#### SP- XX CENTRIFUGALLY CAST PIPE LINER (CCPL) AND INVERT MORTAR REPAIR

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1. **DESCRIPTION**

Work covered by this specification includes providing all labor, materials, equipment, and incidentals required to clean/prepare existing storm sewer pipe, repair invert, install and test Centrifugally Cast Pipe Liner (CCPL) as shown on the Drawings and specified herein. CCPL is a geopolymer or cementitious mortar liner material that may be applied to existing concrete and corrugated metal storm sewer pipe. The CCPL shall be abrasion and corrosion resistant material, tight-fitting against the existing pipe, continuous, waterproof, and structurally reinforced fully deteriorated pipe.

1. **MATERIALS**

Standards:

ASTM C39 – Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

ASTM C78 – Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading). (Note: ASTM C293 – Standard Test method for Flexural Strength of Concrete (Using Simple Beam With Center-Point Loading) – Is not a substitute test for the more conservative ASTM C78, ASTM C293 provides flexural strengths significantly higher than ASTM C78 due to relaxed loading conditions which are not appropriate for this type of structural repair).

ASTM C109 – Standard Test method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in Cube Specimens).

ASTM C157 – Modified Standard Test Method for Length Change of Hardened Hydraulic Cement Mortar and Concrete

ASTM C309 – Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete

ASTM C469 – Standard Test Method for Static Modulus of Elasticity and Poisson’s Ratio of Concrete in Compression.

ASTM C496 – Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.

ASTM C666 – Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.

ASTM C882 (Type II or Type V) – Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete By Slant Shear.

ASTM C1090 – Standard Test Method for measuring Changes in Height of Cylindrical Specimens of Hydraulic-Cement Grout.

ASTM D4541 – Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers

ASTM F1216 – Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin Impregnated Tube

ACI 229 – Controlled Low Strength Materials

**Liner:**

1. The liner shall be applied by centrifugally spin-casting or hand-sprayed.
2. The liner shall be capable of fitting into irregularly shaped pipe sections and through bends and dips within the pipeline.
3. The wall color of the interior pipe surface of CCPL after installation shall be a relatively light reflective color so that a clear detailed examination with closed circuit television inspection equipment may be performed.
4. The liner shall be chemically resistant to chemicals found in stormwater runoff; such as but not limited to gasoline, oil products, grass clippings, and fertilizers.
5. When cured the liner shall form a continuous, tight-fitting, watertight and impermeable liner.
6. Existing pipe conditions shall be reflected in the design of the liner thickness. In particular, the ovality of the existing pipe and, thus, the liner pipe shall be accurately estimated and reflected in the design calculations.
7. The thickness of the liner shall be the largest thickness as determined by calculations for deflection, bending, buckling, and minimum stiffness. Minimum liner thickens shall be 1/2-inch.
8. CCPL materials submitted by the manufacturer shall have been used in CCPL installation for at least 5 years. Also, CCPL shall have been used in the rehabilitation of at least 10,000 linear feet of storm sewer piping (concrete and corrugated metal).
9. The CCPL shall conform to the following properties under laboratory conditions:

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| **CCPL PROPERTIES** |
| **Property/Test Method** | **Duration** | **Results** |
| Compressive StrengthASTM C-39/C-109 | 1 Day28 Days | Min. 2,500 psi Min. 8,000 psi |
| Flexural StrengthASTM C-78 | 7 Day28 Days | 750 psi1,500 psi |
| Modulus of ElasticityASTM C-469 | 1 Day28 Days | 3,000,000 psi5,000,000 psi |
| Bond Strength to ConcreteASTM C-882 | 1 Day28 Days | Min 900 psiMin. 2,500 psi  |
| Set Time 70 °F (Geopolymer)ASTM C-807 Initial Cure Time | Initial SetFinal Set | 60-75 Minutes90-110 Minutes |
| Set Time 70 °F (Cementitious)ASTM C-403 Initial Cure Time | Initial SetFinal Set | Approx. 150 MinutesApprox. 300 Minutes |
| Freeze Thaw DurabilityASTM C-666 | 300 Cycles | 100%Zero Loss |
| ShrinkageASTM C-1090 | 28 Days | 0.00% @ 65% R.H. |
| Tensile StrengthASTM C-496 | 28 Days | Min. 800 psi |

