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Experimental Tied Back Crib Wall With Salvaged Guardrail Facing

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Debra A. Bieber

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16. ABSTRACT
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The cost effectiveness of the project and potential for use in other Districts throughout the state is summarized in the concluding remarks. Due to favorable results on the project, the TransLab expects to implement more projects that utilize salvaged guardrail. This report serves as a guide for the design and construction of tied back steel crib walls using salvaged materials.

17. KEYWORDS
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STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING SERVICES
OFFICE OF TRANSPORTATION LABORATORY

EXPERIMENTAL TIED BACK CRIB WALL WITH SALVAGED GUARDRAIL FACING

Study Supervised by .... Kenneth A. Jackura, P.E.

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Jerry Chang, P.E.

Co-Investigator .... Debra A. Bieber, P.E.

Report by .... Debra A. Bieber, P.E.

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Chief, Office of Transportation Laboratory

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CONVERSION FACTORS

English to Metric System (SI) of Measurement

Quantity	English unit	Multiply by	To get metric equivalent
Length	inches (in)or(")	25.40 .02540	millimetres (mmm) metres (m)
	feet (ft)or(')	.3048	metres (m)
	miles (mi)	1.609	kilometres (km)
Area	square inches (in^2)	6.432×10^{-4}	square metres (m^2)
	square feet (ft^2) acres	.09290 .4047	square metres (m^2) hectares (ha)
Volume	gallons (gal)	3.785	litres (l)
	cubic feet (ft^3)	.02832	cubic metres (m^3)
	cubic yards (yd^3)	.7646	cubic metres (m^3)
Volume/Time			
(Flow)	cubic feet per second (ft^3/s)	28.317	litres per second (l/s)
	gallons per minute (gal/min)	.06309	litres per second (l/s)
Mass	pounds (lb)	.4536	kilograms (kg)
Velocity	miles per hour (mph) feet per second (fps)	.4470 .3048	metres per second (m/s) metres per second (m/s)
Acceleration	feet per second squared (ft/s^2)	.3048	metres per second squared (m/s^2)
	acceleration due to force of gravity (G)	9.807	metres per second squared (m/s^2)
Weight Density	pounds per cubic (lb/ft^3)	16.02	kilograms per cubic metre (kg/m^3)
Force	pounds (lbs) kips (1000 lbs)	4.448 4448	newtons (N) newtons (N)
Thermal Energy	British thermal unit (BTU)	1055	joules (J)
Mechanical Energy	foot-pounds (ft-lb) foot-kips (ft-k)	1.356 1356	joules (J) joules (J)
Bending Moment or Torque	inch-pounds (ft-lbs) foot-pounds (ft-lbs)	.1130 1.356	newton-metres (Nm) newton-metres (Nm)
Pressure	pounds per square inch (psi)	6895	pascals (Pa)
	pounds per square foot (psf)	47.88	pascals (Pa)
Stress Intensity	kips per square inch square root inch (ksi $\sqrt{in}$)	1.0988	mega pascals $\sqrt{metre}$ (MPa $\sqrt{m}$)
	pounds per square inch square root inch (psi $\sqrt{in}$)	1.0988	kilo pascals $\sqrt{metre}$ (KPa $\sqrt{m}$)
Plane Angle	degrees (°)	0.0175	radians (rad)
Temperature	degrees fahrenheit (F)	$\frac{tF - 32}{1.8} = tC$	degrees celsius (°C)

[illegible]MENT BOND
[illegible] PRODUCT

[illegible]

ACKNOWLEDGEMENTS

The author wishes to thank the following individuals for their contributions to the completion of this report: Dave Castanon, Assistant Transportation Engineer, for instrumentation monitoring, data collection and reduction. Thang Le, for construction inspection and technical guidance. The District 7 survey crew including W. Stewart, R. Alanis, R. Cochran, and B. Reynolds for their continued support. The TransLab graphic services staff and especially Darla Bailey who did the word processing.

TABLE OF CONTENTS

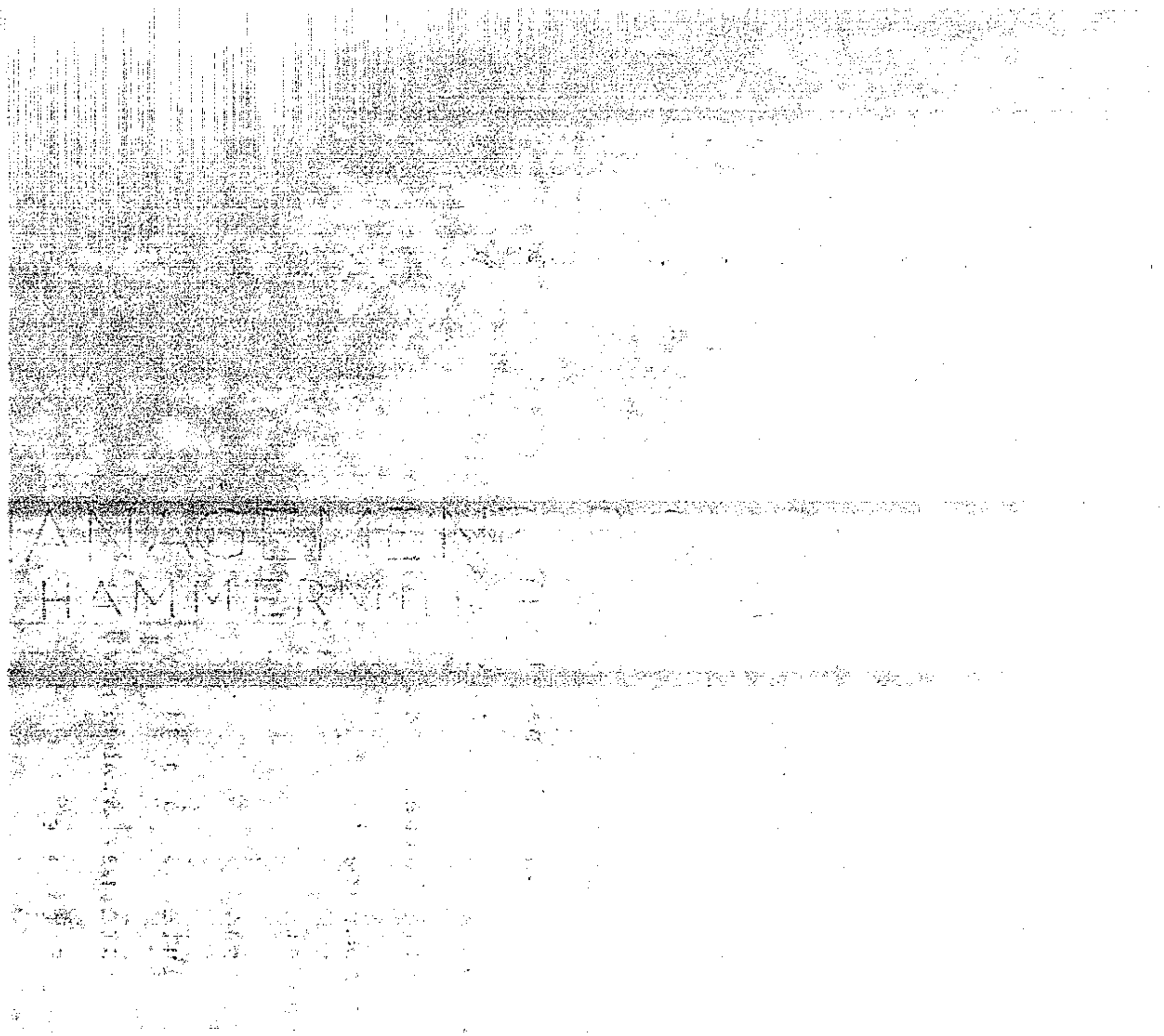

TABLE OF CONTENTS (Continued)

I. INTRODUCTION

Over the years, the California Department of Transportation has replaced miles of steel guardrail with the more efficient Type 50 concrete barrier and the excess guardrail material stockpiled for future use. TransLab in Sacramento was enlisted to find a use for the salvaged guardrail. Concurrently, the Geotechnical Section at TransLab, under the direction of Messrs. Forsyth, Hannon and Chang, was investigating the use of different types of earthwork reinforcement(1,2). The combination of excess guardrail material and need for creative reinforcement systems led Caltrans engineers to develop a tied back retaining wall using the recycled guardrail materials. The system was hypothesized as a combination tieback and earthwork reinforcement retaining wall. Instrumentation would be incorporated into the backfill of a prototype wall to test this hypothesis. A three year federally financed research project began in 1981 to study the mechanics of the tied back crib wall. The objective of the study was to determine whether tied back crib walls of recycled materials would be feasible for use on state highway systems. This would be accomplished as follows:

1. Determine the actual field stresses developed in the anchor ties and relate them to theoretical design stresses.

2. Measure vertical and lateral movements occurring at the face of wall.

3. Make design modifications which improve performance and maximize future use of salvaged materials.

Several sites were suggested for the construction of the first prototype wall. The selected site was part of a reconstruction and widening project on Highway 101 in Thousand Oaks, California (Contract No. 07-100544). The contract plans called for a 200-foot long wall varying in height between 8 and 15 feet. Alternate Type "B" steel face with salvaged "W" type guardrail was selected for use as facing material.

The project was advertised on December 29, 1980. Bids were opened on February 26, 1981.

II. CONCLUSIONS

Upon the completion of three years of monitoring, the following conclusions were reached:

1. The standard plans for crib walls can serve as an adequate guideline for the design of retaining walls constructed from recycled materials. Connections and materials used in the construction of said walls must conform to the standard plans in the areas of steel grade and yield strength.

2. Stresses measured in the experimental tied back crib wall correlated with the stresses one might expect for a gravity retaining wall. The tied back system transmitted the forces equally along the reinforcing element which acted more as a tieback connector than as earthwork reinforcement.

3. The computed pullout resistance contributed by the sign posts alone is adequate (minimum safety factor of 2.1) to resist lateral earth stresses for the backfill used at this particular site.

4. The use of salvaged guardrail materials for retaining wall construction is limited by the severity of damage to the guardrail.

5. The experimental crib wall constructed of salvaged guardrail materials would be most economical for small retaining walls constructed by district maintenance personnel. The cost for an 8-15 foot wall can be as low as $20 per square foot if sufficient salvaged materials are available.

6. Recycled materials can be used on the highway system if their engineering properties are properly considered and thorough calculations accompany creative design.

III. RECOMMENDATIONS

This report, along with the Standard Plans, can be used as a design guideline for the construction of retaining walls fabricated from recycled materials. Engineering techniques used to determine stresses in conventional retaining wall systems can be applied to salvaged material. Efforts should be made to utilize salvaged guardrail on retaining walls throughout California. Due to the limited amount of guardrail that is usable, up-to-date inventories should be maintained. When a contract requires a small structure or maintenance needs to make minor repairs, the inventory should be checked and guardrail used if feasible.

A new connection should be designed to allow the use of straightened guardrail that no longer conforms to new guardrail dimension specifications.

Additional research is needed to determine the minimum requirements for backfill materials. With competent materials, walls can be designed as an earthwork reinforcement system. If the materials are below minimum values, the tied back crib wall concept is necessary.

IV. IMPLEMENTATION

1. Whenever possible, salvaged guardrail materials should be used by districts that have a sufficient inventory of recycled material.

2. A new connection will be designed allowing use of straightened guardrail that no longer conforms to new guardrail dimension specifications.

3. The TransLab, in cooperation with other departments, will recommend the use of guardrail materials until the present supply is depleted.

V. DISCUSSION

A. Design

1. Overview

The dimensions for the prototype tied back crib wall were taken from the Standard Plans for steel crib walls(3). Because the wall height exceeded 12 feet, the bottom tie-backs were extended an additional 2 feet (Figure 2). The wall is 200 feet long and varies in height from 8 to 15 feet. Alignment of the face is controlled by 5/8 inch diameter steel rods embedded in a reinforced concrete footing on 3.35 foot centers and extending vertically upward. The facing is attached by means of a connecting plate slipped over the vertical rods and bolted to the facing. Tie rods consisting of steel sign posts extend into the backfill from the vertical alignment rods. The tie rods are connected to channel sections of rubbing rail from "W" type guardrail installations that serve as anchor beams. (Photos accompany detailed construction descriptions in Section B.)

The upper 10 feet of the wall has 8-foot long tiebacks. Where the wall height exceeds 10 feet, the lower portion of the wall has 12-foot long tiebacks. The tiebacks are placed on 13 5/8-inch vertical intervals. All embedment dimensions were taken from the standard plans for crib walls.

The entire wall system with tiebacks was galvanized to extend its service life.

2. Design Parameters

The safety factor for sliding along the base was 1.5. The safety factor for overturning was 2.0. In accordance with the Standard Plans, the required foundation bearing capacity was to be a minimum of 1.5 tons per square foot. A subsurface drainage system was provided to capture and drain excess water. Class 2 permeable material was included on the backslope. Steel connections were made with ASTM A307 bolts, nuts and washers. Horizontal steel ties were required to be continuous heavy duty sign posts weighing 2.25 lbs per linear foot. Connector plates conformed to ASTM Designation A36 and were galvanized. A copy of the special provisions for the tied back crib wall is included in the Appendix.

3. Soil Tests

Laboratory soil tests were conducted on foundation and backfill soil samples obtained from the wall site. These tests included gradation, relative compaction, Atterberg limits, shear strength determination and sand equivalent. Resistivity and pH values of the soil samples were also determined to estimate the corrosion rate of the steel reinforcements. A summary of laboratory test results for the soil samples is shown in Table 1. The backfill material, with an internal angle of friction of 30° and a cohesion of 440 psf was quite competent, thus contributing to the success of the wall.

B. Construction

1. Foundation Preparation

The existing ground was first excavated and rough graded to the design level foundation grade. The slope was cut to 3/4:1 behind the wall fill area.

A 12 inch by 12 inch footing trench was then excavated, formed, and fitted with the required reinforcing. For ease of construction, vertical rods welded to metal plates were placed at the bottom of the footing trench. The guardrail would be slipped over the rods during construction. Concrete was then placed for the footing and allowed to cure.

2. Shop Wall Preparation

Part of the wall items were shop assembled prior to being transported to the wall site. This consisted of bolting the U-shaped mounting bracket to the "W" type guardrail. The remaining parts of the wall system — anchor beam, four street sign posts and four connection plates — were temporarily cradled in the guardrail and trucked to the wall site on a flatbed truck equipped with a boom for unloading.

3. Wall Face and Tieback Assembly

At the wall site, the cradled units were unloaded at the approximate installation location (Photo 1). A crew of four unloaded the tieback components from the guardrail and began assembly by bolting the sign post to the prenotched salvaged rubbing rail which served as the anchor beam (Photos 2 and 3). After the connection plates had been slipped onto the vertical rods, the four workers lifted the guardrail and mounting bracket unit and slipped the mounting brackets onto the vertical rods (Photo 4). The tieback, sign post, and anchor beam assembly was then dragged to the guardrail wall facing and bolted to the connection plate (Photo 5). The tieback portion was roughly leveled leaving it ready for burial with backfill material. The above process generated 12.5 feet by 1 foot area of wall facing and required approximately 15 minutes time.

