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16. Abstract The purpose of this study was to document the construction procedures and evaluate the effectiveness of wick drains as a foundation stabilization method. Field data was primarily obtained from field surveys and pneumatic piezometers installed in the approach foundation. Construction procedures used have been determined to be generally acceptable. The wick drains appear to have effectively dewatered the foundation during embankment construction.				13. Type of Report and Period Covered Interim	
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Research Report
UKTRP-87-24

EVALUATION OF WICK DRAIN STABILIZATION OF
APPROACH FILL FOUNDATION (Bullitt County)

by

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Commonwealth of Kentucky

and

Federal Highway Administration
U. S. Department of Transportation

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October 1987

INTRODUCTION

In April 1985, construction began on a bridge to carry Interstate 65 over the L & N railroad in Bullitt County, Kentucky (Figure 1). The foundation at the site was composed of clayey material. Settlement calculations indicated an unacceptable time period would be required for primary consolidation. With existing conditions, 90-percent consolidation would require from 4 to 16 months. The method chosen for accelerating consolidation was to dewater the foundation by use of prefabricated vertical wick drains. Due to time limitations and other factors no other alternatives were considered. With wick drains, the estimated time for completion of primary consolidation would be from 1.7 to 2.7 months.

As seen in Figure 2, the bridges span 46 feet over the railroad. The approaches are approximately 28 feet in height with vertical reinforced earth walls retaining the front slopes (Figure 3). The foundation area where wick drains were installed extends 111 feet on either side of centerline of Interstate 65 and, beginning at the face of each wall, extends 25.8 feet back of each wall.

The drains chosen for installation were the "ALIDRAIN SYSTEM" supplied by Burcan Industries. The specific drain used was the Alidrain. This drain consists of a polyethylene core encased in filter fabric. The core is studded on both sides and perforated. The filter is a polyester fiber fabric. Overall drain dimensions are 100 millimeters in width and 7 millimeters in thickness. Alidrain specifications are listed in Appendix A. A total of 8,034 linear feet was installed at a bid unit cost of \$21.00 per linear foot of drain.

STUDY OBJECTIVES

Because the wick drains were considered an experimental feature, a study was initiated to instrument and monitor the site. Objectives of the study were

1. to document construction procedures and obtain experimental data on wick-drain effectiveness,
2. to analyze field behavior using settlement and piezometric data, and
3. to make recommendations as to the effectiveness and future use of this method.

SUBSURFACE AND GEOLOGIC DATA

This site lies in an area of lacustrine deposits and older alluvium of the Pleistocene series of the Quaternary System. Subsurface sampling conducted during the initial site investigation indicated foundation depths up to 30 feet. The material generally classified as A-7-6 or A-6 by the AASHTO system. Natural moisture contents ranged from 17 to 40 percent. Borings made after construction began indicated foundation depths of 14 to 16 feet north of the railroad and 20 feet south of the railroad.

INSTRUMENTATION

Instrumentation at the site included pneumatic piezometers placed near mid-depth of the southbound approach foundations, settlement monitoring gages at the foundation-embankment interface, and elevation

monitoring points on the wall. Instrumentation locations are shown in Figures 4 and 5.

Four piezometers were installed prior to wick-drain installation. Two were located under each approach of the southbound bridge. The piezometers under the north approach (Numbers 1 and 2) were vandalized approximately five months after installation. The vandalized piezometers were in operation long enough to reveal useful data concerning the initial dewatering performance of the drains. Long term performance data, which might have been significant in light of possible foundation pore pressure increases associated with later construction, was lost.

Settlement monitoring gages were destroyed by the equipment used for placement of the first wall sections and backfill. Personnel from this agency were not at the site when these instruments were destroyed. Loss of these gages limited settlement monitoring to monitoring the overall settlement of the foundation, wall, and embankment combined. Seven settlement monitoring points were placed on the wall (Figures 4 and 5).

CONSTRUCTION

To maintain traffic flow, construction proceeded in two phases. The southbound lanes were constructed first, and these lanes were then used to carry traffic during construction of the northbound lanes. Construction of the southbound approach began in April of 1985. The existing embankment was removed to a point that permitted construction of approximately one-half the new embankment. The remaining embankment was retained with driven piling and in some cases wood lagging. The soil was excavated to 1 foot below the bottom of the wall and

piezometers were installed at that time.

A geotextile fabric was placed on the foundation and a stone drainage blanket 1 foot thick was placed prior to wick-drain installation. Figure 6 shows the retaining piling, the geotextile fabric exposed near the piling, the drainage blanket partially in place, and the piezometers in the south approach of the southbound lanes. Drainage blanket specifications are found in Appendix B. Wick drains were installed on a 6-foot triangular spacing and extended to bedrock. Drains were cut off at least 6 inches above the drainage blanket. Four hundred fifty drains totaling 8,034 linear feet were installed. Installation required approximately three working days for an average installation rate of 335 feet per hour. Figure 7 shows an installed wick drain extending through the drainage blanket, and Figure 8 shows a typical wick-drain layout. Special notes pertaining to wick-drain installation are found in Appendix C.

A footer for the reinforced earth wall was poured and construction of the wall and embankment proceeded after installation of the wick drain. Limestone sand was used to backfill the area behind the wall where the supporting straps lay. Figure 9 shows a wall footer and Figure 10 shows the construction of the reinforced earth wall.

Construction of the southbound lanes began in mid April of 1985 and was completed in early June of 1985. Construction of the northbound lanes began in August of 1986 and was completed in September of 1986. A photograph of the completed structure with the southbound lanes in the foreground is shown in Figure 11.

Design of the wick drains and drainage blanket did not provide for drainage from the blanket. It was decided in the field, however, to

provide for drainage from the blanket by extending the drainage blanket to the embankment slope surface or other drainage structures.

FIELD DATA

Piezometer data reflect pore-pressure changes associated with embankment construction. Piezometers 1 and 2 (Figure 12) and 4 (Figure 13) reached their respective highest pressures at about the same time, which coincided with completion of the approach embankments. Piezometers 3 and 4 indicated a rise in pressure coinciding with the construction of the approaches for the northbound lanes. Piezometer 3, nearest the northbound approaches, indicated the pore-pressure rise sooner than Piezometer 4.

Pressure increases ranged from 3 to 5 feet of water. By the time Piezometers 1 and 2 were vandalized, pressure at those locations had returned to near initial pressures. Piezometers 3 and 4 continue to function and indicate pressures near initial values.

Early settlement data were obtained on the reinforced earth wall (southbound lanes) by inspection personnel. This part of the monitoring effort was maintained for only one month. During that month, (beginning when the first wall sections were in place and concluding with completion of the backfill) the north wall settled 0.15 foot and the south wall settled 0.41 foot. These monitoring points were apparently for use during construction only and thus were of a temporary nature. The points were lost when inspection personnel ceased monitoring them.

When the first sections of wall were being placed under the northbound lanes, monitoring points were placed along the length of the

wall. Those points would indicate the movement of the eastern half of the wall and provide follow-up data on the western half of the wall. Settlement data at Points 1 through 4 indicate settlement of 0.1 to 0.2 foot in 500 to 700 days (Figure 14). Data on this part of the wall are plotted with the initial data on monitoring points set equal to the settlement as indicated by inspection personnel records. Settlement at Points 5, 7, and 8 ranged from 0.5 to 0.6 foot (Figure 15). All monitoring points indicate an increase in elevation occurring at approximately 800 days (winter-spring of 1987). The increase ranged from 0.086 foot at Point 8 to 0.420 foot at Point 4.

Settlement of the south approach of the southbound bridge was monitored by means of profile elevations along the edge of pavement. These data reveal an apparent increase in the elevation of the approach slab up to 0.522 foot (Figure 16). This increase occurred from July 1986 to June 1987. The rise at the bridge expansion joint nearest monitoring Points 3 and 4 was 0.280 foot.

CONCLUSIONS AND RECOMMENDATIONS

The use of prefabricated vertical wick drains to dewater the foundation and accelerate primary consolidation was apparently successful. Estimates up to 2.7 months for 90-percent consolidation are generally supported by settlement data. Piezometers installed in the foundation indicate the initial rises in foundation pore pressures coincided with embankment construction and the subsequent drop in pore pressure with completion of embankment. Foundation pore pressure dropped to, or near to, initial levels within approximately 4 months after

completion of embankment construction.

Construction procedures involved with installation of these wick drains generally were efficient and satisfactory. A construction rate of 335 feet per hour appears to have been satisfactory. There were no significant problems with this procedure and no major change orders were issued.

The construction cost of \$21.00 per linear foot of wick drain is higher by a factor of ten than at a nearby site. A part of the reason for high unit cost is the relatively small amount of drain installed. Mobilization would cause the unit cost to be greater. Because no other alternatives were considered, no cost effective comparison information is available.

