GEOTEXTILE REINFORCED BRIDGE APPROACH EMBANKMENT

Lost River Bridge
Malin Highway
Klamath County, Oregon

Construction Report

OREGON EXPERIMENTAL FEATURE PROJECT #OR90-05

by

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ABSTRACT

The City of Portland identified pavement surface distress on East Burnside Street between East 39th Avenue and East 47th Avenue. Therefore, the City developed a construction project to improve the pavement. The project included cold planing, placing an asphalt concrete leveling course, placing geotextile fabrics, and placing an asphalt concrete overlay.

The City of Portland decided to use geotextile fabrics for pavement reinforcement and crack retardation. In September 1991, the City placed Glasgrid and Polyguard geotextile fabrics on East Burnside Street. If the fabrics successfully retard reflective cracking, the City anticipates the following benefits:

1. Reduction of water infiltration into underlying cracks;
2. Retardation of vegetation growth in cracks;
3. Improvement of pavement surface quality; and
4. Reduction of future pavement maintenance costs.

The installation of the two geotextiles is discussed in this report. Based on the installation of the geotextiles, conclusions and recommendations were made. The recommendations include:

1. When placing small quantities of Polyguard or similar self-adhesive membrane with a protective plastic sheet and without a spreading machine, the roll should be set with the adhesive side face down, and the protective sheet removed as the fabric is rolled into position.
2. When placing quantities larger than those placed for this project, a spreading machine should be used for both types of fabric.
3. A leveling course is not necessary prior to placing the highly adhesive Polyguard membrane; however, thorough rolling with a rubber tired roller or normal traffic rolling in the traffic lanes should be required if no leveling course were applied.
4. A leveling course is essential prior to placing Glasgrid fabric. Rolling with a rubber tired roller should follow placement of Glasgrid, followed as quickly as possible with a final lift of pavement prior to opening the street to traffic.

ACKNOWLEDGEMENTS

The author would like to thank the following Oregon Department of Transportation (ODOT) personnel for their help in gathering information and reviewing this report: Wes Heidenreich, Liz Hunt, Keith Martin, Bo Miller, Scott Nodes, Jan Six, John Stucky, and Glenn Thommen. In addition, the author thanks Cal Frobig, Federal Highway Administration, and Julie Kliewer, Oregon State University, for reviewing this report. Furthermore, the author thanks JoAnne Robison, ODOT, and Lisa Kling, ODOT, for typing this report.

DISCLAIMER

Geotextile Reinforced Bridge Approach Embankment

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1.0 INTRODUCTION

The transition from the roadway to the deck of a rigidly supported bridge is of concern to engineers and the travelling public. It is a common occurrence to feel a discontinuity between the roadway and bridge structure. Bridge engineers have tried to overcome this discontinuity by the use of transition slabs. However, embankment material under the slabs continues to settle and/or consolidate, and the discontinuity at the roadway to bridge transition is simply transferred to the end of the transition slabs. This results in a bump felt by the motorist, which is not only uncomfortable, but may be hazardous. Additionally, when heavy vehicles impact the bump, they may contribute to accelerated damage to the approach slabs and the bridge deck. Studies have shown that the use of geotextiles in combination with specific fill soil gradation and compaction requirements have resulted in approach fills that settle less than fills built using standard construction procedures (1). This project provides an opportunity to evaluate the effects of the inclusion of geotextiles in approach fill construction.

Settlement of the approach fill is a result of settlement of the newly constructed embankment, settlement of the underlying foundation material beneath the new fill, or a combination of both. This study considers the first type of settlement problem, and the use of geotextile reinforcement to reduce or eliminate its contribution to the total embankment settlement.

Unless otherwise stated, the term "fill settlement" refers to the settlement and/or consolidation of the newly constructed fill, excluding any contributions from the settlement and/or consolidation of the foundation materials.

2.0 LOCATION AND DESIGN

2.1 SITE LOCATION

The construction site is located on the Lost River Bridge, which is situated at mile post 12.21 on Highway 50 (Oregon Route 39), approximately 8 miles south of Klamath Falls in Klamath County (Figure 2.1).

