CONSTRUCTION SPECIFICATION FOR THE REHABILITATION OF GRAVITY PIPE AND BOX CULVERT BY GLASS-FIBER REINFORCED PLASTIC (GRP) PIPE INSERT LINER

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467.01 SCOPE

This specification covers the requirements for the rehabilitation of an existing pipe culvert, stormsewer, and box culvert using a standalone glass-fiber reinforced plastic (GRP) structural liner through pipe insert lining trenchless technology technique.

467.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 409	Closed-Circuit Television (CCTV) Inspection of Pipelines
OPSS 411	Construction Specification for the Cleaning and Flushing of Culverts, Pipe Sewers, Catchbasins, Maintenance Holes, Ditch Inlets, and Oil-Grit Separators
OPSS 490	Construction Specification for Site Preparation
OPSS 491	Preservation, Protection, and Reconstruction of Existing Facilities
OPSS 510	Construction Specification for Removal
OPSS 517	Construction Specification for Dewatering
OPSS 539	Construction Specification for Temporary Protection Systems
OPSS 919	Formwork and Falsework

Ontario Provincial Standard Specifications, Material

OPSS 1301 Material Specification for Cementing Materials

Ontario Ministry of Transportation Publications

MTO Forms:

PH-CC-701 Request to Proceed
PH-CC-702 Notice to Proceed

ASTM International

C33/C33M-18	Specification for Concrete Aggregates
C39/C39M-21	Test Method for Compressive Strength of Cylindrical Concrete Specimens
D638-22	Test Method for Tensile Properties of Plastics
D695-15	Test Method for Compressive Properties of Rigid Plastics
D790-17	Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
D1598-21	Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure
D2412-21	Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
D2584-18	Test Method for Ignition Loss of Cured Reinforced Resins
D2837-22	Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Design Basis for Thermoplastic Pipe Products
D2990-17	Test Method for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastic
D2992-22	Practice for Obtaining Hydrostatic Pressure Design Basis for “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Fittings
D3262-20	Specification for “Fiberglass” (Glass Fiber Reinforced Thermosetting Resin) Sewer Pipe
D3567-17(2022)	Practice for Determining Dimensions of “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Fittings
D3681-18	Test Method for Chemical Resistance of “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe in a Deflected Condition
D4161-14(2019)	Specification for “Fiberglass” (Glass Fiber Reinforced Thermosetting Resin) Pipe Joints Using Flexible Elastomeric Seals
D 6783-05a(2022)	Specification for Polymer Concrete Pipe
D 6910/D6910M-19	Test Method for Marsh Funnel Viscosity of Construction Slurries

467.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Annular Space means the space between the new inserted pipe and the host pipe or box culvert.

Applicator means a manufacturer-certified product application company for the construction of the GRP insert liner as per the manufacturer’s requirements and to its satisfaction.

Box Culvert means existing culvert constructed of precast reinforced concrete box units rectangular in cross-section.

Bulkheads mean seals constructed at the inlet and outlet of the host pipe or box culvert to seal the annular space and contain the grout.

Design Engineer means the Engineer retained by the Contractor who produces the design and Working Drawings and other engineering documents required of the Contractor.

Glass-fiber Reinforced Plastic (GRP) means a polyester material reinforced with the addition of glass fiber. The composite material is made of two or more different materials, the qualities of which combine to provide superior strength.

GRP Insert Liner means GRP material which acts as a lining inside the host pipe or box culvert. It is being installed through the pipe insert liner trenchless technique by insertion into the host pipe or box culvert and grouting the annular space between the two pipes.

Host Pipe means existing original pipe culvert or sewer to be internally rehabilitated by pipe insert liner.

Liner means a material which acts as a lining inside the host pipe or box culvert.

Non-Destructive Testing means a testing and analysis technique used by the industry to evaluate the properties of a material, component, structure or system without damaging or destroying the object being tested.

Pipe Insert Liner means insertion of a new solid pipe of smaller diameter by pulling or pushing it into the host pipe or box culvert and grouting the annular space. The inserted pipe used may be continuous or a string of discrete pipes.

