John Kalvelage and Steve Starkey

5.1.9.3 and 5.1.9.4 Seismic Retrofit Example No. 1 (Phase 1)

Proposed Retrofit:

Longitudinal: Restrainer cables at interior bents.
Seat extensions, if required, at end bents.

Transverse: Shear lugs at interior and end bents.

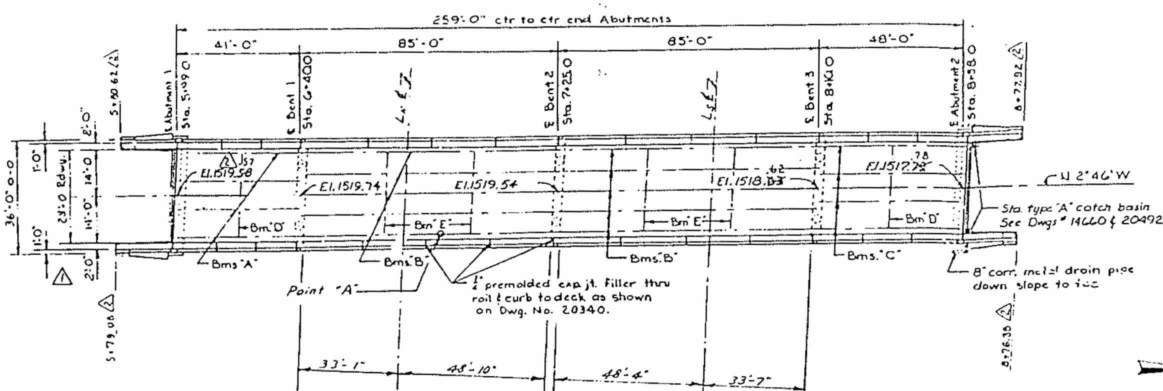
Longitudinal Procedure:

Sheet	Step	Procedure/Description
1-5		Structure plans.
6-7	1.	Calculate superstructure dead load for each bent.
8-14	2.	Calculate plastic moment capacities for columns and the connection forces required to develop this moment. Do this for each interior bent. Conservatively assume there is sufficient column ductility to develop the full plastic moment.
15	3.	Design connections for superstructure to substructure at bents with only the deck continuous over the bent (interior bents).
16-17	4.	Compute substructure stiffness coefficients. Consider connection flexibility of step 3 design along with column stiffness and footing springs (if appropriate) for the interior bents. Consider soil at one end bent.
18	5.	Compute other substructure capacities (column plastic moments already done in step 2). Include connection forces required to induce soil failure beneath footings and the capacity of one end bent's soil.
19-24	6.	Plot the force/deflection relationship--include capacity limitations also.
19-24	7.	Compute the end bent deflection. Use dynamic loading from a single-mode analysis--assume a final force and deflection to determine the oscillator's equivalent stiffness; calculate the period and resulting response coefficient; calculate the dynamic force and plot it on the force-deflection curve; review the stiffness, period, response coefficient and dynamic loading to verify the force and deflection are consistent for the oscillator model; recycle through this process as needed for closure.
25	8.	Compute specification value for required seat length at end bents.

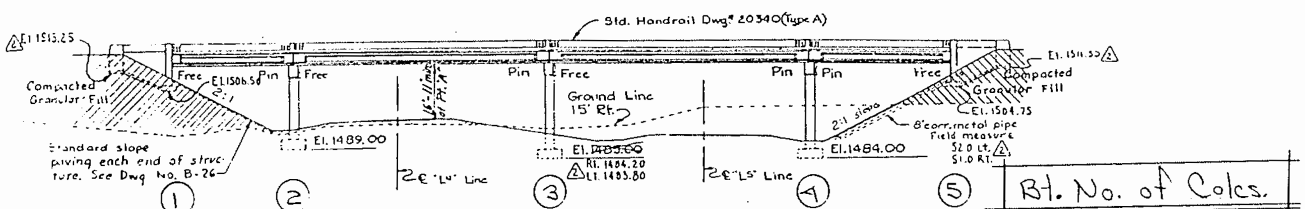
Sheet	Step	Procedure/Description
25	9.	Use the larger deflection from step 7 multiplied by 4, or step 8, and compare to the available seat length after reducing it for creep, shrinkage and temperature.
	10.	Provide seat extensions if required.

Transverse Procedure:

Sheet	Step	Procedure/Description
26-27	1.	Calculate additional plastic moment capacities for interior bent crossbeams.
28	2.	Calculate connection forces to form a failure mechanism (typical each bent).
	3.	Use these forces, prorated to back and ahead side of bent by dead load ratios, to design force restrainers.
29	4.	Design similar force restrainers at the end bents using forces of 2.5 x A x (supported dead load).

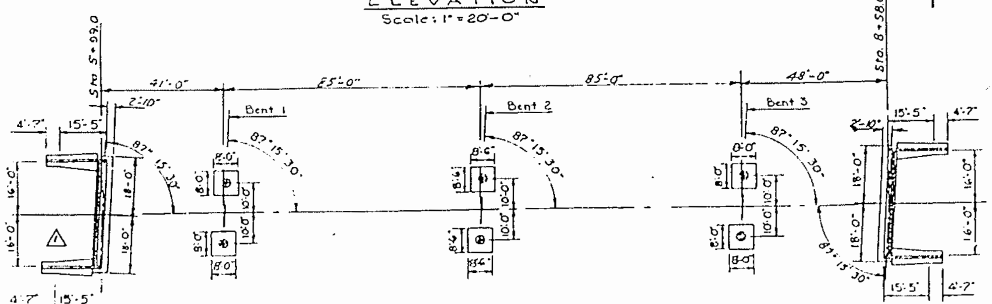


PLAN
Scale: 1" = 20'-0"

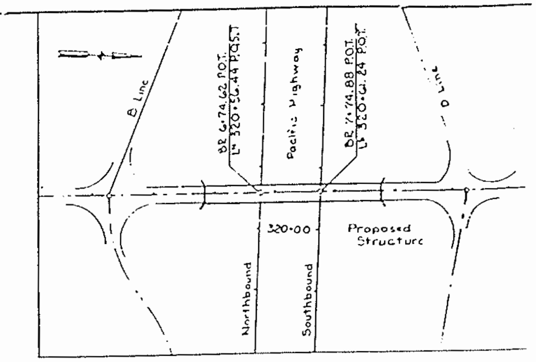


ELEVATION
Scale: 1" = 20'-0"

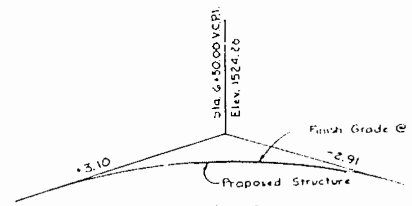
Bt. No. of Cols.



FOOTING PLAN
Scale: 1" = 20'-0"



VICINITY MAP



GRADE LINE DIAGRAM
No Scale

GENERAL NOTES

Bridge designed for HS 20-44 loading with an allowance for future wearing surface.

All concrete, except that in prestressed beams and slope paving shall be class "A" and shall attain a design strength of 3,300 psi in 28 days (fc=1320 psi.) See Dwg. No. 20494 for concrete in prestressed beams.

All reinforcing steel except for prestressing strands shall be intermediate grade deformed bars. Bars number 3 to 11 shall conform to A.S.T.M. specifications A305 and shall be lapped 20 dia. at all splices unless noted or shown otherwise. All main reinforcing bars shall be placed 2" clear of nearest face of concrete unless noted or shown otherwise (fs = 20,000 psi.) See Dwg. No. 20494 for prestressing strands.

