

# Memo



**To:** Paul Thomas  
Holtec International

**From:** Francis D. Leathers, P.E.

**Date:** December 18, 2017

**Re:** Results of One-Dimensional Consolidation and Swell Tests  
Proposed Holtec HI-STORE CISF, Lea County, New Mexico  
GEI Project No. 1703345

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In this memorandum, we summarize the results of two one-dimensional consolidation and swell tests, SW1 and SW2, performed on core samples of the Chinle Formation mudstone. The test results are shown in the attached plots. The samples were obtained from HQ rock core in B107 at depths of about 74 and 101 feet below the ground surface.

## Sample Preparation and Testing Procedure

The consolidation – swell tests were performed in accordance with GEI's Laboratory Test Procedures 239 and 244. The samples were taken from visually intact specimens of rock core. We used a one-dimensional consolidation ring with a diameter of 6.35 cm which was slightly larger than the diameter of the rock cores (5.67 cm and 6.24 cm, respectively) so that we did not have to trim the diameter of the friable rock samples. We trimmed the ends parallel and as flat as practical. The annular space between the sides of the sample and consolidation ring was backfilled with rounded fine quartz (Ottawa) sand, gently vibrated as it was place. A thin layer of the sand was placed on the top and bottom faces of the sample, just thick enough to even out any small irregularities in the trimmed surface.

The samples were consolidated and partially unloaded in a "dry" state, i.e., at their natural water content without addition of water to the container surrounding the sample and ring. Loading increments were applied up to a maximum of 16 tons per square foot (tsf), and then unloaded to 4 tsf. During the "dry" increments, the consolidation or rebound occurred very quickly, typically in less than 1 minute. Each increment was held for approximately 30 to 60 minutes. The "dry" consolidation and rebound load curve and the coefficient of consolidation values are shown on the plots.

After unloading to 4 tsf, the sample in SW1 was flooded with water. The swell as the sample absorbed water was measured for a period of about 3 hours, and then the sample was further unloaded in increments with each swell increment held for about 3 hours. In test SW2, the swelling at 4 tsf was measured for a period of about 22.5 hours. The swelling stopped after a period of about 8 hours, with no swell during the last 14.5 hours of the test. No further unloading steps were performed for SW2.

## Discussion of Test Results

These tests demonstrate that the Chinle mudstone has a potential to swell about 0.3% to 0.4% in the presence of free water, with confinement ranging from 0.125 tsf to 4 tsf, equivalent to the vertical stress at depths of about 2 feet to over 60 feet. Potential swell at greater depths is expected to be less due to the increase in confining pressure.

Based on available literature, the measured swell would classify the Chinle mudstone as having a low potential for both probability and amount of significant swell (reference: Expansive Soils, Problems and Practice in Foundation and Pavement Engineering, by John D. Nelson and Debora J. Miller, John Wiley and Sons, New York, 1992).

Although most of the existing residual soil will be removed from beneath the ISFSI pads, it is our opinion that these test results are also indicative of the expected behavior of the remaining residual soil below foundation level.

We note that the potential for swell is not likely to actually occur in the field, because the presence of the ISFSI pads and improvements to site drainage means that there will be less water infiltration from the surface than occurs presently. Even with reduced evapotranspiration, we anticipate that the water content of the rock in the ground will not increase significantly with time, and certainly will not approach a state of saturation. Therefore, it is our opinion that the ISFSI pad will not experience heave due to swell of the foundation soils and rock.

### **Limitations**

The evaluations and recommendations provided above are based on our current understanding of the proposed project, and the currently available data on subsurface conditions. We will update our evaluations and recommendations as the project design is further developed by Holtec.

### **Attachments**

One-Dimensional Consolidation and Swell Test Results, SW1 and SW2

FDL:mrh

O:\Nuclear Program\Nuclear QA Projects\1703345 - Holtec HI-STORE\1703345 - Final\Admin\Correspondence\2017-12-18 Memo\Memo - Results of One-Dimensional Consolidation and Swell Tests - Dec 18, 2017.docx

### SAMPLE INFORMATION

Boring: B107  
 Sample: C4  
 Depth (ft): 73.9-74.6  
 Test: SW1  
 Type: HQ-diameter core  
 Description: Reddish-brown mudstone

### SPECIMEN INFORMATION

	Initial	Final
Specimen Height	2.054 cm	2.061 cm
Specimen Area	25.25 sq. cm	25.25 sq. cm
Specimen Volume	51.86 cc	52.03 cc
Water Content	13.74 %	14.80 %
Total Unit Weight	2.211 gm/cc	2.224 gm/cc
Dry Unit Weight	1.944 gm/cc	1.937 gm/cc
Saturation	91.1 %	97.0 %
Void Ratio	0.415	0.419

