Research Report
KTC-05-28/SPR 239-02-1F

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CORROSION EVALUATION OF MECHANICALLY STABILIZED EARTH WALLS

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KENTUCKY TRANSPORTATION CENTER
176 Raymond Building
University of Kentucky
Lexington, Kentucky 40506-0281

(859) 257-4513
(859) 257-1815 (FAX)
1-800-432-0719
www.ktc.uky.edu
ktc@engr.uky.edu

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Corrosion Evaluation of Mechanically Stabilized Earth Walls

By

Tony L. Beckham
Research Geologist

Leicheng Sun
Research Engineer

Tommy C. Hopkins
Program Manager

Kentucky Transportation Center
College of Engineering
University of Kentucky

in cooperation with the
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16. Abstract
Numerous reinforced walls and slopes have been built over the past four decades in Kentucky, the United States, as well as worldwide. Tensile elements used in constructing low-cost reinforcing walls and slopes consist of metal polymer strips or grids. Although reinforced structures have been used extensively, the effects of corrosion on the metal tensile elements are unknown. Mechanically stabilized earth walls are expected to remain stable for many decades. An examination of the effects of corrosion of metal tensile elements used to construct these walls can provide invaluable data regarding the longevity of reinforced walls and slopes. Four mechanically stabilized earth walls constructed with galvanized steel reinforcing elements were instrumented and corrosion rates obtained. Corrosion data obtained indicate the designed sacrificial thickness will not be used during the design life of the structures. No visible corrosion was observed in reinforcing elements removed from a mechanically stabilized earth wall that had been in service for more than 20 years. A database was constructed to manage inventory of mechanically stabilized earth walls constructed and maintained by the Kentucky Transportation Cabinet.

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EXECUTIVE SUMMARY

The Kentucky Transportation Cabinet began using mechanically stabilized earth walls with galvanized metal reinforcing elements in the 1970's. Numerous reinforced walls and slopes have been built since then. The walls are designed so that most of the loads are transferred to the tensile elements, attached to the wall face. Although reinforced structures have been used extensively, the effects of corrosion on the metal tensile elements are unknown.

Mechanically stabilized earth walls are expected to remain stable for many decades. A design life of 75 years is recommended for retaining walls and 100 years for bridge abutment walls.

More than 120 mechanically stabilized earth walls on Kentucky highway routes were inspected. A database was constructed to document attributes and manage inventory of mechanically stabilized earth walls constructed and maintained by the Kentucky Transportation Cabinet.

Four mechanically stabilized earth walls constructed with galvanized steel reinforcing elements were instrumented and corrosion rates were obtained. Corrosion data obtained indicate the designed sacrificial thickness will not be used during the design life of the structures. Some corrosion was observed at the oldest wall tested. Measured corrosion rates were less when large-sized (2 to 2 ½ inch top size), uniformly graded, aggregate was used as backfill. Corrosion rates were largest when the backfill was not uniformly graded.

No visible corrosion was observed in reinforcing elements removed from a mechanically stabilized earth wall that had been in service for more than 20 years. This wall was constructed with larger sized uniformly graded backfill.

INTRODUCTION

Changes of elevation in the construction of earthworks usually require building some type of slope (non-reinforced), or a slope reinforced with tensile elements, or a retaining wall. When a non-reinforced slope is constructed more space is normally required than in the latter two cases because a gradual change in elevation of the slope is required to prevent instability. In the second case, a reinforced slope requires less space than the first case, that is, the reinforced slope can be constructed at a steeper angle, or slope, than the non-reinforced slope. A wall requires less space than the other two structures, but it is usually the more expensive solution, and is usually limited to situations where right-of-way constraint is the main issue. In the past, concrete gravity walls and concrete cantilever walls have been the most popular conventional wall systems. Another popular historical wall system includes the metal crib wall. Consequently, where space constraints are the primarily issue, such as in urban areas where expensive right-of-ways exist, or at ramps of an interchange where space is very limited, the use of low-cost slopes and retaining walls reinforced with tensile elements has emerged.

Numerous reinforced walls and slopes have been built over the past four decades in Kentucky, the United States, as well as worldwide. Tensile elements used in constructing low-cost reinforcing walls and slopes consist of metal and polymer strips and grids. The walls are designed so most of the loads are transferred to the tensile elements, attached to the wall face**.** Although reinforced structures have been used extensively, the effects of corrosion on the tensile elements are unknown. Reinforced earth walls are expected to remain stable for many decades. Hence, an examination of the effects of corrosion on the tensile elements used to construct these walls can provide invaluable data regarding the longevity of reinforced walls and slopes. A rapid deterioration of the elements due to corrosion can cause wall and slope instability and eventually lead to failure**.**

The use of mechanically stabilized earth (MSE) walls and steep slopes are used widely. Thousands of these types of structures have been built throughout the country. The most commonly used soil-reinforcement elements for retaining walls on transportation projects include galvanized steel (either in strip or grid configuration, which account for 95 % of applications to date). Configurations include either grid or strips (Elias, 1997). Another material, which has come into use, is polymer reinforcements. Long-term durability of reinforcing materials is a major concern for MSE walls and slopes because of suspected corrosion of the tensile elements due to the chemical harshness of the soil-water environment.

Inventory and Screening of Reinforced Walls and Slopes in Kentucky

Numerous MSE reinforced walls have been built in Kentucky over the past four decades. The first walls constructed by the Kentucky Transportation Cabinet were in the late 1970’s. Most known MSE walls were identified, although a few may have been missed. The total number of MSE walls inventoried to date is 129. A listing of all inventoried walls is in Appendix A. Others may have been constructed after the field inventory was completed. Some existing walls were probably not inventoried. Any walls not inventoried can be easily added to the database at a later date. Attributes of each structure were documented. These included: location, type of wall, route number, type of reinforcing elements, geometry of wall (height and length), environmental conditions, age, backfill materials, photographs, manufacturer and other pertinent information. Also, the basic function of the reinforced wall or slope, such as providing support for a bridge abutment, retaining wall, etc. was noted. To provide a means of uniquely identifying the locations of reinforced walls, the latitudes and longitudes of the sites were determined using mapping-grade GPS equipment (sub-meter accuracy). By measuring the latitude and longitude, the sites can be plotted on various types of electronic maps.

All sites were be grouped into two major types. The first group includes walls and slopes with metallic reinforcements while the second group includes sites where polymeric reinforcements have been used. Walls with polymeric reinforcements are included in the inventory. This study was mainly directed toward the walls with metallic reinforcing elements.

SELECTION OF WALLS FOR CORROSION MONITORING

Four MSE walls with metallic reinforcements were selected for corrosion monitoring. The walls were selected due to age, possible backfill that may contribute to corrosion, geographic location, and accessibility. The oldest MSE walls in the state are part of the I-71-75 and I-275 interchange in Kenton County. None of those walls were selected because of poor accessibility; high traffic volume and concerns the metallic strips from adjacent walls may overlap. Metallic reinforcing strips that are wired for corrosion monitoring cannot be in contact with any other electrical conductor.

Fayette County; Lexington Civic Center; Manchester Street (KY Route 1681, Jefferson Street (KY Route 1928) Interchange and Bridge

Five retaining and two abutment MSE walls were constructed in 1979 due to new bridge and interchange construction at this site. These walls are believed to be the second oldest in the state. One wall, as shown in Figure 1, was selected from this group for corrosion monitoring. The backfill was crushed limestone. Gradation of the backfill varied with each sample obtained from three access holes. Samples from two access holes had top sizes between 2 and 1.5 inches. A third sample had a top size of 1 inch. Gradation specifications of the backfill are not known. Access to the wall for testing was through the Lexington Civic Center parking lot. Some rust or corrosion was visible where the reinforcing strap was attached to the panel.

Figure 1. MSE Wall Tested in Fayette County; Parking Lot of Lexington Civic Center, below KY 1681.

Floyd County; US 23, KY 114, KY 2555 Interchange and Bridge

The second MSE retaining wall selected for corrosion monitoring is located in Floyd County and situated adjacent to KY 2555. It is located below the US 23 overpass. Construction of this wall began in 1992 and was completed in 1993. The walls were constructed due to route widening, new bridge and interchange construction. A wall in this site was selected because of geographic location. A few MSE walls have been constructed in Eastern Kentucky. It was felt that at least one MSE wall in Eastern Kentucky should be tested. The back fill immediately behind the wall was crushed limestone with a top size between 2.5 and 2-inches. A view of the wall is shown in Figure 2.

Figure 2. MSE Wall Tested in Floyd County, KY 2555 below US 23.

Bullitt County; KY 245 over I-65 Bridge

Two abutment MSE walls, for KY route 245 overpass were constructed in the late 1980's as part of the I-65 widening project. A wall at this site was selected because it is located in an area where New Albany Shale formation is the predominant bedrock type. The shale was used to construct the approach embankment. Leachate from the New Albany shale is very acidic. Mitigation measures have been implemented to neutralize run-off from older highway cut slopes constructed in the New Albany shale. The Kentucky Transportation Cabinet now has a policy of covering exposed slopes with compacted clay. The acidic shale is part of the embankment supported by the abutment. The backfill immediately behind the face of the wall was crushed limestone, or manufactured sand.

Figure 3. MSE Wall Tested In Bullitt County, KY 245 over 65.

Jefferson County; I-264 US 60 Interchange and Bridges

Jefferson County-Louisville is Kentucky's largest urban area. MSE walls are frequently constructed in urban areas because of spacing restraints. There were 123 MSE walls inventoried in Kentucky; 78 of those walls are located in Jefferson County. Sixty-four of the walls in Jefferson County are located on the Waterson Expressway, I-264, or on interchanges with I-264 and other routes. At least five additional MSE walls on I-264 have been designed. Three abutment and eight retaining walls were constructed in the mid 1980's as part of the I-264 widening and US 60 interchange project. The wall selected for corrosion monitoring is shown in Figure 4. A construction engineer from the Kentucky Transportation Cabinet indicated some of the fill material in this location consisted of New Albany Shale (see Bullitt County site information). The back fill immediately behind the wall was crushed limestone with a top size between 3 and 2.5 inches. Access to the wall was obtained through the adjacent St. Mathews Mall.

Figure 4. MSE Wall Tested in Jefferson County, ramp from US 60 to I 264 at St. Mathews Mall.

Coring and Backfill Sampling

Procedures established for the Federal Highway Administration (Elias, 1990, 1997, 2000), (Berkovitz and Healy, 1997) for wiring, installation of coupons, and corrosion monitoring for MSE walls were generally followed. At the panel selected for monitoring a six-inch diameter core was drilled, as illustrated in Figure 5, through the concrete panel adjacent to a galvanized steel-reinforcing strip attached to the panel. The hole was drilled by mounting a portable, electric powered, pavement-coring machine to the face of the MSE wall. When possible, a second six-inch hole was drilled next to another reinforcing element, at the same elevation. A third six-inch diameter hole was drilled adjacent to a reinforcing strap attached to the panel. Panels typically have four or more reinforcing strips attached. After removing the core, backfill material was removed and stored in sealed plastic containers for future testing. Any

Figure 5. Coring an Access Hole.

material contaminated from the core drilling process was discarded. An additional boring (2.5-inch diameter) was drilled through the panel to allow access for a copper copper-sulfate half cell (an electrode with a copper element inside a copper sulfate solution) to contact with the backfill during corrosion testing.