4. Fill Compaction

A tractor with an open front end bucket placed, spread, and compacted the fill material behind the wall (Photo 6) and followed within two guardrail lengths of the erecting crew. At first, water was added to the newly placed backfill material by a fire hose connected to a water truck but later was added to the stockpiled material to produce a more uniform moisture content.

Hardware cloth was placed over the horizontal space between the panels just prior to hand compaction of the two feet nearest the inside wall face (Photo 7).

The permeable blanket at the back side of the fill was dumped over the existing slope edge simultaneously with fill construction (Photo 8). The wall was 14 panels high at the maximum height and 8 panels high at the minimum height. Average daily wall facing erection progress was two guardrail rows per day. Total erection time for all wall facing and backfill was 10 working days.

C. Instrumentation

Survey points were set on the wall at three different elevations. To monitor wall movements, strain gages were attached to the soil reinforcement posts at five different levels, A through E. A unique tracking rail for the instrumented strain gage plate was designed to monitor stresses within the steel posts (Photos 9 and 10).

Since only low strains in the steel sign posts were anticipated, a section of a sign post was removed and replaced with a smaller cross-section instrumented steel strap (Figure 1). A rigid metal guide assembly kept the sign post ends in their original position relative to each other. The location and identification of each strain gage is shown in Figures 2 and 3. Strain gage readings were taken periodically both during and after construction. The time history of stresses in the instrumented sign posts is shown in Figures 4 through 8. All strain gages indicated an increase in stresses with an increase in fill height from installation until completion of the backfill except for gage No. 11, which malfunctioned after installation. The stresses for all gages then appeared to stabilize until the placement of the road structural section. Subsequently, all gages generally indicated a slight increase in stresses. The time history of stresses two feet from the face of the wall for each level is shown in Figure 9. The variation of stresses with depth behind the wall is shown in Figure 10.

Reference monuments on the berm and reference points along the top and on the face of the wall were installed to measure horizontal and vertical movement (Photos 11 through 13).

The reference monuments on the berm indicated a vertical movement from 0.01 to 0.02 foot except for monument (CW-2) which indicated settlement of 0.29 foot. These survey points also indicated horizontal movement in the magnitude of 0.01 foot or less with the exception of the one monument, CW-2, which displayed a maximum movement of 0.05 foot. The reference points on the face of the wall indicated settlements of 0.01 to 0.05 foot and horizontal movements of 0.02 to 0.07 foot. The reference points along the top of the wall indicated 0.01 to 0.05 foot settlements with 0.01 to 0.02 foot horizontal movement.

D. Problems

Original plans called for use of salvaged rubbing rail and reshaped "W" type guardrail. Reshaping of the guardrail did not return all of the guardrails close enough to their original shape, therefore only 50% of the salvaged panels were utilized. New guardrail was used for the remainder of the job at a considerable additional cost.

During construction, what appeared to be an underground spring was uncovered at the wall site. A gravel filled trench was placed at the spring location for drainage to a pond between the wall and a nearby golf course. The rate of water flow remained constant until the end of construction.

The reference monument (CW-2) that indicated a settlement of 0.29 foot at the berm did not exhibit the same amount of settlement at the top of the wall. The wall, because of its articulated nature, distributed the berm settlement between the guardrail elements along the face so that the maximum settlement realized at the top of the wall was 0.05

foot. Monument CW-2 was located near the underground spring and this was the cause of excessive settlement in the area. The integrity of the wall did not suffer due to excessive settlement in this area.

E. Analysis

The guardrail wall is actually a hybrid system drawing on elements of tieback walls and earthwork reinforcement systems to achieve structural integrity. A review of the data collected at the site (Figures 4-8) reveals that stresses increase in the bars as the wall fill is advanced. As of October 1981, the stresses leveled off. When traffic began, there was a minor increase in bar stress. The time history of steel stresses two feet from the inside face of the wall also exhibits the increased bar stresses that eventually become constant as time proceeds (Figure 9). The bar stresses are evenly distributed along the tie rods on each level except Level B (Figure 10). The bars at Level B were the first to extend an extra two feet into the back slope. From the data collected, one can analyze the wall for external and internal stability.

1. Internal Stability

In order to understand the internal mechanism, the bar stresses were analyzed to see if either system mechanism -- tieback or earthwork reinforcement -- dominated. Based on this analysis, it became apparent that the wall was functioning as a tieback with the forces transmitted undiminished along the tie rod. Calculations utilizing the tieback analysis compare well with measured results. The steel sign posts connected to the anchor beam provide adequate internal stability.

2. External Stability

In most cases, bar stresses compare closely to those predicted by the Rankine active state(4). The stresses in the bottom of the wall are high and correlate with the greatest overburden. If the wall is analyzed as a retained earth system, stresses expected at the back of the wall correlate well with those measured. Therefore, for external stability, it is justifiable to use a block analysis to design this type of wall system. The entire unit can be considered a gravity wall. There is only one apparent discrepancy to this theory and this is at level A. Level A is in the zone where the passive wedge at the front of the wall exists (Figure 2). The expected decrease in stress does correlate to a block system that might have a passive wedge to resist active soil pressure. Therefore, the gravity block concept is consistent with experimentally determined results.

F. Cost Estimate

The estimated cost for materials on this project can be found in the Appendix. Change orders and limited availability of materials could increase the wall cost.

Final contract bid price including change orders was $54 per square foot of facing area. This price does not reflect actual cost for the wall due to unbalanced bidding and other contractual discrepancies. Change orders on the job amounted to 7% of the original bid price. The greatest change order was for the purchase of new materials because the available supply of guardrail was not sufficient to meet the needs at the job. However, state estimated costs using all recycled materials and including excavation and backfill is $20 per square foot of facing area. Final cost will vary depending on location, but the itemized list in Appendix C serves as a guide for engineering estimates.

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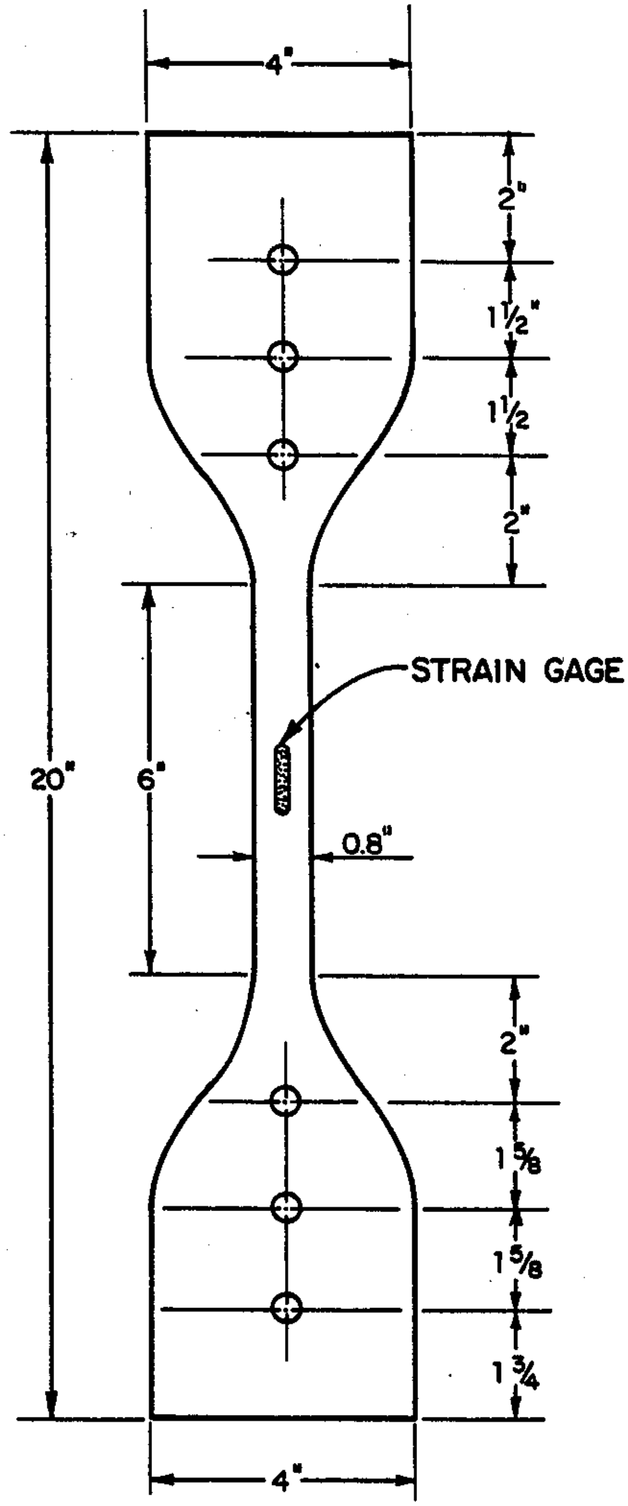
[illegible]

TABLE I

LABORATORY SOIL TEST RESULTS

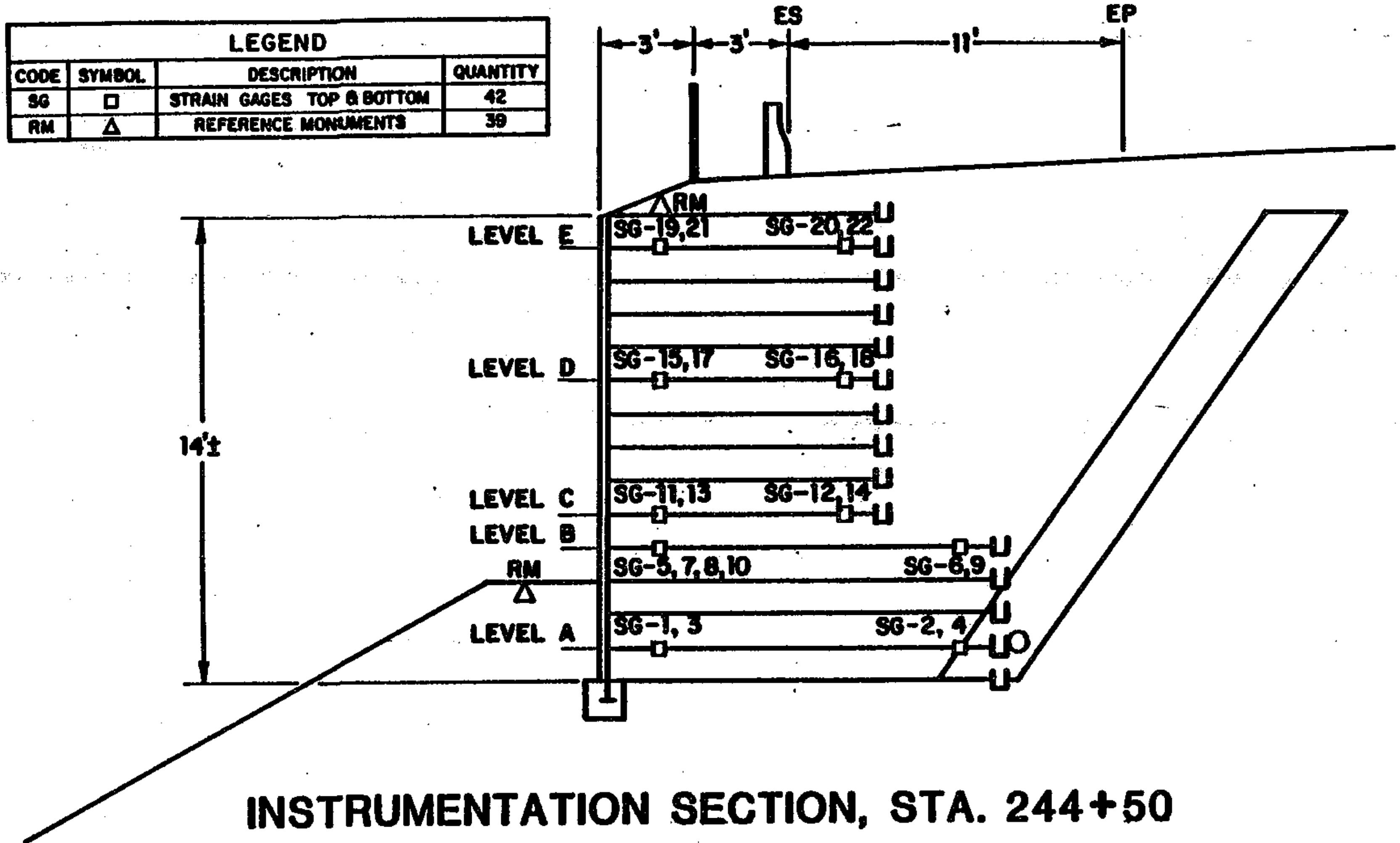
I.D.	FOUNDATION MATERIAL	IMPORTED BACKFILL
Friction Angle, φ(°)	31°	39
Cohesion (psf)	0	440
Max. Wet Density (pcf)	110	119
Resistivity (ohm-cm)	920	5733
ph	7.8	8.3
Sand Equivalent	25	34
Plasticity Index	7	NP
No Ground Water Encountered to Elevation 680.		
Grading	Percent Passing by Weight	
2"	100	100
1½"	97	99
1"	92	98
3/4	89	97
½"	83	96
3/8"	78	95
# 4	66	88
# 8	57	79
# 16	48	66
# 30	40	48
# 50	32	31
#100	24	18
#200	20	12
5 M	7	4
1 M	3	3



1/8" STEEL TEST ASSEMBLY

FIGURE 1

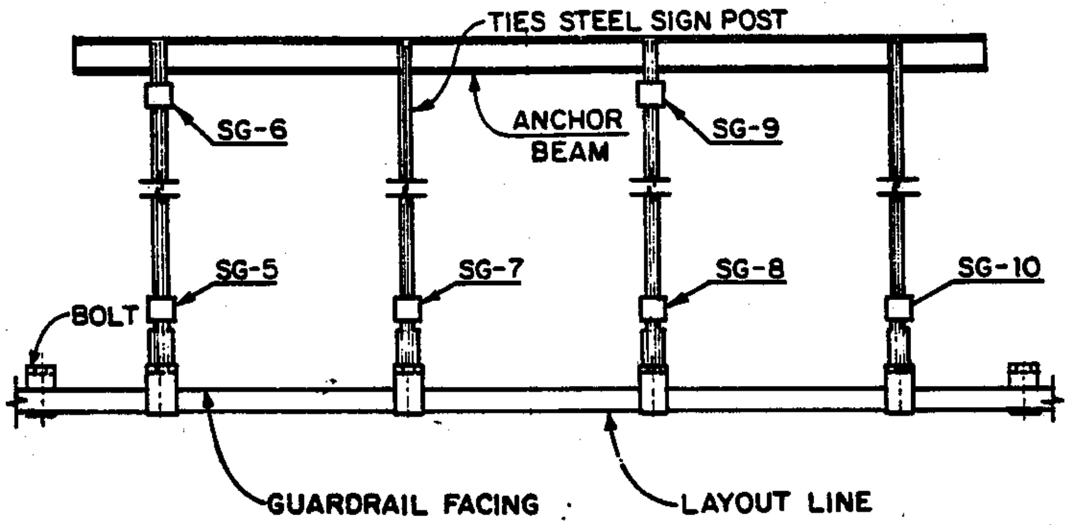
LEGEND			
CODE	SYMBOL	DESCRIPTION	QUANTITY
SG	□	STRAIN GAGES TOP & BOTTOM	42
RM	△	REFERENCE MONUMENTS	39



