



SewperCoat Hoop Compression Test

In May 2007, a Master's candidate in the Civil Engineering department of Queen's University in Ontario Canada performed a hoop compression test on SewperCoat PG as part of his thesis. The intent of the test was to quantify the level of deflection of coatings and linings used in wastewater manhole applications. The test externally loaded lined concrete and lined brick host structures with numerous materials, including SewperCoat PG. We have been given some interim information regarding our product's performance which is discussed in this document. We will have the full published thesis by late September.

Sample Preparation – SewperCoat Lined Brick Structure

New Dry bricks (Ontario Size – 213mm x 102mm x 60mm) were dry-stacked in circular staggered layers to form a manhole model with an average outer diameter of 90 cm and an average inside diameter of 75 cm. Bricks were underlain by a concrete well tile of the same outer diameter to simulate the manhole footing. The inner walls of the manhole sample were moistened with clean fresh water, after which the SewperCoat product was mixed and applied to the inner walls with a trowel to an average thickness of 13mm. The sample was then wrapped in plastic and left to cure for a minimum of 24 hours.

Sample Preparation – SewperCoat Lined Concrete Structure

Two sections of new well tile with average outer diameters of 90cm and average inner diameters of 75cm were cut circumferentially to fit into the cell. The well tile sections were then cut lengthwise to simulate vertical spalling while two sections of the manhole were ground thin to simulate acid attack, both of which are commonly experienced by manholes in the field. The entire sample was then moistened, and subsequently grouted on the inner walls using the SewperCoat product by with a trowel to an average thickness of 13mm. The sample was then wrapped in plastic and left to cure for a minimum of 24 hours.

Backfill

The backfill material placed around each manhole specimen was synthetic olivine sand; a poorly graded material (Unified soil classification – SP) with a mean grain size of 0.5mm, a uniformity co-efficient C_u of 1.46, a curvature co-efficient C_c of 0.94, and an angle of internal friction of 44° . Minimum and maximum densities of the olivine, as measured in the laboratory are 1.27 g/cm³, and 1.61 g/cm³, respectively. The olivine was backfilled into the cell using 15cm lifts, each compacted to an average density of 1.45g/cm³.

Instrumentation

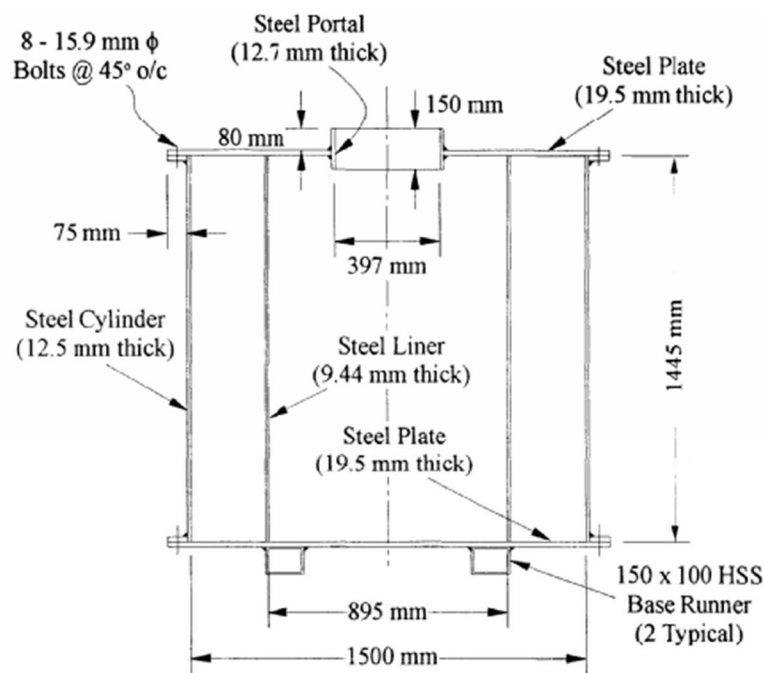
High powered digital photography was used to capture and quantify the radial and circumferential displacements of each sample. 45 to 58 targets spanning the inner circumference of each sample at multiple sections were used as points of reference for the digital camera. Photographs captured every minute during load increment changes were later compared against each other using the software program *Matlab*, to locate and quantify very small deformations in the pipe wall. In conjunction with the camera targets, two Linear Potentiometers were installed perpendicular to each other to physically quantify diameter changes in both samples.

Test Apparatus

Each manhole specimen was placed vertically into the steel hoop compression cell. The hoop compression cell was designed to withstand a maximum radial test pressure of 500 kPa and consists of three major structural components: a 19.5mm thick circular steel top plate, 1675mm in diameter with a 397mm ID; a 12.5mm thick steel cylinder, 1500mm ID with a 75mm continuous steel flange top and bottom; and a 19.5mm thick circular steel bottom plate, 1675mm in diameter with two 150mm x 100mm hollow steel section (HSS) base runners.

