TOLL BRIDGE PROGRAM
OVERSIGHT COMMITTEE
CALTRANS BAY AREA TOLL AUTHORITY CALIFORNIA TRANSPORTATION COMMISSION

Toll Bridge Program Oversight Committee
Department of Transportation
Office of the Director
1120 N Street
P.O. Box 942873
Sacramento, CA 94273-0001

July 12, 2013

Mr. Vincent Mammano
California Division Administrator
Federal Highway Administration
650 Capitol Mall, Suite 4-100
Sacramento, CA 95814

RE: SFOBB Bearing Shims

Dear Mr. Mammano:

The Toll Bridge Program Oversight Committee (TBPOC) requests further assistance from the Federal Highway Administration to conduct an independent review of the Seismic Safety Peer Review Panel proposal to shim the bearings at Pier E2 of the new east span of the San Francisco-Oakland Bay Bridge (SFOBB). This proposal would open the new span to traffic once the bearing shims are installed, but before the shear key retrofit is complete.

The proposal would temporarily restore shear capacity lost due to the failed bolts used to clamp down two shear keys on Pier E2. The bearings were designed to accommodate 20 mm of movement laterally before engaging during a seismic event. The shims would lock the four bearings laterally to engage simultaneously with the two remaining shear keys that are currently in place on the cross beam and functioning as designed.

I am attaching preliminary technical materials related to the bearing shims and asking your team to provide an independent review of the engineering analysis and strategy for this proposal. The TBPOC expects to receive more complete engineering analysis early next week; we will forward more detailed materials to you at that time. If you require any additional information to conduct your review, please contact me as soon as possible. Since the bearing shim proposal may offer the possibility of achieving seismic safety on the SFOBB prior to completion of the shear key retrofit, time is of the essence in the completion of your review.

Thank you for your continued assistance and cooperation in ensuring that we open a safe new bridge for the traveling public at the earliest responsible date.

Sincerely

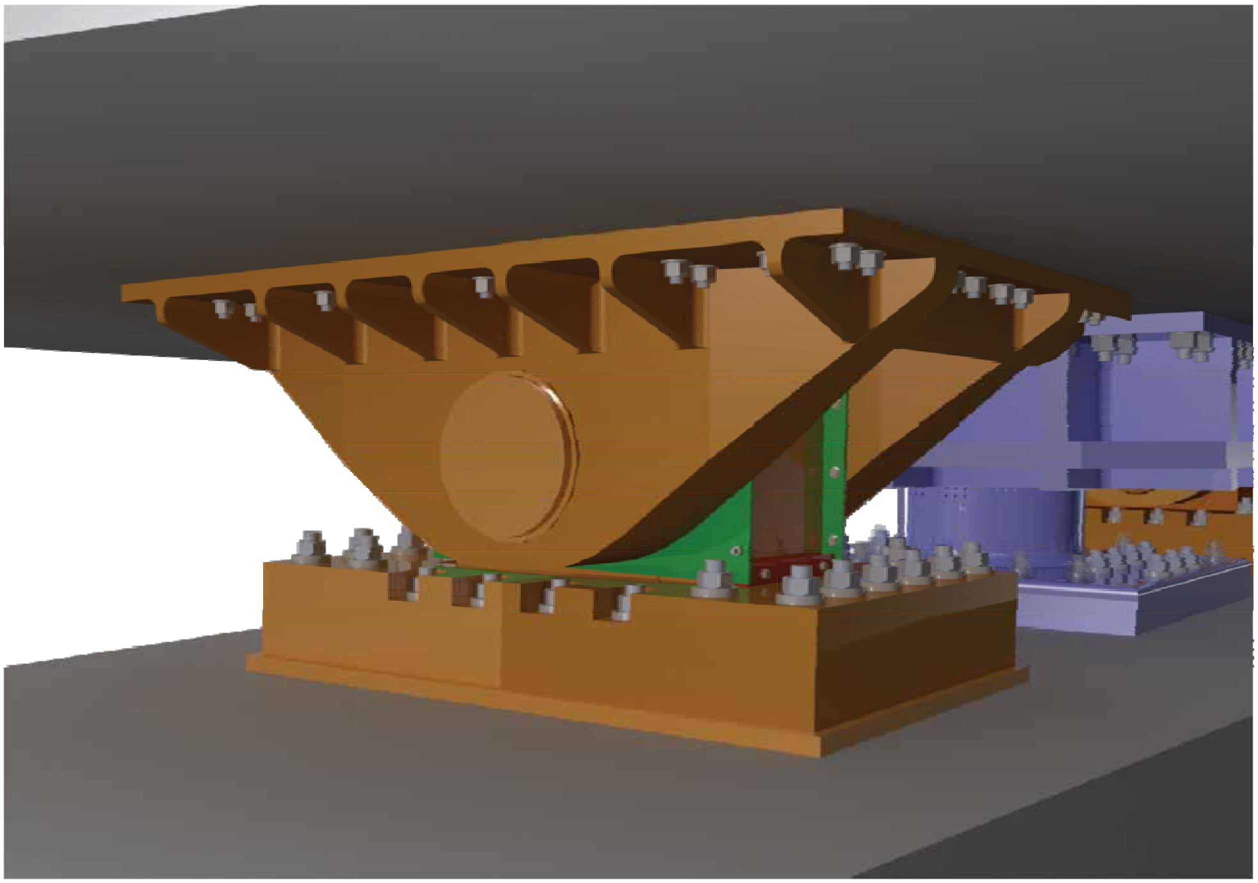
Steve Heminger
Chair, TBPOC

J:\SECTION\EXEC\EO\Andrew Fremier\Correspondence 2013\Mammano_Heminger_SFOBB Bearing Shims_July 11 2013.doc
Attachments
cc: Malcolm Dougherty, Caltrans
Andre Boutros, CTC
Brian Kelly, Transportation Agency

San Francisco-Oakland Bay Bridge

Self-Anchored Suspension Span (SFOBB-SAS)

THE SAN FRANCISCO-OAKLAND BAY BRIDGE SEISMIC SAFETY PROJECTS



SEISMIC EVALUATION OF SAS AT E2 PIER PRIOR TO COMPLETION OF SHEAR KEYS S1 & S2

July 15, 2013

T·Y·LIN INTERNATIONAL
MOFFATT & NICHOL ENGINEERS
a joint venture

TABLE OF CONTENTS:

STATEMENT OF PURPOSE:

This report provides a summary of the technical information for the seismic evaluations of the San Francisco-Oakland Bay Bridge (SFOBB) East Spans Self-Anchored Suspension (SAS) at E2 Pier prior to completion of shear keys S1 and S2.

This report documents information on demand and capacity of relevant stages of construction and service. Additionally, visual images are included to support the understanding of various structural elements and staging. Supporting finite element analysis (FEM) is also provided.

This report evaluates temporary bearing modifications by adding simple shims to the Pier E2 Bearings (B1, B2, B3 and B4) to engage the bearing's reserve capacities for an interim condition.

EXECUTIVE SUMMARY:

As requested by Caltrans and as presented and discussed during the Seismic Safety Peer Review Panel (SSPRP) meeting with Caltrans and the peer review panel on July 3 2013, the Design Joint Venture of T.Y. Lin International / Moffatt & Nichol Engineers have performed an evaluation of the seismic capacity of the shear keys and bearings at Pier E2 of the Self-Anchored Suspension (SAS) Bridge. To this end various alternative load paths were evaluated and compared against the Seismic Demands for the Design Level Earthquake per the Project Specific Design Criteria. These Seismic Demands correspond to the envelope of the maximum time-history analysis response from six different 1500-year ground motions (SEE - Safety Evaluation Earthquake). At the top of Pier E2, these SEE demands total 50MN in the longitudinal direction of the bridge and 120MN in the transverse direction of the bridge.

The design lateral capacity of the shear keys and bearings at Pier E2 can be summarized as follows:

	Longitudinal Direction	Transverse Direction
- Shear Keys S1 & S2:	42 MN	42 MN
- Shear Keys S3 & S4:	42 MN (20mm Gap)	42 MN
- Bearings B1, B2, B3 & B4:	15 MN (20 mm Gap)	30 MN (20 mm Gap)

The design plans account for two alternative load paths:

A) Load Path A (shear keys are engaged) – This load path maintains the 20 mm gaps in S3 & S4 and the Bearings B1, B2, B3 & B4, thereby engaging only shear keys S1 & S2 in both directions and S3 & S4 in the transverse direction only. This provides a total capacity of 84 MN and 168 MN in the longitudinal and transverse directions, respectively.

B) Load Path B (all shear keys discounted) – This load path engages the Bearings B1, B2, B3 & B4 in both directions upon closing of the 20 mm gap due to seismic movement. This provides a total capacity of 60 MN and 120 MN in the longitudinal and transverse directions, respectively.

Assuming that the New Design of the Shear Keys S1 & S2 is not completed and by implementing interim shimming of the Bearings B1, B2, B3 & B4 to close the 20 mm gaps, a third alternative load path to resist the design lateral SEE demands can be developed: (reference Plan Sheet 883S1/1204 “Pier E2 Details No. 1A)

C) Load Path C (shear keys S1 & S2 discounted) – This load path engages the Bearings B1, B2, B3 & B4 by interim shimming of the 20 mm gaps in both directions, in addition to S3 & S4 being engaged in the transverse direction only. This provides a total capacity of 60 MN and 204 MN in the longitudinal and transverse directions, respectively.

The table in the Evaluation of Alternative Load Path at Pier E2 section provides a summary of the Seismic Lateral Capacity at Pier E2 for Load Path A, B & C, the SEE demands, and the associated Factors of Safety.

Enclosed please find a rendering depicting the installation sequence of the shims as well as a Finite Element Analysis (FEM) of the bearings.

BRIAN MARONEY'S (CALTRANS) MEMO:

(FROM EMAIL DATED JUNE 29, 2013 TO PMT / TBPOC / SSPRP)

This memo is to briefly summarize the safety of the Self-Anchored-Suspension bridge segment with respect to the expected performance of the San Francisco-Oakland Bay Bridge during a design level earthquake assuming the S1 and S2 shear key work currently underway is not fully completed by the time of seismic safety opening. In simplified terms, the bridge system between the orthotropic box girder superstructure and the concrete Pier E2 bentcap has enough strength capacity to carry 1500 year return period design level earthquake motion generated shear forces, overwhelmingly driving a shift of public traffic to the replacement bridge from the old bridge based on a desire for public safety.

The bridge capacity to carry the demand loads at Pier E2 is overdesigned to 140% of the worst of six different 1500 year return period earthquake time-history generated loads. The design criteria of the East Spans of the Bay Bridge is based upon 1500 year return period motions, which excides the national standards of 1000 year return period motions. This can be read as there is a 40% extra capacity in the "as-designed" system at Pier E2 above the lifeline criteria that is above the national standard. In simple terms, the system at Pier E2 was not designed to the bare minimum and there was a significant reserve capacity incorporated into the design that we should recognize at this time as leaders consider opening day alternatives. This extra design reserve is important to recognize when accounting for the fact that in construction there has developed a temporary reduction in capacity due to the Pier E2 threaded rod problem. The temporary reduction in strength capacity of the Pier E2 system due to the 2008 rod fractures is less than the overdesign. Therefore, leadership can advance increase public safety by opening the bridge as soon as feasible.

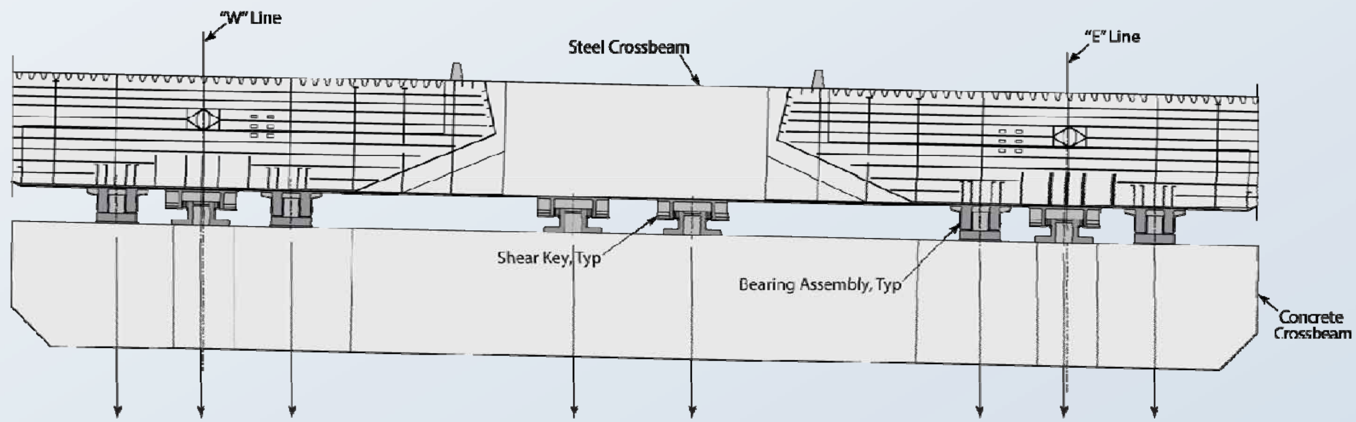
From bridge computer demand analysis models, earthquake lateral demands at the top of Pier E2 can be very simply summarized as 120 MN of force transversely and 50 MN of force longitudinally. If it is conservatively assumed that the S1 and S2 shear keys are completely ineffective, the S3 and S4 shear keys are only effective in the transverse direction and the B1, B2, B3 and B4 bearings are temporarily shimmed to engage them at zero relative displacement, lateral capacity to carry the 120 MN lateral demand is estimated at [2 * (42) + 4 * (30)] = 204 MN. Clearly, 204 MN is greater than 120 MN. Similarly, in the longitudinal direction the four shimmed bearings provide a capacity of [4 * (15)] = 60 MN and 60 MN is greater than 50 MN. These simple calculations demonstrate the new bridge provides well-above standard seismic safety even if the S1 and S2 shear key work is not complete.

The existing bridge was not designed for the most basic "no-collapse" seismic safety criteria that is typically employed in modern bridge design. The old bridge is at risk in large Bay Area earthquakes as was demonstrated during the 1989 Loma Prieta Earthquake. The modest interim retrofit was developed to address the most fundamental seismic risks up to a limit of 25 million dollars. It was a good investment but was never intended to address long-term seismic risks associated with even a standard of 1000 year return period "no-collapse" criteria.

This summarizing discussion demonstrates that the San Francisco – Oakland Bay Bridge East Spans Replacement Structure offers significantly superior seismic safety to the public compared to the old bridge. From a technical perspective, it can be relatively easily concluded that the public should be moved onto the new structure at the first practical opportunity even if the S1 and S2 shear key work is not complete. It should be clear that the S1-S2 work is valuable as it provides the level of extra safety, reliability and toughness that was envisioned in the original design by bridge earthquake specialists and should be completed on an expedited schedule.

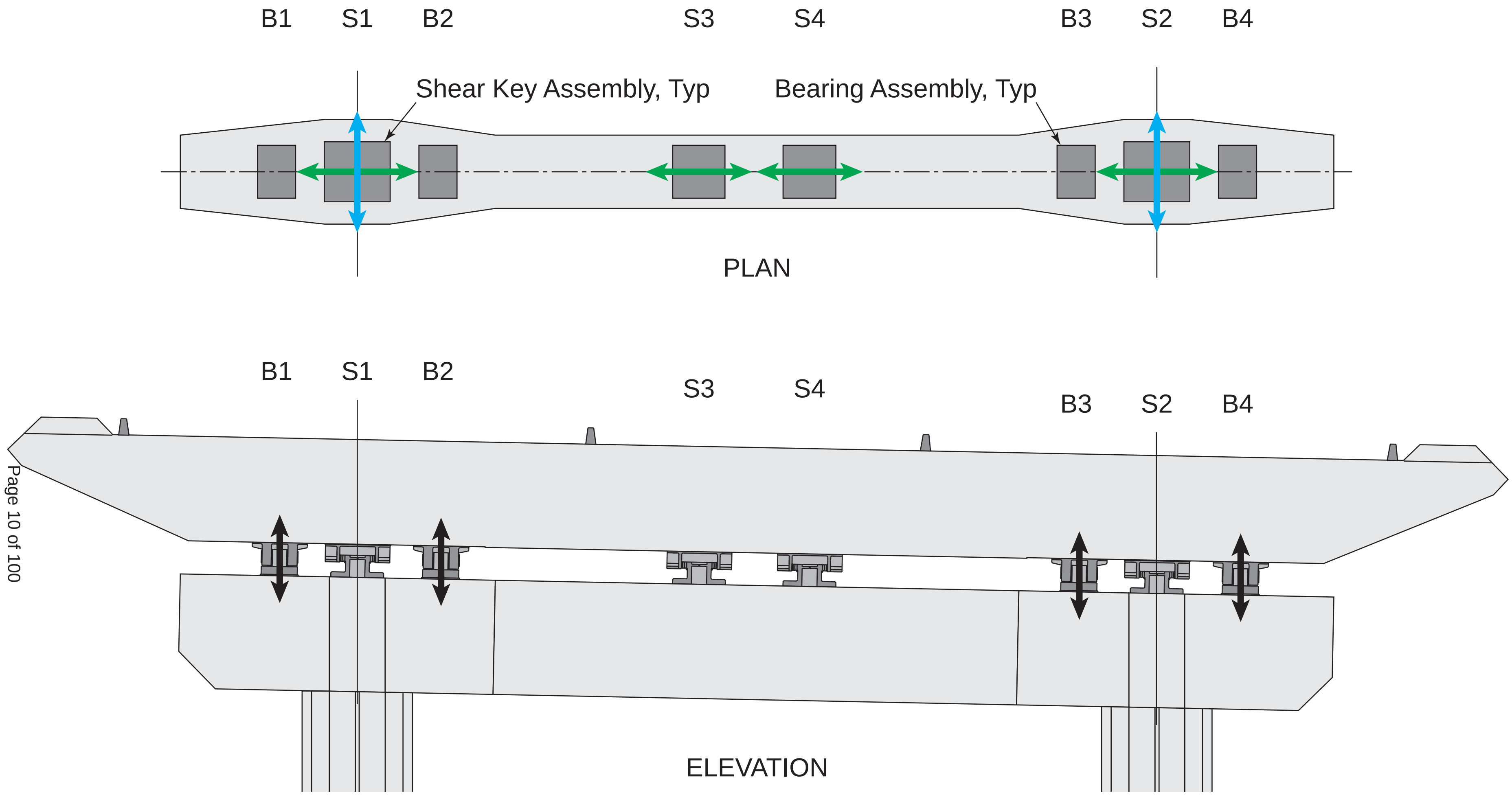
Evaluation of Alternative Load Path at Pier E2

EVALUATION OF ALTERNATIVE LOAD PATHS AT PIER E2 FOR SEISMIC RESISTANCE



		Direction	B1	S1	B2	S3	S4	B3	S2	B4	TOTAL (MN)	SAFETY FACTOR
DEMAND	SEISMIC DEMAND FOR SEISMIC SAFETY EVALUATION (SEE) EARHQUAKE	Long									50	
		Trans									120	
CAPACITY	LOAD PATH A: (ALL SHEAR KEYS ENGAGED)	Long	0[a]	42	0[a]	0[c]	0[c]	0[a]	42	0[a]	84	168%
		Trans	0[b]	42	0[b]	42	42	0[b]	42	0[b]	168	140%
	LOAD PATH B: (ALL SHEAR KEYS DISCOUNTED) (BEARINGS ENGANGED)	Long	15	0	15	0	0	15	0	15	60	120%
		Trans	30	0	30	0	0	30	0	30	120	100%
	LOAD PATH C: (INTERIM SHIM OF BEARINGS) (S1 & S2 SHEAR KEYS DISCOUNTED)	Long	15	0	15	0[c]	0[c]	15	0	15	60	120%
		Trans	30	0	30	42	42	30	0	30	204	170%

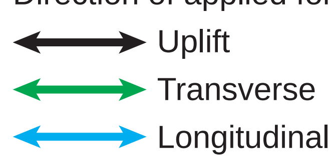
a. 30 mm gap in the longitudinal direction. Bearing (B1, B2, B3, and B4) engage after 30 mm gap is closed by displacement.
b. 20 mm gap in the transverse direction. Bearing (B1, B2, B3, and B4) engage after 20 mm gap is closed by displacement.
c. 43 mm gap filled with neoprene open cell. Shear Keys (S3 and S4) engage in the longitudinal direction after 43 mm gap is closed by displacement.

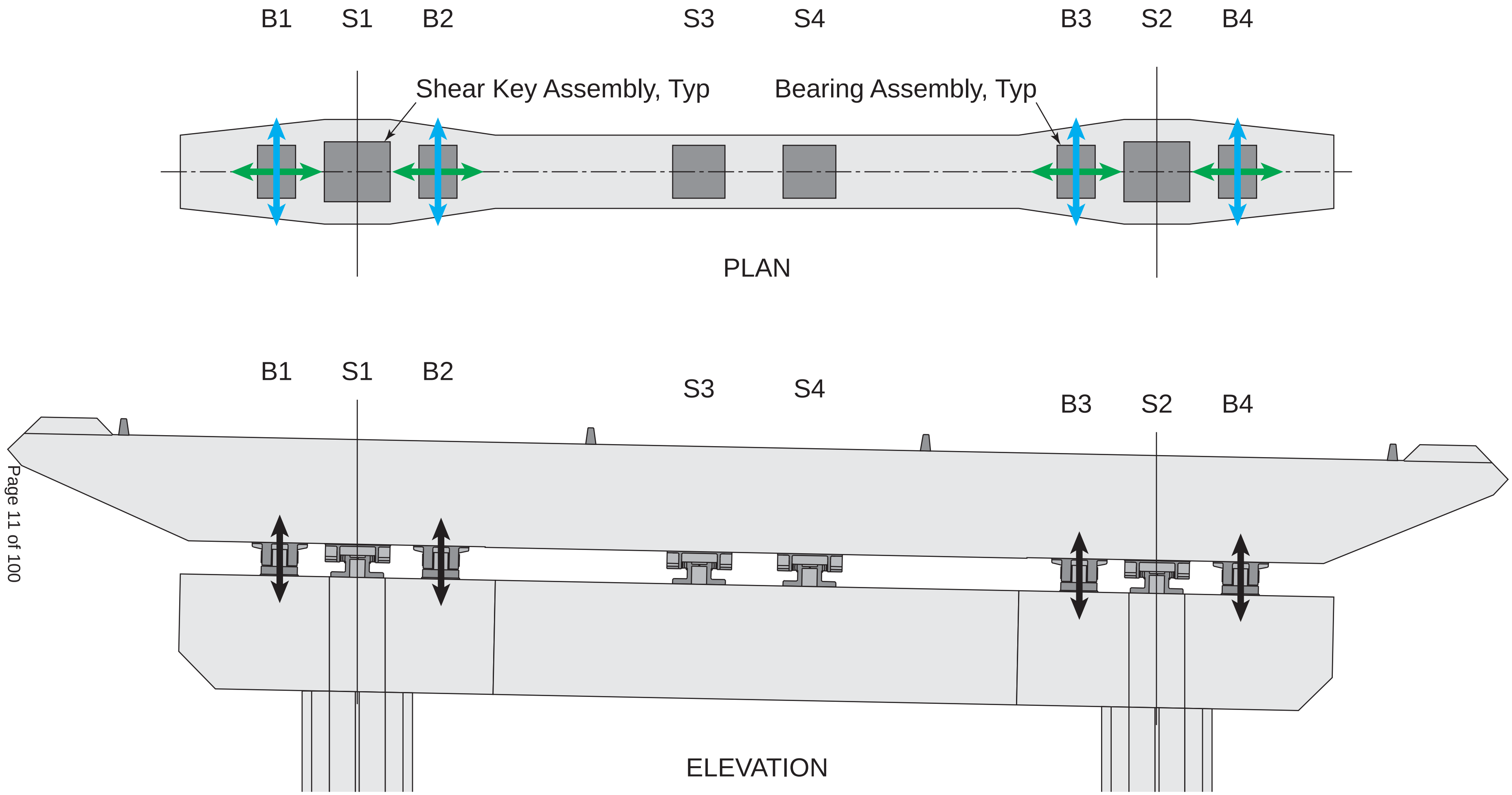


LOAD PATH A — ALL SHEAR KEYS ENGAGED

(Force Resistance Of Shear Keys And Bearings)

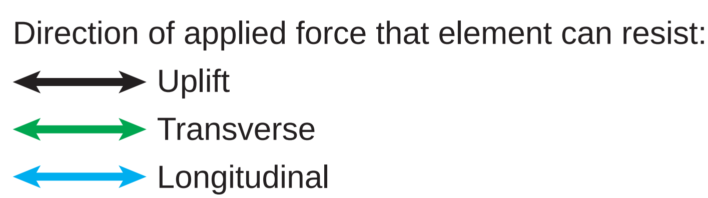
Direction of applied force that element can resist:

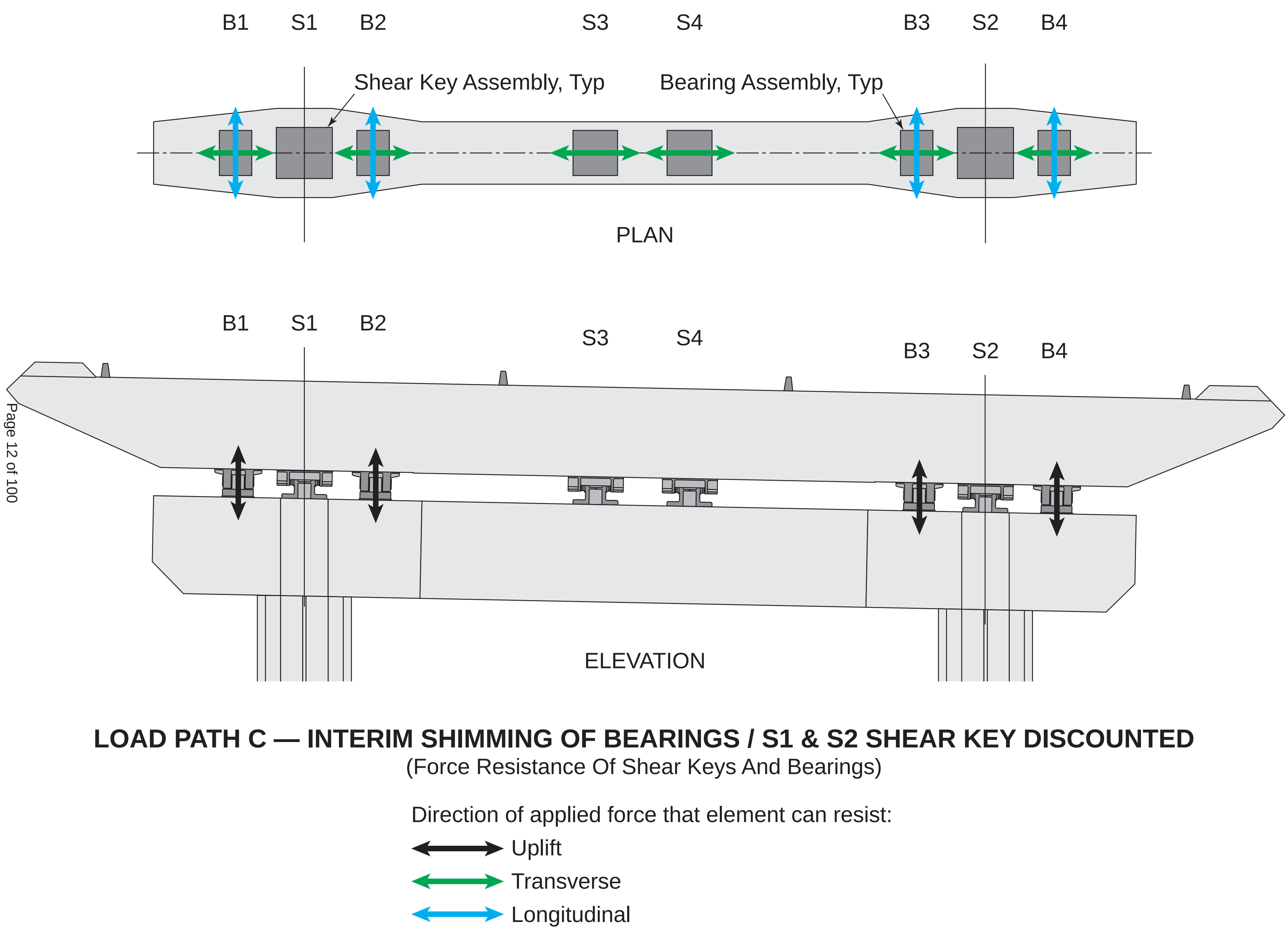




LOAD PATH B — ALL SHEAR KEYS DISCOUNTED / ALL BEARINGS ENGAGED

(Force Resistance Of Shear Keys And Bearings)





LOAD PATH C — INTERIM SHIMMING OF BEARINGS / S1 & S2 SHEAR KEY DISCOUNTED

(Force Resistance Of Shear Keys And Bearings)

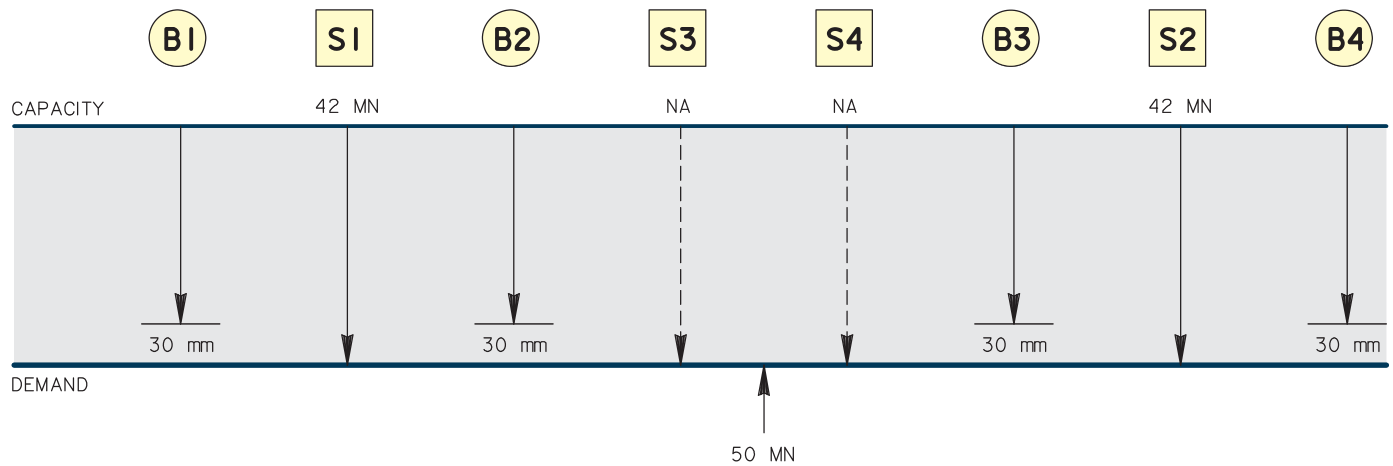
Direction of applied force that element can resist:

LONGITUDINAL

(DEMANDS & CAPACITIES)

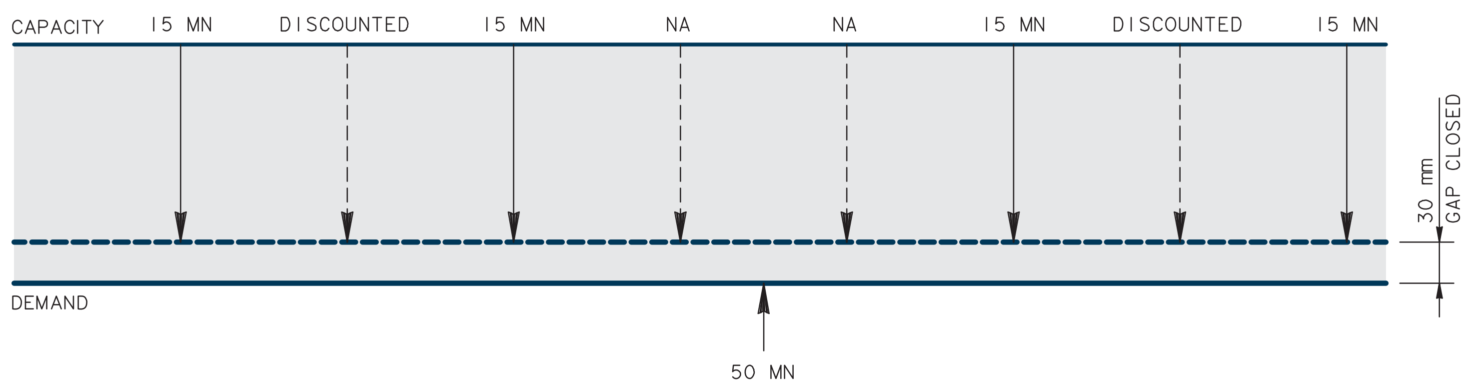
LOAD PATH (A)

– AS DESIGNED NOMINAL



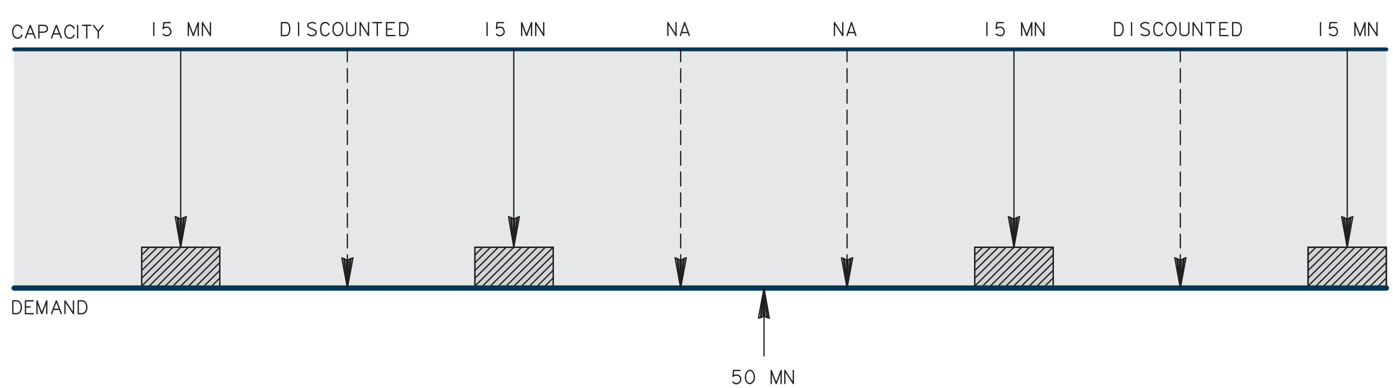
LOAD PATH (B)

– AS DESIGNED GAP CLOSED
– S1, S2 DISCOUNTED
– S3, S4 NOT ENGAGED



LOAD PATH (C)

– INTERIM FIX
– GAP CLOSED BY SHIMMING
– S1, S2 DISCOUNTED
– S3, S4 NOT ENGAGED



TRANSVERSE

(DEMANDS & CAPACITIES)

LOAD PATH (A)