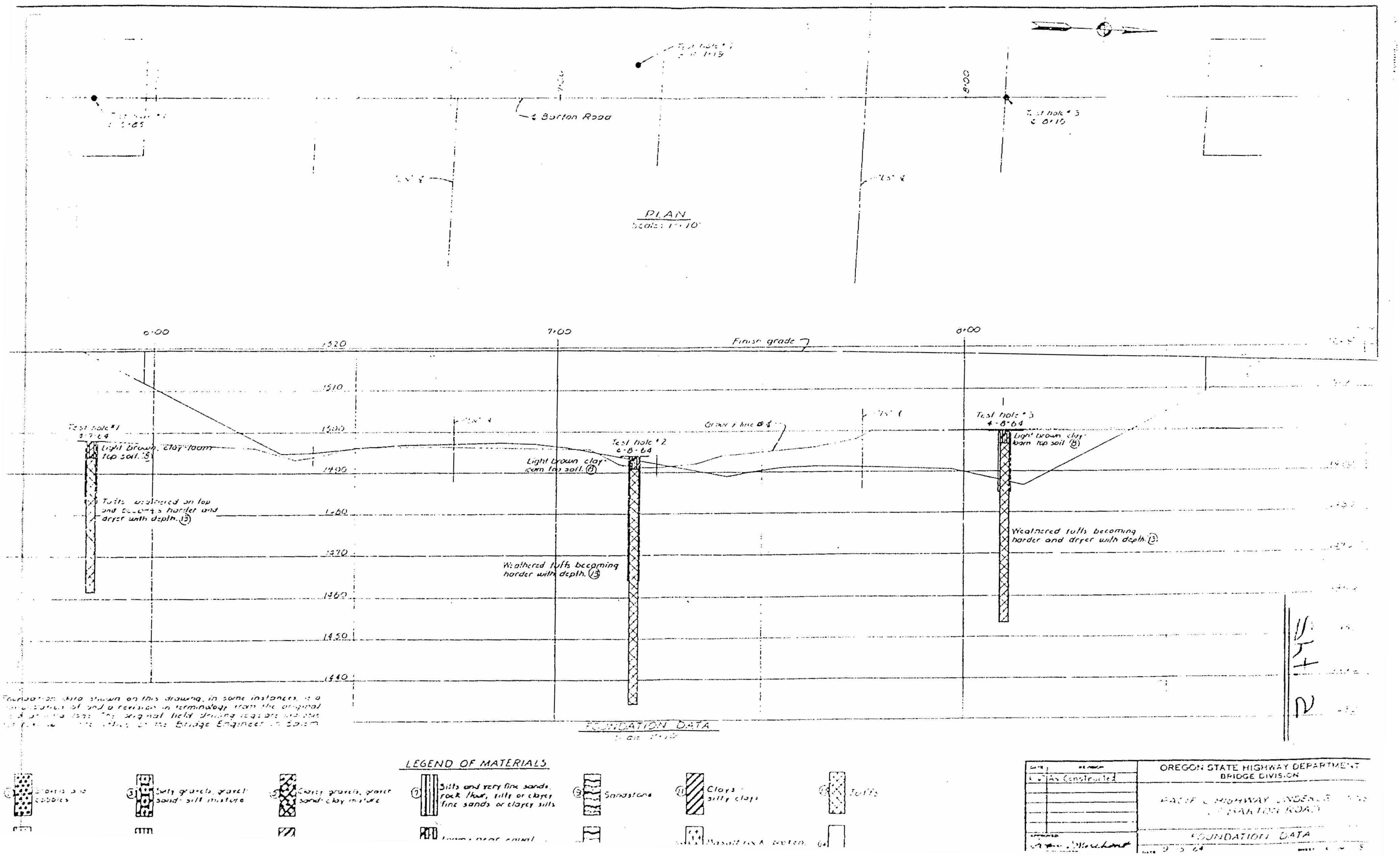
Footing elevations are subject to change depending on conditions in the field and column steel shall not be fabricated until final footing elevations have been determined.

All materials and workmanship shall conform to the Standard Specifications for Highway Construction of the Oregon State Highway Commission.

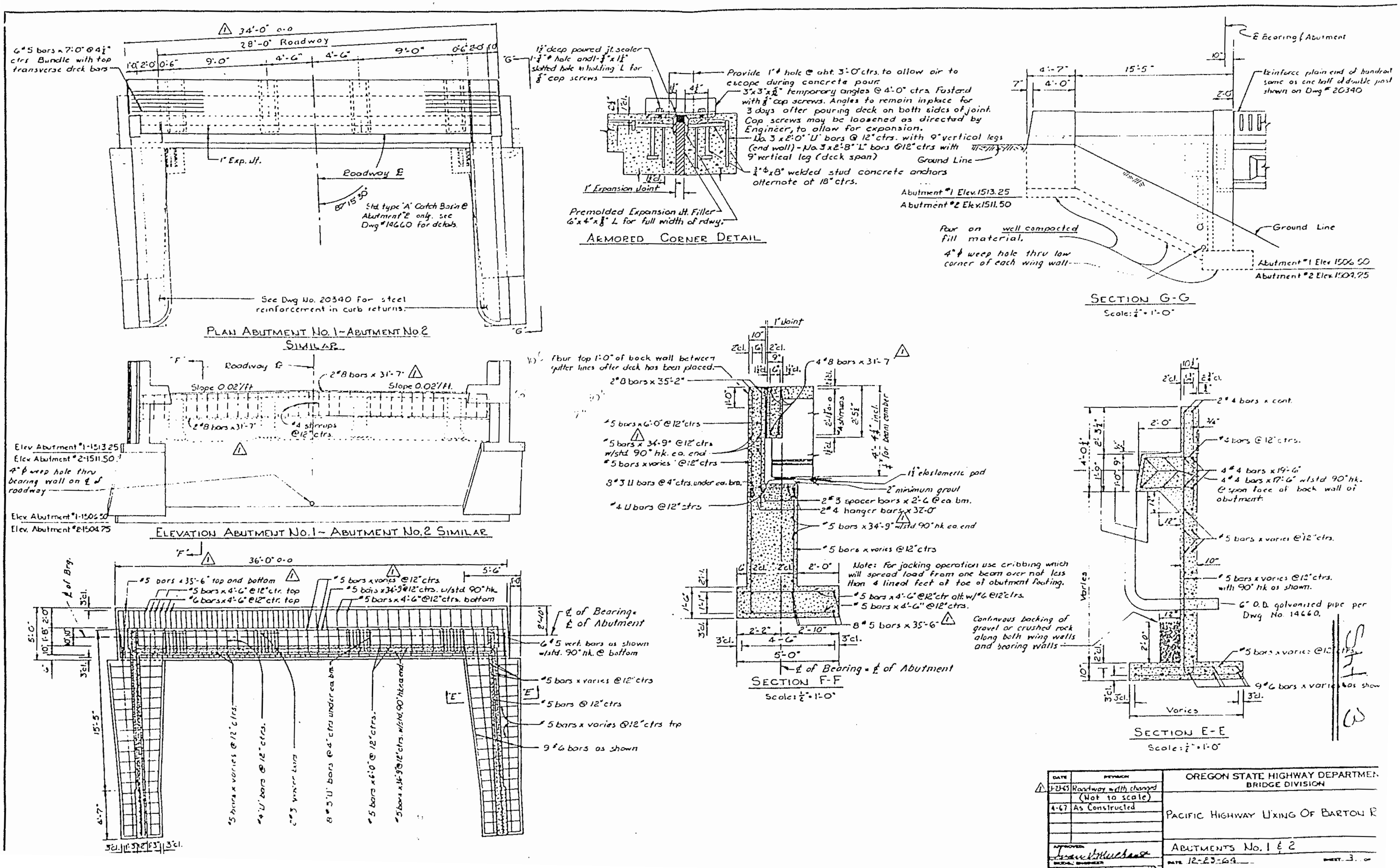
Sht. 1

2 4-67 As Constructed
1 3-23-65 Roadway width changed (Not to scale)

