RON ROCHE
R&D ENGINEERING
3108 Brass Buttons Trl.
AUSTIN, TEXAS 78734
Cell: (713) 775-4715
Email: rrocherr@yahoo.com

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Mario Tamez
Standard Cement Materials, Inc.

Subject: **Flexural Modulus for Epoxy**

Testing Epoxy alone for Modulus of Elasticity is not applicable for strength. Epoxy for liners in the Sewer Industry is used for corrosion resistance only. When there is a liner system such as cement and epoxy then the testing of the epoxy does not apply apply (or matter) to the system; this is when the cement is the only controlling factor.

Instead of relying on a plain, brittle and non-structural epoxy coating to provide structural strength; Standard Cement actually only rely on the structural, high strength Reliner MSP Cement mortar liner to form an essential and permanent system. The repair system restores both structural integrity and provides corrosion resistant in one composite system.

Moreover, instead of trusting Modulus of Elasticity to provide a fundamental, structural property, we are more focused on bond and adhesion strength to concrete. So consequently, we use the 4553® Epoxy Coating to protect the cement mortar liner in all damp environments. It is uncomplicated and well suited for this application, and specially designed to withstand hydrogen sulfide corrosion to 60% sulfuric acid, as well as, provide hydraulic abrasion resistance in sewer manholes and sewerage workings.

The following stress and strength increase calculation results are for the cement and the epoxy coating is for corrosion resistance:

Re: Structural Information –Reliner MSP for Concrete Manholes

Problem: 1. Will the rehabilitated concrete manhole withstand an HS-20 loading?

2. How does the Reliner MSP enhance the structural integrity of an existing concrete manhole?

3. Does the use of Reliner MSP conform to Standard Construction Practice.

Pursuant to performing the following calculations for determining the increased strength due to the rehabilitation of a concrete manhole with a 1 inch Reliner MSP liner I have calculated a 37% increase in manhole strength and a 12.2% reduction in stress.

Given: 4 foot ID diameter manhole w/6 inch brick walls
Unit Compressive Strength = 3000 Psi
f_c' = 8000 Psi for Reliner MSP
HS-20 Loading = 32,000 lbs/axle/16,000 lbs/wheel assy. (AASHTO)

ANALYSIS

"Building Code Requirements for Reinforced Concrete" ACI 318-Latest), American Concrete Institute.

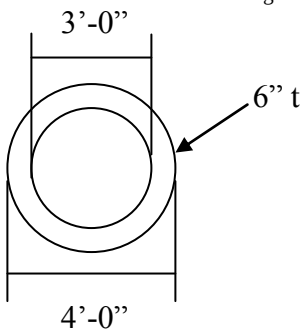
CONCRETE MANHOLE ANALYSIS

Determine Allowable Compressive Stress for the Concrete Manhole – F_a:

See ACI 318, Chapter 9, Design Strength.

$F_a =$ 3000 Psi x 0.70 = 2100 Psi

Determine the Gross Area for the Concrete Manhole - A_g



Area of Concrete Manhole = $A_g = \frac{\Pi (4.0)^2}{4} - \frac{\Pi (3)^2}{4} =$ 12.566 – 7.0686 = 5.497 $Ft.^2$ = 792 in^2

Determine the Actual Compressive Stress due to the HS-20 Loading, f_a

P_{ll} = Service Live Load (HS-20) = 16,000 lbs

P_{ul} = 16,000 lbs x 1.7 = 27,200 lbs

1.7 – Live Load Factor (ACI 318) Chapter 9, Required Strength.

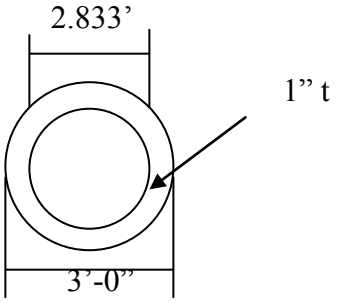
$f_a = P_{ul} / A_g$ = 27,200lbs/762 in^2 = 34.34 Psi

Determine the Ultimate Load Capacity for Concrete Manhole – P_{uc}

$P_{uc} = 0.55 \times \Phi \times f_c' \times A_g$ = 0.55 x 0.70 x 3000 Psi x 732 in^2 = 914,760 lbs

RELINER MSP ANALYSIS

Determine the Gross Area of the Reliner MSP - A_{gmsp}



A_{gmsp} of Reliner MSP = $\frac{\Pi (3)^2}{4} - \frac{\Pi (2.833)^2}{4}$ = 7.0686 – 6.303 = 0.765 Ft^2 = 110.16 in^2

Determine the Actual Compressive Stress of Reliner MSP due to the HS-20 Loading, f_{amsp}

$$f_{amsp} = P_{ll} / (A_g + A_{gmsp}) = 27{,}200 \text{ lbs} / (792 \text{ in}^2 + 110 \text{ in}^2) = 30.15 \text{ Psi}$$

Determine the Percent of Reduction of Stress on the Concrete Manhole w/ Reliner MSP

$$\% \text{ Reduction} = \frac{f_a - f_{amsp}}{f_a} = \frac{34.34 \text{ Psi} - 30.15 \text{ Psi}}{34.34 \text{ Psi}} = 12.2\%$$

Conclusion: The rehabilitated concrete manhole can carry the support of the HS-20 truck loading in addition to having a 12.2% reduction in compressive stress due to axial loading.

Determine the Increase in Structural Capacity in utilizing an Empirical Procedure for the Reliner MSP: Assumption: Analyze as a Load-Bearing Wall w/ no Eccentricity.

Determine the Allowable Stress for the Reliner MSP – F_{amsp}

$$F_{amsp} = \Phi \times f_c' = 0.70 \times 8000 \text{ Psi} = 5600 \text{ Psi}$$

Determine the Axial Load Capacity of the Reliner MSP – P_{umsp}
(ACI 318, Chapter 14, Empirical Design Method)

$$P_{umsp} = 0.55 \times \Phi \times f_c' \times A_{gmsp} = 0.55 \times 0.70 \times 8000 \text{ Psi} \times 110 \text{ in}^2 = 338{,}800 \text{ lbs.}$$

Φ - Strength Reduction Factor (ACI 318, Chapter 9, Design Strength)

Determine the Maximum Load Capacity - P_{tot}

$$P_{tot} = P_{uc} + P_{umsp} = 914{,}760 \text{ lbs} + 338{,}800 \text{ lbs} = 1{,}253{,}560 \text{ lbs}$$

$$\% \text{ increase} = (1{,}253{,}560 / 914{,}760) = 1.37 - 1 \text{ ; } 37 \text{ \% increase in manhole strength}$$

If there is any other information that you need from me or if you would like to talk, please feel free to contact me at the above number.

Sincerely,

Ronald C. Roche, P.E.

10/03/2012

Regards,

Ronald Roche, P.E.