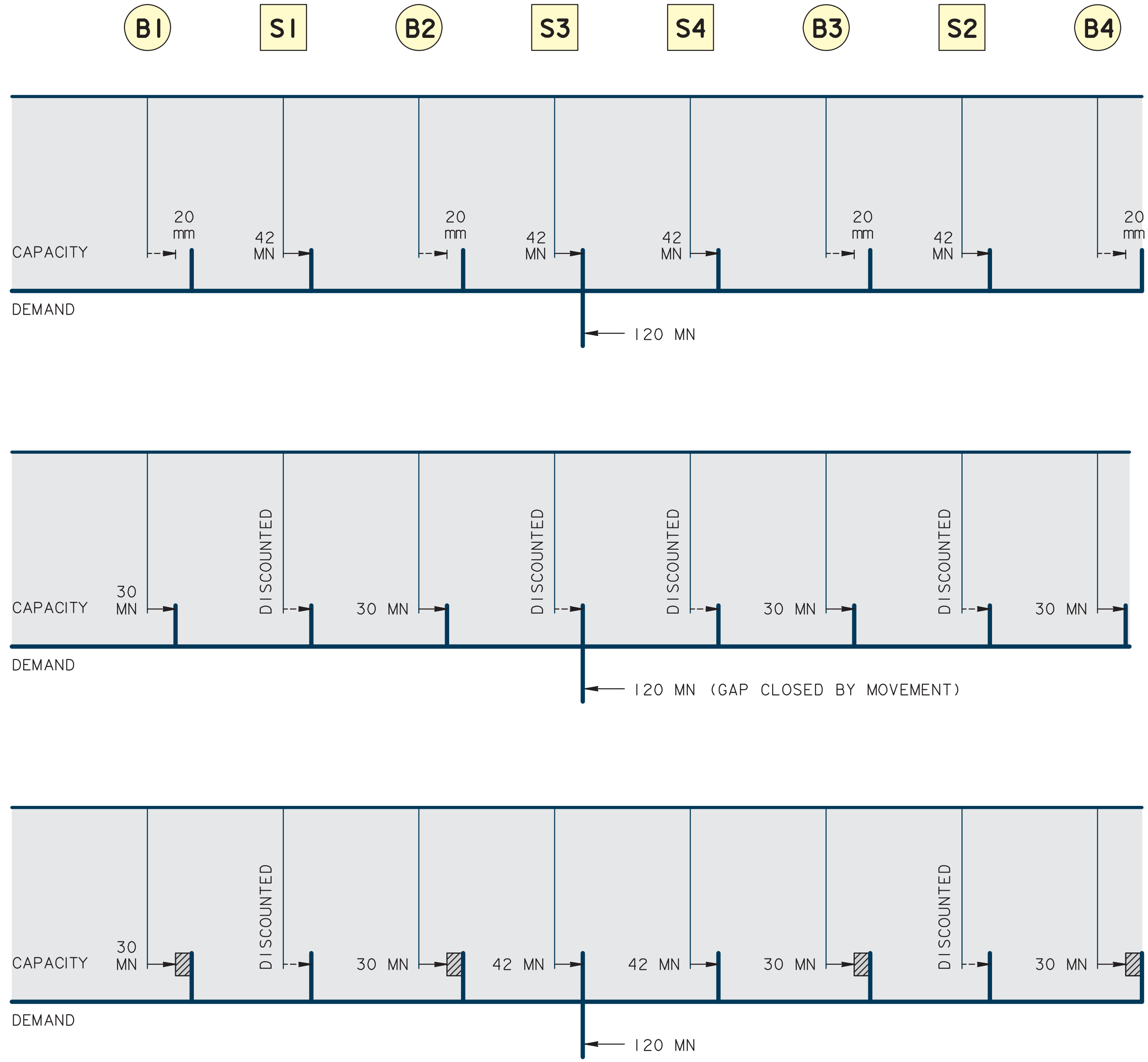
– AS DESIGNED NOMINAL

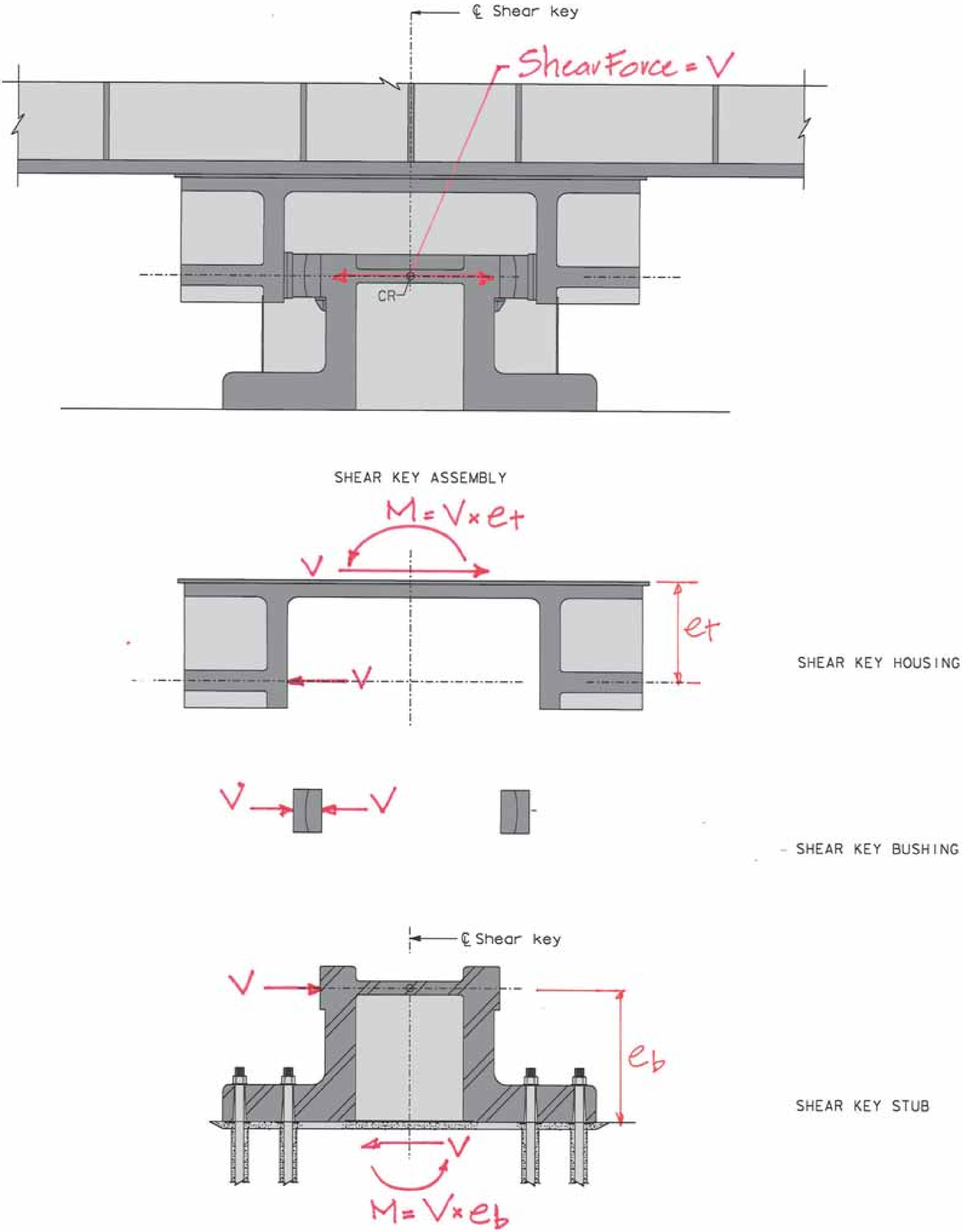
LOAD PATH (B)

– AS DESIGNED GAP CLOSED
– S1, S2, S3 & S4 DISCOUNTED

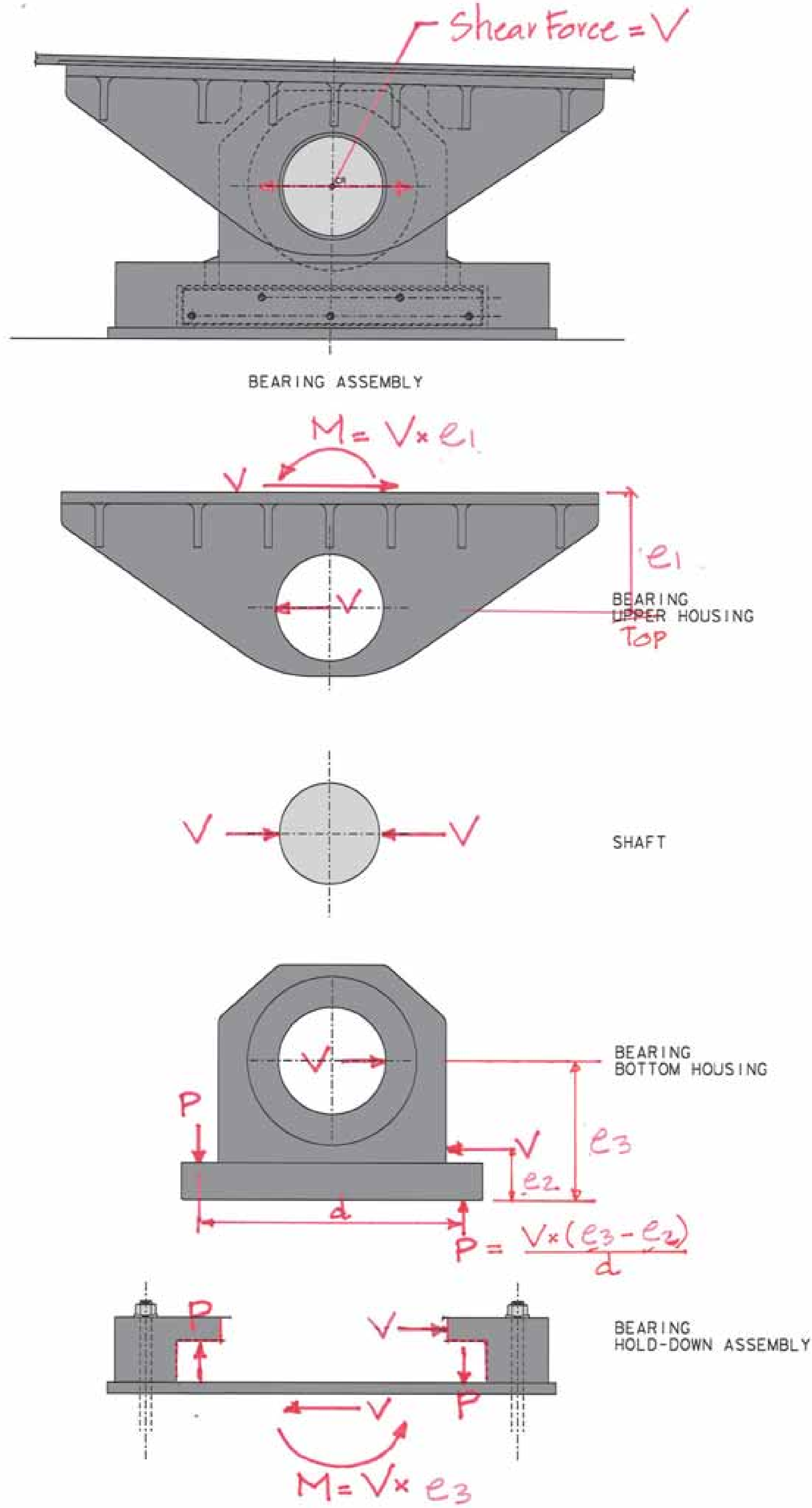
LOAD PATH (C)

– INTERIM FIX
– GAP CLOSED BY SHIMMING
– S1, S2 DISCOUNTED

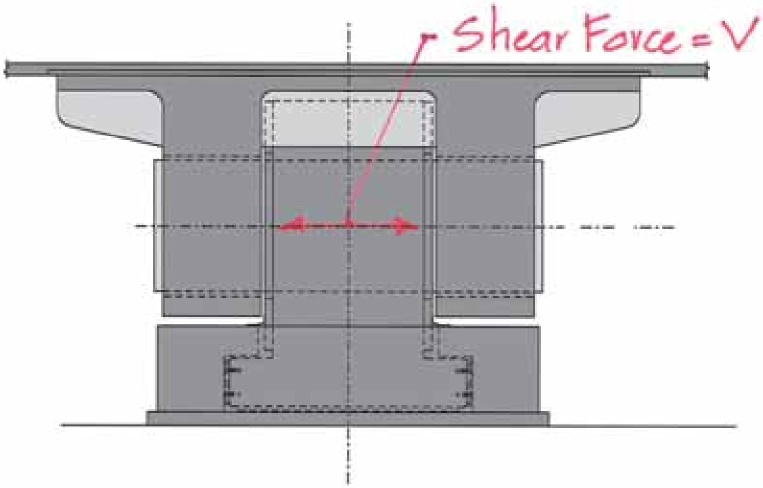


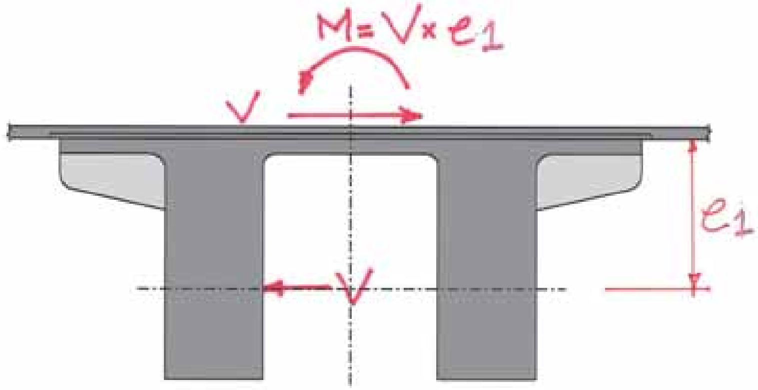


LOAD THROUGH SHEAR KEY

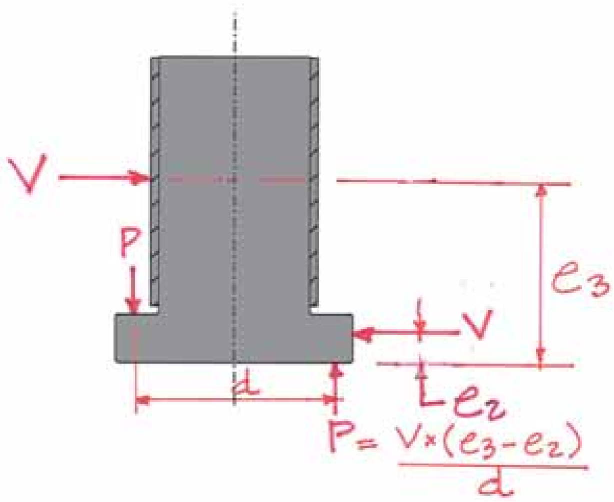


LOAD THROUGH BEARING – LONGITUDINAL SHEAR

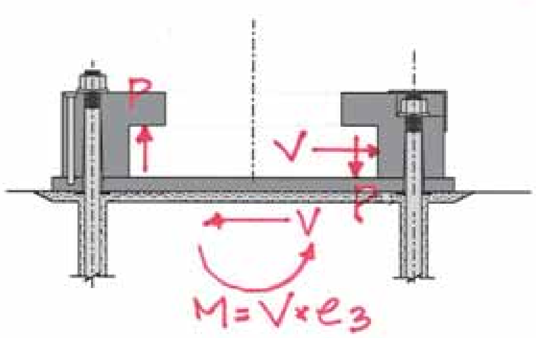




BEARING TOP HOUSING

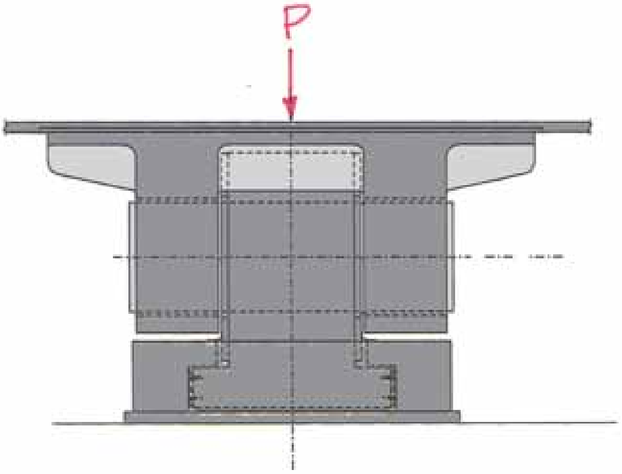


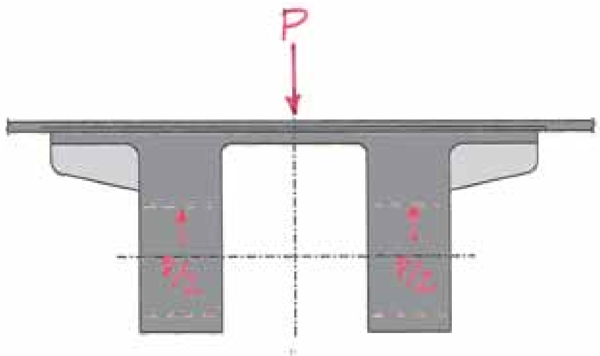
BEARING BOTTOM HOUSING



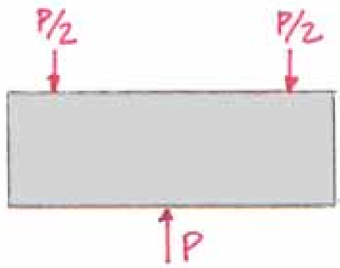
BEARING HOLD-DOWN ASSEMBLY

LOAD THROUGH BEARING – TRANSVERSE SHEAR

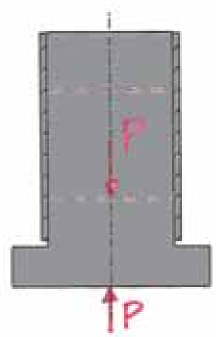




BEARING TOP HOUSING



SHAFT



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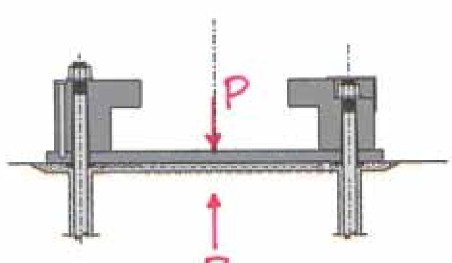
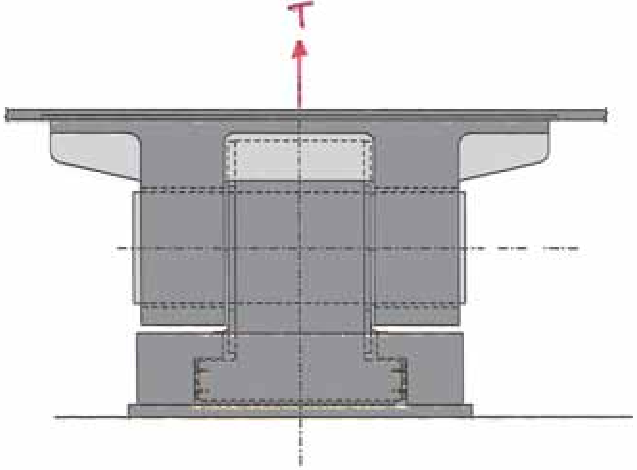
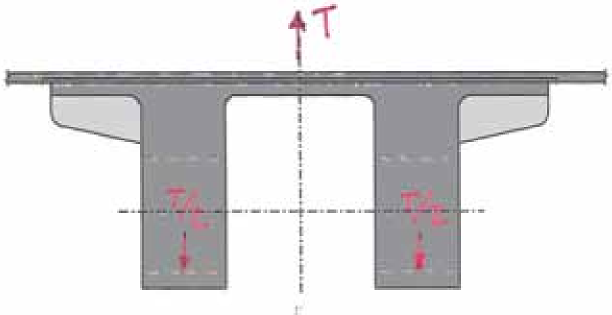


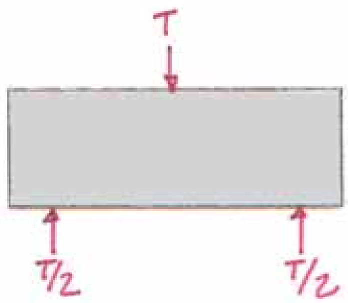
BEARING HOLD-DOWN ASSEMBLY

LOAD THROUGH BEARING – COMPRESSION

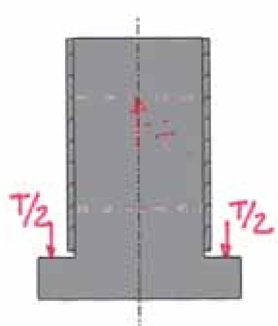




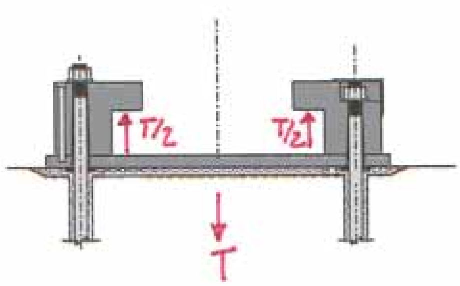
BEARING TOP HOUSING



SHAFT



BEARING BOTTOM HOUSING



BEARING HOLD-DOWN ASSEMBLY

LOAD THROUGH BEARING - UPLIFT

CCO No. 331 – E2 Bearing Shimming Details (883S1 of 1204)

DIST.	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SF	80	13.2/13.9	883SI	1204

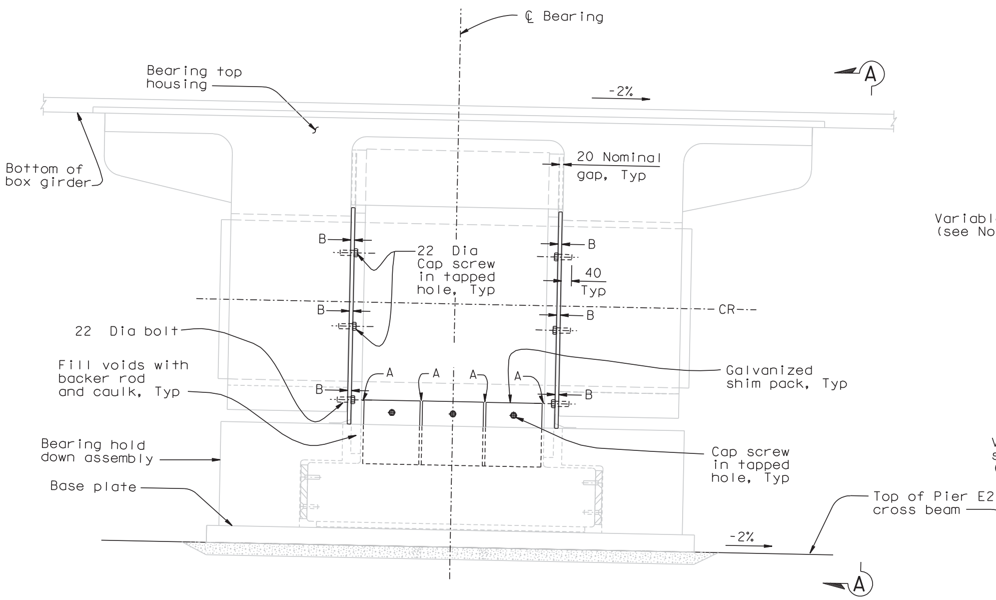
REGISTERED ENGINEER - CIVIL
07-03-13
PLANS APPROVAL DATE

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.

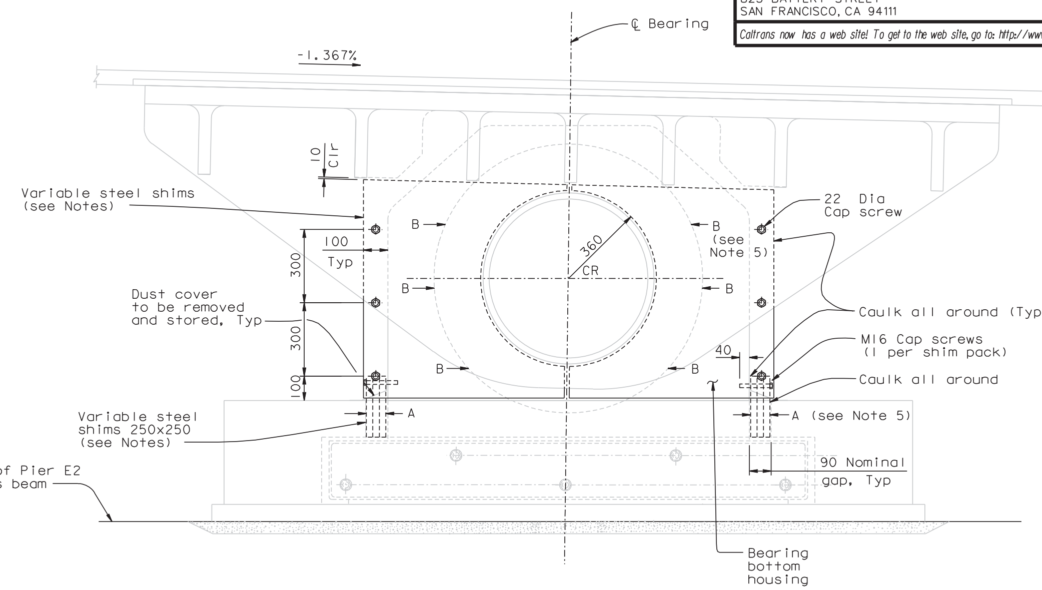
PROFESSIONAL ENGINEER — Marwan N. Nader — No. C 054426 — Exp. 12/31/13 — CIVIL — STATE OF CALIFORNIA

T.Y. LIN / MOFFATT & NICHOL
825 BATTERY STREET
SAN FRANCISCO, CA 94111

Caltrans now has a web site! To get to the web site, go to: http://www.dot.ca.gov



DETAIL OF BEARING ASSEMBLY
1:10



VIEW A-A
1:10

INSTALLATION SEQUENCE FOR BEARING SHIMS:

NOTE: Shimming shall be completed prior to SSO.

1. On one OBG (EB or WB), install longitudinal and transverse shimming on both bearings.
2. On the same OBG and for one temporary bearing at a time, transfer the load to the permanent bearing and remove temporary bearing shimming. Repeat for both temporary bearings.
3. Repeat Steps 1 & 2 for the remaining OBG.

NOTES:

1. Shims shall be galvanized.
2. Each shim shall be PTFE coated on one side.
3. Provide for each shim pack 4 shims tapered at 1/40 maximum, as required per survey.
4. Shim tight to within 2 mm, total of all plies.
5. Variable shims shall be fabricated and provided based on field measurements of gaps in the bearing assembly. Gap "A" in the lower housing is 90 mm nominal. Gap "B" in the upper housing is 20 mm nominal.

E2 BEARING SHIMMING

CONTRACT CHANGE ORDER NO. ____
SHEET ____ OF ____

REQUESTS FOR INFORMATION NOT ADDRESSED IN THIS CCO REMAIN IN FORCE

ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SHOWN

100 % PS&E

MARK	DATE	DESCRIPTIONS	BY	CH'D	CCO#
1	07/03/13	SHIMMING OF E2 BEARINGS	GB	MN	331

REVISIONS

A. Akinsanya / W. Long
DESIGN OVERSIGHT
SIGN OFF DATE 07/03/13

DESIGN BY G. Baker CHECKED N. Vo
DETAILS BY G. Baker CHECKED N. Vo
QUANTITIES BY G. Baker CHECKED N. Vo

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

M. Nader
PROJECT ENGINEER

BRIDGE NO. 34-0006L/R
KILOMETER POST 13.2/13.9

SAN FRANCISCO OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT
SELF-ANCHORED SUSPENSION BRIDGE
(SUPERSTRUCTURE & TOWER)

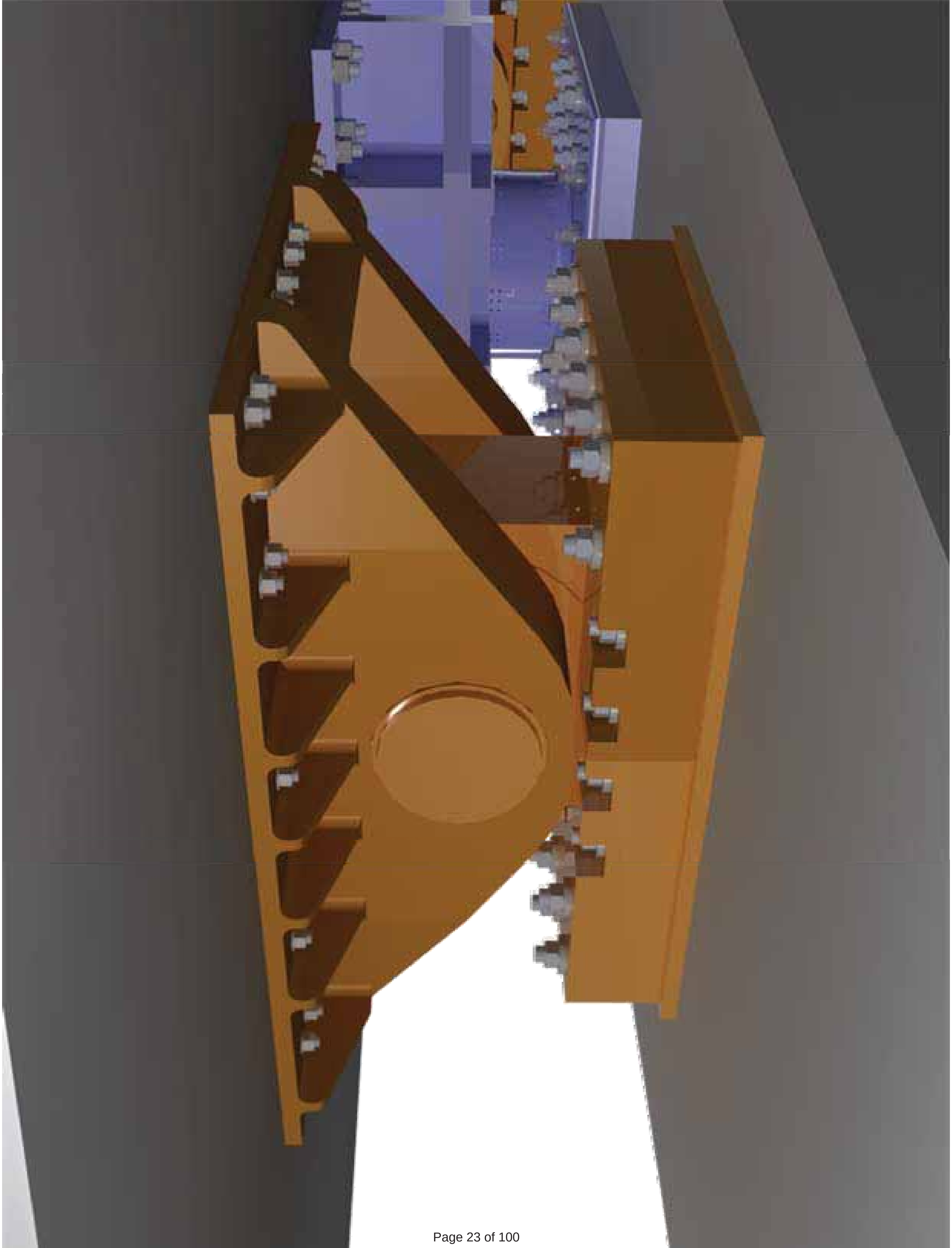
PIER E2 BEARING DETAILS NO. 1A

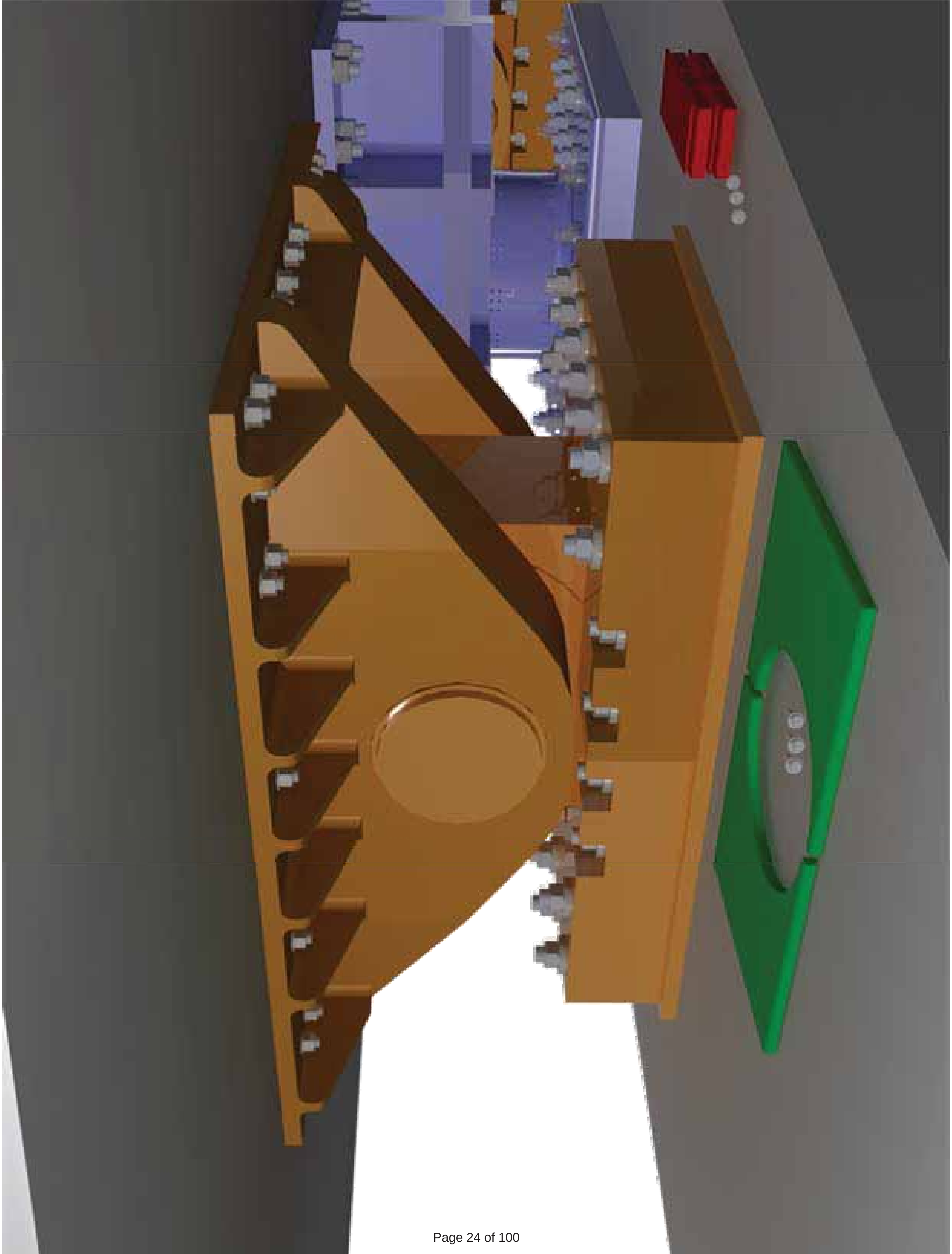
Rev. Date: 5-18-98
ORIGINAL SCALE IN MILLIMETERS FOR REDUCED PLANS 0 10 20 30 40 50 60 70 80 90 100
CU 04
EA 0120F1
DISREGARD PRINTS BEARING EARLIER REVISION DATES 07/03/13
REVISION DATES (PRELIMINARY STAGE ONLY)
SHEET 466SI OF

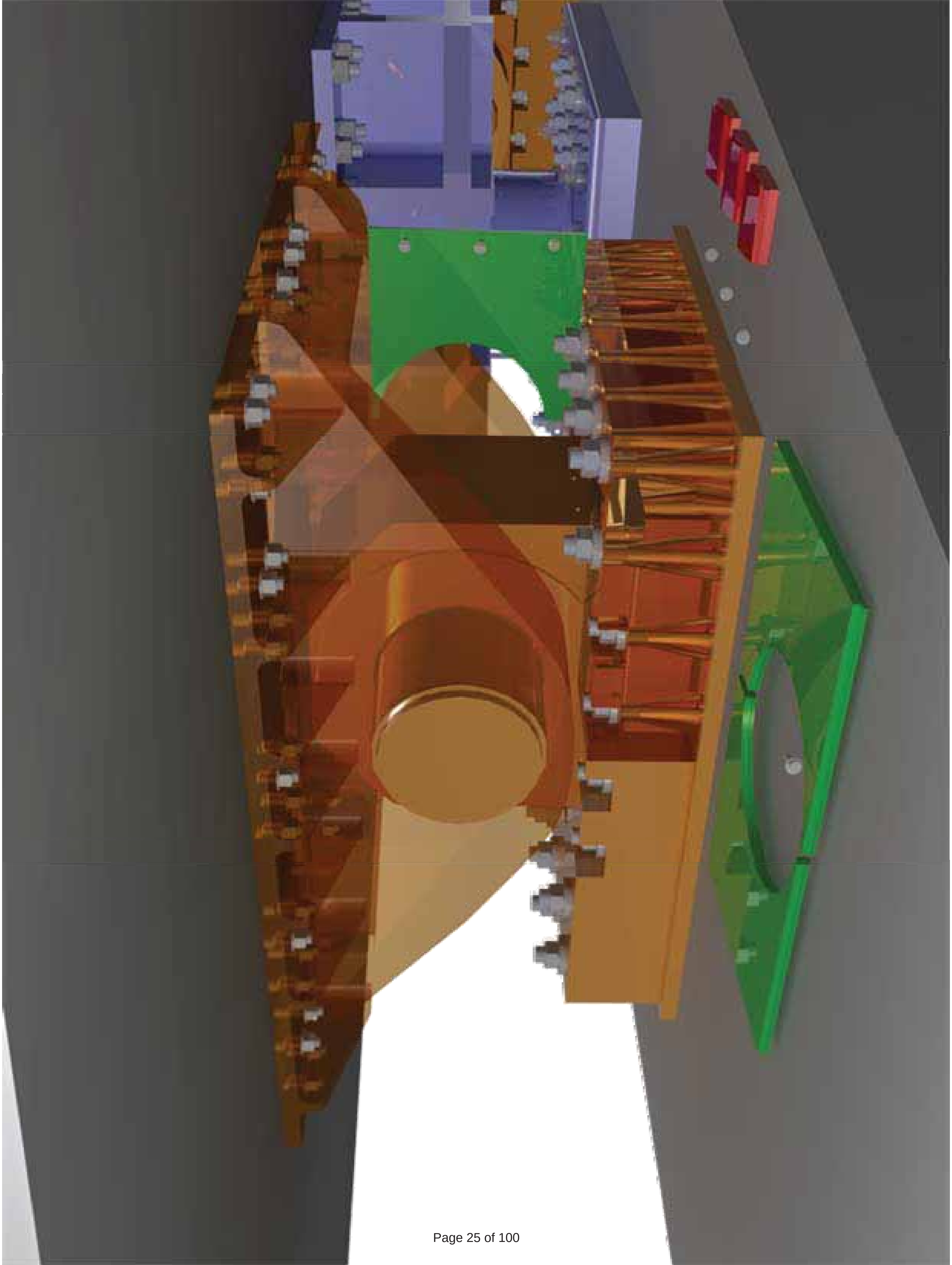
FILE => L:\BB\04-0120O1\SAS\Contract Plans and CCO\CCO\CCO#331\1-Original 07-01-13\DGN\akbrg01a.dgn