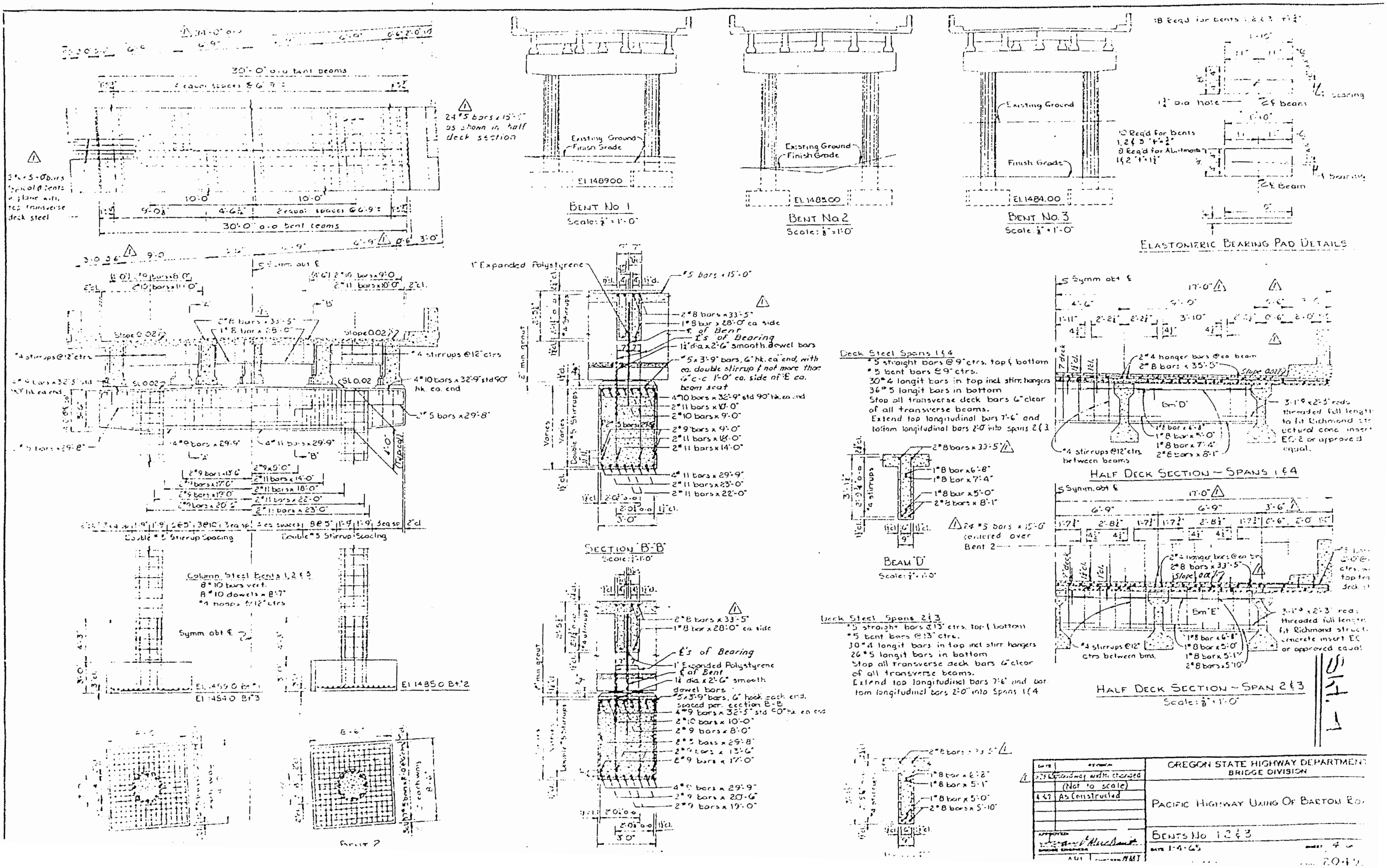
APPROVED	OREGON STATE HIGHWAY DEPARTMENT BRIDGE DIVISION
[signature] CHIEF ENGINEER	PACIFIC HIGHWAY UXING OF BARTON RD
[signature] ASST. STATE HIGHWAY ENGINEER	AZALEA-GLENDALE JUNCTION SECTION
	PACIFIC HIGHWAY DOUGLAS CO.
[signature]	PLAN ELEVATION & FOOTING PLAN



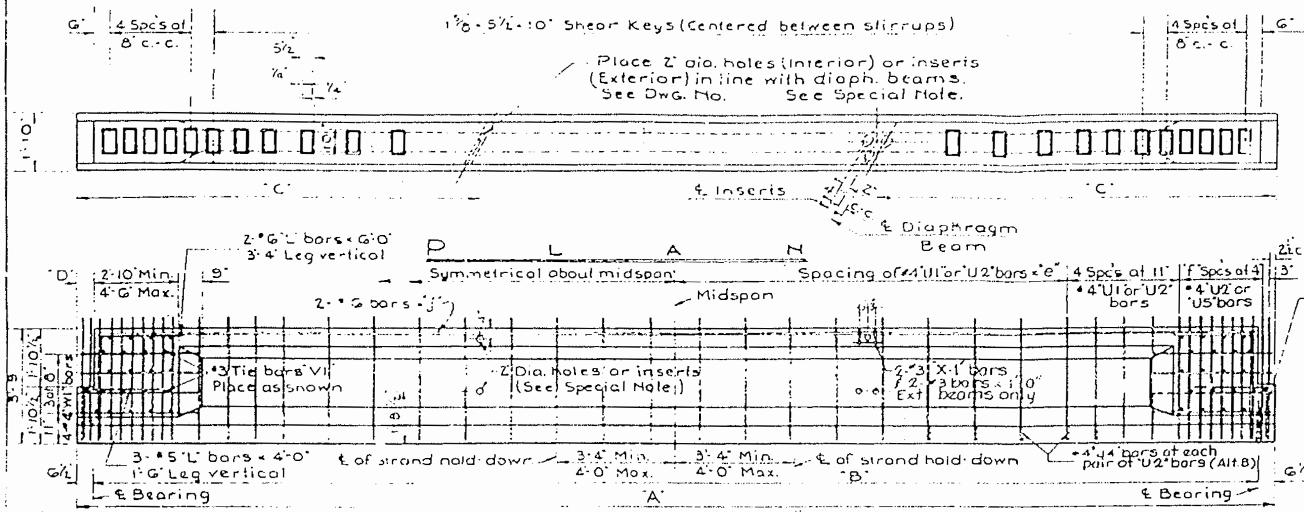
Foundation data shown on this drawing, in some instances, is a ... of and a revision in terminology from the original ... The original field drawing ... office of the Bridge Engineer in Salem.



34'-0" o-o
28'-0" Roadway
6 #5 bars x 7'-0" @ 4½" ctrs Bundle with top transverse deck bars
1" Exp. Jt.
Roadway ℄
Std. type 'A' Catch Basin @ Abutment #2 only. see Dwg #14660 for details.
See Dwg No. 20340 for steel reinforcement in curb returns.
PLAN ABUTMENT NO. 1 - ABUTMENT NO. 2 SIMILAR
Provide 1" ɸ hole @ abt. 3'-0" ctrs. to allow air to escape during concrete pour.
3"x3"x⅜" temporary angles @ 4'-0" ctrs. Fastend with ⅝" cap screws. Angles to remain inplace for 3 days after pouring deck on both sides of joint. Cap screws may be loosened as directed by Engineer, to allow for expansion.
No. 3 x 2'-0" 'U' bars @ 12" ctrs. with 9" vertical legs (end wall) - No. 3 x 2'-8" 'L' bars @ 12" ctrs with 9" vertical leg (deck span)
¾" ɸ x 8" welded stud concrete anchors alternate at 18" ctrs.
1" Expansion Joint
Premolded Expansion Jt. Filler
ARMORED CORNER DETAIL
Ground Line
Abutment #1 Elev. 1513.25
Abutment #2 Elev. 1511.50
Pour on well compacted fill material.
4" ɸ weep hole thru low corner of each wing wall
Abutment #1 Elev 1506.50
Abutment #2 Elev 1504.75
℄ Bearing ℄ Abutment
SECTION G-G
Scale: ¼" = 1'-0"
Roadway ℄
Slope 0.02'/ft
2 #8 bars x 31'-7"
#4 stirrups @ 12" ctrs.
Elev. Abutment #1-1513.25
Elev. Abutment #2-1511.50
4" ɸ weep hole thru bearing wall on ℄ of roadway
Elev. Abutment #1-1506.50
Elev. Abutment #2-1504.75
ELEVATION ABUTMENT NO. 1 - ABUTMENT NO. 2 SIMILAR
Pour top 1'-0" of back wall between gutter lines after deck has been placed.
1" Joint
4 #8 bars x 31'-7
2 #8 bars x 35'-2"
#5 bars x 6'-0" @ 12" ctrs
#5 bars x 34'-9" @ 12" ctrs w/std 90° hk. ea. end
#5 bars x varies @ 12" ctrs
8 #3 U bars @ 4" ctrs. under ea. bm.
#4 U bars @ 12" ctrs
1½" elastomeric pad
2" minimum grout
2 #3 spacer bars x 2'-6 @ ea. bm.
2 #4 hanger bars x 32'-0"
#5 bars x 34'-9" w/std 90° hk ea. end
#5 bars x varies @ 12" ctrs
Note: For jacking operation use cribbing which will spread load from one beam over not less than 4 lineal feet of toe of abutment footing.
#5 bars x 4'-6" @ 12" ctr alt. w/ #6 @ 12" ctrs.
#5 bars x 4'-6" @ 12" ctrs.
8 #5 bars x 35'-6"
℄ of Bearing = ℄ of Abutment
SECTION F-F
Scale: ½" = 1'-0"
Continuous backing of gravel or crushed rock along both wing walls and bearing walls
2 #4 bars x cont.
#4 bars @ 12" ctrs.
4 #4 bars x 19'-6"
4 #4 bars x 17'-6" w/std 90° hk. @ span face of back wall of abutment.
#5 bars x varies @ 12" ctrs.
#5 bars x varies @ 12" ctrs. with 90° hk as shown.
6" O.D. galvanized pipe per Dwg No. 14660.
9 #6 bars x varies as shown
SECTION E-E
Scale: ½" = 1'-0"
36'-0" o-o
#5 bars x 35'-6" top and bottom
#5 bars x 4'-6" @ 12" ctr. top
#6 bars x 4'-6" @ 12" ctr. top
#5 bars x varies @ 12" ctrs
#5 bars x 34'-9" @ 12" ctrs. w/std 90° hk.
#5 bars x 4'-6" @ 12" ctrs. bottom
℄ of Bearing = ℄ of Abutment
6 #5 vert. bars as shown w/std. 90° hk. @ bottom
#5 bars x varies @ 12" ctrs
#5 bars @ 12" ctrs
#5 bars x varies @ 12" ctrs top
9 #6 bars as shown
OREGON STATE HIGHWAY DEPARTMENT
BRIDGE DIVISION
PACIFIC HIGHWAY UXING OF BARTON R
ABUTMENTS NO. 1 & 2
Roadway width changed (Not to scale)
4-67 As Constructed
12-23-64