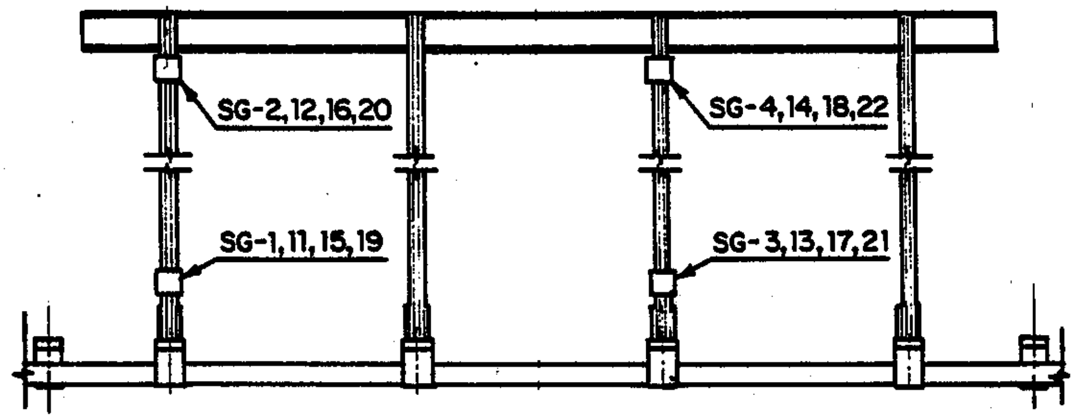
INSTRUMENTATION SECTION, STA. 244+50

TIED BACK STEEL CRIB WALL (EXPERIMENTAL)

FIGURE 2



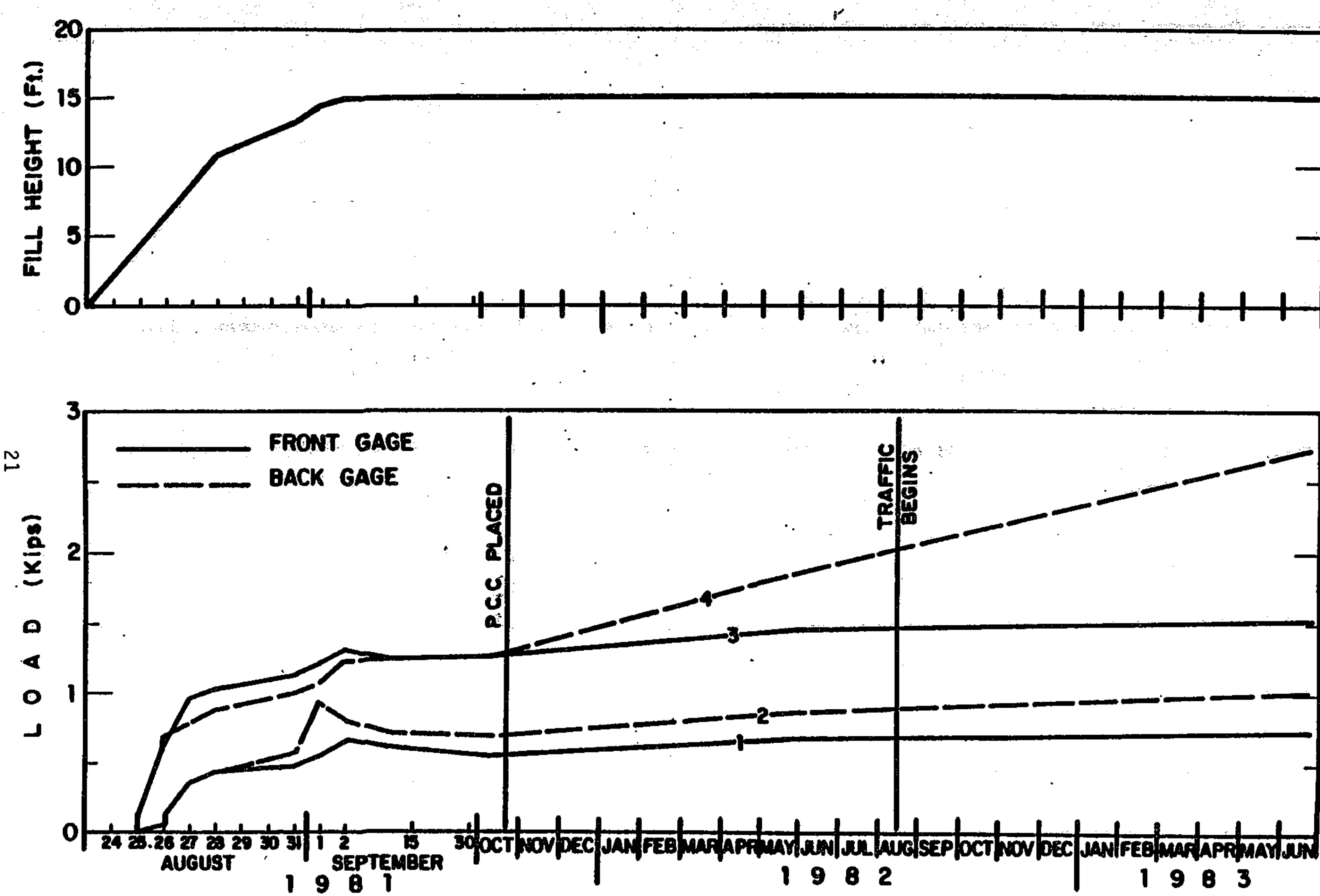
LEVEL B



LEVELS A, C, D AND E

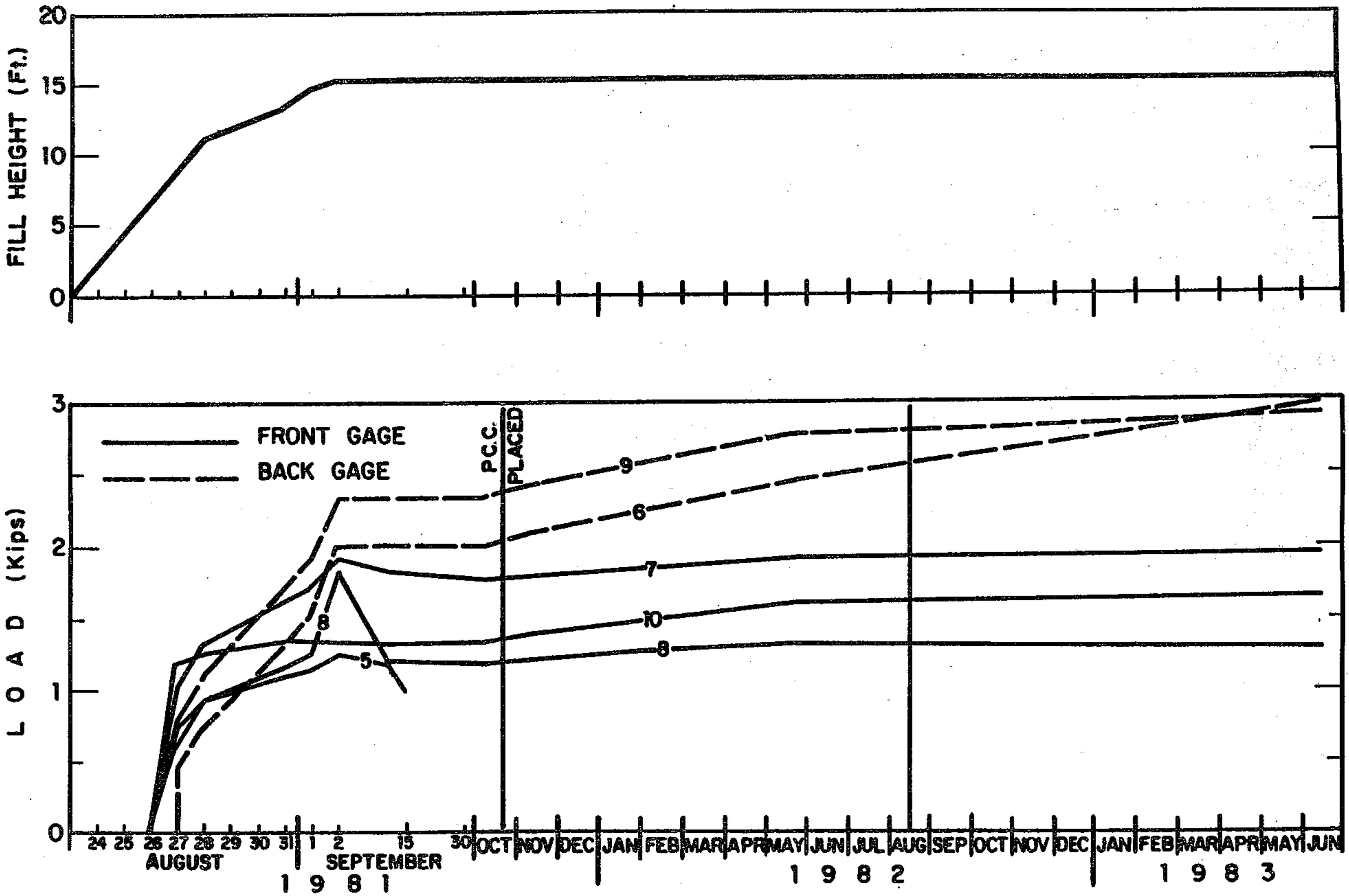
INSTRUMENTATION SECTION, STA. 244+50
TIED BACK STEEL CRIB WALL
(EXPERIMENTAL)

