Corporate Finance Department
Materials Management Division

186-2015 ADDENDUM 2

NON-CIRCULAR TRUNK SEWER REHABILITATION BY GRP LINING

ISSUED: May 12, 2015
BY: A. Braun
TELEPHONE NO. (204) 928-9216

URGENT

PLEASE FORWARD THIS DOCUMENT TO WHOEVER IS IN POSSESSION OF THE BID OPPORTUNITY

THIS ADDENDUM SHALL BE INCORPORATED INTO THE BID OPPORTUNITY AND SHALL FORM A PART OF THE CONTRACT DOCUMENTS

Template Version: A20150105

Please note the following and attached changes, corrections, additions, deletions, information and/or instructions in connection with the Bid Opportunity, and be governed accordingly. Failure to acknowledge receipt of this Addendum in Paragraph 10 of Form A: Bid may render your Bid non-responsive.

PART A – BID SUBMISSION

Replace: 186-2015 Bid Submission with 186-2015 Addendum 2 - Bid Submission. The following is a summary of changes incorporated in the replacement Bid Submission:

Form B(R1): Revised Item No. 5.

Form G2(R1): Revise expiry date on Page 2 of 2.

PART B – BIDDING PROCEDURES

Revise: B12.4 to read: Further to B12.3(a) the Bidder and/or any proposed Subcontractor undertaking a GRP or CIPP liner installation must be able to demonstrate the following specific qualifications in accordance with B12.6 (Form L: Contractor Experience):

(a) A minimum of three examples of successful non-circular GRP and/or CIPP liner installations with a height greater than 1200 mm.

Add: B12.8 Further to B12.3(a) the Bidder and/or any proposed Subcontractor undertaking to install a bonded FRP liner installation must be able to demonstrate the following specific qualifications in accordance with B12.6 (Form L: Contractor Experience):

(a) A minimum of three examples of successful internal bonded FRP pipe liner installations in pipelines larger than 1200 mm in diameter.

PART D – SUPPLEMENTAL CONDITIONS

Revise: D2.1 to read: The Work to be done under the Contract shall consist of installation of non-circular fully structural liners into trunk sewers on Selkirk Avenue and Archibald Street. Segmental GRP liners as defined in Specification E7 shall be approved for installation on either Selkirk Avenue or Archibald Street. Reinforced CIPP liners as defined in Specification E13 shall be also approved for installation on Selkirk Avenue, while Bond FRP Liners as defined in Specification E14 shall also be approved for installation at the Archibald site.

Revise: D2.2 to read: The major components of the Work are as follows:

(a) Flow control

(b) Developing access to the trunk sewers at each site

(c) Installation of fully structural liners as specified

(d) Closing up trunk access points and backfilling

(e) Site restoration

Add: D3.1(h) "**CIPP**" means cured-in-place pipe

Add: D3.1(i) "**FRP**" means fibre reinforced polymer

Add: D3.1(j) "**CFRP**" means carbon fibre reinforced polymer

Add: D3.1(k) "**GFRP**" means glass fibre reinforced polymer

Revise: D16.3 to read: The City intends to award this Contract by June 26, 2015

PART E – SPECIFICATIONS

Add: E6.4(g) Intermittent/short term flow blockages (i.e. up to 1 day, intermittently) of live sewer services will be permitted on the proviso that building occupants are informed of the blockage and adequate steps are undertaken to ensure sewer service backups do not occur. The Contractor shall be responsible for any damages occurring from sewer service blockages in instances where inadequate or improper notice has been provided.

Revise: E7.4.4(b)(v) to read: Verified long and short term values for flexural modulus, long term flexural strain (measured in the hood direction), long term tensile strength, and shear bond strength, all tested in accordance with IGN-4-34-02.

Revise: E7.4.4(b)(vi) to read: Calculate dead load based on soil density of 1920 kg/m^3 and applied dead and live load formula from, Clause X.1.2.2 of Appendix X1 of ASTM F1216. Include an allowance for an AASHTO HS20 concentrated live load in the total external pressure on the pipe. Notwithstanding the requirements outlined herein, the minimum external soil load applied at the crown of the pipe for each site shall be:

- Mission Trunk: 0.132 MPa
- Selkirk Avenue Trunk: 0.123 MPa

Revise: E7.4.5(b)(iii) to read: Verified long and short term values for flexural modulus, long term flexural strain (measured in the hood direction), and long term tensile strength, all tested in accordance with IGN-4-34-02.

Revise: E7.4.4(b)(iv) to read: Calculate dead load based on soil density of 1920 kg/m^3 and applied dead and live load formula from, Clause X.1.2.2 of Appendix X1 of ASTM F1216. Include an allowance for an AASHTO HS20 concentrated live load in the total external pressure on the pipe. Notwithstanding the requirements outlined herein, the minimum external soil load applied at the crown of the pipe for each site shall be:

- Mission Trunk: 0.132 MPa
- Selkirk Avenue Trunk: 0.123 MPa

Revise: E7.6.2 to read: GRP Liner Performance Requirements

(a) GRP Liners shall meet the greater of the Performance Requirements noted in Table 1 of Section 8 of IGN No. 4-34-02 or the project specific design requirements. The manufacturer shall demonstrate Type Testing results to confirm conformance with both the IGN specification and production run testing. Type testing shall be required for confirmation of all short and long term properties in Table 1 (Section 9, Clauses 9.2, 9.3, 9.4, 9.5, and 9.6), while production run tests are also required to substantiate short term properties for short term flexural modulus and strength. Shear bond testing shall be carried out on a production run basis as noted herein.

Add: E7.6.5 Quality Control Testing for Cementitious Grout for Type 1 Installation

(a) Quality control for cementitious grouting materials for Type 1 installations shall conform to Chapter 8 of ACI 229, expect as modified herein.

(b) Confirm flow consistency of grout mixture in accordance with ASTM D6103 or ASTM C939 to ensure conformance with the submitted grouting plan and shear bond tests. Flow properties of grout shall be checked a minimum of once per production run, for every 25 m^3, or once per 30 minutes, whichever is more frequent.

(c) Prepare Quality Control samples for density in accordance with ASTM D6023. Grout density shall be measured and recorded once per production run, for every 25 m^3, or once per 30 minutes, whichever is more frequent. The density shall be maintained within +/- 10 % of the design density. Test samples in accordance to ASTM D6023.

