WERF INFR1R12

STRUCTURAL CAPABILITIES OF NO-DIG MANHOLE REHABILITATION

Main Testing Summary of Results

Warren Test Results

Introduction

For the purpose of this test, **24-inch concrete cylinders** were used as substrates for the tests. The concrete cylinders are standard reinforced concrete pipes manufactured to **ASTM C76** and typically used for storm sewer applications. The test samples were loaded by applying the standard Three-Edge-Bearing Test per **ASTM C497**. The ASTM C497 procedure was slightly modified to install strain gages at four positions (i.e., 12:00, 3:00, 6:00, and 9: 00 o'clock) to measure the tensile and compressive stresses along the internal perimeter of the host pipe (see Figure 1). This allowed the Project Team to compare the strains of lined specimens to that of unlined (bare) specimens during loading. Warren Company lined and tested one set of pipes, which includes three concrete pipes, using epoxy lining material. One of the pipes was instrumented as explained above.

Testing Procedure

1. Surface preparation by the manufacturer certified contractor – Each contractor applied the surface preparation procedure per the manufacturer's instructions. This process varies depending on the lining type.

2. Strain gage installation by the project team – Upon completion of surface preparation, the Project Team installed strain gages to measure strains during loading at the locations shown in **Figure 1.**
3. Liner installation by the manufacturer certified contractor - Each contractor installed the liner per the manufacturer's instructions. This process varies depending on the lining type.
4. Testing by the Project Team – Three-Edge-Bearing Test per ASTM C497 was applied on control (unlined) and lined specimens. The standard ASTM procedure was slightly modified to measure strains during loading.
5. Reporting of the results by the project team – Load (lb) and strain (in./in.) were measured during the test process and **the data were transferred to a processing** unit incorporated into the test setup by the project team. The data processing unit included a PC, wiring, and pertaining software. The results were reported in a standard form prepared specifically for this project.

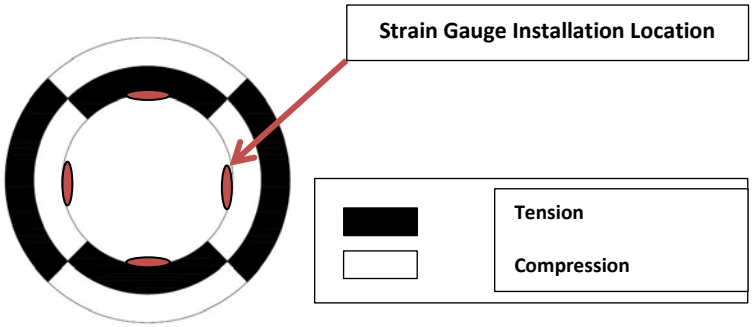

Figure 1- Stress/strain distribution along the pipe section loaded per ASTM C497 (D-Load) test and strain gauges installation location.

(a) (b)

Figure 2- Three-Edge-Bearing Test Setup per ASTM C497 (a) and Strain Gauge Installation.

Discussion of Results

The test results indicate that the epoxy lining material used by Warren Company has significantly increased the structural capabilities of the concrete samples. While the range of increase in failure loads was **45 to 133 percent,** in this case, the **concrete pipe's failure load was increased by 108 percent** as a result of being lined by epoxy material. Figure 3 shows the final test results. Also as a result of lining, the pipes became stiffer than the concrete pipes which resulted in lower values of deflection and strain in compression and tension zones comparing to the bare pipe.

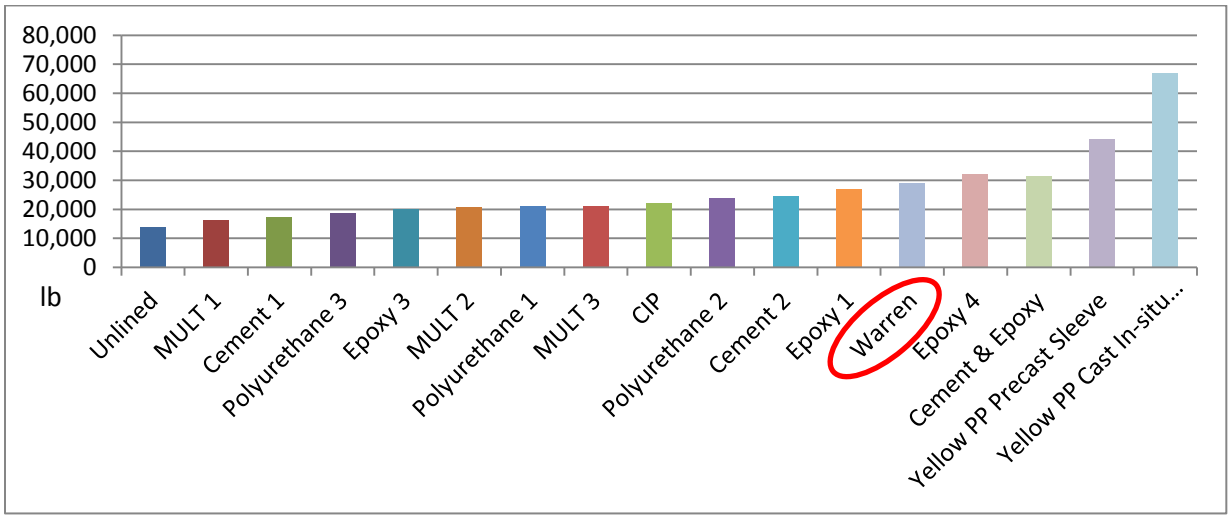

Figure 3- Final Test Results

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Type and Sample Code	Liner Thickness (mils)	Average Peak Load (lb.)	Peak Strain in Compression [(in/in)x 10^{-6})]	Peak Strain in Tension [(in/in)x 10^{-6})]	Peak Stress in Compression (psi)	Peak Stress in Tension (psi)	Maximum Deflection (in.)	% Difference Load	Failure Mode
Bare Pipe									
Bare Pipe	N/A	13,826	-250	105	1,250	525	0.0621	N/A	N/A[1] (Figure No. 4)
Epoxy									
Epoxy 2	180	28,746	-204	76	170	65	0.0193	+(108)	Crack in Lining[2] (Figure No. 5)

[1] 1 Concrete pipe failed with longitudinal cracks on the outside at 3 and 9 o'clock and internal longitudinal cracks at 12 and 6 o'clock.

[2] Both Liner and Concrete pipe failed with longitudinal cracks on the outside at 3 and 9 o'clock and internal longitudinal cracks at 12 and 6 o'clock

Figure 4- Unlined Concrete Pipe at Failure

Figure 5- Lined Concrete Pipe at Failure

General Definitions:

Stress: It is a force that tends to deform the body on which it acts per unit area.

Strain: Measure of the extent to which a body deforms under stress.