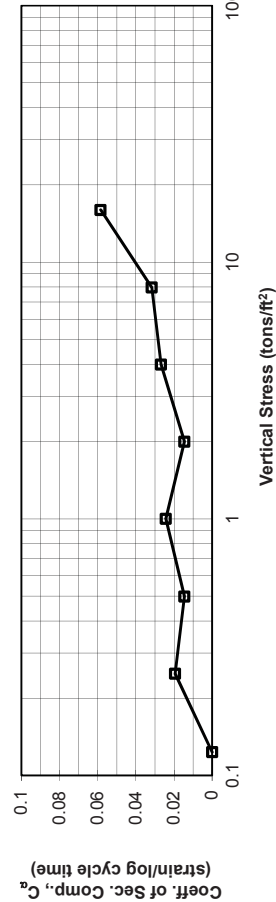
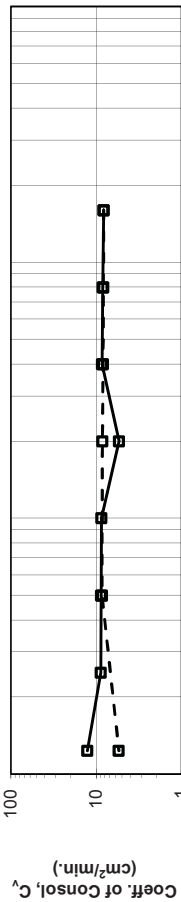
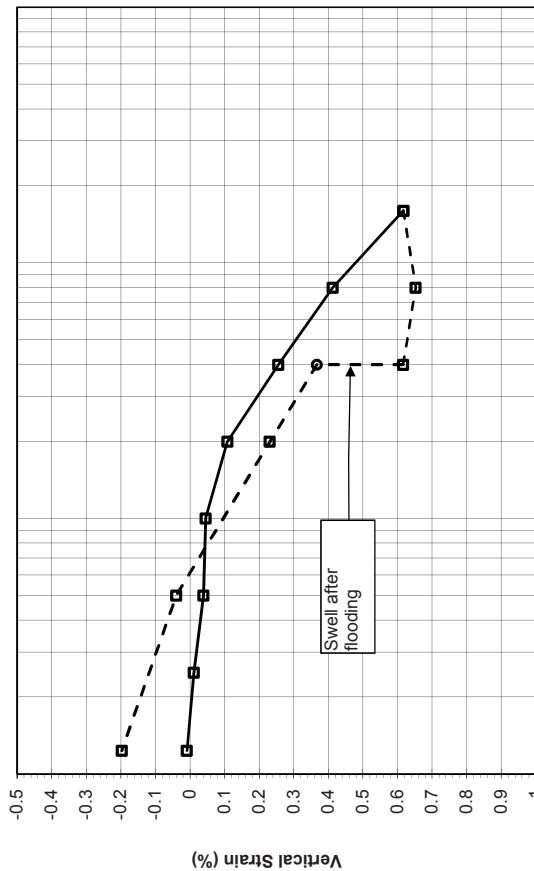
Specific Gravity 2.75 (assumed)

### TEST SUMMARY

Estimated preconsolidation stress (tsf): NA  
 Compression Ratio (strain per log cycle stress): 0.007 (4 to 8 tsf)  
 Swell Ratio (strain per log cycle stress): 0.002 (8 to 4 tsf)  
 Recompression Ratio (strain per log cycle stress): NA  
 Swell after flooding at 4 tsf (% Strain): 0.25

### REMARKS

Results Computed per Square Root of Time Method  
 Specimen consolidated "in the dry" and then flooded at 8 minutes into the 4 tsf unload stage.



Test Date: 12/5/2017  
 Tested By: DJA  
 Check By: FDL  
 Check Date: 12/18/2017

LEGEND:  
 □ End of primary  
 — Loading  
 - - - Unloading  
 ○ End of stage

Holtec Hi-Store CISO  
 Site Characterization  
 Lea County, New Mexico  
 Holtec International  
 Camden, New Jersey



ONE DIMENSIONAL  
 CONSOLIDATION AND SWELL TEST  
 SW1

Project 1703345  
 December 2017  
 Form 239.7 rev.0

**SAMPLE INFORMATION**

Boring: B107  
 Sample: C9  
 Depth (ft): 100.5-101.1  
 Test: SW2  
 Type: HQ-diameter core  
 Description: Reddish-brown mudstone

