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Re: Structural Information –Cement Coating for Sewer Manhole Rehabilitation:

1. Maximum CA™ Cement
2. Maximum CA™ Plus Cement

PROBLEM: 1. Will this rehabilitated brick manhole withstand an HS-20 loading?

2. How does the cement coating enhance the structural integrity of the existing brick manhole?

3. How do the cement and the epoxy coating enhance the structural integrity of the existing brick manhole?

Given: 4 foot ID diameter manhole w/8 inch brick walls (Double Stacked)
Brick = 2-1/2" x 4" x 8-1/4", Grade MM of ASTM C32
Brick Unit Compressive Strength = 5200 Psi
Type M Mortar Compressive Strength = 4500 Psi (Assumption)
f_c' = 8000 - 9000 Psi for Packaged Standard Cement Materials cements
HS-20 Loading = 32,000 lbs/axle/16,000 lbs/wheel assy. (AASHTO)
Maximum CA™ Plus Cement = ½ inch thick

ANALYSIS: Based on the Masonry Standards Joint Committee (MSJC) as developed in the "Building Code Requirements for Masonry Structures" (ACI530/ASCE 5/TMS 402) and;

"Specifications for Masonry Structures" (ACI530.1/ASCE 6.TMS 602);

"Building Code Requirements for Reinforced Concrete" ACI 318-05), American Concrete Institute.

BRICK MANHOLE ANALYSIS:

Determine the Compressive Strength for the Brick Manhole Masonry – f'_m:

See Table 5 – Unit Strength Method of f'm Compliance in the MSJC Specifications – 1525 Psi Linear Interpolation is permitted.

Determine Allowable Average Compressive Stress for the Brick Manhole – F_a:

See Table 2 – Allowable Compressive Stresses in the ACI 530/ASCE 5.

$F_{a =}$ 225 Psi for Grouted Masonry Clay, Type M Mortar, for 4500 Psi or greater.

Determine the Gross Area for the Brick Manhole - A_g
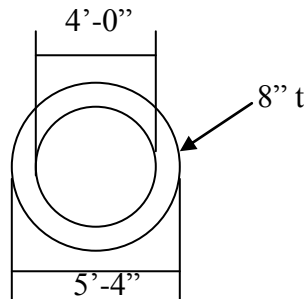
Area of Manhole = $A_g = \dfrac{\Pi\,(5.33)^2}{4} - \dfrac{\Pi\,(4)^2}{4} = 22.34 - 12.57 = 9.77$ Ft.^{2} = 1407 in^2

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

P_l = Service Live Load (HS-20) = 16,000 lbs

1.7 − Live Load Factor (ACI 318-05) Appendix C.2.1
U = 1.4 D + 1.7 L; Neglect D-dead load due to it is
insignificant compared to the live load.

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

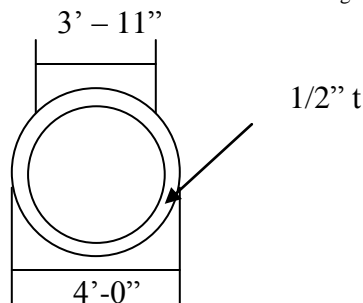$f_a = P_l/A_g$ = 27,200lbs/1407 in^2 = 19.77 Psi < 225 Psi

Determine the Ultimate Load for the Brick Manhole − P_{ubm}

$P_{ubm} = A_g$ x F_a = 1407 in^2 x 225 Psi = 316,575 lbs

MAXIMUM CA™ PLUS ANALYSIS:
Determine the Gross Area of the Maximum CA Plus - A_{gmsp}

A_{gmsp} of Maximum CA Plus = $\dfrac{\Pi\,(4)^2}{4} - \dfrac{\Pi\,(3.917)^2}{4} = 12.57 - 12.05 = 0.52$ Ft^2 = 74.84 in^2

Determine the Actual Compressive Stress due to the HS-20 Loading with Maximum CA Plus, f_{amsp}

$$f_{amsp} = P_1 / (A_g + A_{gmsp}) = 27{,}200 \text{ lbs} / (1407 \text{ in}^2 + 74.84 \text{ in}^2) = 18.36 \text{ Psi}$$

Determine the Percent of Reduction of Stress on the Brick Manhole w/ Maximum CA Plus

$$\% \text{ Reduction} = \frac{19.77 \text{ Psi} - 18.36 \text{ Psi}}{19.77 \text{ Psi}} = 7.1\%$$

Conclusion: The rehabilitated brick manhole with Maximum CA Plus alone can carry the support of the HS-20 truck loading in addition to having a 7.1% reduction in compressive stress due to axial loading.

Determine the Increase in Structural Capacity in utilizing Ultimate Strength Design Method for Maximum CA Plus: Assumption: Analyze as a Load-Bearing Wall w/ no Eccentricity.