After exposure, the metallic strip at each hole was inspected and the condition was noted. Photographs were made to show the condition of the metallic strips. The 2.5-inch diameter hole was used for placing a reference electrode and measuring subsequent potential and polarization values. The other access holes were used to install zinc, galvanized, and carbon steel coupons in addition to testing the galvanized reinforcing strips. The zinc coupon installed in one of the access holes is used to evaluate the rate of zinc loss. This is an estimate of galvanization removal from the structure. The galvanized coupon strips provide a means of determining the condition of the galvanized coating and the steel substrate. Carbon steel coupons are used to estimate the corrosion rate of the steel members once the galvanized coating is lost. Wiring details have been given elsewhere (Elias, 1997). The Federal Highway Administration provided the necessary monitoring equipment and details for installation.

CORROSION

Corrosion of metal occurs when there is a potential difference between two points that are electrically connected. The points in MSE walls are the metallic reinforcing strips that are connected by the backfill serving as an electrolyte. The reinforcing strips are carbon steel coated with zinc to reduce corrosion.

Corrosion Measurement

Corrosion is an electrochemical process, which creates a current or flow of electrons. Currents can be measured when voltages are applied. Corrosion characteristics of a metal reinforcing strap in a backfill can be estimated from the current measurements. The electrochemical reaction that causes corrosion is the oxidation of iron from steel:

$$Fe > Fe^{+2} + 2^{-e} \qquad (1)$$

Corrosion measurements were performed on the in service reinforcing elements and the coupons. The corrosion monitoring equipment used was a Polarization Resistance Monitor, Model PR 4500 manufactured by CC Technologies Systems, Inc**.** (CC Technologies Systems, 1999). The PR monitor measures the linear polarization resistance (LPR) of a corroding electrochemical interface (a metallic strap in a backfill). The polarization resistance, which is the resistance of the interface to current flow, is inversely proportional to the corrosion rate.

Corrosion rates using LPR techniques require that the area of the element (reinforcing strap) being analyzed must be known. This data was obtained from design plans prepared by the Reinforced Earth Company and, or the Kentucky Transportation Cabinet.

Polarization resistance is measured independently of the backfill resistance. The backfill resistance can be measured in the laboratory or the field.

The constant to convert polarization resistance to corrosion rates must be known. Typically a constant of 0.03 to 0.05 can be used. A constant of 0.05 was used for zinc coupons and galvanized reinforcing strips. A value of 0.035 was used for carbon steel coupons.

The composition of the reinforcing element must be known. Better estimates of corrosion rates can be determined if the composition of the surface is known (i.e. galvanized zinc in the early life of an MSE wall).

Current measurements through the backfill material were made by inserting a copper copper-sulfate half-cell into the small 2.5-inch diameter hole. A sponge saturated with water was placed between the half-cell and the back fill to assure contact. Current strength between the half-cell and a reinforcing strap was measured with a hand-held meter by attaching leads from the meter to the element and half-cell.

The backfill at one of the six-inch diameter holes was excavated until the adjacent galvanized metal reinforcing strip was exposed. A ten-gage wire with red coating was attached to the reinforcing element. This element is classified as the "working electrode." The process is repeated for another location where an additional wire is attached to another reinforcing element for use as a "counter electrode." A galvanized steel coated coupon and a carbon steel coupon obtained from the Reinforced Earth Company with white and black wires, respectively, attached were placed in the backfill at two of the holes. These two coupons are the type currently manufactured by the Reinforced Earth Company. A zinc coupon, with a green wire attached, was placed in the back fill through the third six-inch core hole. A typical view of the corrosion monitoring of a MSE wall is shown in Figure 6.

Figure 6. Corrosion Monitoring of a MSE Wall.

Corrosion Rates

Romanoff (1957) developed a model at the National Bureau of Standards to predict corrosion in a wide range of burial conditions at some time after burial:

$$x = Kt^n \qquad (2)$$

where

x = loss of metal,
t = time after burial
K = constant between 150 and 180 µm at the end of the first year for carbon steel, or constant between 5 and 70 µm at the end of the first year for galvanized steel, and
n = constant varying 0.5 to 0.6 for carbon steel, not evaluated for galvanized steel.

Based on this model the following equation may be used for galvanized steel loss for a wide range of soils:

$$x = 25t^{0.65} \text{ (Average)} \tag{3}$$
$$x = 50t^{0.65} \text{ (Maximum)} \tag{4}$$

For carbon steel the equation should be modified to:

$$x = 40t^{0.80} \text{ (Average)} \tag{5}$$
$$x = 80t^{0.80} \text{ (Maximum)} \tag{6}$$

For galvanized steel the average rate of corrosion, r, can be determined using Equation 3, where x = loss of thickness (µm) and

$$r = 0.65(25)t^{(0.65-1)} \text{ and} \tag{7}$$
$$r = 16.25t^{-0.35}. \tag{8}$$

A corrosion rate of 6 µm per year after 16 years is calculated using the average loss model for galvanized steel. The American Association of State Highway Transportation Officials (AASHTO) has accepted a uniform loss model to predict uniform maximum loss rates for the purpose of determining sacrificial thickness (Elias 1997, 2001). The rate loss for zinc is 15 µm per side per year for the first two years of service life. After 2 years the rate suggested is 4 µm per year per side. The carbon steel rate is 12 µm per side per year.

These design values are used when the backfill meets the following recommended electrochemical limits:

Property	Standard
Resistivity	ohm-cm > 3,000
pH	5<pH<10
Organic Content	1% Maximum
Chlorides	<100 PPM
Sulfates	<200 PPM

Ground conditions are considered aggressive with respect to corrosion if backfill properties do not meet these criteria.

Reinforced straps in MSE walls use 2 ounces of zinc coating per square inch with 86-µm minimum thickness of zinc coating. If 30 µm per year are lost in the first two years, then 56 µm are left. The uniform loss model assumes a loss of 4 µm per year after two years. The service life of the zinc galvanized coating would be sixteen years total at these rates. The carbon steel would still be intact after sixteen years, which is close to the value obtained from Equation 3**.** The corrosion rate for the remaining carbon steel is 12 µm per side per year. The thickness of reinforcing straps is typically 4 mm (4,000 µm). Assuming the 86 µm thick galvanized zinc coating on each side is consumed in sixteen years, the remaining carbon steel is 3.828 mm thick. If it corrodes at the model rate of 24 µm per year (12 µm per year per side) it would take about 160 years to corrode entirely.

AASHTO recommends design lives of 75 years for walls and 100 years for abutments when determining the sacrificial thickness of metal reinforcing strips in MSE structures constructed with backfill, which meets the criteria listed above (Elias 1997, 2001).

If the zinc coating (86 µm) is consumed in 16 years and the remaining carbon steel corrodes at a rate of 24 µm per year, for 59 years, the total amount of corrosion is 1588 µm or 1.588 mm. Based on this model, a sacrificial thickness of 1.5 mm is recommended for a 75-year design life that equates to 2.2 mm for a 100-year design life.

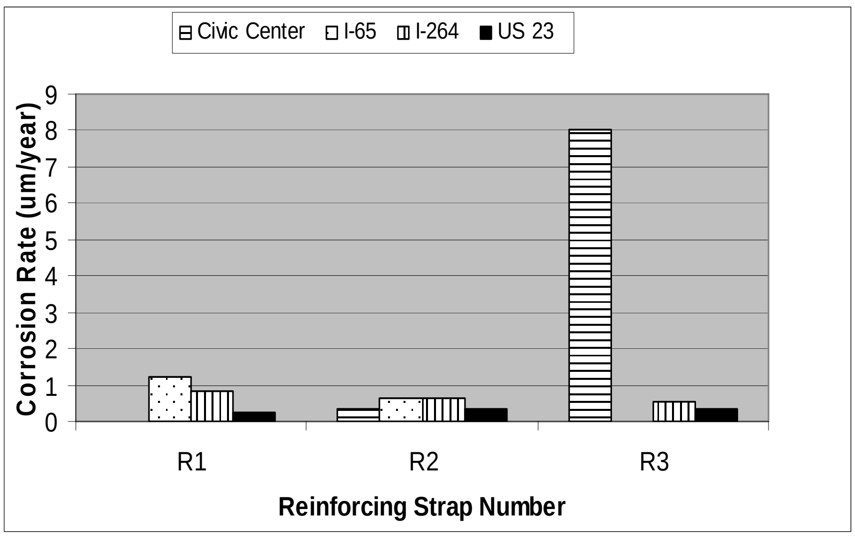


Figure 7. Corrosion Rates of Reinforcing Elements.

Measured corrosion rates of the reinforcing elements for the tested MSE walls are shown in Figure 7. The rates were measured in April 2005 and represent the rate at that time. Measurements were obtained for three reinforcing straps at US 23 in Floyd County and I -264 in Jefferson County. Data for two straps were obtained at the Lexington Civic Center site and the I-65 abutment wall in Bullitt County. Corrosion rates were below 1 µm/year except for strap #R1 in Bullitt County and #R3 at the Lexington Civic Center which measured 1.2 and 8.0 µm/year, respectively.

The 86-µm thick galvanized zinc coating would not be consumed during a 75-year design life at corrosion rates of 1 µm/year.

The largest corrosion rate measured was about 8 µm at the Lexington Civic Center site. This wall is 26 years old. If the 86-µm thick galvanized zinc coating was consumed in 16 years and the remaining carbon steel corroded at the recommended 12 µm per year, for ten years, then 120 µm of the reinforcing strap would be consumed. The 1.5 mm sacrificial thickness would not be used for an additional 162 years at the measured rate of 8 µm per year or 108 years if the recommended 12 µm per year is used.

Metal coupons with wire leads attached where installed at the sites prior to testing. The coupons were installed several months before corrosion testing was performed. Corrosion monitoring of coupons can be useful in determining initial corrosion rates in older walls. Also, rates of different metals can be evaluated. Three types of coupons were installed:

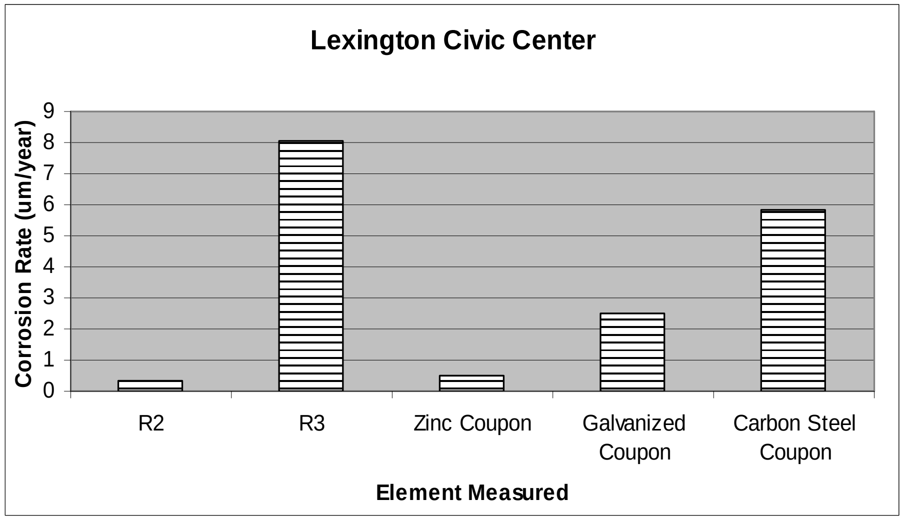


Figure 8. Corrosion Rates of Reinforcing Straps and Coupons, Lexington Civic Center - KY 1681.

- Galvanized steel reinforcing straps,
- Carbon steel reinforcing straps, and
- Zinc (99%)

The Reinforced Earth Company supplied coupons of galvanized metal reinforcing straps currently used for MSE wall construction. They also furnished carbon steel coupons-reinforcing strips before the galvanized zinc coating is applied. The zinc coupons were fabricated at the University of Kentucky from purchased commercially available zinc. Comparisons of corrosion rates for the coupons and reinforcing elements for all of the tested walls are shown in Figures 8 through 11.

