Reinforced Earth ®
Mechanically Stabilized Earth Abutment Walls
Initial Report 1998-3
April, 1998

Reporting on Work Plan 94-S-21

State of Vermont
Agency of Transportation
Materials and Research

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16. Abstract

In 1996 the Vermont Agency of Transportation (VAOT) completed the state's first mechanically stabilized earth (MSE) abutment walls in the Town of Wallingford, Vermont. The project involved construction of a 100 foot simple steel girder bridge on U.S. Route 7 over the Vermont Railway. MSE technology was selected because it solved the problem of constructing abutments in a confined work zone and did so at a considerable cost savings when compared to using reinforced concrete pilings.

The product under study is a proprietary system of the Reinforced Earth Company®. The system is composed of concrete facing panels which are attached to layers of steel reinforcing strips in compacted select backfill material.

The project site has been continuously monitored since before construction with an extensive array of geotechnical instrumentation, including settlement platforms, inclinometers, earth pressure cells, and monitoring wells. Data collected from this project will provide a valuable reference for future use of MSE technology by VAOT.

Follow up reports will be issued throughout the duration of the study.

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Introduction

In 1996 the Vermont Agency of Transportation constructed its first mechanically stabilized earth (MSE) abutment wall. Located in the Town of Wallingford, the project consisted of replacing a badly deteriorated steel I-beam bridge (Figure 1) by realigning U.S. Route 7 and constructing a 100 foot simple span steel girder bridge over the Vermont Railway. Design of the new bridge was complicated by the 30° skew in the roadway over the railway and the height needed to accommodate the rail line. In addition to these constraints, it was necessary to maintain traffic on the existing roadway during construction, creating a confined area in which to erect the structure.

Figure 1. I-Beam Bridge, Constructed 1937

Initial planning focused on using piling at the abutments; but because of the limitations noted, design criteria were pushed to the limit and costs for the foundation alone were estimated at upwards of $900,000. As an alternative to the pile foundation, MSE technology, which offered cost effective solutions to the design challenges, was proposed and accepted.

The Reinforced Earth Company ® (RECO) in conjunction with Barnes & Jarnis, Inc., engineering consultants, assisted the Agency in designing an MSE wall for the U.S. Route 7 project. Because of the unique nature of this project, the MSE wall was designated a Category II Experimental Feature and incorporated extensive geotechnical instrumentation.

Since MSE technology was new territory to both the Agency and the contractor, J.A. McDonald, Inc., design and construction were overseen by technical representatives from RECO. This report documents the lessons learned on the Wallingford project and will serve as a reference for future MSE applications.

Product Description

The mechanically stabilized earth wall system supplied by RECO achieves its structural integrity through use of steel reinforcing strips, placed within layers of compacted fill material, which are attached to vertical concrete panels to form a reinforced earthen embankment, wall, or abutment. The precast concrete panels are interlocked and erected in lifts. To the rear of each panel are tie strips between which the reinforcing strips are bolted. The strips are laid out horizontally behind the panels and covered with compacted select backfill. The layered system of strips forms a reinforced mass which is sufficiently stable to provide structure support without the use of piles, as shown in Figure 2. In the case of obtuse angles at the wingwall, the strips radiate into the embankment and are held by the accumulated compacted weight of the fill material. In the case of an acute angle in the wingwall, the strips are attached directly to the panels on the opposing sides, as was the case with Wingwall 4.

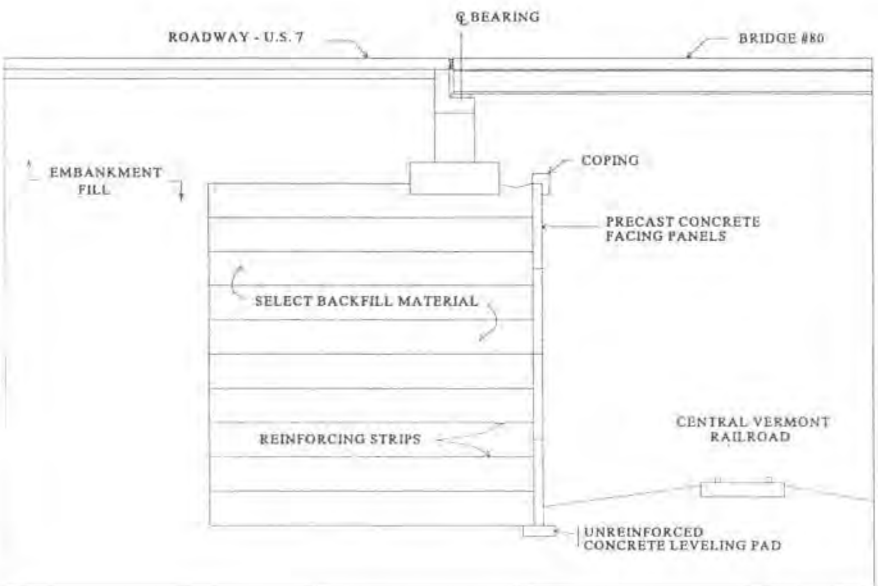


Figure 2. Typical MSE Abutment Section

Reinforcing Strips

The reinforcing strips are galvanized steel measuring two inches wide by 0.157 inches thick, meeting ASTM A-572 grade 65. An unavoidable weakness in the system is the eventual corrosion of the steel strips. In order to prolong the structure life and ensure the 100 year design would be attained, several precautions were taken. Limits were placed on the electrochemical properties of the select backfill used in the reinforced zone of the structure. Backfill was tested to ensure that allowable levels of chloride content, sulfate content, pH and resistivity were not exceeded. The reinforcing strips were galvanized and sized such that sufficient steel would remain to resist tensile loads at the end of the design life. The final precaution taken was the installation of a membrane and drainage system to collect salt laden runoff from snow removal operations. More details of the drainage system will follow.