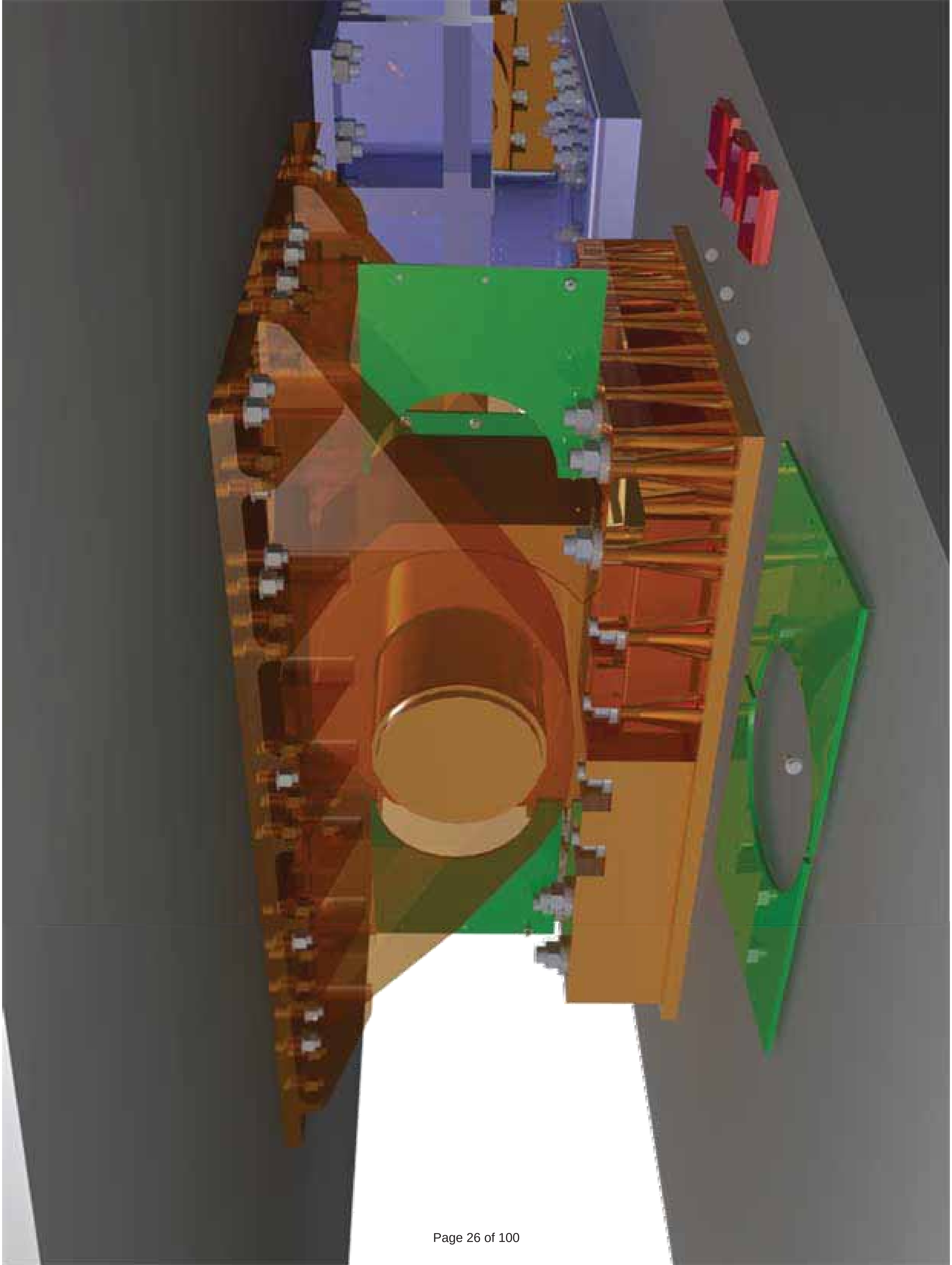
USERNAME => orlvera DATE PLOTTED => 03 JUL 2013 TIME PLOTTED => 18:19:03

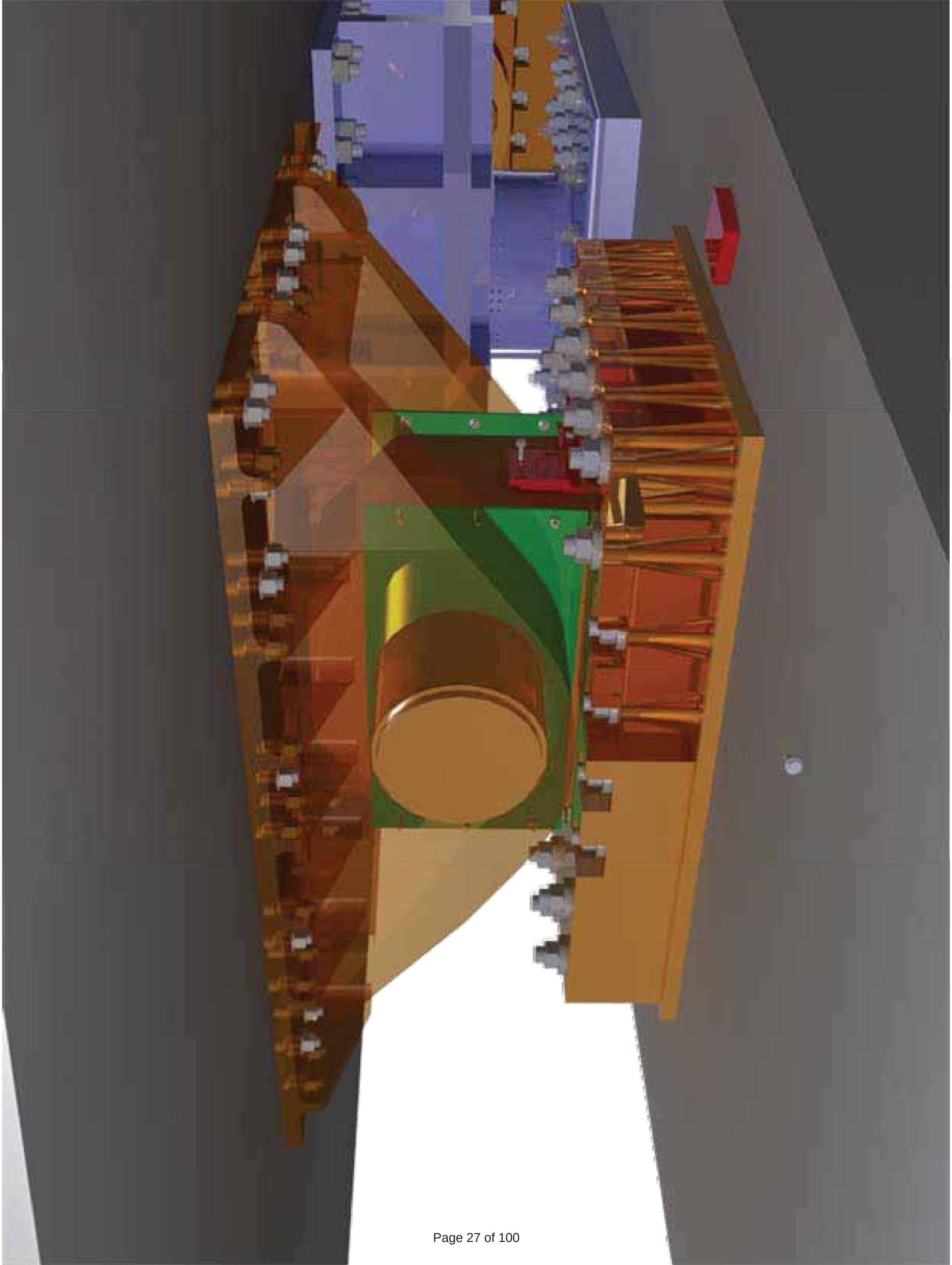
Shim Installation Sequence

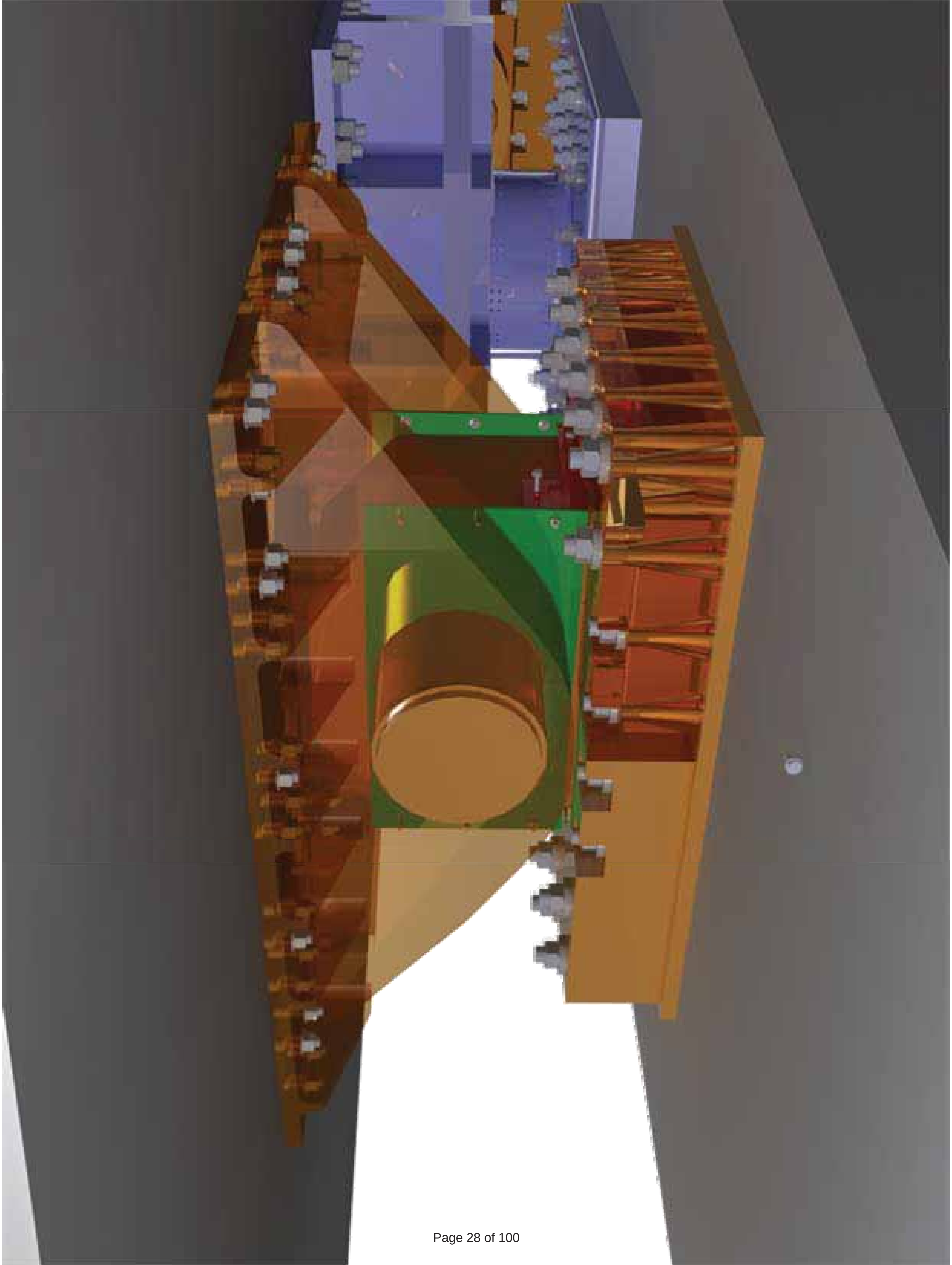


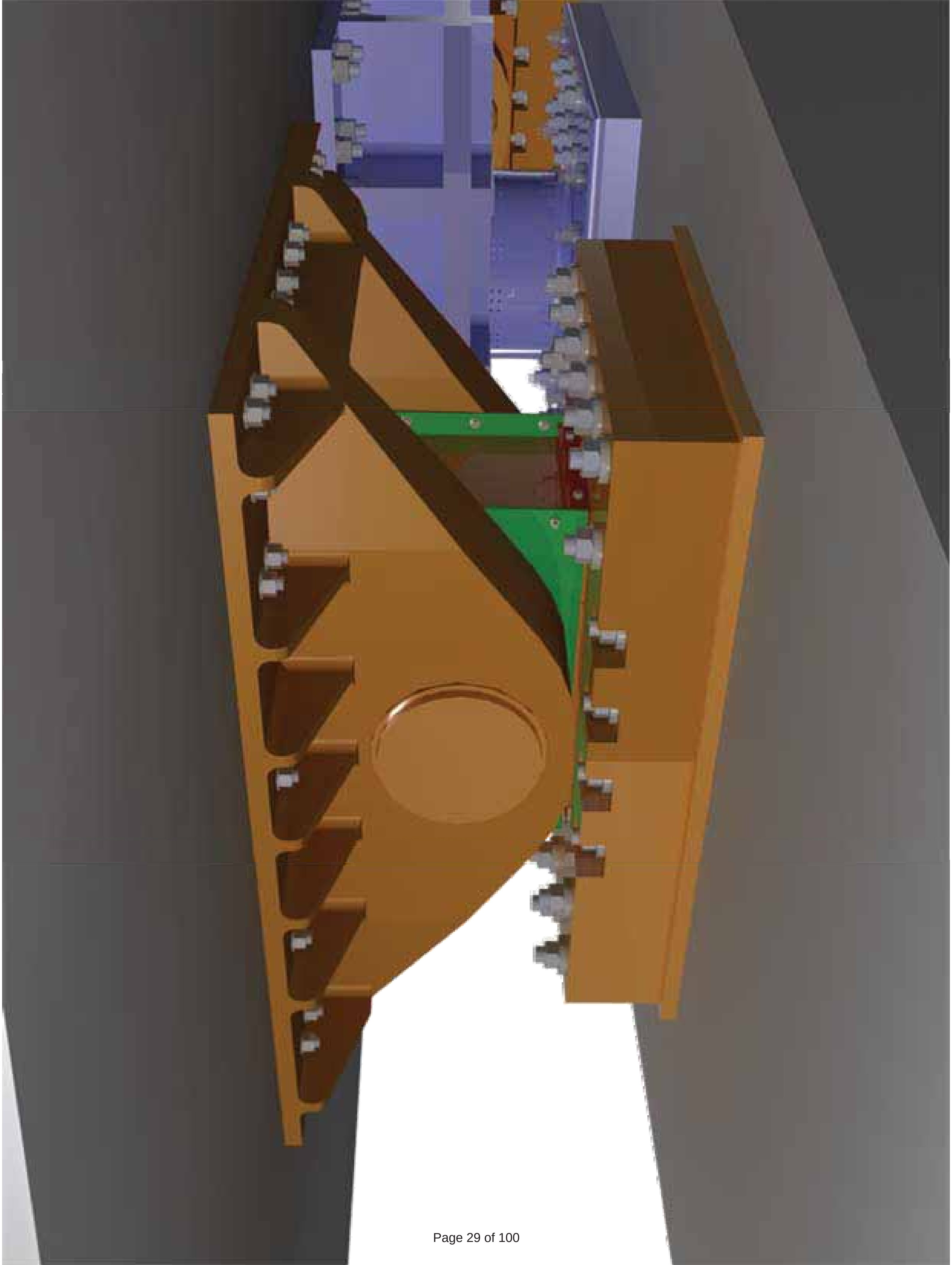












Appendix A - Pier E2 Shear Key and Bearing Design Plans

DIST	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET No	TOTAL SHEETS
04	SF	80	13.2/13.9	418	1204

Caltrans Metric

REGISTERED ENGINEER - CIVIL

12-6-04

PLANS APPROVAL DATE

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T.Y. LIN / MOFFATT & NICHOL
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SAN FRANCISCO, CA 94111

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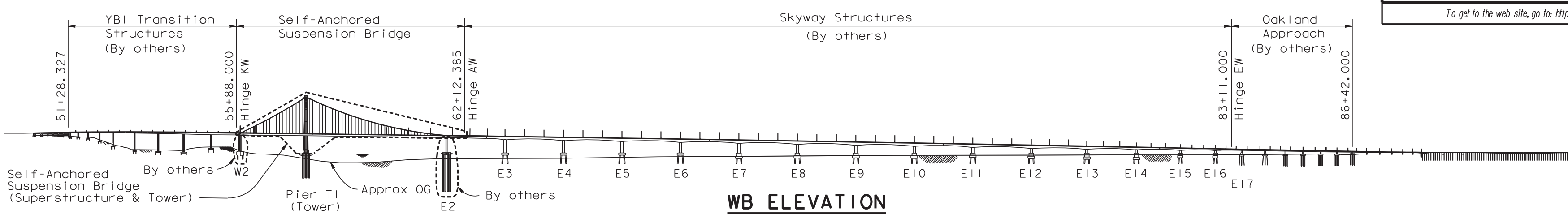

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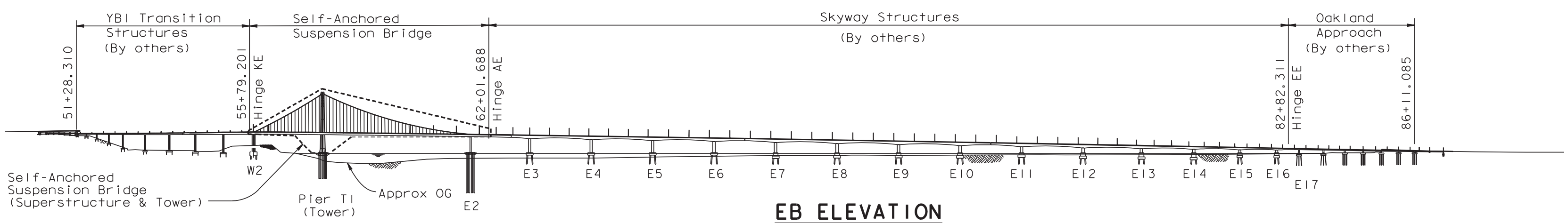

EB ELEVATION
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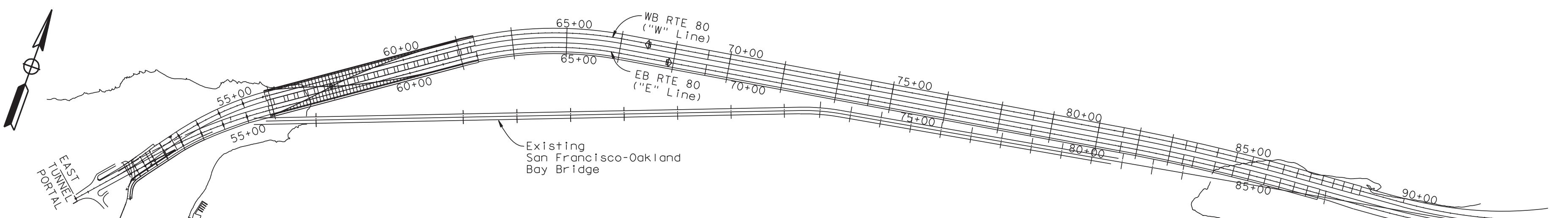

PLAN
1:6000

ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN

R. Valizadeh/V. Toan/Y.L./W.L./F.C.
DESIGN OVERSIGHT
SIGN OFF DATE 12/19/02

DESIGN	BY R. Manzanarez	CHECKED S. Rodriguez	LOAD FACTOR DESIGN	LIVE LOADING: HS20-44, ALTERNATIVE AND PERMIT DESIGN LOAD AND LRT LOADS	
DETAILS	BY M. Nader	CHECKED S. Rodriguez	LAYOUT	BY M. Nader	CHECKED S. Rodriguez
QUANTITIES	BY T. Ho	CHECKED N. Vo	SPECIFICATIONS	BY J. Rucker	PLANS AND SPECS COMPARED J. Rucker

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

R. Manzanarez
PROJECT ENGINEER

BRIDGE NO. 34-0006L/R
KILOMETER POST 13.2/13.9

SAN FRANCISCO OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT
SELF-ANCHORED SUSPENSION BRIDGE
(SUPERSTRUCTURE & TOWER)

PROJECT LIMITS

Rev. Date: 5-18-98

ORIGINAL SCALE IN MILLIMETERS FOR REDUCED PLANS 0 10 20 30 40 50 60 70 80 90 100

CU 04
EA 0120F1

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) 08/02/99 05/31/01 04/08/02 07/01/02 12/19/02

SHEET 001 OF

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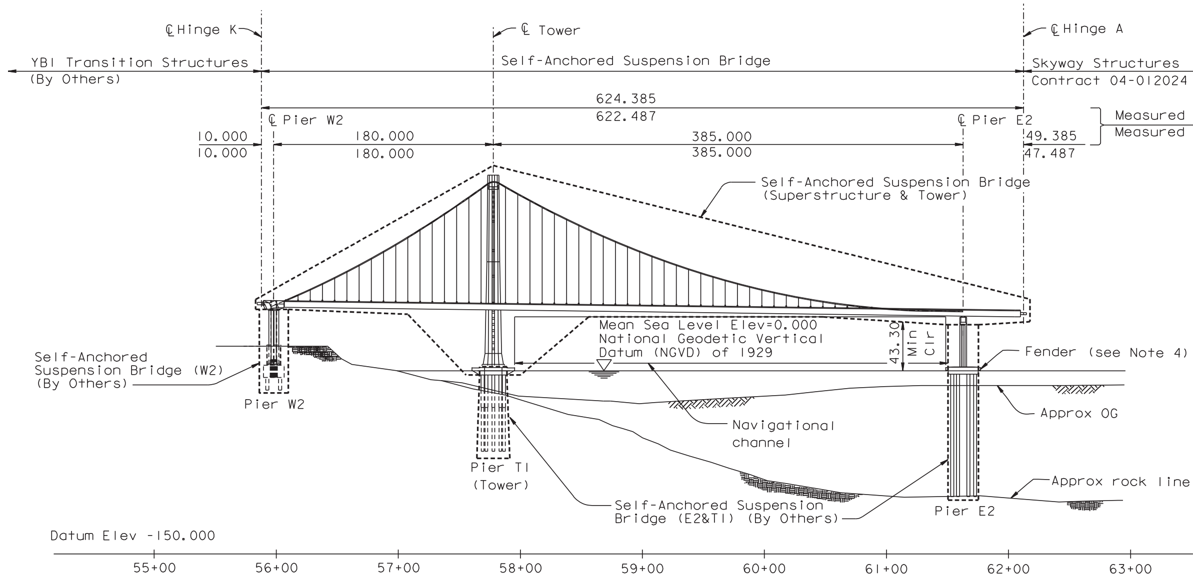

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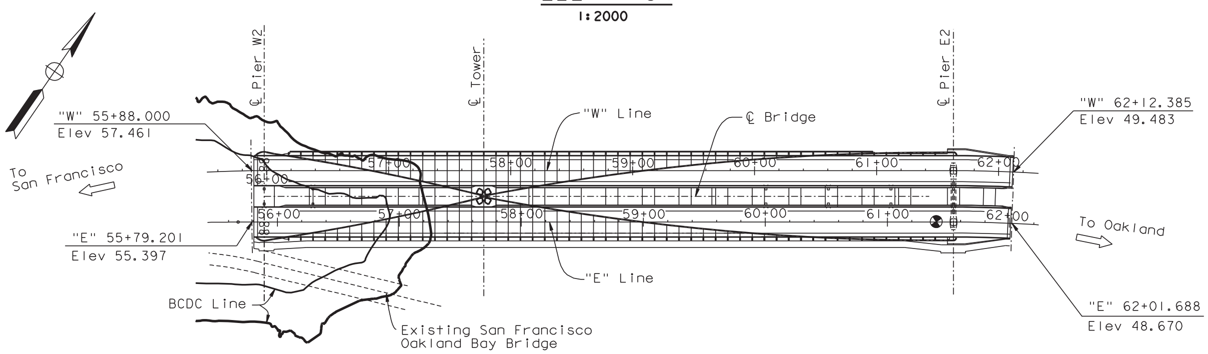

PLAN
1:2000

LEGEND:

- Point of Min vertical clearance
- Indicates direction of travel

NOTES:

1. For index to plans, see "Index To Plans" sheet.
2. For general notes and index to Caltrans Standard Plans, see "General Notes" sheets.
3. For sections, see "Cross Section" sheet.
4. Fender for Pier E2 foundation is part of the Self-Anchored Suspension Bridge (E2 & T1) contract (by others).
5. For profile and superelevation diagrams, see "Deck Contours" sheets.
6. For quantities, see "General Notes No.2" sheet.
7. For hydrologic summary, see "Pile Data" sheet.
8. Tie-down cables, cover slab and chain link railing at Pier W2 are part of Self-Anchored Suspension Bridge (Superstructure & Tower) contract.
9. The Contractor shall verify all controlling field dimensions before ordering or fabricating any material.

DIST	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET No	TOTAL SHEETS
04	SF	80	13.2/13.9	419	1204

REGISTERED ENGINEER - CIVIL
12-6-04
PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER Marwan N. Nader No. C 054426 Exp. 12/31/05 CIVIL STATE OF CALIFORNIA

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825 BATTERY STREET
SAN FRANCISCO, CA 94111

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CALTRANS OVERSIGHT

PROJECT MANAGER	Brian Maroney 12/19/02
CONTRACT MANAGER	Ade Akinsanya 12/19/02
SPECIFICATION MANAGER	Mike Whiteside 12/19/02
SPECIFICATION OVERSIGHT	Steve Margaris 12/19/02

R. Valizadeh/ V. Toan/ Y. Liu/
DESIGN OVERSIGHT W. Long/ F. Carpio
SIGN OFF DATE 12/19/02

DESIGN	BY M. Nader	CHECKED S. Rodriguez	LOAD FACTOR DESIGN	LIVE LOADING: HS20-44, ALTERNATIVE AND PERMIT DESIGN LOAD AND LRT LOADS	
DETAILS	BY M. Nader	CHECKED S. Rodriguez	LAYOUT	BY M. Nader	CHECKED S. Rodriguez
QUANTITIES	BY T. Ho	CHECKED N. Vo	SPECIFICATIONS	BY J. Rucker	PLANS AND SPECS COMPARED J. Rucker

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

R. Manzanarez
PROJECT ENGINEER

ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN

BRIDGE NO. 34-0006L/R
KILOMETER POST 13.2/13.9

SAN FRANCISCO OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT
SELF-ANCHORED SUSPENSION BRIDGE (SUPERSTRUCTURE & TOWER)

GENERAL PLAN

Rev. Date: 5-18-98

ORIGINAL SCALE IN MILLIMETERS FOR REDUCED PLANS 0 10 20 30 40 50 60 70 80 90 100

CU 04
EA 0120F1

DISREGARD PRINTS BEARING EARLIER REVISION DATES
REVISION DATES (PRELIMINARY STAGE ONLY) 01/15/99 05/15/99 08/02/99 05/31/01 04/08/02 07/01/02 12/19/02

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DIST.	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SF	80	13.2/13.9	429	1204

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12-6-04
PLANS APPROVAL DATE
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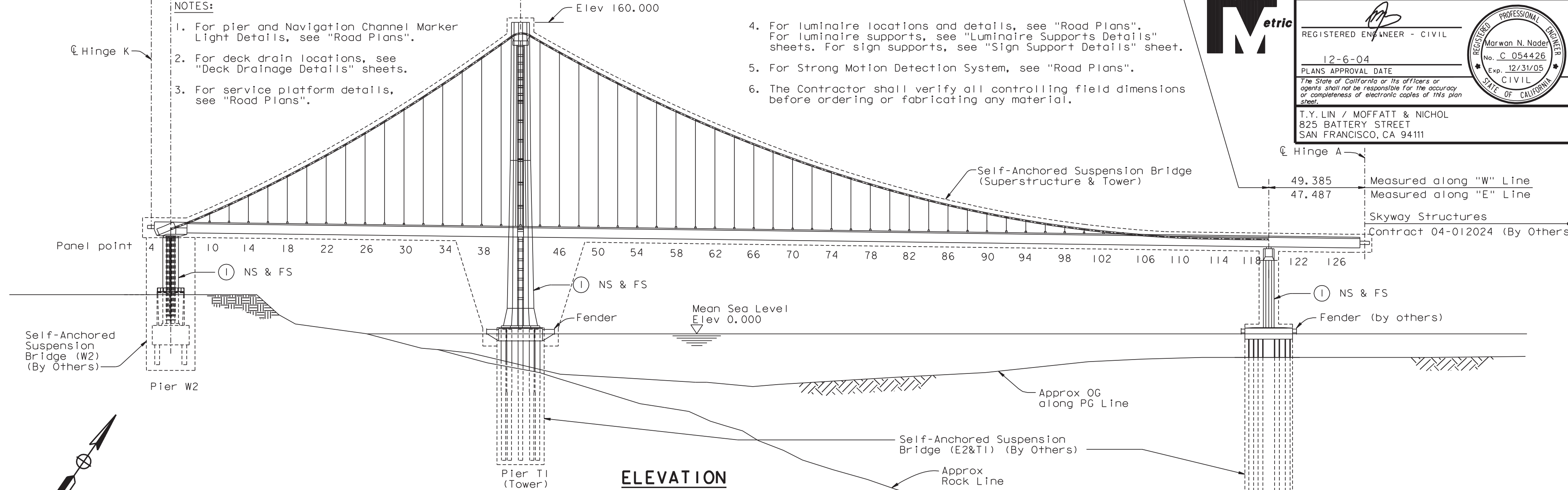
REGISTERED PROFESSIONAL ENGINEER — Marwan N. Nader — No. C 054426 — Exp. 12/31/05 — CIVIL — STATE OF CALIFORNIA

T.Y. LIN / MOFFATT & NICHOL
825 BATTERY STREET
SAN FRANCISCO, CA 94111

NOTES:

1. For pier and Navigation Channel Marker Light Details, see "Road Plans".
2. For deck drain locations, see "Deck Drainage Details" sheets.
3. For service platform details, see "Road Plans".
4. For luminaire locations and details, see "Road Plans". For luminaire supports, see "Luminaire Supports Details" sheets. For sign supports, see "Sign Support Details" sheet.
5. For Strong Motion Detection System, see "Road Plans".
6. The Contractor shall verify all controlling field dimensions before ordering or fabricating any material.



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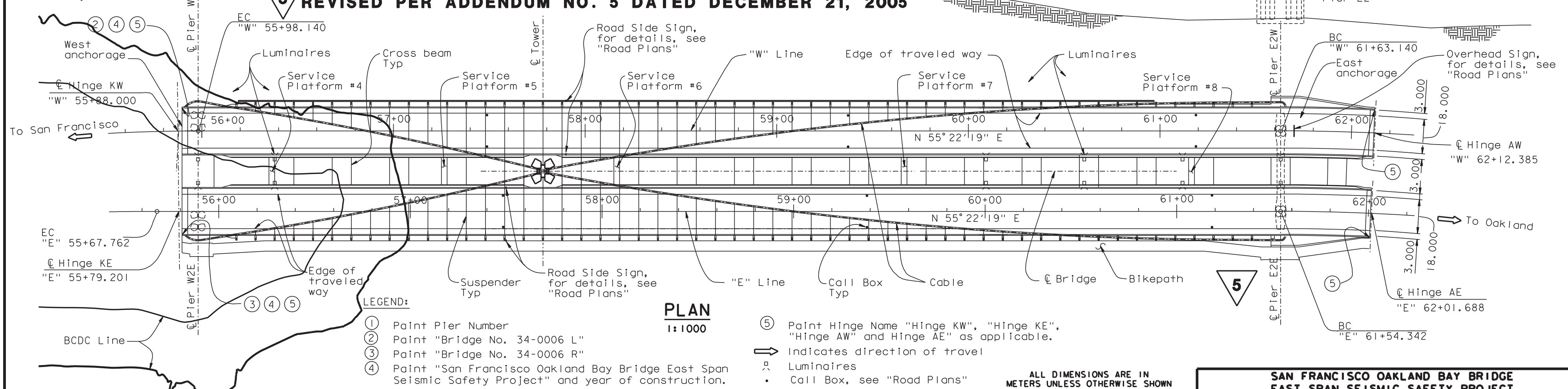
5 REVISED PER ADDENDUM NO. 5 DATED DECEMBER 21, 2005



PLAN
1:1000

LEGEND:

1. Paint Pier Number
2. Paint "Bridge No. 34-0006 L"
3. Paint "Bridge No. 34-0006 R"
4. Paint "San Francisco Oakland Bay Bridge East Span Seismic Safety Project" and year of construction.
5. Paint Hinge Name "Hinge KW", "Hinge KE", "Hinge AW" and Hinge AE" as applicable.