Bolted at the top and bottom of the inner wall of the main cylinder section is a gum-rubber bladder able to withstand a maximum pressure of 1 MPa. The bladder is confined vertically by the steel lid and base to resist rupture from the vertical component of the applied air pressure, and horizontally by the soil surrounding the pipe specimen. As air is pumped into the bladder, the confining soil becomes stressed, simulating axi-symmetric horizontal effective stresses that acts on a vertical pipe specimen at depth. Friction between the backfill soil, and the lid and base was minimized by placing polyethylene sheets lubricated with high-temperature bearing grease along the base and lid. This arrangement reduces the boundary friction to less than 5°.

Figures 1, 2 and 3 diagram the hoop compression cylinder.



Section A-A

Figure 1: Section through Hoop Compression Cylinder

Note: The inner steel cylinder (895mm diameter) is removed from the apparatus. Thus, only the outer steel walls of the cylinder confine the soil. The inner walls of the cell house an air bladder that spans the section from the top flange to the bottom flange. The air bladder is inflated, which acts against the soil that has been backfilled into the void between the pipe specimen and the outer walls. Please refer to Figure 3 for clarification.

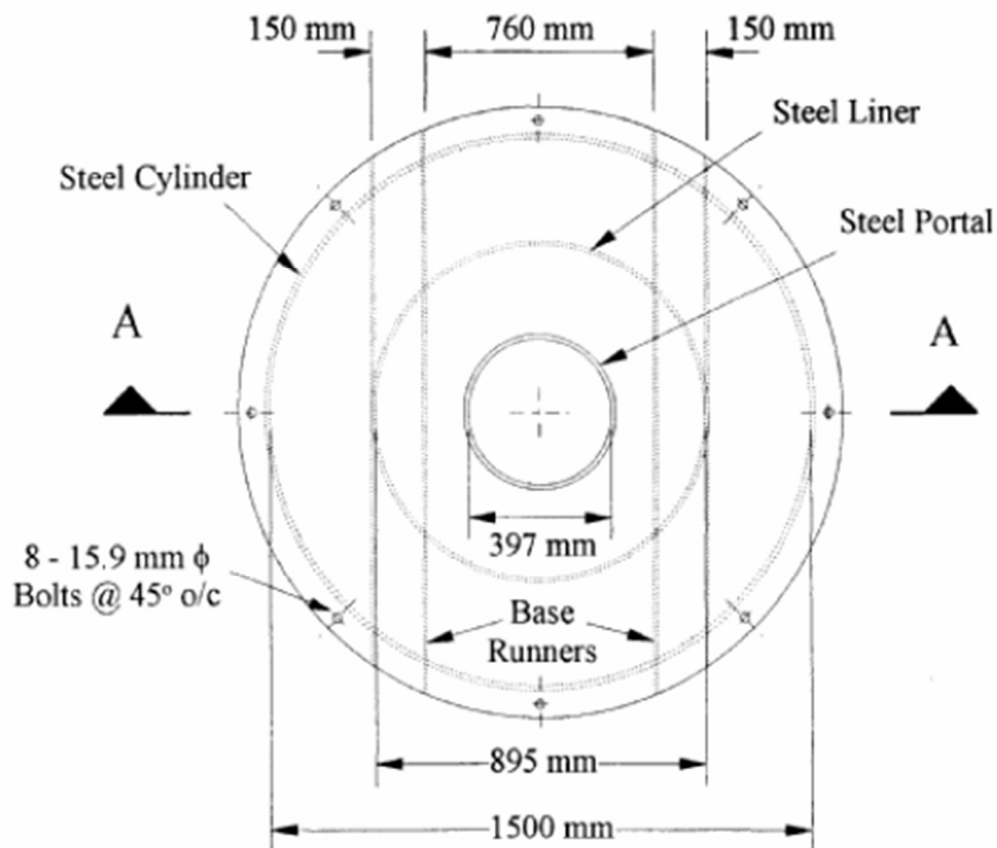


Figure 2: Plan View Hoop Compression Cell.



Figure 3: Plan view of Hoop Compression Cell with lid removed; under prep for profiled pipe test.

Loading Scheme

Both samples were subjected to the same load increment pertaining to the same time frame. 50 kPa Load increments were used every 30 minutes, up to a maximum air bladder pressure of 500 kPa.

Results

SewperCoat Lined Brick Structure

The brick sample demonstrated very stiff characteristics with small radial deformations throughout the test. A maximum radial deformation of 0.2mm was measured at the maximum pressure of 500kPa. Figure 5 details the pressure level against radial deformation. Figure 4 shows the SewperCoat lined, dry-stacked brick structure in the compression cell before being backfilled.