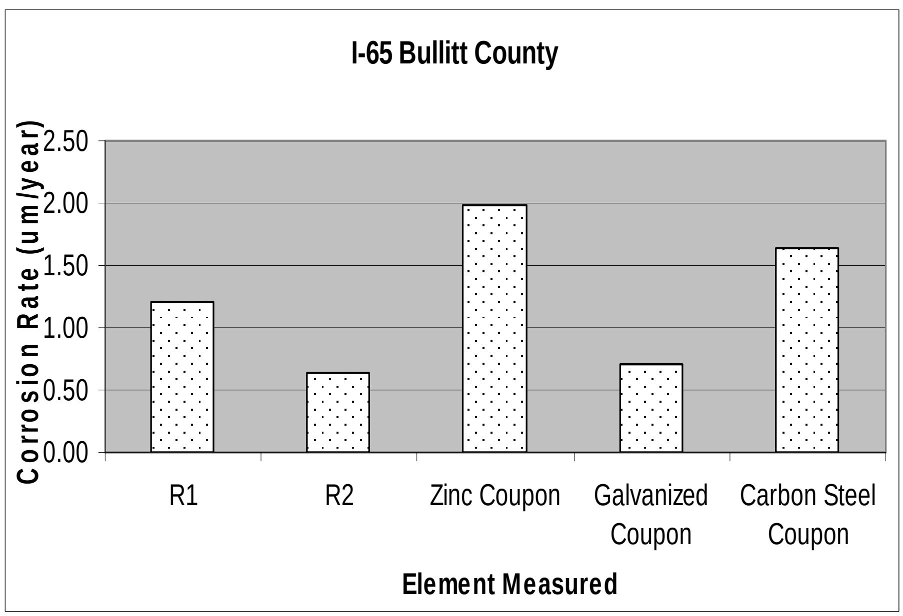


Figure 9. Corrosion Rates of Reinforcing Straps and Coupons, I-65 Bullitt County

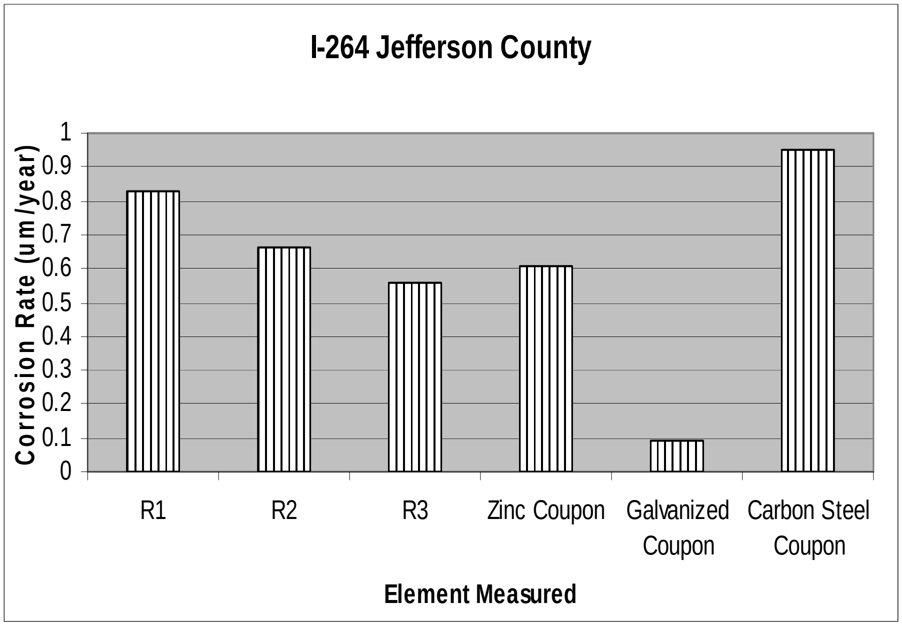


Figure 10. Corrosion Rates of Reinforcing Straps and Coupons, I-264 Jefferson County

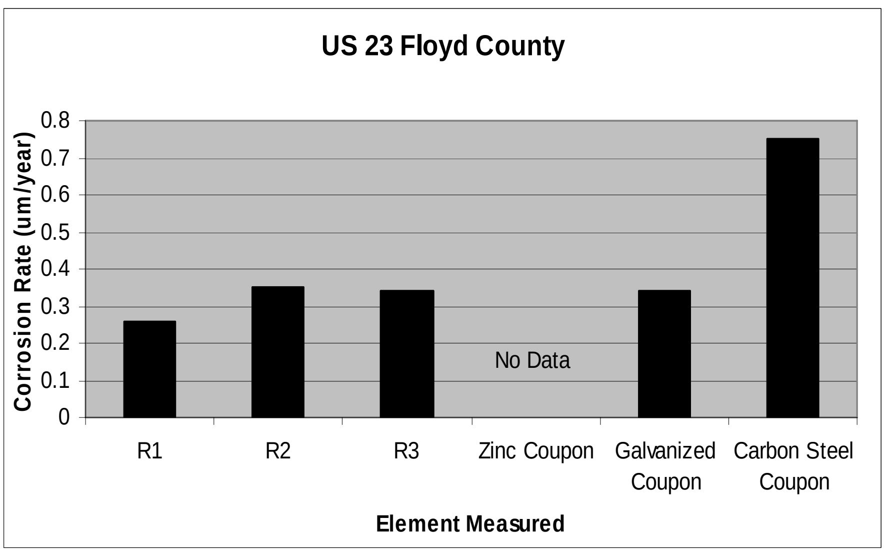


Figure 11. Corrosion Rates of Reinforcing Straps and Coupons, US 23 Floyd County

The carbon steel coupon at Lexington Civic Center had a rate similar to reinforcing strap R3 (almost 6 µm per year for the steel coupon and about 8 µm per for strap R3) indicating the galvanized coating may be consumed in the reinforcing strap as shown in Figure 8. Strap R3 had a corrosion rate about eight times greater than the corrosion rate of the other strap identified as R2.

Carbon steel coupons had larger corrrosion rates than zinc and galvanized coupons at all of the sites except I-65 in Bullitt County Figure 9) where the zinc coupon had a slightly higher rate: 2 µm per year versus 0.7 and 1.6 µm per year for ther galvanized and carbon steel coupons, resprectively. The galvanized steel coupon had corrosion rates similar to the reinforcing elements at Bullitt County wall. Corrosion rates for the two reinforcing elements measured were within 0.5 µm per year.

Corrosion rates for the coupons and reinforcing straps were all below 1 µm per year at the I-264 wall in Jefferson County (Figure 10). Corrosion rates for the reinforcing straps were very consistent for the wall at I-264 (0.6 to 0.8 µm per year). The zinc coupon had a similar rate of 0.6 µm per year, while the galvanized ccoupon was lower at 0.1 µm per year.

Corrosion rates for three reinforcing straps and the galvanized coupon at the US 23 wall were also very low, about 0.3 µm per year as shown in Figure 11. Measurements could not be obtained on the zinc coupon. The coupon was removed to check wiring connections. A thin film had developed on the coupon possibly preventing the flow of electricity between the coupon and backfill.

The backfill material behind all of the MSE walls was crushed limestone. The walls at I-264 in Jefferson County and US 23 in Floyd County had larger sized aggregate– top size of aggregate particles ranged upward to 3-inch diameter with little or no fine aggregate.

Free Corrosion Potential Measurements

Free corrosion potential measurements were also performed on the reinforcing straps and coupons. Current in the backfill between a reinforcing element, or an installed coupon and a copper copper-sulfate reference electrode is measured with a hand-held voltmeter. The reference electrode is placed in contact with the backfill through an access hole. Current is measured after the leads from the voltmeter are connected to the reference electrode and the reinforcing element or coupon.

The free corrosion potential for carbon steel coupons, as shown in Table 1, ranged from -419 to -620 millivolts, which is within the range of potentials for carbon steel (-350 to -750 millivolts). The free potential of the galvanized and zinc coupons were more negative ranging – 760 to 1031 millivolts. These values are also within typical values for zinc, or well-galvanized steel (- 7650 to -1100 millivolts)**.** Changes in these values with time can indicate corrosion is occurring. If the reading of galvanized reinforcing elements becomes less negative with increasing time, then some corrosion is probably occurring.

Table 1. Free Corrosion Potential Measurements

Element	Civic Center Fayette County	I-264 Jefferson County	US 23 Floyd County	I-65 Bullitt County
	Free Corrosion Potential (milli-volts)			
Zinc Coupon	-920	-880	-928	-1031
Galvanized Coupon	-750	-897	-819	-966
Steel Coupon	-620	-420	-443	-419
R 1		-830	-589	-722
R 2	-570	-833	-748	-729
R 3	-550	-795	-597	

Obtaining free corrosion potential using a reference electrode is relatively easy and quick method to evaluate corrosion. Free corrosion potential is also obtained from LPR measurements. Free corrosion is measured between elements or coupons instead of a reference electrode and elements using LPR techniques, so the values will vary some. Comparison of free corrosion potential obtained with a copper copper-sulfate reference electrode and LPR equipment is shown in Figure 12.

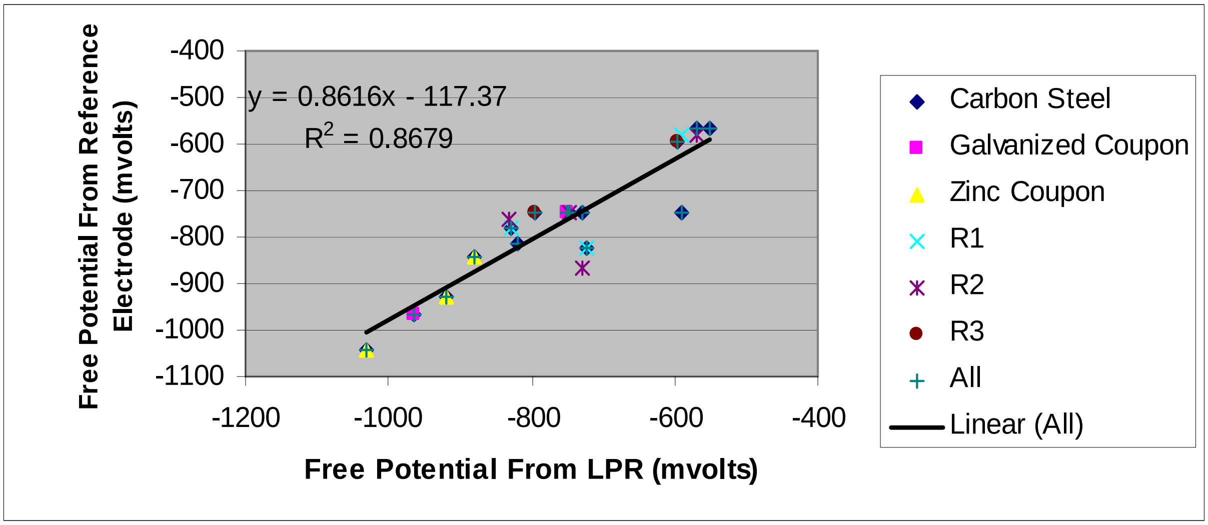


Figure 12. Relationship between Free Corrosion Potential Obtained from Reference electrode and LPR Equipment.

LABORATORY TESTS

Laboratory tests were performed on samples of the backfill material collected from each site. These tests included moisture content, grain size, pH, organic content, chlorides, sulfates, and resistivity. Results from these tests are stored in conjunction with corrosion data, in a Microsoft Access database when corrosion data is obtained using a PR 4500 corrosion monitor. Chlorides, sulfates, and sulfites have been identified as chief agents in promoting corrosion. Electrochemical test results are summarized in Table 2.

