# BRUGG CABLE MESH ROCKFALL FENCE

## CONSTRUCTION REPORT

Experimental Features
Project No. OR 90-03

Shellrock Mountain
Columbia River Highway (Interstate 84)
Hood River County
Federal Aid # IR-84-2(31) 052

by

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**Oregon Department of Transportation**

**Prepared for**

**Oregon Department of Transportation**
**Salem, Oregon 97310**

**and**

**Federal Highway Administration**
**Washington, D.C. 20590**

**May 1992**

# ABSTRACT

The Brugg Cable Mesh Rockfall Fence was installed in 1991 along I-84 from MP 52.1 to 52.7 to prevent large (>3 foot diameter) rocks from entering the travel lanes. This was one of the first major installations of the Brugg Cable Mesh Rockfall Fence in the United States and it was a FHWA experimental features project. The fence is a patented proprietary item and consists of cable mesh attached to H-beam posts that incorporate a friction brake. The fence was installed in the Columbia River Gorge Scenic Area; to minimize its visual impact, it was painted a dark earth tone.

The bid price of installing the fence was $27.00 per square foot face. Even though this was the contractor's first installation, both the contractor and the Oregon Department of Transportation (ODOT) inspector considered the constructability very easy.

# ACKNOWLEDGEMENTS

Recognition needs to be given to the numerous ODOT personnel involved with the development and construction of this experimental features project, especially Glen Fleming (Location Project Designer), Mary Goldberg (Final Project Design), and Marge West (Assistant Project Manager, Construction). I would also like to thank Rich Watanabe (ODOT Geotechnical Team Leader) and Ron Chassie (FHWA Geotechnical Engineer Region 8) for their time and consideration in reviewing this report.

# DISCLAIMER

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# 1.0 INTRODUCTION

On a section of Interstate 84 (I-84), large boulders fall on to the travel lanes creating a significant safety hazard. A Brugg Cable Mesh Rockfall Fence was installed to eliminate this hazard. Since this was one of the first major installations of the Brugg Fence on a United States interstate highway and was also installed in an environmentally sensitive area, the project was designated as a Federal Highway Administration (FHWA) experimental features project. The evaluation of the construction, cost, visual impact, maintenance, and rockfall effectiveness will be documented in this report.

The Brugg Fence consists of cable mesh attached to steel H-beam posts with cables that incorporate a friction brake. This is then draped with gabion mesh to prevent smaller rocks from passing through the fence. The Brugg Cable Mesh Rockfall Fence is a patented proprietary item and all design standards, specifications, and plans for this project were provided by:

Brugg Cable Products, Inc.
R.R. 16 Box 197E 11 East Frontage Road
Santa Fe, New Mexico 87505

The cable mesh fence was installed from MP 52.1 to 52.7 along eastbound I-84, Columbia River Highway (Highway No. 2) as shown in Figure A.1. I-84 travels along the base of Shellrock Mountain in this area. Construction of the fence began at the end of April, 1991 and was completed in October, 1991.

# 2.0 BACKGROUND

Shellrock Mountain is a volcanic neck of dacite intrusive rock. Around the volcanic neck is a 1,500 foot high talus slope (Figure A.2). Due to natural erosion processes, one to three foot diameter rocks fall from the cliffs above the talus and roll down the talus slope.

A metal bin wall of varying heights was installed in 1964 along the shoulder to act as a rock fallout area (Figure A.3). It was only partially effective and approximately every two to three years one or more large diameter rocks entered the eastbound travel lanes of I-84. These events generally occurred where the existing rock fallout area was less than seven feet high. The Brugg Cable Mesh fence was installed along the top of the existing bin wall in areas where the existing rock fallout width and depth were inadequate.

This project is located in the Columbia Gorge Scenic Area. The Columbia River Gorge Commission must approve all highway designs in this area, therefore, the appearance of the fence was very important. Remnant segments of the Historic Columbia River Highway exist behind the bin wall and it was critical that it was not damaged and future development impeded by the fence installation.

The criteria for selecting the Brugg Cable Mesh Fence over other mitigation options were the following:

1. Prevention of large diameter rocks from entering the I-84 travel lanes.
2. Maintenance and repair had to be low in cost and easily performed by maintenance crews.
3. Cost effective in comparison to other equally effective mitigation measures.
4. Minimal visual impact.
5. Constructable on top of the existing bin walls.
6. Minimal disruption to the existing talus slope environment.
7. No damage to or prevention of future development of the remnant segments of the Historic Columbia River Highway.

This construction report only evaluates items three through seven of these criteria.

# 3.0 DESIGN AND COSTS

## 3.1 DESIGN

The design and specifications for this experimental features project were provided by Brugg Cable Products and are given in Appendix B. The special provisions are given in Appendix C. The fence on this project was designed to withstand a rock impact energy of 75 ft.-tons. Achieving a minimum rock fallout area depth of ten feet determined the fence height.

The standard Brugg Cable Mesh Rockfall Fence design includes tieback anchors at each column with a friction brake. The tie-back anchors which are usually located on the up slope side of the fence, were eliminated from the fence at Shellrock Mountain because the tiebacks would have damaged and prevented future development of the remnant segments of the Historic Columbia River Highway. The strength of the fence columns and their brake away elements were increase to compensate for the loss of the tie-backs.

## 3.2 COSTS

The original total bid price for this project was $468,882. There were only two contract bid items for this project (Appendix D). All components for fence installation were bid for square foot face of the fence, at $27/ft$^2$. For payment purposes, estimates were made by the contractor for separate components of fence installation. These unit costs and quantities are presented in Table 3.1.

**Table 3.1: Payment Estimates for Materials and Installations**

| ITEM | QUANTITY | UNIT COST | TOTAL COST |
|---|---|---|---|
| Footings | 115 ea. | $600/ea. | $69,000 |
| Columns | 115 ea. | $750/ea. | $86,250 |
| Fence | 16,615 ft$^2$ | $17.656/ft$^2$ | $293,355 |
| **TOTAL** | | | **$448,605** |

The final costs for the materials and installation of the Brugg Cable Mesh Rockfall Fence at Shellrock Mountain including the unanticipated costs are summarized in Table 3.2:

**Table 3.2: Final Costs for Brugg Fence Installation**

| ITEM | QUANTITY | UNIT COST | TOTAL COST |
|---|---|---|---|
| Entire fence installation | 16,615 $ft^2$ | \$27/$ft^2$ | \$448,605 |
| Temporary protection and direction of traffic | | | \$49,393 |
| Unanticipated costs - Additional excavation required to provide permanent access behind wall and paint gabion mesh | | | \$4,970 |
| **TOTAL** | | | **\$502,968** |

There were two other equally effective mitigation options considered during the preliminary design for this project. These were constructing a ten foot gabion wall on the existing bin wall estimated at \$380,000, and installing two new sections and extending the existing bin wall to a minimum ten foot height estimated at \$570,000. These costs do not include temporary protection and direction of traffic. The visual impact of these options was considered unacceptable by the Columbia River Gorge Commission and therefore, not viable options.

# 4.0 INSTALLATION

## 4.1 VISUAL IMPACT

The entire fence was painted with a color selected by a Forest Service Representative for the Columbia River Gorge Commission. All parts of the fence were treated in the factory for corrosion. The mesh was then painted in the Contractor's yard and all remaining parts (columns, bracing rope, etc.) were painted in the field after installation. The contract specified that the gabion mesh not be painted. Once installed, the unpainted gabion mesh dominated the visual appearance of the fence. The gabion mesh was then spray painted in the field the same color as the rest of the fence. This improved the fence's appearance as illustrated in Figure A.4 showing the transition between painted and unpainted gabion mesh. The final fence only minimally affects the visual corridor in this area (Figure A.5).

## 4.2 CONSTRUCTION

Installing the Brugg Cable Mesh Rockfall Fence on the top of the bin wall created the following design and construction concerns:

1. Installation of the footing into the center of the bins required excavation into coarse granular backfill material.
2. Concern for damage to the face of the bin wall from construction activities.
3. Concern that during a rockfall event, a detached fence component might damage the face of the bin wall.
4. Constructability problems due to the large variations in the profile of the top of the bin wall.

The specified cast in place footing for the fence columns (Appendix B) was replaced prior to construction with 3' x 3' pre-cast footings (see Figure A.6). Due to the type of material excavated, the pre-cast footing allowed an easier installation with no concrete waste. Only one incident of minor damage to the bin wall cap was reported during construction.

The top profile of the bin wall stepped up and down throughout its length (see Figure A.7 for a profile detail of the bin wall). The variations required specially designed posts and mesh sections. There were fourteen different mesh sections details and fourteen different column details because of the profile variations. Due to inaccuracies in the wall profile used for design, it was necessary to redesign most of the rockfall fence after the contract was awarded. Of the 110 mesh sections, it was necessary to change 83 and add four sections and change all necessary columns accordingly. The required changes are shown in Figure A.8.

We learned that an accurate profile of the ground surface exactly where the fence will be constructed is essential to the accuracy of the design.

The construction sequence and time for each activity are given in Table 4.1. Figures A.9 through A.13 illustrate the construction sequence.

The completed fence is shown in Figure A.14. One other construction design change was at the east end of the project where the footings had to be installed in rock instead of in the bin wall. This included a total of one different bracing rope anchor detail (Figure A.15), and two different footings details (Figure A.16). Also, the length and orientation of the bolt on the post (Appendix B, Sheet 2A-11) was reversed because the bolt was too short.

**Table 4.1: Construction Sequence and Times**

| ACTIVITY | DESCRIPTION | WORK DAYS |
|---|---|---|
| Pour Precast Footings | Done in the contractor's yard. | 9 wk days<br>4/18/91 - 5/2/91 |
| Excavate and Set Footings<br>(Figures A.9 and A.10) | Excavate with backhoe, make leveling pad, place pre-cast footings, backfill material. | 7 wk days<br>5/6/91 - 5/14/91 |
| Attach Columns to Footings | Attach base plate leveled with grout, anchor factory primed columns and break-away assembly. | 9 wk days<br>5/23/91 - 6/4/91 |
| Paint Columns and Fence | Paint: Spar enamel Miller Paints #2500 series. Spray paint columns at site. Spray paint cable mesh sections in yard to minimize wastage. Spray paint remaining parts of fence painted after they are attached to the fence. | 10-14 wk days<br>6/5/91 - 7/30/91 |
| Attach Wire Bracing and Perimeter Rope<br>(Figure A.11) | Attach 5/8-inch rope, tension with 2 ton come-along, fasten with thimble and 4 cable clips tightened to 3.36 ft-lbs, install friction brakes with torque wrench. | 4 wk days<br>6/3/91 - 6/6/91 |
| Attach Cable Mesh Sections<br>(Figure A.12) | Lace mesh with 5/16-inch seam rope to perimeter rope. | 8 wk days<br>8/6/91 - 8/13/91 |
| Attach Gabion Mesh<br>(Figure A.13) | Hog clip gabion mesh to fence, leave a 5-foot drape at bottom. | 5 wk days<br>8/26/91 - 8/30/91 |
| Paint gabion mesh | Spray paint gabion mesh in field. | 2 wk days |
| Excavate access road | Use a small cat to even out fallout area behind fence to provide access and increase depth of fallout area. | 2 wk days |

# 5.0 CONCLUSIONS

This was the first Brugg Cable Mesh Rockfall Fence installation for the contractor. The contractor along with the ODOT inspectors considered its constructability to be very easy. Their only problem was spray painting on site; it was difficult due to the high winds common in this area. To have an accurate fence design for construction, it is critical to have an accurate profile of the ground surface where the fence will be located.