(d) Prepare quality control samples for compressive strength in accordance with ASTM D4832. Prepare a minimum of two (2) 150 mm by 300 mm test cylinders for each production run, or every 25 m^3, whichever is more frequent. The Contractor shall arrange to have cylinders tested at an approved testing facility in accordance with ASTM D4832.

Add: E7.6.6 Shear Bond Testing

(a) Shear bond testing for Type I liner designs shall be undertaken in accordance with Appendix D of IGN-4-34-02. Shear bond testing is only required for Type I GRP liner designs. Intent of shear bond testing is to verify the shear bond values used in the GRP liner design. As long as the GRP product and cementitious grout is the same for both sites, one set of shear bond testing as per Clause D.3.2 of IGN No. 4-34-02 will suffice for the project. Where different grout mixtures or GRP products are proposed, separate shear bonds tests will be required.

(b) Shear bond testing shall be undertaken under the direction of Dr. Mark Knight of the University of Waterloo (1-519-888-4567 Ext:36919) or approved alternative testing facility in accordance with B7. The Owner shall pay for the initial round of shear bond tests. Any additional testing required as a result of not meeting design requirements, shall be carried out at the Contractor's expense.

(c) Shear bond testing shall be completed a minimum of ten (10) Business Days prior to commencement of lining work on site.

(d) The Contractor shall arrange with the testing laboratory to facilitate casting of the test samples. Test samples shall be cast with the same grout mix and constituent materials proposed in the grouting submission.

(e) The testing laboratory shall submit a test report in accordance with IGN-4-34-02.

Revise: E7.9.1(a) to read: Pre-Design Inspection: As required to determine size and shape of host pipe and liner in accordance with E7.9.4. Undertake Pre-Design inspection prior to manufacture of liner. No coding submission required. Control flow only as required to adequately determine the host pipe dimensions.

Revise: E7.9.1(d) to read: Warranty Inspection: Before expiration of the warranty period and acceptance. No coding required. Control flow not required.

Revise: E7.13.5 (a) to read: Liner installation will be measured on a length basis for each size and paid for at the Contract Unit Price for "Supply and Install Structural Sewer Liner". Length to be paid for will be the total number of liner meters of GRP liner supplied and installed in accordance with this specification, accepted and measured by the Contract Administrator.

Revise: E7.13.5 (b) to read: Measurement for the supply and installation of GRP liners will be made horizontally at grade, above the centreline of the pipe from centre to centre of manholes or termination of the liner, whichever is longer.

Revise: E7.13.5(c) to read: Eighty (80) percent of the payment will be made upon satisfactory completion of the GRP installation work. The remaining twenty (20) percent of the payment will be made upon confirmation of the grout strength and delivery and acceptance of all required submissions, Shop Drawings, and reports.

Add: E9.4(f) Shaft locations shown on the drawings are approximate only and may be adjusted to facilitate construction. Confirm shaft locations with Contract Administrator prior to commencement of shaft construction.

Add: E9.5(c) Piles (if used) shall be installed with a minimum of 500 mm of clear separation between the pile and the outside of the existing sewer wall.

Add: E9.5(d) Locate the extents of the existing sewer prior to pre boring and installing shoring using soft dig methods. Please note the wall thicknesses and outside diameter of the existing trunk sewers are unknown.

Add: **E13. CURED-IN-PLACE PIPE (CIPP)**

E13.1 Description

(a) As an alternative to segmental GRP lining the Contractor may elect to rehabilitate the Selkirk Avenue Trunk using CIPP.

(b) This specification covers the supply and installation of full segment CIPP.

E13.2 Definitions

(a) Cured-in-place-pipe (CIPP) means trenchless sewer rehabilitation by installing a resin-felt composite structure which when cured will form a continuous-close fit liner within an existing sewer.

(b) Full segment CIPP means CIPP extending from manhole to manhole or manhole to node (wye or tee connection to another sewer).

(c) Minimum material requirements for CIPP shall conform to ASTM D5813 “Standard Specification for Cured-In-Place Thermosetting Resin Sewer Pipe” and the supplemental requirements noted herein.

E13.3 Materials

E13.3.1 Reinforced CIPP Products

(a) Reinforced CIPP products shall conform to the requirements of ASTM F2019. Notwithstanding ATSM F2019, the fabric tube may be reinforced with either glass or carbon fibres, as required to achieve the desired long term material properties.

E13.3.2 CIPP Design Objectives

(a) Maximize the structural enhancement of the sewer by installing a close-fit CIPP.

(b) Maintain or increase the hydraulic capacity of the rehabilitated sewer.

(c) Reduce infiltration and exfiltration.

(d) Prevent root intrusion.

(e) Provide sufficient chemical resistance to prevent further sewer pipe degradation related to the conveyance of sewage.

(f) Minimize sewer service disruption during rehabilitation.

(g) Minimize the time required to complete the sewer rehabilitation.

(h) Minimize disturbance to pavements and boulevards.

(i) Minimize disruption to vehicular and pedestrian traffic.

(j) Minimize the impact of construction on commercial, industrial, and institutional facilities.

(k) Select CIPP and plan approach to rehabilitation toward maximizing the achievement of these design objectives.

E13.3.3 CIPP Design – General

(a) Minimum design life of 50 years.

(b) Design CIPP as a low head pipe in a fully deteriorated pipe condition using depths of cover calculated from the pipe profile provided on the Drawings.

(c) Size CIPP in accordance with the design objectives to provide a close-fit to the host pipe with no annulus except for the maximum allowable diametric shrinkage due to curing permitted in ASTM D5813.

(d) Maximise hydraulic capacity of the lined sewer section. Complete hydraulic design checks in accordance with E7.4.3. Ensure design meets the hydraulic requirements set forth in E7.4.3. Utilize a "ks' value of 0.03 mm for the CIPP liner.

E13.3.4 Non-Circular CIPP Design – Fully Deteriorated Condition

(a) Design CIPP for a fully deteriorated pipe condition in as a non-circular Type II liner in accordance with Section 5 of Volume II – Sewer Renovation, WRc Sewerage Rehabilitation Manual, 4th Edition. The design shall consider full overburden loads using the following minimum design assumptions.