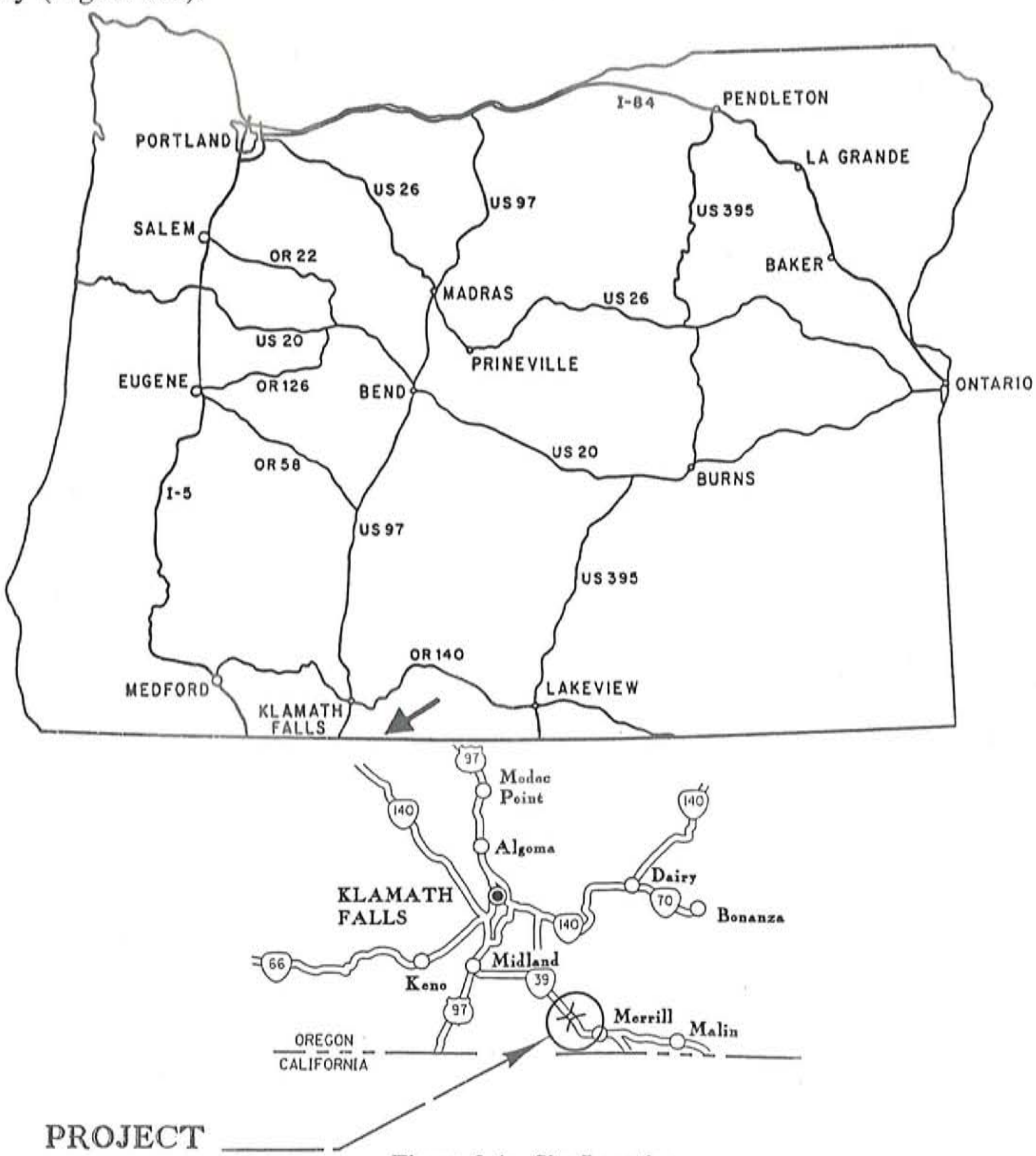

Figure 2.1: Site Location

2.2 MATERIALS

The designed fills for the geotextile reinforced bridge approach embankment consisted of: the geotextile reinforcement, the soil, the settlement plate, and the special wall backfill.

The woven geotextile reinforcement material, Amoco CEF 2016, had the physical properties indicated in Table 2.1.

Table 2.1 Properties of Amoco CEF Style 2016[1]

Property	ASTM Test	ODOT Standard	Minimum Roll Avg. Value	Typical Value
Grab Tensile, lb	D-4632	230	300	330
Grab Elongation, %	D-4632	N/A	20	20
Mullen Burst, psi	D-3786	290[2]	800	850
Puncture, lb	D-4833	110	120	150
Trapezoidal Tear, lb	D-4533	N/A	120	140
U.V. Resistance, %SR	D-4355	N/A	80	80
AOS, US Sieve #	D-4751	30	40	40
Permittivity, 1/sec	D-4491	N/A	.55	.82
Permeability, cm/sec	D-4491	0.005	0.045	0.068

1 These values are a result of testing conducted in on-site laboratories.
2 ODOT uses a modified version of the ASTM standard.

The embankment material was to conform to section 203.38 of the 1984 Oregon Standard Specifications for Highway Construction (2). The relevant information from section 203.38 is included in Appendix A.

A settlement plate (Figure 2.2) was placed to allow the measurement of the underlying foundation settlement. The design called for the base to be made from a 4′×4′ sheet of 1″ thick exterior grade plywood. A steel flange was to be mounted at the center of the plywood that would allow a 2″ diameter pipe to be attached to the settlement plate. The pipe would rise above the new fill, and the elevation of the top of the pipe is used by a surveyor to determine the settlement of the underlying foundation.