Presently, there is no obvious explanation for the apparent rise in elevation of the wall and adjacent components. It should be noted that there has been a rise in pore pressure at the two remaining piezometers. Pore pressure at Piezometer 3 began rising during construction of the northbound approach. Piezometer 4 also reflects the pore pressure increase, but indicates the increase a few days later than at Piezometer 3. The most rise or heave occurred at points farthest west on the wall. To date, the cause of the increase in pore pressure has not been determined. Surveying errors and/or changes in benchmark elevation have apparently been eliminated as a source of error.

At this particular site, wick drains appeared to be effective in reducing the time of consolidation in the foundation. Therefore, wick drains can be recommended on future projects with similar conditions.

Monitoring of the site will continue and a memorandum report will be issued.

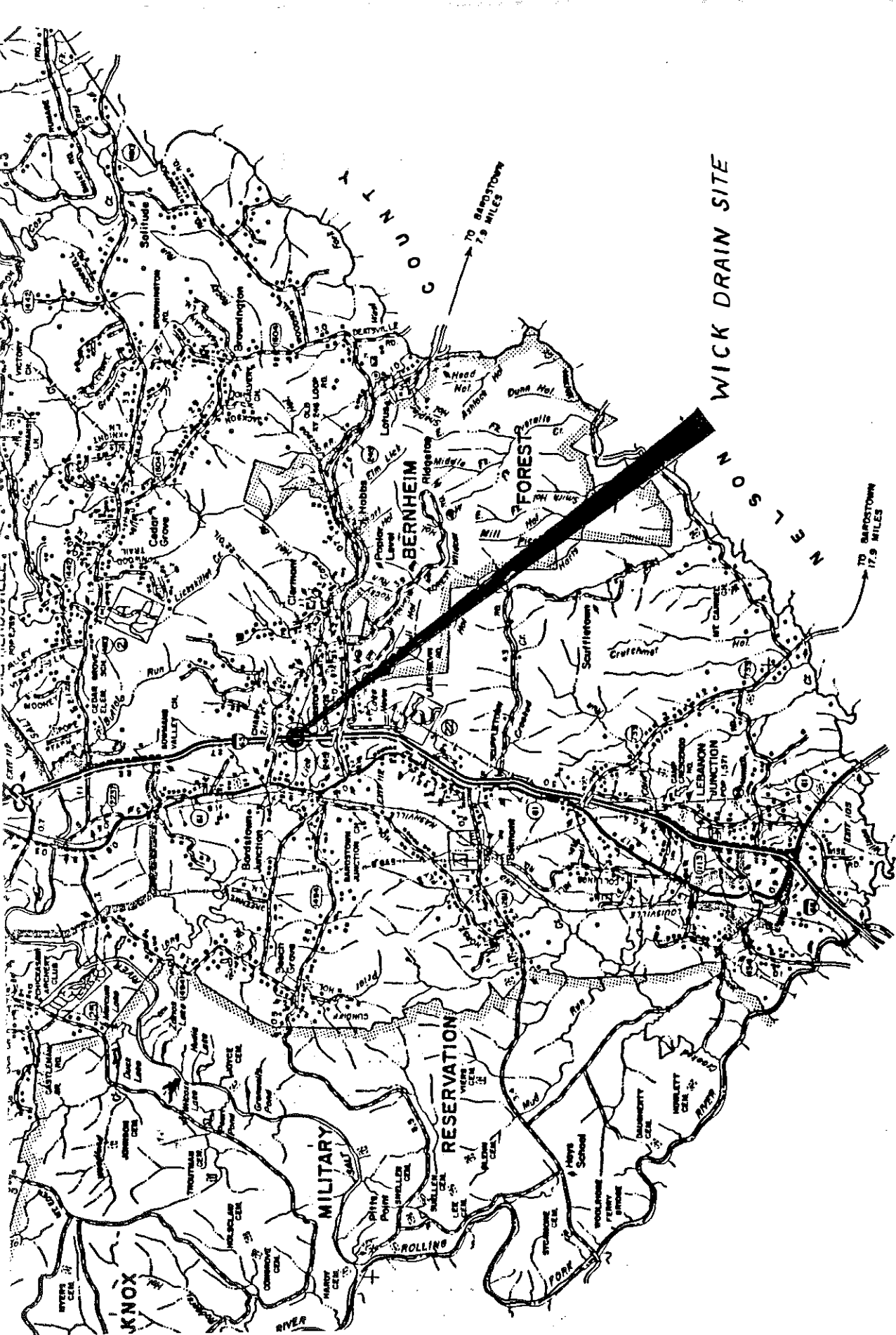


Figure 1. Interstate 65 over Louisville and Nashville Railroad Bridge in Bullitt County, Kentucky.

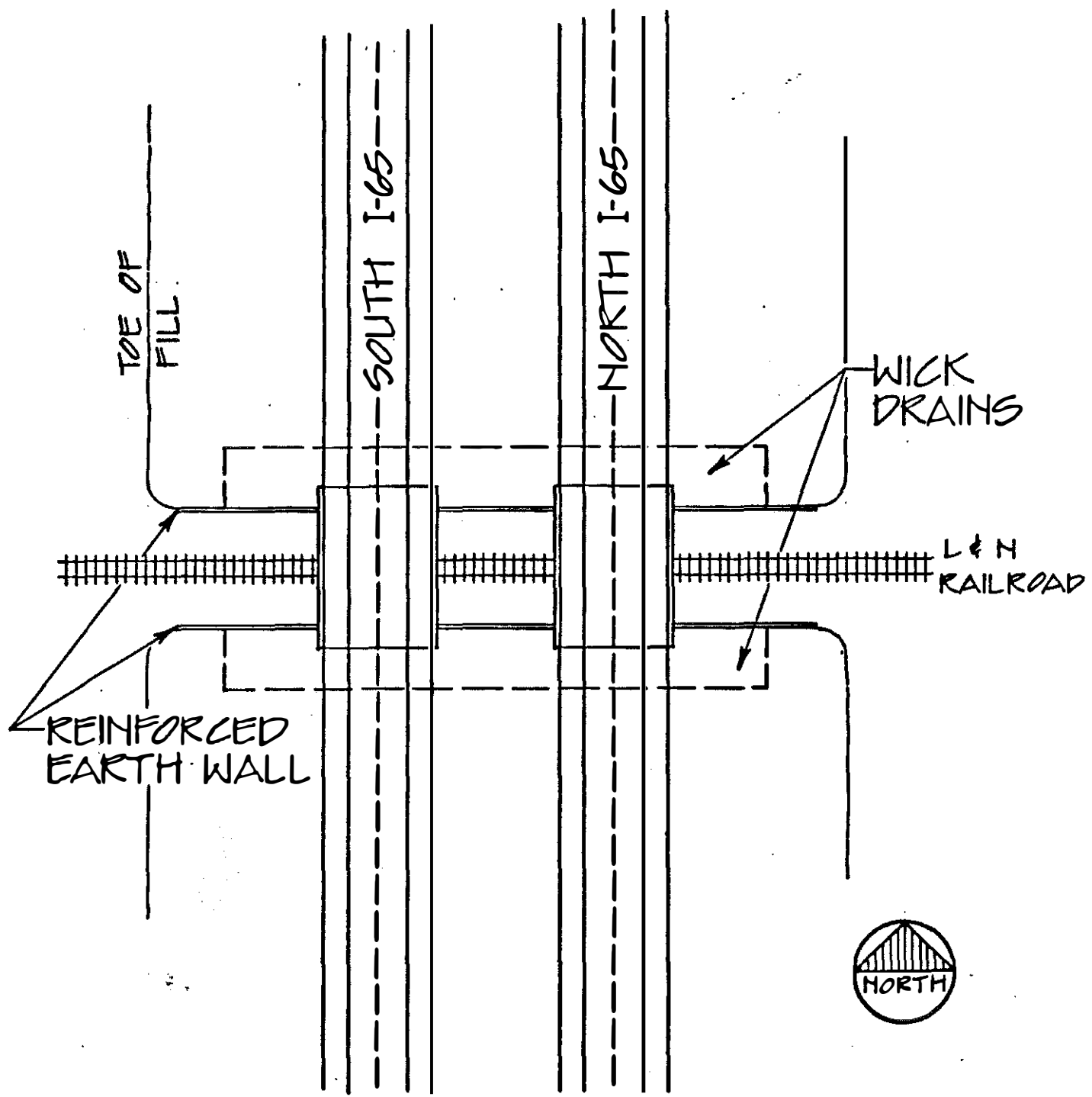
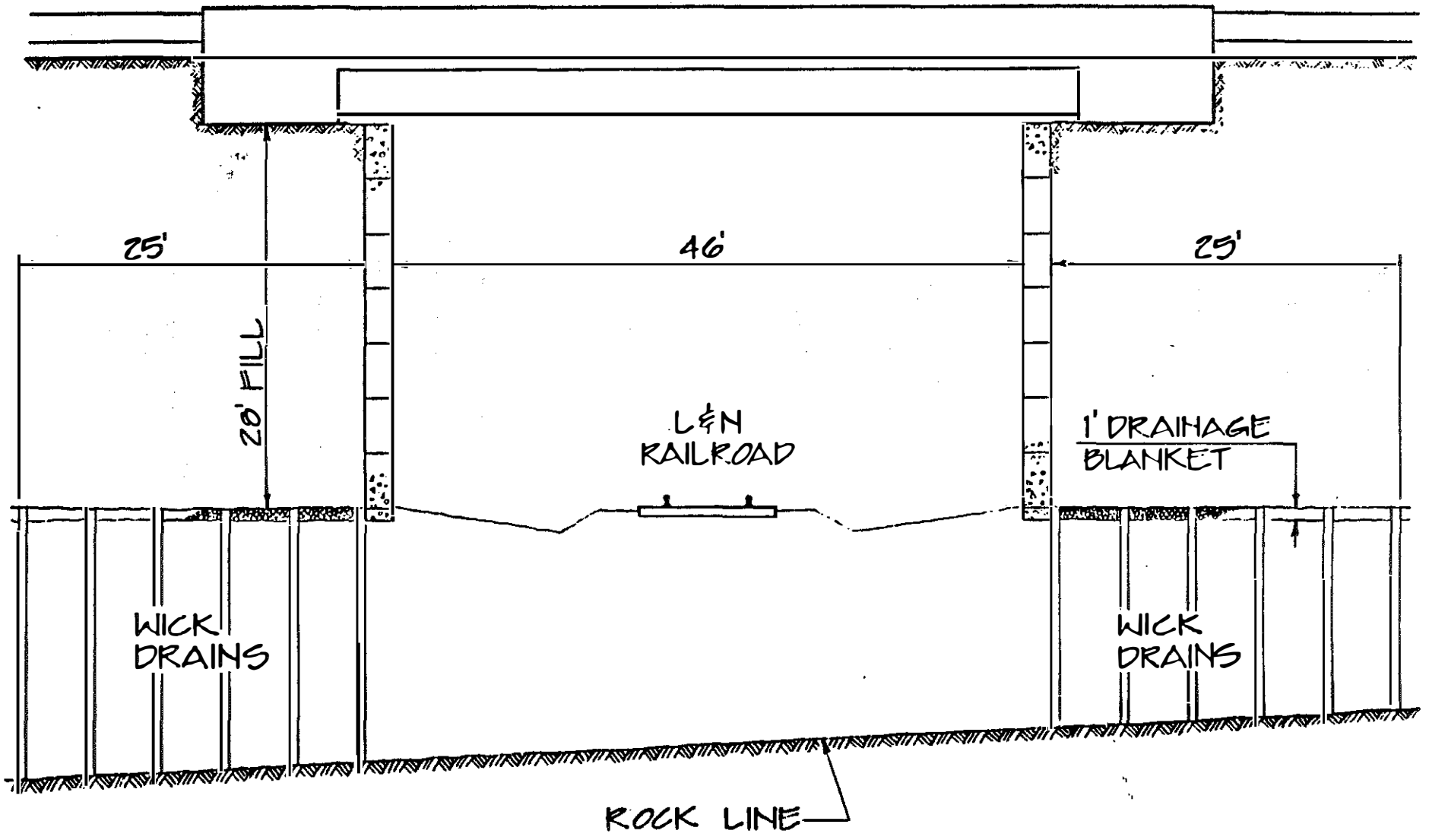