# APPENDIX A

## FIGURES

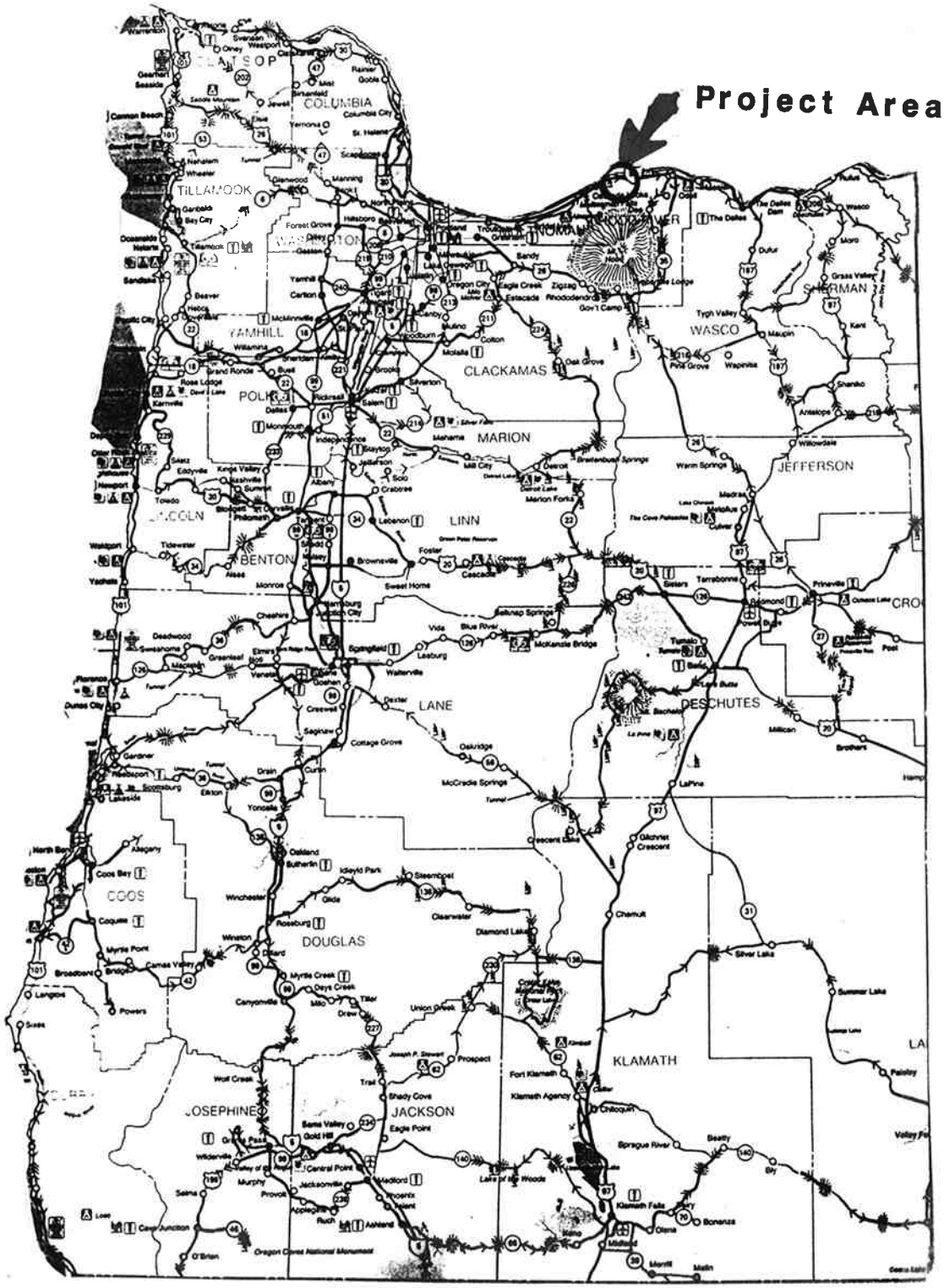



**Figure A.1: Project Location**

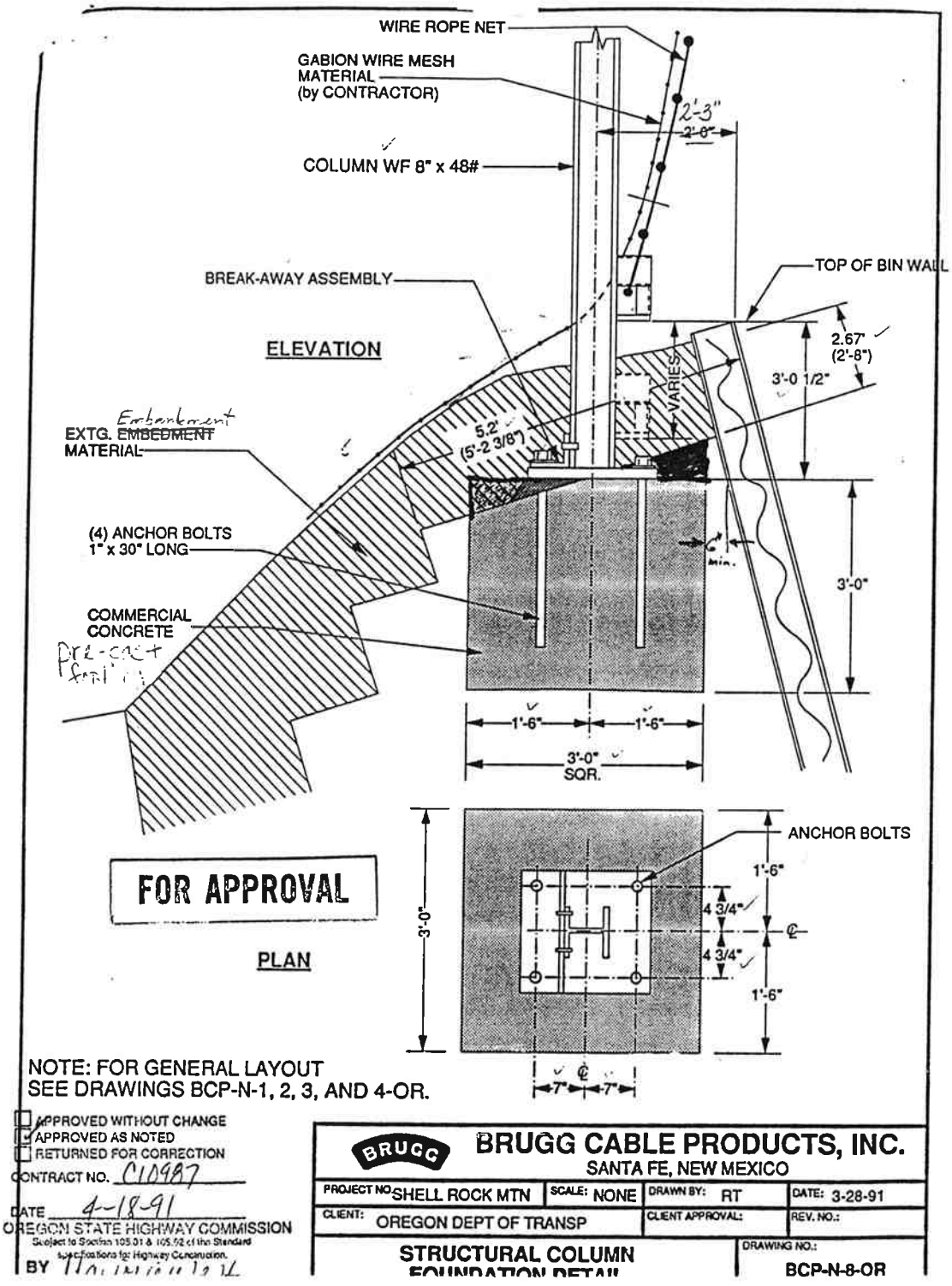
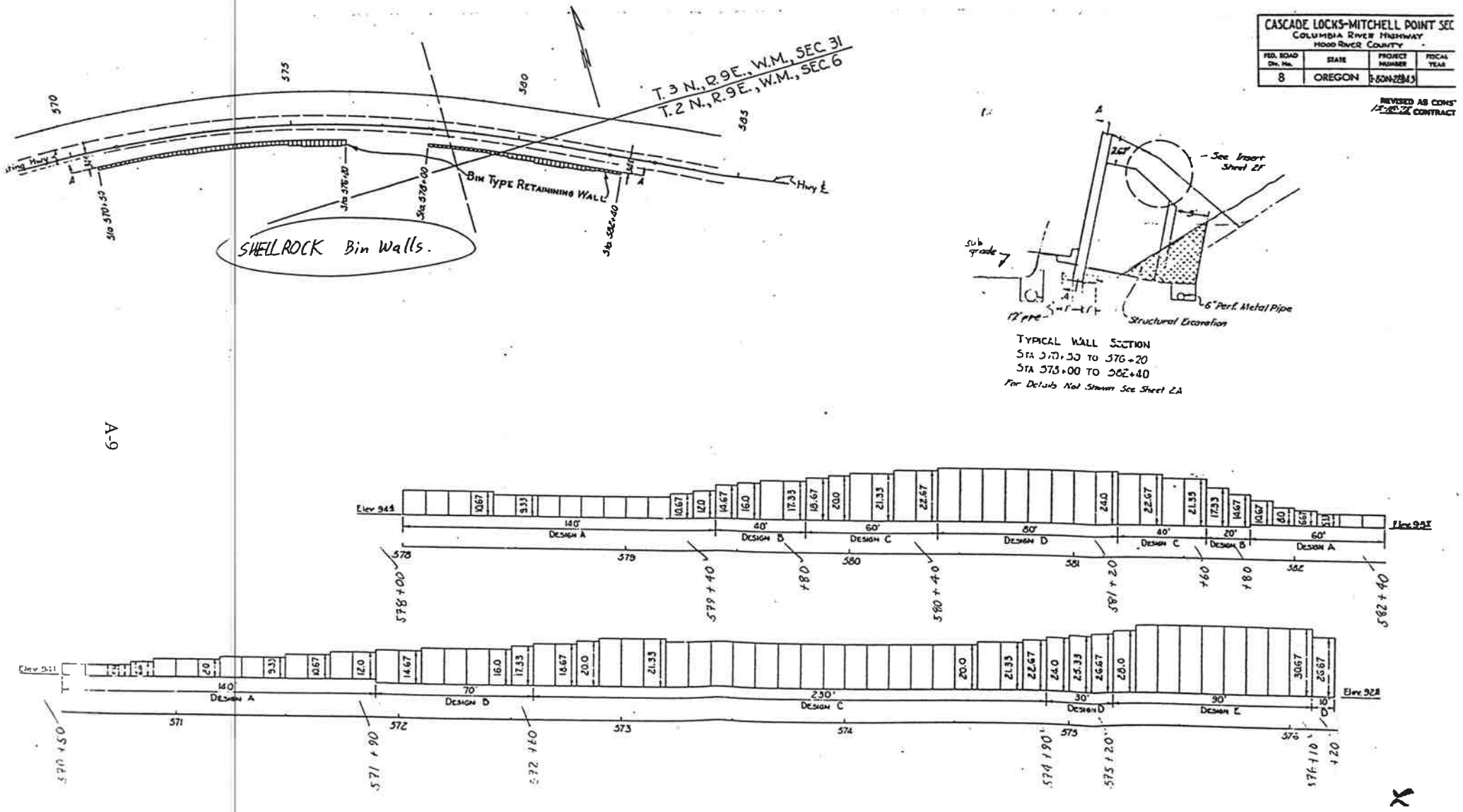



**Figure A.6: Pre-cast footing detail.**




A-9

**Figure A.7: Existing bin wall profile.**

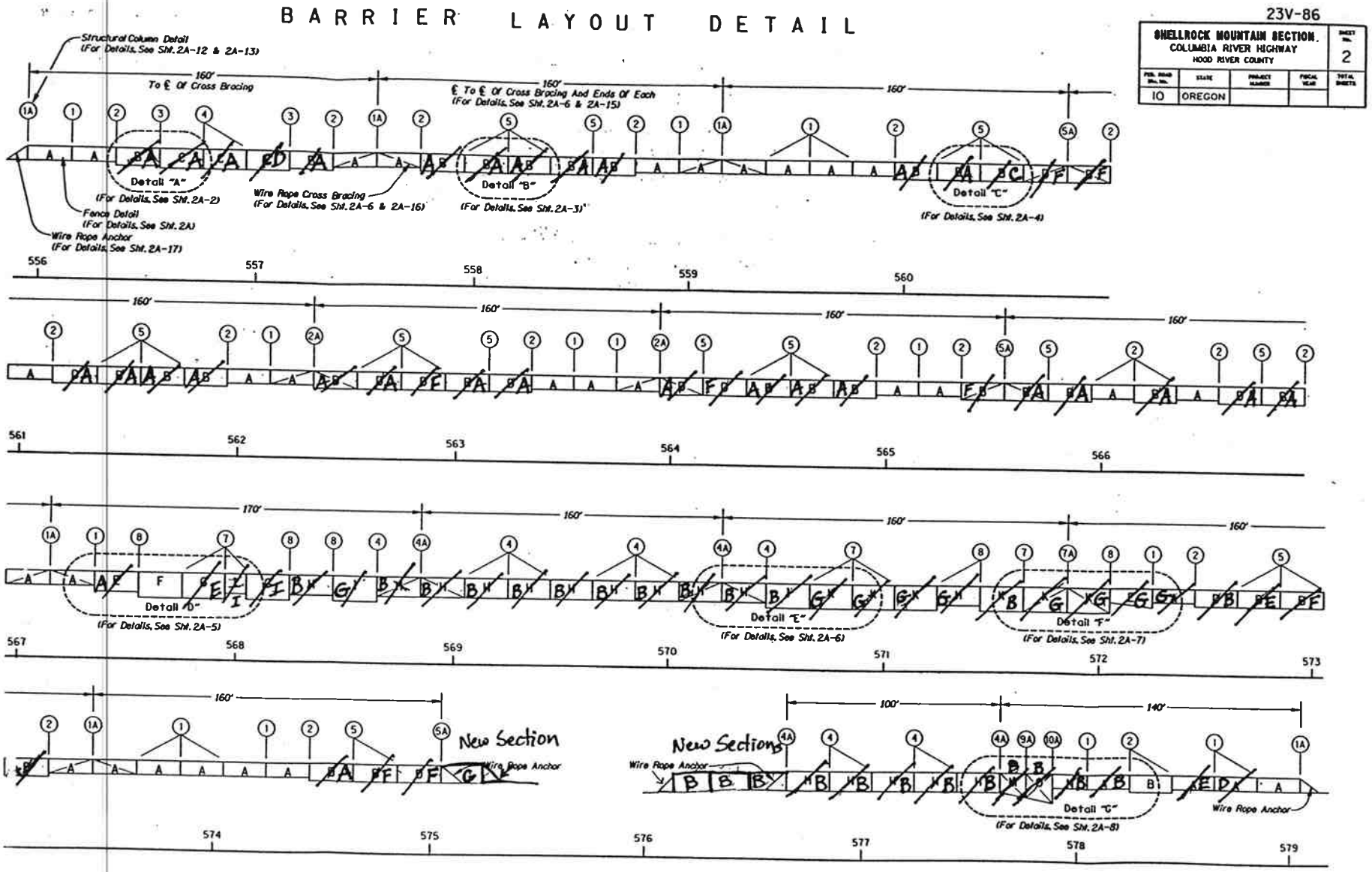



Figure A.8: Detail of mesh section changes.