The special wall backfill was to conform to the requirements of Section 251 of the 1984 Standard Specifications for Highway Construction (2). The relevant information regarding Section 251 is included in Appendix A.

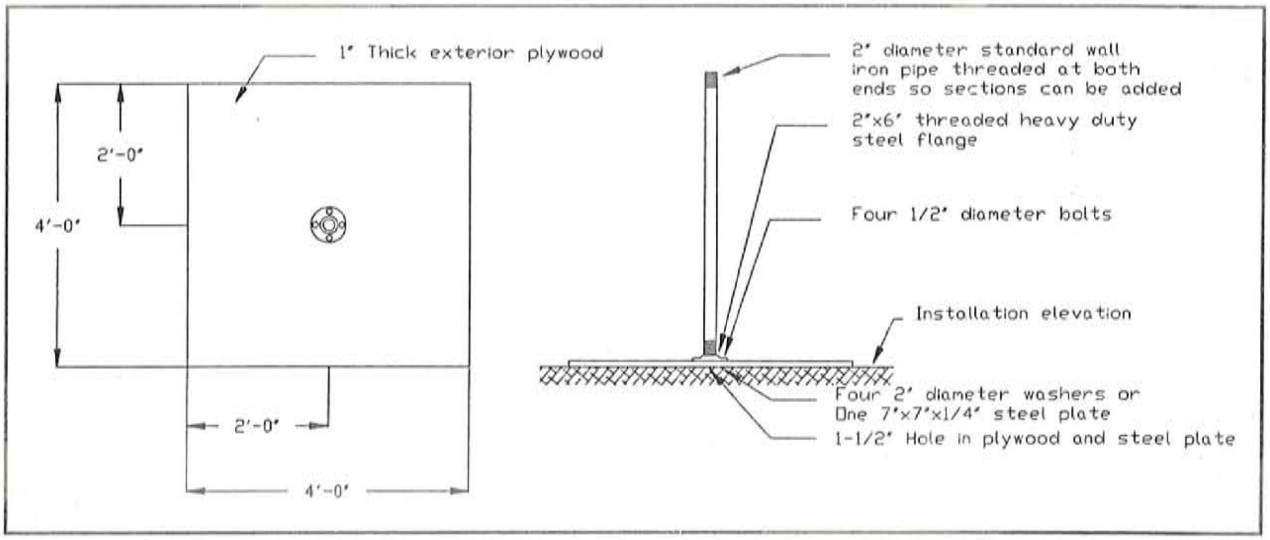

Figure 2.2: Settlement plate design

The Foundation Data Sheet is shown in Figure B.1, Appendix B. In general, the foundation materials were not expected to settle significantly; therefore, this was a good site to measure embankment material settlement.

2.3 PLANS

The original plans were to remove the existing bridge and replace it with a wider bridge along the same alignment. This would require the placement of symmetrical sliver fills on each approach to the bridge; four sliver fills would have been needed, two for the northbound lane and two for the southbound lane. The northbound lane was to serve as the control lane, and be constructed using standard highway construction methods. The southbound lane was to be widened using the geotextile reinforced bridge approach embankment and serve as the test lane.

These plans changed prior to construction to include the following modifications. First, it was decided to leave the original bridge in place and widen the deck 10′3″ on each side (Figure B.2 in Appendix B). This design still required sliver fills at each of the four corners of the bridge; however, neither the project plans nor the Project Special Provisions depicted the research project. According to John Stucky, the Assistant Project Manager, this presented a problem because the research work plan indicated construction of fills for northbound lanes according to Standard Specifications and the southbound lanes with geotextile reinforcement. Project plans indicated using geotextile reinforcement on all embankments.

Since the contract plans and Special Provisions did not indicate the two construction methods, the Contractor's bid was based on the use of geotextiles. All geotextile material was on the job site, and could not be returned.

Several discussions concerning the above were held between the ODOT Project Manager's office and the ODOT Foundations Unit. The final decision was to construct all embankments with the geotextile reinforcement. This left the project without a control fill for comparison to the geotextile reinforced fill.

The sliver fills were to consist of six 1′ lifts, on 1½:1 slopes, layered with the geotextile reinforcement (Figure B.3). Each lift was to be compacted to 95% of maximum density. Settlement plates were to be placed to measure any settlement that occurred below the newly placed sliver fills at all four locations. Total settlement could then be measured at a location near the settlement plate riser. The settlement of the new fill could then be found by subtracting the reading of the settlement plate from the total settlement.

3.0 CONSTRUCTION

The Experimental Features Project portion was broken into two stages. Stage I of the project consisted of widening the southbound lane, and installing geotextile reinforced sliver fills at each end. Stage II was identical to Stage I, but it was done on the northbound lane. The construction outline was as follows:

Contractor: Holm II
ODOT Project Manager: Richard J. Steyskal
ODOT Assistant Project Manager: John H. Stucky

Stage I (Geotextile reinforced bridge approach embankment only)
Work Started: 1-6-92
Work Finished: 1-11-92

Stage II (Geotextile reinforced bridge approach embankment only)
Work Started: 5-1-92
Work Finished: 5-14-92

The construction of each sliver fill followed the same process. Much of the widening was already in place from the existing guardrail areas. The bridge was only widened 10′3″ on each side, so that the sliver fills were very narrow and short.

