



**CONSTRUCTION SPECIFICATION FOR THE
REHABILITATION OF GRAVITY PIPE AND
BOX CULVERT BY CONCRETE CANVAS LINER**

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464.01	SCOPE

This Special Provision covers the requirements for the construction and materials for the application of Concrete Canvas to rehabilitate an existing concrete or Corrugated Steel Pipe (CSP) using an approved Geosynthetic Cementitious Composite Mat (GCCM) Liner.

464.02 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	Cleaning and Flushing of Culverts, Pipe Sewers, Catchbasins, Maintenance Holes, Ditch Inlets, and Oil-Grit Separators
OPSS 490	Site Preparation
OPSS 491	Preservation, Protection, and Reconstruction of Existing Facilities
OPSS 510	Removal
OPSS 517	Dewatering

ASTM International

C33/C33M-18	Specification for Concrete Aggregates
C39/C39M-21	Test Method for Compressive Strength of Cylindrical Concrete Specimens
C78/C78M-22	Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
C267-20	Test methods for Chemical Resistance of Mortars, Grouts, and Monolithic Surfacing and Polymer Concretes
C469/C469M-22	Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression
C473-19	Test Methods for Physical Testing of Gypsum Panel Products
C496/C496M-17	Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens
C666/C666M-15	Test Method for Resistance of Concrete to Rapid Freezing and Thawing
C807-21	Test Method for Time of Setting of Hydraulic Cement Mortar by Modified Vicat Needle
C1090/C1090M-15	Test Method for measuring Changes in Height of Cylindrical Specimens of Hydraulic-Cement Grout
C1138M-19	Test Method for Abrasion Resistance of Concrete (Underwater Method)
C1185-08(2016)	Test Methods for Sampling and Testing Non-Asbestos Fiber-Cement Flat Sheet, Roofing and Siding Shingles, and Clapboards
C1353/C1353M-20e1	Test Method for Abrasion Resistance of Dimension Stone Subjected to Foot Traffic Using a Rotary Platform Abraser
D6460-19	Test Method for Determination of Rolled Erosion Control Product (RECP) Performance in Protecting Earthen Channels from Stormwater-Induced Erosion
D8030/D8030M-19	Practice for Sample Preparation for GCCM
D8058-19	Test Method for Determining the Flexural Strength of a Geosynthetic Cementitious Composite Mat (GCCM) Using the Three-Point-Bending Test
D8329-21	Test Method for Determining of Water/Cementitious Materials Ratio for Geosynthetic Cementitious Composite Mats (GCCMs) and Measurement of the Compressive Strength of the Cementitious Material Contained Within
D8364/D8364M-21	Specification for Geosynthetic Cementitious Composite Mat (GCCM) Materials

American Concrete Institute (ACI):

ACI PRC-305-20	Guide to Hot Weather Concreting
ACI PRC-306-16	Guide to Cold Weather Concreting

464.03 DEFINITIONS

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

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

Concrete Canvas Liner means a flexible concrete impregnated fabric that hardens upon hydration to form a durable concrete layer as a liner. It is also known as GCCM.

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

Geosynthetic Cementitious Composite Mat (GCCM) means a class of geosynthetic material consists of flexible concrete impregnated fabrics that harden on hydration to form a thin, durable, waterproof and fire resultant concrete layer.

Host Pipe means existing pipe culvert or sewer to be internally rehabilitated by installation of the concrete canvas liner.

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

Receiving Site means a certified waste treatment facility, or certified waste disposal site.

464.04 DESIGN AND SUBMISSION REQUIREMENTS

464.04.01 Design Requirements

464.04.01.01 Pre-Work Culvert Survey

The cross-sectional dimensions shall be surveyed along the length of the host pipe or box culvert and verify that the proposed concrete canvas liner can be installed within the host pipe or box culvert with allowance for anchorage and grouting as required.

All dimensions and elevations shall be verified of the host pipe or box culvert on site against the proposed work and report any discrepancies to the Contract Administrator before the start of construction.

464.05.01.02 Concrete Canvas Liner

The concrete canvas liner material shall be compatible with the thermal and chemical conditions of the host pipe. If the manufacturer requires data related to weather, temperature and pH of water at the site, the work shall include acquiring the data and supplying it to the manufacturer.

The finished concrete canvas liner material shall be according to Table 1. The physical requirements must be verified by an independent, certified, third party testing laboratory and must be submitted with the bid package.

464.04.01.02.01 Thickness of Concrete Canvas Liner

The thickness of concrete canvas liner shall be calculated and designed based on the minimum design criteria for a project or as specified in the Contract Documents. The liner's thickness shall correspond to the manufacturer's recommended permissible velocity.