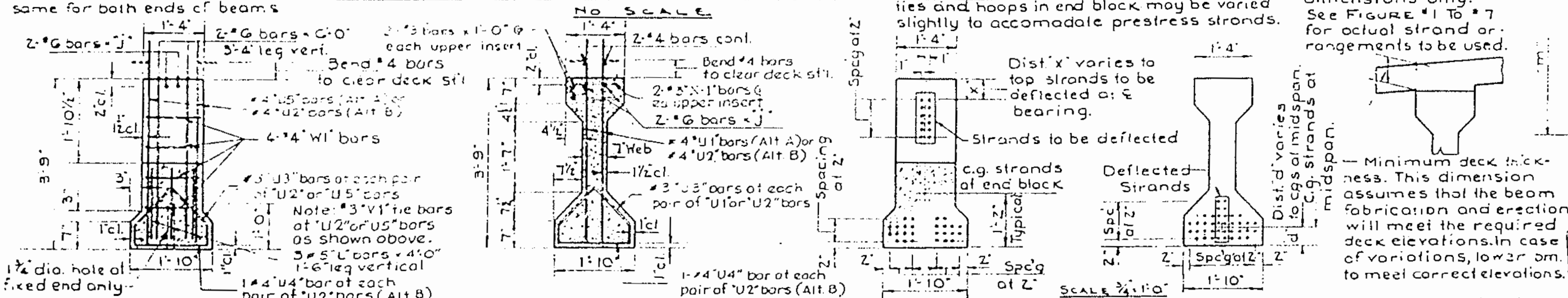


Bent No 1
Scale: 1/8" = 1'-0"
Bent No 2
Scale: 1/8" = 1'-0"
Bent No 3
Scale: 1/8" = 1'-0"
Existing Ground
Finish Grade
El 1489.00
El 1485.00
El 1484.00
Elastomeric Bearing Pad Details
Section 'B-B'
Beam 'D'
Half Deck Section ~ Span 2 & 3
Scale: 3/8" = 1'-0"
Deck Steel Spans 1 & 4
#5 straight bars @ 9" ctrs. top & bottom
#5 bent bars @ 9" ctrs.
30 #4 longit bars in top incl. stirr. hangers
36 #5 longit bars in bottom
Stop all transverse deck bars 6" clear of all transverse beams.
Extend top longitudinal bars 7'-6" and bottom longitudinal bars 2'-0" into spans 2 & 3
Deck Steel Spans 2 & 3
#5 straight bars @ 13" ctrs. top & bottom
#5 bent bars @ 13" ctrs.
30 #4 longit bars in top incl stirr hangers
26 #5 longit bars in bottom
Stop all transverse deck bars 6" clear of all transverse beams.
Extend top longitudinal bars 7'-6" and bottom longitudinal bars 2'-0" into Spans 1 & 4
Column Steel Bents 1, 2 & 3
8 #10 bars vert.
8 #10 dowels x 8'-7"
#4 hoops @ 12" ctrs
30'-0" o-o bent beams
1" Expanded Polystyrene
E's of Bearing
OREGON STATE HIGHWAY DEPARTMENT
BRIDGE DIVISION
Pacific Highway Uxing Of Barton Rd
Bents No 1, 2 & 3
(Not to scale)
As Constructed
1-4-65
Sht. 1



Note: Dimensions & steel details are the same for both ends of beams

Note: Location of ties and hoops in end block may be varied slightly to accomodate prestress strands.



End Block Section Scale ¾" = 1'-0" Mid-Span Section

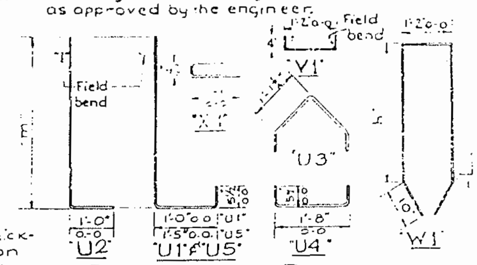
Typical Mild Steel Arrangement

End Block Section Mid-Span Section Scale ¾" = 1'-0"

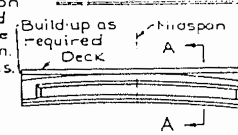
Typical Strand Arrangement

Note: These sections for dimensions only. See Figure #1 to #7 for actual strand arrangements to be used.

Minimum deck thickness. This dimension assumes that the beam fabrication and erection will meet the required deck elevations. In case of variations, lower dm. to meet correct elevations.



Bar Bending Details



Section "A-A"

Beam soffit shall be on level grade prior to prestressing. Difference between deck elev. & camber in beams shall be compensated for by build-up over beams.

Special Note:

For beams with total length (Dim. "A") greater than 60'-0" use two diaphragms as shown. For beams with total length equal to or less than 60'-0" use one diaphragm at midspan. See Dim. "C" in table below. Place 5-Richmond Structural concrete inserts EC-2 or approved equal in exterior beams only at each diaphragm. 1" dia. × 2'-3" Rod threaded full length to fit into each insert.

Bearing Details

Fixed End

1¼" Dia. × 1'-0" deep hole in beam. Beam is centered over 1¼" dia. dowel and elastomeric pad.

Expansion or Free End

No hole in beam; intersection of ℄ of beam and ℄ bearing is centered over center of elastomeric pad.

General Notes:

Specifications: O.S.H.D. Standard bridge specifications. Beams designed for H20-S16-44 live loading. Distribution is based on Case II, Sec 3-3-1 of O.S.H.D. bridge specifications.

Precast Prestressed Concrete: All concrete shall be Class "AA". This concrete shall have a 28 day compressive strength of either 5000 p.s.i. or 6000 p.s.i. and is shown in the table below as Concrete Strength in 28 days. The concrete strength at prestress release varies and is shown in table below as Concrete Strength at Transfer.

Pretensioning Steel: All strands shall be ½" dia. 7-wire strands with a minimum ultimate strength of 41,300 lbs (Grade 2, See Specifications.) Straight strands shall be tensioned initially to 28,910 lbs unless shown otherwise in the table below. Deflected strands shall have the same tension after deflecting.