Select Backfill Material

Prior to bid letting, three sources (pits) of select backfill material were tested for the following:

- Gradation
- Resistivity
- pH
- Chlorides
- Sulfates
- Friction Angle
- Plasticity Index
- Soundness

These sources were included in the specifications for the project. The contractor found an alternative source at the Park Association's pit in Wallingford. Following testing, the material was placed throughout the reinforced zone. Test results are shown in Table 1.

Table 1. Select Backfill Test Results

Property	Test Method	Test Result	Specification Requirement
Passing 4" Sieve, %	AASHTO T 27	100	100
Passing 3" Sieve, %	AASHTO T 27	100	75-100
Passing #200 Sieve, %	AASHTO T 27	8.7	0-12
Uniformity Coefficient, Cu		7.5	>2
Plasticity Index	AASHTO T 90	NP [1]	≤ 6
Magnesium Sulfate Soundness, % loss	AASHTO T 104	6	≤ 30
Resistivity, Ω-cm	ASTM G57-78	3300	>3000 @ 100% Saturation
pH	ASTM G51-77	8.1	5-10
Chlorides, ppm	ASTM D512-88	41	≤ 100
Sulfates, ppm	ASTM D516-88	159	≤ 200
Friction Angle, degrees	AASHTO T 236	34.9[2]	>34
Maximum Dry Density, γ_d, pcf	AASHTO T 99	115	
Optimum Moisture, w%	AASHTO T 99	9	

(1) NP = Non-Plastic
(2) Tested at γ_d = 106.3 pcf

Precast Panels

The precast panels were fabricated by William E. Daily, Inc. of Shaftsbury, Vermont. The ashlar stone finish was achieved with form liners to create a stone wall effect, as shown in Figure 3. The concrete mix was colored a light gold using Bay ferrox 3950 3 ½% (heat stable) pigment, which was selected to blend with prominent buildings in Wallingford Village. The resulting color is consistent among the panels and is considered better in appearance than the varying shades of grey common to conventional Portland cement. The textured finish adds to the overall aesthetics of the structure by masking the unavoidable misalignment of the panels at the slip joints anticipated due to differential settlement.

Design Considerations

Early designs of this structure included conventional reinforced concrete abutments supported on H-piles driven to bedrock. This was due primarily to the presence of wet loose silts and sandy silts overlying the bedrock in the area, the need to construct relatively high abutments to clear the railroad, and the significant lateral loads associated with these abutments. As the design began to materialize, it was realized that in order to resist the lateral loads an excessive number of piles would be required and the cost soon escalated beyond reason. The estimated cost for the foundation alone was over $900,000.

Figure 3. Ashlar Stone Panels

To reduce the cost of the foundation, the Agency asked its consultant to pursue the use of an MSE wall for the abutments. As these types of structures are generally more tolerant of movement and are particularly cost effective in fill applications, it was felt this would be a good use of the technology. Working in cooperation with RECO, solutions for settlement problems, both differential and total, were designed into the project. Since the depth to bedrock was quite variable and the soils beneath and directly adjacent to the existing embankment had been pre-loaded, up to eight inches of differential settlement was expected along the MSE wall face. To compensate for the movement, vertical slip joints were placed in the wall at no greater than 100 foot intervals.

Figure 4. Acute Corner Reinforcing Strip Layout

As the clearance over the railroad tracks needed to be maintained throughout the project life, it was decided to monitor settlements extensively throughout the MSE wall footprint during and following construction. By ensuring that the majority of the settlement had occurred prior to constructing the superstructure, future settlement and reduction of clear height would be minimal. Each of the MSE abutments was constructed to the bottom of the stub abutment footing elevation. A 30 day delay was then observed and settlement monitored. Once the rate of settlement stabilized, construction of the remaining portions of the structure was completed.

Maintaining traffic on the existing roadway during construction caused some unique design problems. The alignment of the new roadway required Wingwall 4 be constructed within six feet of the existing road. This, combined with the 30 degree skew to the railroad line, necessitated an acute corner which was designed like a bin section. In the acute corner, reinforcing strips are tied across from the abutment wall panels to the adjacent wingwall panels. Additional reinforcement was placed radially back from the acute corner to prevent it from being pushed out by the retained soil mass as shown in Figure 4. Note the close proximity of the temporary sheet piling on the left side of the figure.

As previously noted, a corrosive-free environment is essential for extending the service life of the reinforcing strips. Preventing intrusion of road salt was a critical design feature and was accomplished by creating a drainage system over the reinforced zones.

The reinforced zones are protected by an impermeable 30 mil membrane liner over both abutments. A drain was constructed over the membrane by grading a six inch layer of 3/4" concrete stone towards a series of six inch perforated PVC underdrains, as shown in Figure 5. The drainage system was then covered with filter fabric, as shown in Figure 6, allowing runoff to collect in the drain field while preventing fines from filling the voids. The slope was then backfilled and seeded. This system effectively protects the reinforcing strips from corrosion by collecting and removing contaminants.

Figure 5. Membrane Liner

Figure 6. Filter Fabric

Construction

The contract was awarded to J.A. McDonald, Inc. of Lyndon, Vermont and construction started during the summer of 1996. The first stage of construction involved placing the one foot by six inch non-reinforced concrete leveling pad on which the panels rest. Next, the alternating half-sized panels were placed and shored; then the full sized panels were interlocked in place. This was followed by placing backfill material in ten inch lifts up to the level of the first tie strips. The steel reinforcing strips were then placed and attached to the panel (Figure 7). After securing the strips, backfill material was placed on top of the strips. Material was dumped at the access and pushed ahead by bulldozer to ensure that no vehicles would drive on, and damage, the exposed strips. A vibratory drum roller was used to compact the material, except within three feet of the wall, where a hand compactor was used.