**SPECIMEN INFORMATION**

	Initial	Final
Specimen Height	2.409 cm	2.364 cm
Specimen Area	30.53 sq. cm	30.53 sq. cm
Specimen Volume	73.55 cc	72.17 cc
Water Content	8.00 %	10.54 %
Total Unit Weight	2.287 gm/cc	2.386 gm/cc
Dry Unit Weight	2.118 gm/cc	2.158 gm/cc
Saturation	73.7 %	105.7 %
Void Ratio	0.299	0.274

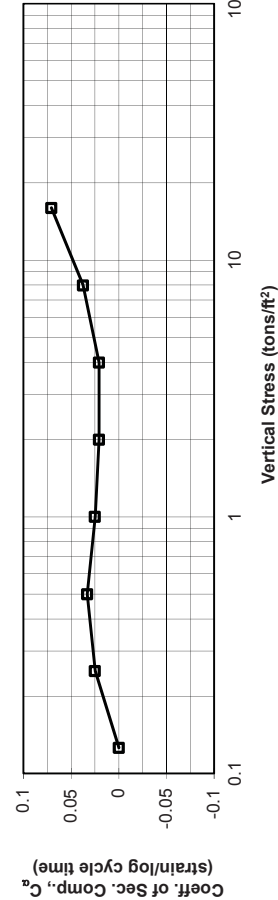
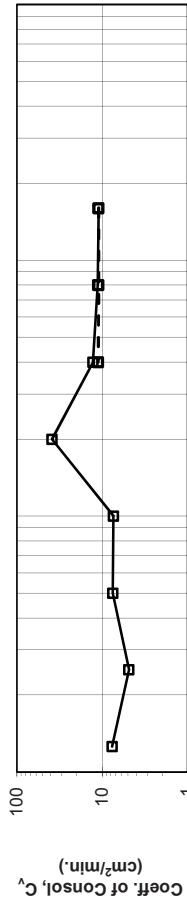
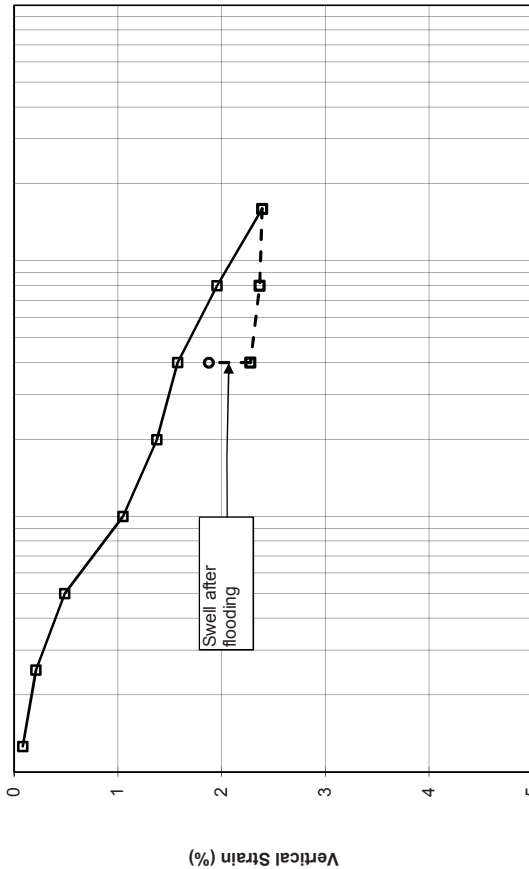
Specific Gravity 2.75 (assumed)

**TEST SUMMARY**

Estimated preconsolidation stress (tsf): NA  
 Compression Ratio (strain per log cycle stress): 0.014  
 Swell Ratio (strain per log cycle stress): 0.003  
 Recompression Ratio (strain per log cycle stress): NA  
 Swell after flooding at 4 tsf (% Strain): 0.40

**REMARKS**

Results Computed per Square Root of Time Method  
 Specimen consolidated "in the dry" and then flooded at 8 minutes into the 4 tsf unload stage.



Test Date: 12/8/2017  
 Tested By: DJA  
 Check By: FDL  
 Check Date: 12/18/2017

LEGEND:  
 □ End of primary  
 — Loading  
 - - - Unloading  
 ○ End of stage

Holtec Hi-Store CIFS  
 Site Characterization  
 Lea County, New Mexico  
 Holtec International  
 Camdem, New Jersey



Project 1703345

ONE DIMENSIONAL  
 CONSOLIDATION AND SWELL TEST  
 SW2

December 2017 Form 239.7 rev.0