Figure 2. Plan View of Site (I 65 over L&N Railroad).



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Figure 3. Centerline Section of Site (I 65 over L&N Railroad).

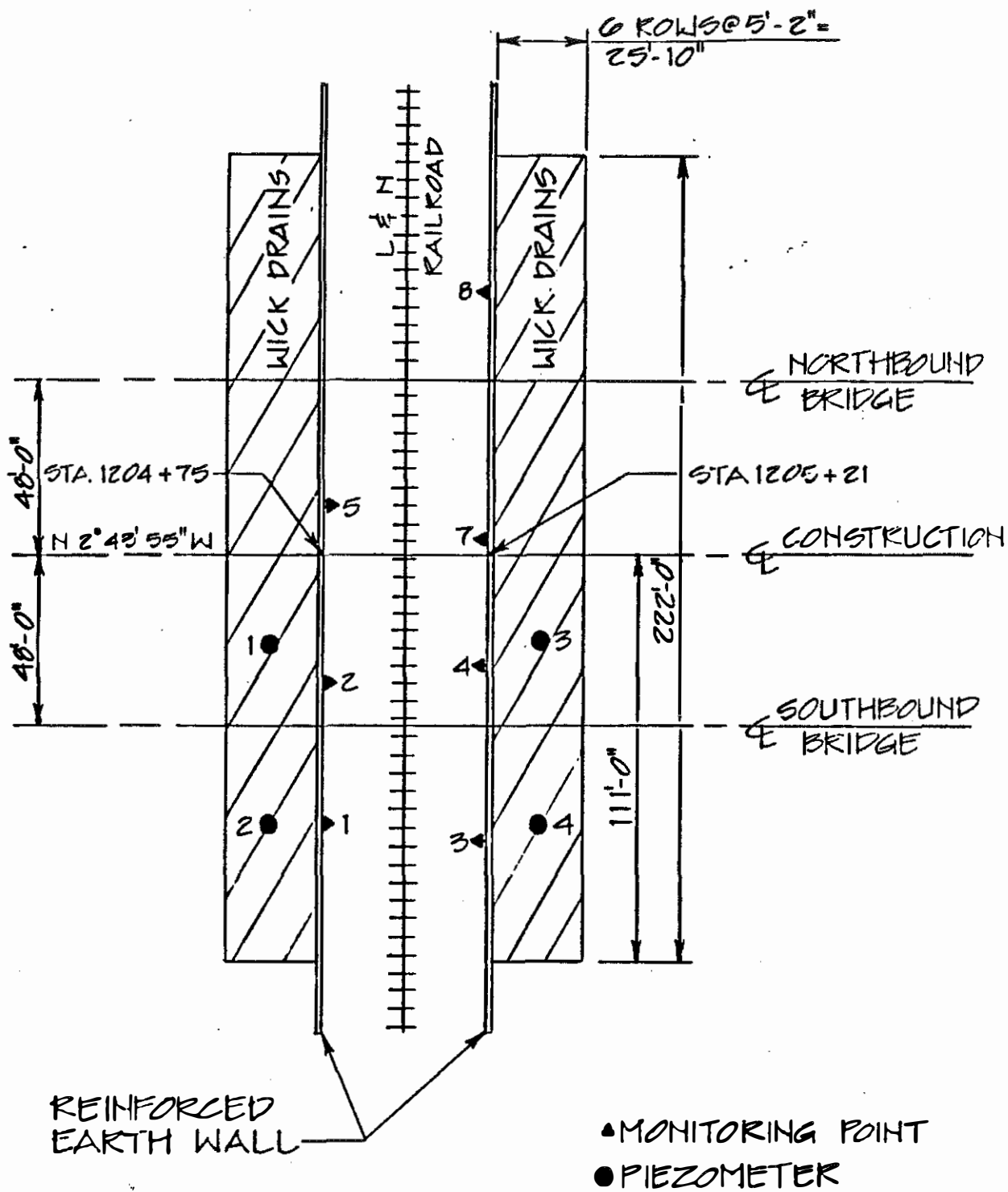


Figure 4. Plan View of Instrumentation Locations.