Table 2. Electrochemical Properties of MSE Wall Backfill

	Moisture Content (%)	pH	Organic Content (%)	Chlorides (ppm)	Sulfates (ppm)	Resistivity (ohm-cm)
Fayette 1	3.8	9.1	2.46	5.0	35.4	
Fayette 2	24.1	9.0		8.8	45.1	72,000
Fayette 3	3.8	9.0				4,800,000
Bullitt	4.9	7.7	0.60	2.3	10.7	280,000
Floyd	1.1	9.3	0.34	17.6	48.8	
Jefferson	1.3	8.8	0.52	54.0	185.5	

Gradations of backfill samples obtained from the core holes were consistently the same at each of the MSE walls in Bullitt, Johnson and Jefferson Counties. The samples obtained from each cored hole were combined into one sample for characterization of properties for each individual wall. Material obtained from each of the six-inch core holes in the Fayette County wall was different.

Individual gradation tests were performed on samples from each location. Samples identified as Fayette 1 and 2 were obtained from core holes located near the bottom of the panel. Both of these samples appeared to be random crushed limestone fill. Sample Fayette 1 obtained from a hole in the top portion of the panel appeared to be a crushed limestone aggregate obtained from a rock quarry. The sample meets the gradation requirements of a number 57 stone. The backfill for the Bullitt County wall was crushed limestone sand. The crushed limestone backfill from the Floyd and Jefferson County walls met the gradation requirements for number 23 stone. The type of backfill specified for construction of the walls is not known. Results from gradation tests are shown in Table 3.

Table 3. Gradations of MSE Wall Backfills.

	Percent Passing												
Sieve	3”	2 ½”	2 “	1 ½”	1”	¾”	½”	3/8”	No. 4	No. 8	No. 16	No. 100	No. 200
Fayette 1			100.0	75.0	28.0	9.4	5.9	4.8	3.9				
Fayette 2			100.0	95.1	83.0	76.6	66.4	60.4	51.7	43.7			
Fayette 3					100.0	90.1	49.6	12.2	4.6	3.7			
Bullitt								100.0	98.9	77.3	48.1	8.8	4.5
Floyd		100.0	87.2	70.6	15.4	3.9	1.1	0.7	0.2				
Jefferson	100.0	93.9	65.6	36.4	7.2	3.8	3.2	3.1	3.0				

All of the backfill materials met established limits except for the Organic Content of the sample from Fayette 1, which exceeded the limit of 1%. Resistivities of the backfill from Floyd and Jefferson County walls were not measured because the aggregate size was too large.

MSE WALL BLUEGRASS AIRPORT; LEXINGTON, KENTUCKY

A MSE wall, manufactured by the Reinforced Earth Company, was constructed at Bluegrass Airport in Lexington, Kentucky in the early 1980’s. The wall was located at the end of a runway and adjacent to a highway, US route 60. The wall was demolished in March 2004 to allow for construction of a runway safety zone. The wall was in service for more than 20 years. Photographs of the wall before and during demolition are shown in Figures 13 and 14, respectively. Photographs of two sections of a reinforcing strip are shown in Figure 15. The

Figure 13. MSE Wall at Bluegrass Airport; Lexington, Kentucky

Figure 14. Demolition of an MSE Wall at Bluegrass Airport; Lexington, Kentucky.

reinforcing straps sections were obtained adjacent to the wall panel and at the free end where the limestone backfill and compacted clay meet. No visible corrosion was observed. The brown color seen in the photographs is soil. Crushed limestone was used for the back fill of the MSE wall is shown in Figure 15. Compacted clay was used to construct the embankment behind the backfilled area.

A representative of the University of Kentucky Transportation Center obtained samples of the galvanized reinforcing straps and backfill after the Reinforced Earth Company made arrangements with authorities of the Bluegrass Airport and the contractor, who was demolishing the wall. The reinforcing straps and backfill sample were sent to the Reinforced Earth Company after visual examination at the Kentucky Transportation Center.

The contractor removed sections of reinforcing straps at several locations during demolition. The sections removed were obtained from each end of the reinforcing strap (at the panel connection and at the free end where the granular backfill, which contains the reinforcing strips, meets the compacted clay). The strap was cut with a saw at the panel connection. A photo of the sections from one strap is shown in Figure 15. The section obtained adjacent to the panel is on the left and the free end section is shown on the right hand side of the photograph. No visible corrosion was observed in any of the straps. The layer of zinc galvanization was still visible after more than 20 years of service.

Figure 15. Sections of a reinforcing strap obtained from a MSE Wall at the Bluegrass Airport in Lexington, Kentucky

The backfill behind the wall was crushed limestone, which consisted of a top size aggregate of 2.5 to 3 inches with very small amounts of fine aggregate (Figure 16). No gradation tests were performed on the backfill sample. The lack of corrosion may be attributed to the backfill. The smallest corrosion rates measured on the four tested walls were two that had large-sized, uniformly graded, backfill.

DATABASE MANAGEMENT SYSTEM

MSE walls identified in the study were cataloged into a computerized management system built in a Windows® client-server environment. The MSE wall module is part of a Geotechnical Database developed for the Kentucky Transportation Cabinet (Hopkins et al 2005) (Hopkins et al 2003). Graphical user interfaces (GUI) screens were built using PowerBuilder® 8.0. Oracle® 8i is used to store all field and other types of data. The database resides on a server maintained by the Kentucky Transportation Cabinet. Each of the twelve

Figure 16. Backfill Sample from the MSE Wall at the Bluegrass Airport in Lexington, Kentucky.

highway district offices and several Central Offices are currently connected to this server by an intranet connection.

Access to the database is obtained with a user ID and a password issued by a database administrator as shown in Figure 17. The database was developed to allow many users with different roles. Three types of systems maintain security of the database. The first is a *registered user system*. The user must be approved and registered by a database administrator. The system automatically checks the user's identification and password when logging in the system. Connection to the database is completed after the user identification and password are confirmed. The second security system is a *role-based system.* Users are assigned to different groups based upon their roles, establishing a hierarchy of users. User defined roles are: Database Administrator (DBA), Officer, Data Entry, Regional Data Entry, and Viewer. The DBA has full operational functions including read, update, delete, and manage user identifications. Data Entry Users have full operational functions statewide. Regional Data Entry Users have full operational functions within their own districts. The Viewer is only allowed to read and print stored data.

The third security system is a *recording system.* Internally, the data base application records and writes each operation performed by a user such as logon and logout times, insert, update, and delete functions. Reviewing this record, allows a DBA to trace a user's operations, if necessary. This is very valuable in tracking and locating errors that may occur during data entry.

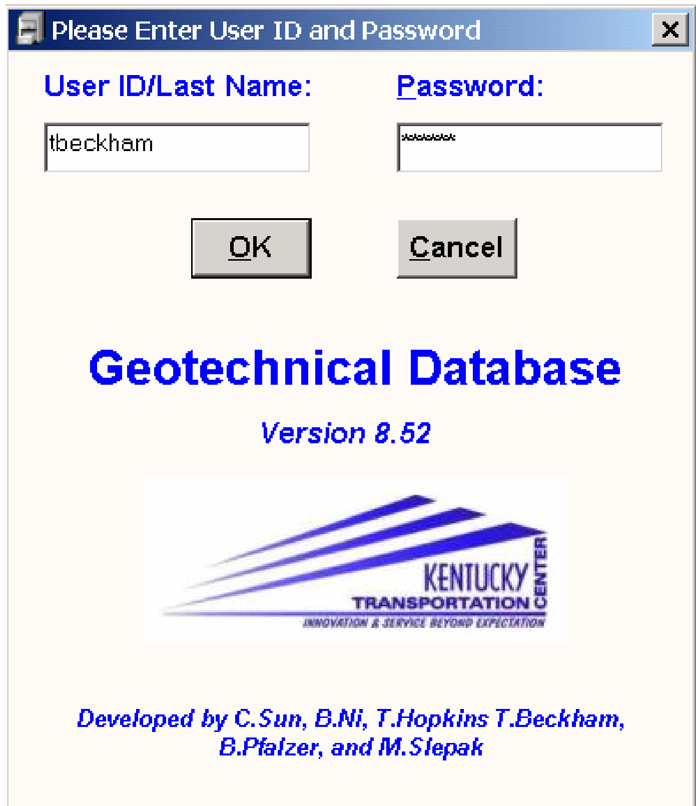


Figure 17. Log In Screen to the Kentucky Geotechnical Data Base

Database Search

Clicking the **Search Existing Data** tab (Figure 18) returns a screen to refine the search parameters base on project type, route, county, etc. shown in Figure 19. The **Project Type** is selected from a drop down menu in the upper right hand corner. Route number can be entered into the fields in the lower left. The county or counties can be selected from the list of counties in the **County** selection fields on the right hand side of the screen. **Multiple Project Types** and