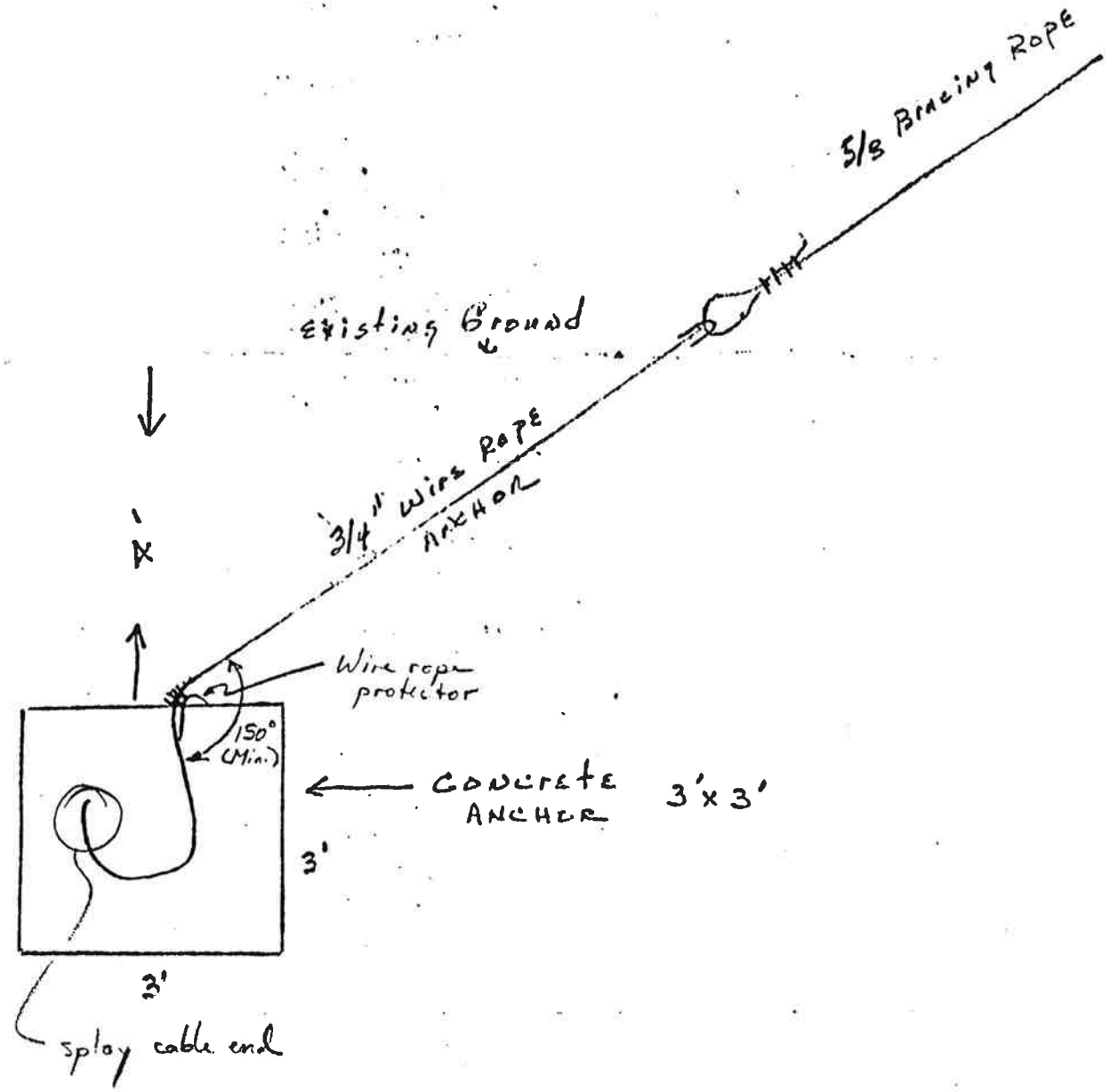
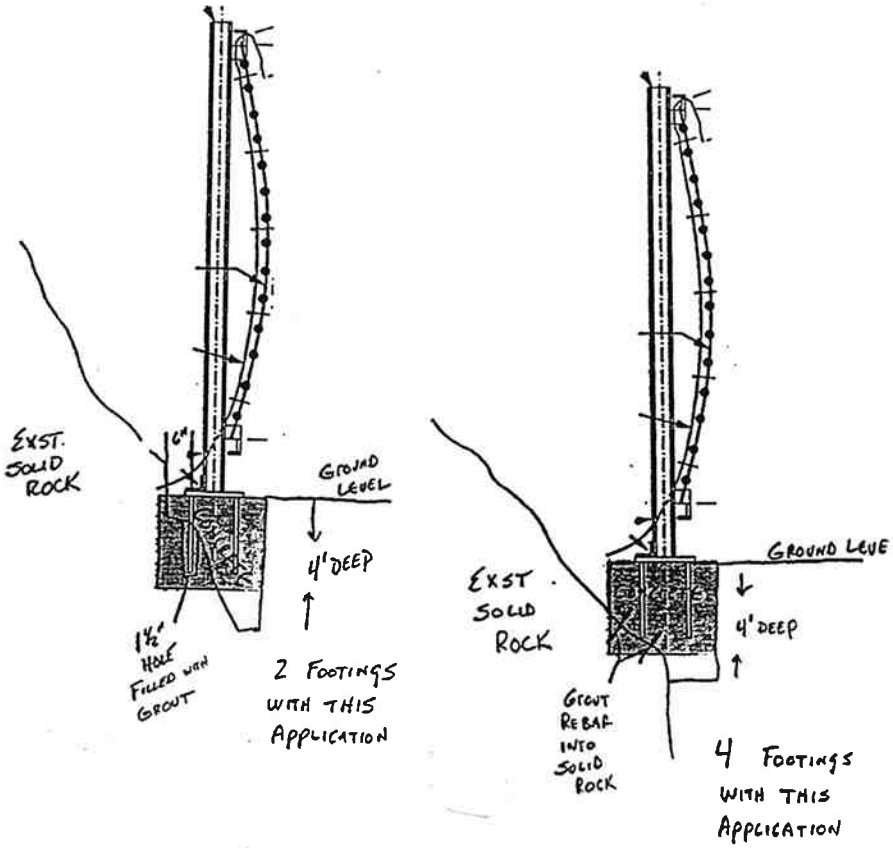



**Figure A.15: Alternative anchor detail**

**Coral Construction Company**

SPECIALTY HIGHWAY AND GENERAL CONTRACTORS

P.O. Box 347
Wilsonville, Oregon 97070
Phone (503) 682-2252
Fax (503) 682-0110




☑ APPROVED WITHOUT CHANGE
☐ APPROVED AS NOTED
☐ RETURNED FOR CORRECTION

CONTRACT NO. C10987

DATE _____

OREGON STATE HIGHWAY COMMISSION
Subject to Section 105.01 & 105.02 of the Standard Specifications for Highway Construction

BY _____

Contractor's Licenses AK AA04706; AZ 069377-008 \ 332441A; ID 5944-AAA-4, MT 4413A; NV 0017757A; OR 62616; UT 0000394303; WA CORALCC211NZ

Figure A.16: Footings in rock

# APPENDIX B

## PLANS

23V-86

| SHELLROCK MOUNTAIN SECTION<br>COLUMBIA RIVER HIGHWAY<br>HOOD RIVER COUNTY | | | | SHEET No. 1 |
|---|---|---|---|---|
| FED. ROAD Div. No. | STATE | PROJECT NUMBER | FISCAL YEAR | TOTAL SHEETS |
| 10 | OREGON | IR-84-2(31)052 | | |

| INDEX OF SHEETS | | |
|---|---|---|
| SHEET NO. | DESCRIPTION | |
| 1 | Title Sheet | |
| 2, 2A, 2A-2 Thru 2A-17 Incl. | Details | |
| 2B | Summary | |
| 3, 4 | Plan | |

REGISTERED PROFESSIONAL ENGINEER — OREGON — JULY 14, 1972 — JOHN W. SULLIVAN

Drg. Nos.
S-1, S-6, S-12, 2126C, 2200, 2202, 2204 — Temporary Protection And Direction Of Traffic

STATE OF OREGON

# DEPARTMENT OF TRANSPORTATION

STATE HIGHWAY DIVISION

PLANS FOR PROPOSED PROJECT

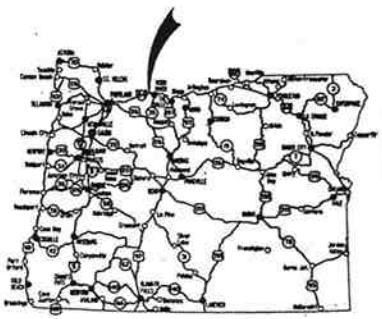
## ROCKFALL PROTECTION FENCE

# SHELLROCK MOUNTAIN SECTION

## COLUMBIA RIVER HIGHWAY

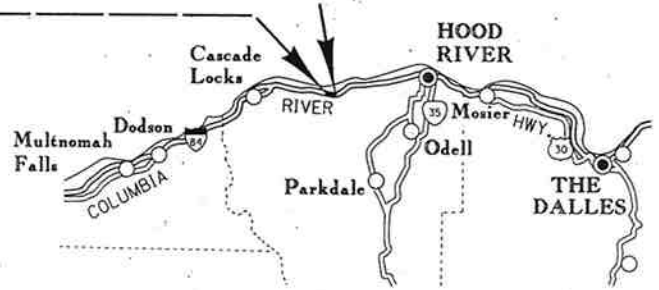
### HOOD RIVER COUNTY

### OCTOBER, 1990



**END OF PROJECT IR-84-2(31)052**
**STA. 579+50 (M.P. 52.6)**

**BEGINNING OF PROJECT IR-84-2(31)052**
**STA. 555+50 (M.P. 52.1)**




N

OREGON TRANSPORTATION COMMISSION

| | |
|---|---|
| Michael P. Hollern | CHAIRMAN |
| John Whitty | VICE CHAIRMAN |
| David F. Bolender | COMMISSIONER |
| Cynthia J. Ford | COMMISSIONER |
| Roger L. Breezley | COMMISSIONER |
| Robert N. Bothman | DIRECTOR OF TRANSPORTATION |

REGISTERED PROFESSIONAL ENGINEER — 4388 — OREGON — MAY 5, 1972 — DUANE O. CHRISTENSEN

Duane O. Christensen

PROJECT DEVELOPMENT ENGINEER

2021100.10303561FDT51 21-Sep-1990 1403

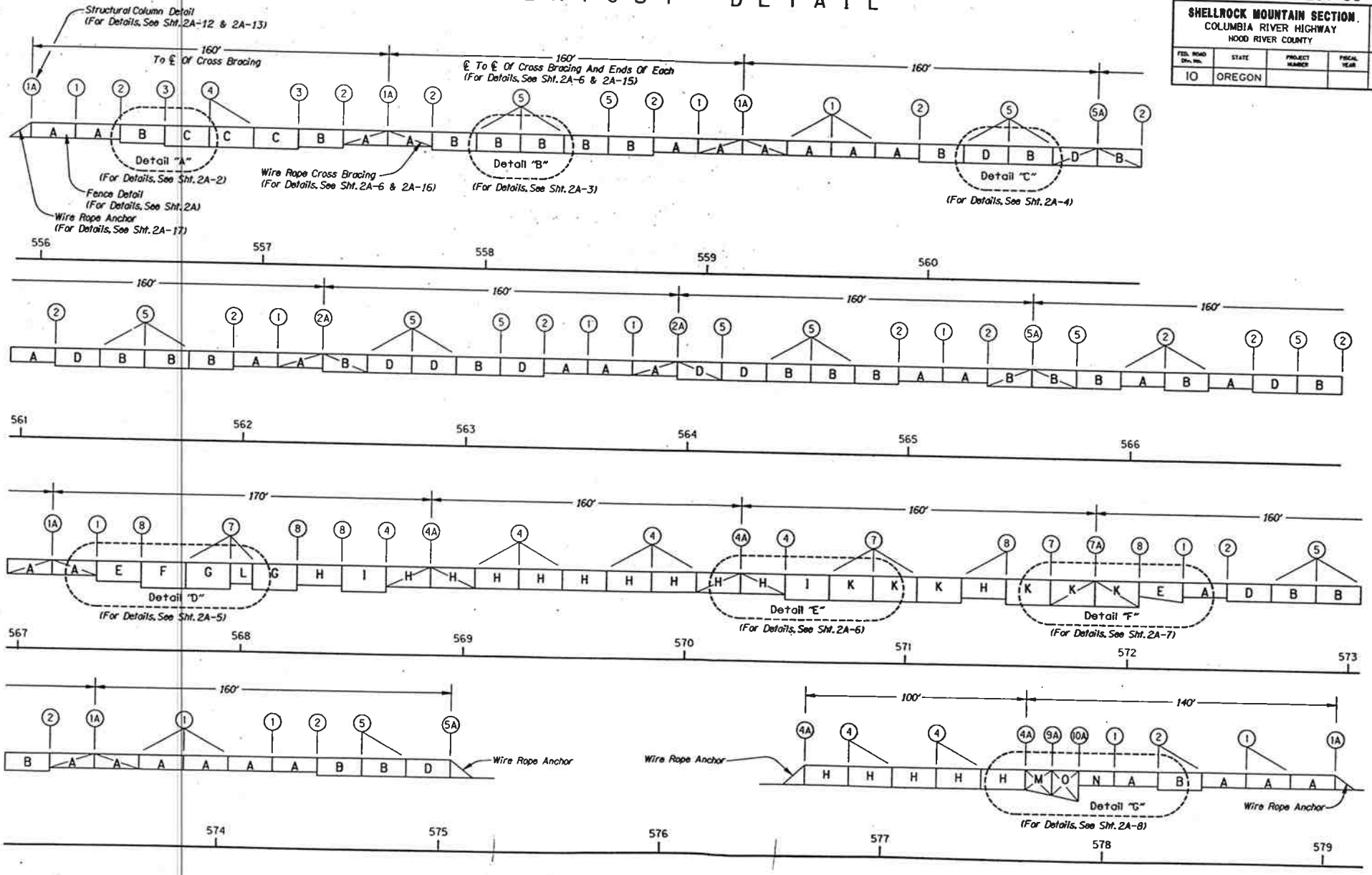
VIEW-A5

# BARRIER LAYOUT DETAIL

23V-86

| SHELLROCK MOUNTAIN SECTION. COLUMBIA RIVER HIGHWAY HOOD RIVER COUNTY | | | | SHEET No. 2 |
|---|---|---|---|---|
| FED. ROAD DIV. NO. | STATE | PROJECT NUMBER | FISCAL YEAR | TOTAL SHEETS |
| 10 | OREGON | | | |

R/W Map No. 68-35-6



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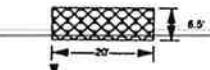
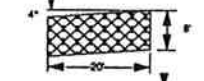
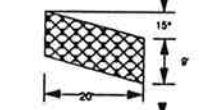
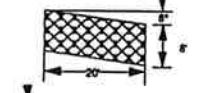
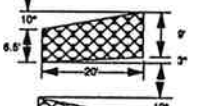
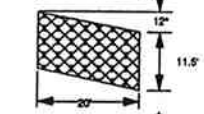
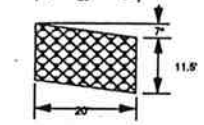
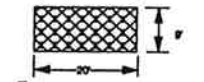
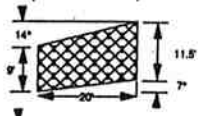
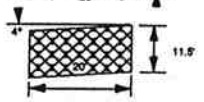
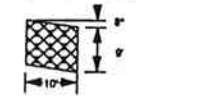
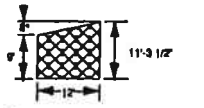
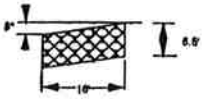
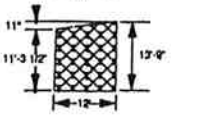
| Ⓐ |  | 33 | 130 | 4290 |
| Ⓑ |  | 29 | 160 | 4640 |
| Ⓒ |  | 3 | 180 | 540 |
| Ⓓ |  | 11 | 160 | 1760 |
| Ⓔ |  | 2 | 155 | 310 |
| Ⓕ |  | 1 | 230 | 230 |
| Ⓖ |  | 2 | 230 | 460 |
| Ⓗ |  | 16 | 180 | 2880 |
| Ⓘ |  | 2 | 205 | 410 |
| Ⓚ |  | 6 | 230 | 1380 |
| Ⓛ |  | 1 | 90 | 90 |
| Ⓜ |  | 1 | 122 | 122 |
| Ⓝ |  | 1 | 104 | 104 |
| Ⓞ |  | 1 | 150 | 150 |