FIGURE 3



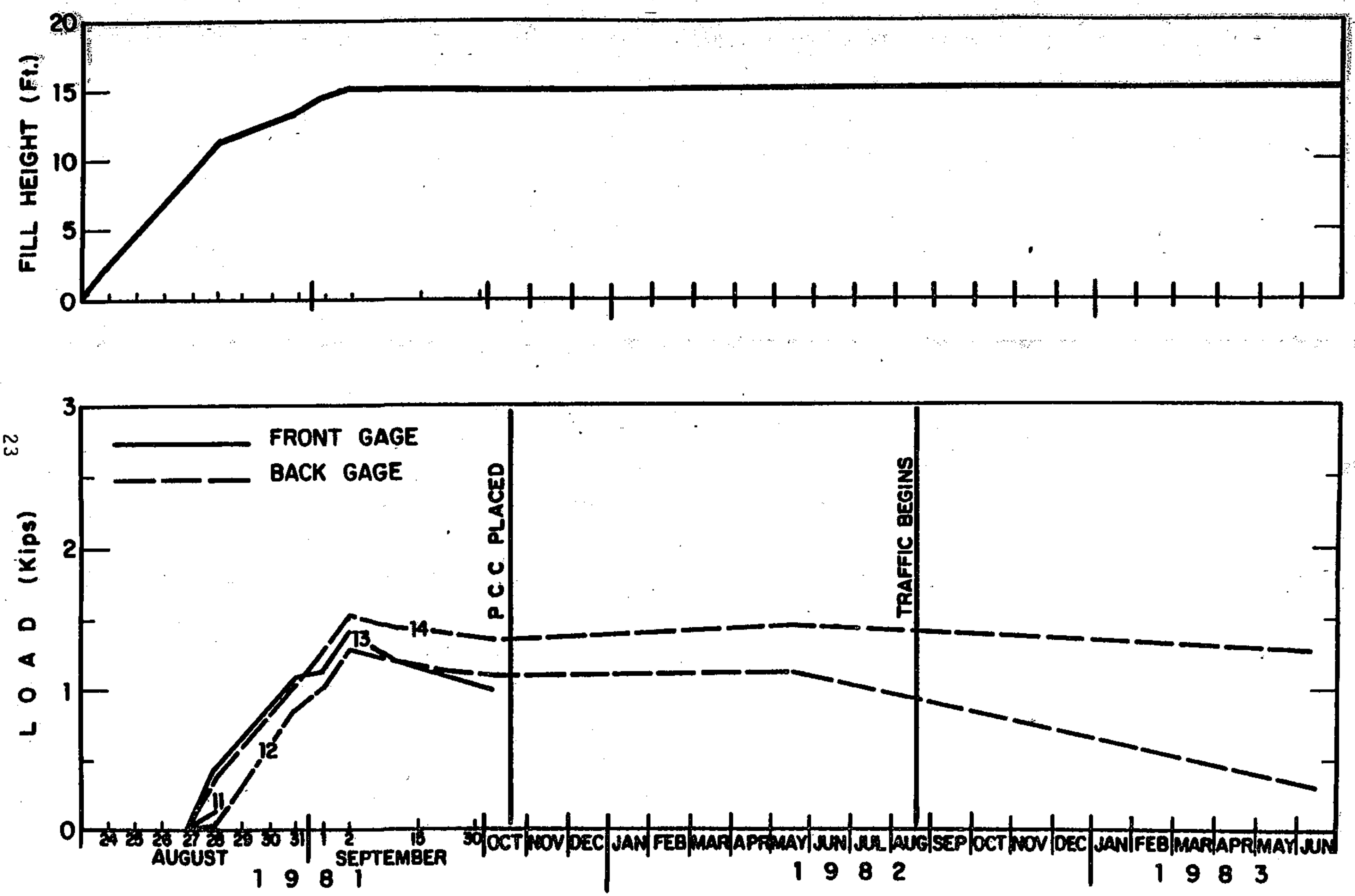
LEVEL A - GAGE NO. 1, 2, 3, 4

FIGURE 4. TIME HISTORY OF MEASURED LOAD ON TIEBACK POSTS



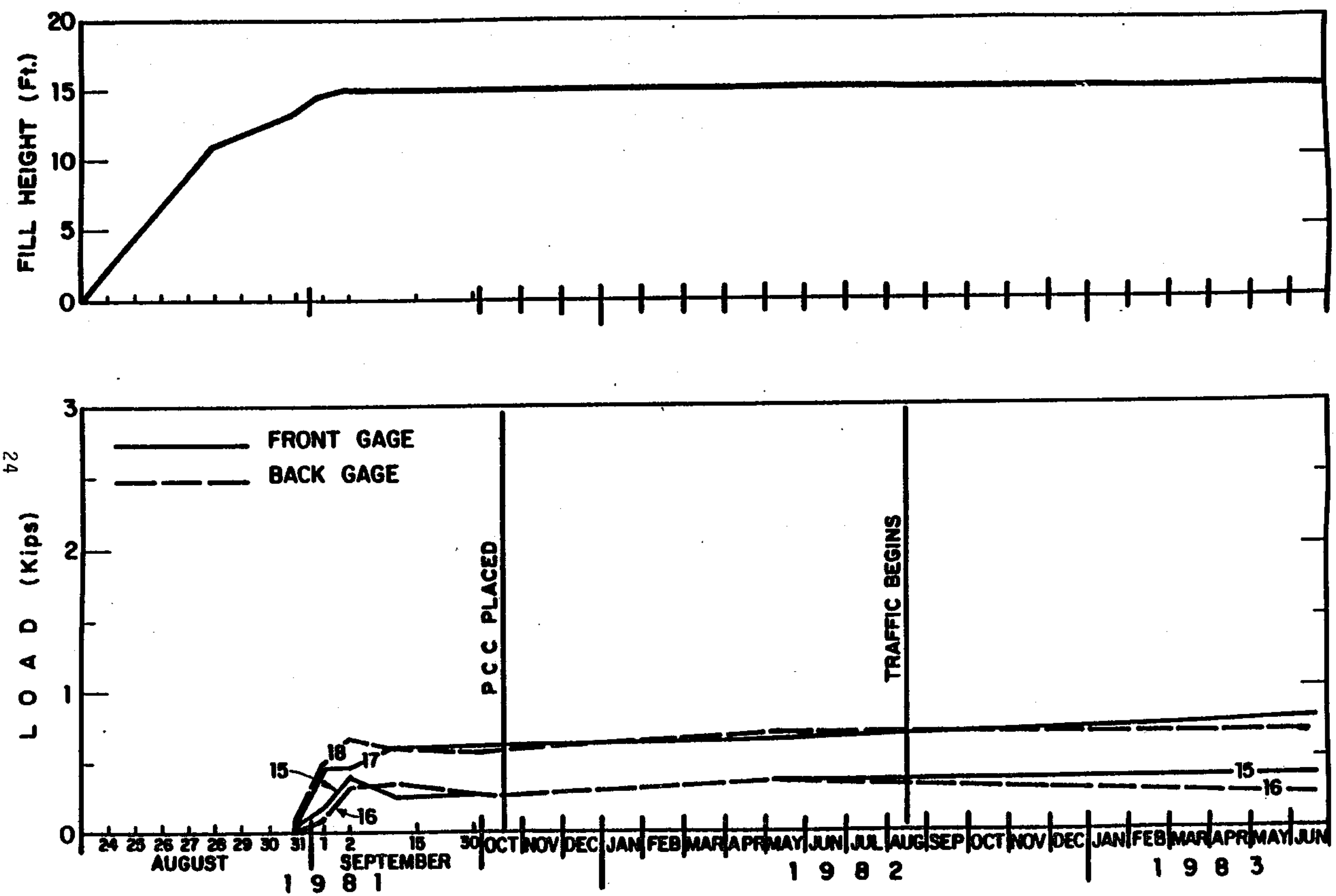
LEVEL B - GAGE NO. 5, 6, 7, 8, 9, 10

FIGURE 5. TIME HISTORY OF MEASURED LOAD ON TIEBACK POSTS



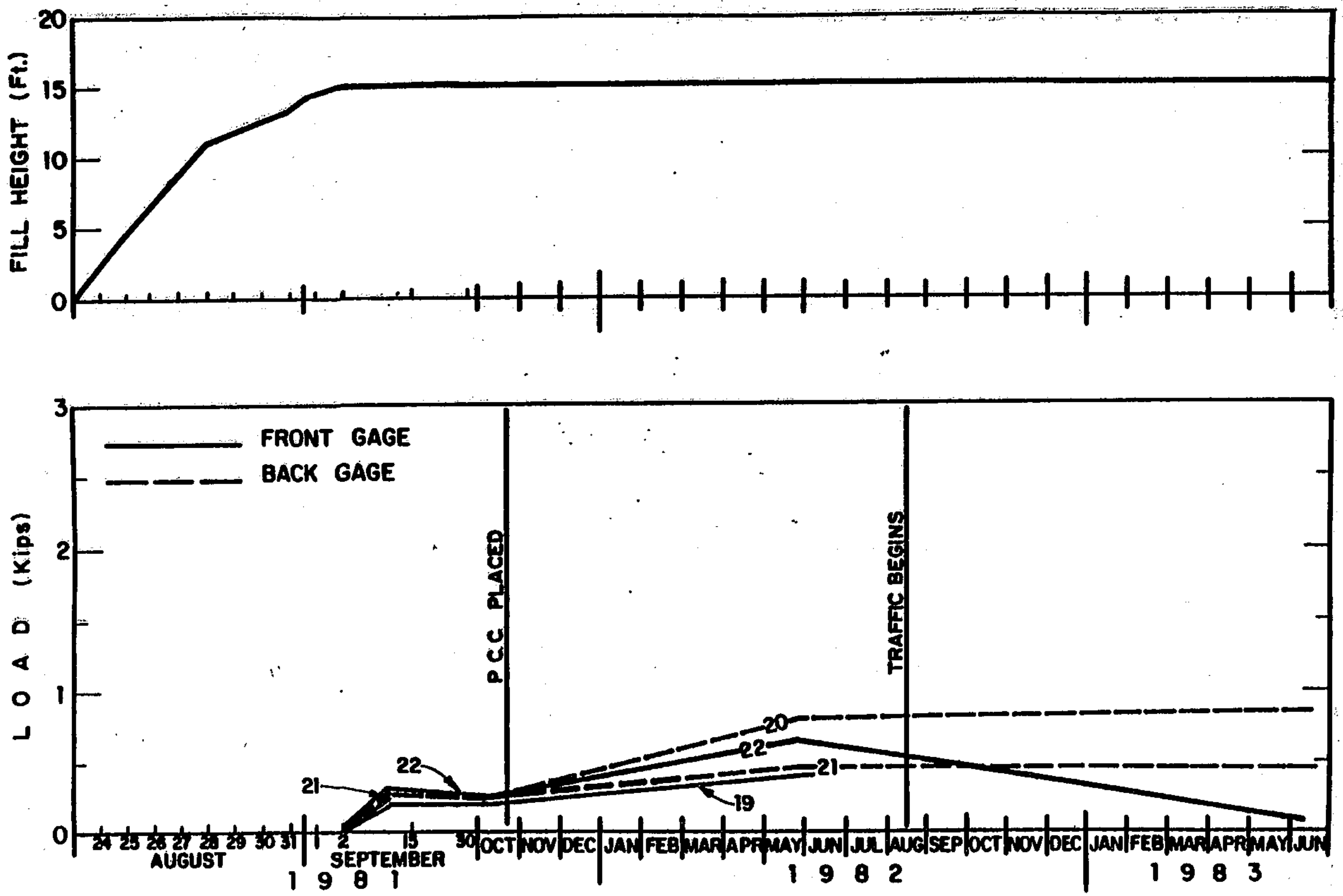
LEVEL C - GAGE NO. 11, 12, 13, 14

FIGURE 6. TIME HISTORY OF MEASURED LOAD ON TIEBACK POSTS



LEVEL D - GAGE NO. 15, 16, 17, 18

FIGURE 7. TIME HISTORY OF MEASURED LOAD ON TIEBACK POSTS



LEVEL E - GAGE NO. 19, 20, 21, 22

FIGURE 8. TIME HISTORY OF MEASURED LOAD ON TIEBACK POSTS

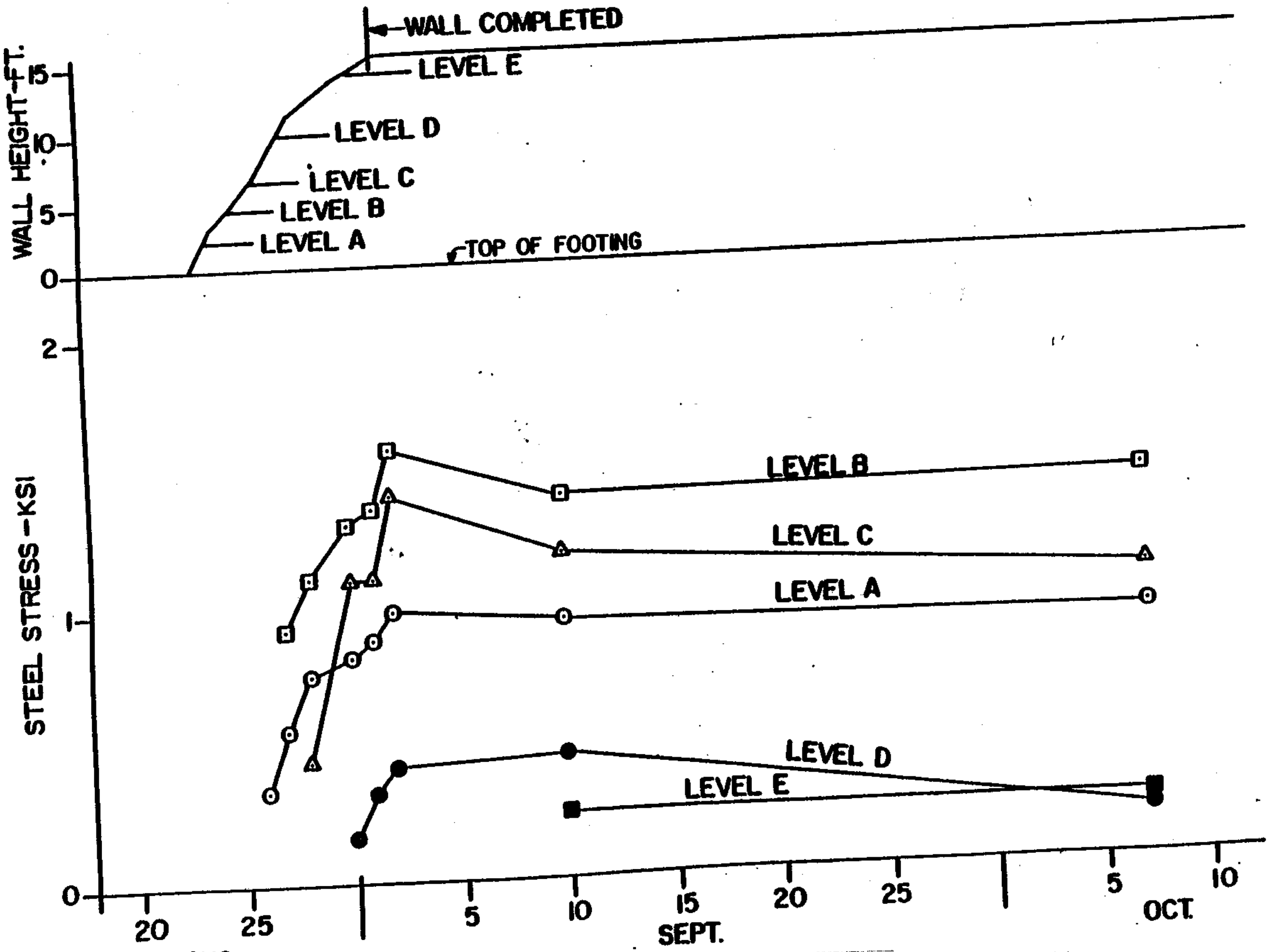


FIGURE 9. TIME HISTORY OF STEEL STRESS 2' FROM INSIDE FACE OF WALL

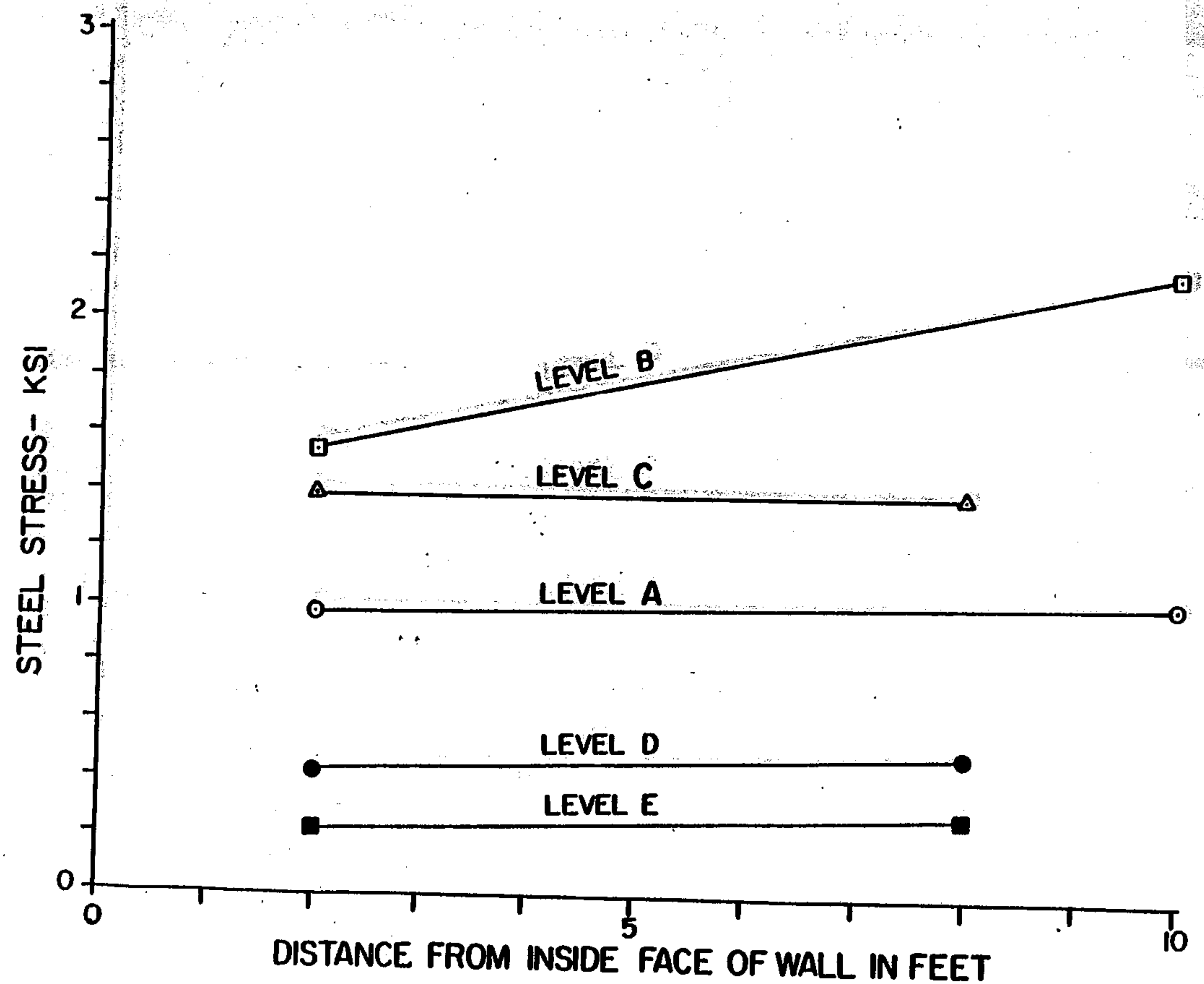


FIGURE 10. AVERAGE STEEL STRESS AT COMPLETION OF BACKFILL

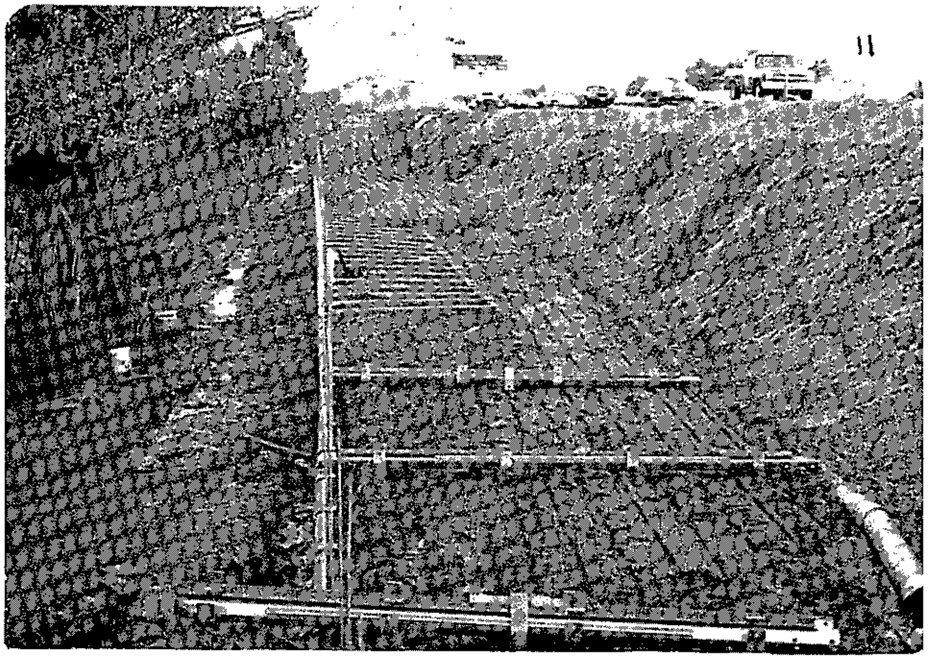


Photo 1. Guardrail and Tieback Packages Laying in Proximity of Installation Location