467.04 DESIGN AND SUBMISSION REQUIREMENTS

467.04.01 Design Requirements

467.04.01.01 Design of GRP Insert Liner

The GRP insert liner shall be designed as a standalone rigid structural liner and is not to rely on the strength of the host pipe/box culvert or the bond with the grout.

467.04.02 Submission Requirements

467.04.02.01 Product Data

The following items shall be submitted to the Contract Administrator a minimum of 2 weeks or as per the Contract Documents, prior to commencement of the GRP insert liner installation:

a) Technical data sheet, including ASTM test results indicating the product conforms to and is suitable for its intended use per these specifications.

b) Project specific guidelines and recommendations including required grout preparations, handling, storage requirements, on-site quality control recommendations, and a list of all materials to be used.

467.04.02.02 Certifications

The following shall be submitted to the Contract Administrator:

a) Certification from the manufacturer that the supplied product meets the product technical specifications and is designed to withstand all conditions specific to the site where the materials will be installed and is suitable for the specified application;

b) An original third-party verification that materials meet physical properties specified for design for short term and long term. The long-term testing shall be in accordance with ASTM standards, minimally ASTM D1598, D2837, and D2990.

c) An original third-party verification of material formulation that all components of the product are styrene and VOC free.

d) Manufacturer’s materials warranty certificate.

e) Installer's job history and reference certificates.

f) Proof of any necessary federal, provincial, or local permits or licenses necessary for the project.

467.04.03 Working Drawings

A minimum of 2 weeks or as specified in the Contract Documents, prior to commencement of the GRP insert liner installation, three copies of written procedures and Working Drawings showing the design calculations and entire work plan for the GRP insert liner rehabilitation of the host pipe or box culvert shall be submitted to the Contract Administrator. Prior to making a submission, the seal and signature of a design Engineer shall be affixed on the written procedures and Working Drawings verifying the drawings are according to the Contract Documents.

The written procedures and Working Drawings shall include the following:

a) The Working Area layout;

b) A work plan outlining the materials, procedures, methods and schedule to be used to execute the work;

c) A work plan including all materials and methods for any repairs necessary to the host pipe or existing box culvert prior to installing the GRP insert liner;

d) A safety plan including the company safety manual and emergency procedures;

e) Material mixture for filling voids and installation procedures;

f) Details of the bulkheads to be used at the ends of the GRP insert liner;

g) Calculations for the theoretical volume of the grout required to fill the annular space based on the pipe specifications and the field measured dimensions of the interior of the host pipe or box culvert;

h) Determine the required dimensional ratio (DR) to withstand the grouting pressure and installation forces;

i) The GRP insert liner size shall be the maximum allowable internal diameter liner size that will fit the host pipe or box culvert as per the manufacture's specifications unless specified in the Contract Documents;

j) Demonstrate, in conjunction with the manufacturer's specifications, that the heat resistance of the pipe material is sufficient to tolerate, without damage, the heat of hydration generated by the grout curing;

k) Dewatering or temporary flow by-pass plan, when specified in the Contract Documents;

l) Work permits required under the authorities having jurisdiction necessary to complete the work;

m) A containment and contingency plan in conformance with the Contract Documents for the following potential conditions:

    i) Improper placement of the GRP insert liner.
    ii) Damage to the host pipe or box culvert.
    iii) The liner's failure to achieve the intended use.
    iv) Potential environmental impacts and emergency containment and clean-up procedures.

467.04.04 Applicator's Qualifications

A certified statement from the manufacturer shall be submitted to the Contract Administrator that the applicator performing the work has been trained and approved in the handling and installing of the product to be used. Certification letter shall be dated within 6 months of the bid date.

467.05 MATERIALS

467.05.01 GRP Insert Liner

The GRP inset liner shall be GRP according to ASTM D3262. The liner material shall provide a Manning's 'n' of less than or equal to 0.012 and hydraulically efficient minimum post-lined hydraulic opening.