Figure 7. Reinforcing Strip Connection

Being new technology to both the contractor and the Agency, there were many lessons to be learned in constructing the MSE wall. One problem which arose was how to ensure that the panels remained plumb when subjected to pressure from compaction of the backfill. It was decided that the panels should be leaned slightly inward so that when the select backfill was compacted, the effect would be to push the panels outward and vertical. After compacting a few courses, the contractor became familiar with the amount of movement to expect (1/4" of horizontal movement in three feet vertical) and was able to achieve very consistent vertical alignment throughout the project.

Once all layers were in place, forms were erected and the coping was cast-in-place, after which the drainage system was constructed (see Design Considerations for description).

While constructing Wingwall 4, the panels developed a slight outward bow. Although the backfill was contained at the slip joint by geo-textile fabric and the wall was in no risk of failure, the bow made it impossible for the slip joint covers to fit flush with the joint. Attempts were made to relieve pressure on the fabric by placing large aggregate in the gap; but the appearance of the repair gave the false impression that aggregate was actually coming out of the joint. In response, the joint was filled with mortar after all anticipated movement had subsided (Figure 8).

Figure 8. Repaired Slip Joint Wingwall 4

The exact cause of the movement is unknown, but it has been speculated that the wall shifted when the temporary sheet pilings, just six feet away, were vibrated for removal. This was aggravated by the fact that the area between the wing wall and abutment is very narrow. As previously noted, the reinforcing strips were attached directly to opposing panels to compensate for the lack of volume, but until sufficient layers of panels could be placed, the structure was susceptible to movement. As of the date of this report, the joint has experienced no further distress.

An oversight during construction was discovered when the cast-in-place concrete coping over Abutment # 1 panels developed a crack at the corner of Wingwall 1. The crack was attributed to a bond forming between the panels and the coping. The crack was repaired with mortar compound, which appears to have arrested the problem. Compressible cork bond break material should have been placed between the panels and the coping to prevent cracking but was overlooked during construction.

Another problem encountered during construction involved the spacer bars used to keep the panels in position while the next course of panels was being placed. The bars were inconsistent in length, some deviating as much as 1/8", which caused the panels to be misaligned. The result was that it was difficult to fit some of the panels together because the alignment pins were off-center. It is recommended that the spacer bars be more accurately fabricated to avoid this problem on future projects.

The only material failure observed since completion of construction was two cracked concrete slip joint covers. The slip joint covers were placed in five foot sections along the vertical face of the joint. Where the cracks have occurred it appears as though panels are not flush, which has caused an uneven distribution of the load and placed undo stress on the corner of the cover resulting in some minor spalling. The reason for the misalignment and methods of repair are under investigation, although this problem is not considered serious.

Geotechnical Instrumentation

Concerns for differential and total settlements of the structure and a desire to monitor the performance of the wall as a Category II Experimental Feature resulted in the use of the following types of instrumentation:

- Monitoring wells both within and outside the wall section to monitor the effectiveness of the free draining backfill in the reinforced zone.
- Two types of settlement platforms to monitor the differential and total settlements within the structure and to give the Resident Engineer the flexibility to advance the construction sequence if settlement occurred more rapidly than predicted.
- Earth pressure cells behind the wall panels and beneath the base of the wall to measure lateral and vertical earth pressure.
- Inclinometers in the reinforced section, the slopes and in front of the wall to measure ground stability within the wall, adjacent to the railroad and along the roadway.

The location of all the instrumentation in the area of the MSE walls is shown in Figure 9.

Monitoring Wells

A pair of two inch diameter PVC groundwater observation wells (OWs) were installed to measure static groundwater levels inside (OW-1) and outside (OW-2) the wall face. The purpose of the these wells was to measure the effectiveness of the select backfill material in draining water during construction and the ability of the membrane and drainage system to keep chloride laden snow melt and rain water from infiltrating the reinforced zone of the MSE walls. Throughout construction groundwater levels in both wells remained approximately one foot below the bottom of the drainage swale in front of the wall. Water samples tested for chloride ions in accordance with AASHTO T 291 were 5 ppm in OW-1 and 27 ppm in OW-2 after two winters. Both of these values are well below National secondary drinking water standards for chlorides of 250 ppm.

Settlement Platforms

Two types of settlement platforms were used to monitor the vertical displacements anticipated due to the addition of the MSE walls, approach embankments and the bridge. The 30 day delay period following MSE wall construction was specified to ensure the majority of the total and differential settlement predicted would occur prior to superstructure placement. Six Type I standpipe settlement platforms and four vibrating wire settlement platforms were placed at the locations given in Table 2. Type I platforms consisting of three inch diameter galvanized steel