**Invert Repair Mortar:**

1. All materials shall be in accordance with Division 10 of the *NCDOT Standard Specifications for Roads and Structures*, ACI 229 – Controlled Low Strength Materials, as shown on the plans, or directed by the Engineer.
2. Abrasion and corrosion resistant mortar, based on advanced cements and additives including rust inhibitors. When mixed with the appropriate amount of water, a self-consolidating free flowing material will develop with high 24-hour compressive strength and adhesion.
3. **qualifications**

The Contractor performing the CCPL installation shall be fully qualified, experienced and equipped to complete this work expeditiously and in a satisfactory manner and shall be certified and/or licensed as an installer by the CCPL manufacturer.

* 1. The Contractor shall have no less than (3) years of experience installing CCPL and rehabilitating storm sewer systems.
	2. Provide name of the CCPL manufacturer and list of prior work for the CCPL manufacturer and supplier.
	3. Provide certified statement from the manufacturer that contractor is certified and / or licensed for the proposed CCPL system.
	4. Provide list of municipal clients for whom the Contractor has performed this type of work. Include reference contact information and a description of work that includes diameter of pipe and linear footage installed.
1. **Submittals**

The Contractor shall submit for review and approval by the Engineer the following information, fifteen (15) business days prior to beginning work on the site:

* 1. Shop drawings of all CCPL materials. Shop drawings shall be prepared by a North Carolina Registered Professional Engineer. The following supplemental information shall also be included: product MSDS sheets and manufacturers shipping, handling, and storage recommendations.
	2. Certified test report from a Testing Laboratory or Manufacturer, that the CCPL material was manufactured and tested in accordance with all ASTM standards specified and referenced herein.
	3. Engineering calculations specifying the design and required thickness (no less than 1/2"-inch) for each segment of CCPL installation, which are signed and sealed by a North Carolina Registered Professional Engineer. The CCPL shall be designed to the following minimum criteria:
		1. All sections of pipe shall be considered fully deteriorated.
		2. All pipes shall be subjected to soil loads of 120 pounds per cubic foot.
		3. The soil modulus shall be no more than 1,000 psi.
		4. All pipes located shall be assumed to carry AASHTO HS20-44 live loads
		5. The contractor shall assume a factor of safety of 2.0.
		6. Ground water is assumed 3 feet below surface elevation, unless site-specific data is available.
		7. The depth of cover as shown on plans.
		8. CCPL design life 50 years or greater.
		9. Hydraulic Capacity – Overall, the hydraulic cross-section shall be maintained as large as possible. The CCPL shall have a Manning’s “n” value of 0.013 or less after installation.
	4. Health and Safety Plan, including confined space safety plan.
	5. Emergency Response Plan. The Contractor shall include a plan to address reported backups or other problems resulting from the work, including personnel contact, equipment, disposal, etc. The minimum response time to address any issues shall be two hours unless otherwise directed by the Engineer.
	6. Maintenance of Base Flows plan. The plan shall include but not be limited to pump sizes, capacity, power requirements, pump selection and other calculations, pump curves, and piping sizes and locations. Bypass pumping systems shall include as a minimum one or more pumps capable of handling the base flow and storm events without the stored water level exceeding the crown of the pipe and one standby pump equal to the largest pump used.
	7. Identification of water source(s) that will be used during CCPL installation. Contractor is responsible for securing and providing the necessary water for curing the CCPL. Contractor shall coordinate with the City of Charlotte if proposed water is obtained from fire hydrants. The Contractor is responsible for obtaining permits from Charlotte Water for water and sewer usage.
	8. Identification of staging area(s) necessary for CCPL installation.
	9. Comply with the most current Work Area Traffic Control Handbook (WATCH).
	10. Contingency plan for equipment malfunctions or equipment that becomes immovable.
	11. Contractor shall provide a hard copy summary of all inspections performed, defining all pipe sections inspected, measured lengths to features (pipe penetrations, structures, damage, etc.), and inspection date. An electronic copy of the inspection report, inspection still images, the pipe inspection video files, and inspection database provided on a CD, DVD, or other approved digital media device, shall also be provided.
1. **CONSTRUCTION METHODS**