(i) Calculate live load using an AASHTO HS 20 design vehicle in accordance with AASHTO LRFD Bridge Design Specifications.

(ii) Calculate dead load based on soil density of 1920 kg/m^3.

(iii) Groundwater table is 2.0 m below the existing ground surface.

(iv) Long-term value for flexural modulus of elasticity will be considered to be the projected value at 50 years of a continuous application of the design load based on the specific resin and felt composite as established by ASTM D2990 and approved for use in the pre-qualification process. Physical properties shall be verified by third party testing agency.

(v) Calculate external loads using the applied dead and live load formula from, Clause X.1.2.2 of Appendix X1 of ASTM F1216. Notwithstanding the requirements outlined herein, the minimum external soil load applied at the crown of the pipe for each site shall be:

- Mission Trunk: 0.132 MPa
- Selkirk Avenue Trunk: 0.123 MPa

(vi) Minimum factor of safety (N) of 2.

E13.3.5 Submittals Before Starting Work

(a) Provide the required submittals to the Contract Administrator a minimum of twenty (20) Business Days before starting the lining in accordance with E2.

(b) Submit the CIPP design Shop Drawings. Designs shall be sealed and signed by a Professional Engineer licensed to practice in the Province of Manitoba and include the following information.

(i) CIPP thickness computations including all specified design checks. Identify design assumptions based on a review of the Sewer Maintenance Inspection that differ from the information provided in the Specifications for the existing sewer design conditions.

(ii) Calculations showing the hydraulic capacity of the CIPP sewer will be equal to or greater than the existing sewer.

(iii) Name and manufacturer of the resin and tube proposed for each CIPP.

(iv) CIPP curing schedule provided by the resin supplier indicating the temperature, staging, duration and pressure required to achieve a proper cure of the resin and fabric tube composite.

(v) Other information that may reasonably be required by the Contract Administrator to confirm the CIPP design proposed conforms to the specified requirements and design intent.

(c) Provide resin samples as follows:

(i) Arrange for the manufacturer of the resin to forward a reference sample of each type of resin proposed for use on the works to a test laboratory designated by the Contract

Administrator to be used as a comparative reference sample for infrared spectrum testing.

(ii) Deliver a representative sample from each resin batch to be used on the project before adding the catalyst from the wet-out facility to a test laboratory designated by the Contract Administrator.

(iii) If necessary, the Contract Administrator will arrange and pay for an infrared analysis of the samples.

(d) Submit an operations protocol that provides information on the following.

(i) Resin impregnation method.

(ii) Designated location of the wet out facility.

(iii) Documentation the resin to be used has not exceeded its shelf life as recommended by the manufacturer of the resin.

(iv) Volume and weight of resin to be impregnated into each liner and repair section including the proposed excess allowance for polymerization and migration into cracks and joints of the host pipe.

(v) Roller gap setting required to provide the final installed CIPP thickness based on the proposed volume of resin.

(e) Submit a construction protocol providing the following information:

(i) Minimum pressure to hold the tube tight against the existing sewer and the maximum pressure to not damage the sewer or uncured liner.

(ii) Provide the maximum allowable axial and longitudinal tensile stress for the fabric tube and the arrangement for monitoring pull-in forces during installation if liner insertion is to be by pull-in methods.

(iii) Number and location of heat source monitor gauges.

(iv) Minimum and maximum allowable temperature during each phase of the cure period as measured at the heat source return line.

(v) Number of stages and anticipated time for each stage of the curing period based on resin supplier's recommendations.

(vi) Estimated length of time required to reinstate the main line sewer and sewer services.

E13.4 Construction Methods

E13.4.1 Verification of Existing Sewer Dimensions

(a) Verify dimensional requirements of each sewer to be rehabilitated prior to manufacture of the CIPP tube as follows.

(i) Length of sewer from manhole to manhole for full segment CIPP.

(ii) Diameter and cross-section of the sewer at the upstream and downstream manholes and at sufficient intervals along the length of the sewer to be lined to confirm the size of liner required to form a "close-fit" with the host pipe.

(b) Existing sewer dimensions shall be measured so as to accurately size the CIPP liner to facilitate installation of a "close-fit" liner.

(c) Alternatively, existing sewer dimensions may be measured by using sufficiently accurate laser profiling technology that is specifically designed to quantify dimensional requirements for this application.

E13.4.2 Sewer Cleaning and Prep Work

(a) Remove loose and solid debris in accordance with CW 2140 to adequately prepare the sewer for lining.

(b) Repair all major defects in the existing sewer to ensure a smooth and uniform final product. This shall include but is not limited to:

(i) Filling external voids, refer to E7.10(c)

(ii) Restore the sewer invert to provide a smooth and uniform invert, refer to E7.10(d)

(iii) Repair any spalled concrete or other defects which may impact installation of the CIPP liner

(iv) At locations of crown inversion, apply a cementitious or polymer grout product to provide a smooth transition to the non-deformed section of the sewer.

E13.4.3 Sewer Inspections

(a) In addition to the sewer inspections required in E7.9.1 the Contractor shall complete a post design inspection for CIPP liners. The intention of the post-design inspection is to confirm the as-built dimensions of the CIPP. No coding submission will be required for the post-design inspection.

E13.4.4 Installation of CIPP

(a) Install liners by inversion methods in accordance with ASTM F1216 or by pull-in methods in accordance with ASTM F2019.

(b) Full segment and partial full segment CIPP shall be cured by hot water or steam.

(c) Carry out workmanship in accordance with ASTM D5813.

(d) Trim ends of CIPP neatly to fit flush with interior vertical surface and manhole benching and seal to make watertight.

(e) Fill annular spaces where the CIPP does not make an adequate seal with the host pipe at manholes, termination points and sewer services due to broken or misaligned pipe with a resin mixture compatible with the CIPP.

E13.4.5 CIPP Closures

(a) At CIPP launch shafts where CIPP liners cannot practically provide a fully restored sewer invert the Contractor shall restore the existing host pipe up to interface with cast-in-place concrete closure using a hand layup, bonded FRP liner. Provide a smooth transition from CIPP to FRP liner. Complete bonded FRP liner installation in accordance with E14. The invert section of the closure shall form a smooth transition between each CIPP section.

E13.4.6 Quality Control Records

(a) Maintain the following Quality Control records of the work and provide to the Contract Administrator after completion of the work.