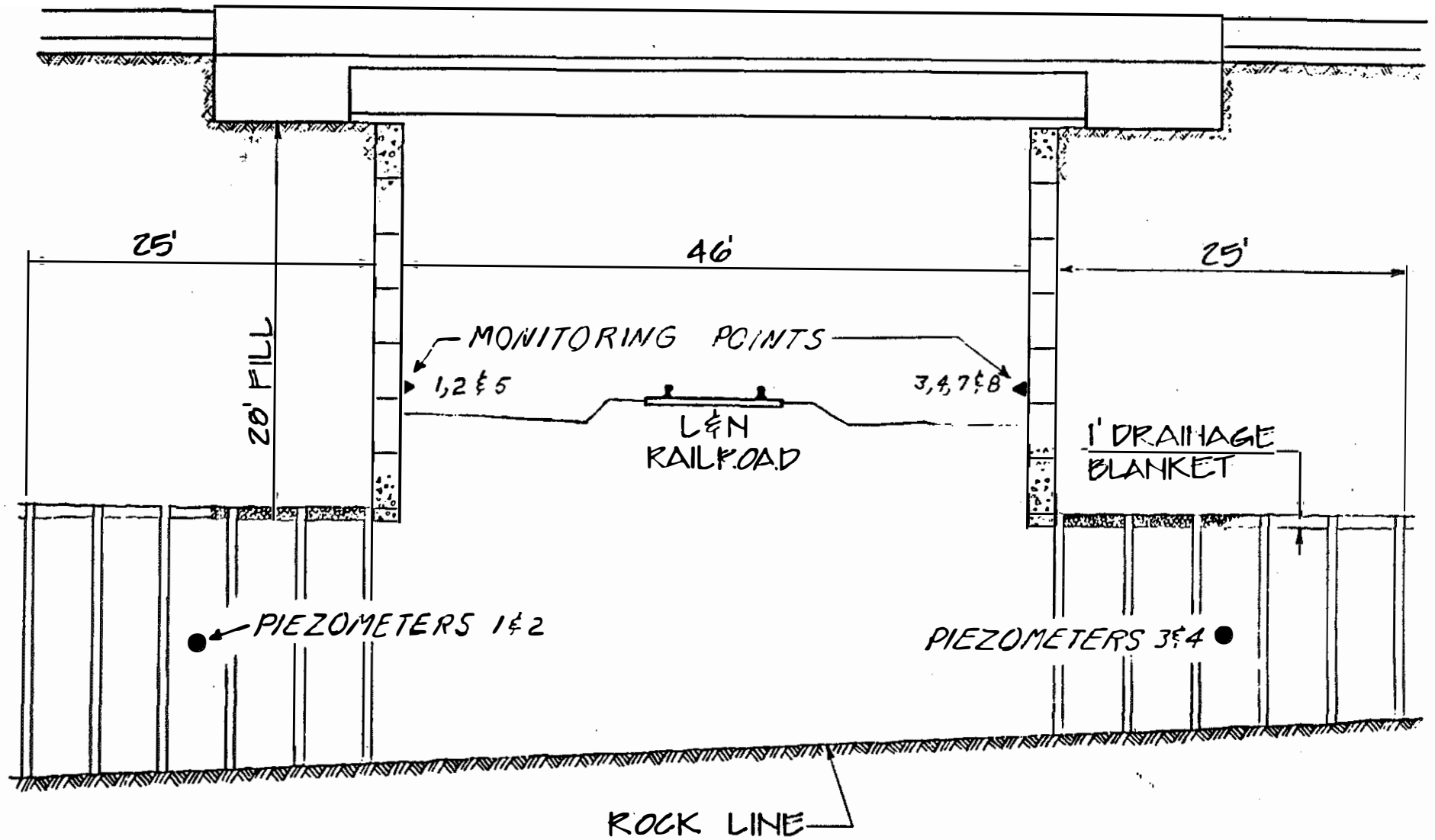


Figure 5. Centerline View of Instrumentation Locations.

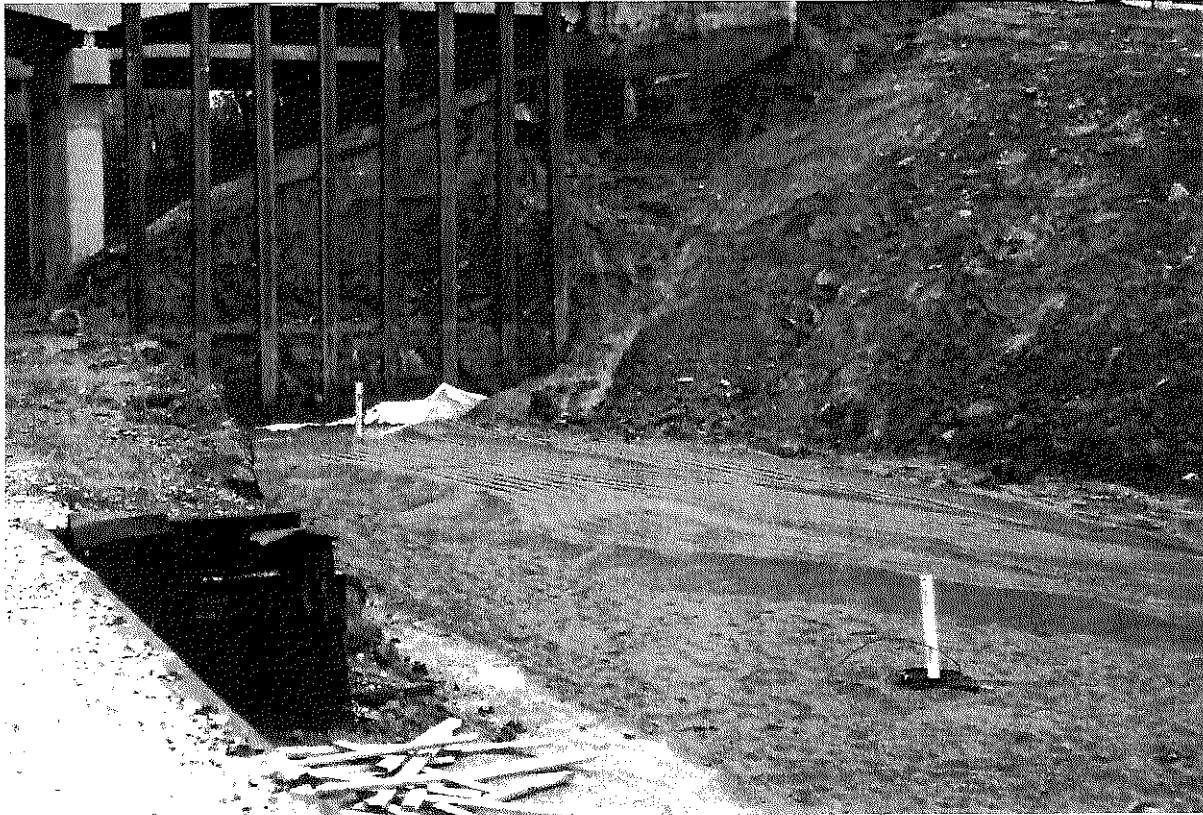


Figure 6. South Approach of Southbound Lanes. Pertinent features includes retaining piling at excavation face, geotextile fabric, partially placed drainage blanket, and piezometer locations.

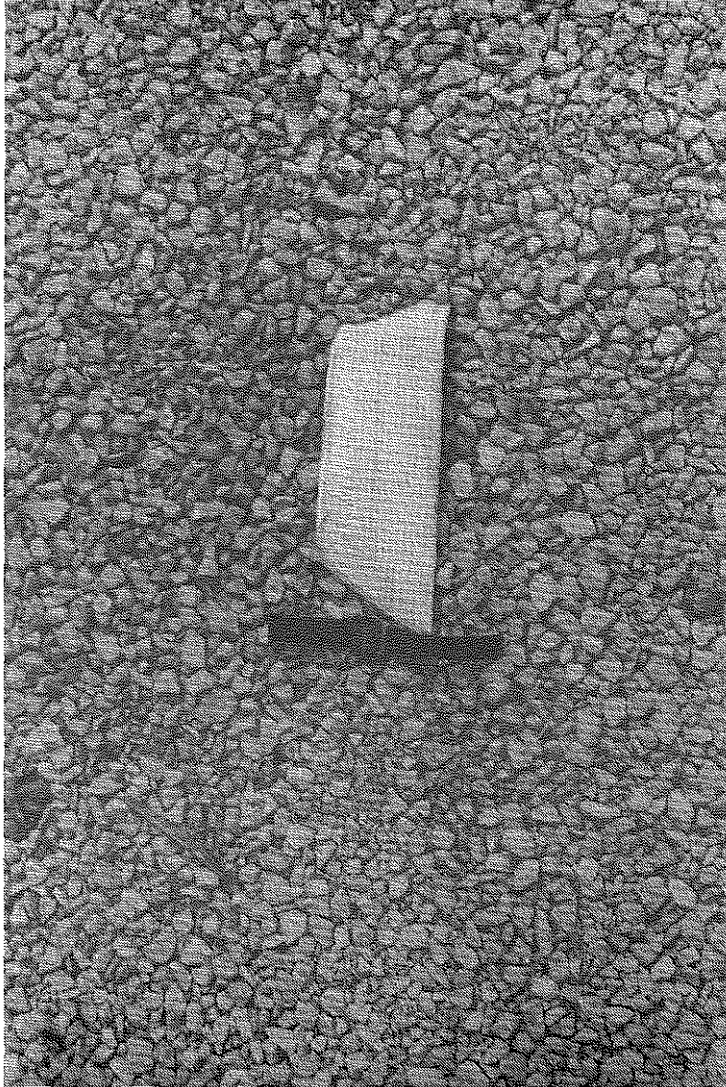


Figure 7. Wick Drain Extending through Drainage Blanket.