**Site Preparation**

The Contractor shall verify site conditions prior to commencing any construction activities. Site conditions include, but are not limited to, inlet and access port accessibility, accessibility to remote locations and encroachment onto private or publicly owned property. Selection of inspection equipment shall be based on the conditions of the storm drainage piping, structures, and inlets at the time the work commences. All dimensions shall be field verified by the Contractor.

The Contractor shall conduct a NASSCO PACP compliant color digital television inspection of each length of pipe prior to ordering liner. The purpose of this inspection is to confirm that existing conditions are suitable for the installation of the proposed lining process, to document the location of all service lateral connections and to confirm point repair locations. Digital recordings on either CD’s or DVD’s shall be prepared and retained by the Contractor and submitted with the post-lining inspection recordings prior to request for payment. Where this television inspection reveals conditions that are not suitable for lining, the digital recordings shall be immediately provided to the Engineer for review.

The Contractor shall protect the storm drainage system and adjacent properties from damage that might result from construction. Any damage caused by the Contractor’s operations shall be repaired to the complete satisfaction of the Engineer at no additional cost.

Protruding lateral connections, if encountered, shall be cut or ground with a robotic cutter flush with the pipe to be lined prior to liner installation. All lateral connections for reconnection after CCPL installation shall be documented. The cutting operation shall be monitored by CCTV equipment to verify proper execution of work. Cutter shall be capable of cutting the following materials: vitrified clay pipe, polyvinyl chloride pipe, ductile iron pipe, high-density polyethylene pipe, or reinforced concrete pipe. Equipment specifically designed for cutting roots from storm drainage pipes (such as a chain cutter) shall not be allowed for this purpose.

If, in the opinion of the CCPL manufacturer, the rate of infiltration in the storm drainage pipe presents washout risk of the applied material, then the Contractor shall perform measures as required to minimize infiltration prior to lining. Any infiltration gusher identified shall be brought to the attention of the Engineer. The Contractor shall submit for approval to the Engineer the measures to prevent any adverse issues to the installation of the final product. The submittals shall be reviewed and approved prior to installation.

**Delivery, Handling and Installation**

Normal precautions for “nuisance dust” shall be observed. Consult manufacturer’s Material Safety Data Sheet for details. The Contractor shall install liner in strict accordance with applicable OSHA standards.

The bypass pump(s) shall be setup and ready for immediate operation. Pumps shall be automatically controlled. The Contractor shall properly maintain the bypass pumping system. A responsible operator shall be on site at all times during bypass pumping operations. Drainage flows from existing storm drainage pipes shall not be allowed to enter the rehabilitated facilities until those facilities have been cleaned and CCPL completely installed including curing.

Contractor shall reopen all existing lateral connections in each length of pipe following liner installation. Lateral connections shall be determined from the pre-installation CCTV inspection. The lateral connections shall be reopened from inside the pipe by means of a television camera controlled cutting device appropriate for the liner material and the pipe. All pipe connections shall be completely opened, clean and neatly cut, shall be flush with the lateral pipe and the cut shall be wire polished. The bottom of the opening shall be flush with the bottom of the lateral pipe so that there is not a lip. All liner penetrations shall be watertight. The Contractor shall be fully responsible for all backups and damage caused by unopened or not fully opening lateral connections, including paying all costs associated with repairing damage as required by the Engineer, Owner and/or property owner.

Contractor shall, with approval from Charlotte Water, discharge all water used for cooling, heating, and curing to the existing sanitary sewer system. Contractor may utilize a vacuum truck to remove the water from the site and discharge directly to a wastewater treatment plant. No water used for the installation of the CCPL shall be discharged into the downstream storm drainage system.