BRUGG CABLE PRODUCTS, INC.
SANTA FE, NEW MEXICO

HIGH IMPACT WIRE ROPE NETS

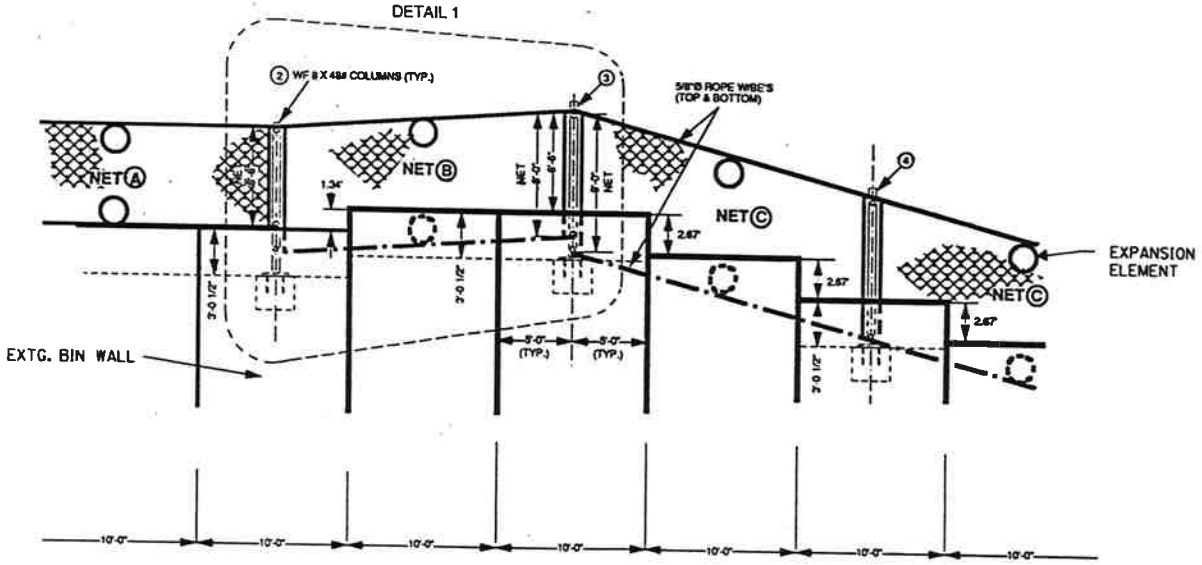
BCP-N-12

SHELLROCK MOUNTAIN SECTION

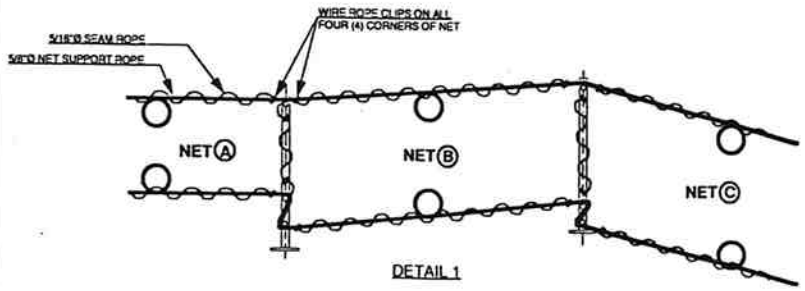
| FED. ROAD DIV. NO. | STATE | PROJECT NUMBER | FISCAL YEAR | TOTAL SHEETS |
|---|---|---|---|---|
| 10 | OREGON | | | |

SHEET NO. 2A

| SHELLROCK MOUNTAIN SECTION<br>COLUMBIA RIVER HIGHWAY<br>HOOD RIVER COUNTY | | | | SHEET NO. 2A-2 |
|---|---|---|---|---|
| FED. ROAD DIV. NO. | STATE | PROJECT | FISCAL YEAR | TOTAL SHEETS |
| 10 | OREGON | | | See Index |




**- DETAIL A -**
**(FRONT VIEW)**

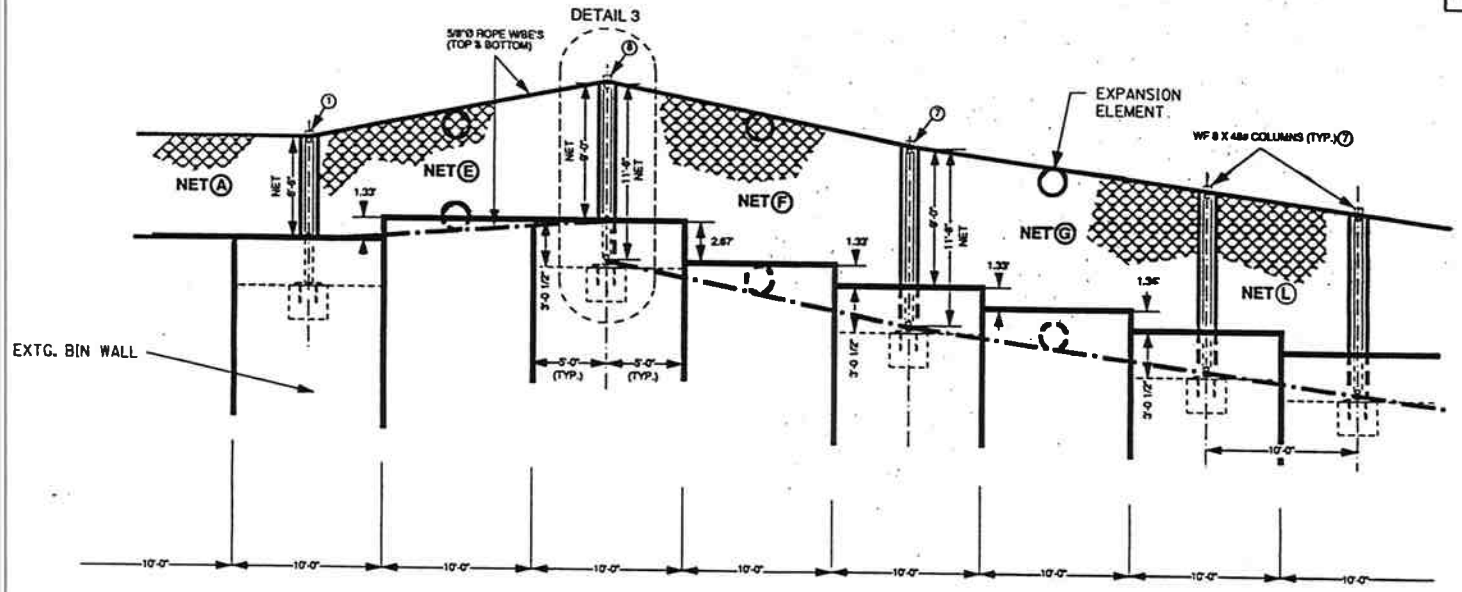



DETAIL 1

NOTE:
FOR CROSS SECTIONS REFER TO DWG'S Nº: BCP-N-2 & 2A
FOR STRUCTURAL COLUMNS FOUNDATION DETAILS SEE DWG Nº: BCP-N-10
FOR TYPICAL WIRE ROPE NET INSTALLATION DETAIL SEE DWG Nº: BCP-N-8

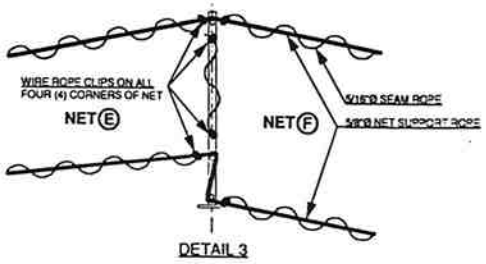
BRUGG CABLE PRODUCTS, INC.
SANTA FE, NEW MEXICO

| SHELLROCK MOUNTAIN SECTION<br>COLUMBIA RIVER HIGHWAY<br>HOOD RIVER COUNTY | | | | SHEET No. 2A- |
|---|---|---|---|---|
| FED. ROAD Div. No. | STATE | PROJECT NUMBER | FISCAL YEAR | TOTAL SHEETS |
| 10 | OREGON | | | |




**- DETAIL D -**

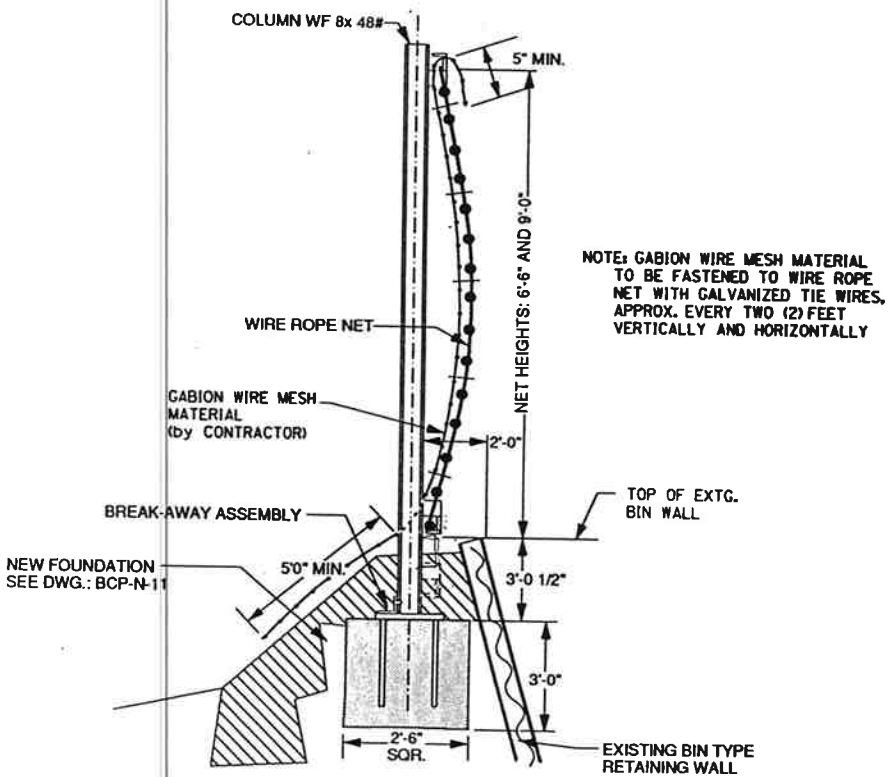
**(FRONT VIEW)**




NOTE:
FOR CROSS SECTIONS REFER TO DWG'S Nº: BCP-N-2 & 2A
FOR STRUCTURAL COLUMNS FOUNDATION DETAILS SEE DWG Nº: BCP-N-10
FOR TYPICAL WIRE ROPE NET INSTALLATION DETAIL SEE DWG Nº: BCP-N-8

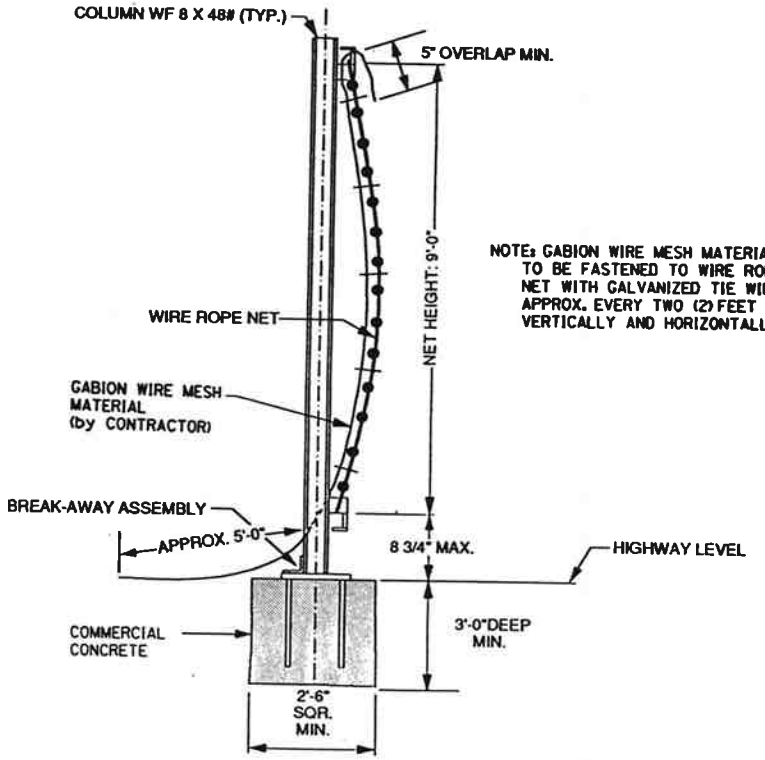
| BRUGG CABLE PRODUCTS, INC<br>SANTA FE, NEW MEXICO | | | |
|---|---|---|---|
| SHELL ROCK MTN | NONE | RT | 3/16/98 |
| OREGON DEPT OF TRANSP | | | 3 - 9/1 |
| ELEVATION | | | BCP-N-1C |

| SHELLROCK MOUNTAIN SECTION<br>COLUMBIA RIVER HIGHWAY<br>HOOD RIVER COUNTY | | | | SHEET No. 2A19 |
|---|---|---|---|---|
| FED. ROAD Div. No. | STATE | PROJECT NUMBER | FISCAL YEAR | TOTAL SHEETS |
| 10 | OREGON | | | |




NOTE: GABION WIRE MESH MATERIAL TO BE FASTENED TO WIRE ROPE NET WITH GALVANIZED TIE WIRES, APPROX. EVERY TWO (2) FEET VERTICALLY AND HORIZONTALLY

NOTE: ARRANGEMENTS ONLY FOR NETTING LOCATED ON TOP OF EXTG. BIN WALL



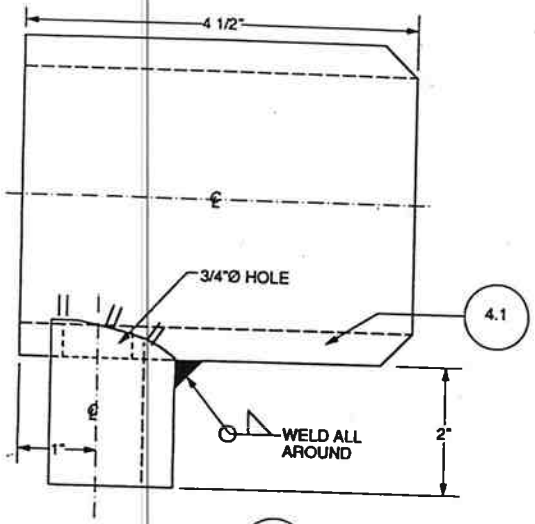

NOTE: GABION WIRE MESH MATERIAL TO BE FASTENED TO WIRE ROPE NET WITH GALVANIZED TIE WIRES, APPROX. EVERY TWO (2) FEET VERTICALLY AND HORIZONTALLY

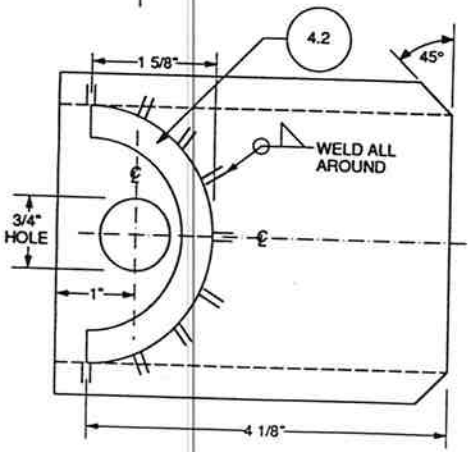
NOTE: THIS ARRANGEMENT ONLY FOR NETTING LOCATED ON HIGHWAY LEVEL.