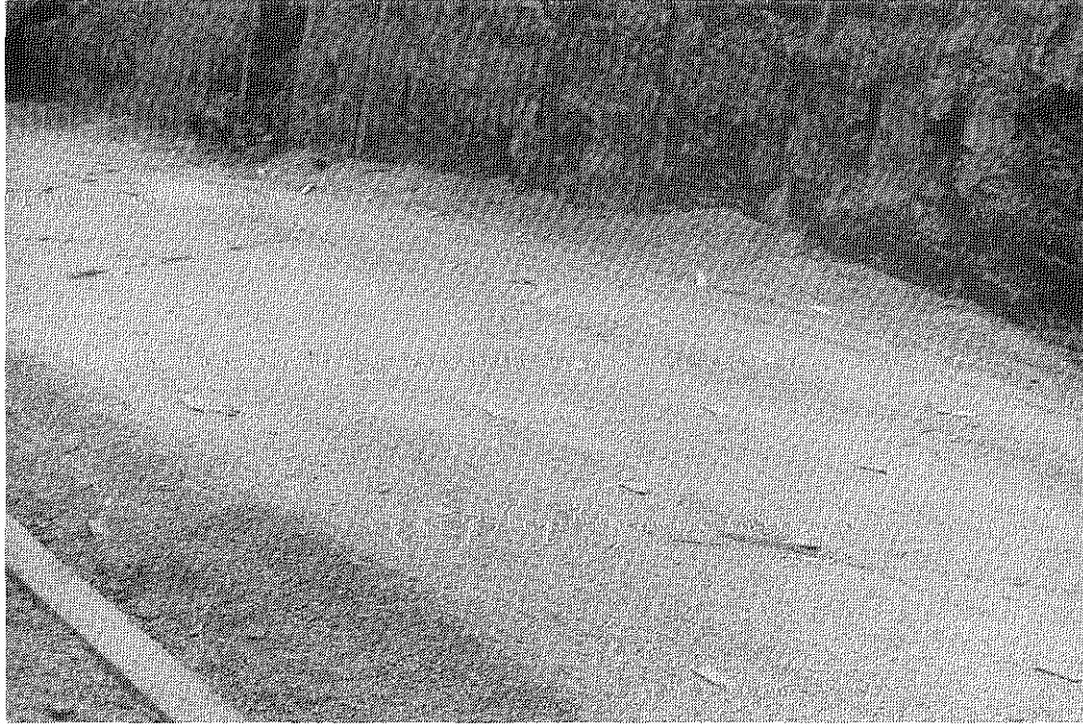


Figure 8. Typical Wick Drain Layout with Reinforced Earth Wall Footer in Left Foreground.

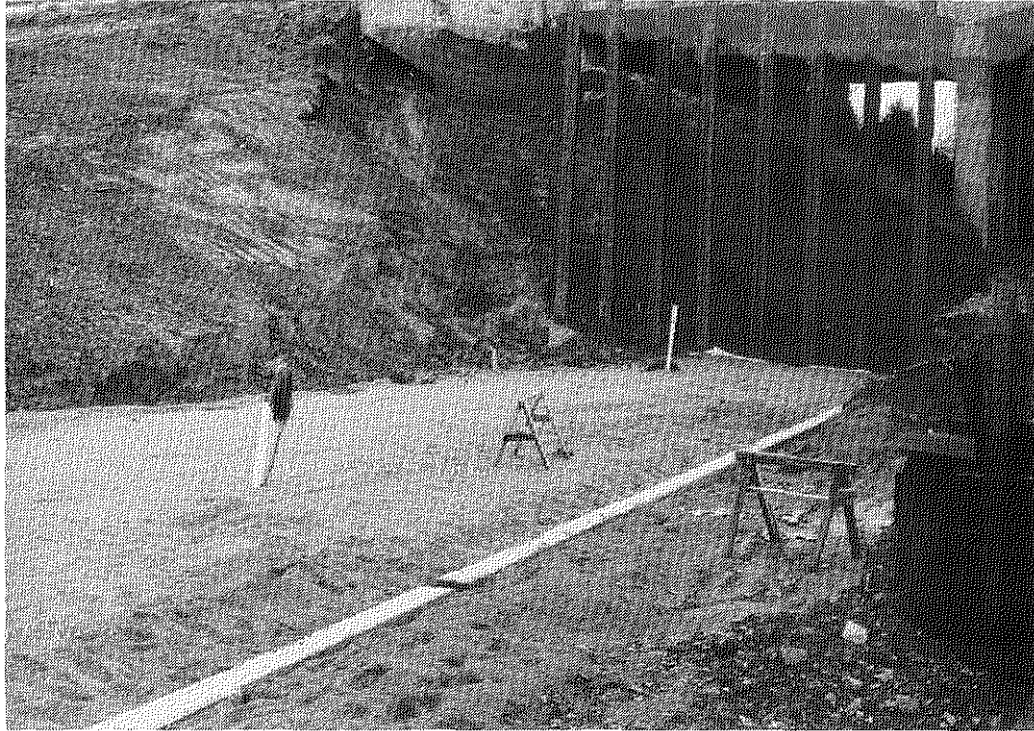


Figure 9. Drainage Blanket and Footer for Reinforced Earth Wall.

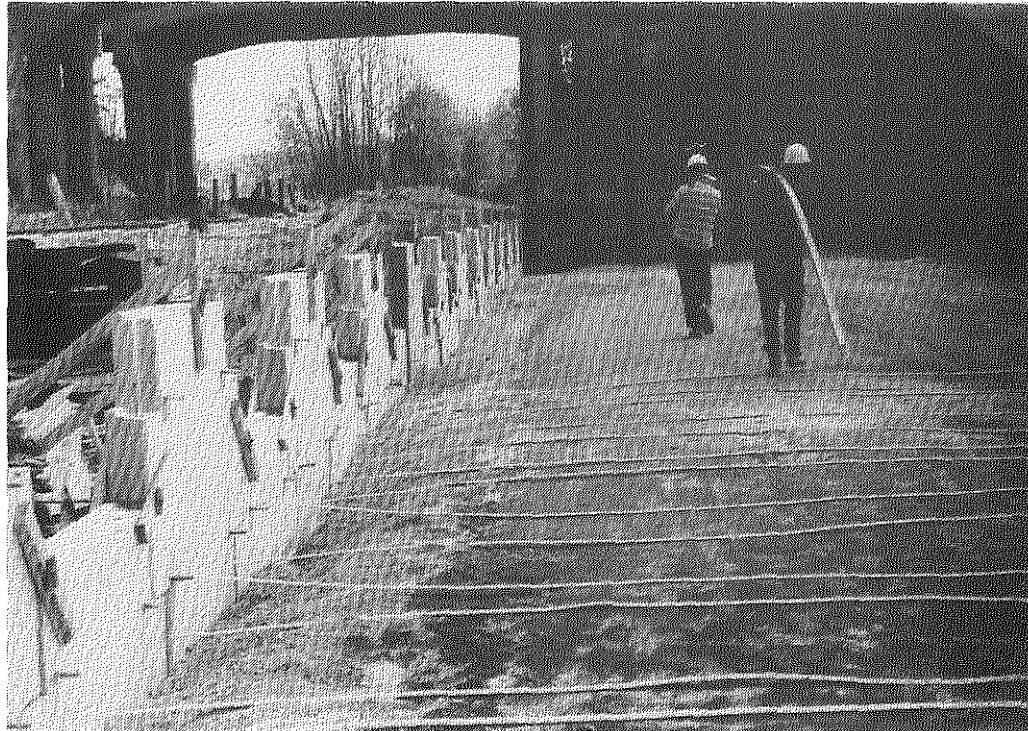


Figure 10. Construction of Reinforced Earth Wall with Supporting Straps in Granular Backfill.