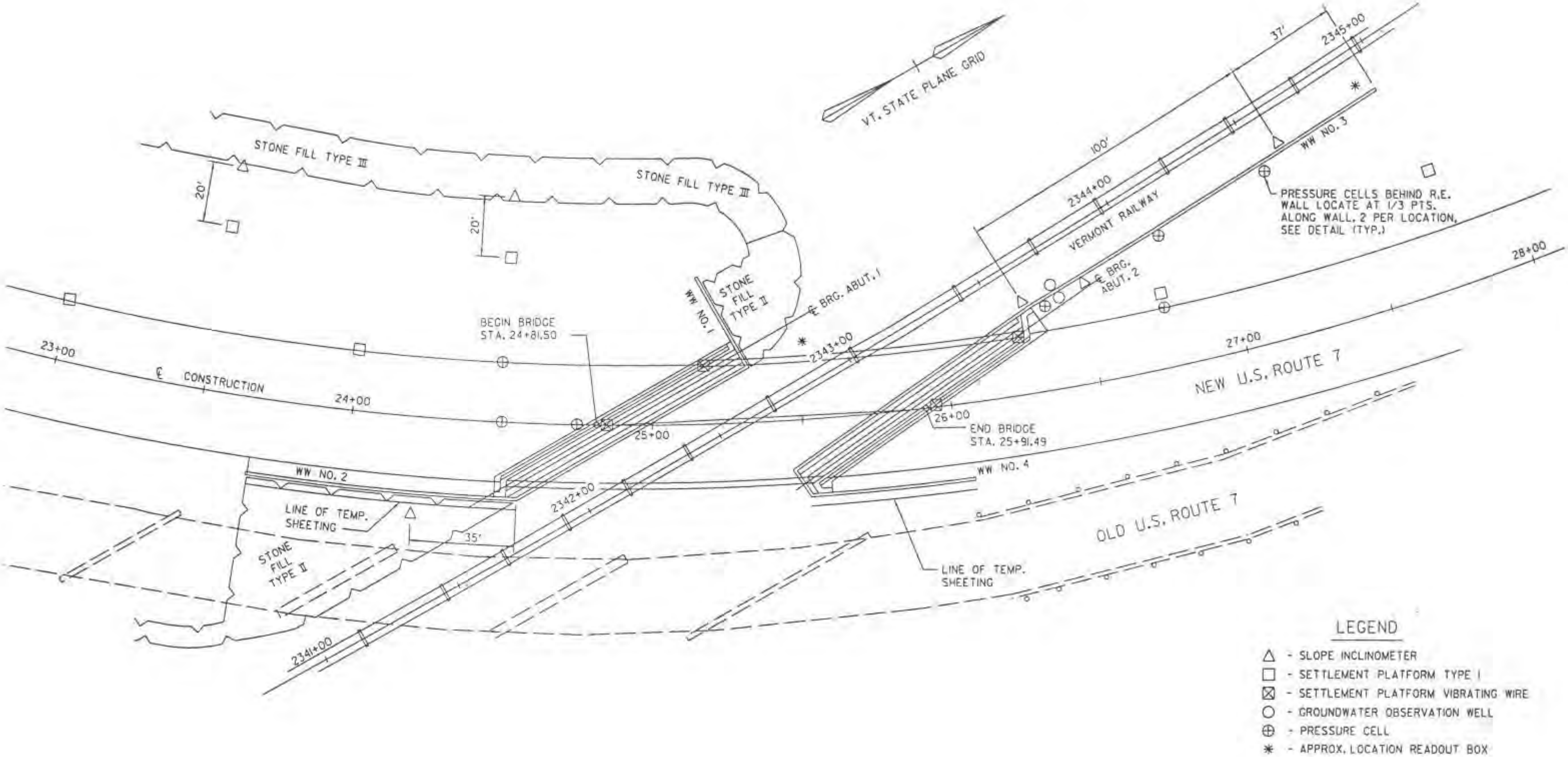


Figure 9. Instrumentation Layout

stand pipes attached to four foot by four foot sheets of pressure treated plywood were placed on existing ground prior to fill placement. As the embankments and wall sections were constructed, additional riser pipe sections were added and the elevation changes were recorded using traditional optical survey equipment.

Table 2. Settlement Platform Results

Settlement Platform Type	Number	Location		Predicted Settlement (inches)	Measured Settlement (1) (inches)
		Station	Offset		
Stand Pipe	SPI-1	26+75	25' LT	1.4	0.27
Stand Pipe	SPI-2	27+75	40' LT	0.9	2.53
Stand Pipe	SPI-3	24+00	20' RT	4.2	2.86
Stand Pipe	SPI-4	24+50	55' LT	5.3	7.84
Stand Pipe	SPI-5	23+50	55' LT	4.6	3.17
Stand Pipe	SPI-6	23+00	20' LT	3.2	3.06
Vibrating Wire	SP-2	24+85	℄	7.7	9.05
Vibrating Wire	SP-3	25+20	20' LT	7.2	8.94
Vibrating Wire	SP-4	25+90	℄	1.8	7.40
Vibrating Wire	SP-5	26+25	20' LT	1.9	1.69

(1) As of 2/10/98

The results of the measurements at each instrument location were plotted against time and fill height. A typical graph of the data taken on Type I stand pipe settlement platform, SPI-6, is shown in Figure 10. Using equations proposed by Cheney[1], predicted settlements were calculated using soil data from standard penetration borings, field density tests, and the embankment geometry at the completion of construction. These results are presented in Table 2. In general, correlation of the calculated settlement with measured values from the Type 1 platforms is considered quite good.

[1] Soils and Foundations Workshop Manual-Second Edition, Richard S. Cheney, National Highway Institute, 1993.