Photo 2. Laborers Attaching Tiebacks to Salvaged Channel Anchor

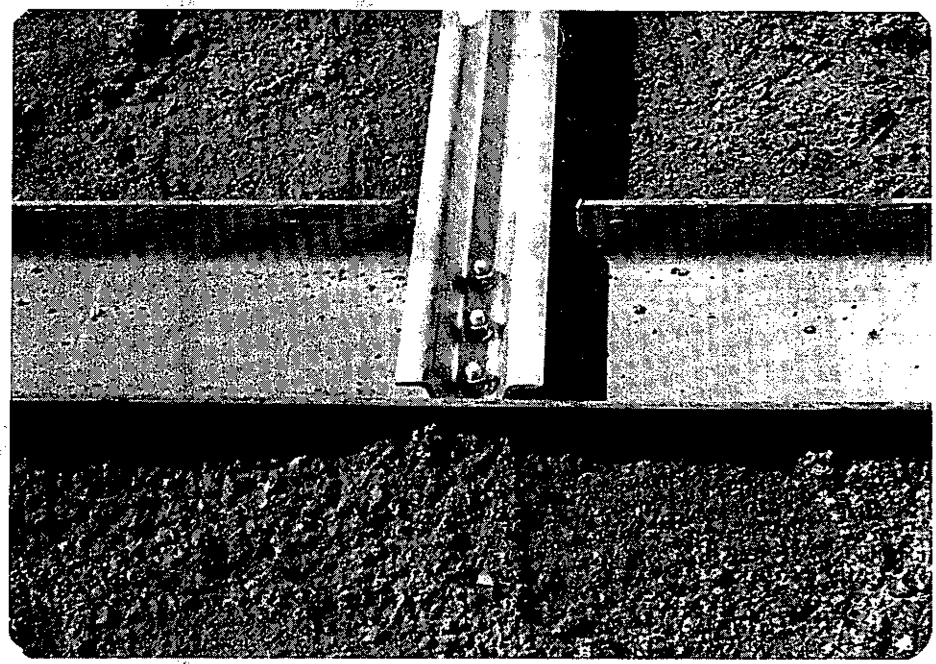


Photo 3. Sign Post Tieback Attached to Rubbing Rail Anchor

Photo 4. Laborers Placing Guardrail Rail and Mounting Bracket Assembly in Position on Vertical Rods

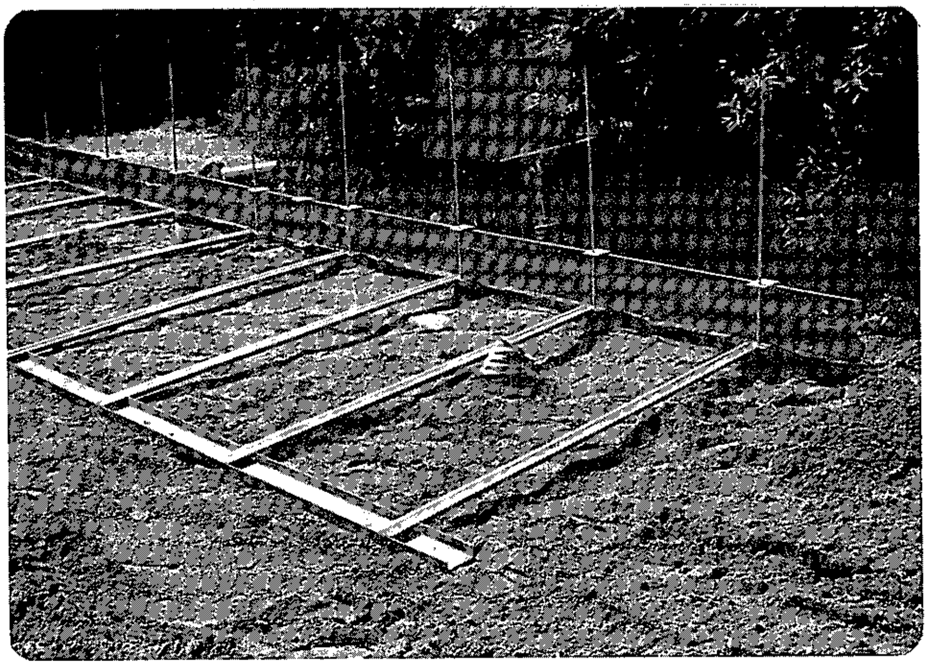


Photo 5. Assembled Guardrail Wall Facing, Sign Post Tieback, and Salvaged Rubbing Rail Anchor Ready for Burial with Backfill Material

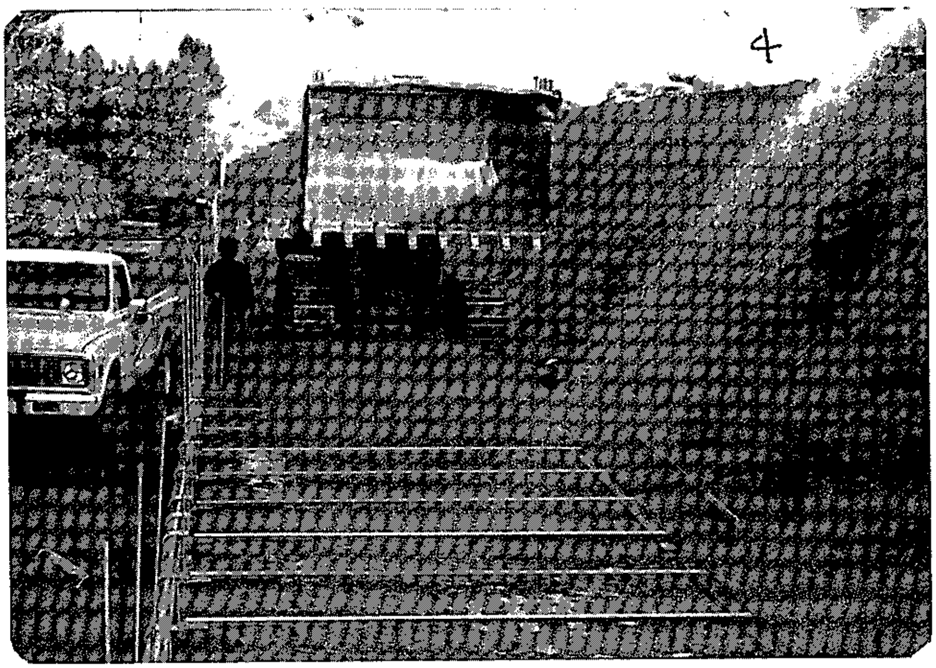


Photo 6. Tractor with Front End Dump Bucket Placing Backfill Material

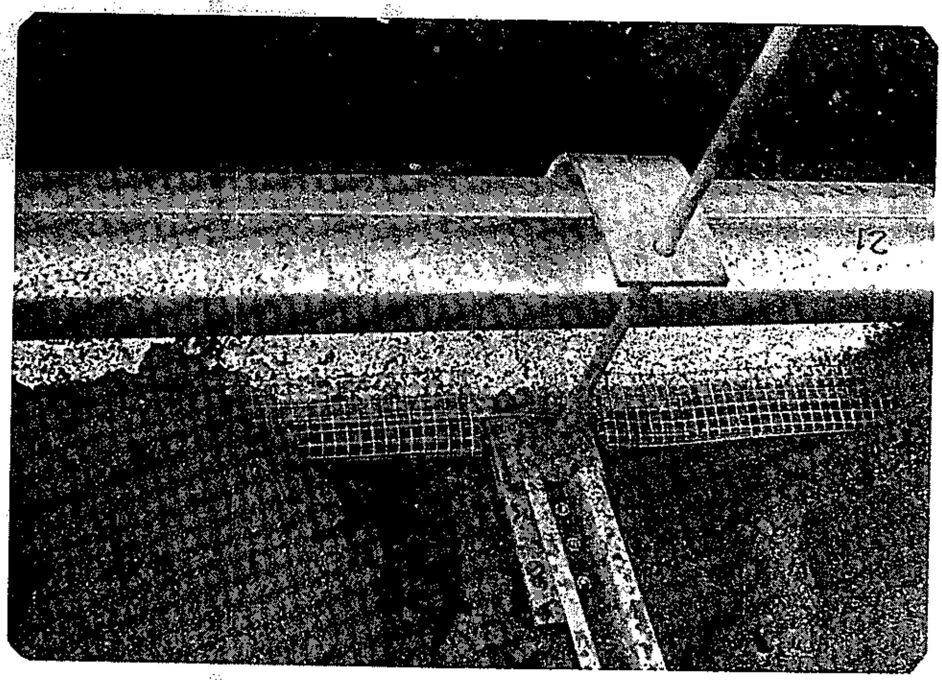


Photo 7. Hardware Cloth in Position Over Horizontal Space Between Guardrails.

Photo 8. Permeable Blanket Material Being Dumped Over Existing Back Slope Into Position