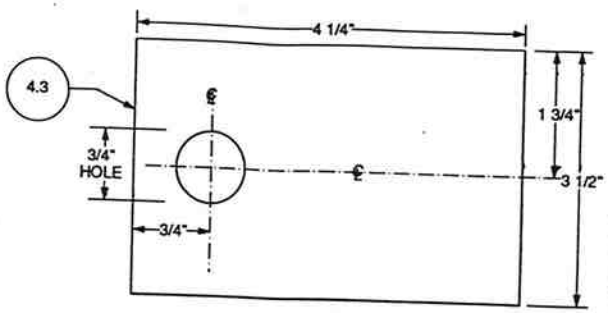
BRUGG CABLE PRODUCTS, INC.
SANTA FE, NEW MEXICO

| | | | |
|---|---|---|---|
| SHELLROCK MTN | NONE | RT | 7/1990 |
| OREGON DEPT OF TRANSP | | | 3-9/1990 |

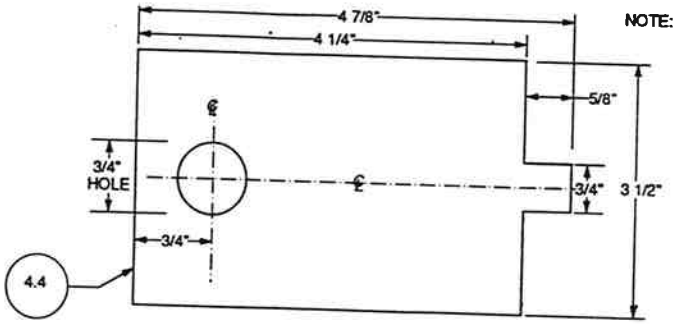
| SHELLROCK MOUNTAIN SECTION<br>COLUMBIA RIVER HIGHWAY<br>HOOD RIVER COUNTY | | | | SHEET No. |
|---|---|---|---|---|
| | | | | 2A-10 |
| FED. ROAD Div. No. | STATE | PROJECT NUMBER | FISCAL YEAR | TOTAL SHEETS |
| 10 | OREGON | | | |




FOR BOTTOM ASSEMBLY



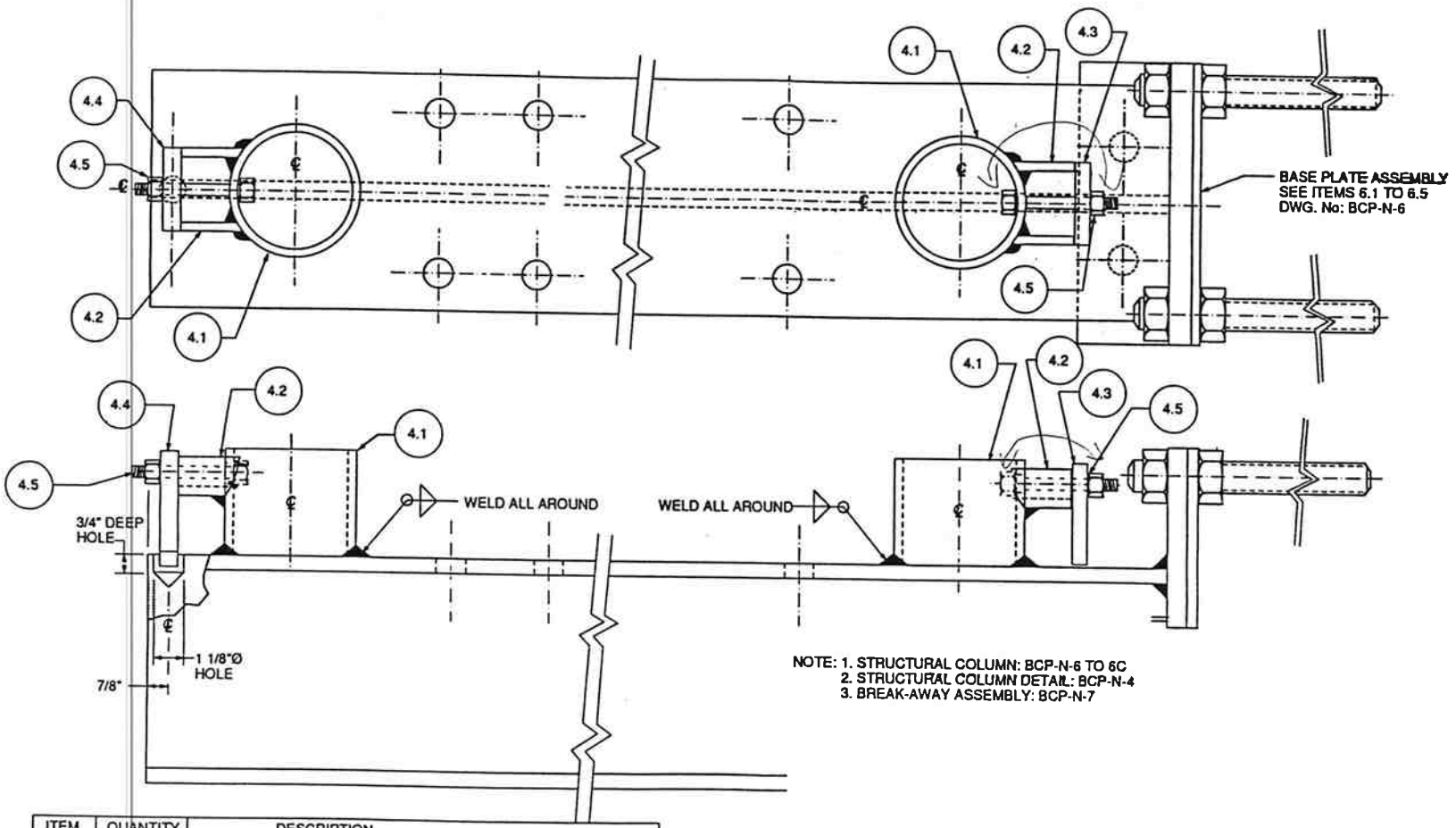

FOR TOP ASSEMBLY

| ITEM | QUANTITY | DESCRIPTION |
|---|---|---|
| 4.1 | 254 | PIPE 4"Ø (NOMINAL) X 14.98# EXTRA STRONG |
| 4.2 | 254 | PIPE 3"Ø (NOMINAL) X 10.25# EXTRA STRONG |
| 4.3 | 143 | PLATE 3/4" THICK X 3 1/2" X 4 1/4" |
| 4.4 | 111 | PLATE 3/4" THICK X 3 1/2" X 4 7/8" |

NOTE: 1. STRUCTURAL COLUMNS: BCP-N-6 TO 6C
2. STRUCTURAL ASSEMBLIES: BCP-N-5

| BRUGG CABLE PRODUCTS, INC.<br>SANTA FE NEW MEXICO | | | |
|---|---|---|---|
| SHELLROCK MTN | NONE | RT | 7-18-90 |
| OREGON DEPT OF TRANSP | | | 3 9-10-90 |
| STRUCTURAL COLUMN DETAILS | | | BCP-N-4 |

| SHELLROCK MOUNTAIN SECTION<br>COLUMBIA RIVER HIGHWAY<br>HOOD RIVER COUNTY | | | | SHEET NO. 2A-11 |
|---|---|---|---|---|
| FED. ROAD DIV. NO. | STATE | PROJECT NUMBER | FISCAL YEAR | TOTAL SHEETS |
| 10 | OREGON | - | | |

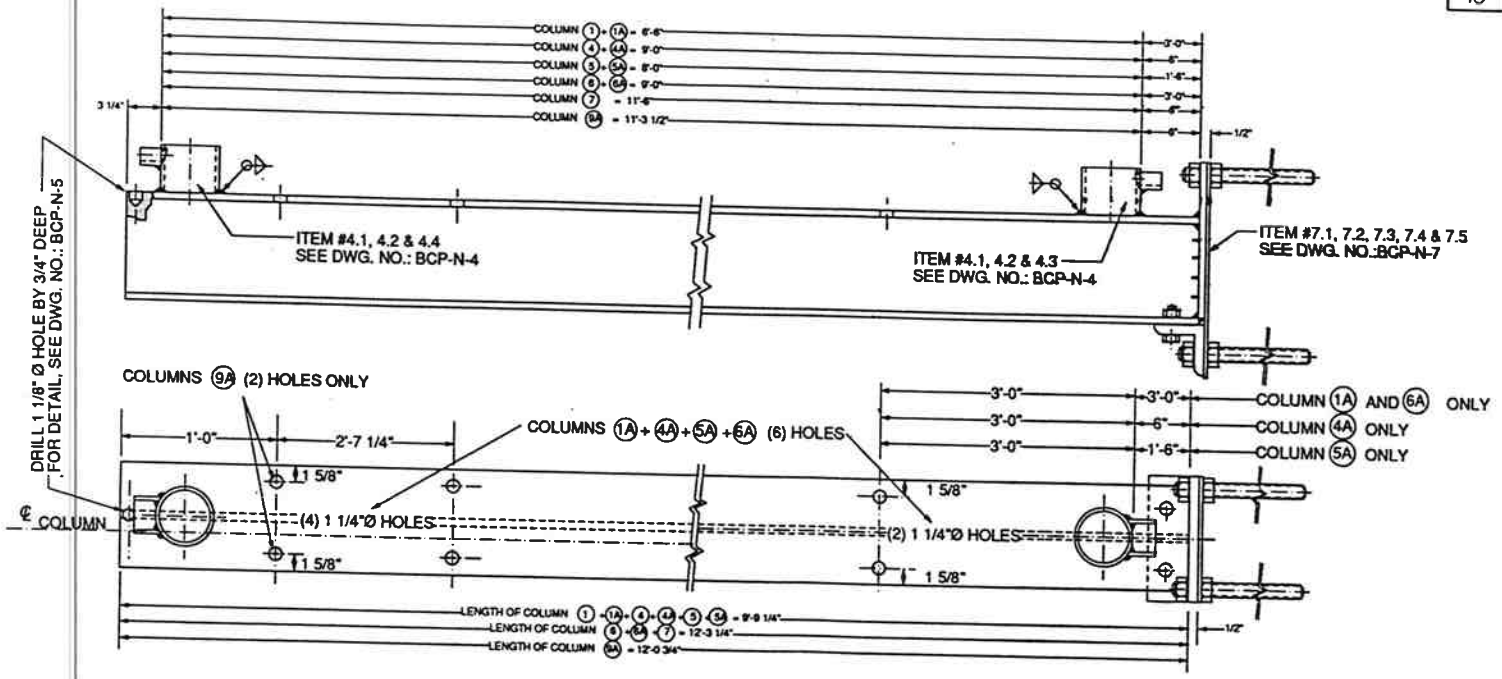



NOTE: 1. STRUCTURAL COLUMN: BCP-N-6 TO 6C
2. STRUCTURAL COLUMN DETAIL: BCP-N-4
3. BREAK-AWAY ASSEMBLY: BCP-N-7

| ITEM | QUANTITY | DESCRIPTION |
|---|---|---|
| 4.5 | 222 | 5/8"Ø BOLT W/ NUT & WASHERS TO BE FITTED WHEN ASSEMBLING |

| BRUGG CABLE PRODUCTS, INC.<br>SANTA FE, NEW MEXICO | | | |
|---|---|---|---|
| SHELLROCK MTN | NOVE | RT | 7/18/90 |
| OREGON DEPT OF TRANSP | | | 2 - 9/10/90 |
| STRUCTURAL ASSEMBLIES | | | BCP-N-5 |

| SHELLROCK MOUNTAIN SECTION<br>COLUMBIA RIVER HIGHWAY<br>HOOD RIVER COUNTY | | | | SHEET NO. 2A-12 |
|---|---|---|---|---|
| FED. ROAD DIV. NO. | STATE | PROJECT NUMBER | FISCAL YEAR | TOTAL SHEETS |
| 10 | OREGON | | | |




| ITEM | QTY | DESCRIPTION | REMARKS |
|---|---|---|---|
| (1) | 18 | COULUMN WF 8 X 48#, 9'-9 1/4" LONG | WITHOUT HOLES |
| (1A) | 6 | COLUMNS WF 8 X 48#, 9'-9 1/4" LONG | WITH (6) 1 1/4"Ø HOLES |
| (4) | 14 | COLUMNS WF 8 X 48#, 9'-9 1/4" LONG | WITHOUT HOLES |
| (4A) | 4 | COLUMNS WF 8 X 48#, 9'-9 1/4" LONG | WITH (6) 1 1/4"Ø HOLES |
| (5) | 25 | COLUMNS WF 8 X 48#, 9'-9 1/4" LONG | WITHOUT HOLES |
| (5A) | 3 | COLUMNS WF 8 X 48#, 9'-9 1/4" LONG | WITH (6) 1 1/4"Ø HOLES |
| (6) | 4 | COLUMNS WF 8 X 48#, 12'-3 1/4" LONG | WITHOUT HOLES |
| (6A) | 1 | COLUMNS WF 8 X 48#, 12'-3 1/4" LONG | WITH (6) 1 1/4"Ø HOLES |
| (7) | 3 | COLUMNS WF 8 X 48#, 12-3 1/4" LONG | WITHOUT HOLES |
| (9A) | 1 | COLUMNS WF 8 X 48#, 12'-0 3/4" LONG | WITH (2) 1 1/4"Ø HOLES |