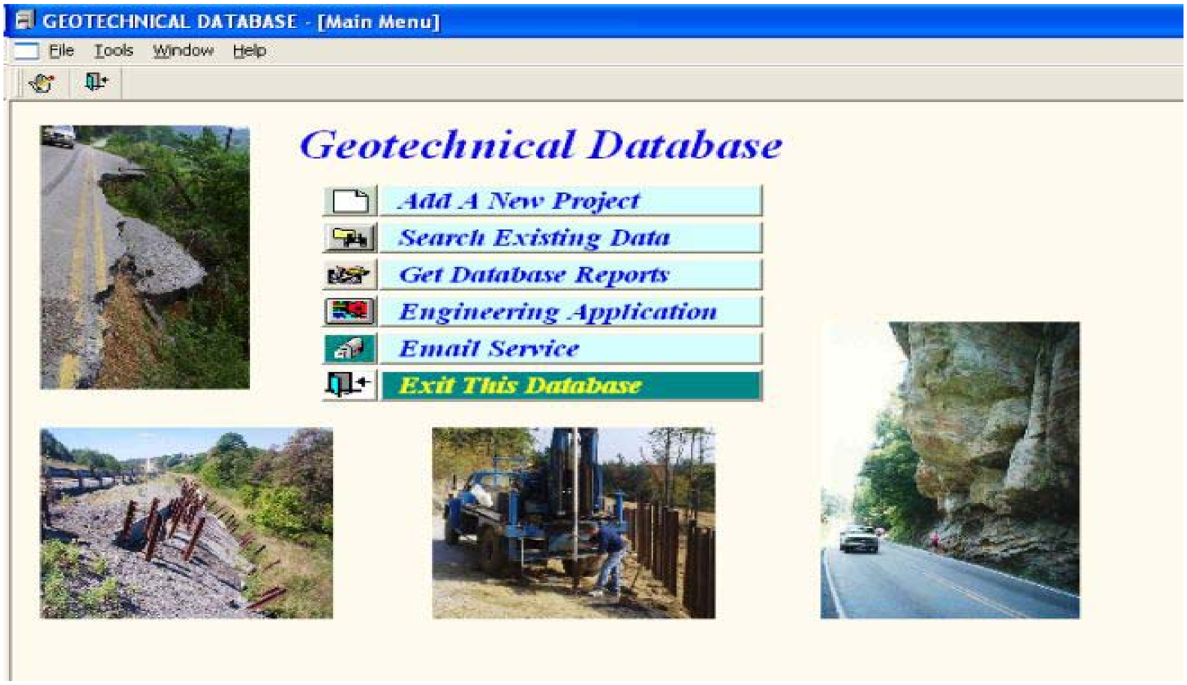


Figure 18. Kentucky Geotechnical Database Menu Screen

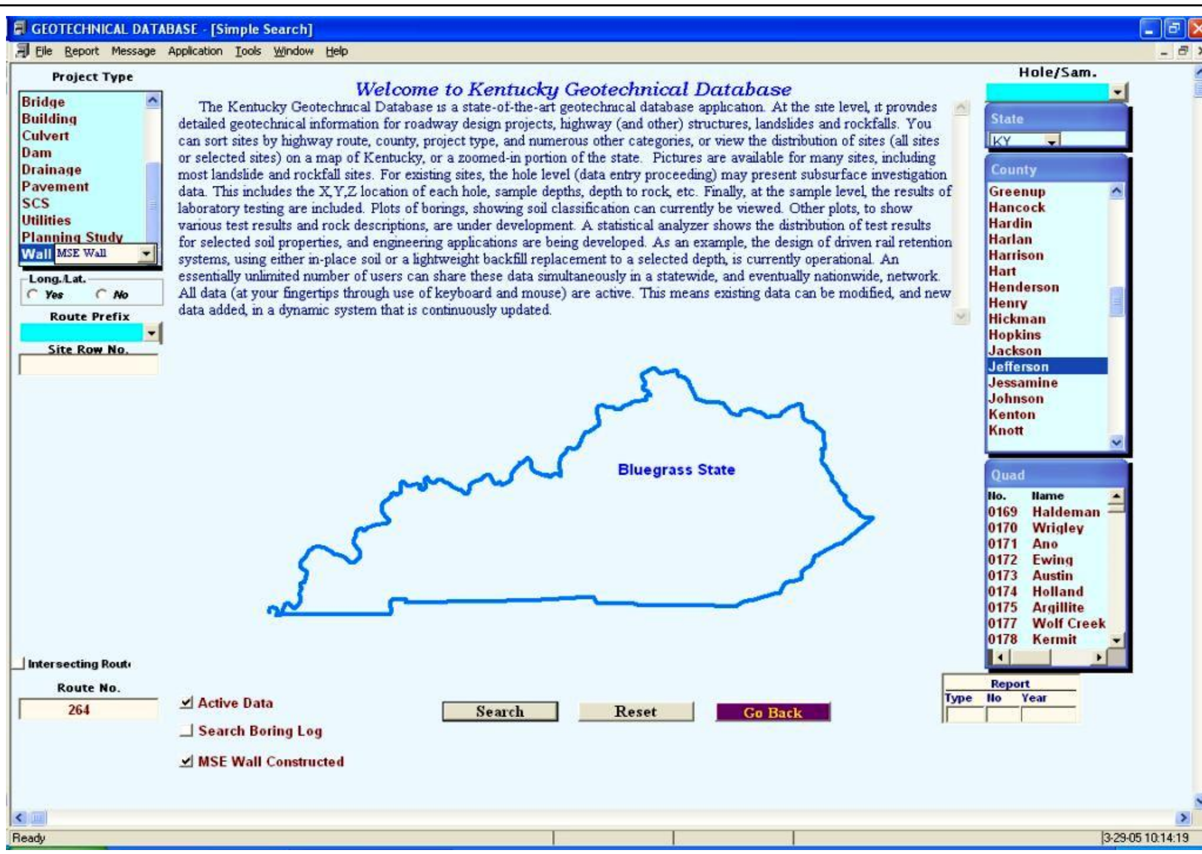
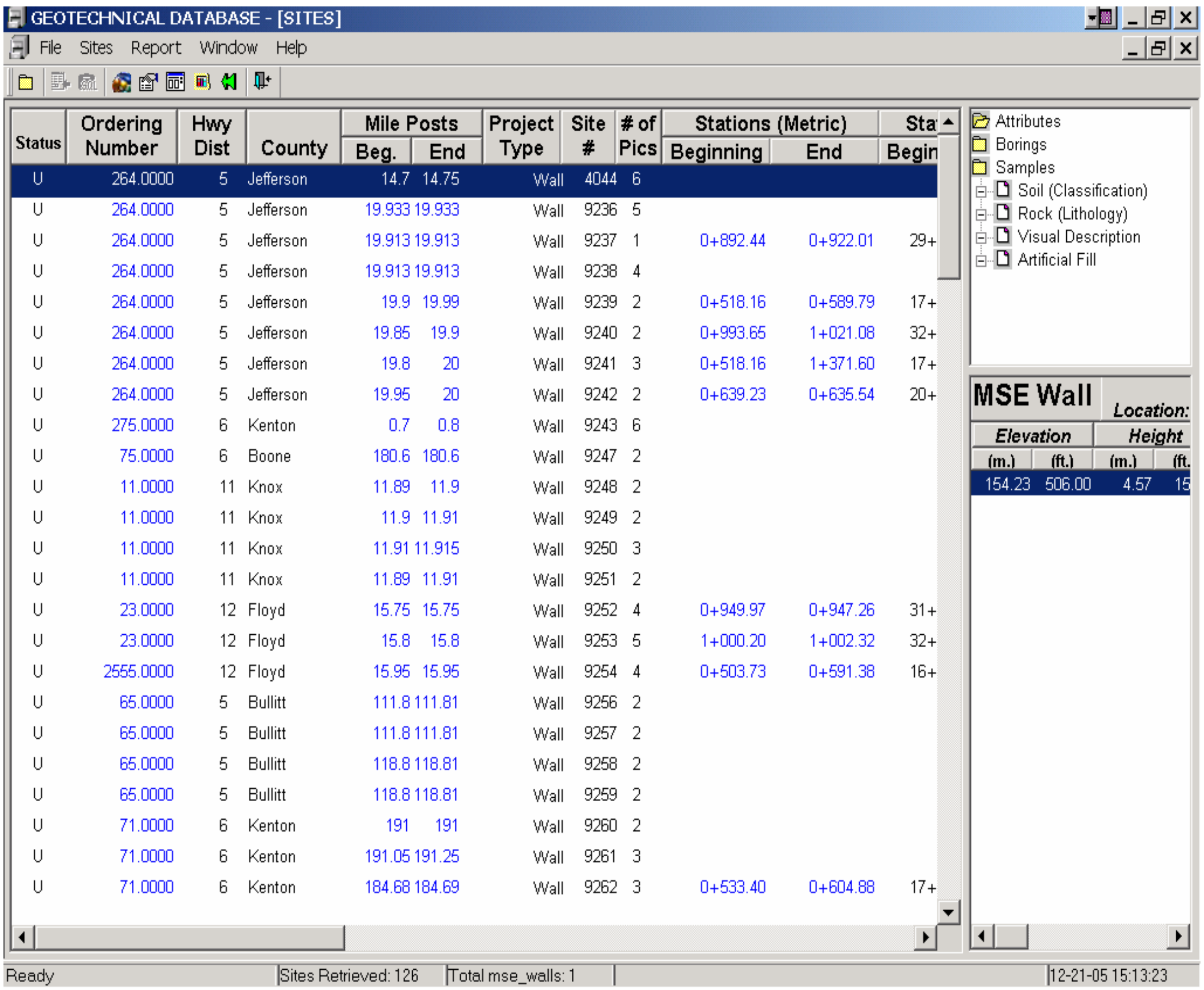


Figure 19. Example Search Screen

Counties can be selected also by depressing the Ctrl key and selecting with the Project Type and County with the mouse pointer simultaneously. The MSE Wall Constructed box was checked. This option refines the search to constructed walls. MSE walls in the design stage are also included in the database. Leaving the Active Data box unchecked can retrieve them. The search functions in this example returns a listing of all constructed MSE walls on Route I-264 in Jefferson County displayed in Figure 20. The screen is divided into two portions. The left-hand side displays site information for each wall such route number, Highway District, County, Mile points, **Project Type**, and **Station Numbers**. Other information including latitude and longitude and a description can be seen by moving the bar at the bottom of the screen to the right. The



Status	Ordering Number	Hwy Dist	County	Mile Posts Beg.	Mile Posts End	Project Type	Site #	# of Pics	Stations (Metric) Beginning	Stations (Metric) End	Sta Begin
U	264.0000	5	Jefferson	14.7	14.75	Wall	4044	6			
U	264.0000	5	Jefferson	19.933	19.933	Wall	9236	5			
U	264.0000	5	Jefferson	19.913	19.913	Wall	9237	1	0+892.44	0+922.01	29+
U	264.0000	5	Jefferson	19.913	19.913	Wall	9238	4			
U	264.0000	5	Jefferson	19.9	19.99	Wall	9239	2	0+518.16	0+589.79	17+
U	264.0000	5	Jefferson	19.85	19.9	Wall	9240	2	0+993.65	1+021.08	32+
U	264.0000	5	Jefferson	19.8	20	Wall	9241	3	0+518.16	1+371.60	17+
U	264.0000	5	Jefferson	19.95	20	Wall	9242	2	0+639.23	0+635.54	20+
U	275.0000	6	Kenton	0.7	0.8	Wall	9243	6			
U	75.0000	6	Boone	180.6	180.6	Wall	9247	2			
U	11.0000	11	Knox	11.89	11.9	Wall	9248	2			
U	11.0000	11	Knox	11.9	11.91	Wall	9249	2			
U	11.0000	11	Knox	11.91	11.915	Wall	9250	3			
U	11.0000	11	Knox	11.89	11.91	Wall	9251	2			
U	23.0000	12	Floyd	15.75	15.75	Wall	9252	4	0+949.97	0+947.26	31+
U	23.0000	12	Floyd	15.8	15.8	Wall	9253	5	1+000.20	1+002.32	32+
U	2555.0000	12	Floyd	15.95	15.95	Wall	9254	4	0+503.73	0+591.38	16+
U	65.0000	5	Bullitt	111.8	111.81	Wall	9256	2			
U	65.0000	5	Bullitt	111.8	111.81	Wall	9257	2			
U	65.0000	5	Bullitt	118.8	118.81	Wall	9258	2			
U	65.0000	5	Bullitt	118.8	118.81	Wall	9259	2			
U	71.0000	6	Kenton	191	191	Wall	9260	2			
U	71.0000	6	Kenton	191.05	191.25	Wall	9261	3			
U	71.0000	6	Kenton	184.68	184.69	Wall	9262	3	0+533.40	0+604.88	17+

Figure 20. Search Results' Screen

right-hand side of the screen displays attributes associated with each wall. By activating the Borings or Sample option in the right-hand corner of Figure 20, the number of borings, or soil and rock data, may be retrieved. Boring and sample data are not currently available for constructed MSE walls. Double clicking the highlighted row returns the Site Information screen (Figure 21) for the selected wall. The site is created from the **Add a New Project** function on the main menu **(**Figure 18). A **Site Number** is automatically assigned to each database entry when a **New Project** is entered. Sites may be roadway segments, landslides, dangerous rock cuts,