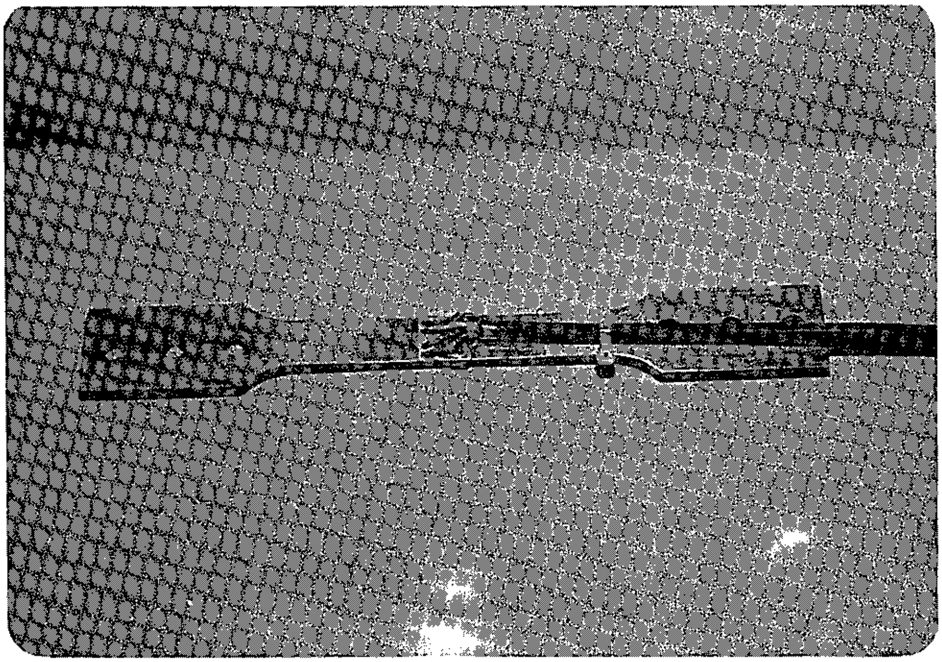


Photo 9. Steel Strip Instrumented with Strain Gage

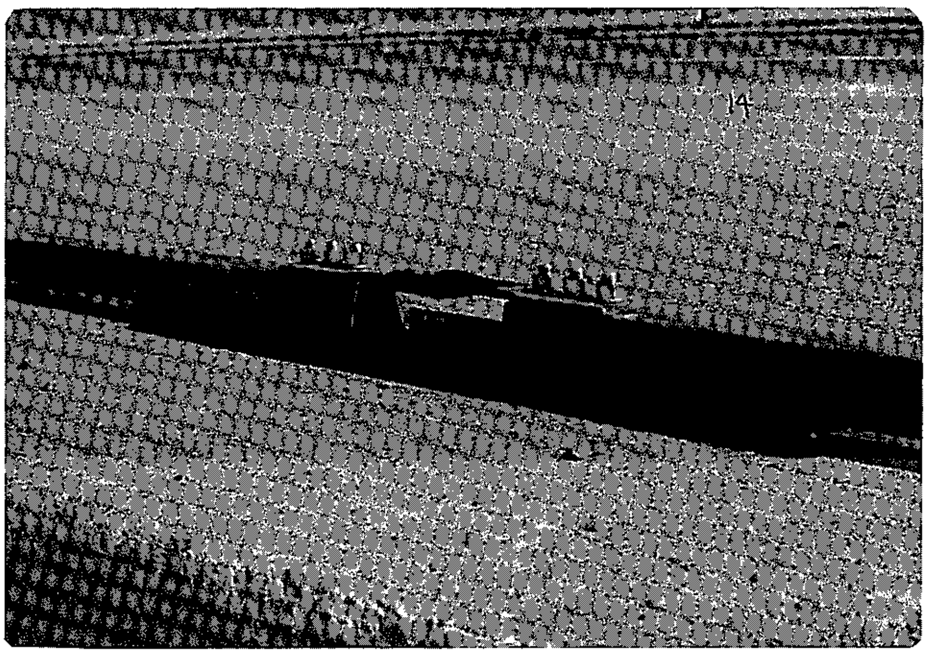


Photo 10. Instrumented Steel Strip in Position on Sign Post Tieback

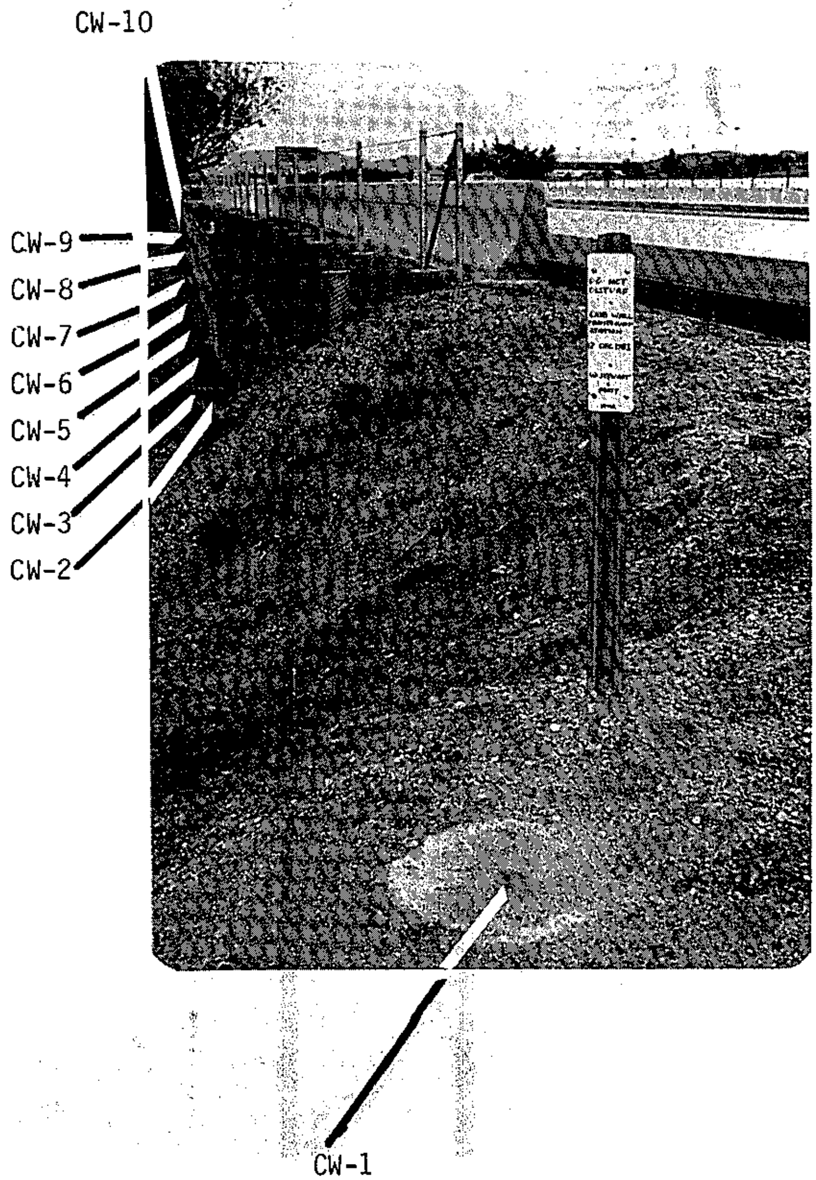
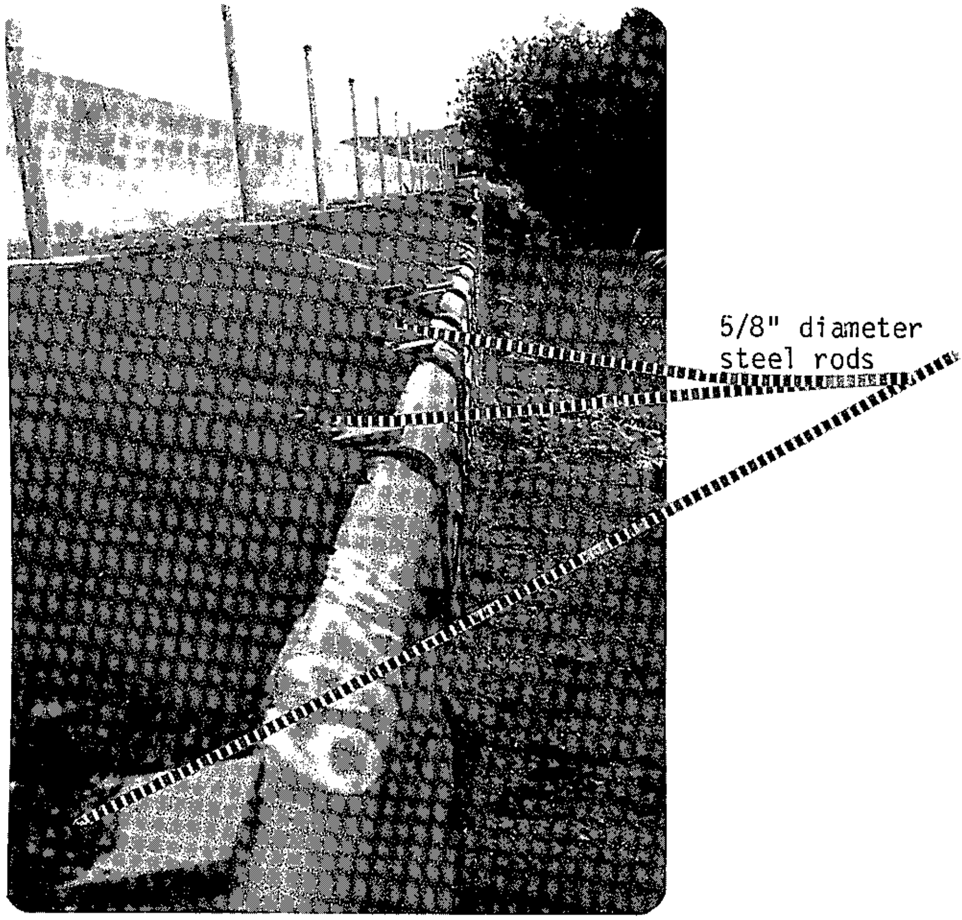
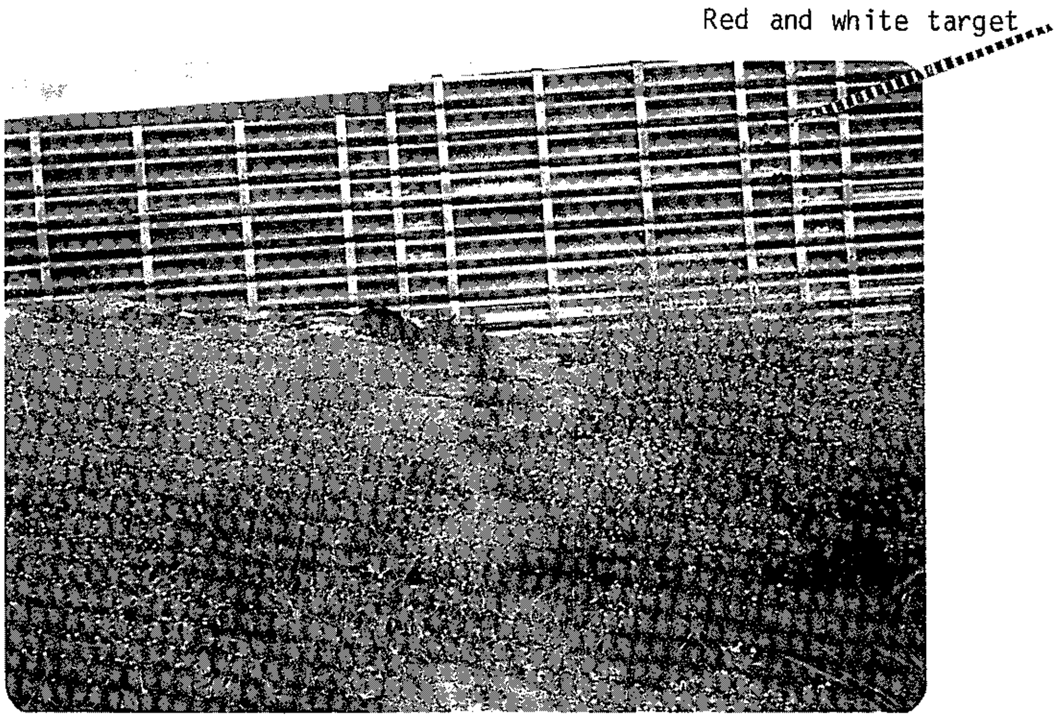
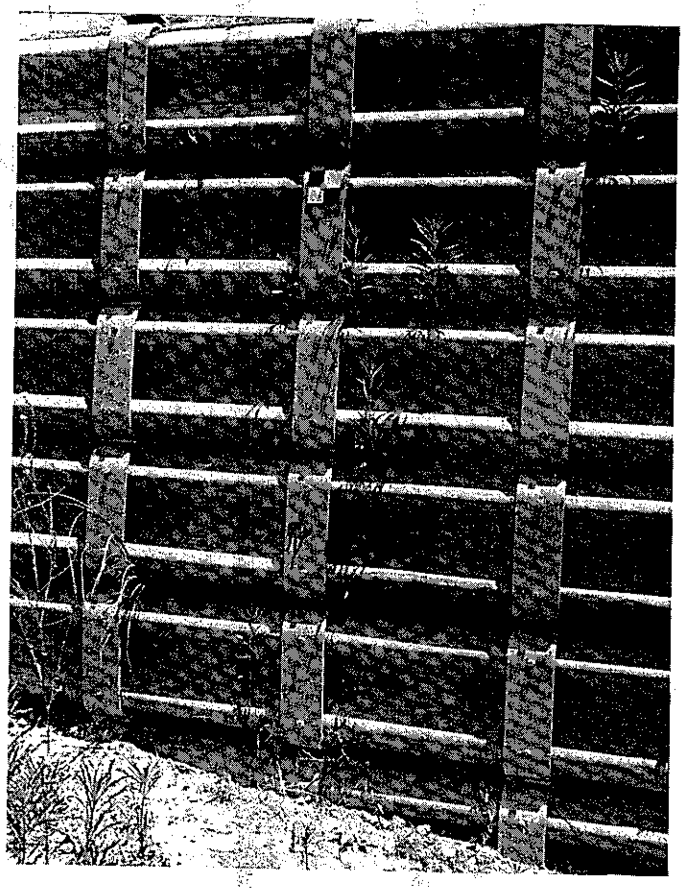


Photo 11. Position of Survey Points Along Berm

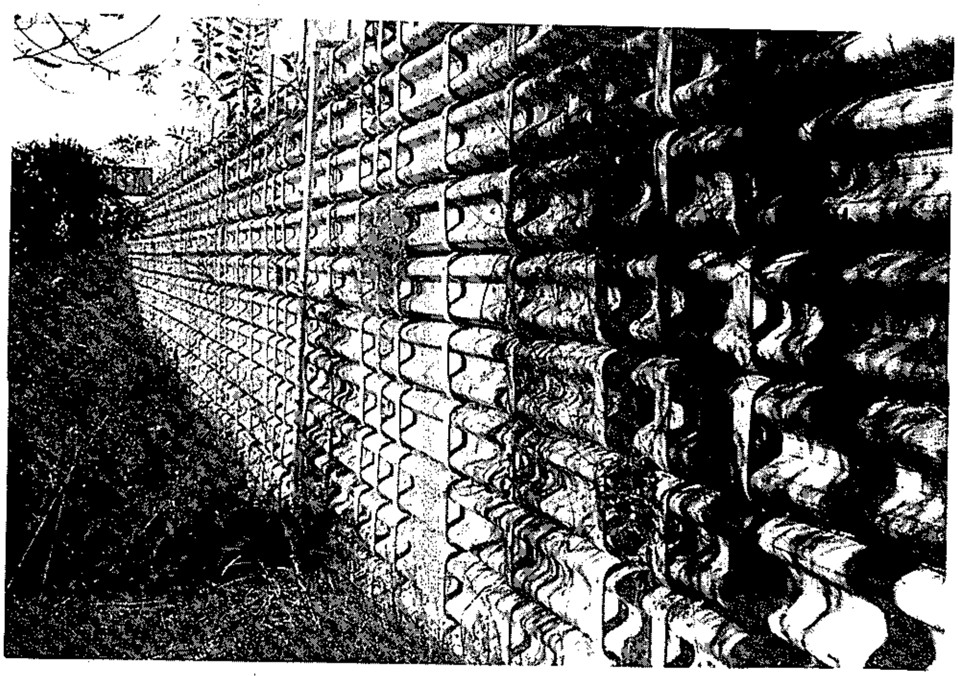




Photos 12 and 13. Position of Reference Points on Wall



1983



1984

Photos 14 and 15. Experimental Tied Back Crib Wall With Salvaged Guardrail Facing

INDEX OF SHEETS

SEE SHEET 5 FOR INDEX OF SHEETS

STATE OF CALIFORNIA
BUSINESS AND TRANSPORTATION AGENCY
DEPARTMENT OF TRANSPORTATION

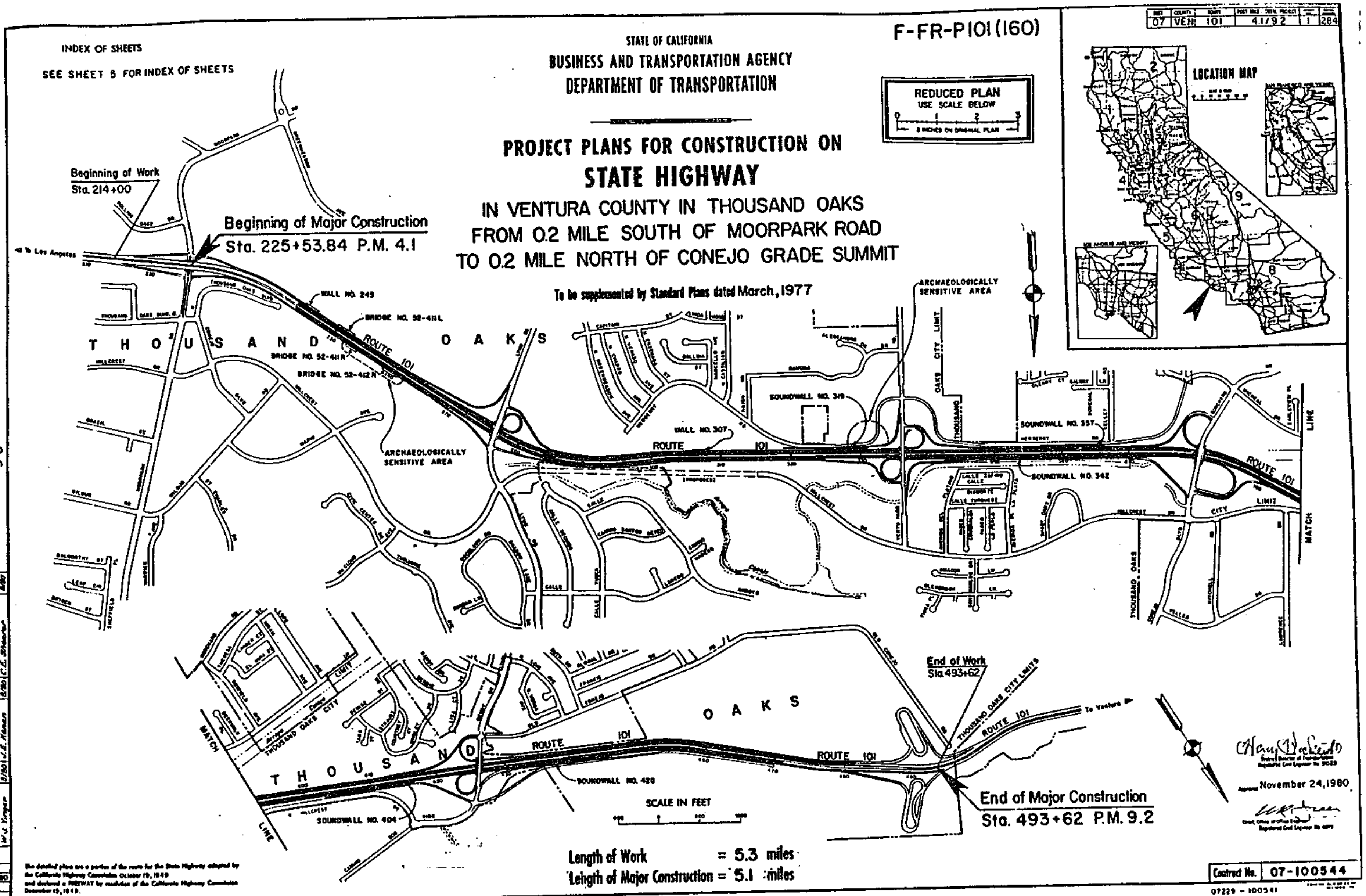
F-FR-P101(160)