NOTE: 1) COLUMN DETAILS: BCP-N-4, N-5 & N-7

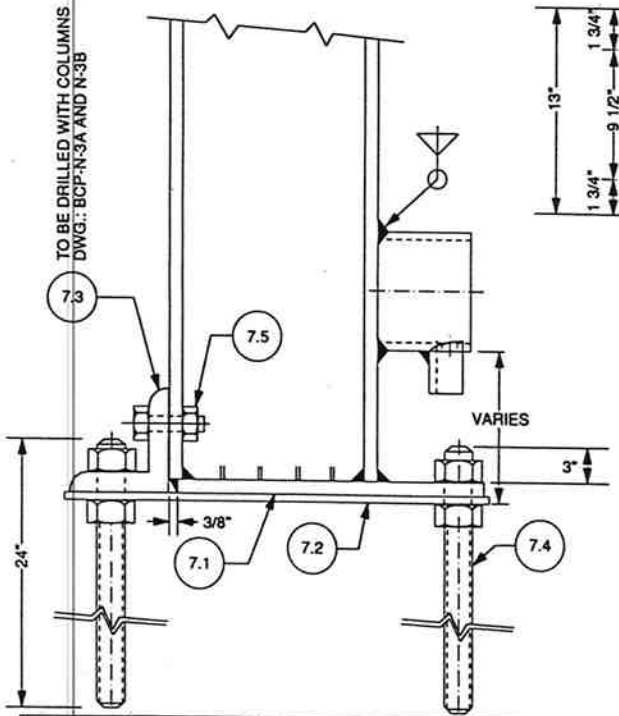
| BRUGG CABLE PRODUCTS, INC. SANTA FE SPRINGS, CA | | | |
|---|---|---|---|
| DESIGNED BY: [illegible] | CHECKED BY: NCM | APPROVED BY: RT | DATE: 7/18/90 |
| DETAILED BY: [illegible] | CHECKED BY: [illegible] | APPROVED BY: [illegible] | DATE: 3 8/1990 |
| STRUCTRUAL COLUMN | | | SHEET NO. BCP-N-6 |

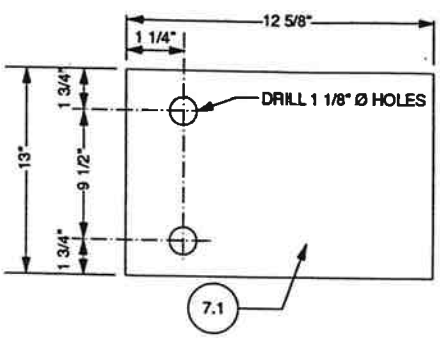
23V-86

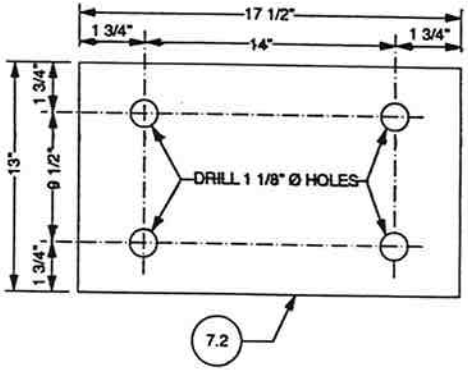
**SHELLROCK MOUNTAIN SECTION**
COLUMBIA RIVER HIGHWAY
HOOD RIVER COUNTY

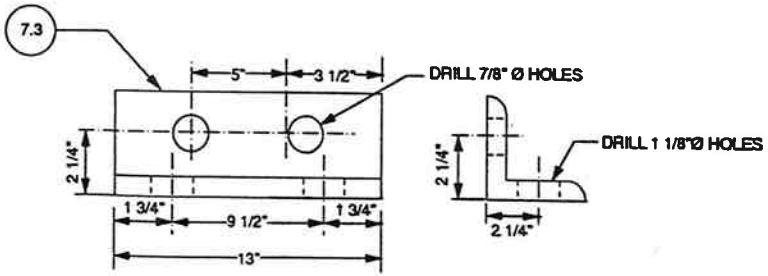
2A-14

| FED. ROAD DIV. NO. | STATE | PROJECT NUMBER | FISCAL YEAR | TOTAL SHEETS |
|---|---|---|---|---|
| 10 | OREGON | | | |



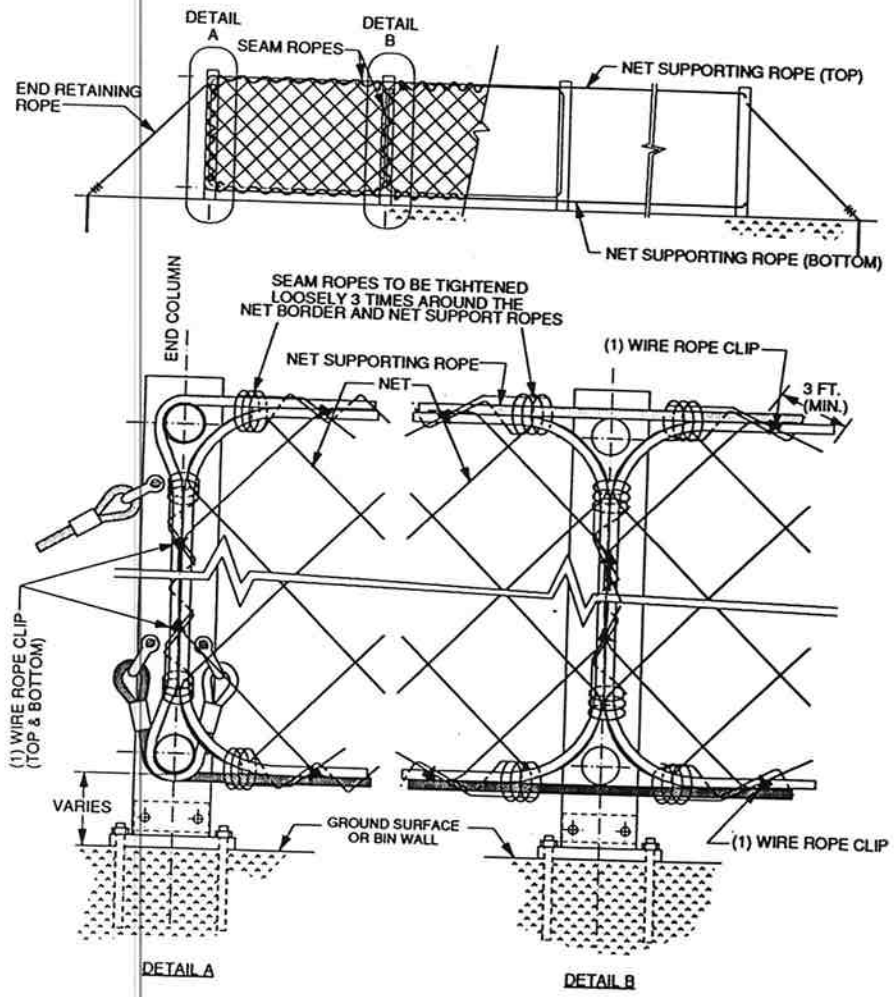

NOTE: 1) FOR STRUCTURAL COLUMN REFER TO DWG. NO.: BCP-N-6 TO 6C.
2) BASE PLATE ARRANGMENT TO BE ASSEMBLED IN THE SHOP PRIOR TO SHIPMENT TO THE FIELD.

| ITEM | QUANTITY | DESCRIPTION |
|---|---|---|
| 7.1 | 111 | PLATE 3/8" THK. 13" x 12 5/8" |
| 7.2 | 111 | PLATE 1/8" THK. 13" x 17 1/2" |
| 7.3 | 111 | ANGLES 3 1/2" x 3 1/2" x 11.1# x 13" LONG |
| 7.4 | 444 | ANCHOR BOLTS 1Ø x 24" LONG W/ NUTS & WASHER |
| 7.5 | 888 | BOLTS 3/4" W/ NUTS (NO WASHERS) |

BRUGG CABLE PRODUCTS, INC.
SANTA FE, NEW MEXICO

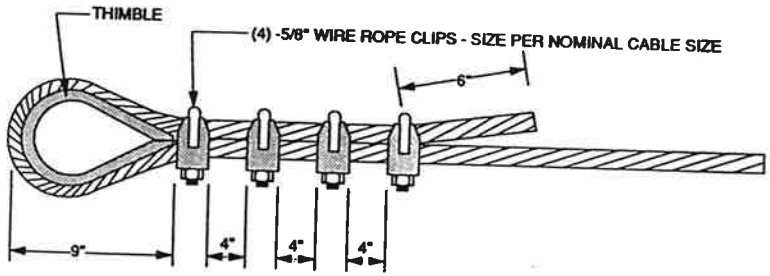
| | | | |
|---|---|---|---|
| SHELL ROCK MTN | HOME | RT | 7/10/90 |
| OREGON DEPT OF TRANSP | | | 3 - 9/10/90 |

| SHELLROCK MOUNTAIN SECTION<br>COLUMBIA RIVER HIGHWAY<br>HOOD RIVER COUNTY | | | | SHEET NO. 2A-15 |
|---|---|---|---|---|
| FED. ROAD DIV. NO. | STATE | PROJECT NUMBER | FISCAL YEAR | TOTAL SHEETS |
| 10 | OREGON | | | |




TYPICAL WIRE ROPE NET INSTALLATION DETAIL

BCP-N-8



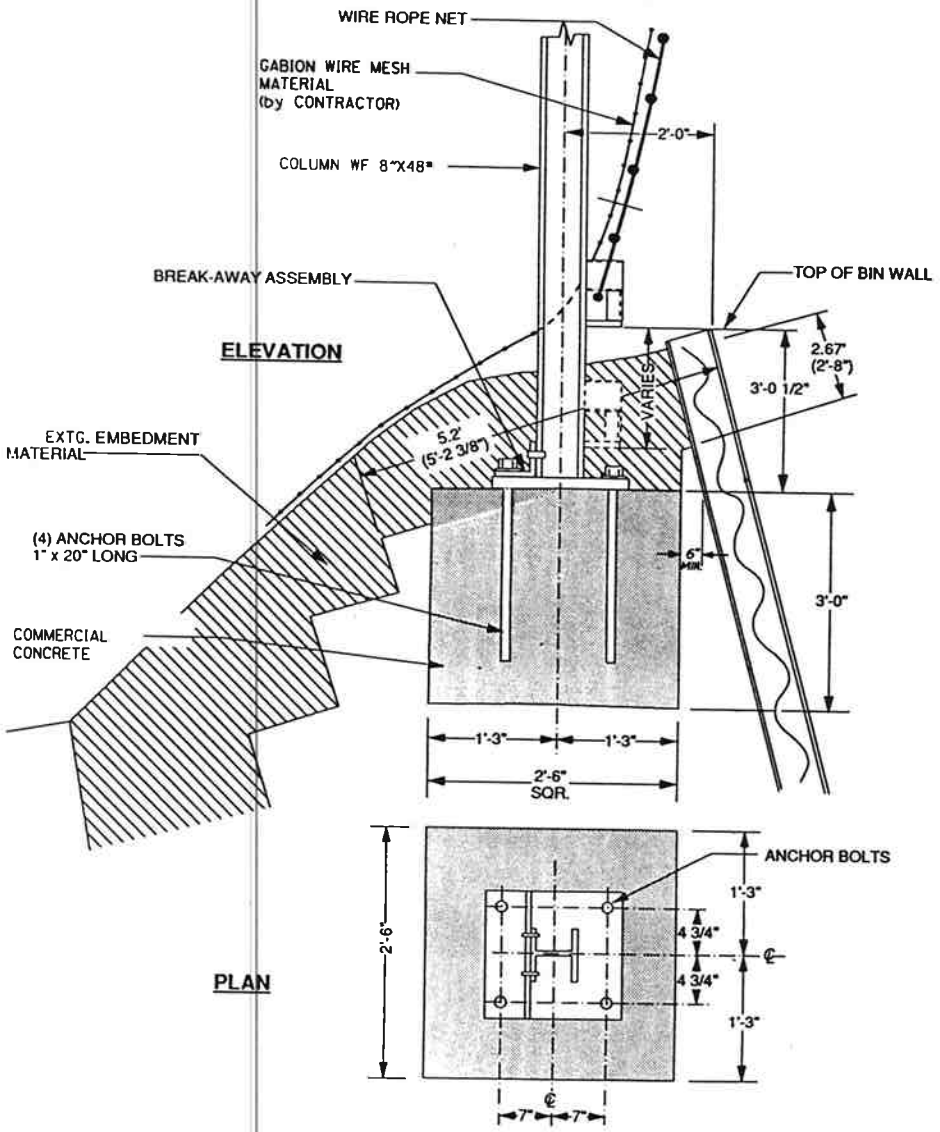

NOTE: 1. Wire Rope Clips To Be Tightened To 3.36 ft-lbs
2. All Net Support Ropes Shall Be 5/8" In Diameter.

WIRE ROPE LOOP DETAIL

BCP-N-9

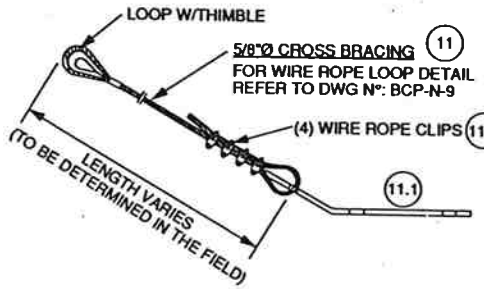
| BRUGG CABLE PRODUCTS, INC.<br>SANTA FE, NEW MEXICO | | | |
|---|---|---|---|
| SHELL ROCK MTN | NONE | RT | 7/15/99 |
| OREGON DEPT OF TRANSP | | | 3 - 9/10/99 |
| | | | BCP-N-8 |

| SHELLROCK MOUNTAIN SECTION<br>COLUMBIA RIVER HIGHWAY<br>HOOD RIVER COUNTY | | | | SHEET NO. |
|---|---|---|---|---|
| | | | | 2A-16 |
| FED. ROAD DIV. NO. | STATE | PROJECT NUMBER | FISCAL YEAR | TOTAL SHEETS |
| 10 | OREGON | | | |

