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June 15, 2000

Rhino USA of Oregon
1212 Alabama Avenue, Suite 27
Bandon, OR 97411

Attn: John Stephens
Re: Polyethylene Manhole Testing

Dear John:

A final manhole test was completed last week and I would like to summarize the results and what conclusions may be drawn from them. As I understand, the goal of the testing was to establish a maximum depth for the polyethylene manholes in terms of radial earth pressures including groundwater effects. This was accomplished by applying a vacuum to the interior of the manhole until failure, and converting the vacuum measured to an equivalent depth. Vacuum, in inches of Mercury (inHg), was converted to pounds per square foot (psf). In turn, psf values was used to back calculate a maximum depth using equation No. 5 of ASTM F-1759-97 (Standard Practice for Design of High-Density Polyethylene (HDPE) Manholes for Subsurface Applications).

In my letter dated May 4th, we just completed a successful test where your standard manhole riser and short base were subjected to gradually increasing vacuum pressures until failure occurred by breaking of the seal at 23 inches of vacuum. It was concluded that the manhole was still structurally sound at a vacuum pressure of 20 inHg and the corresponding manhole depth was 16 feet.

An improved manhole riser and base was constructed by adding stiffening ribs to the riser and thickening the walls of the base by about 20 %. This new riser and base was subjected to the maximum vacuum the pump could produce (23 inHg). A vacuum pressure of 23 inHg corresponds to a manhole depth of 18.5 feet. When the vacuum could no longer be increased, the pump was stopped, valves where closed to observe any additional deflection or any loss of vacuum. After 20 minutes, no additional deflection could be seen, and none of the vacuum was lost.

Please contact me if there are any questions.

Very truly yours,
HGE INC., Architects, Engineers, Surveyors & Planners

Clay Baumgartner, P.E.

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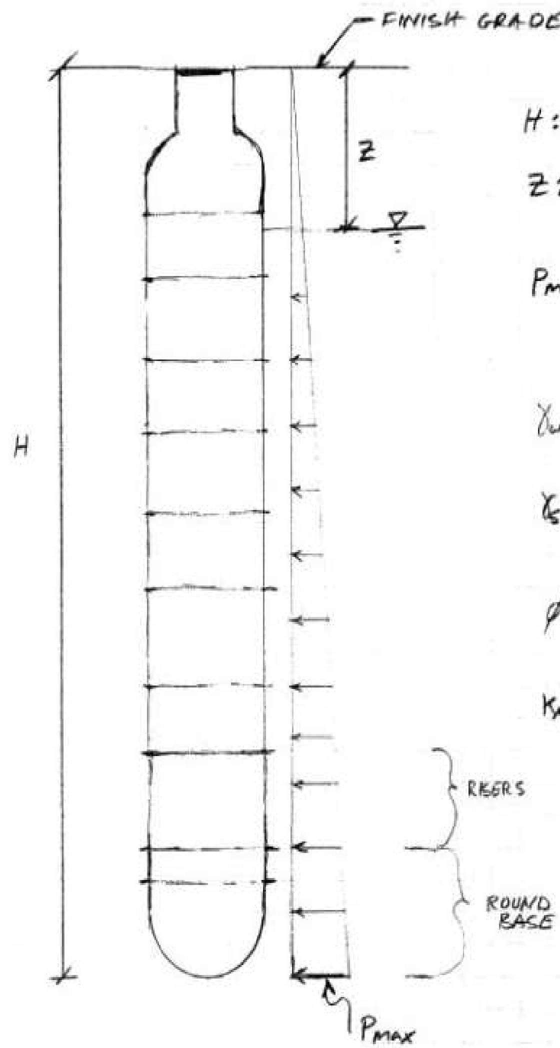

H: MAX. DEPTH (ft.)

Z: DEPTH TO GROUNDWATER (ft.)
WORST CASE = 0 ft

P_{max} = MAXIMUM RADIAL PRESSURE
lbs./ft^2

γ_w = UNIT WEIGHT OF WATER
62.4 lb/ft^3 (pcf)

γ_s = UNIT WEIGHT OF SOIL
125 lb/ft^3

ϕ = FRICTION ANGLE OF SOIL
30°

K_A = ACTIVE EARTH PRESSURE COEFF.

$$K_A = TAN^2\left(45 - \frac{\phi}{2}\right) = 0.333$$

P_{max} @ H=28', Z=0

$$P_{max} = \gamma_w H + 1.21\, K_A (\gamma_s - \gamma_w) H$$

$$= (62.4\ lb/ft^3)(28') + (1.21)(0.333)(125\,pcf - 62.4\,pcf)(28')$$

$$= 2453.45\ lb/ft^2 \text{ or } 17.04\ psi \text{ or } 34.69\ in\ Hg$$

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$P_{max} = \underline{15 \text{ in } Hg} \Rightarrow 7.37 \text{ psi} \Rightarrow 1060.9 \text{ psf}$

$P_{max} = \gamma_w H + 1.21 K_A (\gamma_s - \gamma_w) H$

$P_{max} = H[\gamma_w + 1.21 K_A (\gamma_s - \gamma_w)]$

$H = P_{max} / [\gamma_w + 1.21 K_A (\gamma_s - \gamma_w)]$

$$H = \frac{P_{MAX}}{[62.4 + 1.21(0.333)(125 \text{ pcf} - 62.4)]}$$

$H = 0.01141\, P_{max} (\text{psf})$
$= 0.01141 (1060.9 \text{ psf})$
$= \underline{12.1 \text{ ft}}$

P in inches of Mercury (Hg) to MAX. DEPTH H

$14.7 \text{ psi} = 29.9 \text{ in } Hg$

$H = (0.01141)(P_{max} \text{ psf})\left(\frac{14.7 \text{ psi}}{29.9 \text{ in } Hg}\right)\left(\frac{144 \text{ psf}}{1 \text{ psi}}\right)$

$H = 0.8077\, P (\text{in } Hg)$

$P = 15 \text{ in } Hg \Rightarrow H = 12.1 \text{ ft}$

$P = 17 \text{ in } Hg \Rightarrow H = 13.7 \text{ ft}$

$P = 20 \text{ in } Hg \Rightarrow H = 16.16 \text{ ft}$

$P = 25 \text{ in } Hg \Rightarrow H = 20.2 \text{ ft}$