464.04.02 Submission Requirements

464.04.02.01 General

464.04.02.01.01 Product Data

A minimum of 2 weeks or as specified in the Contract Documents, the manufacturer's product data and installation instructions including handling and storage requirements shall be submitted to the Contract Administrator. This submission shall include required substrate preparations, on-site quality control recommendations, and a list of all materials to be used.

464.04.02.01.02 Product Certification

Installation shall be performed by a licensed installer of the fold and form liner. The following shall be submitted to the Contract Administrator:

- a) A letter of certification from the manufacturer that the product meets or exceeds all technical and packaging requirements.

- b) Manufacturer's certifications that materials have been approved for the installation conditions shown on the Contract Drawings and as specified herein.
- c) An original third-party verification of test data for ASTM C666 testing for samples cured 28-days and subjected to 300 cycles.
- d) Manufacturer's Materials Warranty certificate.
- e) Proof of any necessary federal, provincial, or local permits or licenses necessary for the project.

464.04.02.01.03 Applicator's Qualifications

A certified statement shall be submitted from the manufacturer of the concrete canvas liner that the applicator performing the work has been trained and approved in the handling, and installation of the products to be used. Certification letter shall be dated within 6 months of the bid date.

464.04.02.01.04 Working Drawings and Technical Information

An electronic copy and three hard copies shall be submitted of the written procedures and Working Drawings showing the design calculations and entire work plan for the concrete canvas liner rehabilitation of the host pipe to the Contract Administrator a minimum of 2 weeks or as per the Contract Documents, prior to commencement of the concrete canvas liner installation. 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 consistent with 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 traffic control plan;
- d) A safety plan including the company safety manual and emergency procedures;
- e) The requirement or restriction for man entry into the host pipe to perform concrete canvas liner operations shall be specified;
- f) Material mixture and installation procedures for repairs and/or filling voids;
- g) A work plan including all materials and methods for any repairs necessary to the host pipe prior to the concrete canvas liner application;
- h) Method to verify applied thickness of the finished product during the installation of the concrete canvas liner at the hardened state.
- i) Dewatering or temporary flow by-pass plan, when specified in the Contract Documents;
- j) A containment and contingency plan as specified in the Contract Documents for the following potential conditions:
 - i. Improper placement of the concrete canvas liner.
 - ii. Damage to the host pipe.
 - iii. The product's failure to achieve the intended use.
 - iv. Potential environmental impacts and emergency containment and clean-up procedures.

464.05 MATERIALS

464.05.01 Delivery of Materials

Materials shall be delivered in the manufacturer's original, unopened and undamaged packages. Each package shall clearly identify manufacturer, brand name, contents and stock number.

Packages showing indications of damage that may affect condition of contents shall be rejected.

464.05.02 Transporting, Unloading, and Storing

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

464.05.03 Handling of Materials

Concrete canvas liner materials shall be handled according to their safety data sheets (SDS) and in such a manner as to prevent personnel injury and damage to the product or finishes.

464.07 CONSTRUCTION

464.07.01 General

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

The concrete canvas liner shall be installed to match the grade of the host pipe measured at the upstream and downstream inverts.

Prepare for lining by making any necessary repairs to the host pipe such as smoothing out of ragged edges, removal of debris and filling voids with grout, all as per the manufacturer installation requirements.

The host pipe shall be protected from damage during application. All damage shall be corrected expeditiously and repaired to the satisfaction of the Contract Administrator.

The work shall be undertaken such that the watercourse is protected from the entry of any disturbed sediments. Temporary erosion control shall be according to OPSS 804.

All work shall be conducted in the dry. Reinstate channel flow through the host pipe no sooner than 24 hours after the concrete canvas liner installation.

464.07.02 Site Preparation

Site preparation shall be according to OPSS 490.

464.07.03 Preservation and Protection of Existing Facilities

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

464.07.05 Temporary Protection Systems

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

464.07.06 Host Pipe Cleaning

The host pipe or box culvert cleaning shall be according to OPSS 411.

464.07.07 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. CCTV inspection shall be according to OPSS 409.

The surface of the host pipe to be lined shall be capable of directly receiving the concrete canvas liner material. 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, repair plan shall be submitted to the Contract Administrator prior to proceeding.

Additional materials including quick setting mortars, chemical grouts and hydraulic cements necessary to stop infiltration and create a surface for the concrete canvas liner to be applied to may be necessary 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.

464.07.08 Installation of Concrete Canvas Liner

Manufacturer's recommended installation procedures shall be followed.