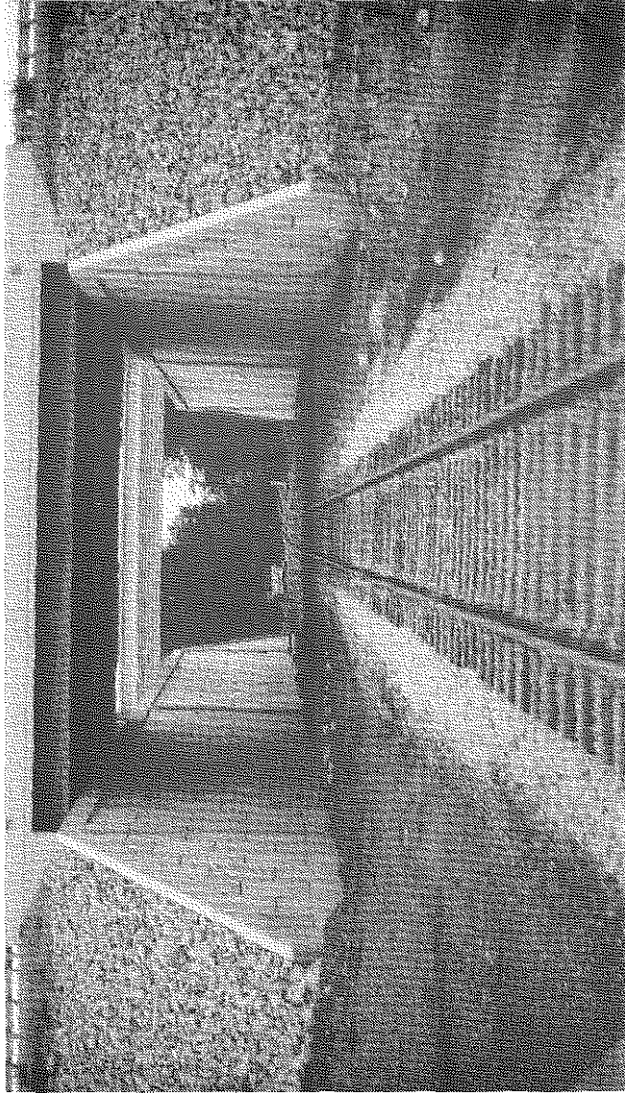
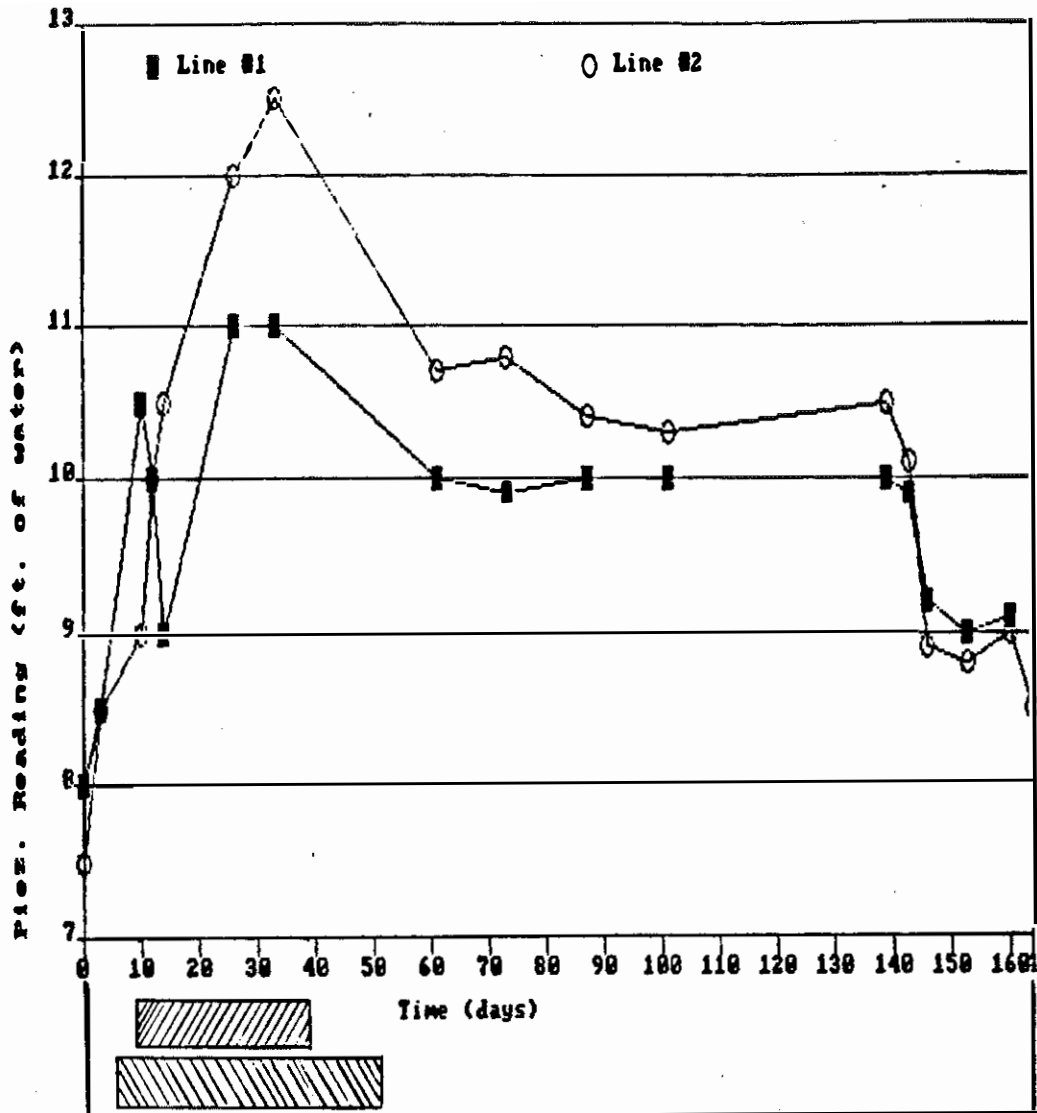


Figure 11. Completed Structure with Southbound Lanes in Foreground.





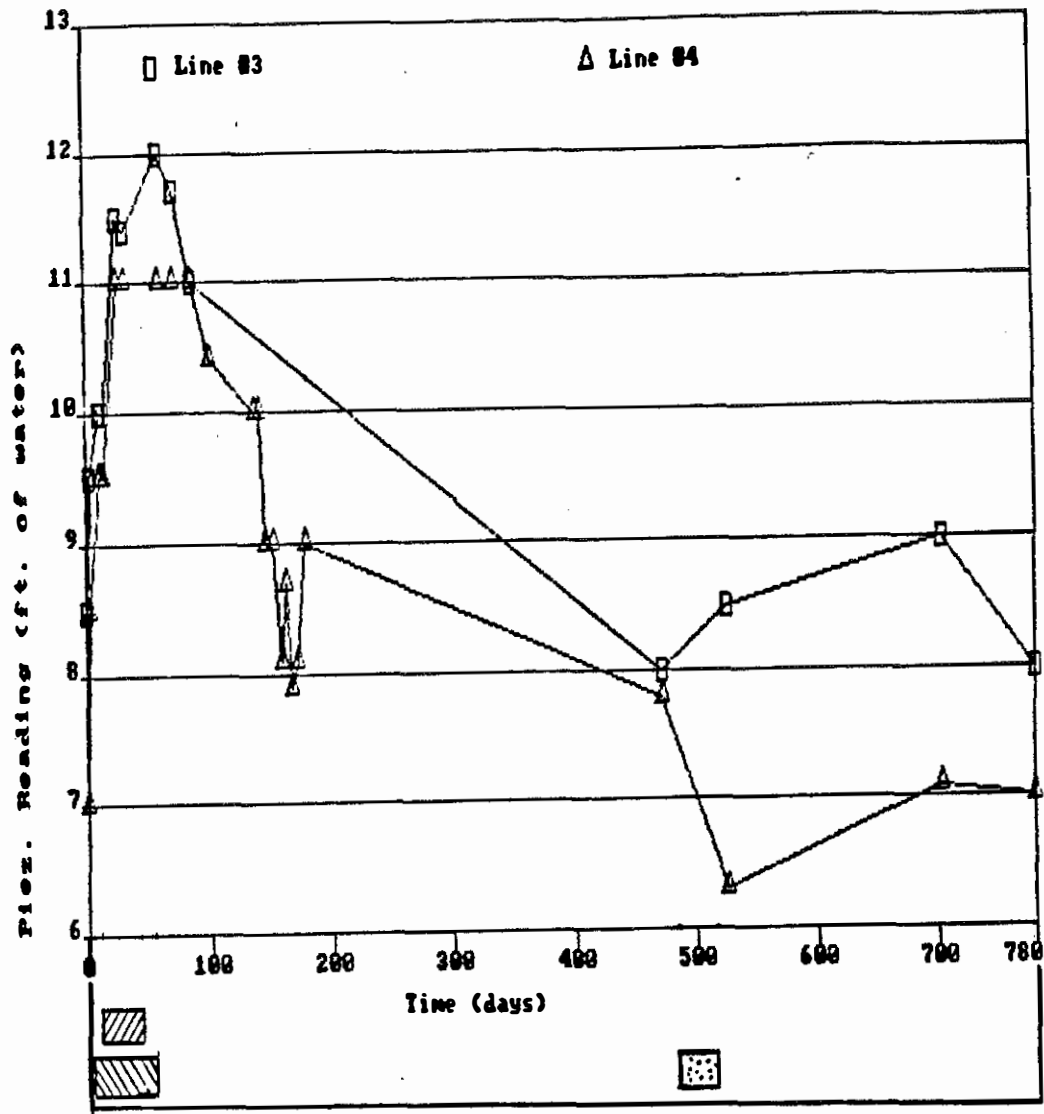
SOUTHBOUND (SOUTH) EMBANKMENT CONSTRUCTION 
 SOUTHBOUND (NORTH) EMBANKMENT CONSTRUCTION 

Figure 12. Foundation Pore-Pressure -- Piezometers 1 and 2.