Determine the Allowable Stress for the Maximum CA Plus – F_{amsp}

      Φ - Strength Reduction Factor (ACI 318-05, Chapter 9, Section 9.3.2.4)
                $\Phi = 0.65$, Bearing on Concrete

      $F_{amsp} = \Phi \times f_c' = 0.65 \times 8000 \text{ Psi} = 5200 \text{ Psi}$

Determine the Ultimate Load of the Maximum CA Plus – P_{umsp} – Conservative approach is to use the Empirical Design Method, ACI 318-05, Chapter 14 – Walls, Section 14.5, Eq. Sec. 14.5.2

                $\Phi P_{umsp} = 0.55 \times \Phi \times f_c' \times A_{gmsp} [1- (klc / 32h)^2]$ Since l_c is continuously supported $l_c = 0$; the expression goes to zero on the right side.

                $= 0.55 \times 0.65 \times 8000 \text{ Psi} \times 74.84 \text{ in}^2 = 214{,}042 \text{ lbs.}$

      $P_{tot} = P_{ubm} + P_{umsp} = 316{,}575 \text{ lbs} + 241{,}042 \text{ lbs} = 530{,}617 \text{ lbs}$

      $\%$ increase $= 530{,}617 / 316{,}575 = 1.68$ 68 % increase in manhole strength

Pursuant to performing the calculations in a manhole rehabilitated with a ½ inch liner to determine strength increase. I have calculated a 68% increase in manhole strength and a 7.1% reduction in stress. This analysis does not take into account the deterioration, age or condition of an existing manhole which would ultimately result in higher and improved values.

MAXIMUM CA PLUS & STANDARD 4553 EPOXY COATING ANALYSIS:

Determine the Gross Area of the Standard 4553 Epoxy Coating - A_{gec}

3' – 10.875"

125 mils, 0.125 in. = t

3'- 11"
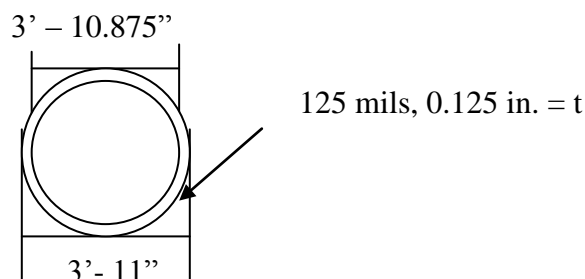
A_{gec} of Maximum CA Plus $= \dfrac{\Pi \,(3.917)^2}{4} - \dfrac{\Pi \,(3.906)^2}{4} = 12.05 - 11.983 = 0.0673\ \text{Ft}^2 = 9.69\ \text{in}^2$

Determine the Actual Compressive Stress due to the HS-20 Loading with Maximum CA Plus, f_{amsp} and Standard 4553 Epoxy Coating, f_{ep}

$$(f_{amsp} + f_{ep}) = P_1 / (A_g + A_{gmsp} + A_{gec}) = 27{,}200\ \text{lbs} / (1407\ \text{in}^2 + 74.84\ \text{in}^2 + 9.69\ \text{in}^2)$$
$$= 18.24\ \text{Psi}$$

Determine the Percent of Reduction of Stress on the Brick Manhole w/ Maximum CA Plus

$$\%\ \text{Reduction} = \frac{19.77\ \text{Psi} - 18.24\ \text{Psi}}{19.77\ \text{Psi}} = 7.74\ \%$$

Conclusion: The rehabilitated brick manhole with Maximum CA Plus and Standard 4553 Epoxy Coating can carry the support of the HS-20 truck loading in addition to having a 7.74% reduction in compressive stress due to axial loading.

<u>Determine the Ultimate Load for the Standard 4553 Epoxy Coating</u> $- P_{ec}$

$$P_{ec} = A_{gec}\ \text{x}\ F_{aec} = 9.69\ \text{in}^2\ \text{x}\ 10{,}550\ \text{Psi} = 102{,}230\ \text{lbs}$$

$$P_{tot} = P_{ubm} + P_{umsp} + P_{ec} = 316{,}575\ \text{lbs} + 241{,}042\ \text{lbs} + 102{,}230\ \text{lbs}$$
$$= 659{,}847\ \text{lbs}$$

$$\%\ \text{increase} = 659{,}847 / 316{,}575 = 2.08 \qquad 108\ \%\ \text{increase in manhole strength}$$

Pursuant to performing the following calculations for determining the increased strength due to the rehabilitation of a manhole with a ½ inch liner and 125 mils of Standard 4553 Epoxy Liner, I have calculated a 108% increase in manhole strength and a 7.74% reduction in stress. This analysis does not take into account the deterioration, age or condition of an existing manhole which would ultimately result in higher and improved values.

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

Sincerely,

Ronald C. Roche, P.E.

September 21, 2009