Mild Steel Reinforcement: All reinforcing steel shall be intermediate grade deformed bars and shall conform to A.S.T.M. specifications A 305. All bars shall be lapped 20 dia. at all splices and placed 2" cl. of the nearest face of concrete unless shown otherwise.

Handling Prestressed Concrete Girders: The girders shall be maintained in an upright position at all times. They shall be lifted by means of lifting bars securely anchored in the end block as approved by the engineer.

Note: Dimensions shown in table are horizontal dimensions. Finished length of beam, ℄ bearing to ℄ bearing, (Dimension B) shall be corrected for variation due to grade. Allowance shall be made by fabricator for elastic shortening, creep and shrinkage. (Dimension "Z")

Beams	Number of Beams Req'd	Location	Span Length Center to Ctr. Bents Along ℄ Beam	Total Strands per Beam	Deflected Strands per Bm.	See Figure	Initial Tension per Strand in Kips	Concrete Strength at Transfer (K.s.i.)	Concrete Strength in 28 Days (K.s.i.)	Variable Concrete Dimensions "A"	"B"	"C"	"D"	Variable Mild Steel Dimensions #4 Stirrups "e"	"f"	"m"	"W1" Bar "h"	Top Bars "j"	Weight of Beams in Kips	Estimated Deflection at Midspan: Upward Deflect. due to Prestressing at Transfer	Upward Deflect. due to Prestress 3 mos. aft. trans.	Downward Deflect. due to Deck Dead Load	"Z" Bm. Shortening Two Weeks After Transfer
A	4	Span 1	41'-0"	12	4	1	28.91	4.0	6.0	41'-6"	40'-5"	20'-9"	7"	17	8	5.0	3-2	40.0	23.4	[illegible]	[illegible]	[illegible]	[illegible]
B	10	Span 2 & 3	85'-0"	36	10	2	28.91	6.0	6.0	84'-11"	83'-10"	[illegible]	7"	15	8	5.0	3-2	83.5	50.8	1⅜"	2"	[illegible]	[illegible]
C	4	Span 4	48'-0"	18	6	3	27.00	4.0	6.0	48'-6"	47'-5"	24'-3"	7"	16	8	5.0	3-2	47.0	29.5	[illegible]	[illegible]	[illegible]	[illegible]

Build-Up Deck Details

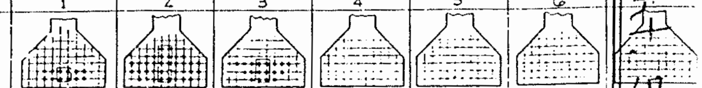
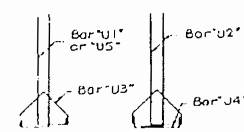


Figure	1	2	3	4	5	6
Total Strands	12	36	18			
Str. Deflected	4	10	6			
"d" Distance	3.00	5.1"	4.44			
"x" Distance	8"	3"	10½"			



Date	Revision
4-67	As Constructed

Oregon State Highway Department
Bridge Division

Pacific Highway U'xing Of Barton Roa[d]

Type III Prestressed Conc. Bea[ms]

Bridge Name: Seismic Retrofit – Example 1

Calculations by: S.K. Starkey Date: 2/4/94 Bridge No.: –

Longitudinal

Superstructure Dead Loads (Step 1)

No ACWS present or future.

Bt. 1:

$$Wt. = \underbrace{\frac{25(4)}{2}}_{Bms} + \underbrace{\frac{7(2.4)(26.7)(0.15)}{12}}_{End\ Bm} + \underbrace{\frac{9(2.5)(23.0)(0.15)}{12\ (2)}}_{Bm\ D}$$

$$+ \underbrace{\frac{7(37)(40.4)(0.15)}{12\ (2)}}_{Deck} + \underbrace{\frac{0.65(41)(2)}{2}}_{Rails}$$

$$= \underline{\underline{150\ k}}$$

Bt. B:

$$Wt. = \frac{30(4)}{2} + 7 + 6 + \frac{7(37)(47.4)(0.15)}{12\ (2)}$$

$$+ \frac{0.65(43)(2)}{2}$$

$$= \underline{\underline{180\ k}}$$

Bt. 2:

$$Wt. = \underbrace{150}_{Sp.1} + \underbrace{\frac{51(5)}{2}}_{Bms} + \underbrace{7 + 6}_{Bm\ E} + \underbrace{\frac{7(37)(83.3)(0.15)}{12\ (2)}}_{Deck}$$

$$+ \underbrace{\frac{0.65(83)(2)}{2}}_{Rails}$$

$$= \underline{\underline{470\ k}}$$

BRIDGE SECTION
Oregon State Highway Division

Sheet 7

Bridge Name Seismic Retrofit - Example 1

Calculations by SS Date 2/4/99 Bridge No. —

Bt. 4:

Wt. = 180 + 320

= 500 k

Bt. 3:

Wt. = 320(2)

= 640 k

Bridge Name: Seismic Retrofit – Example 1

Calculations by: SS Date: 2/4/97 Bridge No. —

Column Capacities (Step 2)

Run ULTCOL for

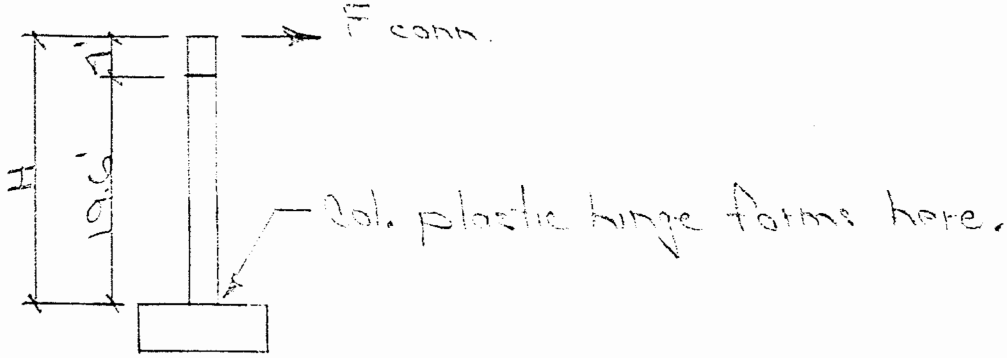
3' ⌀ column w/ 8-#10 (Gd. 40)

$f'_c = 3300$ psi

$\phi = 1.3$ to account for overstrength capacity of materials.

Output follows.

Bt. 2:



$P_D = 470$ k/bt. (2 cols./bent)

Need X-bm & column wts too.

$$\therefore P_D = \frac{470}{2} + \underbrace{\frac{3(4)(30)(0.15)}{2}}_{\text{X-Bm}} + \underbrace{7.1(19.6)(0.15)}_{\text{Col.}}$$

$= 280$ k

& $M_{cap} = 890$ k-ft (interpolate from ULTCOL output)

BRIDGE SECTION

Oregon State Highway Division

Sheet 9

Bridge Name Seismic Retrofit - Example 1

Calculations by SS   Date 2/4/99   Bridge No. —

$$F_{conn} = \frac{890\ k\text{-}ft}{23.6\ ft} = 38\ k/col.$$

Other bents similar.

