      |
| 0421-7220            | 2200 mm  | 2500 × 1830 mm  | -              | -              | -                                   |
| 0421-7240            | 2400 mm  | 2800 × 1950 mm  | -              | 2590 × 1880 mm | 3070 × 1950 mm                      |
| 0421-7250            | 2500 mm  | -   | -              | 2690 × 2080 mm | -                                   |

### 3. Pipe Culvert Extensions

xxx mm Pipe Culvert Extensions

xxx S xxxxxx

xxx C xxxxxx

The designer selects the pipe culvert tender item and enters the pipe size required for the pipe culvert extension. All pipe culvert extension tender items are selected in this fashion.

| <b>CPS Tender Item Code</b> | <b>CPS Tender Item Title</b>   |
|-----------------------------|--------------------------------|
| 0421-6205                   | 1400 mm Pipe Culvert Extension |
| 0421-6206                   | 1600 mm Pipe Culvert Extension |
| 0421-6207                   | 1800 mm Pipe Culvert Extension |
| 0421-6211                   | 400 mm Pipe Culvert Extension  |
| 0421-6212                   | 500 mm Pipe Culvert Extension  |
| 0421-6213                   | 600 mm Pipe Culvert Extension  |
| 0421-6214                   | 700 mm Pipe Culvert Extension  |
| 0421-6215                   | 800 mm Pipe Culvert Extension  |
| 0421-6216                   | 900 mm Pipe Culvert Extension  |
| 0421-6217                   | 1000 mm Pipe Culvert Extension |
| 0421-6219                   | 1200 mm Pipe Culvert Extension |

### 4. Non-Circular Pipe Culvert Extensions

xxx mm Non-Circular Pipe Culvert Extensions

xxx S xxxxxx

xxx C xxxxxx

The designer selects the pipe culvert tender item and enters the equivalent pipe diameter required for the pipe culvert extension. All non-circular pipe culvert extension tender items are selected in this fashion.

| <b>CPS Tender Item Code</b> | <b>CPS Tender Item Title</b>                |
|-----------------------------|---|
| 0421-6222                   | 500 mm Non-Circular Pipe Culvert Extension  |
| 0421-6223                   | 600 mm Non-Circular Pipe Culvert Extension  |
| 0421-6224                   | 700 mm Non-Circular Pipe Culvert Extension  |
| 0421-6225                   | 800 mm Non-Circular Pipe Culvert Extension  |
| 0421-6226                   | 900 mm Non-Circular Pipe Culvert Extension  |
| 0421-6227                   | 1000 mm Non-Circular Pipe Culvert Extension |
| 0421-6229                   | 1200 mm Non-Circular Pipe Culvert Extension |