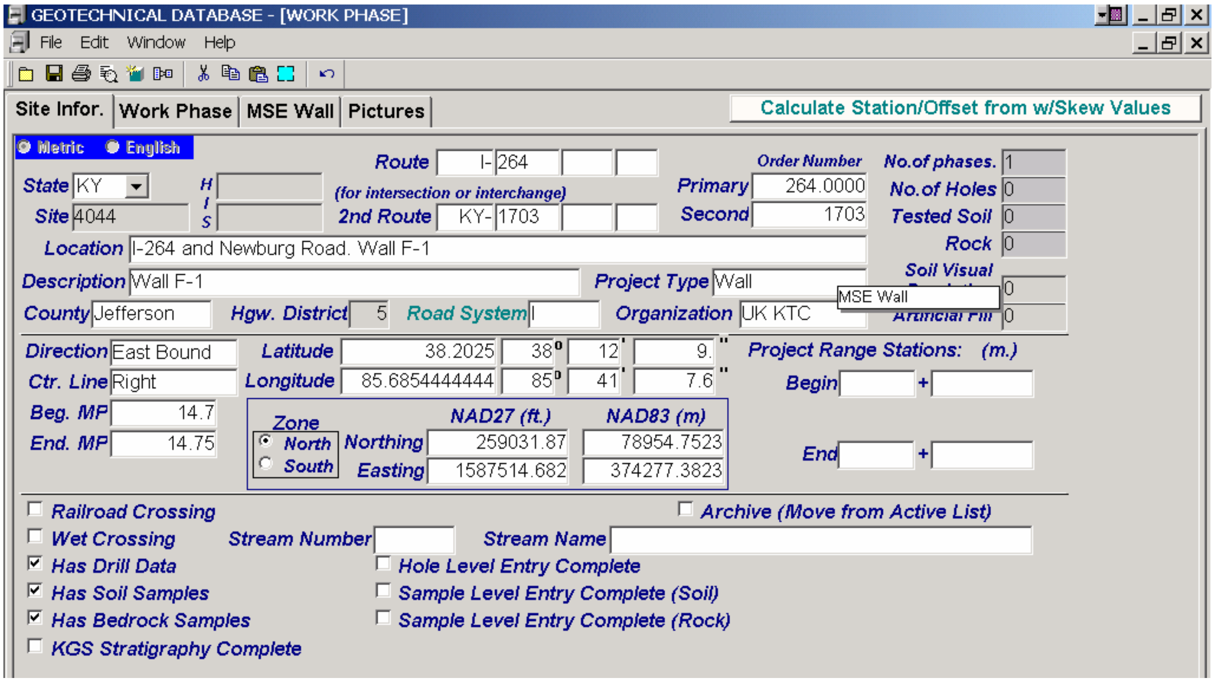


Figure 21. Site Information Screen.

bridges, culverts, dams, retaining walls, or any structure or feature that is part of a highway. Information includes physical location, route prefix, location and description information, route number, county, district (automatically entered when county is selected), latitude, longitude, State Plane Coordinates, beginning and ending station numbers. Latitude and longitude can be entered as degrees, minutes, and seconds or as decimal degrees. State plane coordinates can be entered as North American Datum (NAD) 27 or 83. Routines have been programmed to calculate coordinates for all the systems based on a single entry type. For example, if latitude and longitude are entered as degrees, minutes and seconds, the coordinates are automatically calculated and stored in decimal degrees. Coordinates for the two State Plane systems are also calculated and stored permanently. Locations can be displayed on electronic maps embedded in the program. They can also be exported to other Geographical Information Systems.

English to metric conversions are built into the system. Check boxes are used to track boring and sample and other information. If the **Hole Level Entry Complete, Sample Level Entry Complete (Soil)**, and **Sample Level Entry Complete (Rock)** boxes are checked the number of holes (borings), soil samples and rock samples are displayed on the **Site Information** screen (Figure 21). Boring, rock, and soil sample data are entered on other GUI screens described elsewhere (Hopkins, et al 2005). The wall can be removed from the database by activating **Archive (Move from Active List)** check box. A user may exercise this option if the wall is demolished or no longer in service. The wall information is archived and can be retrieved.

MSE Wall Attributes

The Work Phase screen (Figure 22) was developed to tabulate geotechnical reports, including any addendums, and generate a listing of MSE wall. A unique item number assigned to projects by the Kentucky Transportation Cabinet can be entered. This number is used in all aspects of a

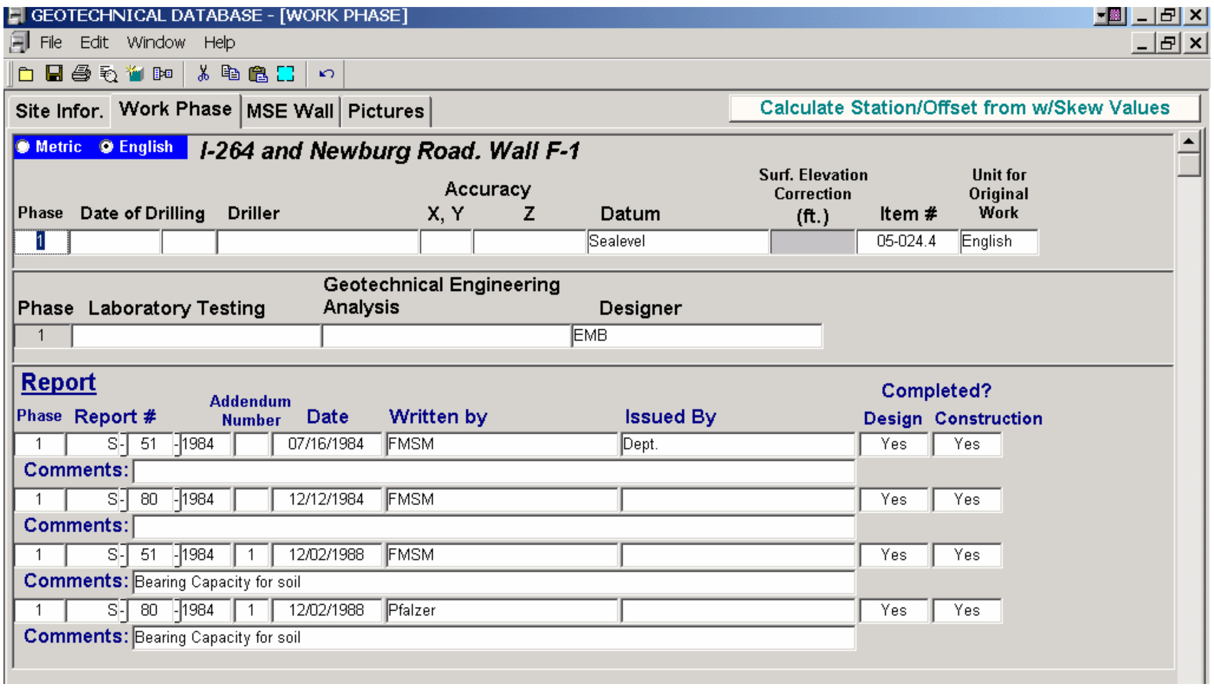


Figure 22. MSE Wall Work Phase Screen.

project highway. This number can be used in the Get Data Base Reports' screen. The Transportation Cabinet or consulting firms, involved with the initial geotechnical investigation drilling, testing, analysis, or design of the wall, can be entered and maintained as a permanent record. The MSE Wall (Figure 23) screen is used to store attributes obtained from visual examinations, engineering drawings, and other sources of information. The information displayed at top is automatically transferred from the Site Information Screen except for elevation, height and length. Visual Evaluation, Topography, Manufacturer, General Soil Conditions, Backfill Material, pH properties, and Type of Reinforcement are selected from drop down menus. The attributes selected were based on recommendations from the Federal Highway Administration (Berkovitz and Helay 1997).

Additional work phases can be added if major changes are made in the wall such as reconstruction, lengthening, etc. Colored photographs of MSE walls can provide valuable visual information. The Multiple Images screen (Figure 24) is used to input and display electronic photographs of walls associated with a site. A maximum of 12 images can be stored for each wall. The images are displayed in a slide show type format. Attributes can be viewed in photographs that are not evident in some physical descriptions.

Photographs are entered using the option, ***Choose a Picture to Input or Change Function*** on the screen. Using this feature directs the user to select a directory where the image is stored. Highlighting the name of the image and selecting **Open** will store the photograph. Photos can be deleted also by using the ***Delete Last Picture*** option. Double clicking on an image in the slide show format will enlarge the picture. Selecting ***Size to Fit*** will fit the image to the monitor screen. The image can be printed using the ***Print*** feature (Figure 25).

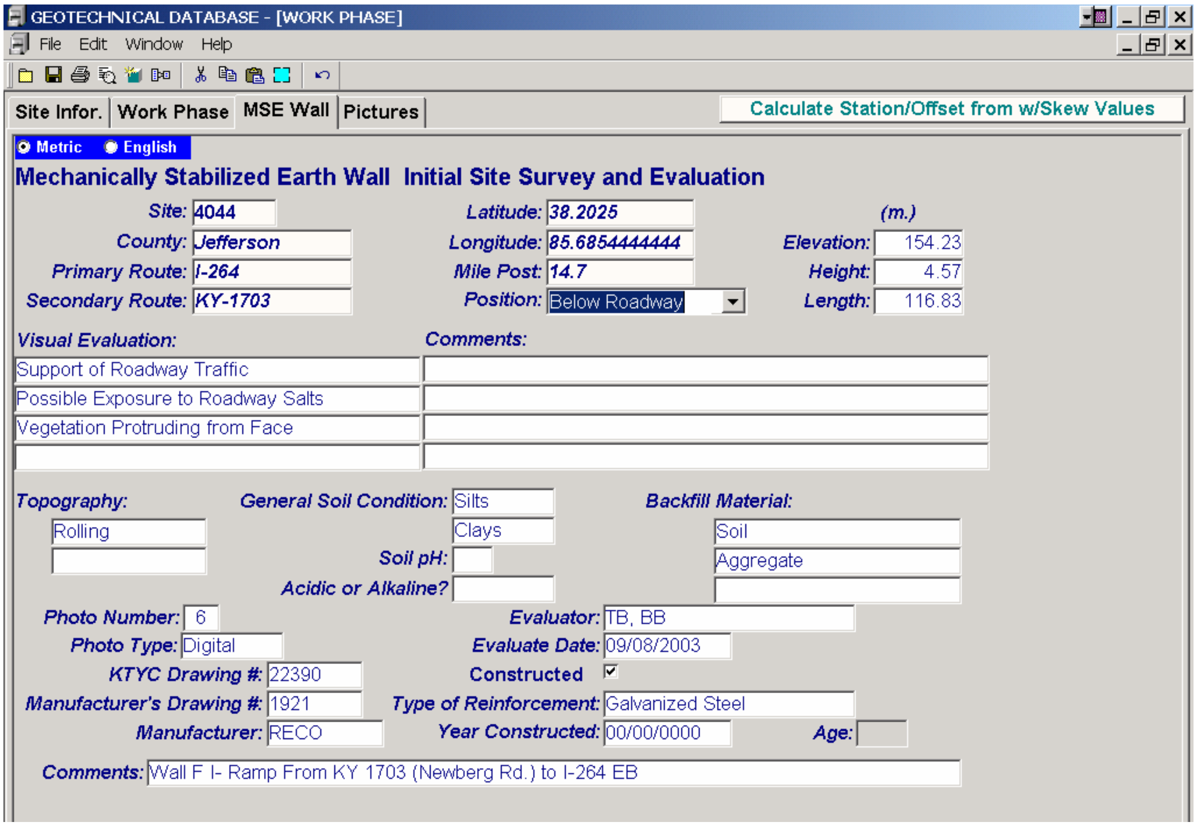


Figure 23. MSE Wall attributes screen.