Summary:

Bt.	P_D (k/col.)	$M_{cap.}$ (k-ft)	H (ft)	F_{conn} (k)
2	230	890	23.6	38
3	370	970	28.1	35
4	300	910	27.2	33

Per col. conn. forces

10

```
******* U L T C O L *******

*     CONCRETE COLUMN STRENGTH      *

*     OSHD BRIDGE DESIGN SECTION     *

*     VERSION 2, MOD 1,  JUNE 1983     *

******* U L T C O L *******


PROBLEM   1                                      PAGE   0


BR. 9351A  BARTON ROAD UXING  STARKEY  1-31-94    (SKSULCA)
BENTS 2, 3, AND 4 COLUMN
RUN AT 09:54:24 ON 01/31/94
```

BR. 9351A BARTON ROAD UXING STARKEY 1-31-94 (SKSULCA)
BENTS 2, 3, AND 4 COLUMN
RUN AT 09:54:24 ON 01/31/94

```
CONCRETE  3.3
CIRCULAR  36.
REINFORCING 40.
CIRCULAR  8  1.27  29.6
PRINT
```

* * * * * * * * * * * * BASIC SECTION DATA * * * * * * * * * * * *

FOR 3.3 KSI CONCRETE WITH USABLE STRAIN = .00300
EQUIV. RECT. STRESS RATIO (K) = .850 AND DEPTH RATIO (A/C) = .850

COLUMN IS 36.0 IN BY 36.0 IN WITH GROSS AREA = 1013.7 IN2
CGC AT X = .0 Y = .0

FOR 40.0 KSI REINFORCING WITH E = 29000.0 KSI
TOTAL AREA OF 8 BARS = 10.2 IN2 (= .010 OF CONCRETE AREA)
CGR AT X = .0 Y = .0

BR. 9351A BARTON ROAD UXING STARKEY 1-31-94 (SKSULCA)
BENTS 2, 3, AND 4 COLUMN
RUN AT 09:54:24 ON 01/31/94

COORDINATES

- - - - CONCRETE	- - - -		- - - - - - REINFORCING	- - - - - -		
ID	X	Y	ID	X	Y	AREA
1	.00	18.00	1	.00	14.80	1.270
2	2.82	17.78	2	10.47	10.47	1.270
3	5.56	17.12	3	14.80	.00	1.270
4	8.17	16.04	4	10.47	-10.47	1.270
5	10.58	14.56	5	.00	-14.80	1.270
6	12.73	12.73	6	-10.47	-10.47	1.270
7	14.56	10.58	7	-14.80	.00	1.270
8	16.04	8.17	8	-10.47	10.47	1.270
9	17.12	5.56				
10	17.78	2.82				
11	18.00	.00				
12	17.78	-2.82				
13	17.12	-5.56				
14	16.04	-8.17				
15	14.56	-10.58				
16	12.73	-12.73				
17	10.58	-14.56				
18	8.17	-16.04				
19	5.56	-17.12				
20	2.82	-17.78				
21	.00	-18.00				
22	-2.82	-17.78				
23	-5.56	-17.12				
24	-8.17	-16.04				
25	-10.58	-14.56				
26	-12.73	-12.73				
27	-14.56	-10.58				
28	-16.04	-8.17				
29	-17.12	-5.56				
30	-17.78	-2.82				

31	-18.00	.00
32	-17.78	2.82
33	-17.12	5.56
34	-16.04	8.17
35	-14.56	10.58
36	-12.73	12.73
37	-10.58	14.56
38	-8.17	16.04
39	-5.56	17.12
40	-2.82	17.78
41	.00	18.00

```
PHI  1.30  1.30
INTER  1   '8-#10'
LINE   0.0
```

BR. 9351A BARTON ROAD UXING STARKEY 1-31-94 (SKSULCA)
BENTS 2, 3, AND 4 COLUMN
RUN AT 09:54:24 ON 01/31/94

INTERACTION DIAGRAM 1 - 8-#10
STEP 1 : NEUTRAL AXIS PHI = 0. DEGREES
REINFORCING RATIO = .010
STRENGTH REDUCTION FACTORS (SRF) : 1.300 AXIAL, 1.300 BENDING

P	MXX	MYY	SRF
.1	628.41	.00	1.30
220.5	838.89	.00	1.30
441.1	1030.83	.00	1.30
660.6	1196.79	.00	1.30
881.3	1316.94	.00	1.30
1102.9	1407.88	.00	1.30
1321.6	1476.71	.00	1.30
1543.9	1525.39	.00	1.30
1763.4	1537.77	.00	1.30
1983.5	1514.31	.00	1.30
2203.5	1466.73	.00	1.30
2422.4	1397.06	.00	1.30
2647.3	1307.32	.00	1.30
2867.9	1199.51	.00	1.30
3086.8	1071.19	.00	1.30
3306.4	919.25	.00	1.30
3528.7	737.06	.00	1.30
3746.8	521.59	.00	1.30
3966.9	269.22	.00	1.30
4184.8	3.62	.00	1.30

FINISH

* * * * END OF INPUT FILE * * * *
1 PROBLEM(S) ANALYZED THIS RUN

BRIDGE SECTION
Oregon State Highway Division

Sheet 15

Bridge Name: Seismic Retrofit - Example 1

Calculations by: SS Date: 2/4/94 Bridge No.: —

Connections - Interior Bents (Step 3)

No full design at this time.

Per ODOT standard practice (O.P. 5.2.5) use 7/8" ∅ cables (A 603 mat'l.)

$F_{allow} = 60.4 \text{ k}$ (O.P. 5.1.7.2)

$A = 0.361 \text{ in}^2$

$E = 10{,}000 \frac{k}{in^2}$ (not prestretched)

$$\text{No. Req'd} = \frac{39(2)}{60.4} = 1.3 \frac{\text{cables}}{\text{bent}}$$

For symmetry in connecting to each beam use 2 cables/beam.

For symmetry about ℄ structure use cables at two beams.

∴ use 4 cables on back side of bent and 4 cables on ahead side of bent.

Cable length normally between 10' and 20'. This situation requires 7' length.

734-3136 (11-8)

BRIDGE SECTION
Oregon State Highway Division

Sheet 16

Bridge Name: Seismic Retrofit - Example 1

Calculations by: SS Date: 2/7/94 Bridge No.: —

Stiffness Coefficients (Step 4)

Bt 1 (E5):

Use only the backwall acting on the fill.

Use $25 \frac{k}{ft^2\text{-}in}$ per O.P. 5.1.2.3

$$k_1 = \left(\frac{25\ k}{ft^2\text{-}in}\right)(4.2\ ft)(34.0\ ft)$$

$$= 3600\ k/in$$

Bt. 2:

Spread footings founded on weathered tuff (rock).

Ignore footing springs - assume full fixity for footing.

$$\therefore\ k = \frac{3EI}{L^3}$$

$$= \frac{3(3300)(3.9)}{(23.6)^3}(12)\left(\frac{2\ cols}{bt.}\right)$$

$$= 70 \frac{k}{in\text{-}bt}$$

Bts 3 & 4 similar

$$k = 40 \frac{k}{in\text{-}bt} \quad (bt. 3)$$

$$k = 45 \frac{k}{in\text{-}bt} \quad (bt. 4)$$

Bridge Name: Seismic Retrofit – Example 1

Calculations by: SS Date: 2/7/94 Bridge No.: —

Need cable elongation too:

With 4 cables / bent & 7' length

$$k_{cables} = \frac{EA}{L}$$

$$= \frac{10000(0.361)(4)}{7\,(12)}$$

$$= 170 \frac{k}{in\text{-}bt}$$

At each bent the cable stretch and column deflection from bending are additive – the springs are "in series." Flexibilities (inverse of stiffnesses) are additive ∴

$$k_2 = \left[\frac{1}{70} + \frac{1}{170}\right]^{-1} = 50 \frac{k}{in\text{-}bt.}$$

$$k_3 = 30 \frac{k}{in\text{-}bt.}$$

$$k_4 = 35 \frac{k}{in\text{-}bt.}$$

Bridge Name: Seismic Retrofit - Example 1

Calculations by: [illegible] Date: 2/7/94 Bridge No. —

Substructure Capacities (Step 5)

Bt. 1 (& 5):

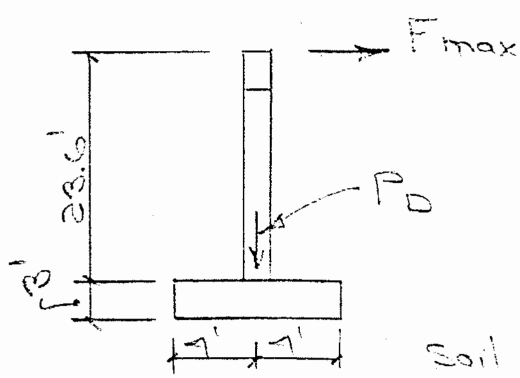
Use $7.7 \frac{k}{ft^2}$ per O.P. 5.1.2.3

$F_{max} = 7.7 \frac{k}{ft^2} (4.3\ ft)(34.0\ ft)$

$= \underline{\underline{1125\ k}}$

Bt. 2:

Due to founding of footings on rock, not concerned w/ soil bearing failure but do check overturning.



Soil Ftg.