⇨ Indicates direction of travel
Luminaires
• Call Box, see "Road Plans"

ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN

DESIGN	BY M. Nader	CHECKED S. Rodriguez	LOAD FACTOR DESIGN	LIVE LOADING: HS20-44, ALTERNATIVE AND PERMIT DESIGN LOAD AND LRT LOADS	
DETAILS	BY T. Ho	CHECKED S. Rodriguez	LAYOUT	BY M. Nader	CHECKED S. Rodriguez
QUANTITIES	BY D. Nguyen-Tan	CHECKED N. Vo	SPECIFICATIONS	BY J. Rucker	PLANS AND SPECS COMPARED J. Rucker

R. Valizadeh/V. Toan/Y.L./W.L./F.C.
DESIGN OVERSIGHT
SIGN OFF DATE 12/07/05

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

R. Manzanarez
PROJECT ENGINEER

BRIDGE NO. 34-0006L/R
KILOMETER POST 13.2/13.9

SAN FRANCISCO OAKLAND BAY BRIDGE EAST SPAN SEISMIC SAFETY PROJECT
SELF-ANCHORED SUSPENSION BRIDGE (SUPERSTRUCTURE & TOWER)

STRUCTURE PLAN NO. 1

Rev. Date: 5-18-98
ORIGINAL SCALE IN MILLIMETERS FOR REDUCED PLANS 0 10 20 30 40 50 60 70 80 90 100
CU 04
EA 0120F1
DISREGARD PRINTS BEARING EARLIER REVISION DATES
REVISION DATES (PRELIMINARY STAGE ONLY) 01/15/99 05/15/99 08/02/99 05/31/01 04/08/02 07/01/02 12/19/02 12/07/05
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DIST.	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
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12-6-04

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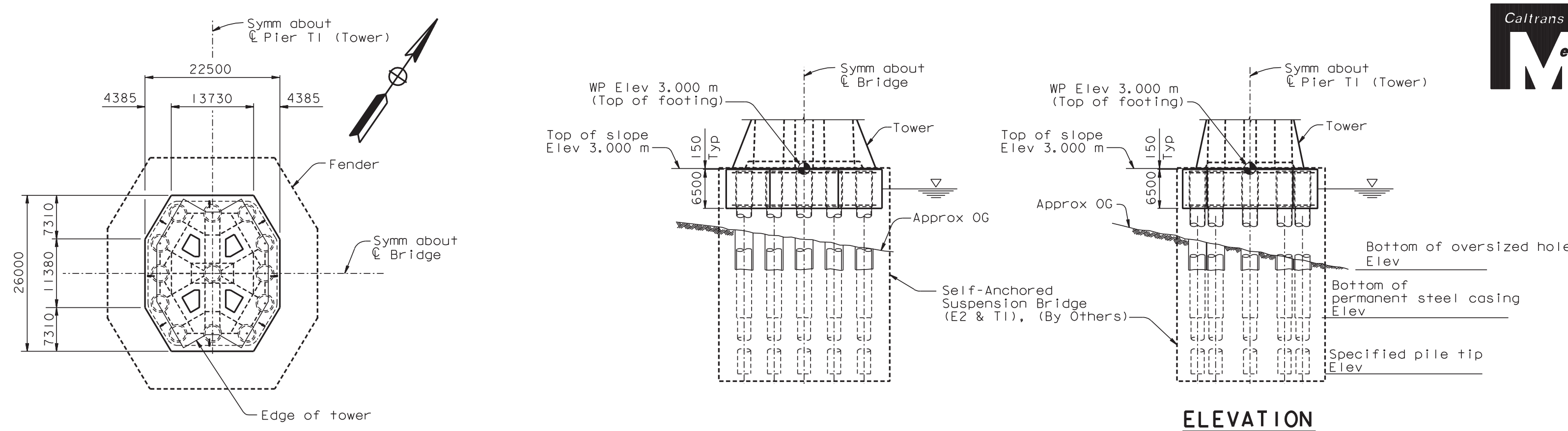


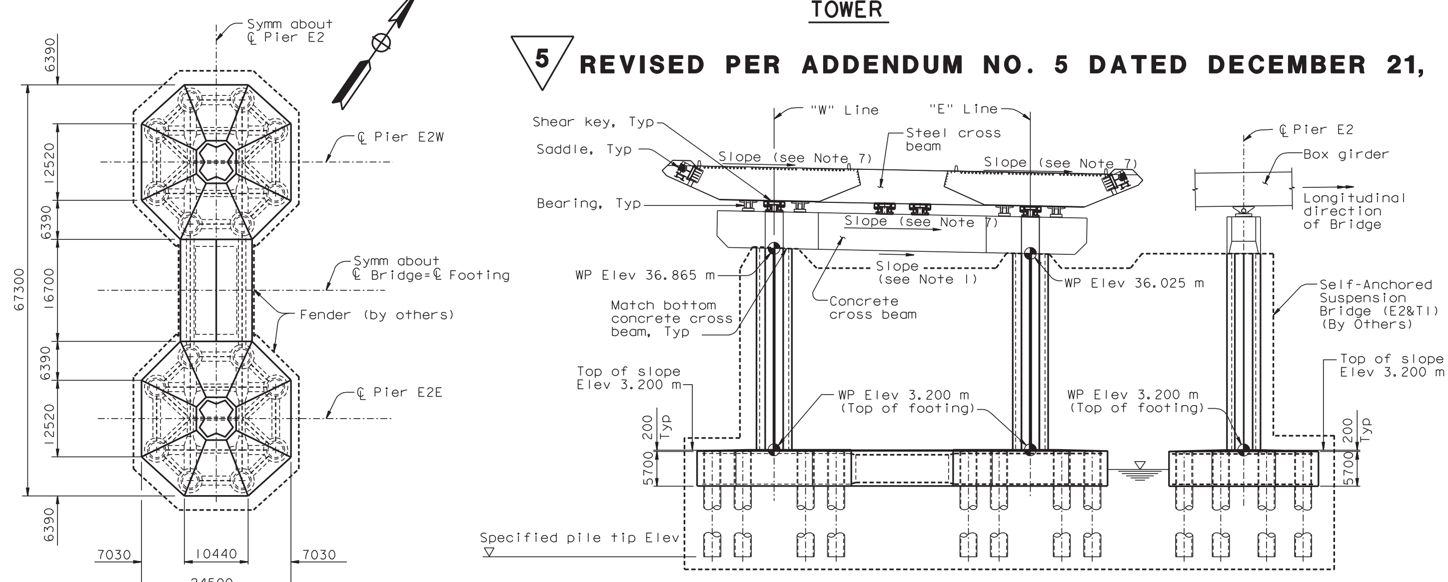
PLAN
1:400

TRANSVERSE ELEVATION
1:400

ELEVATION
1:400

TOWER

5 REVISED PER ADDENDUM NO. 5 DATED DECEMBER 21, 2005



PLAN
1:400

TRANSVERSE ELEVATION
1:400

ELEVATION
1:400

PIER E2

NOTES:

1. Transverse slope of concrete cross beam is constant and shall be computed based on the WP elevations of Piers E2E and E2W.
2. For pier E2 details, see "Pier E2 Details" sheets.
3. For utilities, see "Road Plans".
4. For drainage, see "Tower Drainage Details" sheets.
5. For interface details between tower footing and tower base plate, see "Tower Anchorage Details" sheets.
6. Fenders for Pier E2 foundation is part of the Self-Anchored Suspension Bridge (E2 & T1) contract (by Others). For tower fender details, see "Tower Fender Details" sheets.
7. For Pier E2 cross beam WP Elevations and slopes, see "Pier E2 Details" sheets.
8. The Contractor shall verify all controlling field dimensions before ordering or fabricating any material.

ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SHOWN

SAN FRANCISCO OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT
SELF-ANCHORED SUSPENSION BRIDGE
(SUPERSTRUCTURE & TOWER)

STRUCTURE PLAN NO. 3

R. Valizadeh/V. Toan/Y.L./W.L./F.C.
DESIGN OVERSIGHT
SIGN OFF DATE 12/07/05

DESIGN	BY M. Nader	CHECKED S. Rodriguez
DETAILS	BY G. Houlahan	CHECKED S. Rodriguez
QUANTITIES	BY J. Duxbury	CHECKED N. Vo

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

R. Manzanarez
PROJECT ENGINEER

BRIDGE NO. 34-0006L/R
KILOMETER POST 13.2/13.9

SHEET 014

Rev. Date: 5-18-98

ORIGINAL SCALE IN MILLIMETERS FOR REDUCED PLANS 0 10 20 30 40 50 60 70 80 90 100

CU 04
EA 0120F1

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REVISION DATES (PRELIMINARY STAGE ONLY) 01/15/99 05/15/99 08/02/99 05/31/01 04/08/02 07/01/02 12/19/02 12/07/05

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DIST.	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
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825 BATTERY STREET
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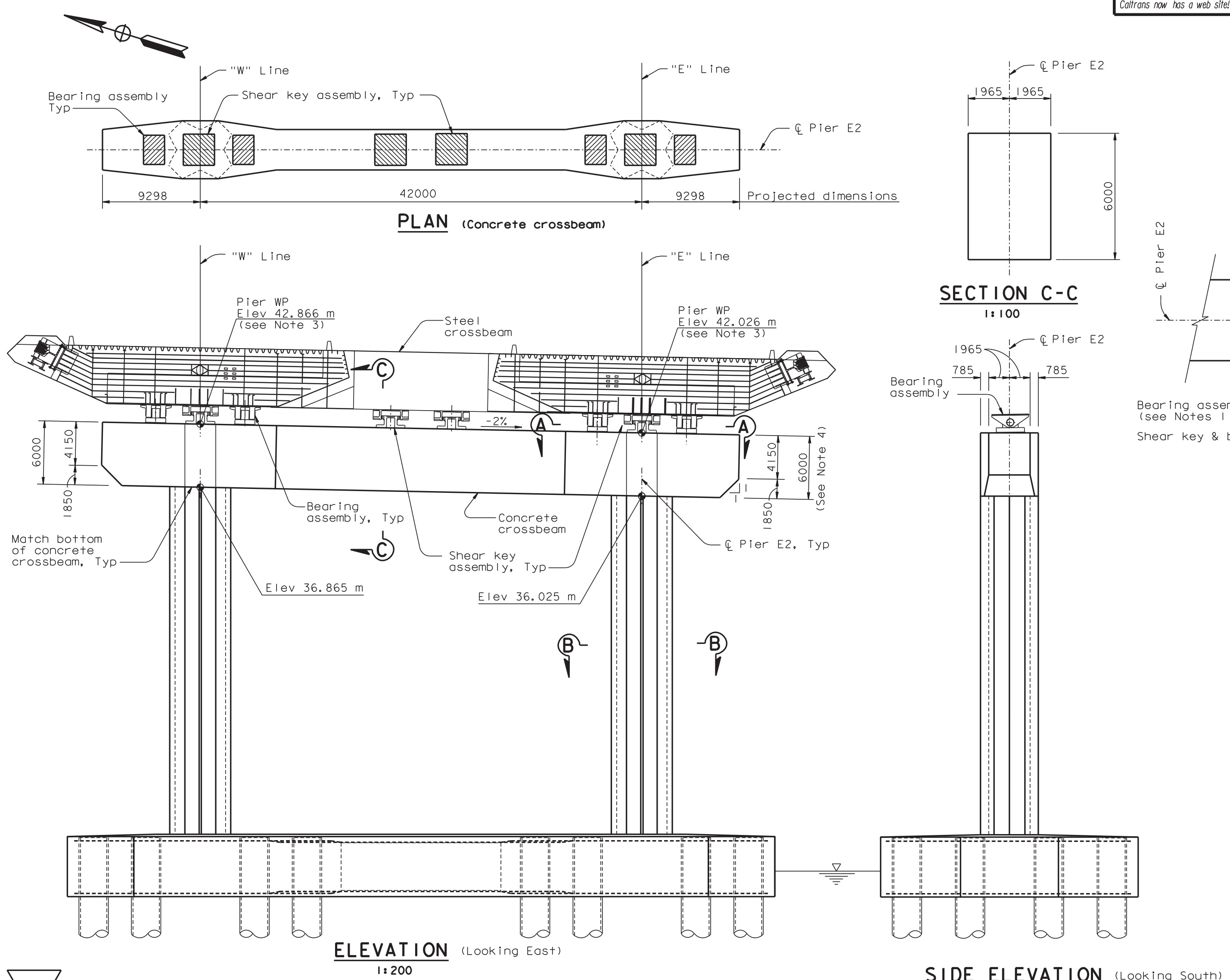

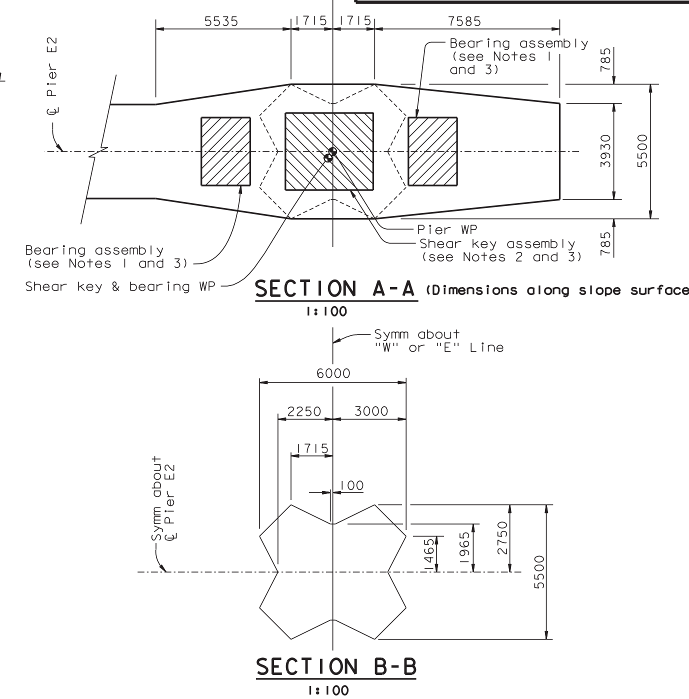

NOTES:

1. For pier E2 bearing details, see "Pier E2 Bearing Details" sheets.
2. For pier E2 shear key details, see "Pier E2 Shear Key Details" sheets.
3. For pier E2 bearing and shear key location, see "Pier E2 Bearing and Shear Key Layout" sheet.
4. Dimensions are normal to the 2% crossbeam slope.
5. For "Pier E2 Details" sheets, the Contractor shall verify all controlling field dimensions before ordering or fabricating any material.

5 REVISED PER ADDENDUM NO. 5 DATED DECEMBER 21, 2005

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R. Valizadeh/V. Toan/Y.L./W.L./F.C.
DESIGN OVERSIGHT
SIGN OFF DATE 12/07/05

DESIGN	BY A. Sanjines	CHECKED J. Chan
DETAILS	BY R. Xu	CHECKED J. Chan
QUANTITIES	BY R. Xu	CHECKED C. Bernardo

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

R. Manzanarez
PROJECT ENGINEER

BRIDGE NO. 34-0006L/R
KILOMETER POST 13.2/13.9

SAN FRANCISCO OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT
SELF-ANCHORED SUSPENSION BRIDGE (SUPERSTRUCTURE & TOWER)

PIER E2 DETAILS NO. 1

Rev. Date: 5-18-98

ORIGINAL SCALE IN MILLIMETERS FOR REDUCED PLANS 0 10 20 30 40 50 60 70 80 90 100

CU 04
EA 0120F1

DISREGARD PRINTS BEARING EARLIER REVISION DATES

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SHEET 93 OF

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DIST.	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
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Alex E. Sanjines
No. C 051153
Exp. 9/30/07
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825 BATTERY STREET
SAN FRANCISCO, CA 94111

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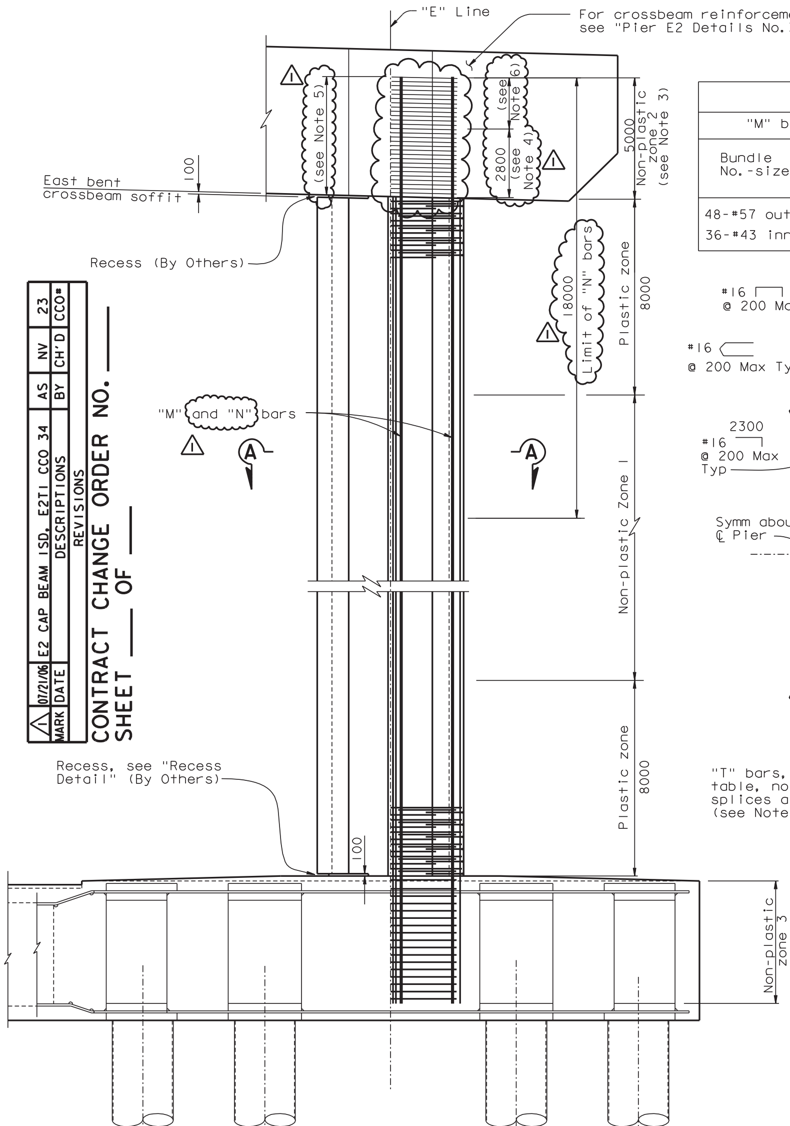
Pier reinforcement (see Note 1)

"M" bars		"N" bars		"T" and "L" bars				Continuous welded hoop							
Bundle No.-sizes	Total per pier	No. -size	Total per pier	Plastic zone		Non-plastic zone 1		Plastic zone		Non-plastic zone 1		Non-plastic zone 2		Non-plastic zone 3	
				Size	spacing	Size	spacing	No. -size	Spacing	No. -size	Spacing	No. -size	Spacing	No. -size	Spacing
48-#57 outer 36-#43 inner	192 144	#43	40	#22	100	#22	100	2-#25	100	#25	100	#25	900 Max	2-#25	150

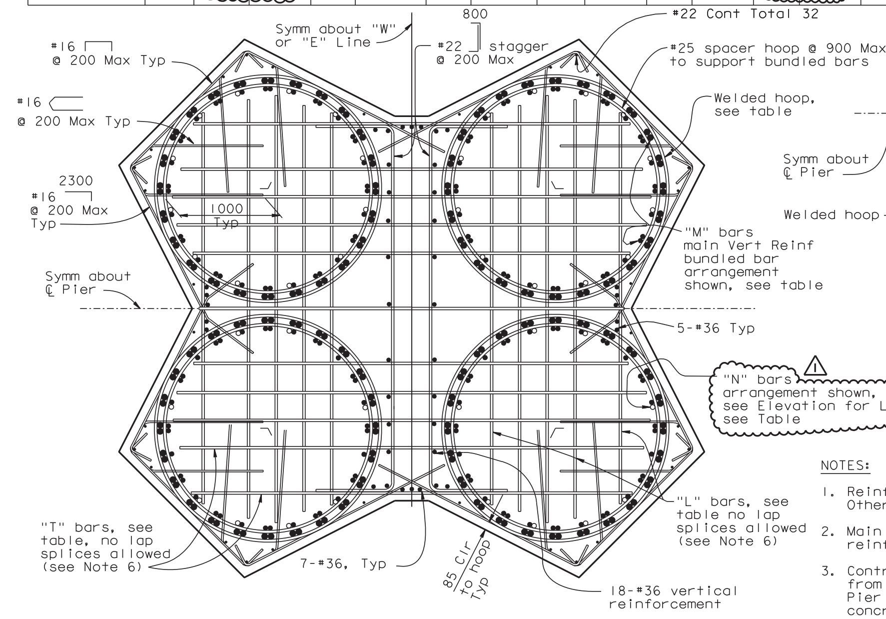


ELEVATION
1:100

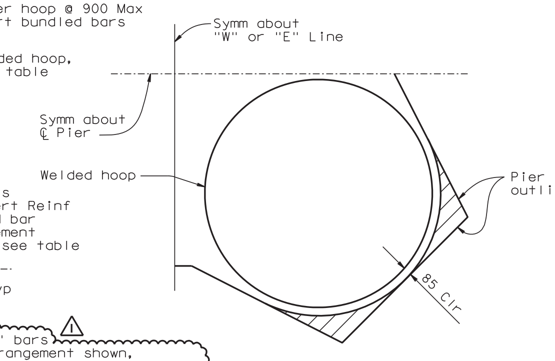
MARK	DATE	DESCRIPTIONS	BY	CH'D	CCO#
1	07/21/06	E2 CAP BEAM ISD, E2T1 CCO 34	AS	NV	23

REVISIONS

CONTRACT CHANGE ORDER NO. ____
SHEET ____ OF ____



SECTION B-B
1:25



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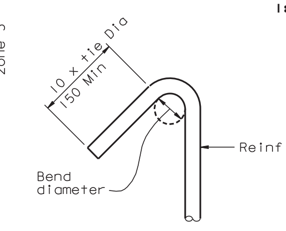
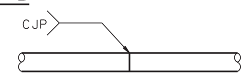
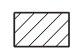


135° SEISMIC HOOK
No scale



BUTT WELDED CONTINUOUS HOOP
NTS

LEGEND:


100 Recess

NOTES:

1. Reinforcement is for information only, and by Others.
2. Main vertical reinforcement and hoop reinforcement are "Ultimate" butt splices.
3. Contractor shall remove the corrosion protection from all reinforcing and shall roughen the existing Pier E2 concrete surface prior to pouring the concrete crossbeam.
4. Contractor shall remove existing continuous welded hoops down to soffit. Replace with continuous welded hoops spaced at 175 mm placed at 2% slope up to 2800 mm from soffit.
5. Refer to "Pier E2 Details No.10" sheet for main vertical reinforcement cutoff allowance.
6. Contractor shall remove existing continuous welded hoops and replace with #36 ▭ @ 175 mm placed at 2% slope. See Section F-F on "Pier E2 Detail No.4" sheet.

ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SHOWN

R. Valizadeh/V. Toan/Y.L./W.L./F.C.
DESIGN OVERSIGHT
SIGN OFF DATE 07/21/06

DESIGN	BY A. Sanjines	CHECKED J. Chan
DETAILS	BY R. Xu	CHECKED J. Chan
QUANTITIES	BY R. Xu	CHECKED C. Bernardo

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

R. Manzanarez
PROJECT ENGINEER

BRIDGE NO. 34-0006L/R
KILOMETER POST 13.2/13.9

SAN FRANCISCO OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT
SELF-ANCHORED SUSPENSION BRIDGE (SUPERSTRUCTURE & TOWER)

PIER E2 DETAILS NO.2

Rev. Date: 5-18-98

ORIGINAL SCALE IN MILLIMETERS FOR REDUCED PLANS 0 10 20 30 40 50 60 70 80 90 100

CU 04
EA 0120F1

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REVISION DATES (PRELIMINARY STAGE ONLY) 08/02/99 05/31/01 04/08/02 07/01/02 12/19/02 05/16/03

SHEET 94R1 OF

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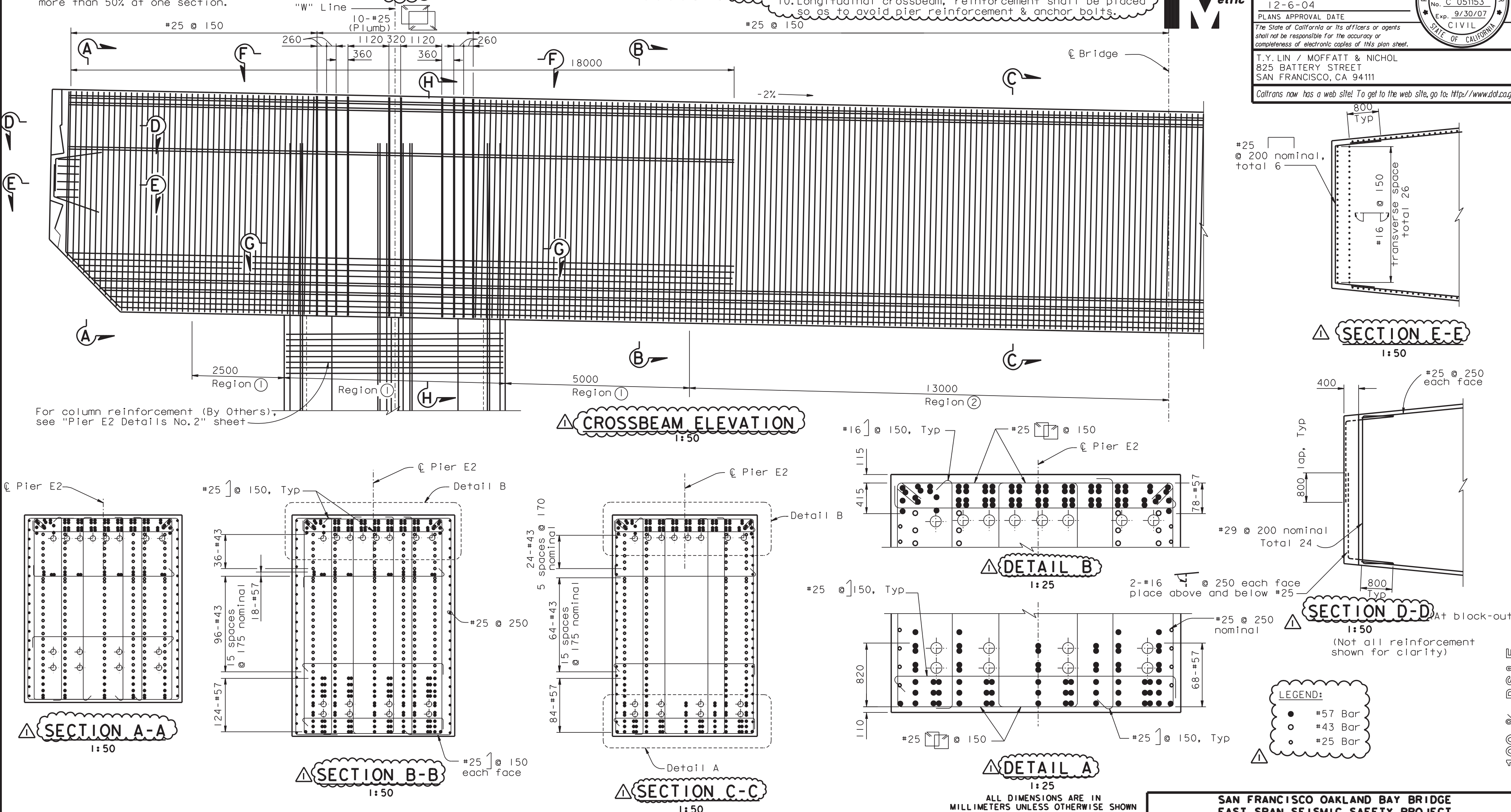
100 % PS&E

NOTES:

1. For Sections F-F and G-G, see "Pier E2 Details No.4" sheet. For Section H-H, see "Pier E2 Details No.7" sheet.
2. No splices permitted in region ①. Splicing within region ② shall be staggered and not more than 50% at one section.
3. Cross beam reinforcement similar about ℄ Bridge.
4. Alternate 90° and 135° seismic hook horizontally and vertically. Hook shall engage horizontal bars.
5. Column hoops shall follow the 2% slope inside the capbeam.
6. PT, Bearing and Shear key hardware not shown for clarity.
7. For additional notes, see "Pier E2 Details No.4" sheet.
8. At the locations of bearings and midspan shear keys, Contractor may replace ties with equivalent headed bars.
9. Reinforcement placement support bars required (not shown), Typical.
10. Longitudinal crossbeam, reinforcement shall be placed so as to avoid pier reinforcement & anchor bolts.



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DIST.	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SF	80	13.2/13.9	512R1	1204

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1	07/21/06	E2 CAP BEAM ISD	AS	NV	23

REVISIONS

R. Valizadeh/V.Toan/Y.L./W.L./F.C.
DESIGN OVERSIGHT
SIGN OFF DATE 07/21/06

CONTRACT CHANGE ORDER NO. ____
SHEET ____ OF ____

	BY	CHECKED
DESIGN	A. Sanjines	J. Chan
DETAILS	R. Xu	J. Chan
QUANTITIES	C. Bernardo	B. Mason

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

R. Manzanarez
PROJECT ENGINEER

BRIDGE NO. 34-0006L/R
KILOMETER POST 13.2/13.9

SAN FRANCISCO OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT
SELF-ANCHORED SUSPENSION BRIDGE (SUPERSTRUCTURE & TOWER)

PIER E2 DETAILS NO. 3

Rev. Date: 5-18-98

ORIGINAL SCALE IN MILLIMETERS FOR REDUCED PLANS 0 10 20 30 40 50 60 70 80 90 100

CU 04
EA 0120F1

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) 08/02/99 05/31/01 04/08/02 07/01/02 12/19/02 05/16/03

SHEET 95R1 OF

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USERNAME => vignotovs DATE PLOTTED => 10 MAY 2007 TIME PLOTTED => 11:17:54

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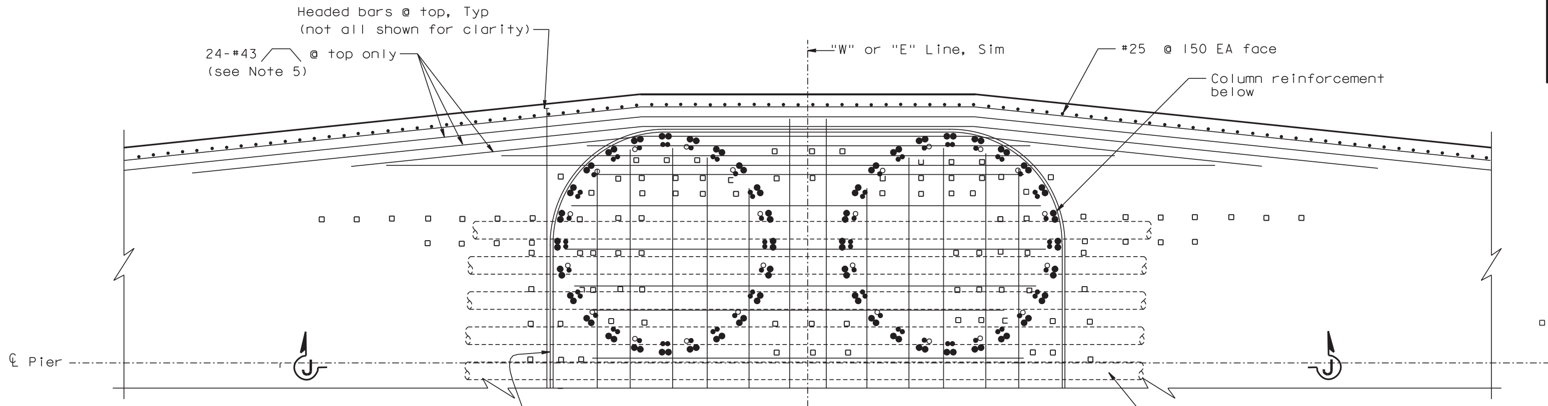
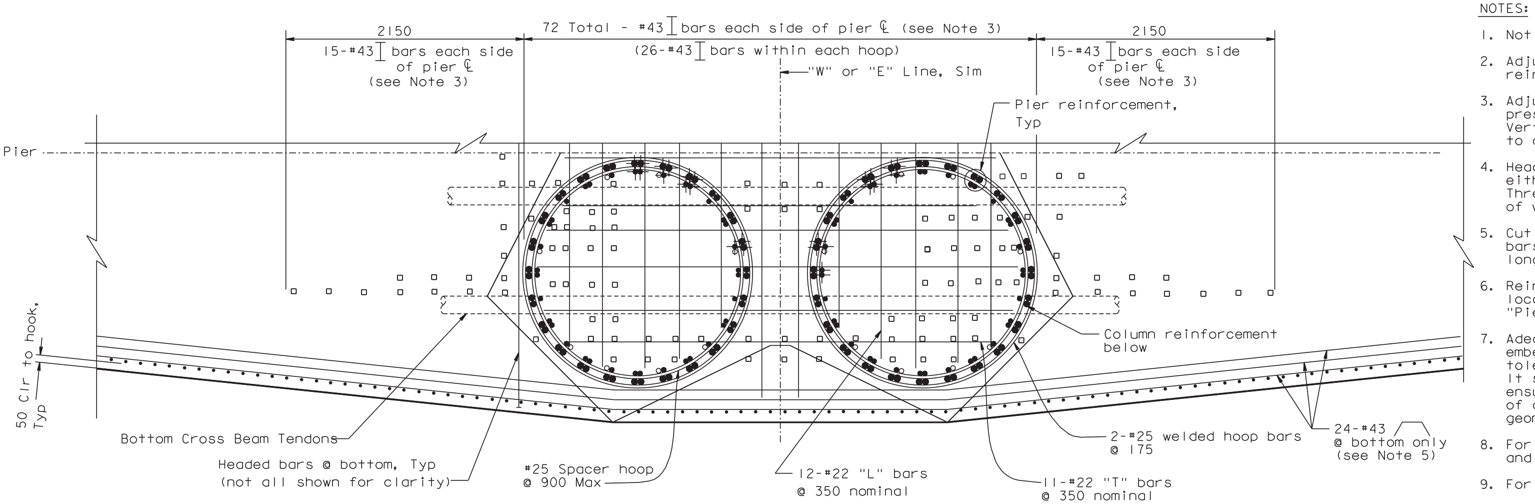


SECTION F-F (top of Crossbeam)

1:25



SECTION G-G (Crossbeam soffit)

1:25

LEGEND

- Indicates Welded Headed bar (see Note 4)

Original Sheet Superseded

NOTES:

1. Not all reinforcement shown for clarity.
2. Adjust reinforcement as required to clear column reinforcement.
3. Adjust vertical headed bars within hoops to clear prestressing and main longitudinal reinforcement. Vertical reinforcement may be terminated subject to approval by the Engineer.
4. Headed reinforcement may consist of rebar with either friction welded plates or threaded heads. Threaded heads must equal or exceed the capacity of welded plates.
5. Cut off #43 top and bottom longitudinal bars at widened beam to avoid main Crossbeam longitudinal reinforcement as required.
6. Reinforcement details reflect strict adherence to the location of pier column reinforcement defined on "Pier E2 details No. 2" sheet.
7. Adequate fabrication and placement of all permanently embedded items may require more stringent tolerances than ordinary industry standards. It shall be the Contractor's responsibility to ensure the adequate fabrication and placement of all permanently embedded items within the geometric constraints of the plans.
8. For anchor rod layouts and details for bearings and shear keys, see "Pier E2 details No. 9" sheet.
9. For Section J-J see "Pier E2 Details No. 7" sheet.

DIST.	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
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1	07/21/06	E2 CAP BEAM ISD	AS	NV	23

REVISIONS

CONTRACT CHANGE ORDER NO. ____
SHEET ____ OF ____

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SAN FRANCISCO OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT
SELF-ANCHORED SUSPENSION BRIDGE
(SUPERSTRUCTURE & TOWER)

PIER E2 DETAILS NO. 4

R. Valizadeh/V. Toan/Y.L./W.L./F.C.
DESIGN OVERSIGHT
SIGN OFF DATE 07/21/06

	BY	CHECKED
DESIGN	A. Sanjines	J. Chan
DETAILS	R. Xu	J. Chan
QUANTITIES	C. Bernardo	B. Mason

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

R. Manzanarez
PROJECT ENGINEER

BRIDGE NO. 34-0006L/R
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SHEET 96R1 OF

Rev. Date: 5-18-98

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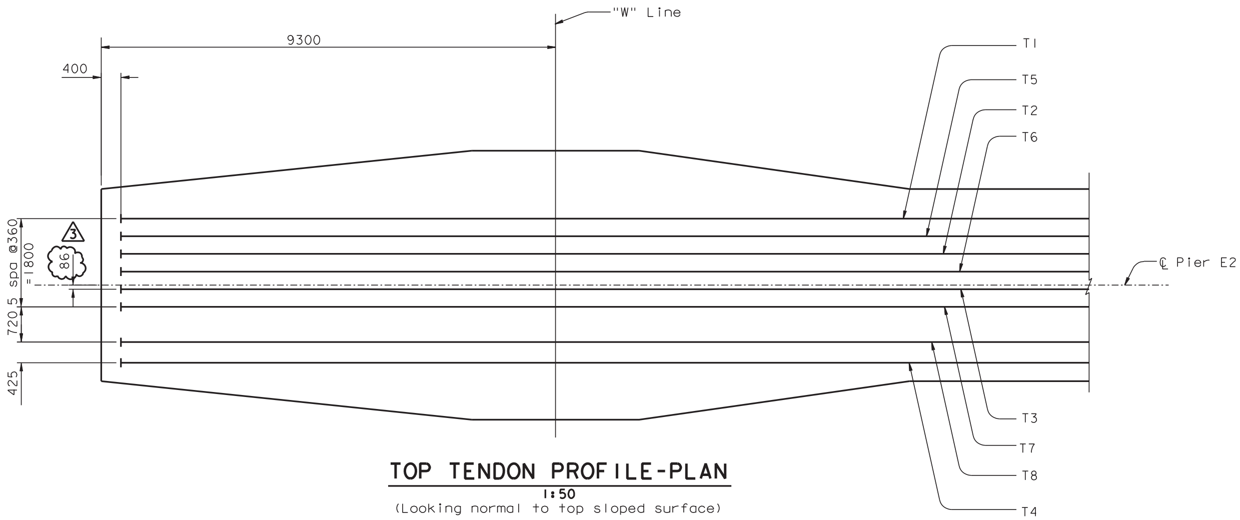
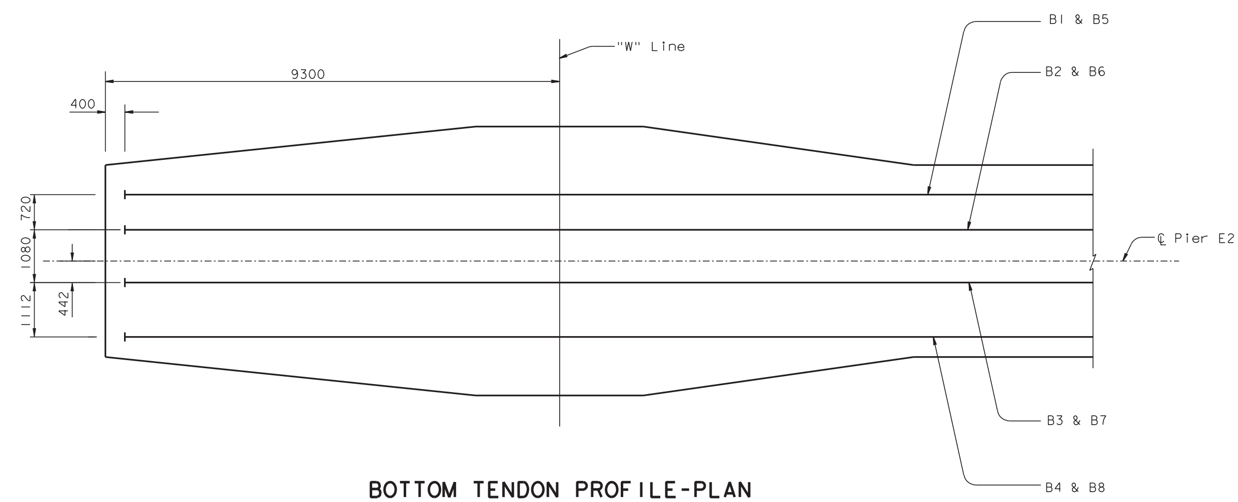


TOP TENDON PROFILE-PLAN

1:50
(Looking normal to top sloped surface)



BOTTOM TENDON PROFILE-PLAN

1:50
(Looking normal to top sloped surface)

DIST.	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SF	80	13.2/13.9	514R3	1204

REGISTERED ENGINEER - CIVIL
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PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER
Alex E. Sanjines
No. C 051153
Exp. 9/30/09
CIVIL
STATE OF CALIFORNIA

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REQUESTS FOR INFORMATION NOT ADDRESSED IN THIS CCO REMAIN IN FORCE

MARK	DATE	DESCRIPTIONS	BY	CH'D	CCO#
3	09/26/08	E2 CROSS BEAM	AS	JD	71
2	07/18/07	E2 CAP BEAM ISD RESOLUTION	AS	JD	34S2
1	07/21/06	E2 CAP BEAM ISD	AS	NV	23

REVISIONS

CONTRACT CHANGE ORDER NO. ____
SHEET ___ OF ___

NOTES:

1. "W" Line shown, "E" Line similar.
2. For tendon anchorage block-out details, see "Pier E2 Details No.8" sheet.
3. For concrete crossbeam reinforcement, see "Pier E2 Details No.3", "Pier E2 Details No.4", and "Pier E2 Details No.7" sheets.
4. For stressing force, use two end stressing and initial jacking stress = 0.75 f_{pu} = 0.75 x 1860 = 1390 MPa.
5. For additional prestressing notes, see Prestressing Notes" sheet.
6. The post-tensioning and grouting sequence shall prevent ducts from crushing.
7. The outer diameter of the PT duct shall not be greater than 180 mm.
8. At the Contractor's option, alternative post-tensioning anchorage sizes may be used provided the center of gravity of the prestressing force and the total prestressing force remains unchanged, subject to review and approval of the Engineer.