The settlement plates were installed prior to the first lift. They were set on the original ground in the shoulder area, approximately 5′ from the bridge ends on all four quadrants. Sections of 2″ diameter pipe were extended from the settlement plate during construction of each lift (Figure 3.1).

Once the settlement plates were in place, the embankments were constructed. Six layers of geotextile reinforcement and soil were placed at each quadrant. Each lift was compacted with a double drum vibratory roller (Figure 3.2). Figure 3.3 shows the geotextile material used on the first lift on Bent 1, Stage II. The soil used for the lifts was native soil from the job site, and somewhat granular in nature. It was noted that the native soil was a mixture of about 4 different types of materials, which made it nearly impossible to perform nuclear gauge tests for compaction with any accuracy. However, compaction tests were performed on each lift on three of the sliver fills and are summarized in Tables 3.1A-C. Compaction tests for Stage I, Bent 1 were not performed because the soil was too rocky to test. Instead, the soil was visually inspected until there was no deflection under the weight of the equipment. The required compaction for the project was 95%. Any lifts that did not meet the compaction requirements were recompacted and tested again until the compaction

Table 3.1B Compaction Tests for Stage II - Bent 4[1]

Station	Offset	Date	Lift	Density (pcf) Wet	Density (pcf) Dry	% Compaction
841+85	20'-LT	5-11-92	O.G.[2]	112.7	97.5	96.2
841+84	19.5'-LT	5-11-92	1	111.9	96.4	95.2
841+90	18.5'LT	5-11-92	2	112.2	97.0	95.7
841+95	18'-LT	5-11-92	3	107.5	92.6	91.4[3]
841+95	18'-LT	5-11-92	3	112.5	96.7	95.5
841+92	17.5'-LT	5-11-92	4	109.9	93.3	92.1[3]
841+92	17.5'-LT	5-11-92	4	113.3	97.6	96.4
841+95	17'-LT	5-12-92	5	117.3	101.1	99.8

1 Nuclear gauge type: Cambell MC-1
2 O.G. stands for Original Ground
3 Failed to meet compaction requirements

Table 3.1C Compaction Tests for Stage II - Bent 1[1]

Station	Offset	Date	Lift	Density (pcf) Wet	Density (pcf) Dry	% Compaction
840+55	20'-LT	5-11-92	O.G.[2]	116.7	99.6	98.3
840+50	19.5'-LT	5-12-92	1	112.5	96.9	95.7
840+45	19'-LT	5-12-92	2	114.6	98.7	97.4
840+52	18'-LT	5-13-92	3	120.6	100.5	99.2
840+48	17.5'-LT	5-13-92	4	114.9	98.6	97.3
840+51	17'-LT	5-13-92	5	120.1	100.8	99.5

1 Nuclear gauge type: Cambell MC-1
2 O.G. stands for Original Ground

4.0 EVALUATION

According to John Stucky, the geotextile material was relatively easy to work with, considering the confined space of the sliver fill environment. He does recommend that if this type of construction is to be used in future projects, that it be used on wider fills. He feels it is useless to employ this construction method unless the geotextile material is placed along the full width of the approach, and believes that if the problem of settlement in the bridge approach is to be alleviated, the geotextile material should not be limited to the shoulder area.

The ride on the bridge approaches immediately after construction was good. There were no bumps at the road-to-bridge transition after construction of the fill and base aggregates. The pavers did however leave a small bump at the approach to the structure due to an error in the paving operation.

The cost to construct the geotextile reinforced bridge embankments was $13,500. This was a lump sum bid item. Since the geotextile fabric was used in constructing both sides of the approaches it is impossible to determine if its use is cost effective. To determine if the use of the geotextile fabric is cost effective, the maintenance costs of a geotextile reinforced bridge approach lane would have to be compared to a lane on the same approach that was constructed under standard specifications.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

It is very difficult to evaluate the effectiveness of the geotextile reinforced approach embankments because there is no control embankment. Consequently, there is no quantitative method to compare any of the settlements that occur in the bridge approaches.

5.2 RECOMMENDATIONS

If research is to be conducted on future projects of this nature, a control embankment needs to be construct so that the geotextile embankment settlement can be compared to the control embankment settlement.

6.0 REFERENCES

1. TRB, NCHRP *Synthesis of Highway Practice 159: Design and Construction of Bridge Approaches*, Transportation Research Board, National Research Council, Washington, D.C. (July 1990).