The batched rolls of concrete canvas liner shall be unrolled transversely across the width of the host pipe or box culvert. The adjacent concrete canvas liner layers shall be overlapped by 100 mm and shingled in the direction of water flow. The overlaps shall be screwed together with 30 mm stainless steel tech screws. The top edges of the concrete canvas liner shall be sealed with a line of grout to prevent water ingress behind the material. The upstream edge of the concrete canvas liner shall be keyed into a trench, secured with gabion stones and backfilled interstices with washed gravel.

All activities shall be confined to the designated Working Areas.

464.07.09 Hydration and Curing of Concrete Canvas Liner

Manufacturer's recommended schedule shall be followed in hydrating and curing of the concrete canvas liner. The material shall be allowed to cure for a minimum of 4 hours and until the material has reached the final set condition, whichever is longer, prior to the release of bypass or flow through the host pipe. The concrete canvas liner shall be sufficiently hydrated and cured. Any surface water diversion/dewatering requirements must remain active until curing and post-construction inspection is complete.

Refer to ACI PRC-305 Guide to Hot Weather Concreting

Refer to ACI PRC-306 Guide to Cold Weather Concreting

464.07.10 Post Installation pH Monitoring

Upon completion of the installation, pH monitoring shall be carried out as water is introduced for the hydration. Any excess water in the host pipe shall be pumped to an upland to infiltrate.

Once the concrete canvas liner has hardened, water shall be pumped through the host pipe, tested, and pumped to an upland until the pH readings are 0.5 units within the range of 6.5 - 8.5, prior to reinstating the flow.

464.07.11 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.

464.07.12 Preservation and Protection of Existing Facilities

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

464.07.13 Site Restoration and Cleanup

Site restoration shall be according to OPSS 492.

464.07.14 Supervision

The project 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.

464.07.15 Environmental Protection and Contingency

Environmental protection requirements and mitigation measures shall according to the Contract Documents. Additionally, the following shall apply:

- a) Install containment measures to prevent the escape of the cementitious dust from the host pipe or box culvert undergoing concrete canvas liner procedure.
- b) Reinstatement water flow no sooner than 24 hr after installation of the concrete canvas liner.
- c) Capture and properly dispose-off the rinse water/first flush water until pH levels are confirmed to be at or below a pH level of 9.

464.07.16 Management of Excess Material

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

464.08 QUALITY ASSURANCE

464.08.01 Concrete Canvas Liner Material

The concrete canvas liner shall be free of all visual and material defects except those resulting from pre-lined conditions. Such conditions shall be brought to the attention of the Contract Administrator prior to the concrete canvas liner installation.

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.

In the event that the concrete canvas liner requires repair, materials used in the repair shall not contain styrene and the thickness of the repair shall not exceed the thickness of one concrete canvas liner.

Appropriate hydration and curing procedures must be adhered to during the installation phase to reduce the risk of compromising the structural integrity of the concrete canvas liner.

464.08.02 Inspection of Materials

The concrete canvas 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.

464.08.03 Closed-Circuit Television (CCTV) Inspection

Lined host pipe or box culvert with concrete canvas liner shall be inspected using visual observations or specified CCTV/zoom camera. 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, when specified in the Contract Documents.

464.08.04 Non-Conforming Work

The Contractor shall be responsible for identifying all non-conforming work. The Contractor shall submit a written proposal for repair or replacement for all non-conforming work identified by either the Contractor or the Contract Administrator. All non-conforming work shall be repaired or replaced according to the submitted written proposal.

464.09 MEASUREMENT FOR PAYMENT

464.09.01 Actual Measurement

464.09.01.01 Concrete Canvas Liner

Measurement for payment shall be the length in meters of the concrete canvas liner installed, as measured along the centerline of the invert of the host pipe or box culvert.

464.09.02 Plan Quantity Measurement

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

464.10 BASIS OF PAYMENT

464.10.01 Concrete Canvas 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.

TABLE 1
Physical Properties of Concrete Canvas Liner

Property	Test Method	Minimum Value	
Compressive Strength	ASTM C39	1 Day	17 MPa
		28 Day	55 MPa
	ASTM C78	7 Day	5 MPa
		8 Day	9 MPa
Flexural Strength - 24hrs from Hydration	ASTM D8058	Initial Break	>4 MPa
		Final Break	>6 MPa
Tensile Strength	ASTM 1185	7 Day	3.3 MPa
Shrinkage	ASTM C1090	28 Day	0% at 65% RH
Modulus of Elasticity	ASTM C469	1 Day	20,000 MPa
		28 Day	35,000 MPa
Bond Strength	ASTM C882 Type II	1 Day	6 MPa
		28 Day	17 MPa
Freeze Thaw Durability	ASTM C666	300 Cycles	100% Zero Loss
Set Time	ASTM C807	Initial	120 min
		Final	240 min
Abrasion Resistance	ASTM C1353	mm/1000 cycles	0.2