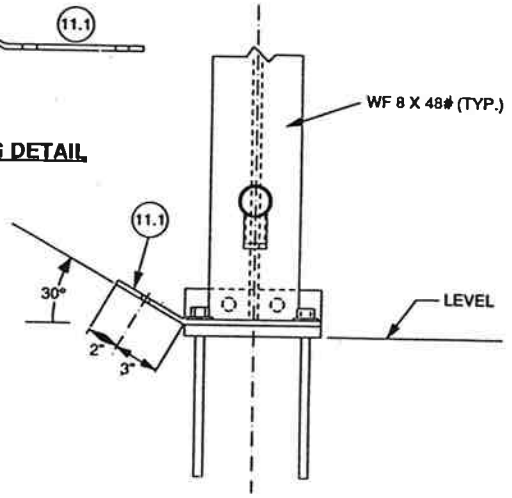



STRUCTURAL COLUMN FOUNDATION DETAIL

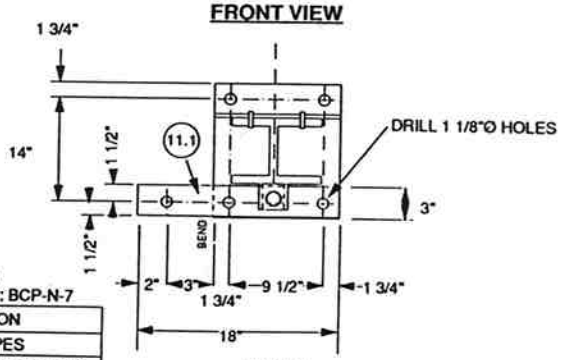
BCP-N-10




FASTENING DETAIL




FRONT VIEW




PLAN

NOTE: FOR STRUCTURAL DETAILS AND ASSEMBLIES, REFER TO DWG N°: BCP-N-7

| ITEM | QUANTITY | DESCRIPTION |
|---|---|---|
| 11 | 26 | 5/8"Ø BRACING ROPES |
| 11.1 | 26 | PLATE 1/2" THK., 3" X 18" LONG |
| 11.2 | 104 | 5/8" WIRE ROPE CLIPS |

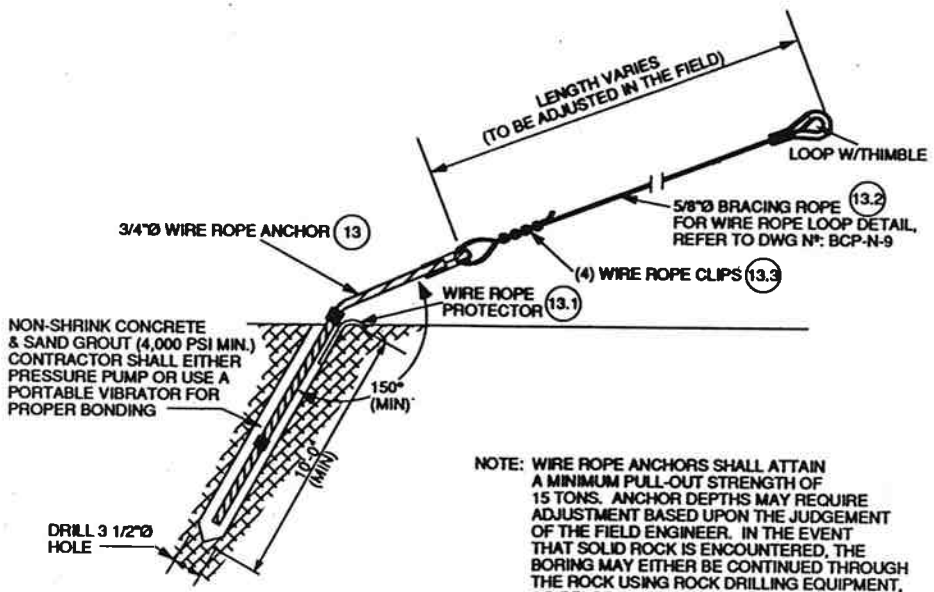
WIRE ROPE ANCHOR & BRACING ROPE DETAIL

BCP-N-11

BRUGG CABLE PRODUCTS, INC.
SANTA FE, NEW MEXICO

| | | | |
|---|---|---|---|
| SHELLROCK MTN | NONE | RT | 7/15/99 |
| OREGON DEPT OF TRANSP | | | 3 - 9/10/99 |

| SHELLROCK MOUNTAIN SECTION<br>COLUMBIA RIVER HIGHWAY<br>HOOD RIVER COUNTY | | | | |
|---|---|---|---|---|
| FED. ROAD DIV. NO. | STATE | PROJECT NUMBER | FISCAL YEAR | TOTAL SHEETS |
| 10 | OREGON | | | |




NOTE: WIRE ROPE ANCHORS SHALL ATTAIN A MINIMUM PULL-OUT STRENGTH OF 15 TONS. ANCHOR DEPTHS MAY REQUIRE ADJUSTMENT BASED UPON THE JUDGEMENT OF THE FIELD ENGINEER. IN THE EVENT THAT SOLID ROCK IS ENCOUNTERED, THE BORING MAY EITHER BE CONTINUED THROUGH THE ROCK USING ROCK DRILLING EQUIPMENT, OR RELOCATED 5' AWAY FROM ORIGINAL POSITION.

| ITEM | QUANTITY | DESCRIPTION |
|---|---|---|
| 13 | 4 | 3/4"Ø WIRE ROPE ANCHOR |
| 13.1 | 4 | WIRE ROPE PROTECTOR |
| 13.2 | 4 | 5/8"Ø BRACING ROPE W/THIMBLE |
| 13.3 | 16 | 5/8" WIRE ROPE CLIPS |

BRUGG CABLE PRODUCTS, INC.
SANTA FE, NEW MEXICO

| | | | |
|---|---|---|---|
| SHELL ROCK MTN | NONE | RT | |
| OREGON DEPT OF TRANSP | | | |

WIRE ROPE CROSS BRACE & FASTENING PLATE DETAIL — BCP-N-15

# SUMMARY

23V-86

| ITEM | UNIT | QUANTITY | SEGREGATION OF QUANTITIES | |
|---|---|---|---|---|
| | | | | |
| Mobilization | All | All | | |
| Temporary Protection And Direction Of Traffic | All | All | | |
| Temporary Signs | Sq.Ft. | 211 | | |
| Amber Flashers | Each | 2 | | |
| Temporary Barricades | Each | 2 | | |
| Temporary Plastic Drums | Each | 28 | | |
| Sequential Arrow Signs | Each | 1 | | |
| Flaggers | Hour | 100 | | |
| | | | | |
| ROCKFALL PROTECTION FENCE | | | | |
| | | | | |
| Rockfall Protection Fence | Sq.Ft. | 17,366 | | |

| SHELLROCK MOUNTAIN SECTION<br>COLUMBIA RIVER HIGHWAY<br>HOOD RIVER COUNTY | | | | SHEET No. 2B |
|---|---|---|---|---|
| FED. ROAD DIV. NO. | STATE | PROJECT NUMBER | FISCAL YEAR | TOTAL SHEETS |
| 10 | OREGON | | | |

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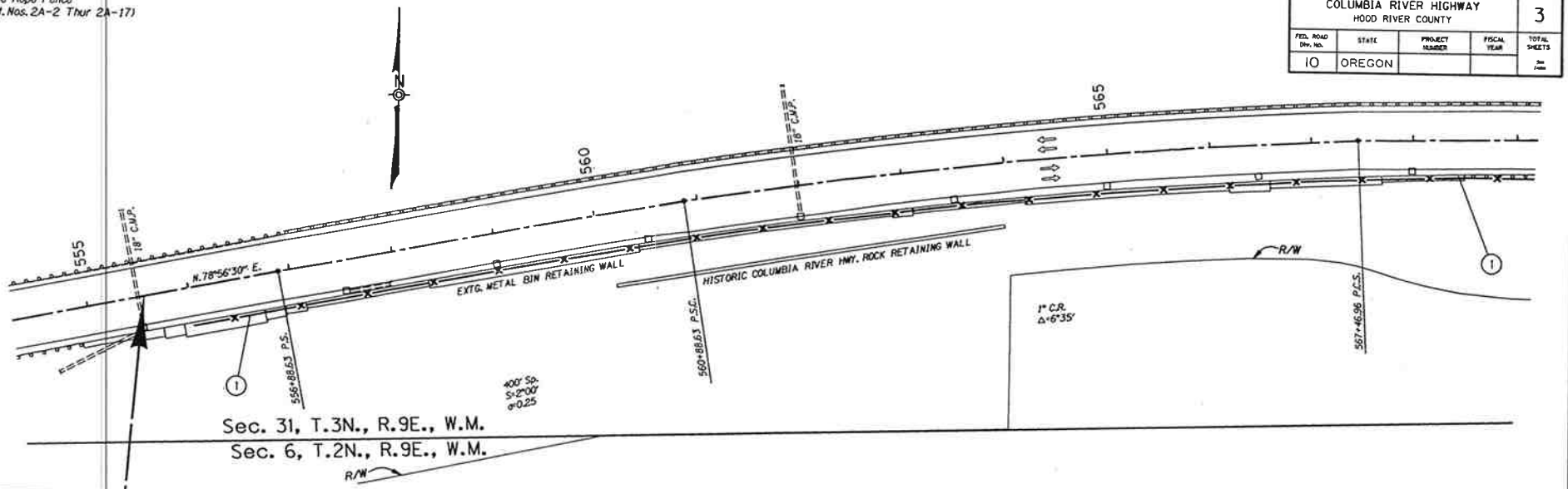
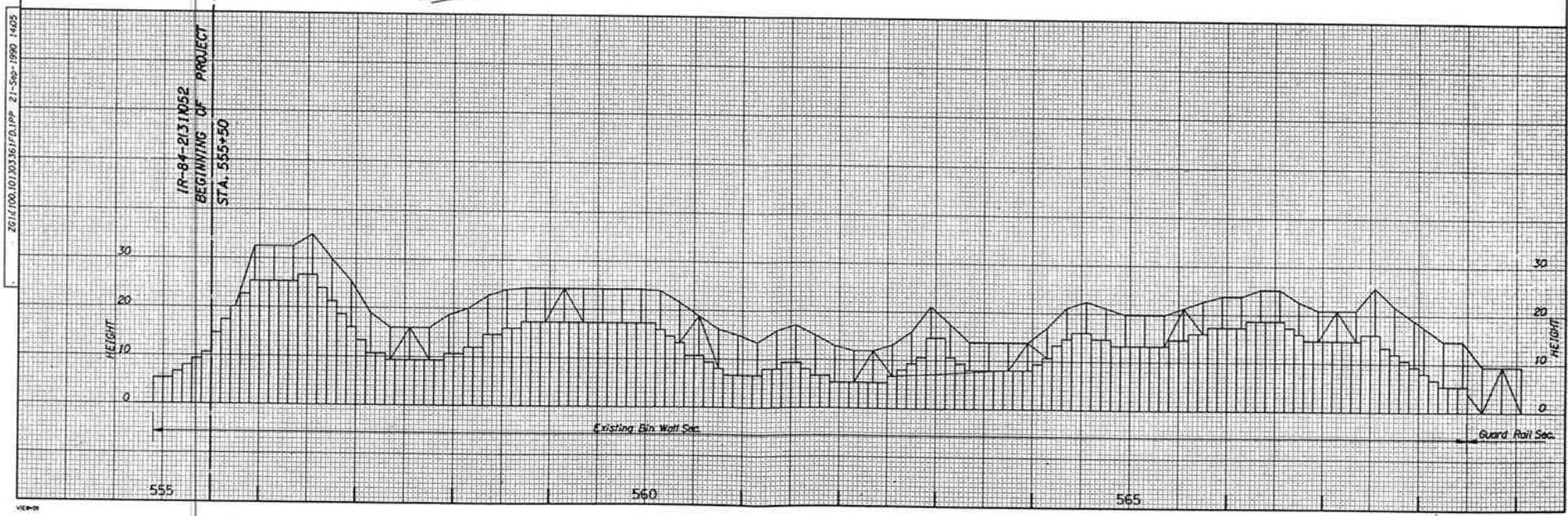
23V-86

| SHELLROCK MOUNTAIN SECTION<br>COLUMBIA RIVER HIGHWAY<br>HOOD RIVER COUNTY | | | | SHEET NO. 3 |
|---|---|---|---|---|
| FED. ROAD DIV. NO. | STATE | PROJECT NUMBER | FISCAL YEAR | TOTAL SHEETS |
| 10 | OREGON | | | |

(1) Sta. 555+80 To Sta. 575+25
Inst. Wire Rope Fence
(See Sht. Nos. 2A-2 Thur 2A-17)