2. Standard Specifications For Highway Construction. Oregon Department of Transportation, Salem, OR (1984).

APPENDIX A: SELECTED PROVISIONS FROM THE 1984 OREGON STANDARD SPECIFICATIONS FOR HIGHWAY CONSTRUCTION

Section 203 - Excavation and Embankment for Roadways

203.38 Use of Selected Materials - As set forth in subsection 203.11, excavated materials are to be selected and used in various parts of the work. The nature, characteristics and qualities of the materials to be selected and used and their use in the work shall be in conformance to the following:

(b) Embankment at bridge ends - At, under and around the ends of bridges, separation structures and trestles, the embankments shall consist of granular materials whenever such are available in the excavations, and of materials selected as to nature, size and gradation which will resist settlement and washout, and which will provide a dense well-filled embankment when compacted. At locations where piling is to be driven, the materials shall contain no rocks or boulders having a dimension exceeding 6 inches.

203.41 Compaction and Density Requirements - These provisions apply to the compaction requirements for each layer of embankments and backfills, to roadbeds in cuts, to foundations for structures, and to other earthwork construction items, any of which are to serve as support for materials or things to be placed or constructed thereon. The several materials involved will be herein collectively referred to as "compacted materials".

(a) Density test basis of determination - All materials which are susceptible to testing for density by the test methods hereinafter set forth under (a-1) shall be compacted in place by whatever equipment and method necessary and at such moisture content as is required to provide density in place to the said compacted materials as hereinafter set forth under (a-2) and (a-3).

Unless otherwise directed by the Engineer, or permitted by the specifications, the moisture content of the materials at the time of compaction shall be within plus 2 or minus 4 percentage points of the optimum moisture as determined by the methods set forth under (a-1)

> **(a-1) Testing methods** - The density of compacted materials in place will be determined in compliance with either AASHTO T 205 or AASHTO T 191, as the Engineer may elect.
>
> The relative maximum density and optimum moisture of the material which is compacted in place will be determined in compliance with OSHD TM 104 or OSHD TM 109. The maximum densities determined by one of the above methods will be adjusted to compensate for differing percentages of coarse particles retained on the No. 4 sieve in the in place density test in compliance with AASHTO T 224.

(a-2) Embankments - In embankments, fills and backfills, the compacted materials within 3 feet of established subgrade elevation shall have a density in place of not less than 95% of relative maximum density, and below 3 feet shall have in place of not less than 90% of relative maximum density.

(a-3) Cuts and foundations - In roadbed cuts, and in foundations for structures, the compacted materials to a depth of 1 foot below established subgrade or foundation elevation shall have a density in place of not less than 95% of relative maximum density.

(b) Deflection basis of determination - All materials and areas which are not susceptible to testing for density as provided under (a-1), shall be compacted in place by whatever equipment and method is practicable or specified and at such moisture content as is required to provide well-filled, dense and firm material in place which will show no appreciable deflection or reaction under the compacting equipment involved.

Section 251 - Structure Excavation and Backfill for Bridges

Description

Subsection 251.01 Scope - This work shall consist of excavation, backfilling and disposing of materials in connection with the construction of bridges, grade separation structures, retaining walls, rigid frame structures and other major structures. The work shall be done in conformance to these specifications and in reasonably close conformity to the lines, grades and cross section shown on the plans or established by the Engineer.

Materials

251.13 Special Backfill Adjacent to Walls - Special wall backfill material shall be sand, gravel or rock, crushed or uncrushed, or combinations thereof meeting the following grading requirements:

Sieve Size Passing	Percentage (by weight)
3"	100
No. 50	0-100
No. 100	0-10
No. 200	0-6

251.39 Backfill - All spaces excavated and not occupied by abutments, piers or other permanent work shall be backfilled or refilled to the upper limit of pay excavation with backfill materials conforming to the requirements of subsections 251.11, 251.12 or 251.13, as applicable and as directed by the Engineer, and its top surface shall be neatly graded.

Backfill which becomes a part of a roadway embankment or which is to support a roadway, rock slope protection or slope paving shall be compacted in conformance to the requirements of Section 203, particularly subsection 203.41.

No backfill shall be placed against any concrete until permitted by the Engineer and normally not until the concrete has been in place 3 days, or until test cylinders show the strength to be 0.4 of the design strength of the concrete when tested in conformance to subsection 504.32. Any backfill which will cause unbalanced loading on the concrete shall not be placed until the concrete has been in place 14 days or until 0.8 of the design strength of concrete has been achieved.

Backfill placed around piers and columns shall be deposited on all sides to approximately the same elevation at the same time. The backfill in front of abutments and walls shall be placed first to prevent the possibility of forward movement. Special precautions shall be taken to prevent any wedging action against the concrete, and slopes bounding the excavation shall be destroyed by stepping or roughening to prevent wedge action. Jetting or puddling the fill will not be permitted. Adequate provision shall be made for thorough drainage of all backfill. Selected granular and free-draining material shall be placed at weep holes.