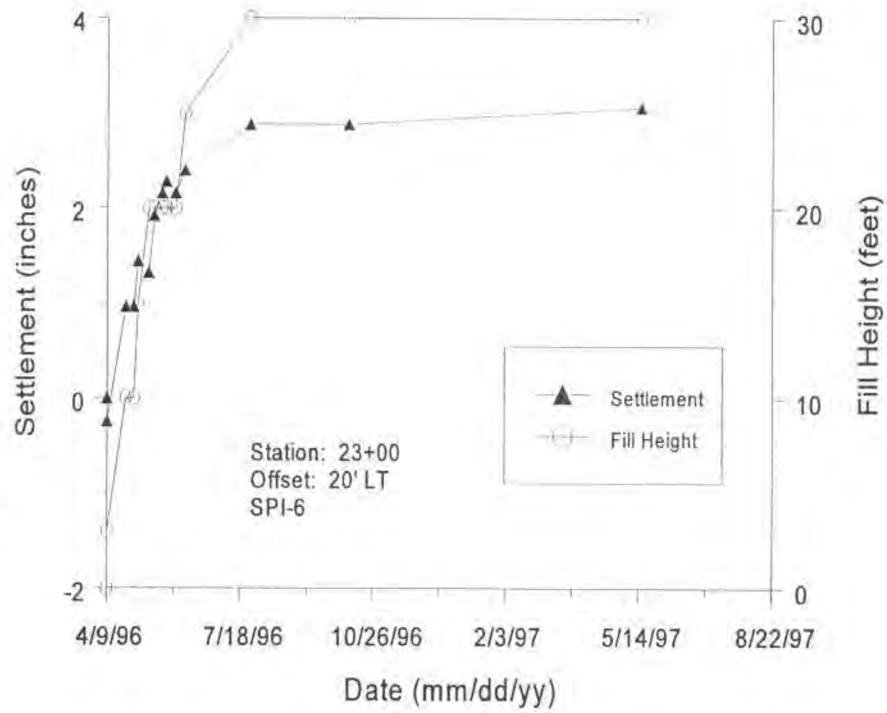


Figure 10. Typical Type I Settlement Platform Results

In areas where the Type I settlement platforms would interfere with traffic or the placement of the concrete made it difficult to maintain the standpipes, vibrating wire settlement platforms supplied by Geokon Incorporated were installed to monitor elevation changes remotely. Vibrating wire pressure transducers lowered into boreholes were attached to reservoirs and settlement plates at the ground surface via fluid filled tubes. As the settlement plates move with the ground surface around them during construction, the transducers sense the change in fluid head in the tubes and provide a measure of the difference in the elevation between the reservoir and the sensor. Via an electric cable running from the sensor to a remote readout location, the vibrating wire settlement platforms were monitored periodically with a Model GK-401 Readout Box and the data plotted against time and fill height as shown in Figure 11.

Results of measured values taken from the vibrating wire settlement platforms also correlated quite well with predictions made using the methods proposed by Cheney as shown in Table 2.

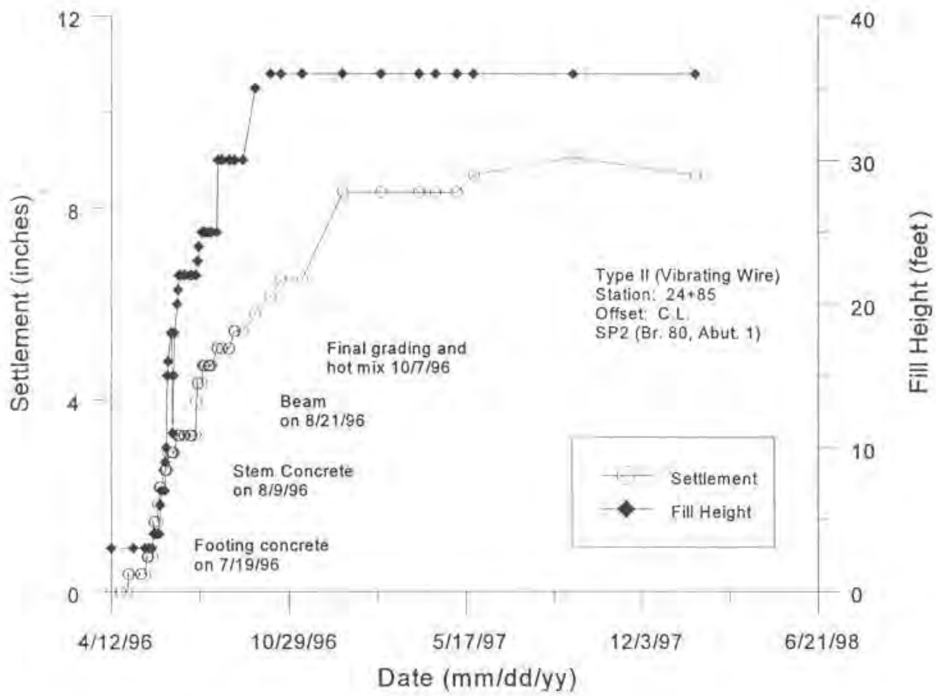


Figure 11. Typical Vibrating Wire Settlement Platform Results

Using the information gathered from the settlement platforms, the rate of settlement observed in the graphs and comparing this to the magnitude of settlement expected, the specified 30 day delay periods were reduced by approximately two weeks.

Earth Pressure Cells

Vibrating wire earth pressure cells were used to monitor vertical earth pressures at the base of the MSE walls and horizontal earth pressure at the interfaces of the wall panels and the select backfill material. Model 4800 E vibrating wire pressure cells manufactured by Geokon, Incorporated were placed at four locations below the MSE wall and the embankments to measure total stress in the fill. The cells consist of two circular stainless steel plates welded together around their periphery and spaced apart by a narrow cavity filled with an antifreeze solution. A length of high-pressure stainless steel tubing connects the cavity to a vibrating wire pressure transducer. External pressures acting on the cell are balanced by an equal pressure induced in the cell fluid. This pressure is converted by the pressure transducer into an electrical signal which is transmitted by a four-conductor buried cable to a remote readout location. Throughout construction and during the months that followed, the instruments were read with the same Geokon model GK 401 readout box used to monitor the vibrating wire settlement platforms. Shown in Table 3 are the peak stresses recorded in each of the cells during fill placement and the predicted values using numerical procedures. Measured results were consistently lower than predicted values. Pressure cell number PC-2 failed shortly after installation for an unknown cause.