(i) Summary of the resin impregnation process including:

- Volume of resin supplied.
- Excess quantity of resin added during the wet out to account for polymerization and migration into the host pipe.
- Roller gap setting.
- Resin catalyst(s) used.
- Time and location of the wet out.
- Means taken to store and transport the resin impregnated CIPP from the wet out facility to the job site.

(ii) Means of curing liners.

(iii) Continuous log of pressure maintained in the liner during the curing period.

(iv) Pulling force used to pull or winch CIPP into place in the host sewer and measured liner elongation.

(v) Continuous log of temperature at boiler in and out and at all thermistors placed between the host pipe and the liner at all manholes during the initial cure, cure, and cool down periods.

E13.4.7 Confined Test Samples

(a) In lieu of a confined test sample, if feasible, remove a section of representatively installed CIPP within the closure section area, large enough to facilitate testing. Repair the area in conjunction with repair of the closure section.

(b) The Contract Administrator will coordinate and pay for initial CIPP sample testing (under this and Clause 13.4.8) to confirm the CIPP flexural strength, flexural modulus and thickness in accordance with the requirements of ASTM D5813, D790, and ASTM D3567. Any supplemental testing required due to non-conformance with design intent will be carried out at the Contractor's expense.

E13.4.8 Test Plate Samples

(a) Obtain and provide the Contract Administrator with test plate samples of each CIPP installation.

(b) Prepare test plate samples on-site from the actual CIPP and cure in the following manner:

(i) in a clamped mold placed in the downtube or manhole for water-cured liners.

(ii) In a clamped mold placed in a container filled with uniformly distributed steam from the installation manhole for steam-cured liners.

(c) The Contract Administrator will coordinate and pay for test plate sample testing to confirm the flexural strength, flexural modulus and thickness in accordance with the requirements of ASTM D5813, D790, and D3567.

(d) Flexural strength and flexural modulus results obtained from test plates will be reduced by the maximum percentage difference of the confined pipe and test plate samples prepared from the same CIPP system for at least 3 previous CIPP linings on the same project.

(e) Obtain and provide the Contract Administrator with pre and post lining measurements taken in accordance with Clause E13.4.1 of this specification to confirm in-place liner thickness.

(f) The Contract Administrator will review liner thickness results taken from test plates or unconfined samples on a case-by-case basis.

E13.4.9 Infrared Spectroscopy

(a) If required, the Contract Administrator will arrange and pay for testing to compare the infrared spectrum of the resin field samples supplied from the wet-out to the reference spectrum generated from the resin sample provided by the resin manufacturer to verify installed material acceptability.

E13.4.10 Post Construction Design Review for Total Performance

(a) The Contract Administrator will perform a post-construction design review to ensure that the completed CIPP meets the 50 year design life structural requirements prior to Total Performance. The design review will utilize the measured values for flexural strength, flexural modulus, and CIPP thickness from the confined pipe sample testing or the reduced strength/modulus values obtained from the test plate testing in circumstances where confined pipe samples are not able to be secured.

(b) CIPP strength values will be further reduced to account for creep based on the creep reduction values recommended in the pre-qualification submissions to assess the suitability of the liner to meet the 50 year design life requirement. The use of full enhancement factors in this analysis will be limited to liners that are confirmed by visual classification to be close-fit liners based on the post-lining sewer inspection.

(c) The Contract Administrator will advise of any discrepancies between the constructed CIPP and the design requirements.

(d) Perform necessary remedial measures to confirm that a CIPP deemed as structurally deficient will comply with the 50 year design life requirement such as confirmation of actual ovality, determination of a more representative groundwater elevation locally through monitoring, and supplemental strength testing and thickness measurements.

(e) Install a supplemental CIPP of the required thickness to structurally enhance the installed CIPP if supplemental testing fails to confirm the CIPP will meet the 50 year design life requirement.

(f) Review remedial action with the Contract Administrator prior to implementation.

(g) Perform further testing, monitoring and calculations and install structural enhancements at own cost.

E13.5 Measurement and Payment

E13.5.1 Sewer Inspections

(a) Post-Design sewer inspection shall be considered incidental to “Supply and Installation Structural Sewer Liner” and will not be measured for payment. No additional payment will be made.

E13.5.2 CIPP Installation

(a) Liner installation will be measured on a length basis for each size and paid for at the Contract Unit Price for “Supply and Install Structural Sewer Liner”. Length to be paid for will be the total length of CIPP supplied and installed in accordance with this specification, accepted and measured by the Contract Administrator.

(b) Measurement for the supply and installation of full segment CIPP liners will be made horizontally at grade, above the centreline of the pipe from centre to centre of manholes or termination of the liner, whichever is longer.

(c) Eighty (80) percent of the payment will be made upon satisfactory completion of the CIPP installation work. The remaining twenty (20) percent of the payment will be made upon confirmation of the CIPP strength and delivery and acceptance of all required submissions, shop drawings, and reports.

(d) Payment for the supply and installation of CIPP shall include but is not limited to the following:

(i) Verification of existing sewer dimensions
(ii) Submittals, including: CIPP designs, material samples, material testing, operations protocol, and construction protocol
(iii) All required sewer preparation work
(iv) Supply and installation of CIPP
(v) Reinstatement of sewer services
(vi) Transitions at liner termination
(vii) Test samples
(viii) Quality control testing and records

Add: **E14 BONDED FRP LINER**

E14.1 Description

(a) As an alternative to segmental GRP lining the Contractor may elect to rehabilitate the Mission Trunk using a bonded, hand applied FRP liner.

(b) This specification covers the supply and installation of bonded, hand applied FRP liners.

E14.2 Definitions

E14.2.1 Fibre reinforced polymer (FRP) lining means trenchless sewer rehabilitation by installing an FRP laminate liner structure to form a continuous bonded liner within the existing sewer.

E14.3 Bonded FRP Liner Design

E14.3.1 Design Objectives

(a) Maximizing the structural enhancement of the sewer by installing a bonded FRP liner.

(b) Maintain or increase the hydraulic capacity of the rehabilitated sewer.

(c) Reduce infiltration and exfiltration.

(d) Prevent root intrusion.

(e) Provide sufficient chemical resistance to prevent further sewer pipe degradation related to the conveyance of sewage.