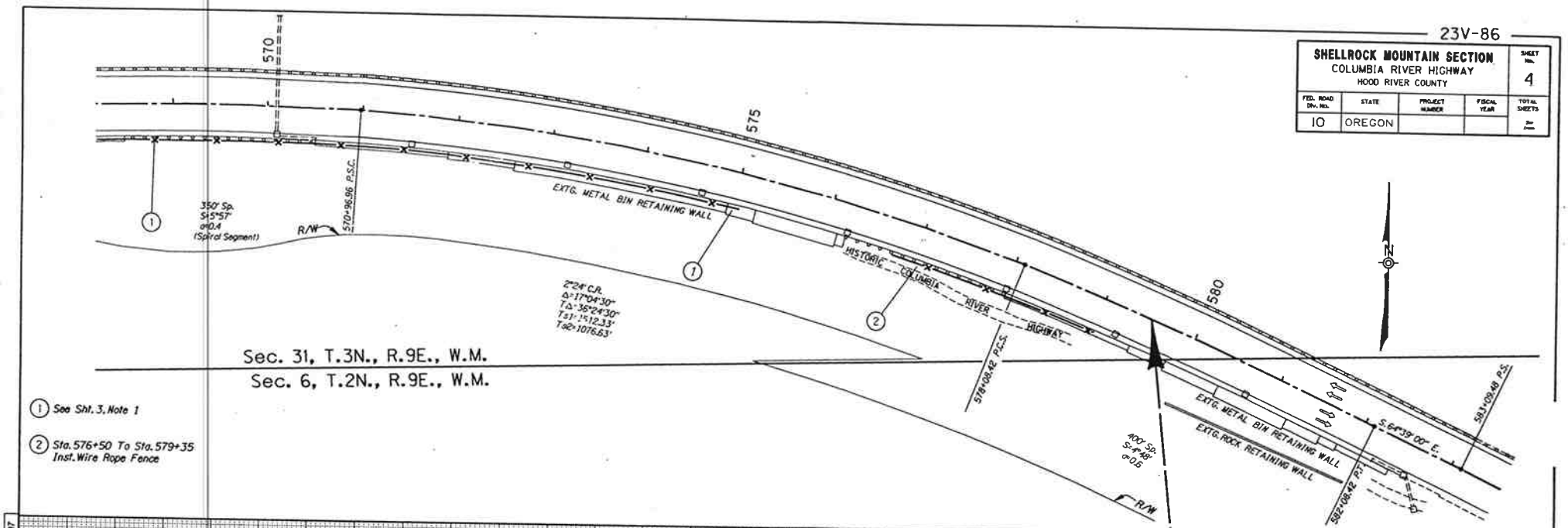



23V-86

**SHELLROCK MOUNTAIN SECTION**
COLUMBIA RIVER HIGHWAY
HOOD RIVER COUNTY

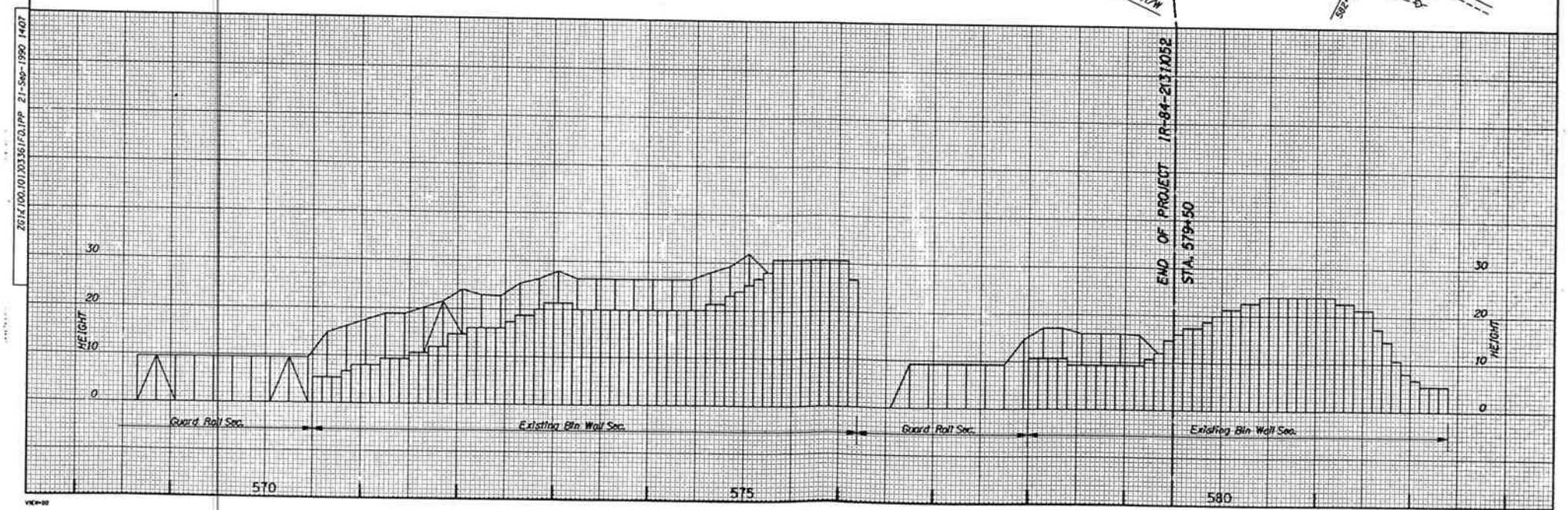
SHEET No. 4

| FED. ROAD DIV. NO. | STATE | PROJECT NUMBER | FISCAL YEAR | TOTAL SHEETS |
|---|---|---|---|---|
| 10 | OREGON | | | |




(1) See Sht. 3, Note 1

(2) Sta. 576+50 To Sta. 579+35
Inst. Wire Rope Fence



# APPENDIX C

## SPECIAL PROVISIONS

Shellrock Mountain Section
Rockfall Protection Fence

## Measurement

554.81 Measurement - No separate measurement will be made for commercial concrete.

## Payment

554.91 Payment - No separate payment will be made for commercial concrete as the cost will be included in payment for the particular items of work using commercial concrete.

## ROCKFALL PROTECTION FENCE

Rockfall Protection Fence shall be constructed in compliance with applicable portions of Section 607 of the Standard Specifications and as follows:

Scope - This work shall consist of the construction of a rockfall protection fence as detailed on sheets 2A through 2A-17 of the plans.

The Contractor shall field verify all measurements before ordering and assembling rockfall protection fence system.

The Contractor may encounter solid rock during footing excavation operations. No separate or additional payment will be made for footing excavation in solid rock.

The Contractor shall install the rockfall protection fence system in accordance with the manufacturer's instructions. The Contractor shall obtain from the manufacturer a construction manual and video, and a maintenance manual and video, which shall become the property of the Division after installation of the system.

Materials:

Materials required for the rock protection fence system, except concrete for footings, gabion wire mesh and paint, shall be provided by Brugg Cable products, Inc., R.R. 16 Box 197E 11 East Frontage Road, Santa Fe, New Mexico 87505, Phone: (505) 438-6161.

Shellrock Mountain Section
Rockfall Protection Fence

Concrete in Footings and Anchors - The portland cement concrete for footings and anchors shall conform to requirements of Section 554 - Commercial Concrete included in a these special provisions.

Gabion Wire Mesh - Gabion wire mesh and attaching wire shall conform to the following:

The wire for gabion wire mesh shall be galvanized steel wire, meeting the requirements of ASTM A 641 with a nominal wire diameter of 0.120-inch and a minimum tensile strength of 60,000 psi.

Paint - Paint shall conform to the requirements of Section 708 of these special provisions, shall be corrosion and u.v. resistent, non-reflective and be dark earth tone in color.

Net Support Columns

The columns shall be fabricated from WF 8 x 48 # wide flange members meeting ASTM A36 for preformed steel shapes.

Each WF 8 x 48 # column shall be equipped with an anchor plate assembly, incorporating four (4) anchor bolts and also featuring a column break-away assembly to prevent the column from being bent and/or damaged from falling rocks which could eventually weaken the overall system capability.

Cable guide assemblies shall be welded to the columns (top & bottom) and shall be fabricated from extra strong steel pipes meeting ASTM A501 requirements.

Plates, angles and other steel shapes shall comply with ASTM A36 and bolts, nuts and washers with ASTM A#25.

Galvanizing

All wire ropes for safety nets, supporting and retaining ropes, seam ropes and for the anchors shall be composed of steel wires which have been individually galvanized prior to being woven into the designated wore rope configuration.

All miscellaneous metal associated with the rockfall system such as shackles, thimbles, bolts, etc., shall be hot-dip galvanized according to subsection 733.11 of the Standard Specifications .

Shellrock Mountain Section
Rockfall Protection Fence

(a) Excavation and Foundation

1. The excavation work by the Contractor shall be executed in accordance with the rockfall system manufacturer's drawings.

Scatter excess excavated material around the vicinity of the rockfall structure to match the existing ground surface. Do not create jump ramps for falling rocks.

2. The foundation work shall be performed in accordance with rockfall system manufacturer's drawings. Prior to pouring the concrete foundation, the Contractor shall make sure that the anchor plates w/bolts and wire rope anchors have been set correctly. The distance from center line to center line of columns shall not vary from the distance as indicated on the layout drawings by more than 3 inches.

3. Prior to placing concrete, remove loose soil or rocks from the hole and moisten the earth subgrade to a minimum depth of 2 inches from the soil and concrete surfaces. Pour concrete against undisturbed material. If hole is over excavated, the entire cavity shall be filled with concrete. No additional payment will be made for concrete which lies outside the plan dimensions.

4. Remove splashes or accumulation of hardened or partially hardened concrete from the anchor plates of the rockfall structure.

(b) Rockfall System Installation

Step 1. Contractor to erect and fasten columns to anchor plates in foundation in accordance with the rockfall system manufacturer's drawings. Columns shall not very from indicated pitch or from vertical by more than 1 inch form top to bottom.

Step 2. After columns are properly set, install and fasten the net supporting ropes with the already installed braking elements to the column as shown on manufacturer's drawings.

Step 3. Place wire rope net system to the net supporting rope and seam together with the seam ropes. Once the seaming is completed, use wire rope clips to securely fasten seam ropes to net system as shown on manufacturer's drawings.

Step 4. The final step is to fasten the gabion mesh material to the wire rope net system with attaching wire. Make sure the system is properly tightened and the installation appearance looks aesthetically-pleasing to the surrounding area.

Shellrock Mountain Section
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Wire Rope Netting

The wire rope net shall be fabricated in accordance with the following specifications: The mesh size of the net shall be 8" x 8" square with a mesh rope diameter of 5/16", 6x7 construction and a minimum breaking strength of 8333 lbs. The perimeter rope of the net shall have a 5/8" diameter, 6x19 construction with a minimum breaking strength of 38,304.

The net shall be diagonally woven in order to assure maximum strength of the net system.

All nets shall be braided with a high strength, hot-dipped galvanized, corrosion-resistant clips or other fastening devices, pressed on so that they are non-movable. While securing the clips, the wire rope shall not be damaged. Even slightly damaged nets will be rejected insofar as they could endanger the integrity of the system.

The wire rope net shall be looped around the border and secured at each point with a heavy duty aluminum stop sleeve.

Two (2) aluminum stop sleeves shall be used at all locations in which two individual wire ropes are joined together.

Nets shall be covered with gabion wire mesh, to prevent particles smaller than 4" in diameter from penetrating the barrier.

Net Supporting & Retaining Ropes

The top and bottom net supporting rope shall each incorporate a braking element and shall have a diameter of 5/8".

The net supporting and retaining ropes shall be galvanized and of 6 x 19 construction, and shall have a minimum breaking strength of 38,304 lbs.

Shackles & Wire Clips

All shackles shall be 3/4" size and wire rope clips shall be for 5/8" dia. net support ropes and for 5/16" dia. seam ropes.

Miscellaneous Material

All miscellaneous hardware such as shackles, thimbles, bolts, etc., shall be supplied by vendor with the system.

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Seam Ropes

The seam ropes shall be used to fasten the wire rope nets to each other and to the net support wire ropes. The seam rope shall have a diameter of 5/16" and shall be 6x7 construction with a minimum breaking strength of 8,333 lbs. The seam ropes shall be galvanized.

Painting

All wire rope netting, including such items as the shackles, thimbles, bolts, etc., shall be painted with corrosion and U.V. resistant paint by the Contractor. The paint shall be non-reflective and dark earth tone in color. The surface of material to be painted shall be cleaned of dirt, oil, grease or any foreign material.

The structural steel columns shall receive one coat of primer prior to being shipped to the job site.

Once the system has been installed in the field, the Contractor shall apply two coats of finish paint to the structural steel columns with same corrosion and U.V. resistant matching paint as was used for the wire rope nets and cables.

Field Installation Supervision

The manufacturer shall provide, at no cost to the Contractor, four days of 8 hours/day installation supervision by a qualified Field Engineer in order to make sure that the system is properly installed.

Shipping and Marking of Material

All material shall be properly marked by the manufacturer in order for the Contractor to identify same easily with the Brugg drawings and minimize installation time.

All material shall be shipped by Manufacturer, F.O.B.: Job Site.

Measurement - The quantity of "Rockfall Protection Fence" to be paid for will be the number of square feet of wire rope net, completed and accepted, measured to the nearest square foot.

Payment - The following pay item applies:

Shellrock Mountain Section
Rockfall Protection Fence

| Pay Item | Unit of Measurement |
|---|---|
| Rockfall Protection Fence | Sq. Ft. |

Payment at the contract price per unit of measurement for the above pay item will be full compensation for furnishing and placing all materials (including concrete, gabion wire mesh and paint), and performing all earthwork, including all labor, equipment tools, and incidentals necessary to complete the work as specified.

## SECTION 701 - HYDRAULIC CEMENT, WATER, ADMIXTURES, AND CURING MATERIALS

Section 701 of the Standard Specifications is supplemented and/or modified as follows:

701.01(b) Specifications - Add the following subsection:

701.01(b-4) The maximum fineness (specific surface, $m^2/kg$), as determined by the Air Permeability test, shall be 430 for any field sampled check test. Results of field sampled check tests will not be averaged.

701.02 Water - Delete the paragraph and substitute the following:

Water used in mixing or curing portland cement concrete and in mixing cement treated base shall be reasonably clean and free of oil, sugar, organic matter, or other substance injurious to the finished product. Potable water may be used without testing if the Contractor provides a written certification as to the potability of the source.

Water of nonpotable or unknown quality shall be tested according to AASHTO T 26 before use in the project and shall meet the following limits:

| | MIN | MAX |
|---|---|---|
| ~~pH, pH units . . . . . .~~ | ~~6.0~~ | ~~8.0~~ |
| Chloride Ion, percent . . . . . | - | 0.15 |

# APPENDIX D

## BID TABULATION SHEET

OREGON STATE HIGHWAY DIVISION

ITEMIZED BIDS RECEIVED

BID OPEN DATE: 10/25/90 SHEET NO. 1

NO. OF BIDS: 04 FAP NO

SECTION: SHELLROCK MOUNTAIN SECTION

HIGHWAY: COLUMBIA RIVER HIGHWAY (I-84)

COUNTY: HOOD RIVER

TYPE OF WORK: ROCKFALL PROTECTION FENCE

| NO. | ITEM NAME | QUANITY | UNIT | Engineers Estimates UNIT BID | AMOUNT | CORAL CONSTR. CO. WILSONVILLE UNIT BID | 2G CONST INC EUGENE UNIT BID | WHITE & WHITE INC LAKE OSWEGO UNIT BID | PYNCH-TURNER, INC. ROSEBURG, UNIT BID |
|---|---|---|---|---|---|---|---|---|---|
| 001 | MOBILIZATION | 1.000 | LUMP SUM | 10,000 18000.00 | 18000.00 | 27924.00 | 50000.00 | 20000.00 | |
| 002 | TEMPORARY PROTECTION AND DIR OF TRAFFIC | 1.000 | LUMP SUM | 1,500 1250.00 | 1250.00 | 3830.00 | 7500.00 | 9200.00 | |
| 003 | TEMPORARY SIGNS | 211.000 | SQ FT | 10 7.00 | 1477.00 | 10.00 | 10.00 | 3.73 | |
| 004 | AMBER FLASHERS | 2.000 | EACH | 1,000 200.00 | 400.00 | 1036.00 | 1000.00 | 161.00 | |
| 005 | TEMPORARY BARRICADES | 2.000 | EACH | 75 45.00 | 90.00 | 168.00 | 100.00 | 92.00 | |
| 006 | TEMPORARY PLASTIC DRUMS | 28.000 | EACH | 40 90.00 | 2520.00 | 56.00 | 60.00 | 37.37 | |
| 007 | SEQUENTIAL ARROW SIGNS | 1.000 | EACH | 3,000 1800.00 | 1800.00 | 2240.00 | 3500.00 | 3800.00 | |
| 008 | FLAGGERS | 100.000 | HOUR | 20 22.00 | 2200.00 | 24.88 | 25.00 | 27.00 | |
| | ROCKFALL PROTECTION FENCE | | | | | | | | |
| 009 | ROCKFALL PROTECTION FENCE | 17,366.000 | SQ FT | 24.50 27.00 | 468882.00 | 29.19 | 29.00 | 32.25 | |
| | TOTAL BID | | | | 496619.00 | 549481.54 | 573104.00 | 598092.89 | |

$477,769.00

Figure D.1: Bid Tabulation sheet