Table 3. Vertical Pressure Cell Measurements

Pressure Cell Number	Location		Predicted Vertical Pressure (psi)	Measured Vertical Pressure (psi)
	Station	Offset		
PC-1	24+50	20' LT	34.1	26.5
PC-2	24+50	℄	34.8	—(1)
PC-3	24+75	℄	47.7	43.1
PC-4	26+75	20' LT	29.6	27.4

(1) Pressure Cell Failed

A typical plot of vertical stress and fill height over time is presented in Figure 12.

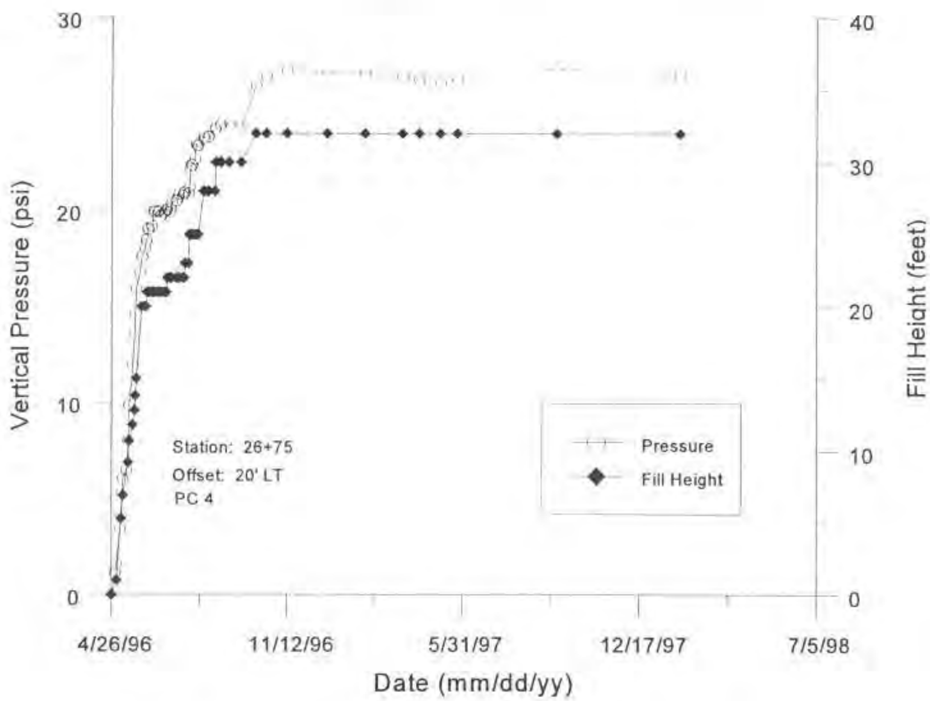


Figure 12. Typical Vertical Pressure Cell Results

Horizontal pressure cells were mounted at six locations on the back face of the MSE wall panels. Model 4810 vibrating wire pressure cells manufactured by Geokon, Incorporated were attached to the panels at just under two feet and 6.83 feet above the top of the leveling pad at varying wall heights along Wingwall 3. The cells were similar in design to those used for vertical earth pressure measurements with exception of the cell wall thickness. The side of the pressure cell mounted on the concrete was thicker and therefore did not flex as readily as the side in contact with the soil. Pressure sensed by the cell is converted by a vibrating wire pressure transducer into an electrical signal which is transmitted by a four-conductor buried cable to a remote readout location. Throughout construction and during the months that followed, the instruments were read with the same Geokon model GK 401 readout box used to monitor the vibrating wire settlement platforms and vertical pressure cells.

Lateral pressure readings tended to be much more erratic than the vertical measurements and generally dropped off after several months of monitoring. It is not known if this is due to a gradual failure of the instrument, a bridging effect in the soil or a general loss of soil to cell contact due to panel movement. A typical example of this tendency is shown in the plot in Figure 13.