**Hot and Cold Weather Applications**

Apply liner material during suitable ambient temperatures per manufacturer’s recommendations. Liner shall be protected in hot (above 80° F and rising) and cold temperatures (below 45° F and falling).

**Post-Installation Inspection and Testing Requirements**

After all liner installation and lateral connection work has been completed, the contractor shall inspect via CCTV all new CCPL within 3 weeks of installation completion. Inspection of pipelines shall be performed by NASSCO PACP certified, experienced personnel, trained in locating breaks, obstacles, and service connections using CCTV inspection techniques. For every segment of CCPL installed, the Contractor shall generate a report that documents the installation including date, time, temperature, curing temperature, curing time, of applied material type and volume. The reports shall be submitted along with the post-installation CCTV inspection to the Engineer prior to acceptance of work and submittal of payment request.

There shall be no dry spots, lifts, ridges, splits, cracks, uncured mortar, delaminations or other defects in the CCPL. There shall be no visible infiltration through the liner or from behind the liner at manholes and service connections. Defects in the finished liner that cause backwater, reduce the pipe’s hydraulic capacity or structural stability or that create voids between the liner and pipe wall will be unacceptable. Defective lining will be repaired to design specifications at no additional cost.

Thickness verification can be done with mass balance calculations where you calculate the amount of material that went in over the surface area to get an average depth.

Indicator tabs can be attached on the piping to verify the proper thickness is achieved. These are positioned to be just below the specified thickness and are left in place when sprayed over.

In addition, the engineer may request at his/her discretion the contractor to remove a test core(s) from the installed liner at specified location(s) at the Contractors’ expense. The Contractor shall mark the core samples with the date that the liner was installed and the date that the core was removed and the location taken. When requested by the engineer, the liner shall be cored at three different clock positions, and the average thickness measured shall be taking as the actual thickness of the liner. If a sample is not within 90% of the specified minimum thickness and or 90% of the 28-day compressive strength, the liner is considered unacceptable. Submit a proposed method of repair or replacement for review and approval by the engineer. Work required to remedy nonconforming work shall be at no additional cost.

Installed CCPL that does not meet the specified strength and / or thickness requirements, regardless of the deviation from these specified requirements, shall be corrected by the Contractor in a manner approved by the Engineer. Options for correcting deficient liner installations that will be considered by the Engineer include removal of the existing liner and re-lining the pipe or complete replacement of the storm drainage pipe.

1. **MEASUREMENT**

The quantity of *Centrifugally Cast Pipe Liner* to be paid for will be the actual number of linear feet of pipe liner, which has been installed and accepted.  Measurement will be made horizontally along the centerline of the installed liner defined as the distance between the upstream and downstream structures using applicable structure inside walls as the beginning and ending point. Measurement from center of structure to center of structure will not be permitted. Measurement will not be made across drainage structures.

*Invert Mortar Repair* will be measured and paid in cubic yards, which has been incorporated into the completed and accepted work in accordance with the special provisions.

1. **PAYMENT**

The quantity of *Centrifugally Cast Pipe Liner*, measured as provided above, will be paid for at the contract unit price per linear foot for *Centrifugally Cast Pipe Liner*. Such payment will be full compensation for all work covered by this special provision including but not limited to: engineering and design costs, permitting costs, submittals, pipe cleaning/preparation, CCTV inspections, installation, materials, labor, equipment, bypass pumping, and materials testing and laboratory services.

Payment will be made under:

**XX – Inch Centrifugally Cast Pipe Liner (CCPL) LF**

Payment is full compensation for furnishing and placing the *Invert Mortar Repair* material as specified or directed and includes proportioning, mixing, handling, hauling, placing, maintenance, and protection of the mortar; providing admixtures, shoring, and steel plates; and all other materials, labor, equipment, tools, supplies, transportation, and incidentals necessary to necessary to complete the work in accordance with the Plans, the Specifications, and as directed by the Engineer.

Payment will be made under:

**Invert Mortar Repair CY**