(f) Minimize disturbance to pavements and boulevards.

(g) Minimize disruption to vehicular and pedestrian traffic.

(h) Minimize the impact of construction on commercial, industrial, and institutional facilities.

E14.3.2 Design Requirements

(a) General

(i) Minimum design life of 50 years. All time-dependent material properties that impact design should be based on their 50 year projected value.

(ii) FRP liner designs shall account for full overburden loads.

(iii) Design the FRP liner based on the depth of cover and pipe profile provided on the Drawings.

(iv) Maximise hydraulic capacity of the lined sewer section. Complete hydraulic design checks in accordance with E7.4.3. Ensure design meets the hydraulic requirements set forth in E7.4.3. Utilize a “ks’ value of 0.03 mm for the FRP liner.

(b) Design the FRP liner as a Type I liner in accordance with Section 4 of Volume II – Sewer Renovation, WRc Sewerage Rehabilitation Manual, 4th Edition using the following minimum design assumptions.

(i) Calculate live load using an AASHTO HS 20 design vehicle in accordance with AASHTO LRFD Bridge Design Specifications.

(ii) Calculate dead load based on soil density of 1920 kg/m^3.

(iii) Groundwater table is 2.0 m below the existing ground surface.

(iv) Calculate external loads using the applied dead and live load formula from, Clause X.1.2.2 of Appendix X1 of ASTM F1216. Notwithstanding the requirements outlined herein, the minimum external soil load applied at the crown of the pipe for each site shall be:

- Mission Trunk: 0.132 MPa
- Selkirk Avenue Trunk: 0.123 MPa

(v) Modulus of soil reaction (E’) will be assumed to be 6900 kPa.

(vi) Minimum factor of safety (N) of 2.

(c) Long-term values for flexural modulus of elasticity, flexural strength, and tensile strength will be considered to be the projected value at 50 years of a continuous application of the design load based on the specific materials proposed for use. Physical properties shall be verified by an accredited testing agency.

(d) Long term design properties used for the design shall be determined in accordance with ACI 440.2R.

(e) The designer shall ensure liner is adequate to withstand long term external hydrostatic pressures. Design checks shall be undertaken using either bond strength between the liner and host pipe or buckling checks in accordance with Section 4 of Volume II – Sewer Renovation, WRc Sewerage Rehabilitation Manual, 4th Edition.

(f) Design FRP liner to accommodate longitudinal thermal stresses imparted on the liner due to the bond between the liner and host pipe.

E14.4 Submissions

E14.4.1 Design Submission

(a) Detailed design shall be submitted for review by the Contractor. Designs shall be completed by personnel experienced in the design of FRP liners for gravity applications. Designs and all Shop Drawings shall be stamped by a Professional Engineer, registered to practice engineering in the Province of Manitoba. Temporary submissions to facilitate project schedule by Engineers with registration pending in the Province of Manitoba will be considered with the proviso that all final submissions shall be sealed by a Professional Engineer, registered to practice engineering in the Province of Manitoba. The design submission shall be submitted for review a minimum of twenty (20) Business Days prior to scheduled start date on site.

(b) The Design Submission shall include the following components:
  (i) Design Brief and Shop Drawings
  (ii) Materials
  (iii) Detailed Liner Installation Procedures
  (iv) Quality Control Plan

E14.4.2 Design Brief and Shop Drawings

(a) FRP thickness computations including all specified design checks. Identify design assumptions based on a review of the Sewer Maintenance Inspection that differ from the information provided in the Specifications for the existing sewer design conditions.

(b) Summary of design and loading conditions.

(c) Calculations showing the hydraulic capacity of the FRP lined sewer will be equal to or greater than the existing sewer.

(d) Number of layers and orientation of fibres

(e) Estimated finished thickness

(f) Physical properties of the composite liner material:
  (i) Composite Ultimate Tensile Strength (ASTM D 3039)
  (ii) Tensile Modulus (ASTM D 3039)
  (iii) Flexural Modulus (ASTM D790)
  (iv) Supporting documentation to verify the use of any time dependent properties (e.g. creep in long term flexure for buckling resistance, hoop stress, etc.)

(g) Confirmation of durability of the liner design relative to the exposed service conditions

(h) Other information that may reasonably be required to confirm the proposed liner design conforms to the specified requirements and design intent.

E14.4.3 Materials Submission

(a) Sufficient information on the raw resin and reinforcing fibre material proposed for use will be required to evaluate the applicability of quality assurance procedures as per Chapter 7 of ACI 440.2R.
  (i) Submit the product name, manufacturer, and properties for the proposed resin, including:
    - Mixing and application requirements, including ambient and substrate temp, relative humidity
    - Accelerators, retarders or other additives proposed
    - Pot Life vs temperature
    - Gel time
    - Cure time vs cure temperatures for all expected cure ranges
    - Normal operating temperature range (min and max)
    - Heat-distortion temperature, per ASTM E2092
    - Tensile strength, modulus of elasticity, and ultimate strain, per ASTM D3039
    - Cohesive strength
    - Adhesion to Concrete, per ASTM D4541
    - Fourier transform infrared spectroscopy (FTIR) report output from the resin manufacturer such that blind testing could be carried out on site at the City's expense to confirm that the same resin is indeed being incorporated into the works.
  (ii) Name and manufacturer of the FRP fabric, and relevant fabric properties
  (iii) MSDS sheets for all products requiring them

E14.4.4 Detailed Liner Installation Procedure

(a) The Contractor shall submit a detailed step-by-step procedure of all key liner preparation and installation activities and processes. This procedure submission shall include as a minimum:

(i) Identification of any services and support required to complete installation.

(ii) List of equipment that will be available and used for the project.

(iii) Material handling, storage and disposal requirements for all raw materials and project waste.

(iv) Details of pipeline preparation for acceptance of the liner, including procedures for:

- Cleaning the pipe surfaces.
- Repairing the pipe surfaces to satisfactory cross section or profile.
- Creating and maintaining environmental conditions to facilitate installation of the liner.