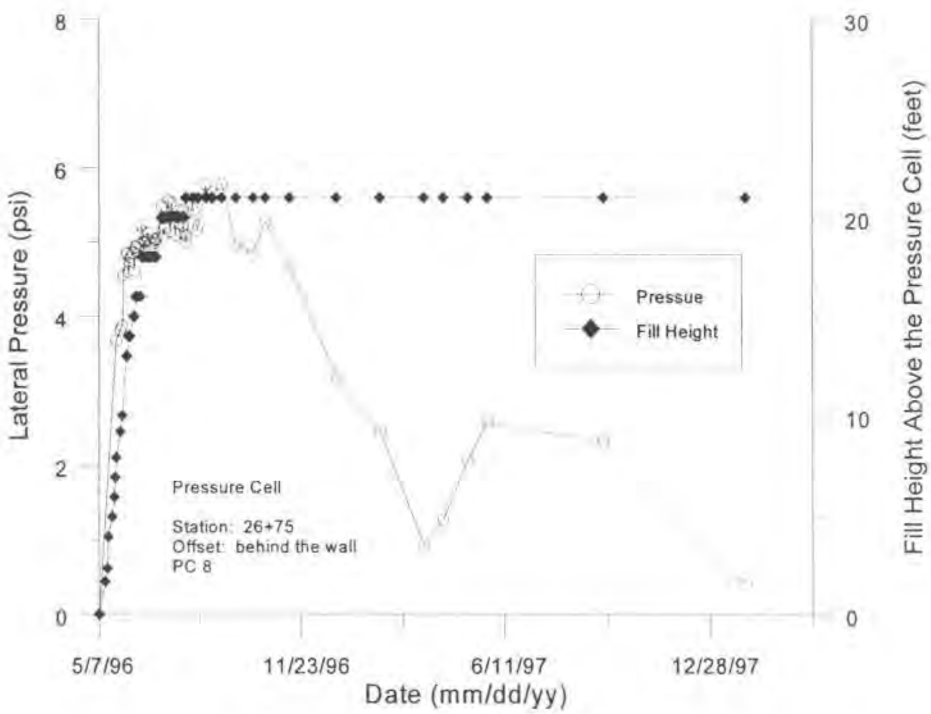


Figure 13. Typical Horizontal Earth Pressure Cell Results

Based on test results for the select backfill used in conjunction with the MSE walls, horizontal earth pressures were calculated in the reinforced zone and compared to the peak measured values at each of the pressure cell locations after all the fill operations were complete. The results of these analyses are shown in Table 4.

Table 4. Horizontal Pressure Cell Measurements

Pressure Cell Number	Location		Predicted Horizontal Pressure (psi)	Measured Horizontal Pressure (psi)
	Station	Height Above Top of Leveling Pad (feet)		
PC-5	26+40	1.96	8.53	6.14
PC-6	26+40	6.83	7.38	5.75
PC-7	26+75	1.88	6.16	4.30
PC-8	26+75	6.83	5.36	5.77
PC-9	27+25	1.88	3.77	3.36
PC-10	27+25	6.83	2.46	2.57

Slope Inclinometers

Slope inclinometers were located within the embankments, in front of the MSE wall sections and through the reinforced fill to monitor lateral movement in the ground during the construction of the MSE walls and embankments. Six inclinometers were installed to the depths, stations and offsets indicated in Table 5 to help ensure railroad track alignment, roadway slope stability and a plumb wall were being maintained during and after construction.

Table 5. Slope Inclinometer Locations

Inclinometer Number	Station	Offset	Depth (feet)
Incl-1	26+29	30' LT	32.5
Incl-2	26+50	32' LT	32
Incl-3	27+28	65' LT	27.5
Incl-4	24+22	32' RT	27.5
Incl-5	24+50	75' LT	29
Incl-6	23+50	75' LT	36.5

Boreholes were advanced five feet into glacial till or bedrock at each location and self-aligning 2.75 inch diameter inclinometer casing were lowered into the pre-grouted holes. The inclinometer casing was manufactured with four internal longitudinal grooves precisely made to fit the dimensions of the inclinometer wheels. The grooves control the orientation (direction) of the sensor which was lowered through the casing to obtain initial readings at two foot depths. The inclinometer probe has two servo-accelerometers in a waterproof housing. One accelerometer has its sensing axis in the plane of the spring-loaded wheels which ride in the casing grooves. The second accelerometer has its sensing at 90 degrees, so that the angle of the inclination of sensor and casing is measured in the two orthogonal directions. Periodic readings at these depths provided data on the location, magnitude, direction and rate of movement of the casing. The inclinometer probe, casing, readout system, and software reduction package were manufactured by the Slope Indicator Company.

Graphs depicting the deviation of the casing with depth were updated as the data became available. Shown in Figure 14 is a plot of the cumulative deviation in the casing installed at the base of wingwall number three referenced to a fixed point at the bottom of the casing. The initial readings taken on April 25, 1996 indicate the casing was out of plumb by approximately five inches. Prior to construction of the leveling pad, the upper five feet of the casing was left unsupported which accounts for the large lateral movement to that depth between the first two sets of readings. Following the May 21, 1996 set of readings, no appreciable movement was detected at the base of the wall.

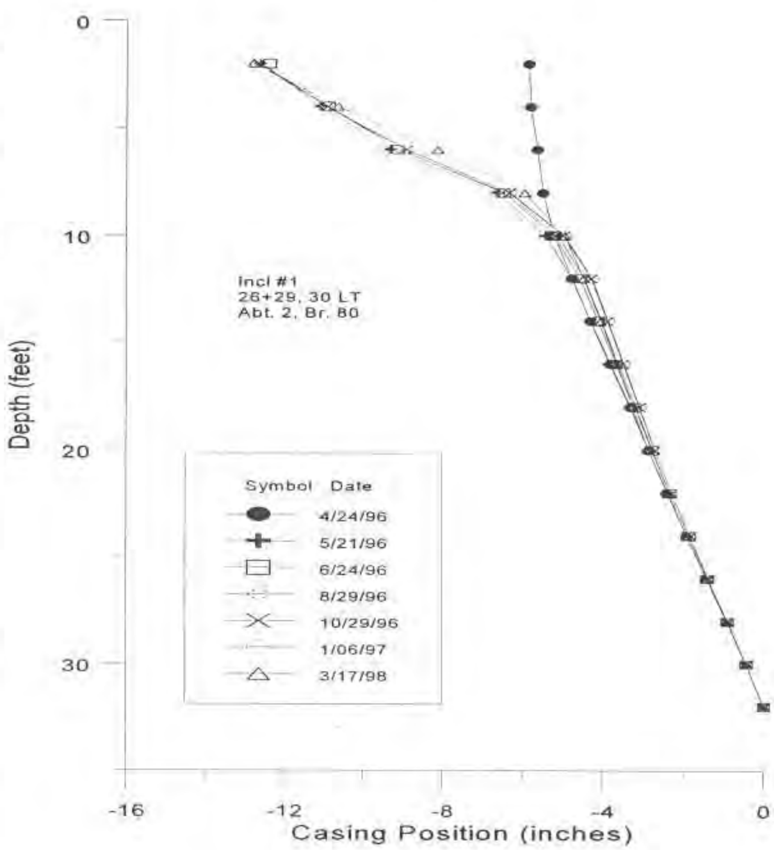
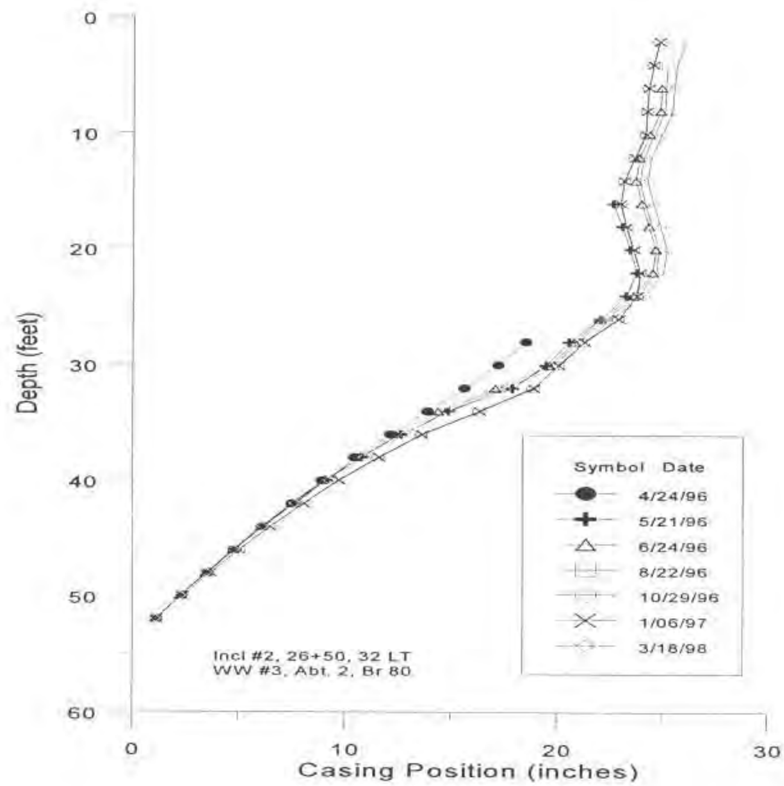