$P_D = 280 + 4.0(8)^2(0.12) + 3.0(8)^2(0.15)$

$= 340\ k$

$F_{max} = \frac{340(4)}{(23.6+3)} = 51 \frac{k}{col} > 33 \frac{k}{col}$ of p. 9

∴ capacity limited by column bending. (p. 9)

By inspection other bents similar.

BRIDGE SECTION
Oregon State Highway Division

Sheet 19

Bridge Name Seismic Retrofit - Example 1

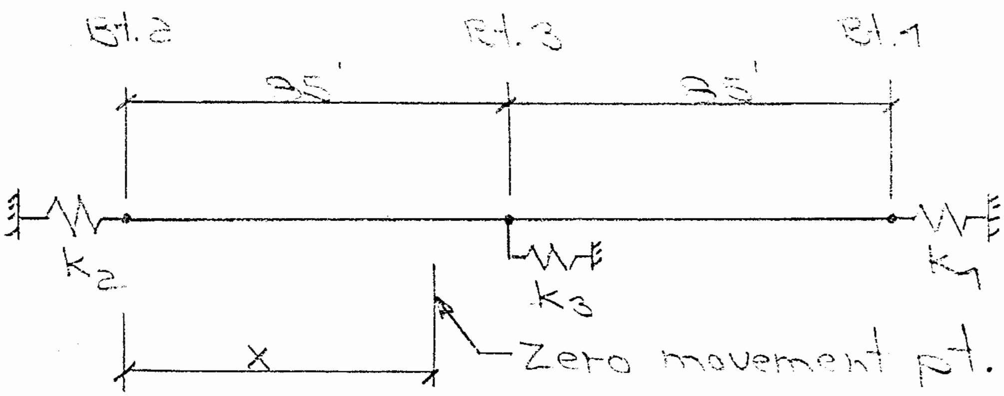
Calculations by SS   Date 2/7/94   Bridge No. —

Period, Dynamic Loading & Dynamic Defl.

(Steps 6 & 7)

Consider creep, shrinkage and temperature fall. These distorsion induced deflections imply a point of no movement.

Recognizing that each bent force is proportional to its distance from the zero movement point and equating horiz. bent forces for stability ($\Sigma F_H = 0$):



$$k_2(x) = k_3(85 - x) + k_4(85 - x + 85)$$

$$50x = 30(85 - x) + 35(85 - x + 85)$$

$$x = 73.9'$$

Creep:

From O.P. 5.1.17.2 for post-tensioned conc.

$$\text{strain initial} \approx \frac{0.44}{100(12)} = 0.00037$$

Bridge Name Seismic Retrofit - Example 1

Calculations by SJ Date 2/7/94 Bridge No. —

Use this value for these prestressed beams.

Creep factor = 1.5 (O.P. 5.1.17.2)

Portion of creep after placing bms = 60%
(O.P. 5.1.17.2)

Shrinkage:

Strain total = 0.0004 (O.P. 5.1.17.2)

Portion after placing bms = 60% (O.P. 5.1.17.2)

Temperature Fall - use coef. = 0.000006 /°F
and Δ_T = 40 °F

Bt. E:

$$\Delta_{CR+SH+TF} = \Big[(0.00037(1.5) + 0.0004)(0.60) + 0.000006(40)\Big](11.1+35+48)(12)$$

$$= \overset{CR}{0.58''} + \overset{SH}{0.42''} + \overset{TF}{0.42''}$$

$$= 1.42'' \quad (\text{use } 1.4'')$$

With 1" expan. jt. built into the end bents the total movement req'd. to engage the backwall / soil is 1.0" + 1.4" = 2.4"

Deflections to develop capacities:

Bt. 2: $\Delta = \frac{38(2)}{50} = 1.5''$ (for 76 k)

Bt. 3: $\Delta = 2.3''$ (70 k)

Bt. 4: $\Delta = 1.9''$ (66 k)

Bt. 5: $\Delta = \frac{1125}{3650} = 0.3''$ (1125 k)

Bridge is near Canyonville

Per ODOT blue sht map (p. 26C of specs.)

$A = 0.19 \Rightarrow$ Category B bridge

Rock site ∴

$S = 1.0$ (soil amplification)

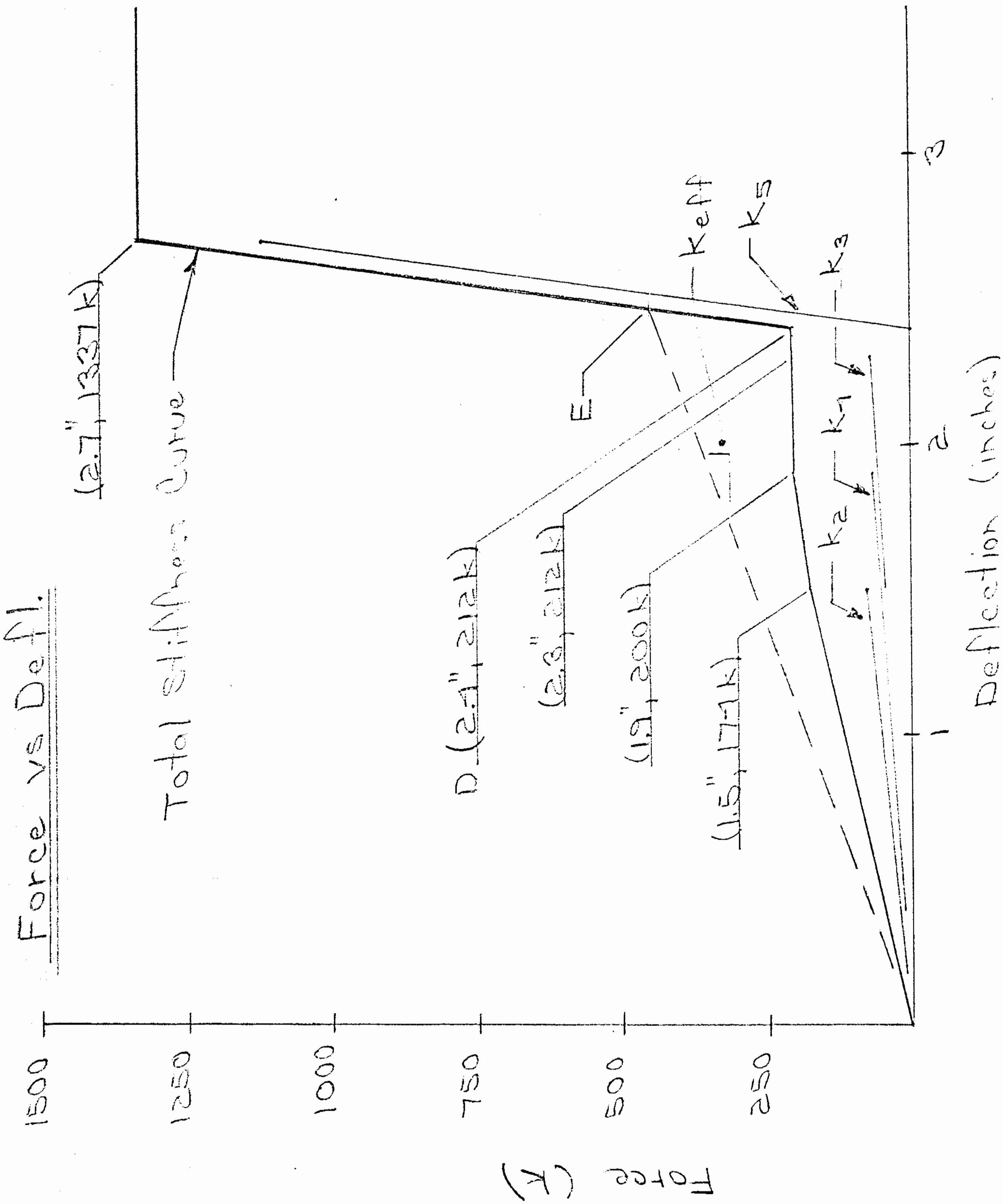
BRIDGE SECTION

Oregon State Highway Division

Sheet 22

Bridge Name Seismic Retrofit – Example 1

Calculations by SS Date 2/7/97 Bridge No. –



Assume dynamic loading to pt. D:
(backwall just engaging, $\Delta = 2.4''$, $F = 212\,k$)
Use the equivalent stiffness and the period formula, $T = 0.32\sqrt{\frac{Wt}{K_{eff}}}$