The GRP insert liner shall match the shape of the host pipe or box culvert and shall not reduce its hydraulic flow.

No styrene based cured-in-place pipe (CIPP) liner shall be utilized anywhere in the Work and the installed materials shall be 100% styrene free and non-VOC.

467.05.02 Grout

Grout material requirements and allowable grouting pressures shall conform to the GRP insert liner manufacturer's recommendations and specifications.

Grout's density shall be as specified in the submitted design according to the Design and Submission section and site conditions.

Calculations for the theoretical volume of the grout required to fill the annular space based on the GRP insert liner specifications and the field measured dimensions of the interior of the host pipe or box culvert.

Grout shall be sufficient to form a solid gap filling material, prevent ground convergence around the pipe and subsequent ground surface subsidence and prevent long-term water flow at the outside boundary of any pipe/culvert and the ground.

Grout mix design shall be chemically and thermally compatible with all pipe systems.

467.05.03 Delivery of Materials

When the delivered quality of certified GRP insert liner product is deemed to be unacceptable by the Contract Administrator, the product shall be rejected.

467.05.04 Transporting, Unloading, Storing, and Handling Materials

Manufacturer's recommendations for transporting, unloading, storing, and handling of materials shall be followed.

467.06 EQUIPMENT

467.06.01 General

Equipment to complete the Work outlined herein shall follow the GRP insert liner manufacturer's recommendations and specifications.

467.07 CONSTRUCTION

467.07.01 General

The Contract Administrator shall be notified, minimum of 48 hours, in advance of starting the work.

The exact size and length of all existing pipes and culverts to be rehabilitated shall be confirmed prior to installation. All required equipment shall be on-site and in satisfactory working order prior to commencing the installation of a lining section.

Appropriate grouting procedures (e.g. grouting in thin layers with effective pressure controls) shall be adopted during the construction phase to reduce the risk of compromising the structural integrity of the liner pipe and liner flotation.

Any joints shall be as per the manufacturer's recommendations, shall be watertight, interlocking, and shall not increase or decrease the inside or outside diameter of the GRP insert liner.

The product shall be protected from damage during the pullback operation.

The minimum allowable bending radius for the product shall not be exceeded.

467.07.02 Site Preparation

Site preparation shall be according to OPSS 490.

467.07.03 Preservation and Protection of Existing Facilities

Preservation and protection of existing facilities shall be according to OPSS 491.

467.07.04 Dewatering

When required, flow diversion, unwatering/dewatering, shall be installed to fulfill the Contract requirements. Dewatering when required shall be according to OPSS 517.

The Environment Canada weather forecast shall be monitored prior to commencement of lining operations. Where the anticipated weather conditions are such that anticipated host pipe/box culvert flows may exceed the installed bypass pumping capacity or may cause potential site flooding, commencement of construction shall be delayed until favourable weather is forecast.

467.07.05 Temporary Protection Systems

The construction of all protection systems shall be according to OPSS 539.

467.07.06 Cleaning of Host Pipe

The host pipe cleaning shall be according to OPSS 411.

467.07.07 Preparation and Pre-Lining Repairs

Prior to liner installation, the host pipe or box culvert shall be inspected using visual observations or when specified, CCTV/zoom camera, especially where personnel entry is impracticable. CCTV inspection shall be according to OPSS 409.

Any open joints and voids shall be sealed with approved material prior to the lining of the host pipe or box culvert. If required, non-destructive testing (e.g. InSight™ Lite, Backscatter Computed Tomography, endoscope camera inspections, or other testing methods approved by the Contract Administrator) shall be performed to confirm that all identified voids and low density soil areas have been successfully filled with the approved material.

If additional repair procedures are required to restore the host pipe or box culvert for lining, for example invert reconstruction, a repair plan shall be submitted to the Contract Administrator prior to proceeding.

All active infiltration shall be sealed prior to application of the fold and form liner material and ensure that the host pipe or box culvert is sufficiently dewatered as per the manufacturer's instructions.