(v) Details of liner preparation and installation, including:

- A sufficiently concise, detailed timeline listing all key steps in the preparation, transfer and installation of the liner. The level of detail provided shall be sufficient to facilitate “near-continuous monitoring of progress by the Contract Administrator or their representative during the course of the shutdown.
- Estimated pot life (catalyzed stability) of the system at various temperatures.
- Details of the wet-out procedure
- Resin impregnation method.
- Designated locations for wet out facilities on-site.
- Volume and weight of resin to be impregnated into each liner and repair section
- Roller gap setting required to provide the final installed FRP thickness based on the proposed volume of resin.
- Method of transferring prepared liner components from the preparation site to the installation site inside the pipeline.
- Method of applying liner components to the pipeline.
- Protection systems to protect liner from damage during construction

(vi) Liner curing requirements, including:

- Monitoring requirements
- Number of stages and anticipated time for each stage of the lay-up and curing periods based on resin supplier’s recommendations.
- Minimum curing requirements to facilitate pipe reinstatement including a graduated table of anticipated strength gain with time

(vii) Weather protection procedures including;

- Hot or cold weather protection for epoxies and impregnated liners during storage mixing, impregnation and transportation
- Protection of work and materials from elements including rain, snow, fog, wind and others
- Contingency planning for inclement weather, including transportation, protection of pipeline access points, staging areas to ensure the works can progress in all weather conditions reasonably prevalent during work windows.

(viii) Estimated length of time required to reinstate the pipeline.

E14.4.5 Qa/Qc Plan

(a) The Quality Management Plan shall consist of the following:

(i) Name and relevant experience of Quality Control Supervisors and staff that will be present on-site to perform the required quality control activities.

(ii) Example Quality Control Record forms to adequately document requirements of the Quality Assurance/ Quality Control section of this specification. Documentation shall demonstrate compliance with ACI 440.2R Section 7.1.

(iii) Proposed on site quality control testing program.

(iv) Proposed independent test laboratory and relevant certifications.

E14.5 Materials

E14.5.1 Constituent materials for the FRP composite structure shall conform to ACI 440.2R.

E14.5.2 The composite FRP fabric shall be reinforced with either glass or carbon fibres and specifically designed for repair and strengthening of concrete or similar structural elements.

E14.5.3 The epoxy resin used for bonding the FRP fabric shall be compatible with the composite fabric and designed as a complete system for application on concrete structures. Only two part 100% solids, ambient cure epoxy resin systems shall be permitted.

E14.5.4 Field thickened epoxy matrix, which is compatible with composite system's resin matrix, may be used to patch "bugholes" and fill voids.

E14.6 Installation

E14.6.1 The installation of the FRP liner is a bond critical application that requires a complete bond between the FRP system and the pipe mortar lining.

E14.6.2 Surface Preparation:

(a) Prepare the concrete surface per FRP manufacturer's recommendations and as specified herein. Surface preparation shall promote continuous intimate contact between the FRP and concrete by providing a clean, dry, uniform surface. The surface of the concrete shall be prepared with hydro blasting to remove scale and to provide a rough profile for bonding of the epoxy in accordance with the epoxy manufacturer's recommendations. The surface shall be prepared to a minimum Concrete Repair Institute concrete surface profile (CSP) level 3.

(b) Surface preparation shall remove all surface latent materials such as: grime, scale, sand, and cement, etc. The purpose of the surface preparation is to expose the core aggregate of the concrete substrate. The prepared surface will provide a uniform exposure of the core's course aggregate such that the surface will be void of surface latent materials, such as the sand and cement cured between the form- work and core concrete during the original concrete pour which took place at the time of pipe manufacturing.

(c) The Contractor shall examine the existing conditions to identify potential obstructions and constraints, manhole locations, shall verify dimensions and geometry and shall repair all flaws and cracks in the concrete core that may compromise the performance of the FRP system.

(i) Prepare, fill, prime, and treat joints and cracks in substrate.

(ii) Fill all voids in the concrete host pipe greater than 12 mm in depth with an epoxy repair grout.

(iii) Fill and seal all visible cracks with an epoxy grout.

(iv) Repair damaged portions of the pipeline, locations of missing invert, and spalled concrete to form a smooth, uniform and competent substrate for application of the FRP liner.

(d) Provide sound concrete surfaces free of laitance, glaze, efflorescence, curing compounds, form-release agents, dust, dirt, grease, oil, moisture and other contaminants incompatible with epoxy resin.

(e) Remove fins, ridges, mortar, and other projections that could cause voids behind the installed bands or damage the woven fiber fabrics. Fill honeycomb, aggregate pockets, holes, and other voids. Repair uneven surfaces by filling with grout or other material approved by the Contract Administrator.

(f) Prevent wash water from sections being cleaned from contaminating previously cleaned or repaired sections.

(g) After cleaning, carefully inspect the pipe surface for defects, including cracking, delamination or spalling of concrete surface, and record. Repair any surface defects in accordance to manufacturer instructions.

E14.6.3 Accurately layout circumferential FRP alignment markings to ensure fabrics are aligned to the proposed layout.

E14.6.4 Environmental Conditions:

(a) The installation of a FRP system requires temperature and moisture control. In conditions with an ambient air temperature less than 10°C, auxiliary clean heat sources may be used to raise the ambient temperature to a desired level.

(b) The presence of moisture inhibits the adhesion of epoxies to concrete surfaces. Portable barriers and blowers shall be erected at the repair locations to dehumidify the concrete surface in the pipe. The environment shall be maintained to meet the recommendation of the project manufacturer. Surface moisture shall not exceed that used for surface bonding qualifications and no more than 3.0°C above dew point.

(c) Monitor installation conditions including temperature, humidity and surface moisture to ensure they are within allowable parameters of the system.

(d) Water leakage through cracks or joints in the host pipe must be stopped by the Contractor prior to installation of FRP panels. Leakage which cannot be stopped by injection with chemical injection (epoxy or polyurethane) or application of hydraulic cement shall be reviewed with the Contract Administrator.

(e) Proper dust control and ventilation shall be provided to meet OH&S requirements.

(f) The work area is a confined space that will require an entry permit in accordance with OH&S regulations. The Contractor is responsible for the training of all personnel, air testing, safety equipment and complying with the requirements of OH&S.

(g) Epoxy resins (including primers) shall be mixed according to the FRP system manufacturer's installation instructions.

(h) Mixed epoxy resins that exceed the pot life specified by the manufacturer shall not be used.