where Wt is in kips and Keff is in k/inch

$$K_{eff} = \frac{212}{2.4} = 88\ k/in.$$

$$Wt = 150 + 190 + 470 + 500 + 640$$
$$= 1950\ k$$

$$T = 0.32\sqrt{\frac{1950}{88}} = 1.50\ sec.$$

$$C = \frac{1.2\,A\,S}{(T)^{2/3}}$$ (AASHTO, Div. I-A, equation 5-1)

$$C = \frac{1.2(0.19)(1.0)}{(1.50)^{0.67}} = 0.17 < 2.5A = 0.48\ ✓$$

$$\therefore F = 0.17(1950) = 330\ k \neq 212\ k$$

Try again, pt E:

$$\Delta = 2.46'' \qquad F = 450\ k$$

$$K_{eff} = \frac{450}{2.46} = 185\ k/in.$$

$$T = 0.32\sqrt{\frac{1950}{185}} = 1.04\ sec$$

BRIDGE SECTION

Oregon State Highway Division

Sheet 24

Bridge Name Seismic Retrofit - Example 1

Calculations by SS Date 2/7/94 Bridge No. –

$$C = \frac{1.2(0.19)(1.0)}{(1.04)^{0.67}} = 0.22$$

$$\therefore F = 0.22(1950)$$

$$= 430\text{ k} \approx F_{assumed} \therefore OK✓$$

$$\& \ \Delta_{dyn} = 2.5''$$

Bridge Name: Seismic Retrofit - Example 1

Calculations by: SS   Date: 2/7/99   Bridge No. —

Specification Seat Length (Steps 8 & 9)

Use the specs equation 7-3A:

$N = 8'' + 0.02(L) + 0.08(H)$

$= 8 + 0.02(259) + 0.08\left(\frac{23.6+28.1+27.2}{3}\right)$

$= 15.3''$ ←

Compare to O.P. 5.1.9.2 requirement:

$N = 4 \times$ elastic defl

$= 4(2.5) = 10''$ ∴ specs. value cntl's.

Available seat length:

Conservatively using the same $\Delta_{CR+SH+TF}$ at bt. 1 as used at bt. 5

$N_{avail} = 10'' + 6\frac{1}{2}'' - 1.4''$

$= 15.1'' \approx N_{req'd} = 15.3''$

∴ no seat extension req'd.

NOTE: The specs. value for $N_{req'd}$ and the ODOT value for $N_{req'd}$ ($4 \times$ elastic defl.) includes adequate residual beam bearing length.

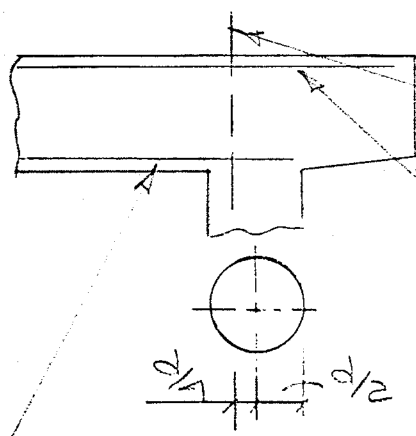
Bridge Name Seismic Retrofit – Example 1
Calculations by SS Date 2/1/94 Bridge No. —

Transverse

Additional Capacities (Step 1)

Use top of column capacities as previously done for the bottom of column.

Crossbeam: Gd 40 rebar
L_d = 2.3' for #9
2.7' for #10
3.7' for #11
↑ 2/3 of Gd 60 values.



Critical Sect -- compute Mcap here.

Bts 2 & 4:
2-#9 fully developed

Bt. 3:
6-#10 fully devel.
2-#11 ✓ ✓

Bts 2 & 4:
4-#9 fully developed
2-#9 w/ 1.0' develp. (45%)

Bt. 3:
4-#11 fully developed
2-#11 w/ 2.3' develop. (60%)
2-#11 w/ 1.8' ✓ (50%)

Bts 2 & 4:

$$+M_{cap.} = 1.3\,(1.0(4) + 1.0(2)(0.45))(40)$$
$$\times\left[45.3 - \frac{196}{2(0.85)(3.3)(36)}\right]\frac{1}{12}$$
$$= 950\ k\text{-}ft$$

$$-M = 1.3(1.0)(8)(40)\left[45.3 - \frac{320}{2(0.85)(3.3)(36)}\right]\frac{1}{12}$$

$$= 1500 \text{ k-ft}$$

By comparing to col. capacities, plastic hinges will form first in the column.

Bt. 3:

By inspection, same hinge formation locations as at bts 2 & 4 (in columns, not the crossbeam).

BRIDGE SECTION

Oregon State Highway Division

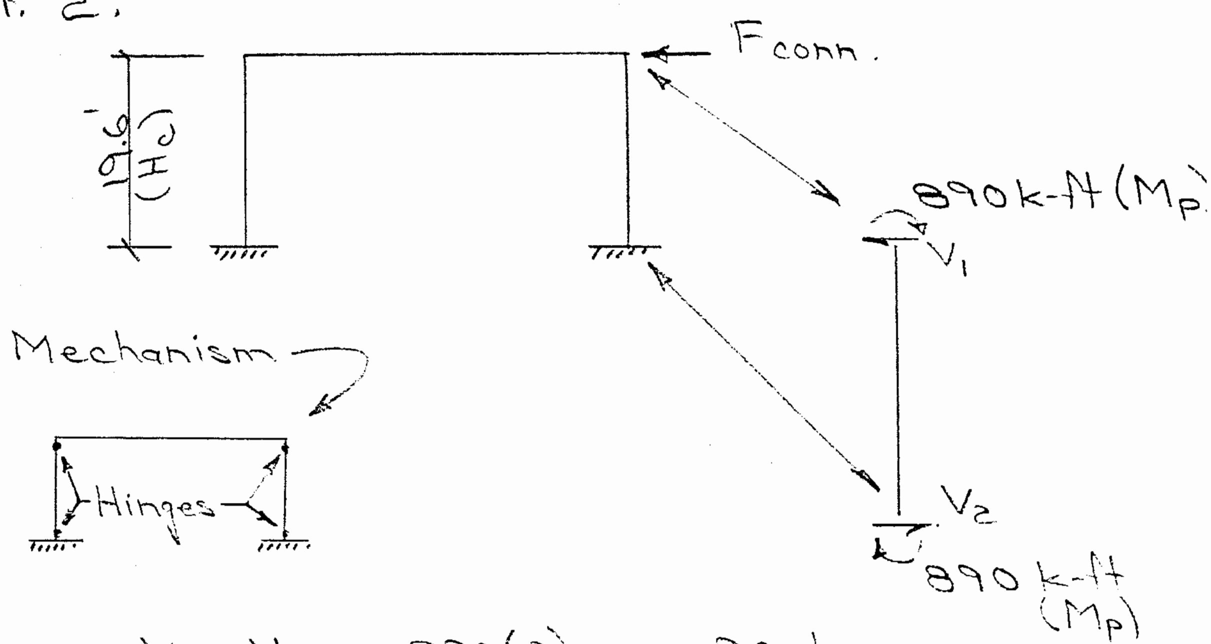
Sheet 28

Bridge Name Seismic Retrofit - Example 1

Calculations by SS Date 2/1/97 Bridge No. —

Failure Mechanisms & Conn. Forces (Step 2)

Bt. 2:



$$V_1 = V_2 = \frac{890(2)}{19.6} = 90 \text{ k}$$

$$\therefore F_{conn} = 2V_1 = 180 \text{ k}$$

Other bents similar.

Summary:

Bt.	M_p (k-ft)	H_c (ft)	$F_{conn.}$ (k)
2	890	19.6	180
3	970	24.1	160
4	910	23.2	155

Use Fconn above to design restrainers (shear lugs). No full design at this time.

BRIDGE SECTION

Oregon State Highway Division

Sheet 29

Bridge Name Seismic Retrofit - Example 1

Calculations by SS Date 2/1/94 Bridge No. —

End Bt. Conn. Forces (Step 7)

Bt. 1:

$F_{conn} = 2.5(0.17)(150)$

$= \underline{70\ k}$

Bt. 5:

$F_{conn} = 2.5(0.17)(180)$

$= \underline{85\ k}$

No full design at this time.