Additional materials including quick setting mortars, chemical grouts and hydraulic cements necessary to stop infiltration and create a surface for the pipe insert liner shall be applied and shall be in accordance with the relevant standards. All products used to stop active infiltration shall be approved by the Contract Administrator and used in accordance with the manufacturer's recommendations.

The diameter, profile, length and all other dimensions of all host pipes or box culvert to be rehabilitated shall be accurately measure for planning all construction activities and choosing appropriate equipment.

The Contract Administrator shall be provided with the assistance and access necessary to check the layout of the pipe installation and associated appurtenances.

467.07.08 Construction and Operational Constraints

The sections shall be limited in length such that the GRP insert liner can be installed in the space available at the end of the host pipe or box culvert. Any necessary excavation shall be approved in writing by the Contract Administrator prior to commencement of such excavation.

All activities shall be confined to the designated Working Areas.

All work, especially the grouting of the annular space, shall be carried out in dry conditions.

The annular space shall be filled with grout as required to ensure that the space is completely filled and free of air voids. When filling the annulus with shotcrete option is chosen, the design of the shotcrete mix and procedure shall be submitted the Contract Administrator for review and approval.

During the installation process, the maximum axial/compression forces and bending moments shall not exceed tolerable limits of the host pipe or box culvert to avoid damaging the host pipe or box culvert.

Bulkheads shall be constructed at the ends of the host pipe or box culvert in order to contain the flowable concrete used for grouting. The bulkheads shall be designed for the weight of the flowable concrete under pressure. The bulkheads shall be completely removed after the grout has cured.

The actual volume of grout shall be accurately measured during the grouting procedure and compared to the theoretical volume. If volume of the grout placed varies by more than 10% from the theoretical volume, a written explanation for the discrepancy shall be provided to the design Engineer and the Contract Administrator.

Within 24 hours of the grouting of the host pipe or box culvert, MTO form PH-CC-701, Request to Proceed and a letter providing the theoretical and actual grout quantities shall be submitted to the Contract Administrator, confirming that the work was carried out as specified in the Contract Documents. The grouting process will be considered complete only when MTO form PH-CC-702, Notice to Proceed has been received from the Contract Administrator.

If required, the host pipe or box culvert's ends shall be removed and reinstated or replaced to facilitate the installation of the new GRP insert liner. Removals shall be according to OPSS 510.

Streambed material shall be placed to restore the elevation at the culvert ends to match reaches immediate upstream and downstream.

Lateral connections, as may be visible in the pre-lining video inspection, shall be reinstated using remote robotic devices. Only experienced operators shall make robotic connection reinstatements.

467.07.09 Supervision

The Superintendent shall have received adequate training from the technology supplier and shall have a minimum of 3 years demonstrated experience on projects with similar scope and complexity.

467.07.10 Site Restoration

Site restoration shall be according to OPSS 492.

467.07.11 Environmental Protection and Contingency

Environmental protection requirements and mitigation measures shall be according to the Contract Documents with the following additions:

a) Install containment measures to prevent the escape of grout from the host pipe or box culvert undergoing GRP insert liner procedure.

b) Reinstate water flow no sooner than 24 hr after installation of the GRP insert liner and as per the manufacturer's recommended schedule.

c) Capture and properly dispose-off the rinse/first flush water until pH levels are confirmed to be at or below a pH level of 9.

467.07.12 Electrical Equipment, Fixtures and Systems

Electrical equipment shall be suitably insulated for noise reduction. Noise produced by electrical equipment must comply with local municipal noise by-laws.

467.07.13 Management of Excess Materials

Management of excess materials shall be according to the Contract Documents.

467.08 QUALITY ASSURANCE

467.08.01 GRP Insert Liner Material

The GRP insert liner shall be continuous over the entire length of the installation and there should be no infiltration of ground water visible through the liner. There shall be no evidence of splits, cracks, breaks, deformed or separated joints, or crazing in the liner.