E14.6.5 Bonded FRP Panel Installation

(a) The application of the FRP system including topcoat shall be performed in accordance with the manufacturer's instructions. The Contractor shall follow all OH&S and local health and safety requirements, especially confined space entry permit requirements.

(b) Install system in accordance to manufacturers written instructions. Monitor quality of installation and ensure tight bonds between substrate and successive layers of FRP.

(c) The epoxy coating shall be installed only on surfaces that have been roughened by hydro/abrasive blasting. After the surface is properly prepared and the surface of the concrete is dry, a high solids epoxy primer shall be applied to the concrete lining. The cleaned and prepared surfaces must be protected against recontamination until the FRP system is applied.

(d) The wet-layup method shall be the only approved method for FRP installation. The Contractor shall utilize a fabric saturator and rolling mechanism such that the epoxy saturated fabric is transported to the point of application through the manhole, which is then applied to the surface of the pipe in a wet lay-up process. No dry-layup application of the FRP fabric shall be permitted.

(e) The saturation machine shall be properly calibrated to ensure proper fiber resin ratio. Weight comparison, fabric to resin weight ratio shall follow the manufacturer's recommendations. The saturated fabric shall be weighed periodically to ensure the saturator is calibrated properly, such that the total weight of the resin absorbed by the fabric equals the weight of the dry fabric. This weight comparison is called the fabric to resin weight ratio. The allowable variance in the fabric to resin weight ratio is ± 10%.

(f) After fiber saturation, the FRP composite material shall sit still on spool in a clean area as required by the manufacturer's recommendations to allow for epoxy permeation into fiber material.

(g) The Contractor shall apply the FRP material in accordance with the approved submittal for the FRP system. Saturated fabric shall be pressed into the surface to achieve intimate contact. Entrapped air between layers shall be released or rolled without wrinkling of the fibers.

(h) A misalignment of more than 12 mm per 300 mm will be rejected. Any fabric kinks, folds or severe waviness shall not be permitted. There shall be a minimum circumferential overlap of 300 mm between layers to ensure a full transfer of load through shear.

(i) When multiple ply installation is required, the sequence and stacking shall follow the special instructions in the construction documents. Each ply shall be installed before the onset of complete gelation of the previous layer. Multiple plies can also be applied in several days and after the previous ply is cured, provided that the surface is roughened by sanding and is cleaned from dust and residue.

(j) FRP layers shall be terminated in stages before the limit of the pipe sections to be rehabilitated. The full design thickness must be achieved no more than 50 mm from the joint.

(k) Following the application of the FRP layers, a final epoxy coating in accordance with the manufacturer's recommendation shall be applied over the composite material to seal the surface. The thickness of the final epoxy layer shall be based on the design by the manufacturer.

(l) The final seal coat shall be cured prior to putting the pipe back into service.

E14.6.6 Curing

(a) All FRP areas shall be cured using the curing schedule recommended by the manufacturer. Curing times and methods shall be submitted and reviewed by the Contract Administrator prior commencing with installation.

(b) The Installer's work schedule shall allow sufficient time between completion of repairs and placing the pipeline into service so that the FRP completes sufficient cure before being exposed to water based on the cure temperature versus time relationship provided by the manufacturer, unless adequacy of lesser percent cure is proven by test data.

(c) The Contractor shall check the cure progress by performing hardness tests on the FRP system and based on the percent completion versus Barcol or Shore D hardness relationship provided by the manufacturer, and inform the Contractor Administrator.

(d) Curing shall take place in a dry environment to prevent amine blush. If heating is used, direct-fired gas or kerosene heater shall not be permitted. Only electric or indirect-fired heaters shall be permitted.

(e) Curing at elevated temperatures is strongly encouraged. This not only minimizes the risk of amine blush but reduces the required curing time and increases the glass transition temperature of the epoxy. Satisfactory performance of the curing schedules used shall be proven by the manufacturer with documentation of pervious satisfactory applications or thermal test results indicating the curing behavior of the epoxy.

(f) Exhaust fumes from vehicles or equipment shall be kept away from FRP applied areas during curing.

E14.6.7 Remediation

(a) Small defects with a diameter between 12 mm and 100 mm will be repaired using low pressure epoxy injection, as long as the defect is local and does not extend through the complete thickness of the laminate. Small entrapped voids or surface discontinuities, smaller than 12 mm in diameter will not be considered defects

(b) In the case of larger defects, the surrounding area, to an extent of at least 20 mm in all directions, will be carefully removed with a grinder. The area will be wiped, cleaned, and thoroughly dried prior to being repaired using patch material with the same characteristics as the original laminate and extending at least 150 mm on all sides of the removed area.

(c) If the final surface coating has areas with visible cracking, the local surface will be lightly sanded, and a new coating with appropriate primer will be applied, based on manufacturer's recommendations. The coating will extend at least 25 mm beyond the limit of the defect.

(d) If the surface coating shows signs of blistering, the entire area with blisters, as well as the surrounding area to a distance of at least 300 mm, will be carefully sanded. In no case will a blistered surface be recoated without complete removal of the existing coating. The area will be wiped clean and then dried thoroughly. Once dry, the area can be re-coated following the application of the primer coat, if required by the manufacturer.

E14.7 Quality Assurance/Quality Control (Qa/Qc)

E14.7.1 Inspection, Evaluation and Acceptance of the installation shall generally follow guidelines as documented in Chapter 7 of ACI 440.2R.

E14.7.2 Onsite Quality Control Requirements:

(a) The Contractor shall observe, monitor and document all phases of FRP application for compliance with the repair Drawings, specifications, and submitted procedures. Report all non-conformances to the Contract Administrator immediately, that prompt remedial action may be initiated.

(b) All FRP composite applied areas shall be inspected in accordance with the manufacturer's specifications for voids, bubbles, and delaminations.

(c) The Contractor shall provide a report signed by a Professional Engineer licensed to practice engineering in the Province of Manitoba, certifying that the installation is acceptable, complete with the testing reports and photographs.

(d) The Contractor shall continually monitor and maintain complete construction record of the following:

(i) Construction temperature and relative humidity (RH) in construction area during installation and curing

(ii) Records of time of mixing of all primers, tack coats and fiber impregnating resins. Record final application times of all products and ensure that they are within the specified pot life parameters of the materials, at the temperature and RH of installation.