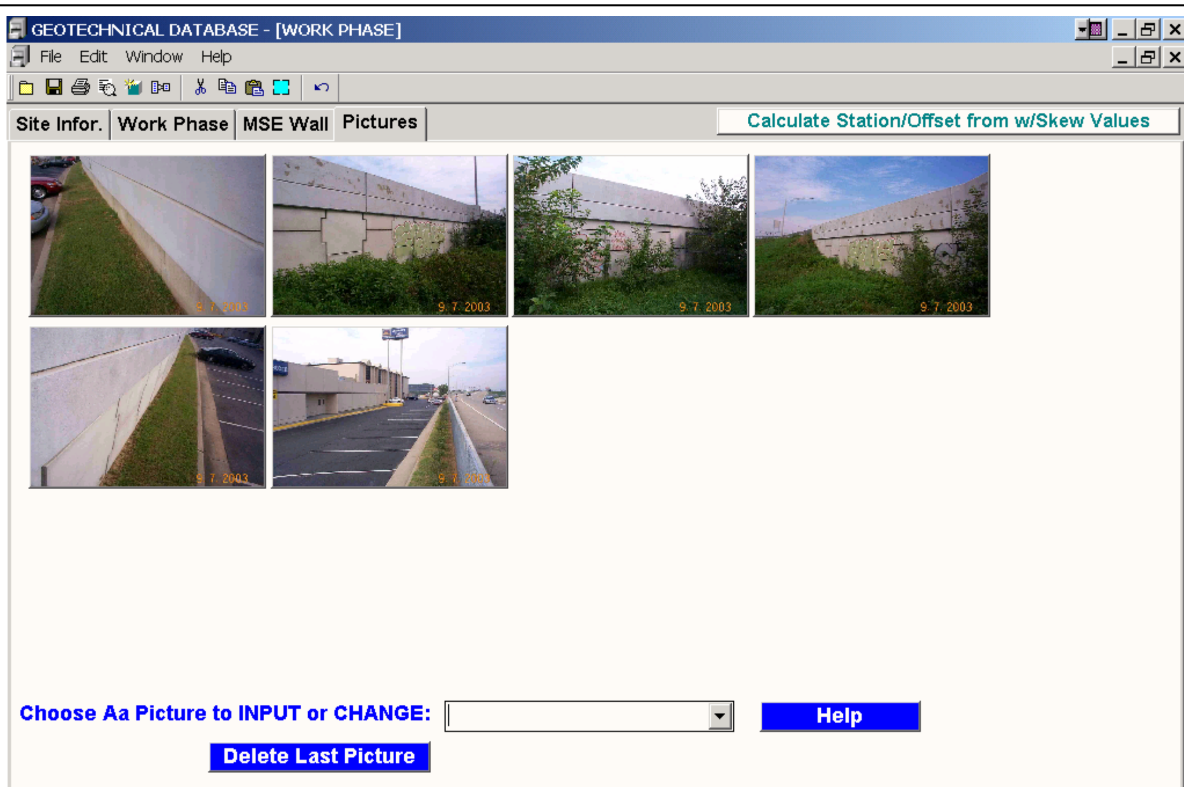


Figure 24. Multiple Images Screen

Figure 25. Individual Photo Screen.

CONCLUSIONS AND RECOMMENDATIONS

Corrosion rates measured during this study of four instrumented MSE walls at different locations in Kentucky are lower than AASHTO design standards. Monitoring of these walls should continue in the future. Details of the walls can be managed using the database system developed in this study. Details of new walls should be entered into the database management system. Some MSE walls should be instrumented during construction for corrosion monitoring. Electrical connections and wiring of elements would be easier to install during construction. Coupons could be installed, monitored and removed at a later date for evaluation. MSE walls where corrosion is suspected due to environmental factors, aggressive backfill, age, etc. should be instrumented and monitored.

Corrosion rates indicated all MSE walls tested have corroded much less than the maximum amounts assumed in the design.

Corrosion rates were more consistent when the backfill was uniform.

Examination of reinforcing straps, obtained from a MSE wall that was in service for more than 20 years, showed that the galvanized coating was still intact. The backfill consisted of large-sized, well-graded crushed limestone.

ACKNOWLEDGEMENTS

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APPENDIX A

INVENTORY OF CONSTRUCTED MECHANICALLY STABILIZED WALLS

Table A1. Inventory of Constructed MSE Walls

District	County	Route	Mile Post Begin	Mile Post End	Latitude	Longitude	Site Location	Wall Type
1	Graves	US 45					US 45 over P & L RR, Abutment Wall #2, North Wall	Bridge abutment
1	Graves	US 45					US 45 over P & L RR, Abutment Wall #1, South Wall	Bridge abutment
2	Hopkins	US 41					No attributes obtained	Bridge abutment
2	Hopkins	US 41					No attributes obtained	Bridge abutment
5	Bullitt	I 65	112.462	112.462	37.9344722	85.6884722	I-65 Over L&N Railroad. Wall # 1	Bridge abutment
	Bullitt	I 65	112.463	112.463	37.9341667	85.6884722	I-65 Over L&N Railroad. Wall # 2	Bridge abutment
5	Bullitt	I 65	111.800	111.810	37.9251474	85.6873550	I-65 and KY 245 Abutment # 1	Bridge abutment
5	Bullitt	I 65	118.800	118.810	38.0221322	85.6968523	I-65 and KY 61 Abutment # 1	Bridge abutment
5	Bullitt	I 65	118.800	118.810	38.0220062	85.6959206	I-65 and KY 61 Abutment # 2	Bridge abutment
5	Bullitt	I 65	111.800	111.810	37.9252333	85.6880442	I-65 and KY 245 Abutment #1	Bridge Abutment
5	Jefferson	I 64	11.850	12.050	38.2381111	85.6268333	Mainline I-64 EB Rt. Cl. Sta 169+00-185+50; Wall #8; CD #3	Retaining Wall
5	Jefferson	I 64	11.900	12.100	38.2359167	85.6222778	I-264 EB to I-64 EB Wall #4, Ramp 7	Retaining Wall below roadway
5	Jefferson	I 64	12.000	12.200	38.2369028	85.6187864	Ramps 4 & 5; Wall 9 I-64 West to I-264 North	Retaining Wall
5	Jefferson	I 64	12.275	12.278	38.2399722	85.6240556	Ramp 8 from I-264 to I-64 East, Retaining Wall 6,	Above Ramp 8 and below Ramp 5
5	Jefferson	I 65	129.700	129.700	38.1782500	85.7200000	Abutment Wall # 1 I-65 Over Grade Lane (Grade Lane stations)	Abutment with retaining wall
5	Jefferson	I 65	129.750	129.750	38.1785000	85.7201389	Abutment Wall # 2 I-65 Over Grade Lane. (Grade Lane stations)	Abutment with retaining wall
5	Jefferson	I 65	129.800	129.880	38.1800833	85.7197222	Wall at Ramp D I-65 NB Rt CL	Retaining Wall
5	Jefferson	I 65	129.950	129.950	38.1817500	85.7222778	Wall # 1 I-65 Over Staniford Lane	Abutment with long retaining wall
5	Jefferson	I 65	130.000	130.000	38.1818889	85.7221667	Wall # 2 I-65 Over Staniford Lane. (Staniford Lane stations)	Bridge Abutment
5	Jefferson	I 264	8.900	9.100	38.1875278	85.7871667	I-264 and Taylor Blvd	Retaining Wall
5	Jefferson	I 264	8.900	9.100	38.1868056	85.7893333	I-264 and Taylor Blvd	Retaining Wall
5	Jefferson	I 264	9.000	9.200	38.1886576	85.7833487	I-264 and Taylor Blvd.	Retaining Wall
5	Jefferson	I 264	9.230	9.230	38.1892370	85.7835511	I-264 and Taylor Blvd.	Bridge Abutment
5	Jefferson	I 264	9.240	9.240	38.1886004	85.7833533	I-264 and Taylor Blvd.	Bridge Abutment
5	Jefferson	I 264	10.100	10.180	38.1897222	85.7652500	I-264 and Southern Parkway	Retaining Wall
5	Jefferson	I 264	10.800	10.950	38.1906111	85.7528889	I-264 and Crittenden Drive	Retaining Wall
5	Jefferson	I 264	10.850	10.950	38.1899444	85.7509167	I-264 and Crittenden Drive	Retaining Wall
5	Jefferson	I 264	11.800	11.800	38.1922366	85.7344541	I-264 Ramp 11 to Airport & Fairgrounds	Bridge Abutment

5	Jefferson	I	264	11.800	11.800	38.1917706	85.7338372	I-264 Ramp 11 to Airport & Fairgrounds	Bridge Abutment
5	Jefferson	I	264	10.950	10.950	38.1897500	85.7509444	I-264 and Crittenden Drive West Abutment	Bridge Abutment
5	Jefferson	I	264	10.980	10.980	38.1897778	85.7506667	I-264 and Crittenden Drive East Abutment	Bridge Abutment
5	Jefferson	I	264	10.980	10.990	38.1896389	85.7532222	I-264 and Crittenden Drive	Wing Wall
5	Jefferson	I	264	10.980	10.990	38.1903889	85.7506111	I-264 and Crittenden Drive	Wing Wall
5	Jefferson	I	264	13.300	13.400	38.1942391	85.7093485	I-264 and KY 864 (Poplar Level Road)	Wing Wall
5	Jefferson	I	264	13.400	13.410	38.1954350	85.7082355	I-264 and KY 864 (Poplar Level Road)	Retaining Wall
5	Jefferson	I	264	13.450	13.460	38.1955252	85.7072173	I-264 and KY 864 (Poplar Level Road)	Retaining Wall
5	Jefferson	I	264	13.600	13.700	38.1972732	85.7054320	I-264 and KY 864 (Poplar Level Road)	Retaining Wall
5	Jefferson	I	264	14.500	14.520	38.2006944	85.6881111	I-264 and Newburg Road. Ramp 1, Wall C	Retaining Wall
5	Jefferson	I	264	14.500	14.510	38.2017024	85.6891045	I-264 and Newburg Road Wingwall B1	Wing Wall B1
5	Jefferson	I	264	14.540	14.560	38.2020712	85.6898103	I-264 and Newburg Road Wingwall A1	Wing Wall A1
5	Jefferson	I	264	14.550	14.650	38.2023611	85.6888889	I-264 and Newburg Road. Ramp 3, Wall D	Retaining Wall
5	Jefferson	I	264	14.580	14.600	38.2022251	85.6884699	I-264 and Newburg Abutment Wing Wall A2	Wing Wall A2
5	Jefferson	I	264	14.590	14.765	38.2018387	85.6882907	I-264 and Newburg Road Wingwall B2.	Wing Wall
5	Jefferson	I	264	14.700	14.750	38.2025000	85.6854444	I-264 and Newburg Road. Wall F-1	Wall F-1
5	Jefferson	I	264	14.980	15.050	38.2047778	85.6813333	I-264 and Newburg Road. Wall F-2	Wall F-2
5	Jefferson	I	264	15.040	15.040	38.2050278	85.6806111	I-264 and Bear Grass Creek Span West Abutment, Wall H	Bridge Abutment
5	Jefferson	I	264	15.050	15.050	38.2053611	85.6811667	I-264 and Bear Grass Creek Wall J	Wing Wall
5	Jefferson	I	264	15.050	15.050	38.2055000	85.6809444	I-264 over Bear Grass Creek East Abutment, Wall K	Bridge Abutment
5	Jefferson	I	264	15.050	15.150	38.2052778	85.6803889	I-264 and Beargrass Creek Wall L, Joins Wall %W at Sta 410+02	Retaining Wall
5	Jefferson	I	264	15.100	15.150	38.2055278	85.6808611	I-264 and Bear Grass Creek Wall M	Wing Wall
5	Jefferson	I	264	15.120	15.150	38.2066900	85.6786800	I-264 and Newberg Rd. Wall N joins Wall &W of next section	Retaining Wall
5	Jefferson	I	264	15.150	15.220	38.2098333	85.6743889	Rt of ramp 7 US 150 to I-264 WB Wall 7W	Retaining Wall
5	Jefferson	I	26	15.200	15.400	38.2063611	85.6783889	I-264 EB to US 150 Wall 5W joins Wall L@ Sta 410+02	Retaining Wall