All QA sampling and testing of the materials shall be in accordance with applicable ASTM test methods and the manufacturer's specifications and design recommendations to confirm compliance with the requirements specified in the Contract Documents.

The Contract Administrator or designated representative shall witness the sampling and administer as specified in the Contract Documents, except that delivery shall be to the qualified independent testing laboratory retained by the Contract Administrator. Samples shall be delivered to the laboratory within 24 hours of sampling.

In addition to the normal QA/QC associated with GRP production, the Contract Administrator will select at least one panel from each production run to secure test plate samples for thickness measurements and the determination of relevant short term flexural modulus and flexural strength values. The Contractor shall coordinate and pay for the test plate sample testing to confirm the flexural strength, flexural modulus and thickness in accordance with the requirements of ASTM D790 or ISO 11296 and provide the results to the Contract Administrator. Testing and documentation shall conform to the GRP insert liner manufacturer's recommendations.

467.08.02 Grout

All QA sampling and testing of the installed grout shall be in accordance with the applicable ASTM test methods and the grout manufacturer's specifications and design recommendations to confirm compliance with the requirements specified in the Contract Documents.

The Contract Administrator or designated representative shall witness the sampling and administer as specified in the Contract Documents. Samples shall be delivered to the laboratory within 24 hours of sampling.

Samples shall be taken during the actual grouting operations. A minimum of two sets of three cubes shall be cast for quality assurance. One set shall be tested after 7-Days and one set shall be tested after 28-Days. Tests results shall be forwarded immediately to the Contract Administrator.

The Contractor shall cast an additional two sets of cubes to be tested at the discretion of the Contract Administrator for quality assurance purposes.

In addition to the quality control, and testing measures put in place by the Contractor during and following the GRP insert liner operations, if required, non-destructive imaging or mapping shall be performed upon completing the grouting operation for the GRP insert liner as a quality control measure to confirm that the grouting process was completed as specified, and to confirm if any voids are present within the annular space. Imaging or mapping shall be completed using endoscope camera inspections, Inversa System Ltd.'s (Inversa) patented InSight™ Lite and/or Backscatter Computed Tomography (BCT) technologies, or an approved equal. The non-destructive imaging or mapping shall provide clear and conclusive diagnostic imaging, and graphical representation that display the grouting assessment information in a format that is easy to interpret.

Based on the results of field inspection, the non-destructive testing, and the desktop analysis, the Contract Administrator will determine if additional grouting of the annular space is required. If additional grouting is required, the Contractor shall perform the additional grouting as indicated by the Contract Administrator.

467.08.03 Inspection of Materials

The GRP insert liner materials shall be subject to rejection by the Contract Administrator at any time on account of failure to meet any of the requirements in the Contract Documents, even though samples may have been accepted as satisfactory at the place of manufacture. Materials rejected after delivery shall be marked for identification and shall be removed from the job site at once.

467.08.04 Closed-Circuit Television (CCTV) Inspection

Lined host pipe or box culvert with GRP insert liner shall be inspected using visual observations or specified CCTV/zoom camera where personnel entry is impracticable. CCTV inspection shall be according to OPSS 409.

In the case of repairs required to restore the host pipe or box culvert for lining, such as joints sealing, invert reconstruction, or additional repairs etc., a post preparation CCTV inspection shall be completed for each host pipe or box culvert, when specified in the Contract Documents.

467.09 MEASUREMENT FOR PAYMENT

467.09.01 Actual Measurement

467.09.01.01 GRP Insert Liner

Measurement for payment shall be the length in meters of the GRP insert liner placed horizontally, as measured along the centerline of the invert of the host pipe or box culvert.

467.09.02 Plan Quantity Measurement

When measurement is by Plan Quantity, such measurement shall be based on the units shown in the clause under Actual Measurement.

467.10 BASIS OF PAYMENT

467.10.01 GRP Insert Liner - Item

Payment at the Contract price for the above tender items shall be full compensation for all labour, Equipment, and Material to do the work.