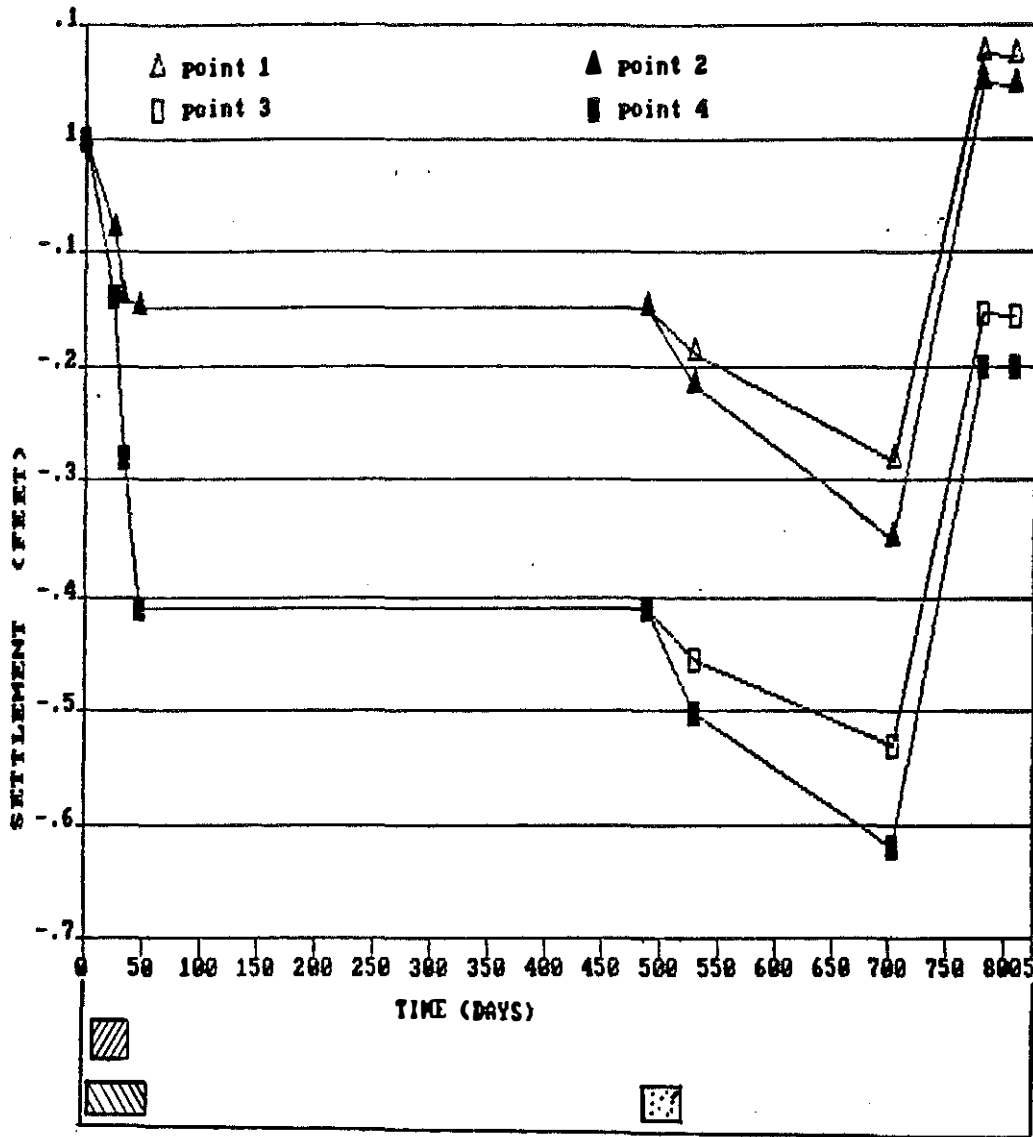
SOUTHBOUND (SOUTH) EMBANKMENT CONSTRUCTION 
 SOUTHBOUND (NORTH) EMBANKMENT CONSTRUCTION 
 NORTHBOUND EMBANKMENTS CONSTRUCTION 

Figure 13. Foundation Pore-Pressure — Piezometers 3 and 4.






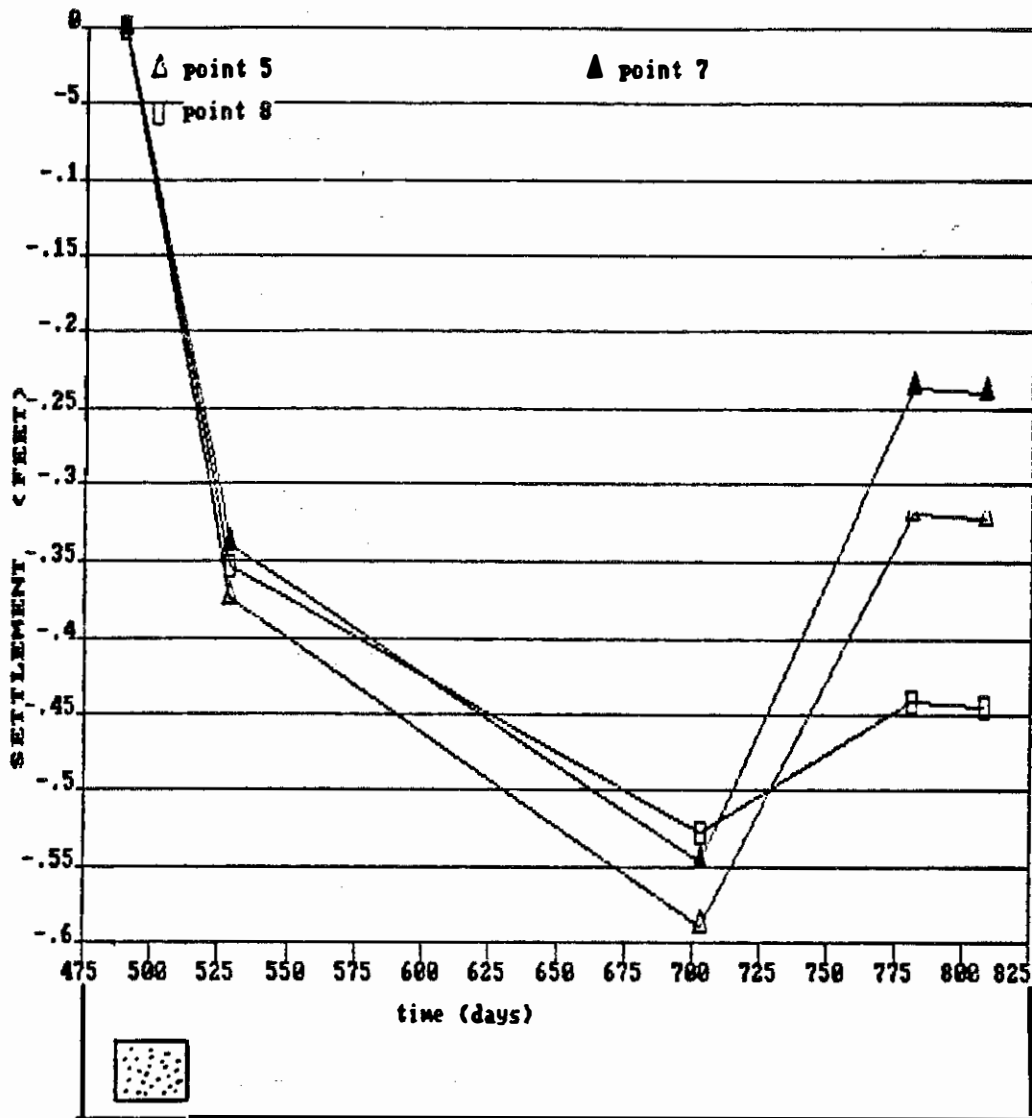
SOUTHBOUND (SOUTH) EMBANKMENT CONSTRUCTION 
 SOUTHBOUND (NORTH) EMBANKMENT CONSTRUCTION 
 NORTHBOUND EMBANKMENTS CONSTRUCTION 

Figure 14. Settlement at Bottom of Reinforced Earth Wall -- Points 1, 2, 3, and 4.



NORTHBOUND EMBANKMENTS CONSTRUCTION



Figure 15. Settlement at Bottom of Reinforced Earth Wall — Points 5, 7, and 8.