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SAN FRANCISCO OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT
SELF-ANCHORED SUSPENSION BRIDGE
(SUPERSTRUCTURE & TOWER)

PIER E2 DETAILS NO. 5

R. Valizadeh/V. Toan/Y.L./W.L./F.C.
DESIGN OVERSIGHT
SIGN OFF DATE 09/26/08

DESIGN	BY A. Sanjines	CHECKED J. Chan	
DETAILS	BY R. Xu	CHECKED J. Chan	
QUANTITIES	BY C. Bernardo	CHECKED B. Mason	

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

R. Manzanarez
PROJECT ENGINEER

BRIDGE NO. 34-0006L/R
KILOMETER POST 13.2/13.9

Rev. Date: 5-18-98
ORIGINAL SCALE IN MILLIMETERS FOR REDUCED PLANS 0 10 20 30 40 50 60 70 80 90 100
CU 04
EA 0120F1
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REVISION DATES (PRELIMINARY STAGE ONLY) 08/02/99 05/31/01 04/08/02 07/01/02 12/19/02
SHEET 97R3 OF

FILE => I:\bb\04-0120I\sas\contract plans and cco\cco\in progress\cco#71\original 09-26-08\dgn\aepir05e.dgn

100 % PS&E
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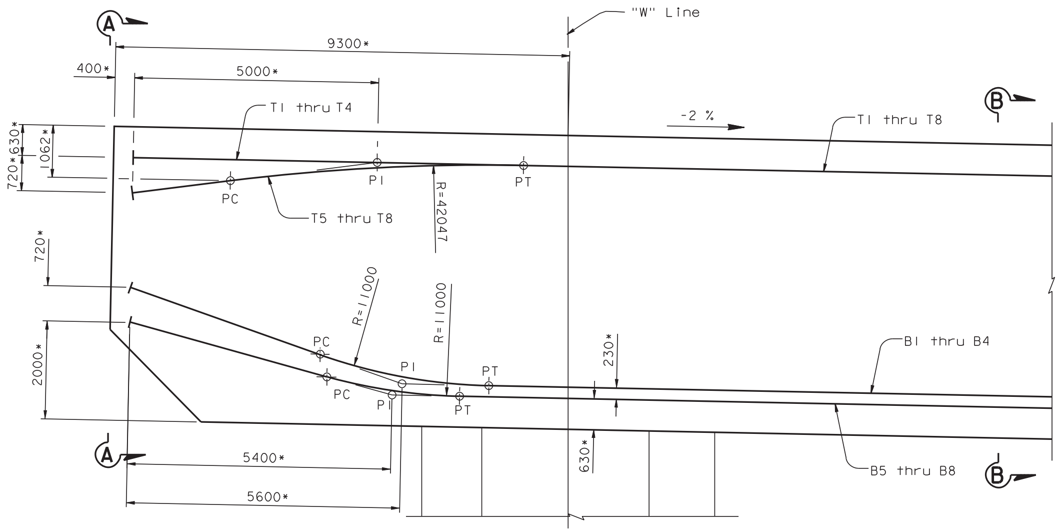
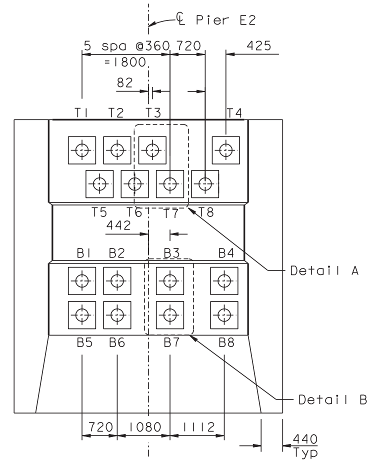


TOP AND BOTTOM TENDON PROFILE-ELEVATION

1:50

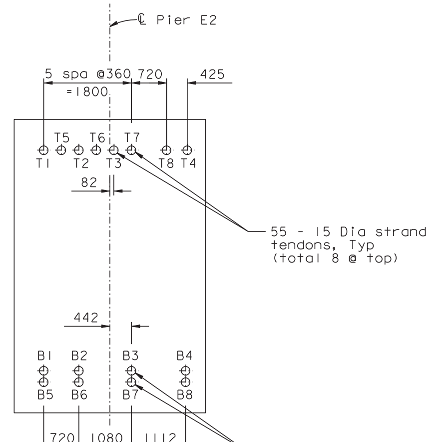
* Dimensions are nominal and parallel to sloped cap beam surface



SECTION A-A

1:50

(reinforcement is not shown for clarity)



SECTION B-B

1:50

(reinforcement is not shown for clarity)

Original Sheet Superseded ⚠1

MARK	DATE	DESCRIPTIONS	BY	CH'D	CCO#
⚠2	07/18/07	E2 CAP BEAM ISD RESOLUTION	AS	JD	34S2
⚠1	07/21/06	E2 CAP BEAM ISD	AS	NV	23

REVISIONS

CONTRACT CHANGE ORDER NO. ____
SHEET ___ OF ___

NOTES:

1. "W" Line shown, "E" Line similar.
2. ⚠2 At the Contractor's option, alternative post-tensioning anchorage sizes may be used provided the center of gravity of the prestressing force and the total prestressing force remains unchanged, subject to review and approval of the Engineer.

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DIST.	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SF	80	13.2/13.9	515R2	1204

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DESIGN	A. Sanjines	J. Chan
DETAILS	R. Xu	J. Chan
QUANTITIES	C. Bernardo	B. Mason

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R. Manzanarez
PROJECT ENGINEER

BRIDGE NO. 34-0006L/R
KILOMETER POST 13.2/13.9

SAN FRANCISCO OAKLAND BAY BRIDGE EAST SPAN SEISMIC SAFETY PROJECT

SELF-ANCHORED SUSPENSION BRIDGE (SUPERSTRUCTURE & TOWER)

PIER E2 DETAILS NO. 6

Rev. Date: 5-18-98

ORIGINAL SCALE IN MILLIMETERS FOR REDUCED PLANS 0 10 20 30 40 50 60 70 80 90 100

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EA 0120F1

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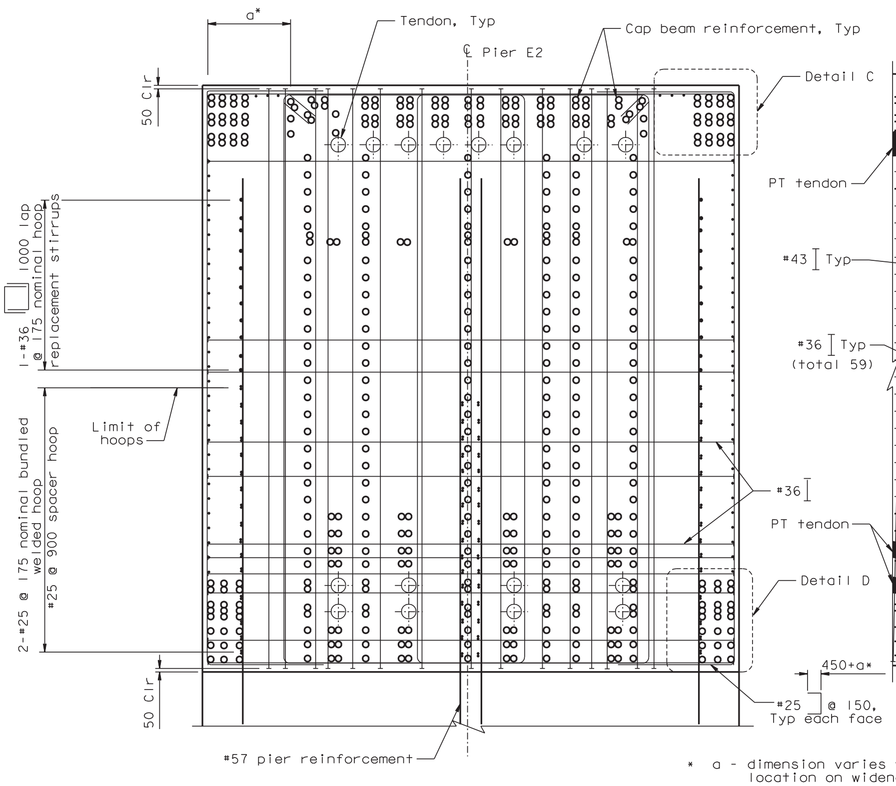
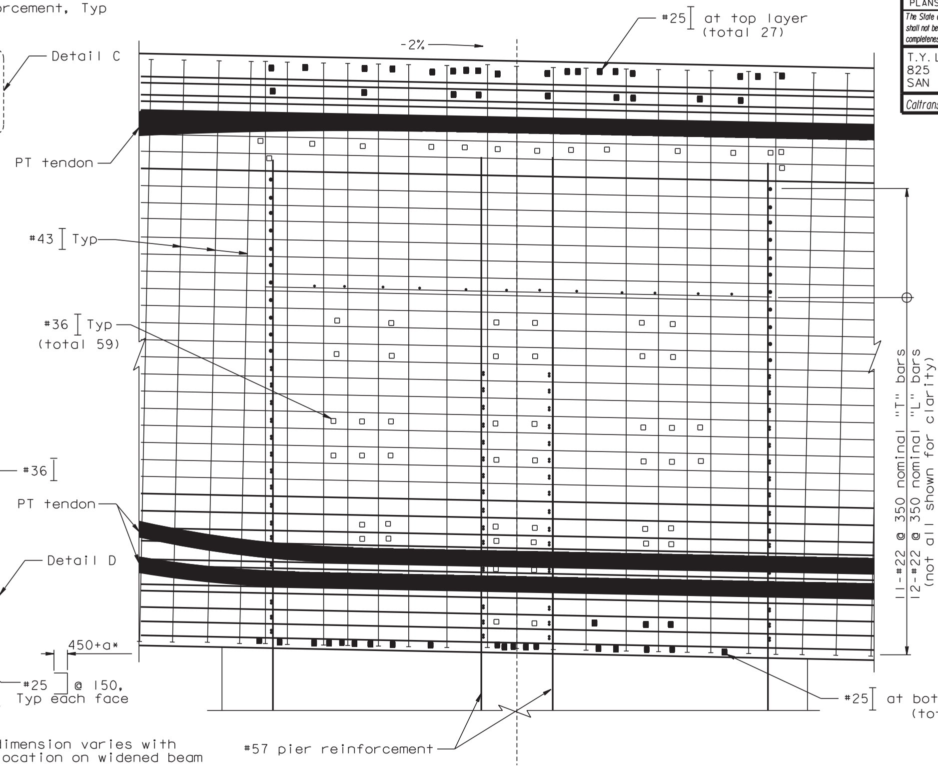


SECTION H-H

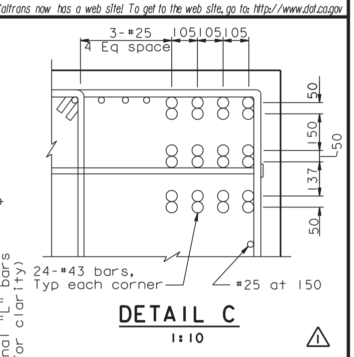
1:25
(Not all rebars shown for clarity)



* a - dimension varies with location on widened beam

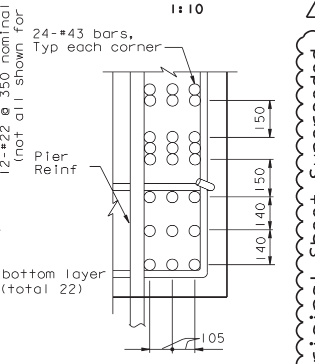
SECTION J-J

1:25
(Not all rebars shown for clarity)



DETAIL C

1:10



DETAIL D

1:10

NOTES:

1. Adjust reinforcement as required to clear column reinforcement. Bars can be moved and bundled to adjacent bars that clear column reinforcement.
2. For additional notes, see "Pier E2 Details No.3" and "Pier E2 Details No.4".

LEGEND

- #43 Headed bar
- #36 Headed bar
- #25 Headed bar

MARK	DATE	DESCRIPTIONS	BY	CH'D	CCO#
1	07/21/06	E2 CAP BEAM ISD	AS	NV	23

REVISIONS

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	BY	CHECKED
DESIGN	A. Sanjines	J. Chan
DETAILS	R. Xu	J. Chan
QUANTITIES	C. Bernardo	B. Mason

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

R. Manzanarez
PROJECT ENGINEER

BRIDGE NO. 34-0006L/R
KILOMETER POST 13.2/13.9

SAN FRANCISCO OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT
SELF-ANCHORED SUSPENSION BRIDGE (SUPERSTRUCTURE & TOWER)

PIER E2 DETAILS NO.7

Rev. Date: 5-18-98

ORIGINAL SCALE IN MILLIMETERS FOR REDUCED PLANS 0 10 20 30 40 50 60 70 80 90 100

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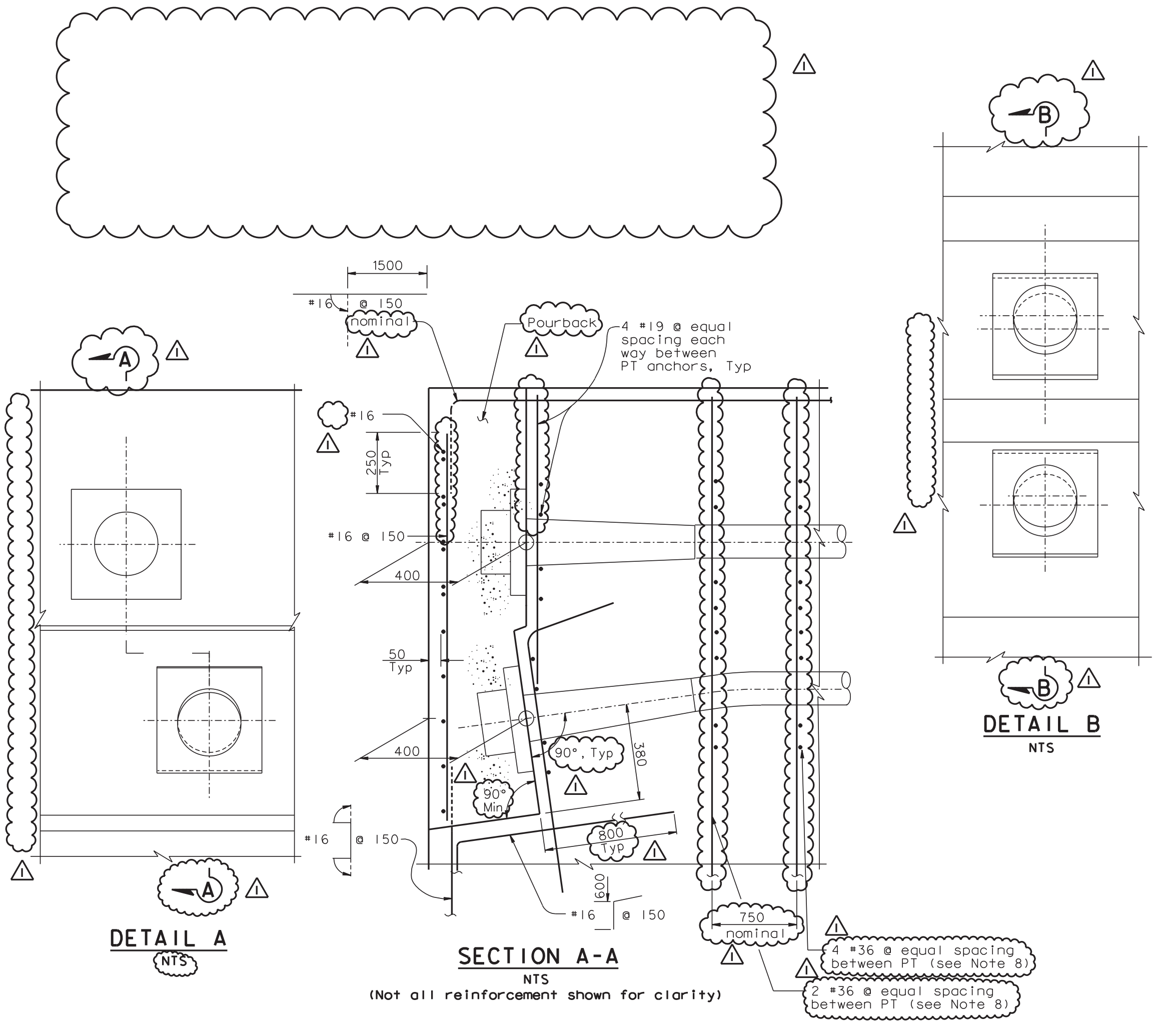

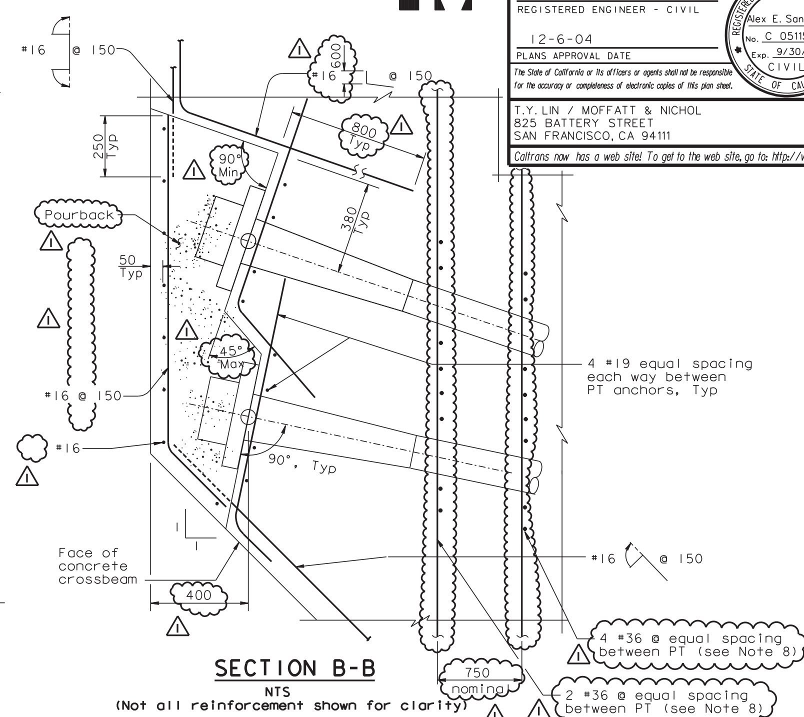

NOTES:

1. For PT tendon plans and crossbeam elevation, see "Pier E2 Details No.5" sheet.
2. For pier E2 column elevation, see "Pier E2 Details No.2" sheet.
3. All PT tendons are 55-15 Dia.
4. Local confining reinforcement (not shown for clarity) per tendon anchor shall be provided by PT hardware supplier.
5. For additional prestressing details, see "Prestressing Notes" sheet.
6. Block-out geometry reflects standard post-tensioning industry requirements. Actual post-tensioning system dimensions may vary; final block-out geometry shall be reviewed and approved by the Engineer.
7. Post-tensioning anchorage details reflect industry standard geometry. Actual dimensions may vary depending on supplier. It shall be Contractor's responsibility to accomodate the actual system to plan geometry.
8. Contractor may vary spacing and size to clear other reinforcement, such that the equivalent steel is provided.

MARK	DATE	DESCRIPTIONS	BY	CH'D	CCO#
1	07/21/06	E2 CAP BEAM ISD	AS	NV	23
		REVISIONS			

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DETAILS	R. Xu	J. Chan
QUANTITIES	C. Bernardo	B. Mason

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R. Manzanarez
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SAN FRANCISCO OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT
SELF-ANCHORED SUSPENSION BRIDGE
(SUPERSTRUCTURE & TOWER)

PIER E2 DETAILS NO. 8

Rev. Date: 5-18-98
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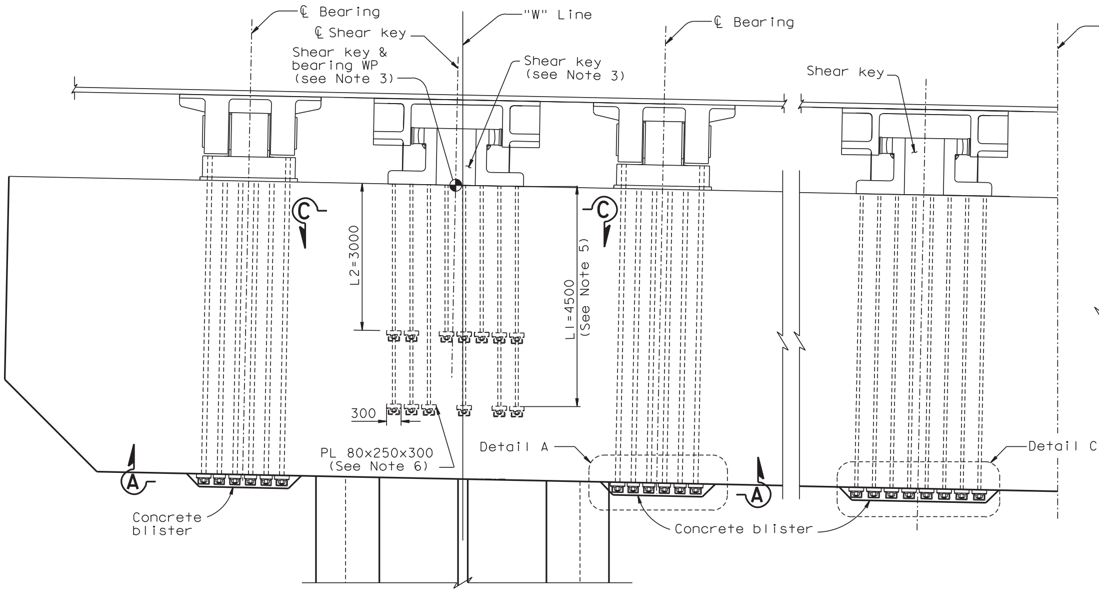
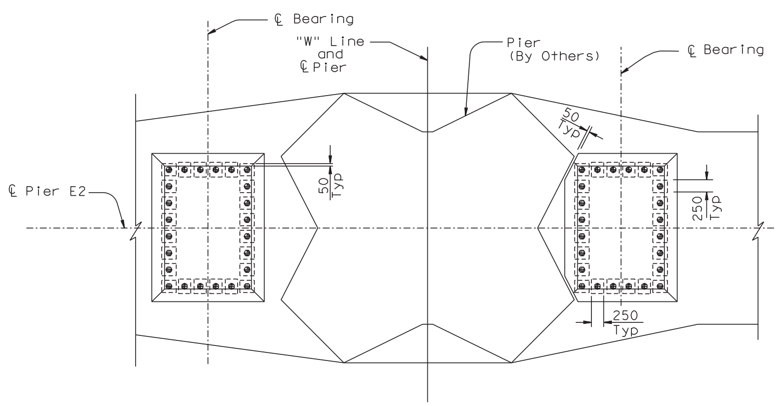
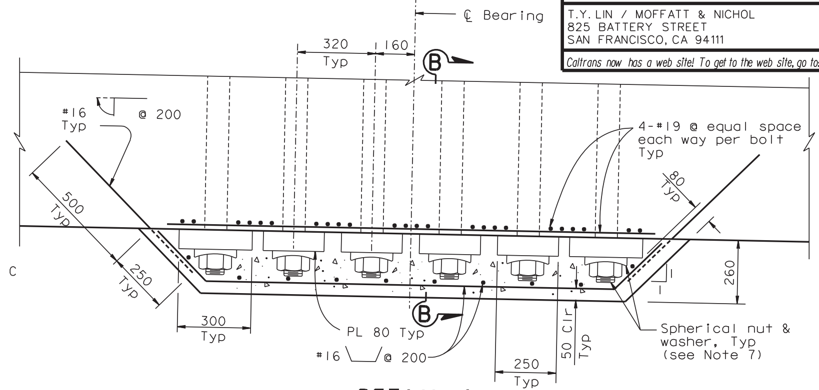


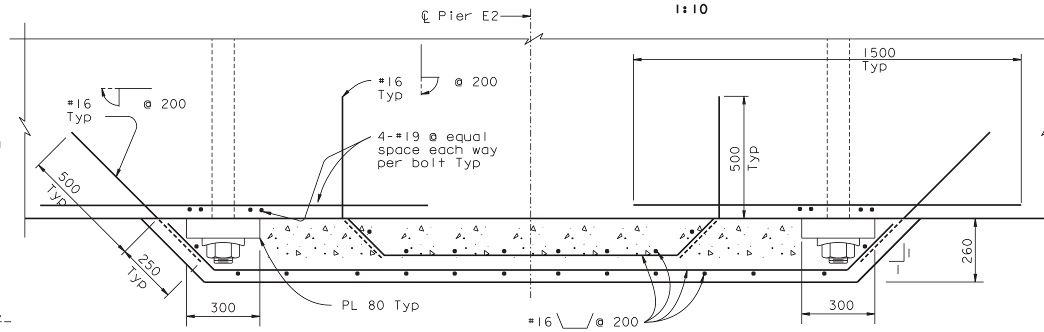
ELEVATION
1:50



SECTION A-A
1:50



DETAIL A (Detail C similar)
1:10



SECTION B-B
1:10

NOTES:

1. For pier E2 bearing hold down assembly, see "Pier E2 Bearing Details" sheets.
2. Local confining spiral reinforcement for bearing HS bolts shall be provided by hardware suppliers, not shown for clarity.
3. For pier E2 bearing and shear key location, see "Pier E2 Bearing and Shear Key Layout" sheet.
4. For Section C-C, see "Pier E2 Details No.10" sheet.
5. For shear key anchor bolt length layout, see "Pier E2 Details No.10" sheet.
6. Rotate shear key anchor plates as necessary to clear column reinforcement.
7. The spherical nut and washer shall be able to accomodate a maximum roation of 3 degress in any direction.
8. End cap shall be provided to prevent concrete from bonding to spherical nut and washer. Anchor bolts shall be able to pivot freely to accommodate construction tolerance.

100 % PS&E

5 **REVISED PER ADDENDUM NO. 5 DATED DECEMBER 21, 2005**

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R. Valizadeh/V. Toan/Y.L./W.L./F.C.
DESIGN OVERSIGHT
SIGN OFF DATE 12/07/05

DESIGN	BY A. Sanjines	CHECKED J. Chan
DETAILS	BY R. Xu	CHECKED J. Chan
QUANTITIES	BY R. Xu	CHECKED C. Bernardo

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

R. Manzanarez
PROJECT ENGINEER

BRIDGE NO. 34-0006L/R
KILOMETER POST 13.2/13.9

SAN FRANCISCO OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT
SELF-ANCHORED SUSPENSION BRIDGE
(SUPERSTRUCTURE & TOWER)

PIER E2 DETAILS NO.9

Rev. Date: 5-18-98

ORIGINAL SCALE IN MILLIMETERS FOR REDUCED PLANS 0 10 20 30 40 50 60 70 80 90 100

CU 04
EA 0120F1

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) 05/31/01 04/08/02 01/07/02 12/19/02 12/07/05

SHEET 101 OF

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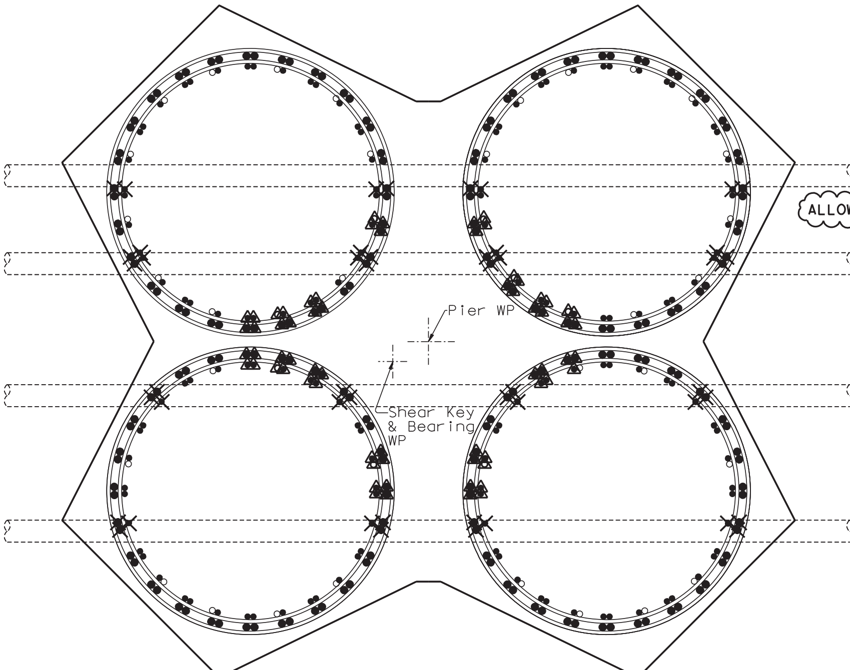
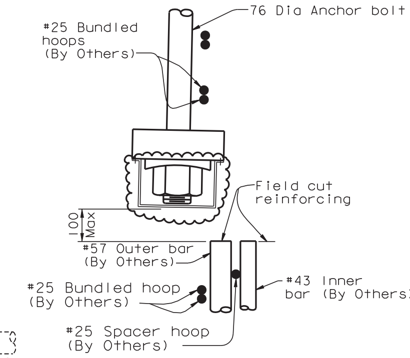


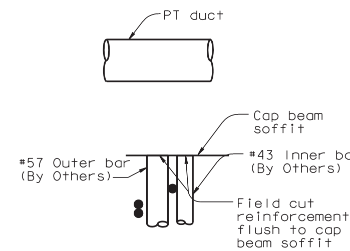
CUTOFF ALLOWANCE FOR COLUMN REINFORCEMENT

NTS

(Allowance shown is theoretical and is for information only. Not for construction). (see Note 2 thru 4)



ALLOWANCE FOR ANCHOR BOLT AND ANCHOR PLATE

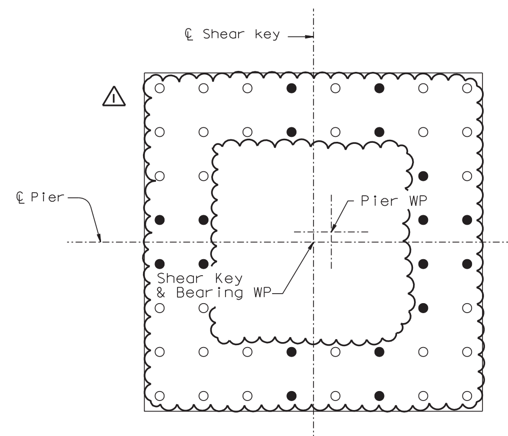


ALLOWANCE FOR PT DUCT

FIELD CUT DETAIL

NTS

(see Notes 2 thru 4)



SECTION C-C

1:20

(Anchor bolt length layout)

LEGEND:

- ○ Anchor bolts length = L1
- ● Anchor bolts length = L2
- × Indicates #43 or #57 column reinforcement may be field cut below the ducts. See "Allowance for PT duct".
- △ Indicates #43 or #57 column reinforcement may be field cut below the anchor bolt or anchor PL. See "Allowance for anchor bolt and anchor plate".

NOTES:

1. Local confining spiral reinforcement for bearing HS bolts shall be provided by hardware suppliers; not shown for clarity.
2. Rotate anchor plates as necessary to clear column reinforcement.
3. Contractor may field cut existing column reinforcement marked with X or △ to clear PT ducts and shear key anchor bolt/anchor plate. See Field Cut Detail.
4. Prior to cutting any column reinforcement, the Contractor is required to submit locations and number of bars to be field cut for Engineer's review and approval.