Figure 14. Inclinometer Results at Base of Wingwall 3

As the MSE wall was constructed, additional sections of inclinometer casing were attached and embedded in the select backfill behind the wall facing. Presented in Figure 15 are the results of readings taken at Inclinometer 2 (Incl-2) as the fill was placed. This inclinometer was installed approximately 20 inches out of plumb. The two inches of displacement recorded at the top of the casing between the initial set of readings taken on April 4, 1996 and the next set on May 21, 1997, were due to the compaction of the initial fill placement next to the casing. Further monitoring of the instrument indicates the top casing rotated out approximately 1.5 inches relative to the base of the wall or about 0.25 degrees.

Figure 15. Inclinometer Results Behind Panels in Wingwall 3



Summary

The mechanically stabilized earth wall constructed on U.S. Route 7 in Wallingford, Vermont has proven to be a valuable exercise into MSE technology for the Vermont Agency of Transportation. The lessons learned on this project will provide a useful reference for future applications of MSE technology. Not only did the MSE abutment walls satisfy challenging engineering problems, it did so at a considerable cost savings. The initial estimates for conventional reinforced concrete abutments was $915,000, compared with the bid cost of $315,350 for the MSE walls.

Extensive geotechnical instrumentation contributed significantly to the success of the Wallingford project. Continuous monitoring of subsurface conditions made it possible for construction to progress without delay by providing a high level of confidence that stabilization was reached at each stage of the project. The instrumentation will be maintained in order to evaluate the structure over time; but as of the date of this report, there has been no significant post-construction movement.

Figure 16. Completed MSE Abutment Walls

The geotechnical instrumentation will be inspected periodically, although is it certain that the more delicate sensors, i.e., vibrating wire settlement platforms and earth pressure cells, will eventually succumb to the environment and no longer provide consistent data. The observation wells and slope inclinometers, which are essentially no more than casings, should last indefinitely.

At present, the MSE abutment walls constructed on the Wallingford project are performing as expected and according to plans. The structure has been stable and no adverse distress has been found. If subsequent inspections show any significant findings, these will be reported in update reports.

Recommendations

Future MSE projects should address the following:

- Geotechnical instrumentation is essential for measuring deformations within and adjacent to the structure, to verify design assumptions, and for construction control.

- The precast plant and the contractor should coordinate delivery of the concrete panels so that the correct materials are on hand. Also, an unambiguous numbering system for the panels is needed.

- The spacer bars used to align the panels need to be fabricated to tighter tolerances.

- *Corner panels should be placed first* to avoid compounding errors from misalignment of internal panels.

- A bond breaker is needed between the top of the precast panels and the coping to avoid cracking from positive bonding.

- Slip joint covers must be installed so as not to put undue stress on the covers' corners which could result in cracking.

- It should be anticipated that compaction of the select backfill will push the concrete panels outward. On this project it was found that the panels needed to be leaned inward 1/4" in 3' to compensate.

- Vibrating wire settlement platforms should be used in conjunction with Type I platforms to insure redundancy in case of electronic malfunction. All instrumentation, except Pressure Cell 2, performed as expected and provided results reasonably close to predicted values during construction. Vibrating wire instruments appear to have a limited service life in the ground and may only give reliable data for one year. Further study of this problem is expected.

In conclusion, it is recommended that the MSE retaining wall system supplied by the Reinforced Earth® Company to the Wallingford project be approved for use on Agency projects and be added to the Vemont Agency of Transportation Earth Retaining System Selection Chart.

It is also recommended that periodic inspections be continued, as outlined in the original work plan for this project, and that significant findings be reported as necessary.