PROJECT PLANS FOR CONSTRUCTION ON
STATE HIGHWAY

IN VENTURA COUNTY IN THOUSAND OAKS FROM 0.2 MILE SOUTH OF MOORPARK ROAD TO 0.2 MILE NORTH OF CONEJO GRADE SUMMIT

To be supplemented by Standard Plans dated March, 1977

Dist	County	Route	Post Mile	Sheet	Total
07	VEN	101	4.1/9.2	1	284



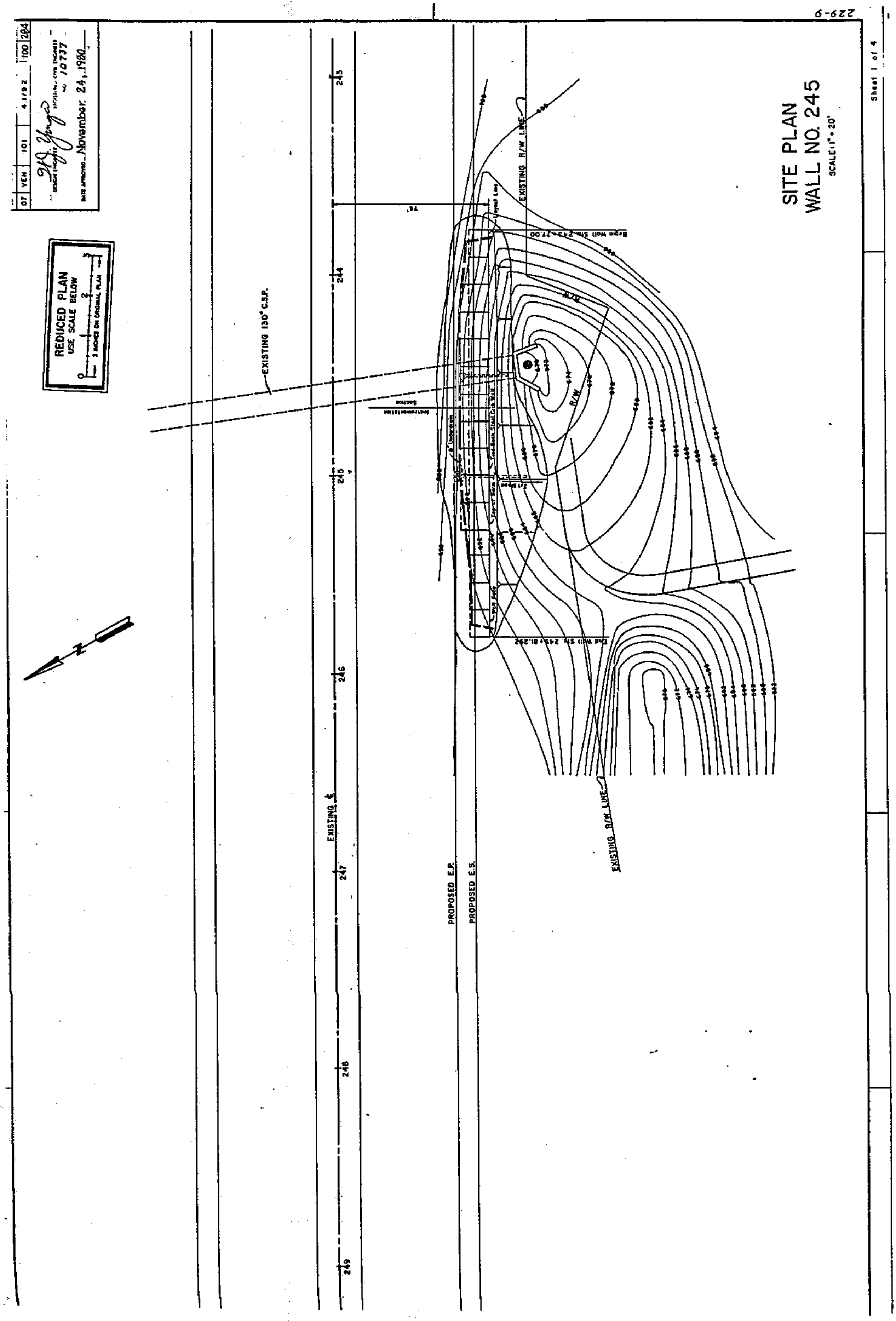
Approved November 24, 1980

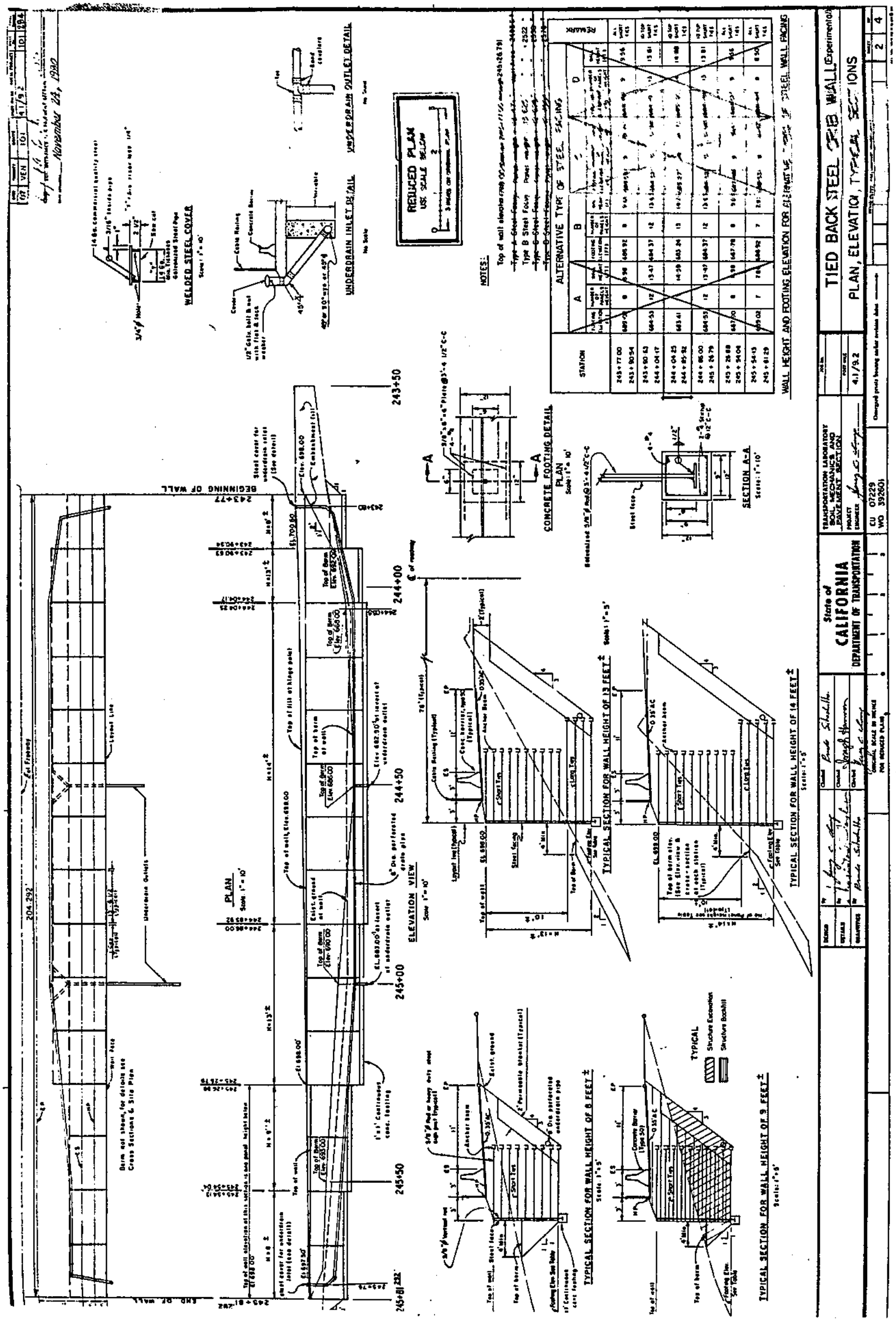
Length of Work = 5.3 miles
Length of Major Construction = 5.1 miles

Contract No. 07-100544

07229 - 100541

FOR REDUCED PLANS ORIGINAL SCALE IS IN INCHES

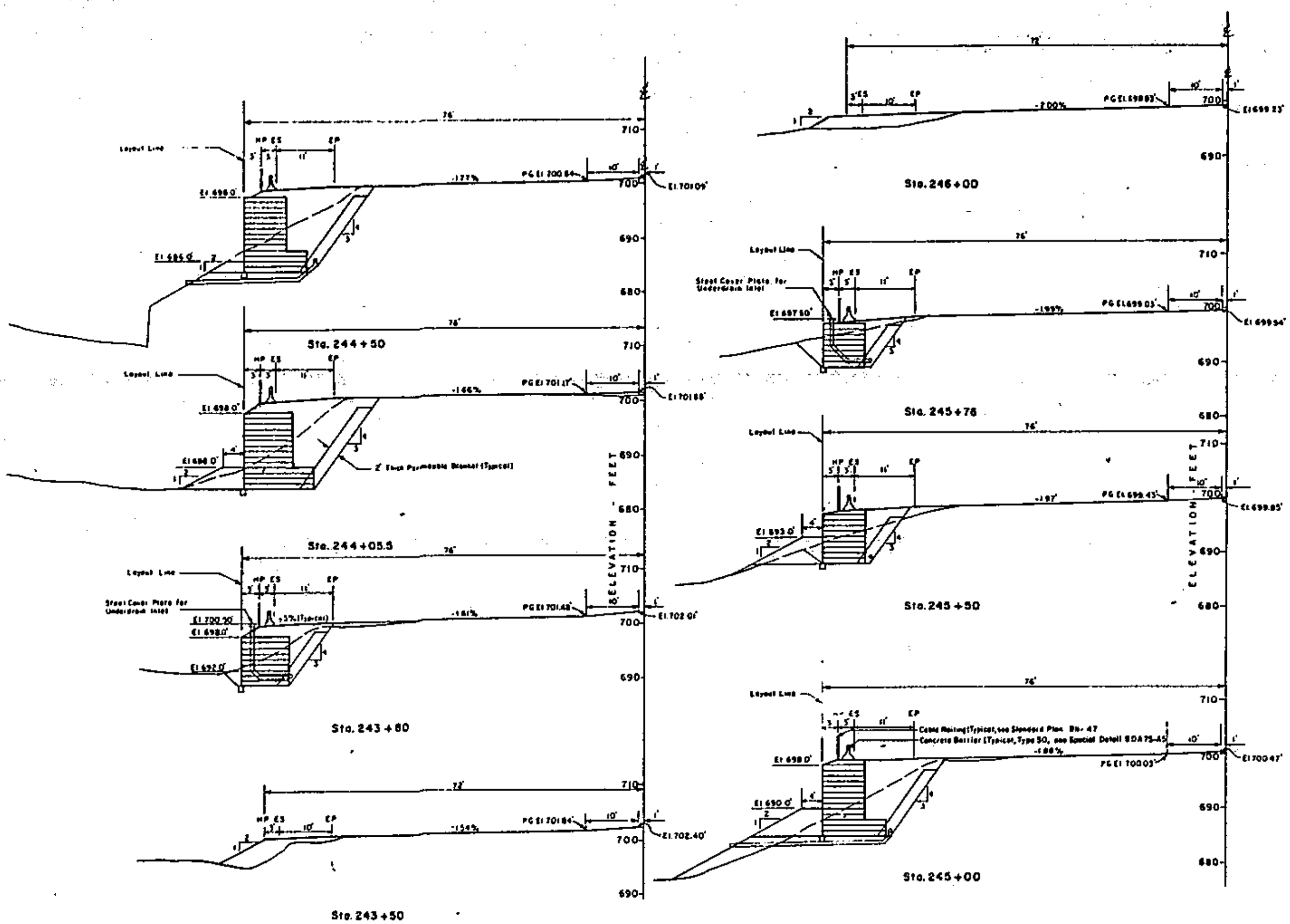

SITE PLAN
WALL NO. 245
SCALE: 1" = 20'
Sheet 1 of 4
229-9
REDUCED PLAN
USE SCALE BELOW
3 INCHES ON ORIGINAL PLAN
November 24, 1980
EXISTING 130" C.S.P.
EXISTING R/W LINE
EXISTING ℄
PROPOSED E.P.
PROPOSED E.S.
R/W
244
245
246
247
248
249



TIED BACK STEEL CRIB WALL (Experimental)
PLAN, ELEVATION, TYPICAL SECTIONS
State of CALIFORNIA
DEPARTMENT OF TRANSPORTATION
TRANSPORTATION LABORATORY SOIL MECHANICS AND PAVEMENT SECTION
CU 07229
WO 392601
REDUCED PLAN
USE SCALE BELOW
PLAN
ELEVATION VIEW
WELDED STEEL COVER
UNDERDRAIN INLET DETAIL
UNDERDRAIN OUTLET DETAIL
CONCRETE FOOTING DETAIL
SECTION A-A
NOTES:
ALTERNATIVE TYPE OF STEEL FACING
WALL HEIGHT AND FOOTING ELEVATION FOR ALTERNATIVE TYPE OF STEEL WALL FACING
TYPICAL SECTION FOR WALL HEIGHT OF 13 FEET ±
TYPICAL SECTION FOR WALL HEIGHT OF 14 FEET ±
TYPICAL SECTION FOR WALL HEIGHT OF 8 FEET ±
TYPICAL SECTION FOR WALL HEIGHT OF 9 FEET ±
BEGINNING OF WALL
END OF WALL

07 | VEN | 101 | 4.1/9.2

November 24, 1980



Note: All cross slopes are -5.00% between EP & HP
Pavement cross slopes are as noted
For footing Elevations see Typical Sections & Elevation View on Sheet 2