(iii) Monitor the mixing of all epoxy components for proper ratio and adherence to manufacturer's recommendations. Record batch numbers for fabric and epoxy used each day, and note locations of installation. Measure square footage of fabric and volume of epoxy used each day. Complete a project report and submit to the Contract Administer and FRP composite system manufacturer at project completion.

(iv) Record all liner installations, including start and stop times of each pipe segment, installation crew, batch number records for all resins.

(v) Submit and review quality control records with the Contract Administrator a minimum of twice per day. Note all deviations from installation and quality control plans and recommend any required remedial action.

E14.7.3 In-Situ Adhesion Tests

(a) Direct tension adhesion testing of cored samples shall be conducted using the method described by ASTM D4541. The Contractor shall install one layer of FRP in a 600 mm by 600 mm area to be used as mock-ups of the installed FRP system in accordance with ASTM D4541. Prepare witness panels for testing, using same preparation, materials and construction techniques as used in construction. Cure panels in the same environment as construction works. The location shall be representative and selected jointly by the Contractor and the Contract Administrator and may be on adjacent non-repair pipe provided that surface preparation is the same as that to be used for the repair pipe. Mock-up shall be prepared on each type of concrete substrate or for each surface preparation technique used if variations in such conditions exist.

(b) Prepare a minimum of one (1) mock-up areas per installation crew.

(c) Pre-construction testing of mock-up panels shall be completed by the Contractor and submitted for review. Testing shall include a minimum of;

(i) Pull-off tests in accordance to ASTM D4541. A minimum of 3 test sets per crew shall be made. Minimum pull-off strength shall be 1380 kPa at the concrete interface. Pull-off tests of less than 1380 kPa that occur greater than 80% by area in the underlying concrete substrate may be acceptable provided a tight bond between the liner and substrate exists Inter-laminar failures or failures at the concrete – liner interface are not acceptable.

(ii) Test tensile strength, modulus and ultimate stain in accordance to ACI 440.3R. Materials shall exhibit the minimum design properties specified and used in the design. A minimum of five (5) samples shall be taken from each witness panel.

(iii) All testing shall be completed in the presence of the Contract Administrator.

E14.7.4 Laboratory Testing

(a) Sampling

(i) Record lot number of fabric and epoxy resin used, and location of installation. Measure square area of fabric and volume of epoxy used each day. Label each sample from each day's production.

(ii) A "sample batch" shall consist of two 300 mm by 300 mm sample panels of cured composite. A minimum of two "sample batches" shall be made daily. The two "sample batches" will be taken at appropriate times during the day as to ensure the maximum material deviance in the components of the FRP composite as accepted by ICC AC 178.

(b) Preparation of Samples

(i) Prepare sample on a smooth, flat, level surface covered with polyethylene sheeting, or 16 mil plastic film, prime with epoxy resin. Then place one-layer of saturated fabric and apply additional topping of epoxy. Cover with plastic film and squeegee out all bubbles.

(ii) Samples shall be stored in a sample box and not moved for a minimum 48 hours after casting. The prepared, identified samples shall be given to a pre-approved and experienced testing agency. The testing agency shall be a qualified testing laboratory that is independent from the installer, capable of performing tests according to the ASTM standards. The laboratory shall then precondition samples for 48 hours at 60°C before testing.

E14.7.5 Laboratory Tension Tests

(a) Testing specimens shall be cut from samples and tested for ultimate tensile strength, tensile modulus and percentage elongation as per ASTM D3039 in the longitudinal fiber direction.

(b) Test a minimum of 15% of all samples as per ICC AC178. If one coupon fails, specimens from the same 300 mm x 300 mm sample will be tested. If these specimens also fail, the other 300 mm x 300 mm sample from the same "sample batch" will be tested. In the extreme case that this sample also fails, the remaining "sample batch" for that day will be tested and appropriate remediation shall be taken to ensure integrity of the system at locations from the failed "sample batch". In addition, 25% of the remaining samples shall be tested by the same criteria as per ICC AC178.

(c) The results of the testing shall be carried out no later than two weeks after the completion of the FRP application and shall be supplied to the Contract Administrator within two weeks of laboratory testing.

(d) FRP design values must be lower than the calculated mean determined from the test results received from the ASTM D3039 field test specimens. Acceptable minimum values for ultimate tensile strength, tensile modulus, and elongation shall not be below the submitted design values.

(e) Any values below the submitted design values will require remediation.

E14.7.6 Post installation inspection of the pipe lining shall be completed in the presence of the Contract Administrator. The liner shall be inspected for defects and imperfections by visual and hammer tap surveys, including delamination from the concrete, inter layer delamination, bubbles, soft and uncured resins. Repair defects identified in the inspection by approved methods.

E14.8 Measurement and Payment

E14.8.1 Bonded FRP Liner Installation

(a) Liner installation will be measured on a length basis for each size and paid for at the Contract Unit Price for “Supply and Install Structural Sewer Liner”. Length to be paid for will be the total length of FRP liner supplied and installed in accordance with this specification, accepted and measured by the Contract Administrator.

(b) Measurement for the supply and installation of FRP liner will be made horizontally at grade, above the centreline of the pipe from centre to centre of manholes or termination of the liner, whichever is longer.

(c) Eighty (80) percent of the payment will be made upon satisfactory completion of the FRP installation work. The remaining twenty (20) percent of the payment will be made upon confirmation of the FRP strength and delivery and acceptance of all required submissions, shop drawings, and reports.

(d) Payment for the supply and installation of Bonded FRP Liner Installation shall include but is not limited to the following:

(i) Submittals, including: FRP designs, material samples, material testing, operations protocol, and construction protocol
(ii) All required sewer preparation work
(iii) Supply and installation of FRP liner
(iv) Reinstatement of sewer services
(v) Transitions at liner termination
(vi) Test samples
(vii) Quality control testing as specified herein and records

DRAWINGS

Replace: 186-2015_Drawing_10985-R0 with 186-2015 _Addendum_2 Drawing_10985-R1

186-2015_Drawing_10986-R0 with 186-2015 _Addendum_2 Drawing_10986-R1

186-2015_Drawing_10987-R0 with 186-2015 _Addendum_2 Drawing_10987-R1

186-2015_Drawing_10988-R0 with 186-2015 _Addendum_2 Drawing_10988-R1