No separate payment will be made for special material placed at weep holes, as such work is incidental to and a part of the backfilling work.

Where excavations are made in paved areas, all or part of which are to be preserved, required pavement replacement shall be made in conformity to the applicable requirements of subsection 603.32. No separate payment will be made for pavement replacement as such work is incidental to and part of the backfilling work.

Excavation materials not required for backfill shall be disposed of by incorporation in roadbed embankments, widening roadbed embankments or disposed of at some other location approved by the Engineer.

APPENDIX B:
PLANS FOR LOST RIVER BRIDGE

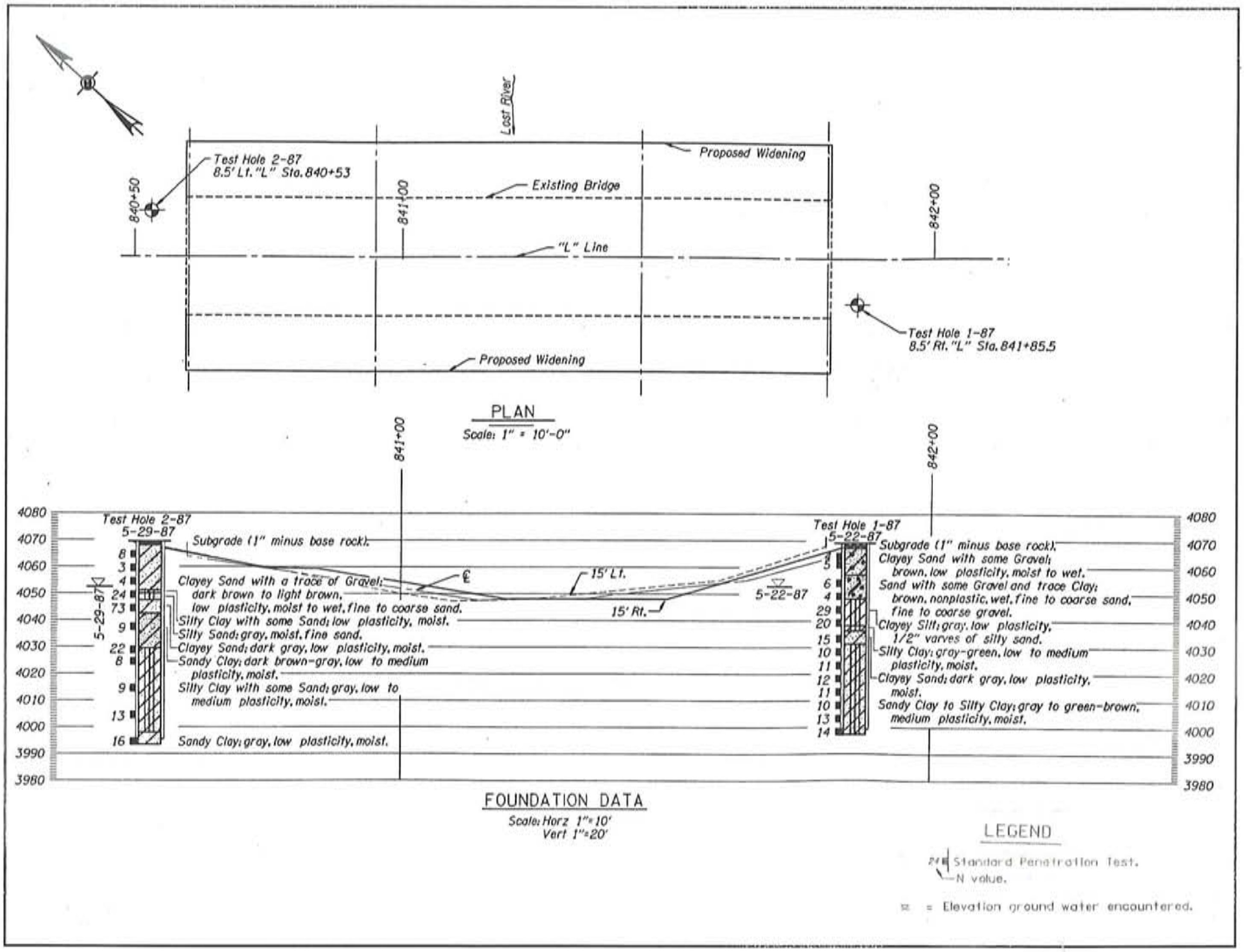

Figure B.1: Lost River Bridge Foundation Data

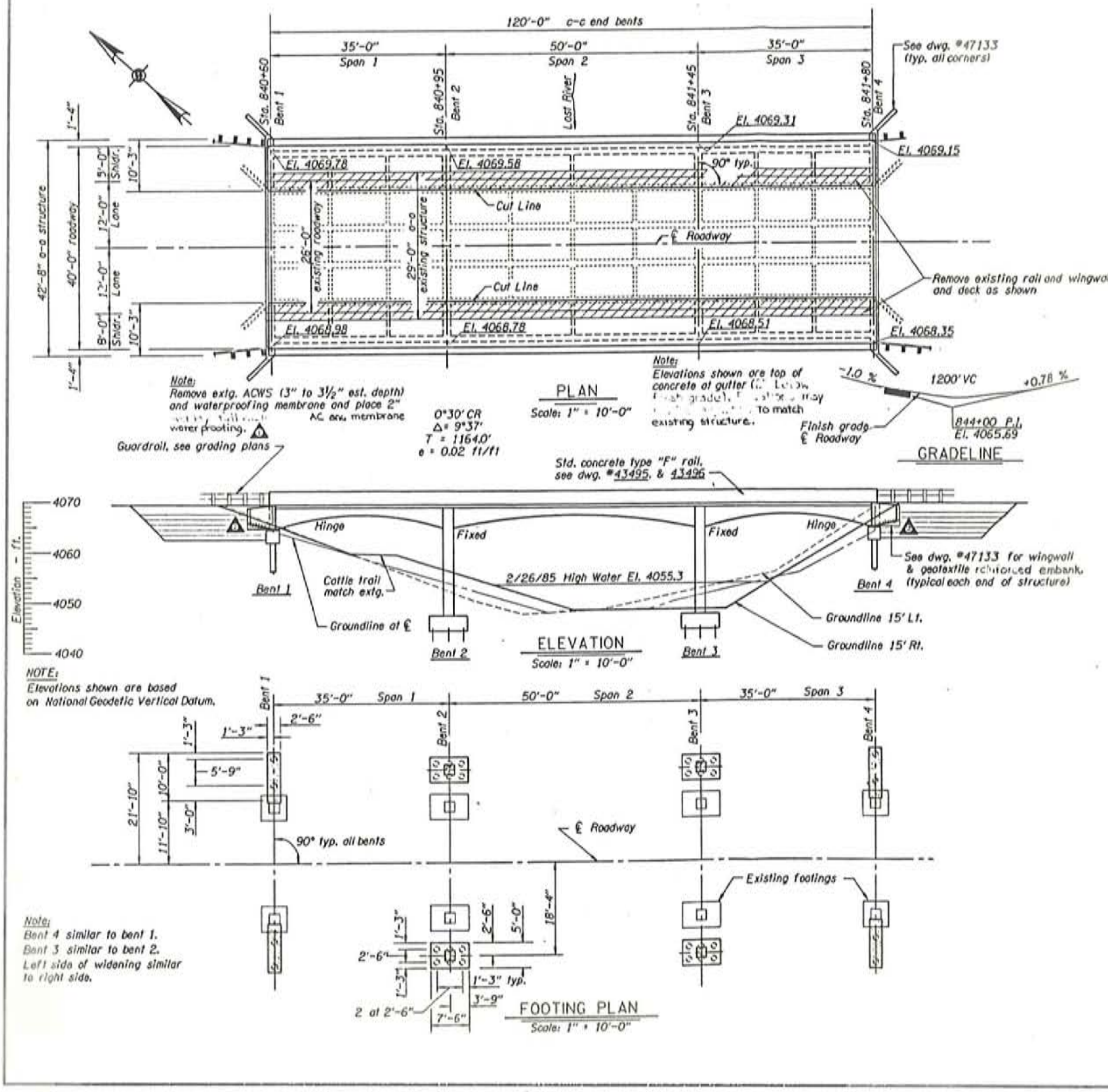

Figure B.2: Plans for Lost River Bridge on Malin Highway

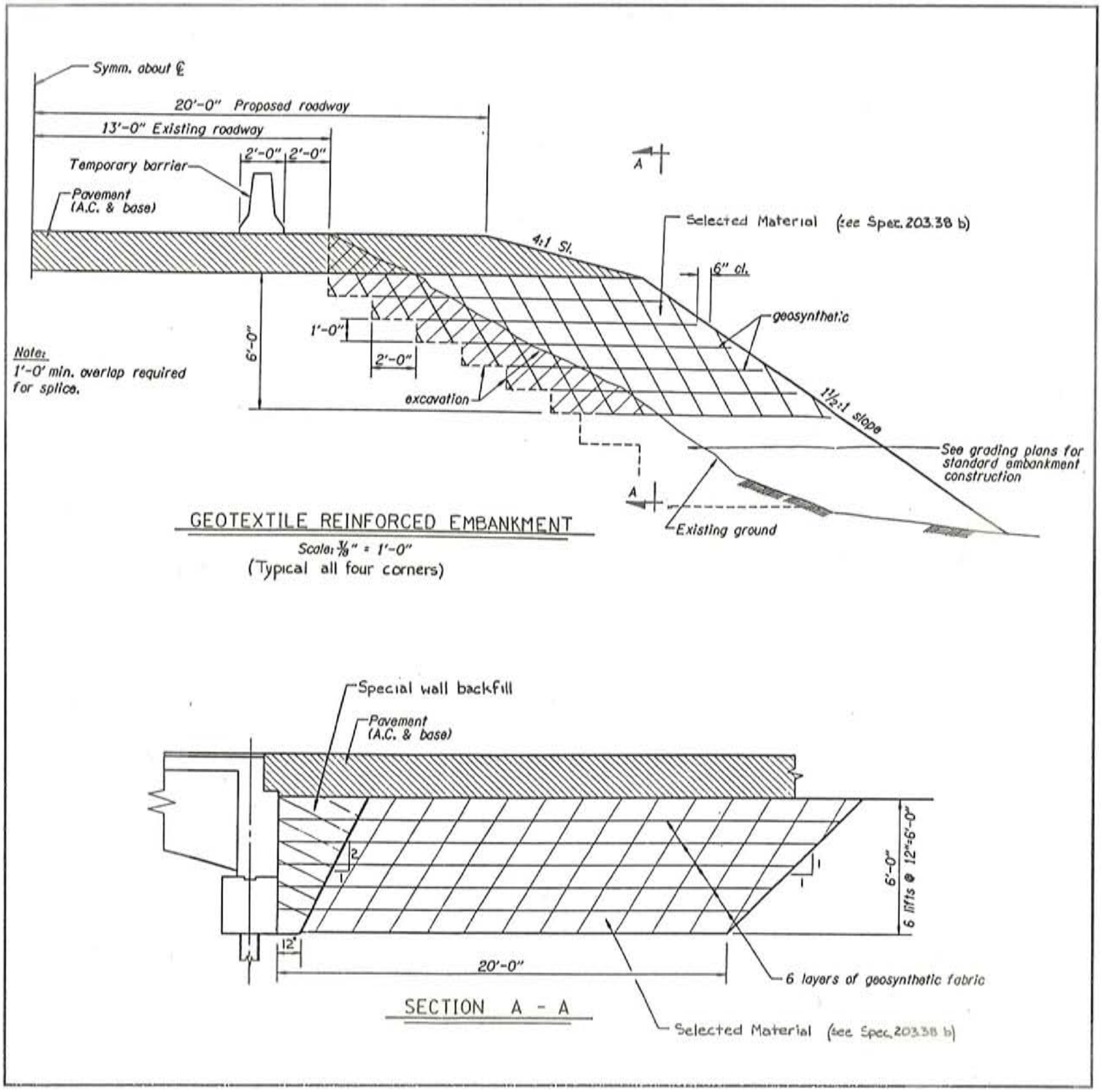

Figure B.3: Sliver fill design for the Lost River Bridge