REDUCED PLAN
USE SCALE BELOW
3 INCHES ON ORIGINAL PLAN

MATERIAL SCHEDULE

No.	Item	Description	Unit	Quantity
1	Perforated Drain Pipe	6" ϕ fittings inclusive	LF	290
2	Permeable Blanket	2' thick, Class 2	CY	205
3	Steel Cover Plate	For 8" Underdrain Inlet	Ea	2
4	Structure Excavation		CY	1200
5	Structure Backfill for Tied-back Wall		CY	2000

Scale: 1" = 10'

State of CALIFORNIA
DEPARTMENT OF TRANSPORTATION

TRANSPORTATION LABORATORY
SOIL MECHANICS & PAVEMENT BR

4.1/9.2

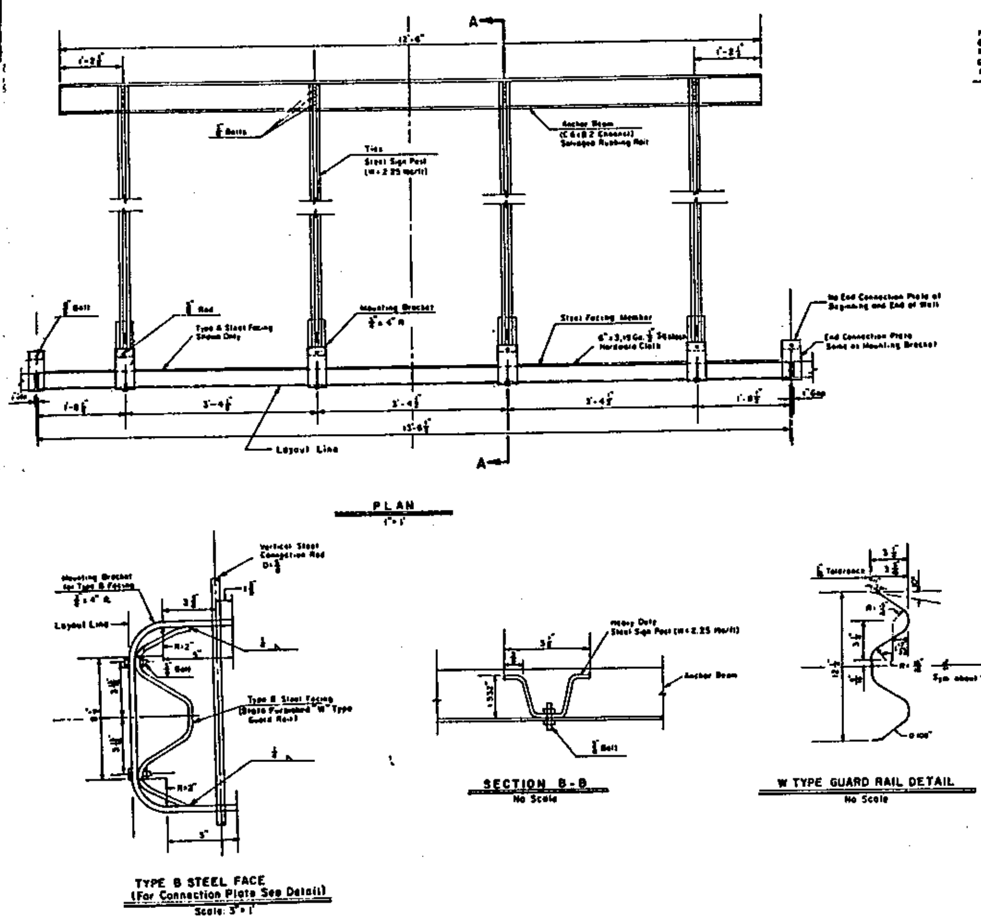
TIED BACK STEEL CRIB WALL (Experimental)

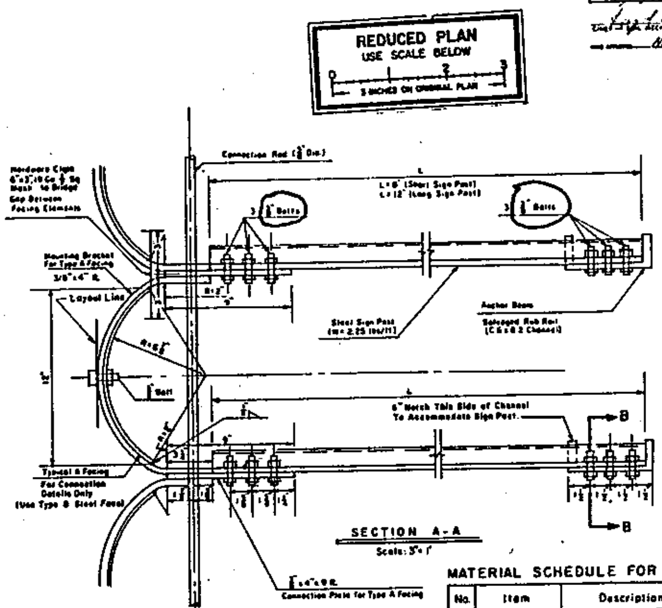
CROSS SECTIONS

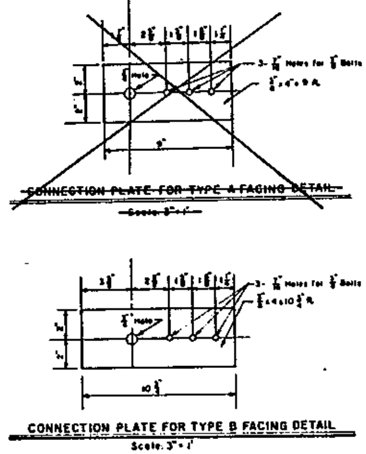
ORIGINAL SCALE IN INCHES FOR REDUCED PLANS

CU
WO

Sheet 3 of 4







MATERIAL SCHEDULE FOR TYPE B STEEL FACING

No.	Item	Description	Unit	Quantity	
~~1~~	~~Type A Steel Facing~~	~~Salvaged Tuthill Guard Rail [illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~
~~2~~	~~Mounting Bracket~~	~~For Type A Steel Facing~~	~~Ea~~	~~[illegible]~~	~~[illegible]~~
~~3~~	~~Vertical Rod~~	~~⅞" ɸ Steel Rod~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~
~~4~~	~~Face Connection Pl.~~	~~For Type A Facing, See Detail~~	~~Ea~~	~~[illegible]~~	~~[illegible]~~
~~5~~	~~Bolts & Nuts~~	~~A 325, ⅝" ɸ [illegible]~~	~~[illegible]~~	~~[illegible]~~	
6	Bolts & Nuts	A 325, ⅝" ɸ w/lock Washer	Set	151	
7	Short Ties	8' Long, Heavy Wt., W=2.25 lbs/ft	Ea	572	
8	Long Ties	12' Long, Heavy Wt., W=2.25 lbs/ft	Ea	144	
9	Anchor Beam	State Furnished Rub Rail C 6x8.2 x 12.5 Channel	Ea	178	
10	Coupling	For ⅞" ɸ Vertical Rod	Ea	100	
11	Hardware Cloth	¼" Mesh, Ga 19, 6" wide x 3' long	Ea	596	
12	Footing Base Plate	⅝" x 6" x 6"	Ea	60	
13	Re-bar	# 4 x 2' Long	Ea	240	
14	Re-bar	# 4 Stirrup, See Detail	Ea	120	
15	Concrete Footing	1' x 1' Continuous	C Y	8	

MATERIAL SCHEDULE FOR TYPE B STEEL FACING

1	Type B Steel Facing	State Furnished "W" Type Guard Rail	Ea	164	
2	Mounting Brackets	For Type B Steel Facing	Ea	807	
3	Vertical Rods	⅞" ɸ Steel Rod	Ft	785	
4	Face Connection Pl.	For Type B Facing, See Detail	Ea	718	
5	Bolts & Nuts	A 325, ⅝" ɸ w/lock Washer	Ea	5608	

DIST	COUNTY	ROUTE	POST MILES—TOTAL PROJECT	SHEET	TOTAL SHEETS
07	VEN	101	4.1/9.2		

November 24, 1980

State of
CALIFORNIA
DEPARTMENT OF TRANSPORTATION

TRANSPORTATION LABORATORY
SOIL MECHANICS & PAVEMENT BR

POST MILE 4.1/9.2

TIED BACK STEEL CRIB WALL (Experimental)

FACING – TIE – ANCHOR BEAM – CONNECTION DETAILS

SHEET 4 OF 4

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS

CU
WO

10-1.33 TIED-BACK STEEL CRIB WALL.--The tied-back steel crib wall consists of steel facing members, horizontal steel ties, and anchor beams with backfill behind the face members. The horizontal steel ties connect to the facing members with a mounting bracket and connection plate by vertical steel rods and bolts, nuts and lock washers and connect to the anchor beam with bolts, nuts and lock washers as shown in detail on the plans and as specified in these special provisions.

STEEL FACING MEMBERS.--Steel facing members consist of State-furnished "W" type guard rail as shown in detail on the plans.

HORIZONTAL STEEL TIES.--Horizontal steel ties shall conform to the shape and minimum unit weight as shown on the plans. Horizontal steel ties shall be hot-rolled high carbon steel and shall conform to the specifications of ASTM Designation: A 499 and shall be galvanized.

VERTICAL STEEL RODS.-- The vertical steel rod shall conform to the specifications of ASTM Designation: A 36. All steel vertical rods shall be galvanized. Each vertical steel rod shall have a minimum length of 5 feet and shall be connected with threaded couplings to conform to the required total length.

MOUNTING BRACKETS, CONNECTION PLATES AND BASE PLATES.--All mounting brackets, connection plates and base plates shall be steel plates conforming to the details shown on the plans. The steel plates shall conform to the specifications of ASTM Designation: A 36 and shall be galvanized. Mounting brackets shall be bent in accordance with the provisions in Section 55-3.07, "Bent Plates," of the Standard Specifications.

ANCHOR BEAM.--Anchor beams consisting of salvaged rub rail (C6x8.2 channel) will be furnished by the State.

BOLTS, NUTS AND WASHERS.--All bolts and nuts shall conform to the specifications of ASTM Designation: A 307 unless otherwise specified in the special provisions or shown on the plans. All bolts, nuts, and washers shall be galvanized. All bolts shall be tightened as directed by the Engineer.

WELDING.--All welding shall conform to the provisions in Section 56-1.04, "Welding," of the Standard Specifications.

GALVANIZING.--All galvanizing shall conform to the provisions in Section 75-1.05, "Galvanizing," of the Standard Specifications.

BAR REINFORCEMENT.--Reinforcing bars shall conform to the specifications of ASTM Designation: A 615, Grade 40 and be placed in accordance with the size and spacing shown on the plans.

CONCRETE FOOTING.--The concrete footing shall conform to the provisions in Section 51, "Concrete Structures," and Section 90-10, "Minor Concrete," of the Standard Specifications and shall contain not less than 564 pounds of cement per cubic yard.

EARTHWORK.--Earthwork shall consist of structure excavation and structure backfill conforming to the provisions in Section 19-3, "Structure Excavation and Backfill," of the Standard Specifications.

The structure backfill material for the tied-back steel crib wall shall consist of selected material and shall be free from stones or lumps exceeding one inch in greatest dimension, organic material, or other unsuitable material, as determined by the Engineer. In addition, backfill material shall be non-plastic as determined by California Test 204.

Structure backfill material shall be placed and compacted simultaneously with the erection of the facing members. Placement and compaction of the structure backfill material shall be accomplished without distortion of the facing members, the horizontal tie rods, or horizontal steel ties, and the anchor beams.

Structure backfill material shall be placed in layers of uniform thickness and shall be compacted to a relative compaction of not less than 90 percent, as determined by California Test 216. The loose thickness of each layer of backfill shall not exceed 0.67-foot before compaction.

Sheepfoot or grid type rollers shall not be used for compacting structure backfill material within the limits of the tied-back steel crib wall. Hand-held or hand-guided compacting equipment shall be used within 2 feet of the facing members. All horizontal tie rods or horizontal steel ties and anchor beams shall be placed on roughly leveled compacted material as directed by the Engineer and shall have soil covering not less than 6 inches prior to compaction of the next lift of structure backfill.

The top 2 feet of the structure backfill material between the face of the wall and the excavated slope shall be compacted impervious material as determined by the Engineer.

PERMEABLE BLANKET.--The permeable blanket shall be placed against the cut slope as shown on the plans. The permeable material for the blanket shall conform to the provisions for Class 2 permeable material in Section 68-1, "Underdrains," of the Standard Specifications.

MEASUREMENT AND PAYMENT.--The tied-back steel crib wall will be measured and paid for by the square foot at the outer face of the wall for the full wall height from the top of the footing to the top of the top facing members and for the full wall length from the beginning to the end of wall as shown in the plans.

The contract price paid per square foot for tied-back steel crib wall (Type B facing) shall include full compensation for furnishing all labor, materials (except State-furnished steel facing members and anchor beams), tools, equipment and incidentals and for doing all the work involved in constructing the tied-back steel crib wall, including excavation and backfill, permeable material and research investigations, as shown on the plans, as specified in the Standard Specifications and these special provisions and as directed by the Engineer.

COST ESTIMATE FOR TIED BACK STEEL CRIB WALL WITH TYPE B FACING
ROAD 07-VEN-101-4.1/9.0

No.	Item	Description	Unit	Quantity	Unit Cost $	Total Cost $
1	Type B Steel Facing	Salvaged W-Type Guard Rail	Ea	164	10	1,640
2	Mounting Brackets	For Type B Steel Facing	Ea	807		4,877
3	Vertical Rods	$\frac{5}{8}$" ϕ Steel Rod	Ft	777		218
4	Face Connection PL	For Type B Facing, See Detail	Ea	716		2,528
5	Bolts & Nuts	A 307, $\frac{3}{8}$" ϕ x 3"	Ea	4952		503
6	Bolts & Nuts	A 307, $\frac{5}{8}$" ϕ x 3"	Set	151		58
7	Sign Posts	8' Long, Heavy Duty W=2.25 lbs/ft	Ea	572	4.76	2,723
8	Sign Posts	12' Long, Heavy Duty W=2.25 lbs/ft	Ea	144	7.14	1,028
9	Anchor Beam	Salvaged Rub Rail C 6x8.2x12.5 Channel	Ea	179	10	1,790
10	Coupling	For $\frac{5}{8}$" ϕ Vertical Rod	Ea	100		56
11	Hardware Cloth	$\frac{1}{2}$" Mesh, Ga 19, 6" wide x 3' long	Ea	596		372
12	Footing base Plate	$\frac{5}{8}$" x 6" x 6"	Ea	60		250
13	Re-bar	# 4 x 2' Long	Pond	321		160
14	Re-bar	# 4 Stirrup, See Detail	Pond	330		165
15	Concrete Footing	1' x 1' Continuous	C.Y.	8	250	2,000
16	Roadway Excavation		C.Y.	1200	6.00	7,200
17	Embankment Backfill		C.Y.	2000	6.00	12,000
18	8" Drain Pipe		LF	290	10.00	2,900
19	Permeable Material	Class 2	C.Y.	205	27.00	5,535
					Total	$46,000

Total Wall Face Area = 2493 sq. ft.

$\frac{\$46000}{2493}$ = $18.50/sq. ft.