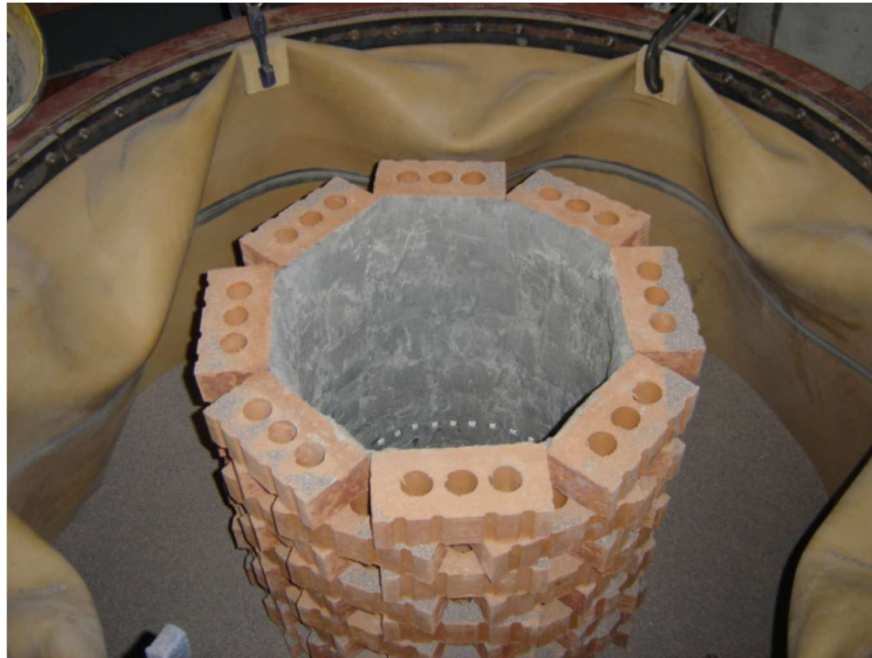


Figure 4: SewperCoat lined, dry-stacked brick prior to backfill.

Concrete SewperCoat

The concrete sample also demonstrated very stiff characteristics with small radial deformations throughout the test. However, upon initial stressing of the sample, up to 2.5 mm of deflections were recorded, possibly due to the closing of the gaps between the spalling cracks in the concrete. After roughly the fourth load step of 200 kPa, the deformations leveled off, and subsequent radial contractions were much smaller, on the order of 0.1 to 0.5mm. Maximum total radial deformations of 2.5-3mm were recorded with this sample. Please refer to Figure 5 for a plot of pressure against deformation.

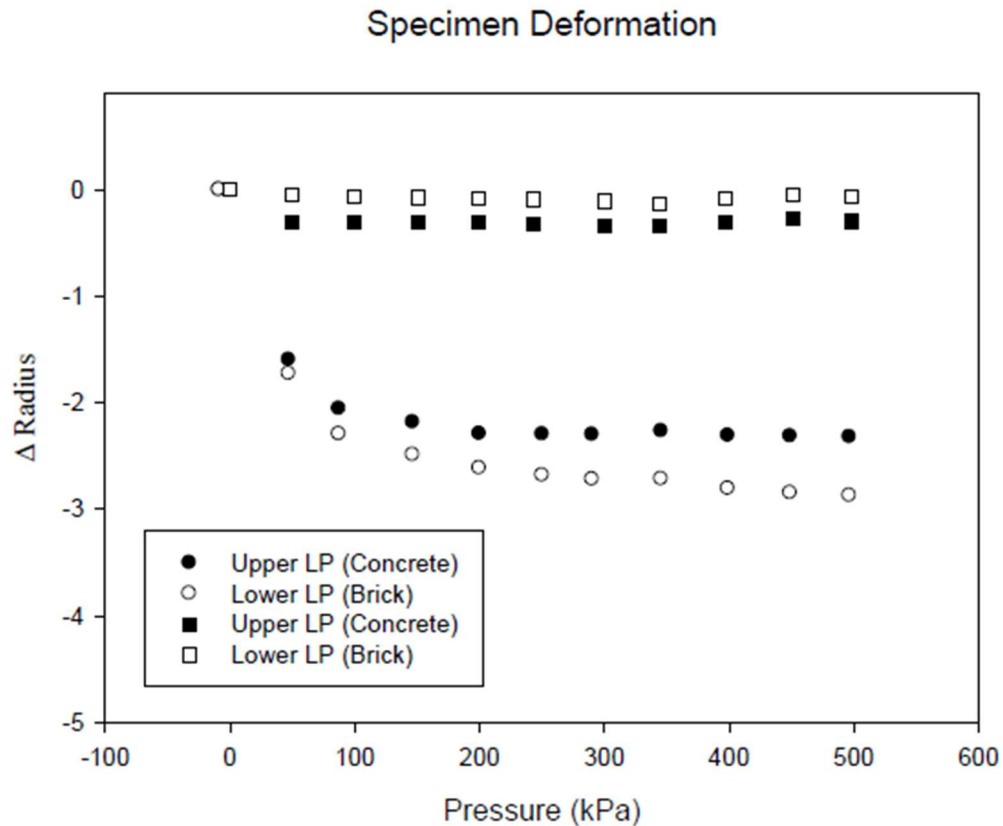


Figure 5: Radial deformation and pressure pertaining to both samples

Conversion

The maximum load of 500kPa is the equivalent of 72.5 psi. Given the average density of the test medium (1.45), this load can be back calculated to burial depth of 115.38 feet.

Maximum load of 500 kPa = 72.5 psi = 115.38 feet of this soil

$$[(75.2 \text{ psi}) * (12 \text{ in/ft}) * (12 \text{ in/ft})] / [(62.4 \text{ lb ft}^3) * (1.45 \text{ avg. density})] = 115.36 \text{ feet of soil}$$