Figure 3.1: 2" Diameter pipe attached to the settlement plate

Figure 3.2: Roller used in the compaction of the geotextile reinforced bridge approach embankment

Figure 3.3: Geotextile reinforcement used on the first lift on Bent 1, Stage 2

Table 3.1A Compaction Tests for Stage I - Bent 4[1]

Station	Offset	Date	Lift	Density (pcf) Wet	Density (pcf) Dry	% Compaction
841+95	23'-RT	1-9-92	O.G.[2]	105.3	85.6	92.9[3]
841+95	24'-RT	1-9-92	O.G.	107.7	90.9	98.7
841+90	23.5'-RT	1-9-92	1	110.5	87.5	95.0
841+90	23'-RT	1-10-92	2	101.6	83.3	90.4[3]
841+90	24'-RT	1-10-92	2	106.2	87.9	95.5
841+94	24'-RT	1-10-92	3	100.5	79.3	86.1[3]
841+96	23'-RT	1-10-92	3	111.2	88.8	96.4
841+90	20'-RT	1-10-92	4	106.2	92.0	99.9
841+87	17'-RT	1-10-92	5	103.0	93.7	101.7

1 Nuclear gauge type: Troxler Moisture/Density Gauge
2 O.G. stands for Original Ground
3 Failed to meet compaction requirements

requirements were met. The nuclear gauge source position was at a depth of 8″ and used direct transmission.

There was difficulty in meeting compaction requirements during the placement of the embankments. It was determined that the roller the contractor was using was not capable of condensing 12″ thick lifts to the required compaction. This problem was resolved by placing the material in lifts that were a maximum of 6″ thick (loose soil), then compacting. Using this technique, required compaction was easily attained. This method was implemented on January 11, 1992, and was used for the remainder of the project.

After the final lift was in place, the aggregate base and pavement were placed. Figure 3.4 shows Bent 4, Stage I after construction was completed. A smooth transition can be seen where the road meets the bridge. The pipe appearing out of the ground is attached to the settlement plate, and is used to monitor the settlement of the original ground. A point on the pavement adjacent to the settlement plate will be used to monitor the total settlement.

Figure 3.4: Bent 4, Stage I after construction