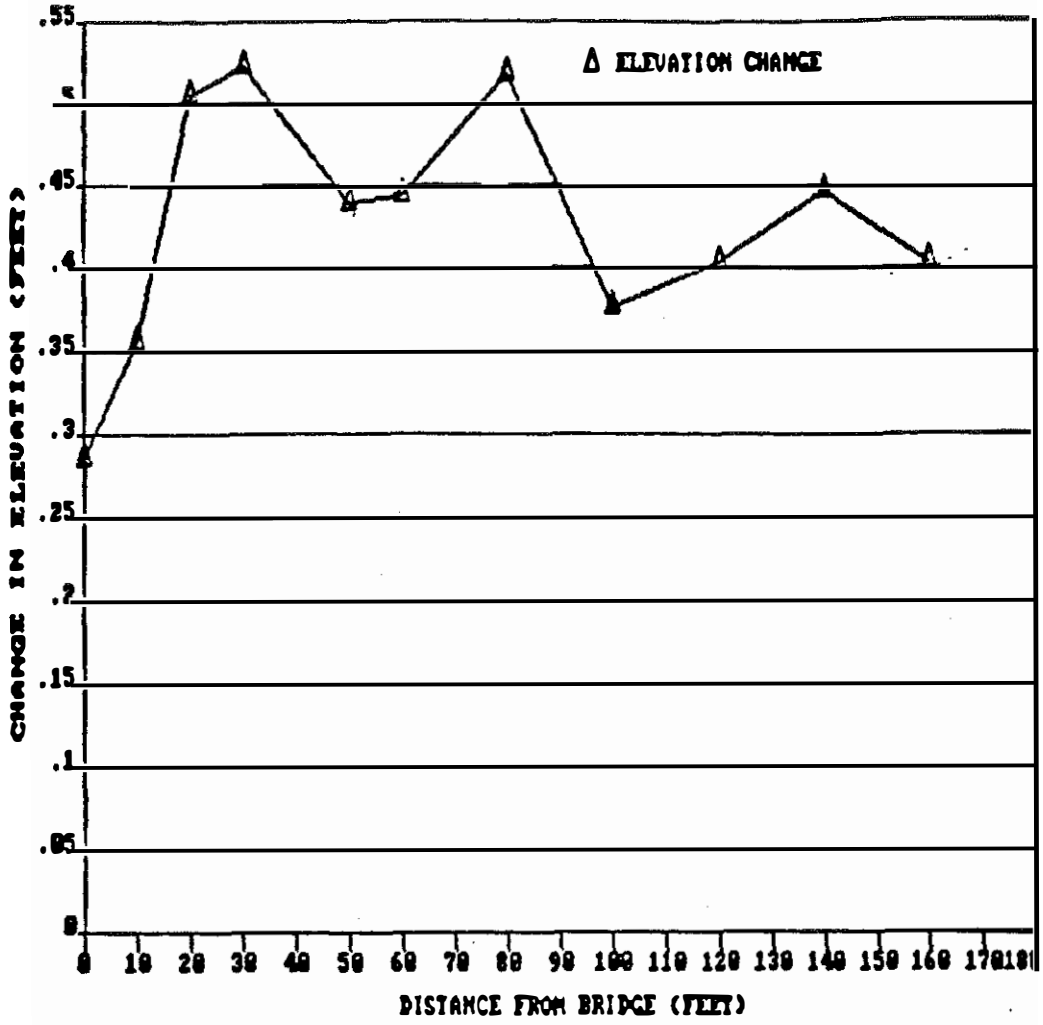


Figure 16. Change in Elevation of South Approach of Southbound Lanes from 7-29-86 to 6-29-87.

APPENDIX A

ALIDRAIN SPECIFICATIONS

ALIDRAIN SPECIFICATIONS

DRAIN

Width	100 mm
Thickness	7 mm
Free Surface Area	180 mm ² /mm
Free Volume	470 mm ³ /mm
Weight (approx.)	165 g/m
1 Roll	140 m
1 Pallet	10 Rolls/235 kg/1.3m ³

CORE

Material	Polyethylene
Type	Studded (both sides), perforated

FILTER

Material	100% Polyester Fibre
Permeability	3 x 10 ⁻⁴ cm/s
Micron Retention	10 - 20 microns

APPENDIX B

DRAINAGE BLANKET SPECIFICATIONS

Memorandum

RECOMMENDATIONS ...

1. Wick drains, in accordance with the Special Note attached to the plans, shall be installed on 6 foot triangular spacing and extending to bedrock in the area of reinforced earth abutments as shown on the attached sketch.

2. Prior to wick drain installation, excavate to 1 foot below bottom of wall and construct a 1 foot thick drainage blanket. Drainage blanket material shall meet the following specifications:

Coarse aggregate, crushed or uncrushed, (including pea gravel), shall meet the quality requirements of Section 805.03 of the 1983 Standard Specifications for Road and Bridge Construction. Gradation shall be uniform and shall meet the following requirements when tested by KM 64-602:

Sieve Size	Percent Passing
4 Inches	100
No. 4	0-75
No. 100	0-4

Natural sand shall have a sand equivalent value not less than 70, and shall meet the following gradation when tested by KM 64-602:

Sieve Size	Percent Passing
3/8 Inch	100
No. 4	75-100
No. 100	0-8

Although any materials meeting these requirements are acceptable, the contractor shall be responsible for furnishing materials that will not affect or impede construction of the wick drains. All soil, mud and other deleterious materials shall be removed from the top of the drainage blanket after wick drain installation and prior to construction of the reinforced earth wall. Any drainage blanket material removed during this operation shall be replaced at no additional cost.

3. Subsurface data indicates some boulders in the area of the existing fill. Preboring in the area of the existing fill may be required for wick drain installation.

4. Geotextile fabric meeting the requirements of Special Provision 39A, Table II, shall be placed between the foundation soil and the drainage blanket.

5. Settlement markers shall be provided on or near the foundation of abutment walls at three or more approximately evenly spaced locations along the walls. The settlement markers shall be monitored during and after construction.

6. The maximum rate of construction for this fill area shall not exceed ten (10) feet per week.

APPENDIX C

WICK DRAIN SPECIAL NOTES

SPECIAL NOTE FOR VERTICAL WICK DRAINS

Description -

This work shall consist of furnishing and placing Prefabricated Vertical Drains at locations shown on the plans or as ordered by the Engineer.

Materials -

The prefabricated drain shall consist of a continuous plastic drainage core wrapped in a non-woven geotextile material. Prefabricated drains used shall be one of the following products:

- | | |
|-------------------------|----------------|
| 1. Ali-Drain | 6. Mebra-Drain |
| 2. Amerdrain (Type 407) | 7. SolCompact |
| 3. Colbond (CX-1000) | 8. Vinylex |
| 4. Geodrain | 9. Bando |
| 5. Hitek Flowdrain | |

The above drains shall be accepted based on certification by the manufacturer.

Construction Details -

The prefabricated drain shall be installed within a protective mandrel or sleeve which shall be intruded into the soil and retracted after each drain is installed. The mandrel or sleeve shall have a maximum cross-sectional area of ten (10) square inches.

Prior to the installation of prefabricated drains, the Contractor shall stake out the proposed locations of the drains and then take all reasonable precautions to preserve the stakes. The location of the drains shall not vary by more than six (6) inches from the locations indicated on the plans or as directed by the Engineer. The Contractor shall then demonstrate that his equipment, method and material produce a satisfactory installation in accordance with this specification. For this purpose, the Contractor will be required to install trial drains at locations within the work area designated by the Engineer.

The prefabricated drains shall be installed in a sequence such that equipment will not travel over previously installed drains. Any drains damaged by the Contractor's operations shall be replaced at the Contractor's expense.

The prefabricated drains shall be installed vertical from the working surface to the elevations shown on the plans or as ordered by the Engineer.

The Contractor shall provide the Engineer with a suitable means of verifying plumbness of the equipment and determining the depth of the drain at any time.

Splices or connections of the prefabricated drain material shall be done so as to insure continuity of flow through the prefabricated drain material shall be done so as to insure continuity of flow through the prefabricated drain material as approved by the Engineer. The prefabricated drain material shall be cut such that at least a six (6) inch length protrudes above the working surface at each prefabricated drain location.

It may be necessary to pre-auger or use some other method to clear obstructions and facilitate installation of the drains. The depth to which pre-augering is used shall be subject to approval by the Engineer.

METHOD OF MEASUREMENT -

The quantity of prefabricated drain shall be the number of linear feet satisfactorily installed from the top of the working surface to the design elevation of the tip of the drain.

BASIS OF PAYMENT -

The unit price bid per linear foot shall include the costs of furnishing all equipment, labor and materials to properly install the prefabricated drains. No payment will be made for pre-augering or other methods used to facilitate installation of the drain.

PREFABRICATED VERTICAL DRAIN SOURCES -

Ali-drain	Vibroflotation Foundation Company, United States Steel Bldg., Suite 3993, 600 Grant Street, Pittsburgh, PA 15219 (800) 245-1762
Hebra-drain	L. B. Foster Company, 415 Holiday Drive, Pittsburg, PA 15220 (412) 928-3475
Geodrain	Griffin International, Inc., 100 South Broadway, Irvington, NY 10533 (800) 438-9281
Bando	Harry Fukuzawa & Associates, 6129 Queenridge Drive, Rancho Palos Verdes, CA 90274 (213) 377-4735
Sol Compact	Moretrench American Corporation, P.O. Box 316, Rockaway, NJ 07866 (201) 627-2100
Colbond (CX 1100)	American ENKA Company, Enka, NC 28728 (704) 667-7110
Amerdrain (Type 407)	International Construction Equipment, Inc., Corporate Offices, 301 Warehouse Drive, Matthews, NC 28105 (800) 438-9281
Vinylex	Vinylex Corporation, P.O. Box 7187, Knoxville, TN 37921 (615) 690-2211
Hitek	Vibroflotation Foundation Company, Route 18, Atlasburg, PA 15004 (800) 245-1762