			4						
5	Jefferson	I	264	15.340	15.480	38.2098333	85.6743889	Rt of ramp 7 US 150 to I-264 WB Wall 7A; No wall 427+75 - 428	Retaining Wall
5	Jefferson	I	264	15.370	15.520	38.2095571	85.6736119	I-264 EB to US 150 Wall 5B	Retaining Wall
5	Jefferson	I	264	15.380	15.444	38.2107122	85.6728244	US 150 to I-264 WB left side of on ramp Wall 7B	Retaining Wall
5	Jefferson	I	264	15.490	15.550	38.2092700	85.6750100	ramp 7 US 150 I-264 Wall 7A w/barrier	Retaining Wall
5	Jefferson	I	264	15.550	15.600	38.2098889	85.6725833	I-264 EB to US 150 Wall 5A	Retaining Wall
5	Jefferson	I	264	16.000	16.150	38.2114247	85.6704547	Ramp 3 US 150 to I-264 EB Wall 3A	Retaining Wall
5	Jefferson	I	264	16.080	16.120	32.2134722	85.6676667	I-264 WB to US 150 Ramp Wall 1A	Retaining Wall
5	Jefferson	I	264	16.000	16.100	38.2119984	85.6705127	I-264 off ramp to US 150 Wall 1B	Retaining Wall
5	Jefferson	I	264	18.000	18.050	38.2291076	85.6355928	I-264 and Breckinridge Lane (KY 1932) North Bridge abutment	Bridge Abutment
5	Jefferson	I	264	18.000	18.050	38.2277881	85.6365052	I-264 and Breckinridge Lane (KY 1932) South Bridge abutment	Bridge Abutment
5	Jefferson	I	264	16.800	16.950	38.2188056	85.6558889	Wall A. Ramp 264 EB to KY 155	Retaining Wall
5	Jefferson	I	264	16.900	17.000	38.2199052	85.6537436	I-264 and KY 155 Wall B	Retaining Wall
5	Jefferson	I	264	17.080	17.080	38.2214173	85.6520698	I-264 and KY 155 Abutment Wall C	Bridge abutment, Wall C
5	Jefferson	I	264	17.090	17.090	38.2215460	85.6496144	I-264 and KY 155 Abutment wall D	Bridge abutment, Wall D
5	Jefferson	I	264	17.150	17.250	38.2220041	85.6505815	I-264 and KY 155, Wall E	Retaining Wall E
5	Jefferson	I	264	18.700	18.700	38.2339722	85.6281389	I-264 and Browns Lane (Browns Lane Station Numbers)	Wall North of I-264
5	Jefferson	I	264	18.700	18.700	38.2323611	85.6268889	I-264 and Browns Lane (Browns Lane Station Numbers)	Wall South of I-264
5	Jefferson	I	264	19.800	20.000	38.2492198	85.6215878	Wall B (RtCl) Ramp 8; from US 60 East to I-264 Westbound, above drainage ditch	Ret. wall of ramp to I-264
5	Jefferson	I	264	19.850	19.900	38.2493421	85.6214562	Wall E (Lt of ramp)Ramp 1 US 60 East to I-264 Westbound	Retaining wall below roadway(I-264)
5	Jefferson	I	264	19.900	19.990	38.2510556	85.6187380	Wall C; Left Ramp #1; from US 60 West to I-264 Eastbound.	Retaining Wall
5	Jefferson	I	264	19.913	19.913	38.2497568	85.6201814	South Abutment Wall; I-264 over US 60	Bridge Abutment
5	Jefferson	I	264	19.913	19.913	38.2499141	85.6216062	Wall D; left ramp #1 connects to wall #4	Retaining Wall
5	Jefferson	I	264	19.913	19.913	38.2499141	85.6216062	South Abutment wall #4 flyover ramp;1 I-264 over US 60; US 60 Stations	Bridge Abutment
5	Jefferson	I	264	19.933	19.933	38.2500675	85.6188118	North Abutment wall I-264 over US 60	North Abutment wall I-264

5	Jefferson	I	264	19.950	20.000	38.2508413	85.6181970	Wall #3; Ramp # 1;US 60 West to I-264 Eastbound.	Ramp 1 Bridge abutment
5	Jefferson	I	264	20.500	20.600	38.2578889	85.6223889	Wall A; End of ramp 7 from US 60 to I-264 Eastbound.	Retaining Wall below roadway.
5	Jefferson	I	264	20.500	20.650	38.2586389	85.6231111	Wall F; to Ramp 2 from I-264 to US 60, South of RR	Retaining Wall below roadway.
5	Jefferson	I	264	20.500	20.650	38.2608056	85.6234444	Wall G north of RR	Retaining Wall below roadway
5	Jefferson	I	265	15.172	15.172	38.1242878	85.6148157	I-265 and Beulah Church Road Abutment Wall No. 2	Bridge Abutment
5	Jefferson	I	265	15.171	15.171	38.1242878	85.6148157	I-265 and Beulah Church Road Abutment Wall No. 1	Bridge Abutment
5	Jefferson	I	265	16.100	16.120	38.1319087	85.6009453	I-265 and Cedar Creek Road.	Bridge Abutment
5	Jefferson	I	265	16.150	16.160	38.1325766	85.6007917	I-265 and Cedar Creek Road.	Bridge Abutment
5	Jefferson	I	265	18.500	18.550	38.1433170	85.5616049	I-265 and Seatonville Road	Bridge Abutment
5	Jefferson	I	265	18.500	18.550	38.1427959	85.5610527	I-265 and Seatonville Road.	Bridge Abutment
5	Jefferson	I	265	21.500	21.550	38.1680882	85.5198971	I-265 and Old Heady Road	Bridge Abutment
6	Boone	I	75	180.100	180.100	38.9861111	84.6427778	Wall C Ramp S71 to US 42. East Abutment	Bridge Abutment
6	Boone	I	75	180.100	180.100	38.9867222	84.6431111	Wall D Ramp S71 to US 42. East Abutment	Bridge Abutment
6	Boone	I	75	180.700	180.700	38.9934167	84.6456389	Wall G Under Ramp S-71 to 3157(Mall Road) East Abutment	Bridge Abutment
6	Boone	I	75	180.600	180.600	38.9918854	84.6439440	Wall A US 42 over I-75 ,Left I-75 CL	Bridge Abutment
6	Boone	I	75	180.600	180.600	38.9916568	84.6440911	Retaining Wall NB Mall Road Ramp to I-75	Bridge Abutment
6	Boone	I	75	180.900	180.900	38.9963339	84.6460268	Retaining Wall J NB Mall Road ramp to I-75	Bridge Abutment
6	Boone	I	75	181.400	181.400	39.0010871	84.6471333	Ramp from Mall road to I-75	Bridge Abutment
6	Kenton	I	75	184.720	184.721	39.0322234	84.6044639	Wall No. 3 Ramp E over Doanldson Ramp I-75 and I-275 Exit 185 interchange	Wing Wall
6	Kenton	I	75	184.715	184.720	39.0315354	84.6052753	Abutment No. 2 Ramp E over Donaldson Ramp I-75 and I-275 Exit 185 interchange	Bridge abutment
6	Kenton	I	75	191.050	191.250	39.0837576	84.5231795	I-75 and KY 8	Retaining Wall
6	Kenton	I	75	191.000	191.000	39.0846481	84.5233912	I-75 and KY 8	Retaining Wall
6	Kenton	I	75	184.700	184.710	39.0315837	84.6054013	Abutment No. 1 Ramp E over Donaldson Ramp I-75 and I-275 Exit 185 interchange	Bridge abutment
6	Kenton	I	75	184.720	184.722	39.0314977	84.6052585	Wall No.4 Ramp E over Donaldson Ramp I-75 and I-275 Exit 185 interchange	Wing Wall
6	Kenton	I	75	184.710	184.712	39.0315878	84.6053963	Wall No.2 Ramp E over Donaldson Ramp I-75 and I-275 Exit 185 interchange	Wing Wall
6	Kenton	I	75	184.680	184.690	39.0313022	84.6059837	Wall No.1 Ramp E over Donaldson Ramp I-75 and I-275 Exit 185 interchange	Wing Wall
6	Kenton	I	275	0.700	0.800	39.0414756	84.6109887	Dolewick Connector Road. MP. 1.4 Constructed 2002	Retaining wall

6	Owen	US	127	8.100	8.100	38.4585459	84.8597027	US 127. Bridge.	Bridge Abutment
6	Clark	KY	1958	2.460	2.570	38.0093889	84.2100556	At I-64 exit ramp to KY 1958	Retaining Wall
7	Fayette	I	75	108.210	108.220	38.0221201	84.4121900	Man O' War Over I-75	Bridge Abutment
7	Fayette	KY	1681	7.700	7.750	38.0510479	84.5062223	Wall C Ky 1681(Manchester Street) and Ky 1928(Jefferson Street)	Wing Wall
7	Fayette	KY	1681	7.790	7.800	38.0508535	84.5049245	Abutment No. 1 Ky 1681 and Ky 1928(Jefferson Street)	Bridge Abutment
7	Fayette	KY	1681	7.780	7.790	38.0514187	84.5061772	Wall A Ky 1681 and ky 1928(Jefferson Street)	Retaining Wall
7	Fayette	KY	1681	7.800	7.823	38.0506018	84.5045344	Wall B Ky 1681 and Ky 1928 (Jefferson Street)	Wing Wall
7	Fayette	KY	1928	0.160	0.160	38.0512105	84.5036295	Abutment No. 2 Jefferson Street and US 25	Bridge Abutment
7	Fayette	KY	1928	0.165	0.166	38.0512413	84.5035668	Wall E Jefferson Street and US 25	Wing / Retaining wall
7	Fayette	KY	1928	0.165	0.165	38.0514604	84.5036599	Wall D Jefferson Street and US 25	Wing Wall
10	Estill	KY	1645	0.180	0.180			KY 1645 over CSX Railroad South Abutment	Bridge Abutment
10	Estill	KY	1645	0.155	0.155			KY 1645 over CSX Railroad North Abutment	Bridge Abutment
11	Knox	KY	11	11.890	11.910	36.8331464	83.8406418	RR overpass	Bridge Abutment
11	Knox	KY	11	11.890	11.900	36.8331451	83.8405518	RR overpass	Bridge Abutment
11	Knox	KY	11	11.900	11.910	36.8332589	83.8408006	RR overpass	Bridge abutment w/ wing wall
11	Knox	KY	11	11.910	11.915	36.8332841	83.8409281	RR overpass	Retaining wall
11	Whitley	KY	312	2.542	2.542	36.9511944	84.0947778	West bridge abutment over Laurel Ave.	Retaining wall
11	Whitley	KY	312	2.542	2.542	36.9511944	84.0947778	MSE wall at Laurel Ave. overpass	MSE wall at Laurel Ave. overpass
12	Floyd	US	23	15.800	15.800	37.6588107	82.7852111	US 23 over KY 114. Abutment wall # 2 North wall	Bridge Abutment
12	Floyd	US	23	15.750	15.750	37.6583140	82.7858944	US 23 over KY 114. Abutment Wall #1 South Wall	Bridge Abutment
12	Floyd	KY	1428	16.950	17.050	37.6872500	82.7871944	Ky 1428 and US 23	Bridge Abutment
12	Floyd	KY	2555	15.950	15.950	37.6614909	82.7862625	US 23 over KY 2555 2 sections - 59.56' and 189.97' length on sides of piers	Retaining Wall
12	Pike	US	119					No attributes obtained	No attributes obtained
12	Pike	US	23	23.850	23.900	37.4760278	82.5390556	US 23 cut to divert river	Retaining Wall
12	Pike	US	119					No attributes obtained	No attributes obtained