MARK	DATE	DESCRIPTIONS	BY	CH'D	CCO#
1	07/21/06	E2 CAP BEAM ISD	AS	NV	23

REVISIONS

CONTRACT CHANGE ORDER NO. ____
SHEET ____ OF ____

ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SHOWN

DIST.	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SF	80	13.2/13.9	519R1	1204

REGISTERED ENGINEER - CIVIL

12-6-04
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DESIGN OVERSIGHT
SIGN OFF DATE 07/21/06

	BY	CHECKED
DESIGN	A. Sanjines	J. Chan
DETAILS	R. Xu	J. Chan
QUANTITIES	C. Bernardo	B. Mason

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

R. Manzanarez
PROJECT ENGINEER

BRIDGE NO. 34-0006L/R
KILOMETER POST 13.2/13.9

SAN FRANCISCO OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT
SELF-ANCHORED SUSPENSION BRIDGE
(SUPERSTRUCTURE & TOWER)

PIER E2 DETAILS NO. 10

CU 04
EA 0120F1

ORIGINAL SCALE IN MILLIMETERS FOR REDUCED PLANS 0 10 20 30 40 50 60 70 80 90 100

DISREGARD PRINTS BEARING EARLIER REVISION DATES
REVISION DATES (PRELIMINARY STAGE ONLY) 05/31/01 04/08/02 07/01/02 12/19/02 05/16/03 12/07/05

SHEET 102R1

Rev. Date: 5-18-98

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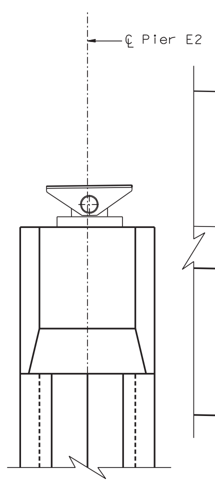
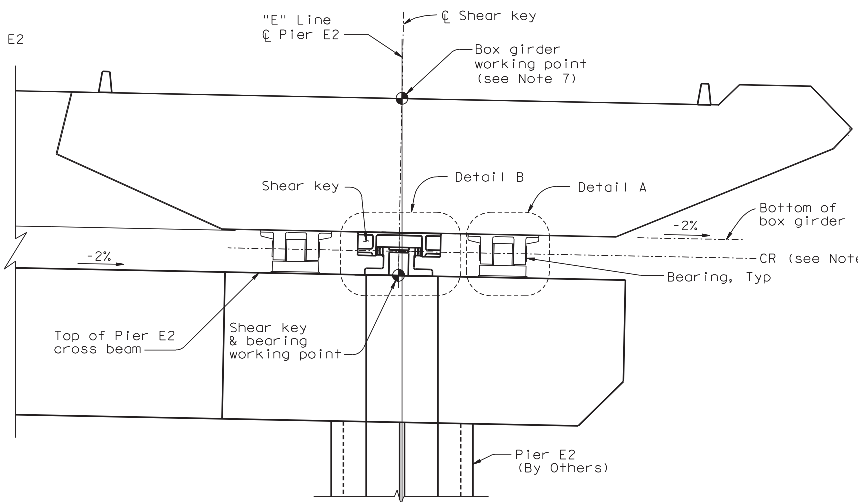
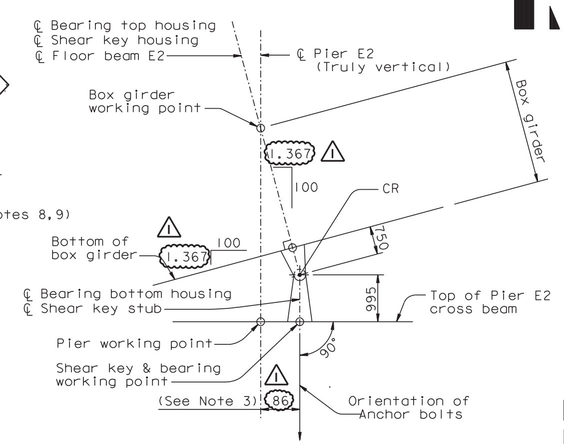


SIDE ELEVATION
1:200
(Looking South)



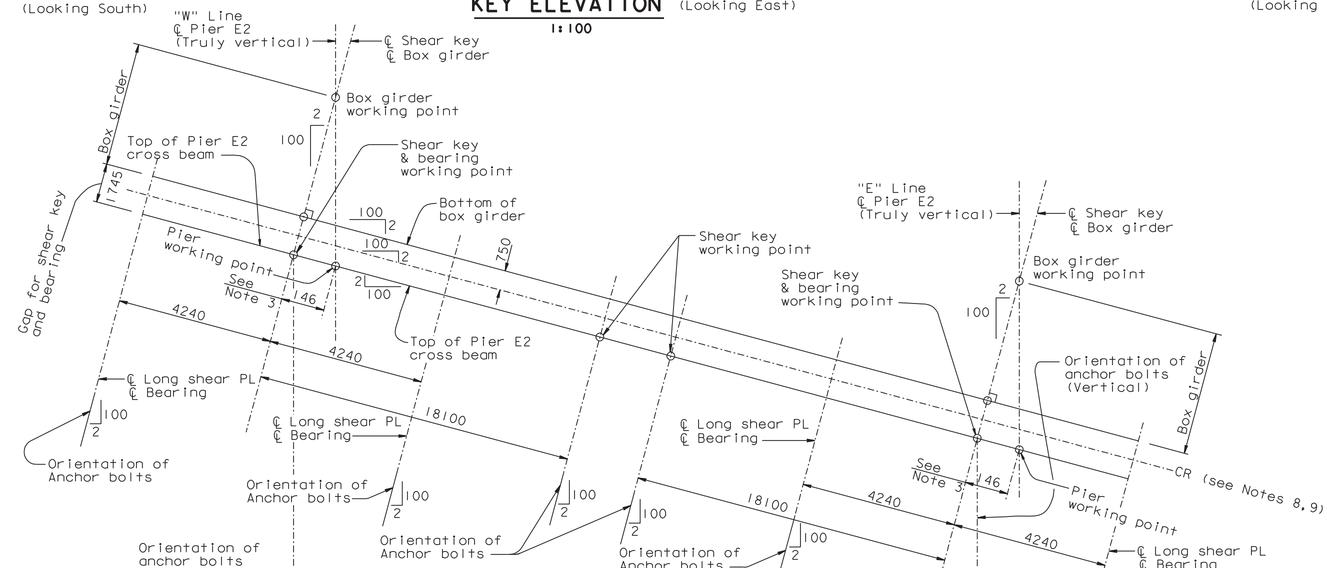
KEY ELEVATION (Looking East)
1:100



SHEAR KEY AND BEARING LOCATION
NTS
(Looking South)

LEGEND:

CR Center of Rotation



SHEAR KEY AND BEARING LOCATION
NTS
(Looking East)

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NOTES:

1. For Detail A, see "Pier E2 Bearing Details No.1" sheet.
2. Detail B is a section view at center line of shear key. For Detail B, see "Pier E2 Shear Key Details No.1" sheet.
3. Offset value is shown for information only. The Contractor shall calculate the offset and verify it in the field before placing the bearings and shear key.
4. The Contractor shall submit the construction sequence of the shear key and bearings based on his ways and means for the Engineer's approval.
5. For floor beam E2, see "Girder at Pier E2" sheets.
6. For longitudinal shear plate, see "Girder at East Transition No.1" sheet.
7. Box girder work point is on the finished profile grade which is the top of 50 mm overlay.
8. At the Contractor's option, small holes may be drilled through the bearings and shear keys for use with a laser alignment method. All holes shall be plugged with tapped screws after bearing and shear key installation.
9. The center of rotation CR shall be a straight line through the pin center of all four bearings, and perpendicular to the bridge axis direction.

DIST.	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SF	80	13.2/13.9	882R1	1204

REGISTERED ENGINEER - CIVIL
12-6-04
PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER Marwan N. Nader No. C 054426 Exp. 12/31/09 CIVIL STATE OF CALIFORNIA

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1	09/26/08	E2 CROSS BEAM	MN	NV	71

REVISIONS

CONTRACT CHANGE ORDER NO. ____
SHEET ____ OF ____

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DESIGN	BY M. Nader	CHECKED L. Rus	
DETAILS	BY N. Vo	CHECKED J. Leventini	
QUANTITIES	BY N. Vo	CHECKED J. Leventini	

R. Valizadeh/V. Toan/Y.L./W.L./F.C.
DESIGN OVERSIGHT
SIGN OFF DATE 09/26/08

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

R. Manzanarez
PROJECT ENGINEER

BRIDGE NO. 34-0006L/R
KILOMETER POST 13.2/13.9

SAN FRANCISCO OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT
SELF-ANCHORED SUSPENSION BRIDGE
(SUPERSTRUCTURE & TOWER)

PIER E2 BEARING AND SHEAR KEY LAYOUT

Rev. Date: 5-18-98

ORIGINAL SCALE IN MILLIMETERS FOR REDUCED PLANS 0 10 20 30 40 50 60 70 80 90 100

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EA 0120F1

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REVISION DATES (PRELIMINARY STAGE ONLY) 04/08/02 07/01/02 12/19/02 12/01/05

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DIST.	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
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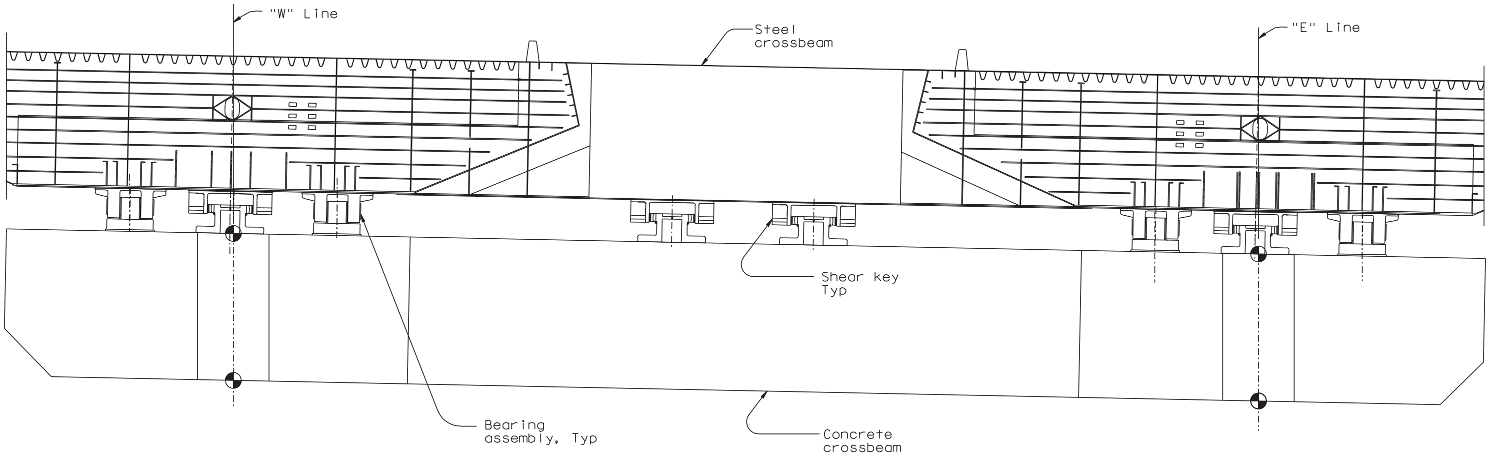

ELEVATION (Looking East)

CLEAN UP/ CLARIFICATION

BEARING ASSEMBLY TABLE

Location	Bearing Typ	Number of bearing units per location	Design Load (kN per bearing)							Design rotation (radians)						Design Displacement (mm)					
			Service			Ultimate				Service			Ultimate			Service			Ultimate		
			Compression	Uplift	Long or Trans	Load Condition	Compression	Uplift	Long / Trans	Trans Axis	Long Axis	Vert Axis	Trans Axis	Long Axis	Vert Axis	Trans Axis	Long Axis	Vert Axis	Trans Axis	Long Axis	Vert Axis
"W" Line	Spherical Bushing	2	35000	0	0	Shear Key Engaged	86000	32000	0	0.009	0	0	0.130	0.032	0.032	5	5	0	20	20	2**
						Shear Key Failed*	68000	17000	13300 / 30500												
"E" Line	Spherical Bushing	2	35000	0	0	Shear Key Engaged	86000	32000	0	0.009	0	0	0.130	0.032	0.032	5	5	0	20	20	2**
						Shear Key Failed*	68000	17000	13300 / 30500												

RFI #760 R0

* Seismic load factor γ = 1.0 (For shear key engaged load condition, γ = 1.4).
** For uplifting only.

Installation Misalignment Tolerances (Per bearing/ Shear Key)	Trans./Long./Vertical	Rotational
	± 2 mm	± 0.5°

SHEAR KEY ASSEMBLY TABLE

Location	Number of Shear Key Units Per Location	Design Load (kN per shear key)						Design rotation (radians)						Design Displacement (mm)					
		Service			Ultimate			Service			Ultimate			Service			Ultimate		
		Trans	Long	Vert	Trans	Long	Vert	Trans Axis	Long Axis	Vert Axis	Trans Axis	Long Axis	Vert Axis	Trans Axis	Long Axis	Vert Axis	Trans Axis	Long Axis	Vert Axis
"W" Line	1	9000	4500	0	42500	35000	0	0.009	0	0	0.130	0.130	0.130	0	0	10	0	0	20
"E" Line	1	9000	4500	0	42500	35000	0	0.009	0	0	0.130	0.130	0.130	0	0	10	0	0	20
Crossbeam	2	9000	1	0	42500	0	0	0.009	0	0	0.130	0.130	0.130	0	5	10	0	20	20

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R. Valizadeh/V. Toan/Y.L./W.L./F.C.
DESIGN OVERSIGHT
SIGN OFF DATE 09/26/08
Rev. Date: 5-18-98

MARK	DATE	DESCRIPTIONS	BY	CH'D	CCO#
1	09/26/08	E2 CROSS BEAM	MN	NV	71

REVISIONS

DESIGN BY M. Nader — CHECKED L. Rus
DETAILS BY N. Vo — CHECKED J. Leventini
QUANTITIES BY N. Vo — CHECKED J. Leventini

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

R. Manzanarez
PROJECT ENGINEER

BRIDGE NO. 34-0006L/R
KILOMETER POST 13.2/13.9

SAN FRANCISCO OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT
SELF-ANCHORED SUSPENSION BRIDGE
(SUPERSTRUCTURE & TOWER)

PIER E2 BEARING AND SHEAR KEY DESIGN FORCES

ORIGINAL SCALE IN MILLIMETERS FOR REDUCED PLANS 0 10 20 30 40 50 60 70 80 90 100

CU 04
EA 0120F1

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12-6-04
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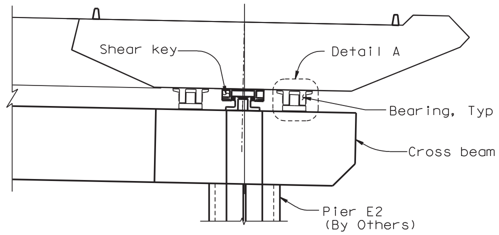
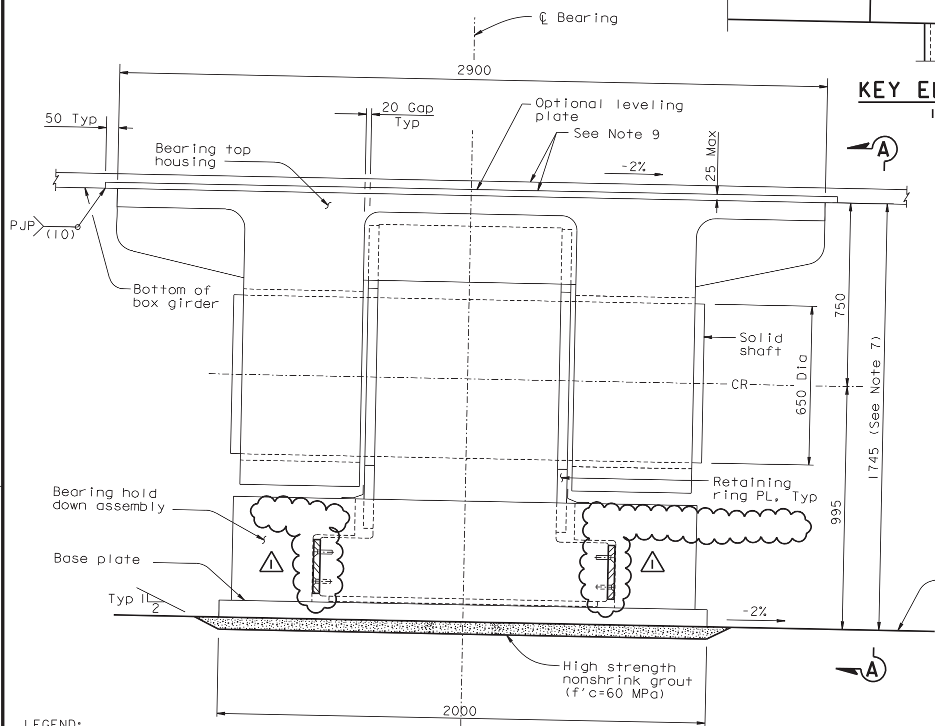


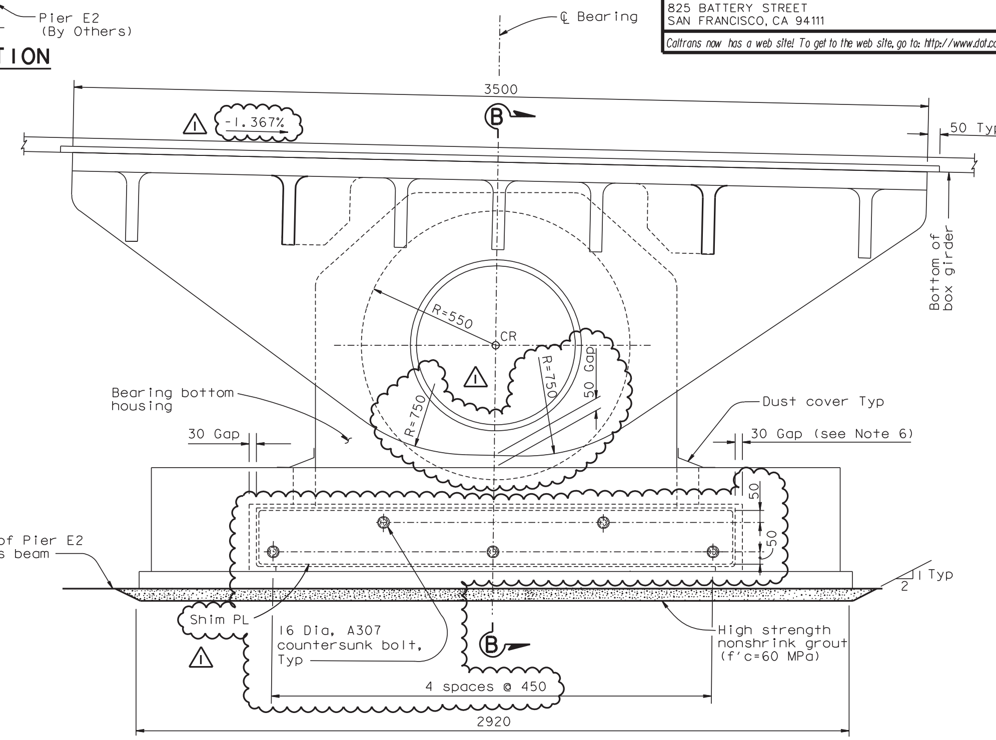
KEY ELEVATION

1:200



DETAIL A (Bearing Assembly)

1:10



VIEW A-A

1:10

LEGEND:

CR Center of Rotation

NOTES:

1. For Section B-B, see "Pier E2 Bearing Details No. 2" sheet.
2. Connections to box girder and Pier E2 are not shown for clarity.
3. The bearing top housing and bearing hold down assembly shall be Structural Casting Grade 345.
4. The bearing bottom housing and the solid shaft shall be Structural Casting Grade 550.
5. The grout pad thickness is shown for information only. Before grout pour, Contractor shall verify in the field the grout pad thickness required to align the center of rotation of the shear key and bearings at 0.750 m from the bottom surface of the box girder and ensure center of rotation of all bearings and shear keys are aligned in the same axis.
6. Gaps shall be maintained during installation by using shims placed below the dust cover locations. ~~Remove shims after grouting.~~ Alternatively, ¾" diameter spacing bolts may be installed. These shall remain undamaged during installation and shall be replaced with plug bolts.
7. The Contractor may provide optional leveling plates to achieve fit-up and level contact surfaces for the bearings and shear keys. The Contractor shall erect the E2 cap beam and E2 girders to the elevations and tolerances specified in the plans and special provisions.
8. Leveling plate shall be attached with plug welds at 0.5 m Max spacing, and a perimeter PJP weld.
9. All faying surfaces of the girder key plate, the bearing top housing, and the optional leveling plate shall be machined after all welding for flatness and smoothness as specified for the top of the bearing top housing. See "Pier E2 Bearing Details No. 3" sheet.

CONTRACT CHANGE ORDER NO. ____
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MARK	DATE	DESCRIPTIONS	BY	CH'D	CCO#
2	07/17/09	E2 CROSS BEAM	MN	NV	71
1	09/26/08	E2 CROSS BEAM	MN	NV	71

REVISIONS

R. Valizadeh/V. Toan/Y.L./W.L./F.C.
DESIGN OVERSIGHT
SIGN OFF DATE 07/17/09

DESIGN BY M. Nader — CHECKED L. Rus
DETAILS BY N. Vo — CHECKED J. Leventini
QUANTITIES BY N. Vo — CHECKED J. Leventini

PREPARED FOR THE STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

R. Manzanarez
PROJECT ENGINEER

BRIDGE NO. 34-0006L/R
KILOMETER POST 13.2/13.9

SAN FRANCISCO OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT
SELF-ANCHORED SUSPENSION BRIDGE
(SUPERSTRUCTURE & TOWER)

PIER E2 BEARING DETAILS NO. 1

Rev. Date: 5-18-98

ORIGINAL SCALE IN MILLIMETERS FOR REDUCED PLANS 0 10 20 30 40 50 60 70 80 90 100

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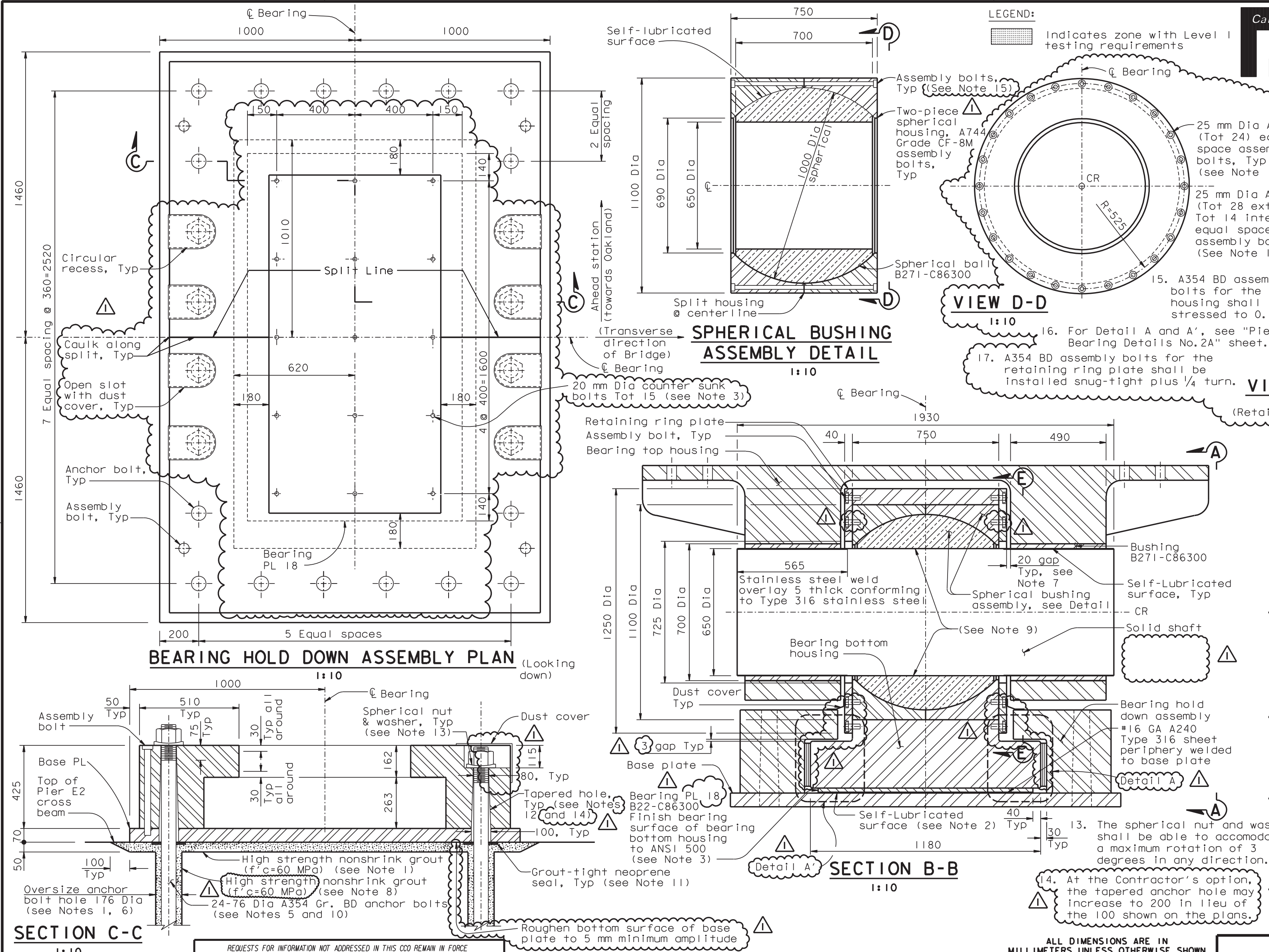

NOTES:

1. The grout pad thickness is shown for information only. The Contractor shall verify in the field the grout pad thickness required to align the center of rotation of the shear key and bearings at 0.750 m from the bottom surface of the box girder.
2. The lubricant shall be Self-lubricated.
3. Bearing plate shall be fastened to bottom of bottom housing using A240 Type 316 counter sunk bolts.
4. All assembly bolts shall be A240 Type 316 unless noted otherwise.
5. The anchor bolt shall be pretensioned to 70% of ultimate tensile strength. Wherever there is no access from the top, anchor bolt shall be prestressed from the bottom.
6. The oversize anchor bolt holes are provided to accommodate construction tolerances.
7. 20 mm gap ±2 mm shall be maintained on both sides during installation.
8. For additional prestressing details, see "Prestressing Notes" sheet.
9. Solid shaft in bushing is press fit.
10. The prestressed anchor bolts shall be wrapped in a PT supplier recommended debonding tape, subject to the review and approval of the Engineer.
11. Grout-tight neoprene seal shown is schematic and is for information only. The seal shall prevent any high strength nonshrink grout from seeping inside the anchor bolt tapered holes during grouting of the base plate. This is necessary for proper stressing of the anchor bolts. The Contractor may propose an alternate detail to suit his erection means and methods, subject to review and approval of the Engineer.
12. For tapered hole details, see "Pier E2 Shear Key Details No. 1" sheet.

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REGISTERED ENGINEER - CIVIL
12-6-04
PLANS APPROVAL DATE

Marwan N. Nader, No. C 054426, Exp. 12/31/09, CIVIL, STATE OF CALIFORNIA, REGISTERED PROFESSIONAL ENGINEER

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REVISIONS

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SIGN OFF DATE 09/26/08

CONTRACT CHANGE ORDER NO. ____
SHEET ____ OF ____

	BY	CHECKED
DESIGN	M. Nader	L. Rus
DETAILS	N. Vo	J. Leventini
QUANTITIES	N. Vo	J. Leventini

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

R. Manzanarez
PROJECT ENGINEER

BRIDGE NO. 34-0006L/R
KILOMETER POST 13.2/13.9

SAN FRANCISCO OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT
SELF-ANCHORED SUSPENSION BRIDGE (SUPERSTRUCTURE & TOWER)

PIER E2 BEARING DETAILS NO. 2

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ORIGINAL SCALE IN MILLIMETERS FOR REDUCED PLANS

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) 04/08/02 07/01/02 12/19/02 05/16/03 12/07/05

SHEET 467R1 OF

Rev. Date: 5-18-98

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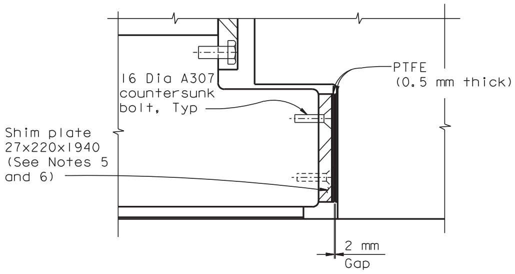
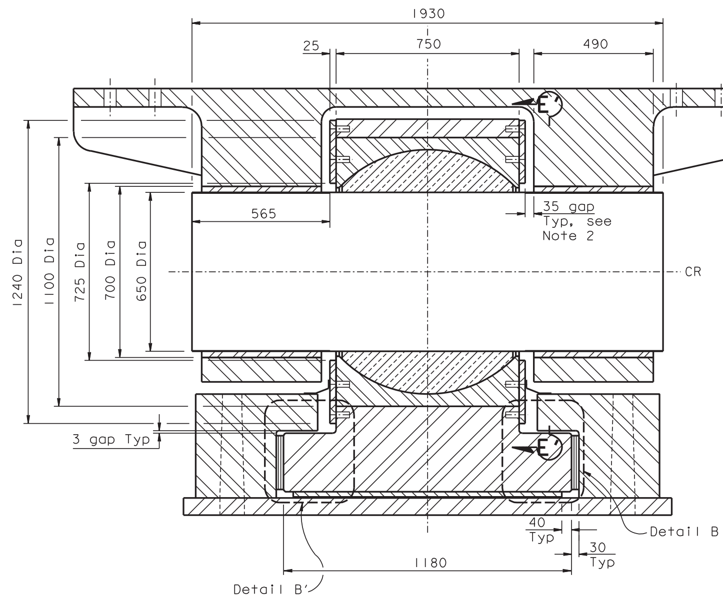
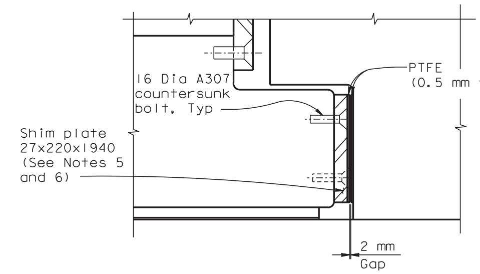


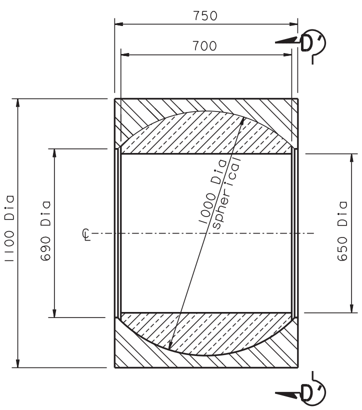
DETAIL A
(Detail A' similar)
1:5



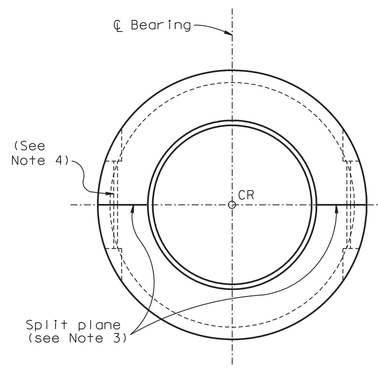
SECTION B-B
1:10



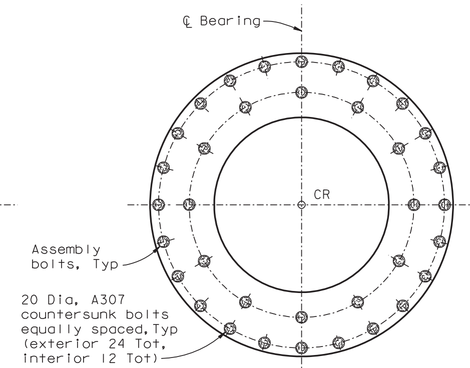
DETAIL B
(Detail B' similar)
1:5



SPHERICAL BUSHING ASSEMBLY DETAIL
1:10



VIEW D'-D'
1:10



VIEW E'-E'
1:10
(Retaining Ring PL)

ALTERNATE BEARING DETAILS (See Note 1)
1:10

ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SHOWN

REQUESTS FOR INFORMATION NOT ADDRESSED IN THIS CCO REMAIN IN FORCE

MARK	DATE	DESCRIPTIONS	BY	CH'D	CCO#
△	09/26/08	E2 CROSS BEAM	MN	NV	71

REVISIONS

CONTRACT CHANGE ORDER NO. ____
SHEET ____ OF ____

NOTES:

1. For details not shown, see "Pier E2 Bearing Details No.2" sheet.
2. 35 mm gap ±2 mm shall be maintained on both sides during installation.
3. The split plane shall be parallel to the base plate in the final erected position.
4. Assembly bolts and recesses are shown schematically. Design and details of assembly bolts for spherical housing shall be per bearing manufacturer.
5. Shim plate and PTFE film shall be provided along the 2 sides of the bearing housing in the longitudinal direction of the bridge.
6. Shim plate details may vary with field conditions subject to review and approval of the Engineer.

DIST.	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SF	80	13.2/13.9	884SI	1204

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REGISTERED ENGINEER - CIVIL
09-26-08
PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — Marwan N. Nader — No. C 054426 — Exp. 12/31/09 — CIVIL — STATE OF CALIFORNIA

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R. Valizadeh/V. Toan/Y.L./W.L./F.C.
DESIGN OVERSIGHT
SIGN OFF DATE 09/26/08

DESIGN	BY M. Nader	CHECKED N. Vo
DETAILS	BY M. Nader	CHECKED N. Vo
QUANTITIES	BY M. Nader	CHECKED N. Vo

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

R. Manzanarez
PROJECT ENGINEER

BRIDGE NO. 34-0006L/R
KILOMETER POST 13.2/13.9

SAN FRANCISCO OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT
SELF-ANCHORED SUSPENSION BRIDGE
(SUPERSTRUCTURE & TOWER)

PIER E2 BEARING DETAILS NO. 2A

Rev. Date: 5-18-98
ORIGINAL SCALE IN MILLIMETERS FOR REDUCED PLANS 0 10 20 30 40 50 60 70 80 90 100
CU 04
EA 0120F1
DISREGARD PRINTS BEARING EARLIER REVISION DATES → 09/27/07
REVISION DATES (PRELIMINARY STAGE ONLY)
SHEET 467SI OF

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USERNAME => ptom DATE PLOTTED => 08 OCT 2008 TIME PLOTTED => 15:37:13

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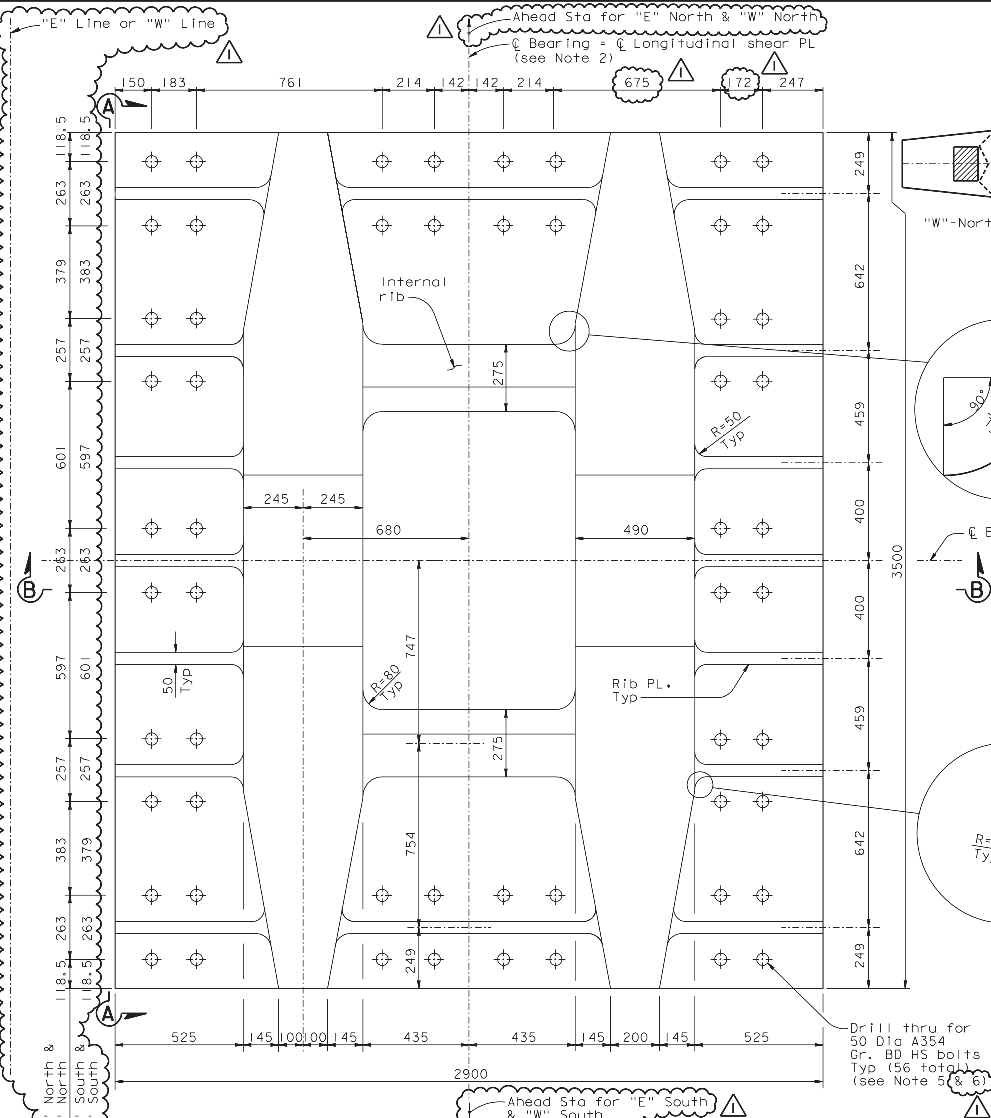
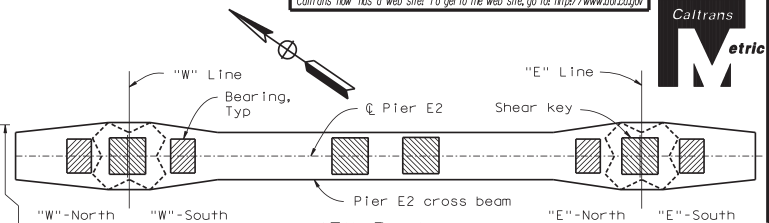


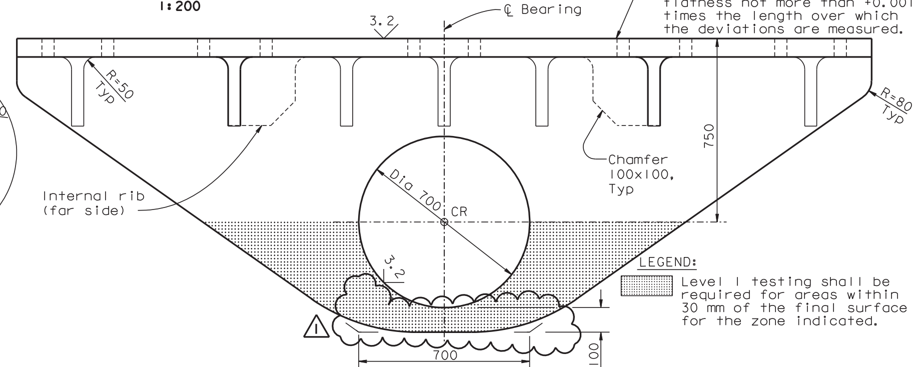
BEARING TOP HOUSING PLAN (Looking Up) ("E" - South Bearing shown. "W" - South similar. See Note 3 and 4)

1:10



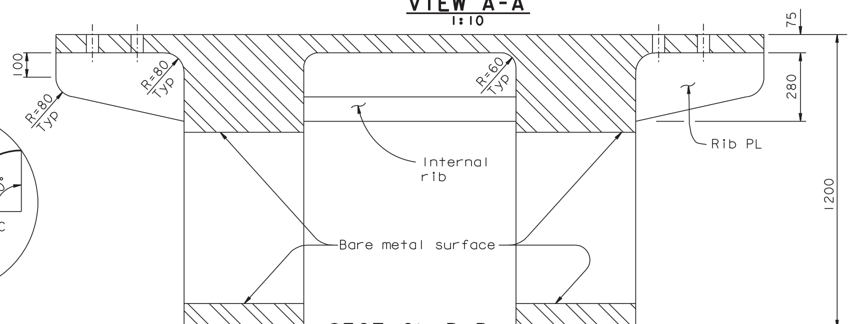
KEY PLAN

1:200



VIEW A-A

1:10



SECTION B-B

1:10

NOTES:

1. Solid shaft in bushings is press fit.
2. For longitudinal shear plate location on box girder, see "Girder At East Transition No. 1" sheet.
3. "E"-South bearing and "W"-South bearing are similar. "E"-North bearing and "W"-North bearing are similar.
4. Bolt hole location shall be cross checked with the box girder stiffener layout before drilling holes. Bolt edge distance and clearance for tightening shall be verified and submitted for review and approval by the Engineer. A template shall be used to drill bolt holes in bearing top housing and girder key plate to ensure hole matching.
5. The anchor bolt shall be pretensioned to 70% of ultimate tensile strength.
6. At the Contractor's option, oversized holes and appropriate washer plates may be used in the bearing top housing.

ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SHOWN

DIST.	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SF	80	13.2/13.9	885R1	1204

REGISTERED ENGINEER - CIVIL

12-6-04

PLANS APPROVAL DATE

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MARK	DATE	DESCRIPTIONS	BY	CH'D	CCO#
1	09/26/08	E2 CROSS BEAM	MN	NV	71

REVISIONS

R. Valizadeh/V. Toan/Y.L./W.L./F.C.
DESIGN OVERSIGHT
SIGN OFF DATE 09/26/08

DESIGN	BY M. Nader	CHECKED L. Rus
DETAILS	BY N. Vo	CHECKED J. Leventini
QUANTITIES	BY N. Vo	CHECKED J. Leventini

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

R. Manzanarez
PROJECT ENGINEER

BRIDGE NO. 34-0006L/R
KILOMETER POST 13.2/13.9

SAN FRANCISCO OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT
SELF-ANCHORED SUSPENSION BRIDGE
(SUPERSTRUCTURE & TOWER)

PIER E2 BEARING DETAILS NO. 3

CONTRACT CHANGE ORDER NO. ____
SHEET ___ OF ___

Rev. Date: 5-18-98

ORIGINAL SCALE IN MILLIMETERS FOR REDUCED PLANS 0 10 20 30 40 50 60 70 80 90 100

CU 04
EA 0120F1

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) 08/02/99 05/31/01 04/08/02 07/01/02 12/18/02 10/13/05 12/07/05

SHEET 468R1

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DIST.	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SF	80	13.2/13.9	886	1204

REGISTERED ENGINEER - CIVIL

12-6-04

PLANS APPROVAL DATE

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PROFESSIONAL ENGINEER REGISTERED Marwan N. Nader No. C 054426 Exp. 12/31/05 CIVIL STATE OF CALIFORNIA

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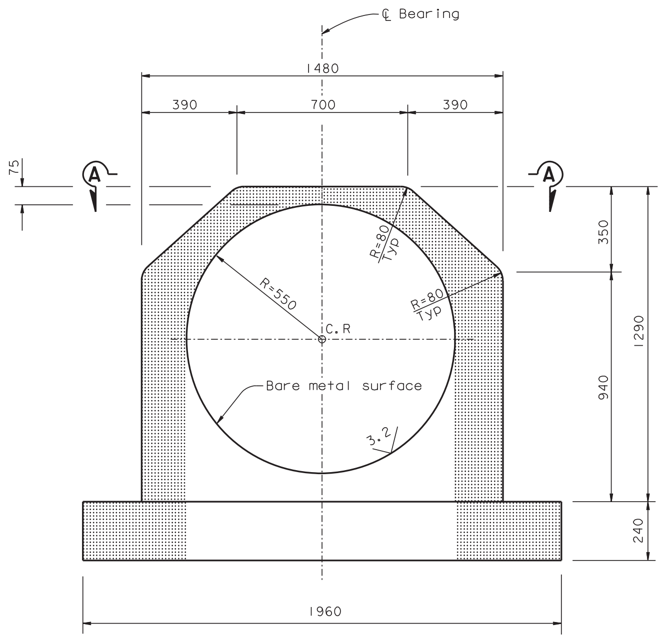
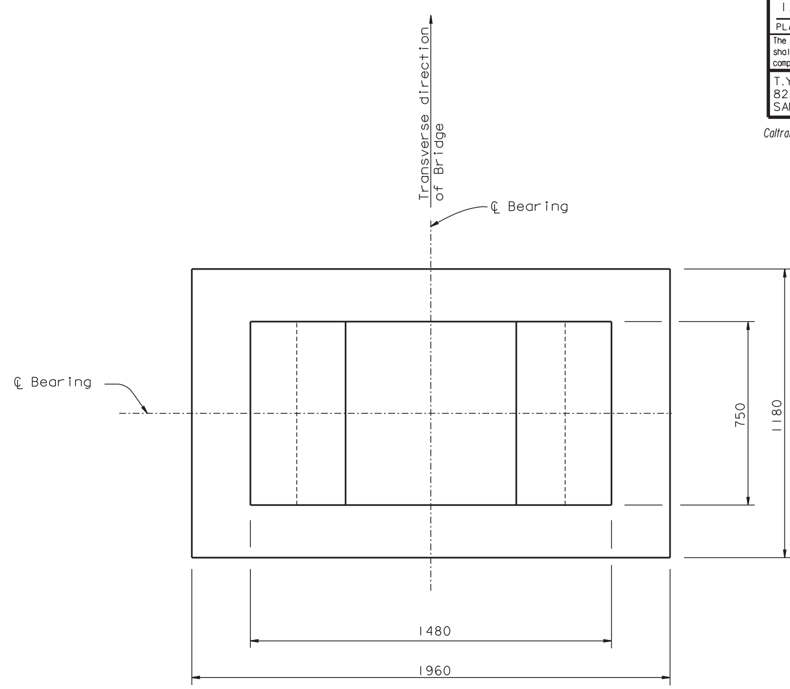


BEARING BOTTOM HOUSING (Looking North)

1:10



VIEW A-A

1:10

LEGEND:

[shaded] Indicates zone with Level 1 testing requirements

ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SHOWN

SAN FRANCISCO OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT
SELF-ANCHORED SUSPENSION BRIDGE
(SUPERSTRUCTURE & TOWER)

PIER E2 BEARING DETAILS NO. 4

R. Valizadeh/V. Toan/Y.L./W.L./F.C.
DESIGN OVERSIGHT
SIGN OFF DATE 12/19/02

DESIGN	BY M. Nader	CHECKED L. Rus
DETAILS	BY N. Vo	CHECKED J. Leventini
QUANTITIES	BY N. Vo	CHECKED J. Leventini

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

R. Manzanarez
PROJECT ENGINEER

BRIDGE NO. 34-0006L/R
KILOMETER POST 13.2/13.9

CU 04
EA 0120F1

ORIGINAL SCALE IN MILLIMETERS FOR REDUCED PLANS 0 10 20 30 40 50 60 70 80 90 100

DISREGARD PRINTS BEARING EARLIER REVISION DATES

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SHEET 469 OF

Rev. Date: 5-18-98

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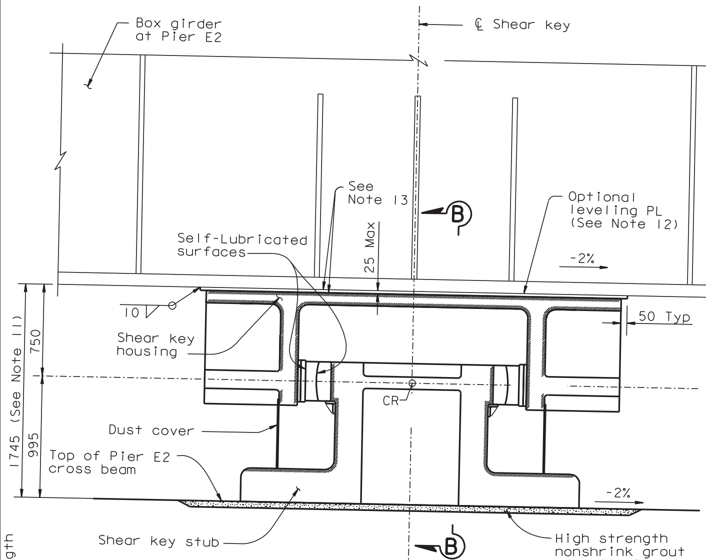
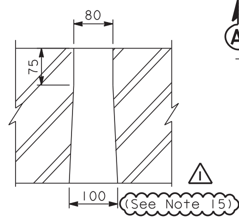


DETAIL B - SHEAR KEY ASSEMBLY

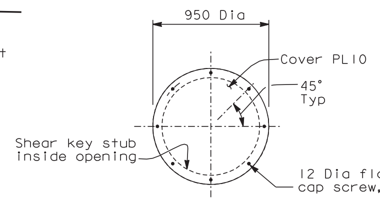
1:20

(Bolts not shown for clarity)
(Looking East)



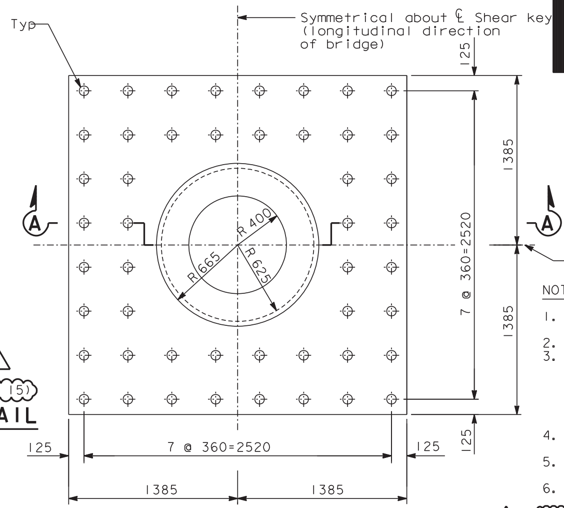
TAPERED HOLE DETAIL

1:5



SECTION C-C

1:20



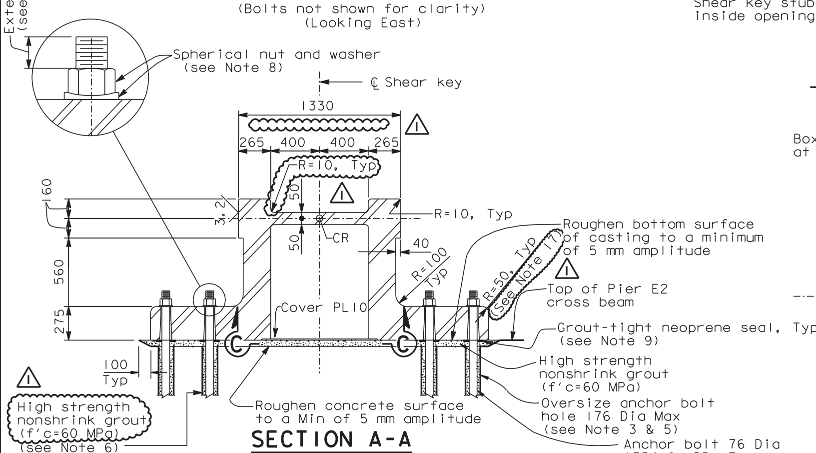
PLAN - SHEAR KEY STUB

1:20

(Anchor bolts not shown for clarity)

LEGEND:

CR	Center of Rotation
(shaded)	Indicates zone with Level 1 testing requirements



SECTION A-A

1:20

CONTRACT CHANGE ORDER NO. ____
SHEET ____ OF ____

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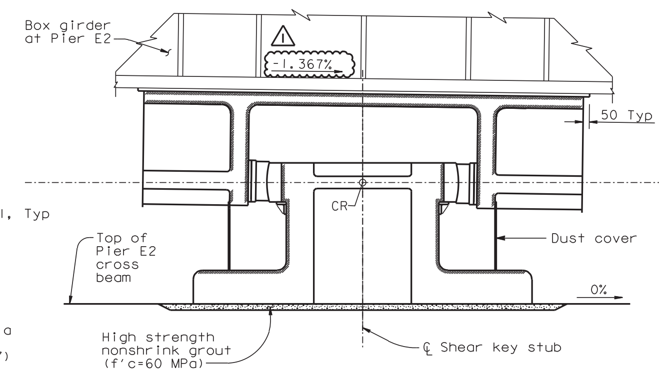

SECTION B-B

1:20

(Bolts not shown for clarity)

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NOTES:

1. The shear key stub shall be Structural Casting Grade 345.
2. The lubricant shall be self-lubricated.
3. The grout pad thickness is shown for information only. The Contractor shall verify in the field the grout pad thickness required to align the center of rotation of the shear key and bearings at 0.750 m from the bottom surface of the box girder.
4. The anchor bolts shall be pretensioned by jacking to 70% ultimate tensile strength.
5. The oversize anchor bolt holes are provided to accommodate construction tolerances.
6. For additional prestressing details, see "Prestressing Notes" sheet.
7. The prestressed anchor bolts shall be wrapped in a PT supplier recommended debonding tape, subject to the review and approval of the Engineer.
8. The spherical nut and washer shall be able to accomodate a maximum rotation of 3 degrees in any direction.
9. Grout-tight neoprene seal shown is schematic and is for information only. The seal shall prevent any high strength nonshrink grout from seeping inside the anchor bolt tapered holes during grouting of the shear key stub. This is necessary for proper stressing of the anchor bolts. The Contractor may propose an alternate detail to suit their erection means and methods, subject to review and approval of the Engineer.
10. Bolted connection between shear key housing and box girder is slip-critical connection with class B contact surface.
11. The Contractor may provide optional leveling plates to achieve fit-up and level contact surfaces for the bearings and shear keys. The Contractor shall erect the E2 cap beam and E2 girders to the elevations and tolerances specified in the plans and special provisions.
12. Leveling plate shall be attached with plug welds at 0.5 m Max spacing, and a perimeter fillet weld.
13. All faying surfaces of the girder key plate, the shear key housing, and the optional leveling plate shall be machined after all welding for flatness and smoothness as specified for the top of the shear key housing. See "Pier E2 Shear Key Detail No. 2" sheet.
14. Extension length for anchor bolts at "E" Line and "W" Line shear keys shall be long enough to engage hydraulic jack.
15. At the Contractor's option, the tapered anchor hole may increase to 200 in lieu of the 100 shown on the plans.
16. The top shear key stub shaft section shall be "snug-fit" inside the spherical ring with a diameter gap between ring and stub of 1 mm Max.
17. At the Contractor's option, 10 mm radius may be used to facilitate stressing of anchor bolts.

DIST.	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SF	80	13.2/13.9	887R2	1204

REGISTERED ENGINEER - CIVIL
12-6-04
PLANS APPROVAL DATE

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MARK	DATE	DESCRIPTIONS	BY	CH'D	CCO#
2	07/17/09	E2 CROSS BEAM	MN	NV	71
1	09/26/08	E2 CROSS BEAM	MN	NV	71

REVISIONS

R. Valizadeh/V. Toan/Y.L./W.L./F.C.
DESIGN OVERSIGHT
SIGN OFF DATE 07/17/09

	BY	CHECKED
DESIGN	M. Nader	J. Denis
DETAILS	N. Vo	J. Denis
QUANTITIES	N. Vo	J. Denis

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

R. Manzanarez
PROJECT ENGINEER

BRIDGE NO. 34-0006L/R
KILOMETER POST 13.2/13.9

SAN FRANCISCO OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT
SELF-ANCHORED SUSPENSION BRIDGE
(SUPERSTRUCTURE & TOWER)

PIER E2 SHEAR KEY DETAILS NO. 1

Rev. Date: 5-18-98

ORIGINAL SCALE IN MILLIMETERS FOR REDUCED PLANS 0 10 20 30 40 50 60 70 80 90 100

CU 04
EA 0120F1

DISREGARD PRINTS BEARING EARLIER REVISION DATES
REVISION DATES (PRELIMINARY STAGE ONLY) 04/08/02 07/01/02 12/19/02 05/16/03 12/07/05

SHEET 470R2 OF

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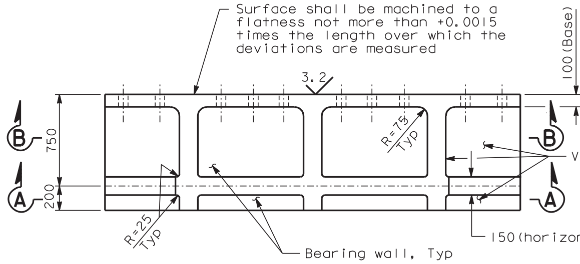
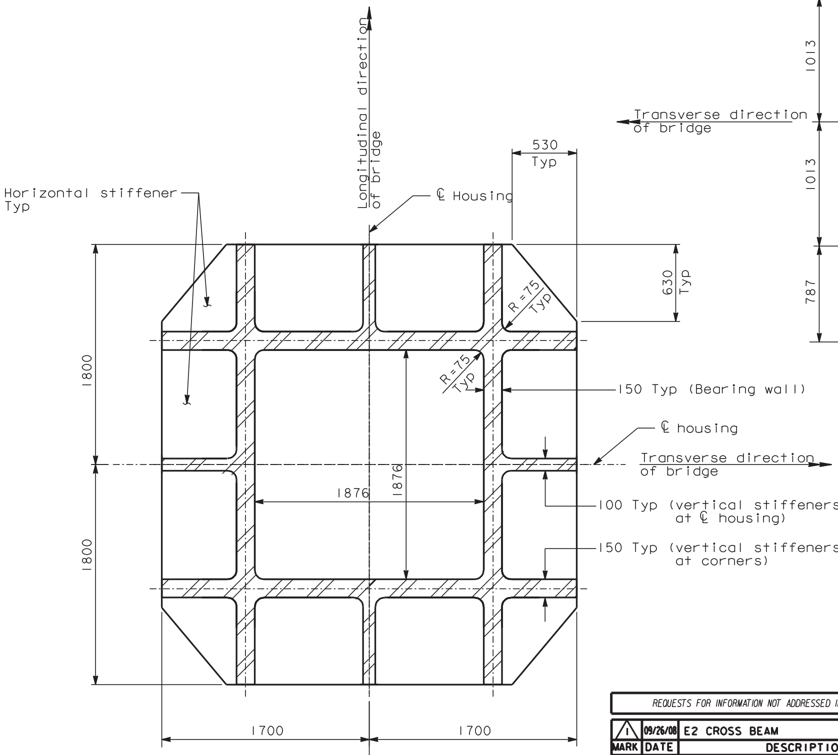
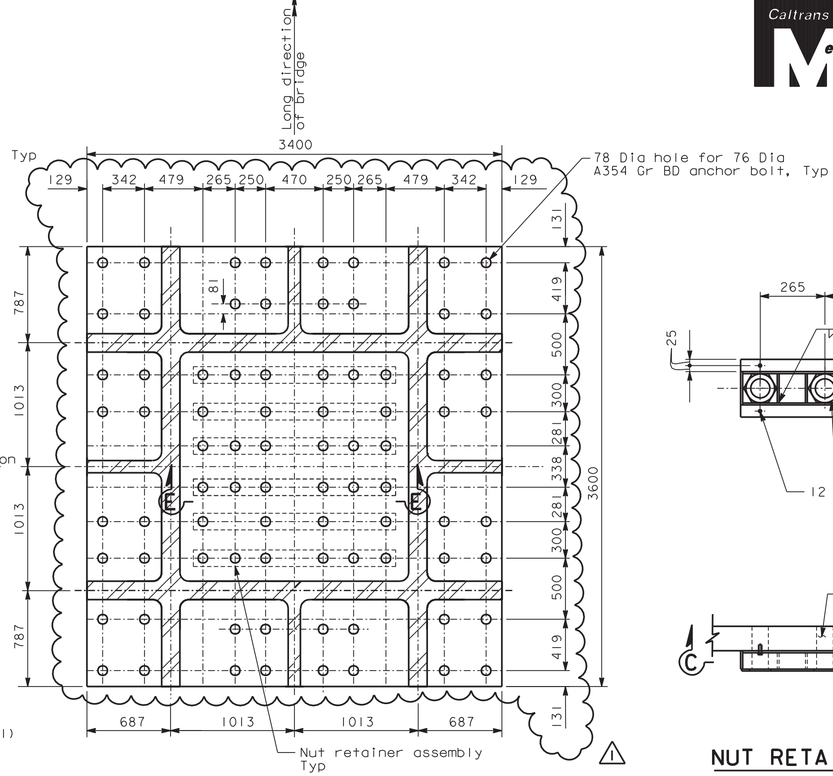


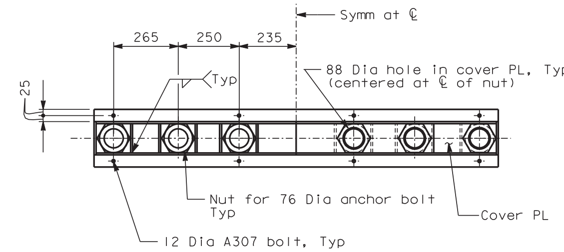
ELEVATION - SHEAR KEY HOUSING
1:20



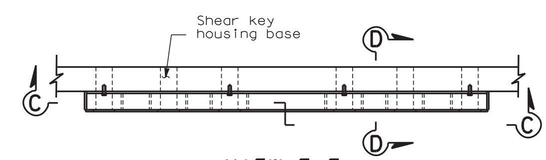
SECTION A-A
1:20



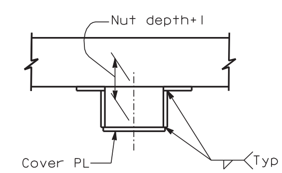
SECTION B-B (For details not shown see Section A-A)
1:20



SECTION C-C
1:10



VIEW E-E
NUT RETAINER ASSEMBLY-ELEVATION
1:10
(All plates 8 mm thick)



SECTION D-D
1:5

NOTES:

1. The shear key housing shall be Structural Casting Grade 345.
2. The shear key housing bolt layout shall accommodate the girder and crossbeam plate stiffener location. For girder details at Pier E2, see "Girder At Pier E2 details" sheet. For crossbeam details at pier E2, see "Crossbeam at Pier E2" sheets.
3. Bolt hole location shall be cross checked with the box girder and crossbeam stiffener layout before drilling holes. Bolt edge distance and clearance for tightening shall be verified and submitted for review and approval by the Engineer. A template shall be used to drill bolt holes in shear key housing and girder key plate to ensure hole matching.
4. The anchor bolts shall be pretensioned to 70% of ultimate tensile strength.
5. Nut retainer assemblies including nuts shall be installed to shear key housing prior to assembling housing to bushing and stub.
6. Machined washers at bolt heads shall be used if necessary at stiffener fillets.

REQUESTS FOR INFORMATION NOT ADDRESSED IN THIS CCO REMAIN IN FORCE

MARK	DATE	DESCRIPTIONS	BY	CH'D	CCO#
1	09/26/08	E2 CROSS BEAM	MN	NV	71

REVISIONS

CONTRACT CHANGE ORDER NO. ____
SHEET ____ OF ____

ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SHOWN

DIST.	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SF	80	13.2/13.9	888R1	1204

REGISTERED ENGINEER - CIVIL
12-6-04
PLANS APPROVAL DATE
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REGISTERED PROFESSIONAL ENGINEER
Marwan N. Nader
No. C 054426
Exp. 12/31/09
CIVIL
STATE OF CALIFORNIA

T.Y. LIN / MOFFATT & NICHOL
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R. Valizadeh/V. Toan/Y.L./W.L./F.C.
DESIGN OVERSIGHT
SIGN OFF DATE 09/26/08

DESIGN	BY M. Nader	CHECKED J. Denis
DETAILS	BY N. Vo	CHECKED J. Denis
QUANTITIES	BY N. Vo	CHECKED J. Denis

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

R. Manzanarez
PROJECT ENGINEER

BRIDGE NO. 34-0006L/R
KILOMETER POST 13.2/13.9

SAN FRANCISCO OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT
SELF-ANCHORED SUSPENSION BRIDGE
(SUPERSTRUCTURE & TOWER)

PIER E2 SHEAR KEY DETAILS NO. 2

Rev. Date: 5-18-98
ORIGINAL SCALE IN MILLIMETERS FOR REDUCED PLANS 0 10 20 30 40 50 60 70 80 90 100
CU 04
EA 0120F1
DISREGARD PRINTS BEARING EARLIER REVISION DATES
REVISION DATES (PRELIMINARY STAGE ONLY) 04/08/02 07/01/02 12/13/02 05/14/03 12/07/05
SHEET 471R1 OF

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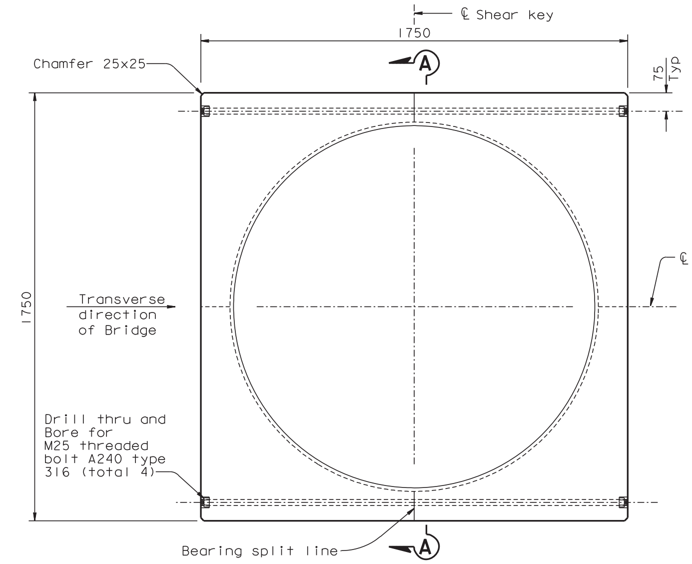
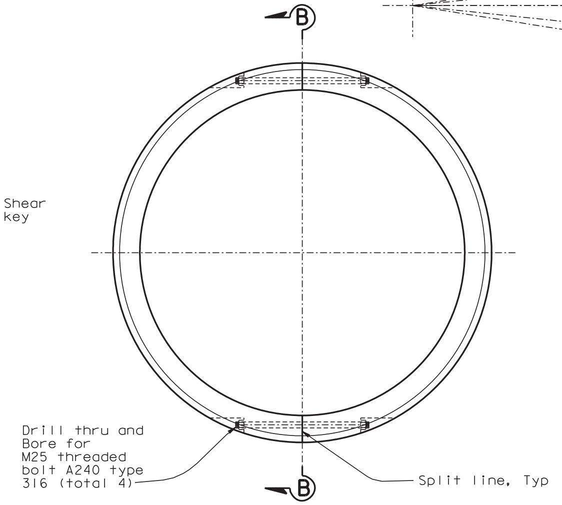
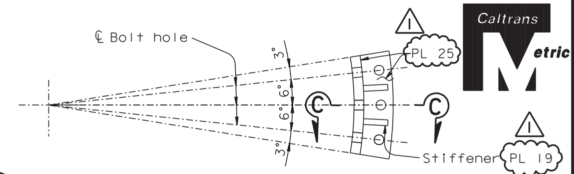


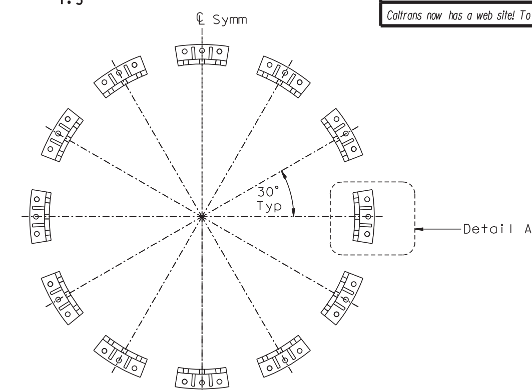
PLAN - SPHERICAL HOUSING
1:10



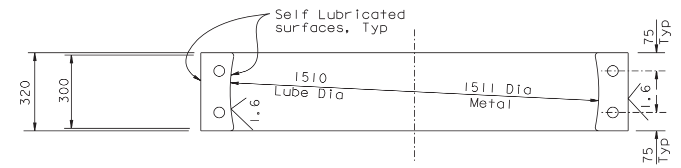
PLAN - SPHERICAL RING
1:10



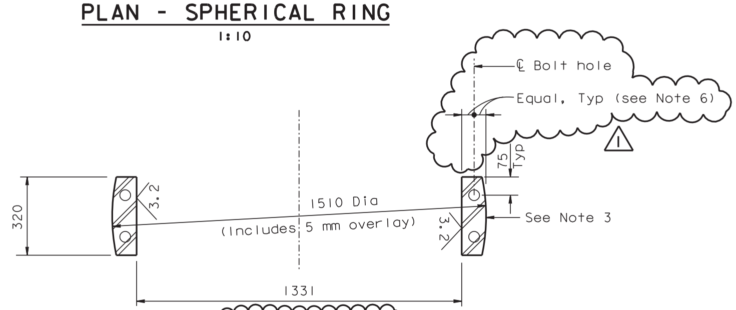
DETAIL A
1:5



PLAN - RETAINER BRACKET (Looking up)
1:10



SECTION A-A
1:10



SECTION B-B
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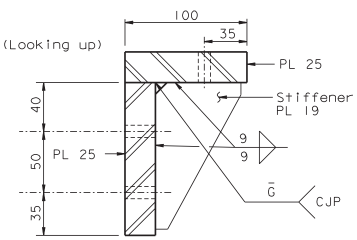

SECTION C-C
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MARK	DATE	DESCRIPTIONS	BY	CH'D	CCO#
1	09/26/08	E2 CROSS BEAM	MN	NV	71

REVISIONS

CONTRACT CHANGE ORDER NO. ____
SHEET ___ OF ___

NOTES:

1. The spherical ring shall be Structural Casting Grade 345.
2. The spherical housing shall be high strength manganese bronze centrifugally cast to the requirements of B271-C86300. All assembly bolts shall be stainless steel A240 Type 316.
3. The mating surfaces of the spherical ring shall be 5 mm thick stainless steel weld overlay conforming to the requirements of A240, Type 316.
4. The lubricant shall be self-lubricated.
5. The spherical ring shall be "snug fit" over the shaft section of the shear key stub with a diameter gap of 1 mm Max.
6. At the Contractor's option, bolt hole location may be adjusted to accomodate seating of bolt nut and washer, subject to review and approval of the Engineer.

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DIST.	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SF	80	13.2/13.9	888ARI	1204

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12-7-05
PLANS APPROVAL DATE

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T.Y. LIN / MOFFATT & NICHOL
825 BATTERY STREET
SAN FRANCISCO, CA 94111

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Caltrans Metric

R. Valizadeh/V. Toan/Y.L./W.L./F.C.
DESIGN OVERSIGHT
SIGN OFF DATE 09/26/08

DESIGN	BY M. Nader	CHECKED J. Denis
DETAILS	BY N. Vo	CHECKED J. Denis
QUANTITIES	BY N. Vo	CHECKED J. Denis

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

R. Manzanarez
PROJECT ENGINEER

BRIDGE NO. 34-0006L/R
KILOMETER POST 13.2/13.9

SAN FRANCISCO OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT
SELF-ANCHORED SUSPENSION BRIDGE (SUPERSTRUCTURE & TOWER)

PIER E2 SHEAR KEY DETAILS NO. 3

Rev. Date: 5-18-98
ORIGINAL SCALE IN MILLIMETERS FOR REDUCED PLANS 0 10 20 30 40 50 60 70 80 90 100
CU 04
EA 0120F1
DISREGARD PRINTS BEARING EARLIER REVISION DATES 12/07/05
REVISION DATES (PRELIMINARY STAGE ONLY)
SHEET 471ARI OF

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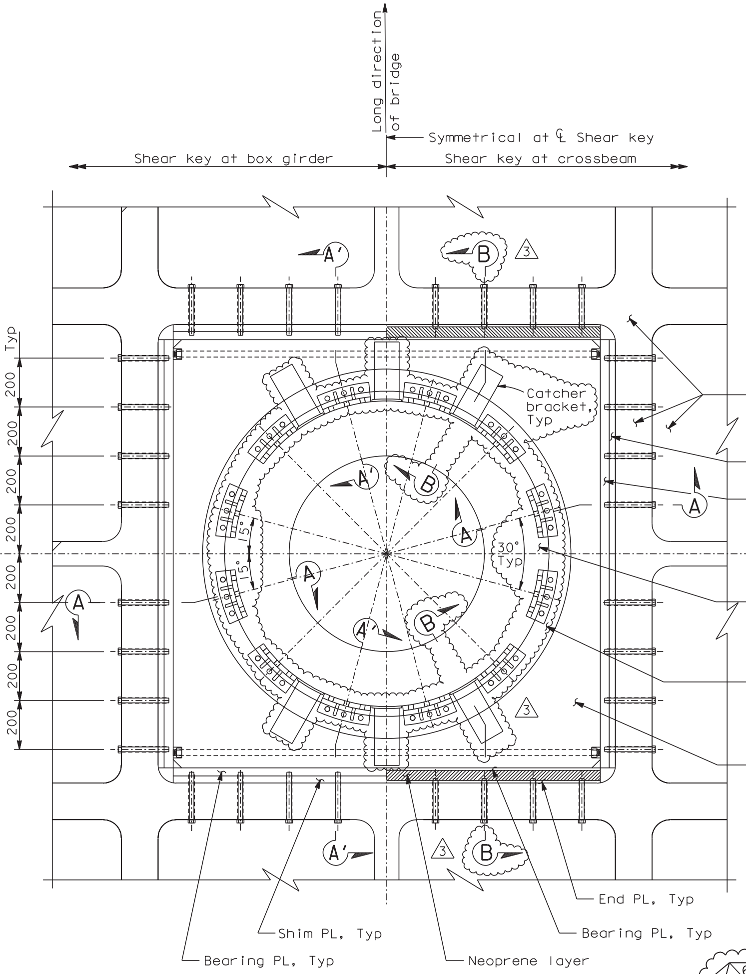

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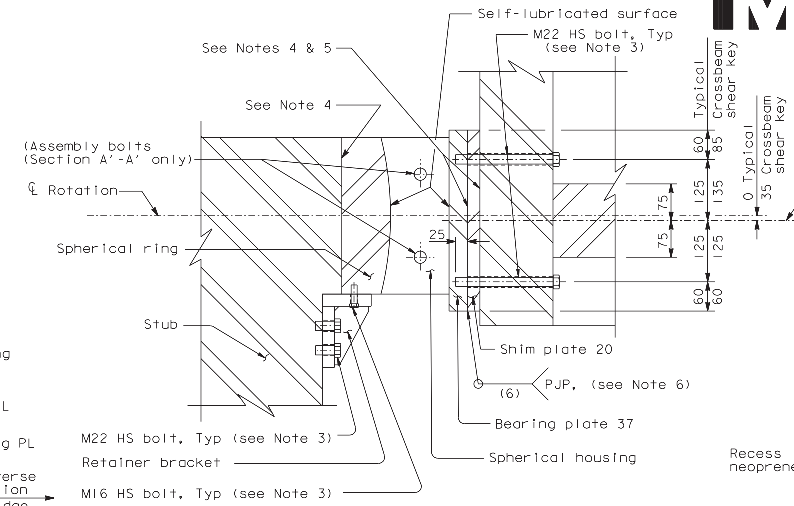

SECTION A-A (Section A'-A' similar)

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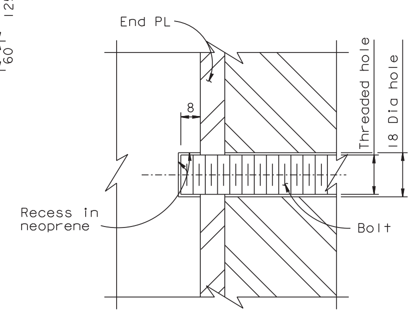
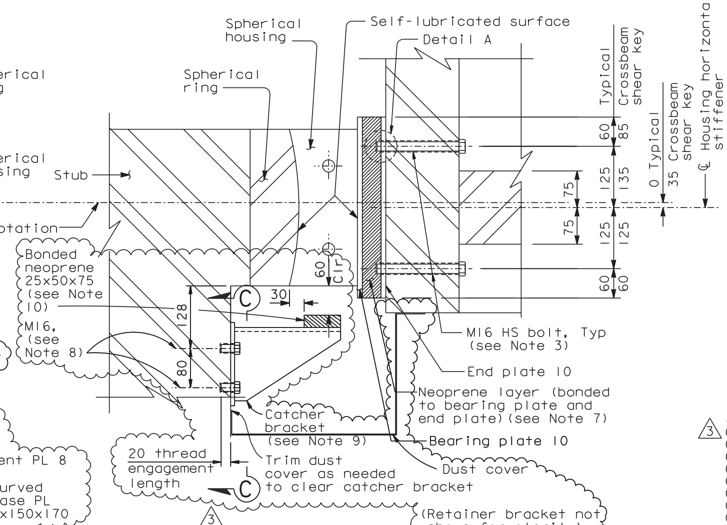


DETAIL A

1:1



SECTION B-B

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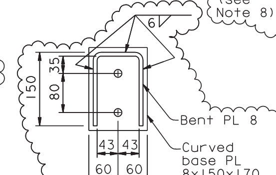

SECTION C-C

1:5

NOTES:

1. The mating surfaces of the spherical ring and bearing plate shall be 5 mm thick stainless steel weld overlay conforming to the requirements of A240, Type 316.
2. The lubricant shall be self-lubricated.
3. High strength bolts shall be installed snug-tight only.
4. Contact steel surfaces shall comply with Class A surface (slip coefficient 0.33).
5. The Contractor shall ensure the flatness requirements are met at the faying surfaces.
6. Welding shall be made after field measurement and actual shim plate thickness has been determined.
7. Field measurement shall be made to determine actual thickness of neoprene layer.
8. Bolts shall be installed snug-tight plus 1/4 turn.
9. Catcher brackets shall be installed for shear keys at crossbeam only.
10. Neoprene pad shall satisfy the requirements of Caltrans Standard Specifications Section 51-1.14.

ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SHOWN

CONTRACT CHANGE ORDER NO. ____
SHEET ____ OF ____

REQUESTS FOR INFORMATION NOT ADDRESSED IN THIS CCO REMAIN IN FORCE

MARK	DATE	DESCRIPTIONS	BY	CH'D	CCO#
3	01/04/11	E2 SHEAR KEY CATCHER BRACKETS	MN	NV	71S1
2	02/13/09	E2 CROSS BEAM	MN	NV	71
1	09/26/08	E2 CROSS BEAM	MN	NV	71

REVISIONS

DIST.	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SF	80	13.2/13.9	888BR3	1204

REGISTERED ENGINEER - CIVIL

12-9-05

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REGISTERED PROFESSIONAL ENGINEER Marwan N. Nader No. C 054426 Exp. 12/31/11 CIVIL STATE OF CALIFORNIA

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Caltrans Metric

R. Valizadeh/V. Toan/Y.L./W.L./F.C.
DESIGN OVERSIGHT
SIGN OFF DATE 01/04/11

	BY	CHECKED
DESIGN	M. Nader	L. Rus
DETAILS	A. Sanjines	J. Leventini
QUANTITIES	A. Sanjines	J. Leventini

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

R. Manzanarez
PROJECT ENGINEER

BRIDGE NO. 34-0006L/R
KILOMETER POST 13.2/13.9

SAN FRANCISCO OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT
SELF-ANCHORED SUSPENSION BRIDGE
(SUPERSTRUCTURE & TOWER)

PIER E2 SHEAR KEY DETAILS NO. 4

Rev. Date: 5-18-98

ORIGINAL SCALE IN MILLIMETERS FOR REDUCED PLANS 0 10 20 30 40 50 60 70 80 90 100

CU 04
EA 0120F1

DISREGARD PRINTS BEARING EARLIER REVISION DATES 12/07/05

SHEET 471BR3

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Appendix B – Bearing Upper Housing FEM

ANALYSIS OF BEARING UPPER HOUSING FOR SEISMIC LOADS

Self-Anchored Suspension Bridge

San Francisco Oakland Bay Bridge East Span Seismic Safety Project

Caltrans Project No. 04-0120F4

T.Y. Lin International / Moffatt & Nichol Joint Venture

July 15, 2013

INTRODUCTION

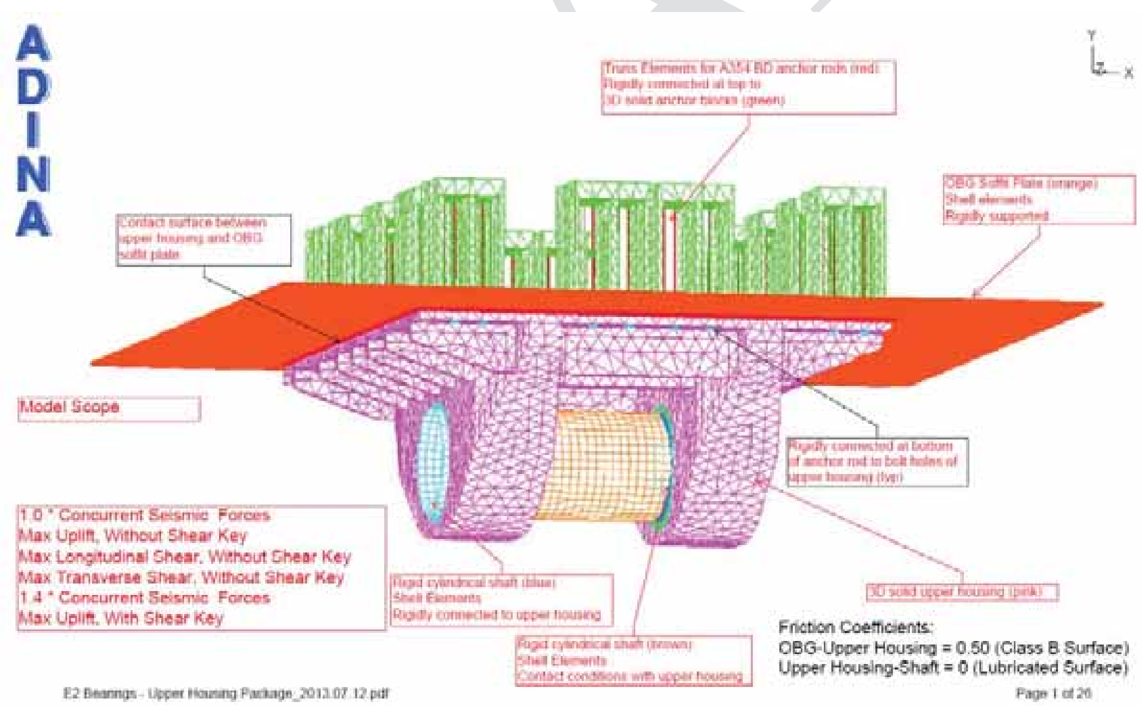
This study investigates the scenario of using only the permanent bearings to resist the seismic safety evaluation earthquake (SEE) load (without shear keys engaged – Load Path B and C).

MODEL

The behavior of the bearing upper housing was evaluated using a finite element model. This model was created using ADINA.

As shown in the figure below, the model includes the following structural components:

1. Bearing upper housing (Pink)
2. OBG base plate (Orange)
3. Bearing anchor bolts (Red vertical lines)
4. Anchor blocks for the bearing anchor bolts (Green)
5. Rigid Shell at the outer boundary of bearing shaft (Blue and Brown)

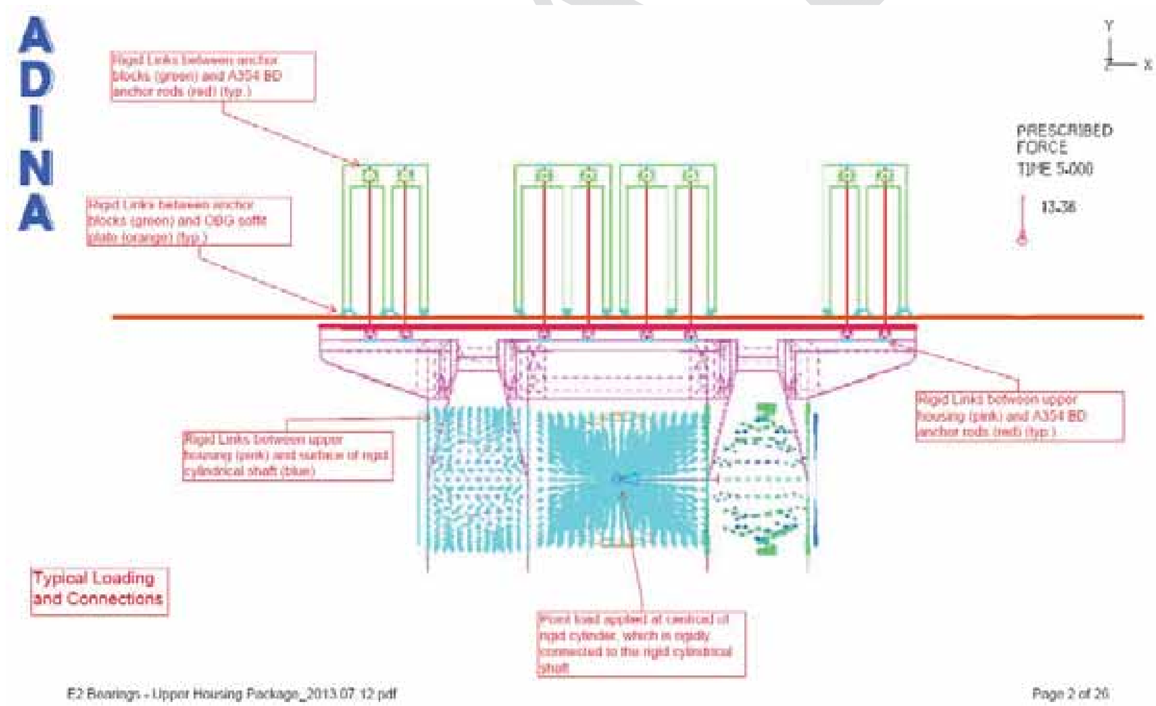


CONNECTIVITY AND BOUNDARY CONDITIONS

In order to apply the designated loading, the surface of the bearing shaft is modeled with shell elements. The loading To ensure stability of the analysis model, the shell is fully connected to one side (left in the above figure) of the bearing upper housing, through rigid links between the shell and inner face of the bearing housing arm. It is noteworthy that this rigid linked connection is expected to distort the results in the vicinity of the connection locations as an artifact of the modeling that should be discounted. Therefore, the results from the other arm (right) of the bearing housing should be used when applicable. Part of the shell body between the two arms of the bearing upper housing is rigidly connected to the loading point defined per plan, at the CG of the bearing shaft. A coupled contact surface is established between the shell body and the inner face of the other bearing housing arm. The contact surface assumes zero friction to simulate a lubricated interface.

The bearing upper housing is in contact with the bottom face of the OBG base plate. The contact friction coefficient is set to be 0.5, for the designated Class B finish. The upper housing is held to the OBG by A354BD anchor bolts of 3 inch diameter. The anchor bolts are constrained to the bolt holes on both the bearing upper housing and the anchor blocks. The anchor bolts are pretensioned to 0.7fpu under the dead load condition.

For simplicity, the OBG base plate is fully fixed, providing a rigid contact surface for the bearing upper housing. The anchor blocks are also rigidly supported, as they are welded to the OBG frame, which is not fully modeled in this analysis.



LOADS

Bearing forces were extracted from a seismic (time history) analysis of the self-anchored suspension bridge including the bearings and shear keys. The total longitudinal, transverse, and vertical loads transferred from the westbound and eastbound box girders to Pier E2 were extracted from the analysis and distributed to the bearings and shear keys in accordance with the plans. The bearing loads are shown in Table 1.

Normal functioning of the bearing corresponds to the case “Shear Key Engaged”. The bearing is only required to carry vertical loads. These are either downwards—case C—or upwards—case U. Upwards loads are of greatest concern and are addressed in this report. A “safety factor” of 1.4 is applied to the calculated loads from the seismic analysis.

The bearing is also intended to function as a secondary mechanism to resist longitudinal and transverse loads should the shear keys fail. The three cases of greatest interest are those corresponding to the peak uplift on the bearing (case U), the peak transverse load (case T), and the peak longitudinal load (case L). In each case the orthogonal loads occurring simultaneously with the peak loads are also tabulated (and analyzed). These loads are applied with a “safety factor” of 1.0, since they are based on the conservative assumption that the shear key has failed.

Bearing Forces (SF=1.4)

Case	Case	Trans.	Long.	Vert.
Shear Key Engaged (Load Path A)	C	0	310	81104
	U	**0**	**108**	**-13355**

Bearing Forces (SF=1.0)

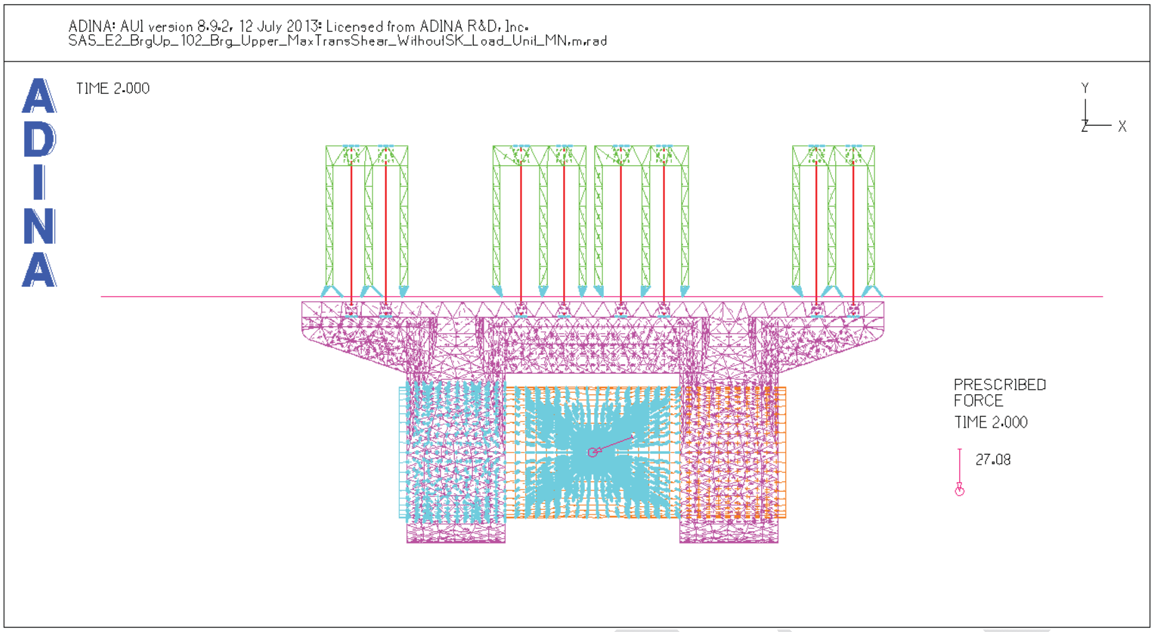
Case	Case	Trans.	Long.	Vert.
Shear Key Failed (Load Path B & C – See Note)	C	10799	4770	57932
	U	**25287**	**1628**	**-9539**
	T	**30496**	**8186**	**16441**
	L	**1340**	**13232**	**19255**

Note: The same seismic demands are conservatively assumed for Load Path C.

Table 1, Bearing Loads

As mentioned previously, the loading on the model is assigned at the CG of the bearing shaft, which transfers the force from the bearing upper housing to the bearing lower housing.

The load is modeled as pressure loading applied at relevant surfaces, with some simplifications.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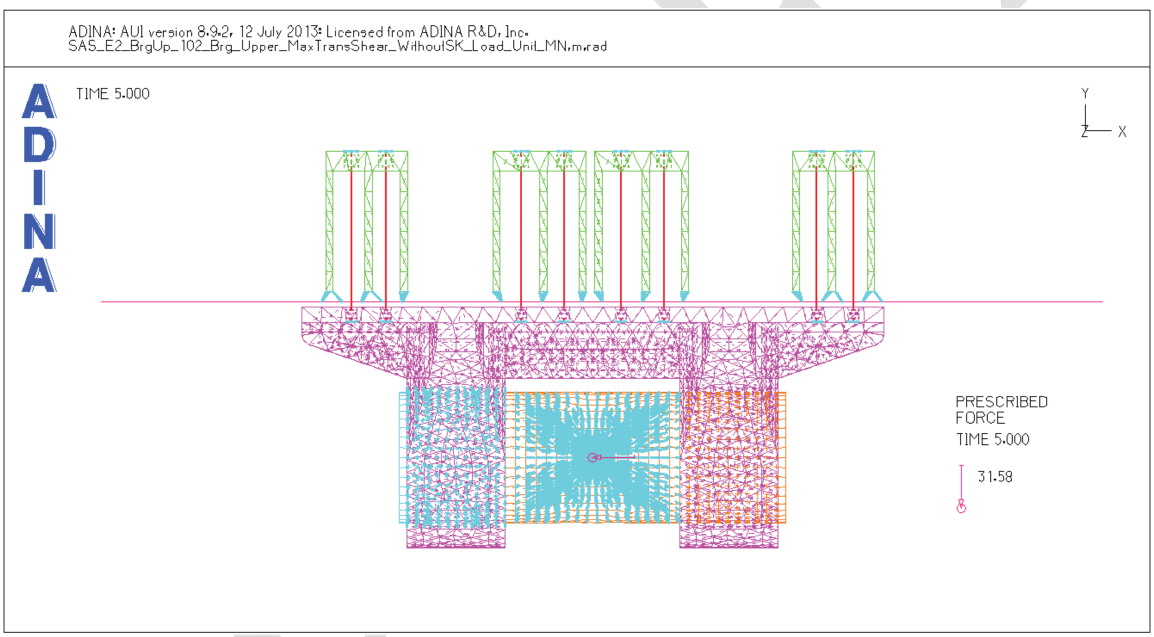
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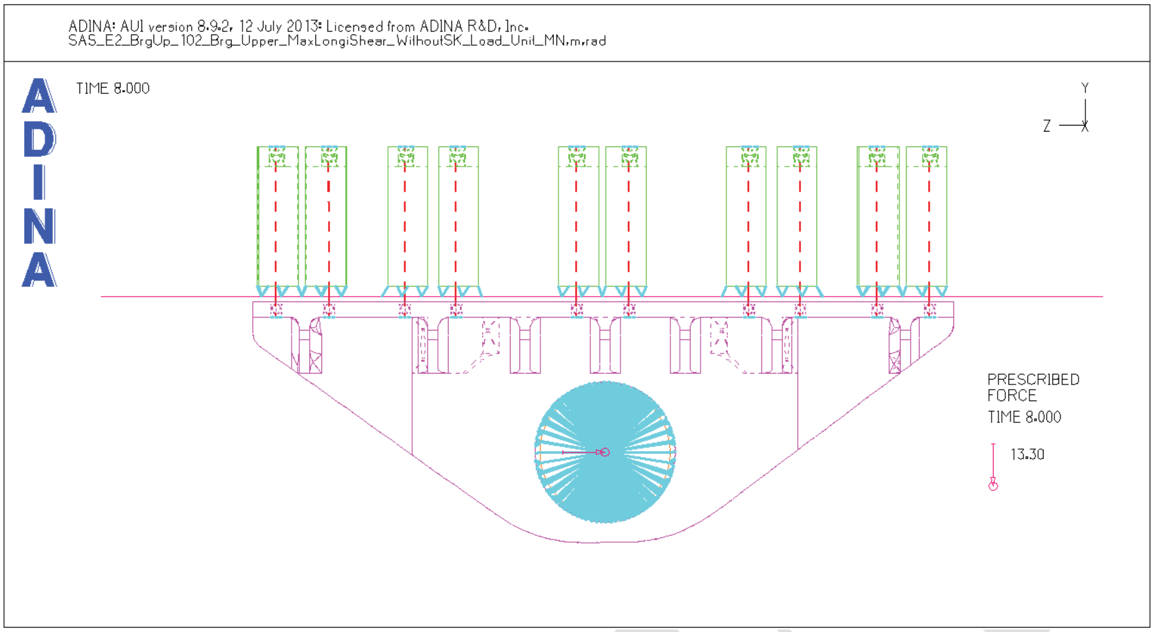
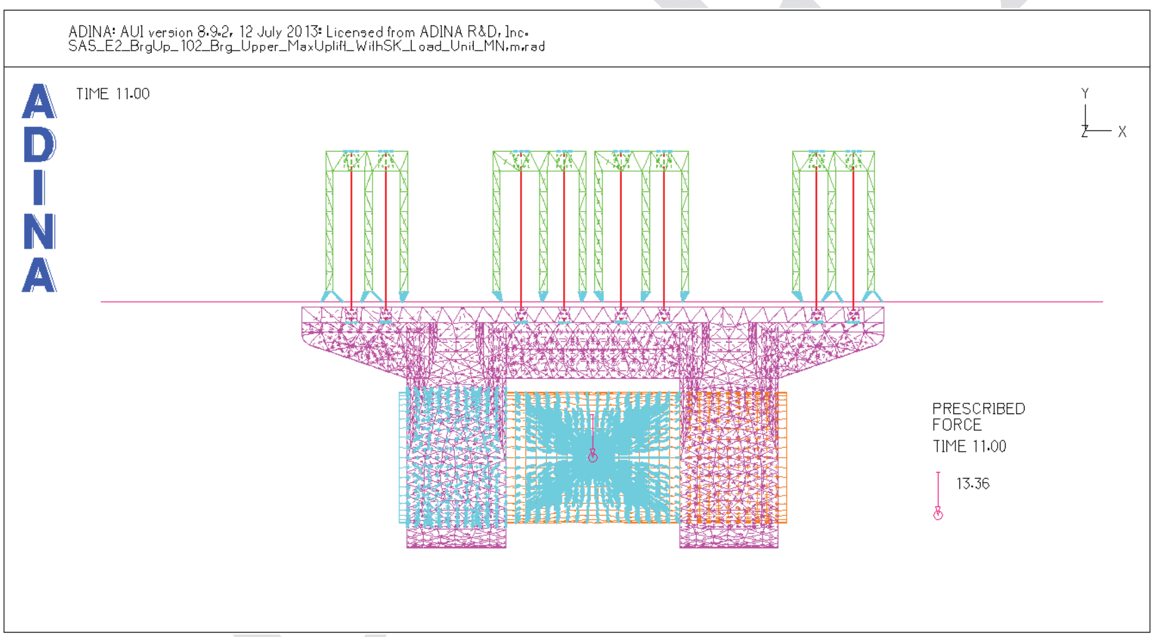




ASSUMPTIONS

Assumptions are made in this analysis model, due to various constraints. The assumptions might be implied in the model description above, but are summarized as follows:

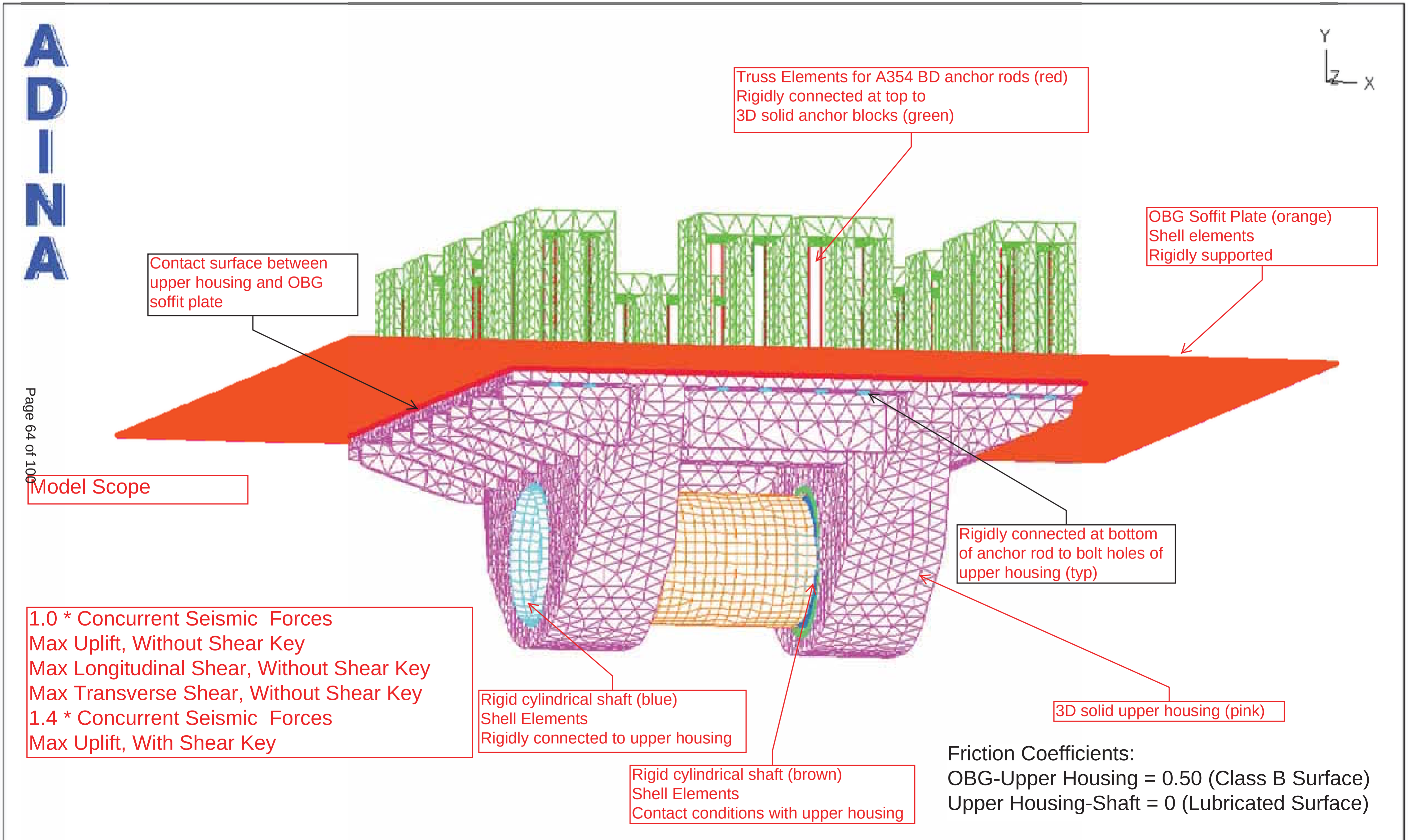
1. The load transfer mechanism within the bearing might be more complicated than the simplified single node loading. But the current loading scheme is considered to capture the behavior with sufficient accuracy.

2. The stiffness of the supporting OBG structure, and the bearing shaft and lower housing, will affect the stress distribution of the upper housing. But it is considered to have minor effect and therefore is not included in this analysis.

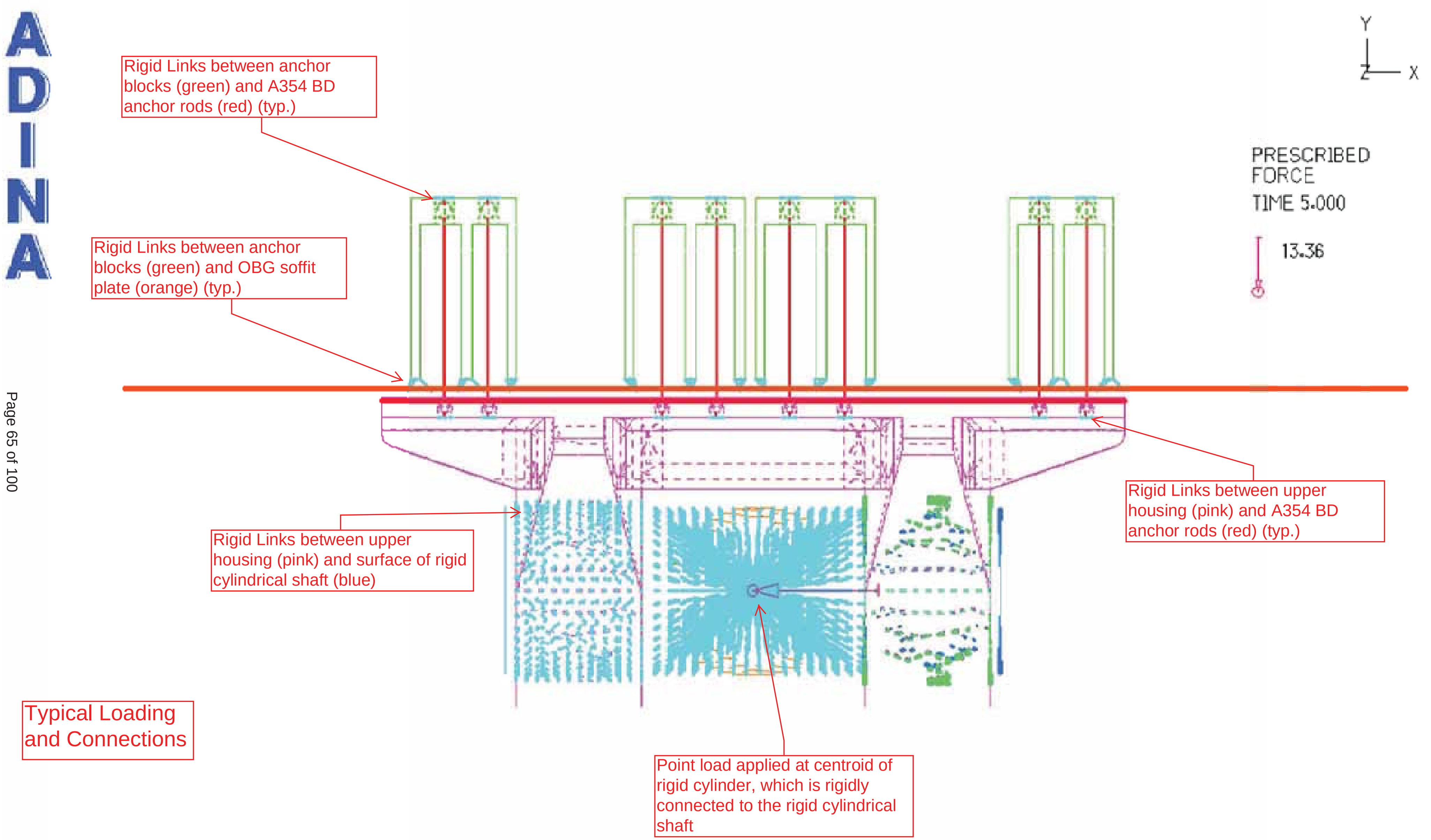
3. No shearing and bearing action is considered for the bolt model, only axial tension with the corresponding friction that holds the various components of the model together.

CONCLUSIONS

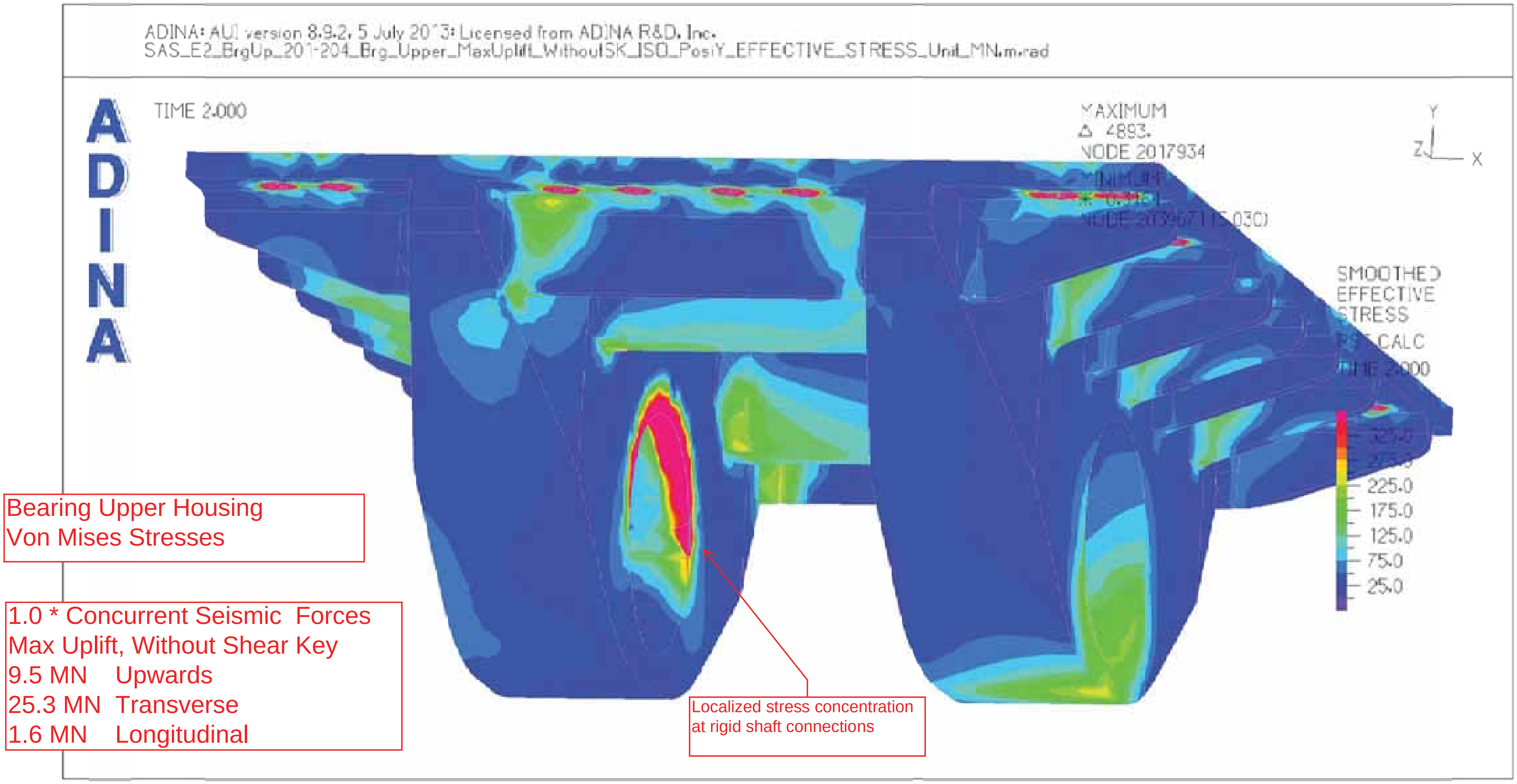
A series of finite element analyses were performed to determine the response of the bearing upper housing to seismic loads. Of particular interest are the stresses induced by peak uplift and peak transverse and longitudinal loads (with orthogonal loads occurring simultaneously). In all cases, the effective stresses in the housing are less than the yield strength of the material (not counting stresses concentrations related to simplified load application and boundary conditions – these superficial concentrated stresses are of no concern).



Brg_Upper_ModelOverview_Mesh



Brg_Upper_ModelOverview_Force



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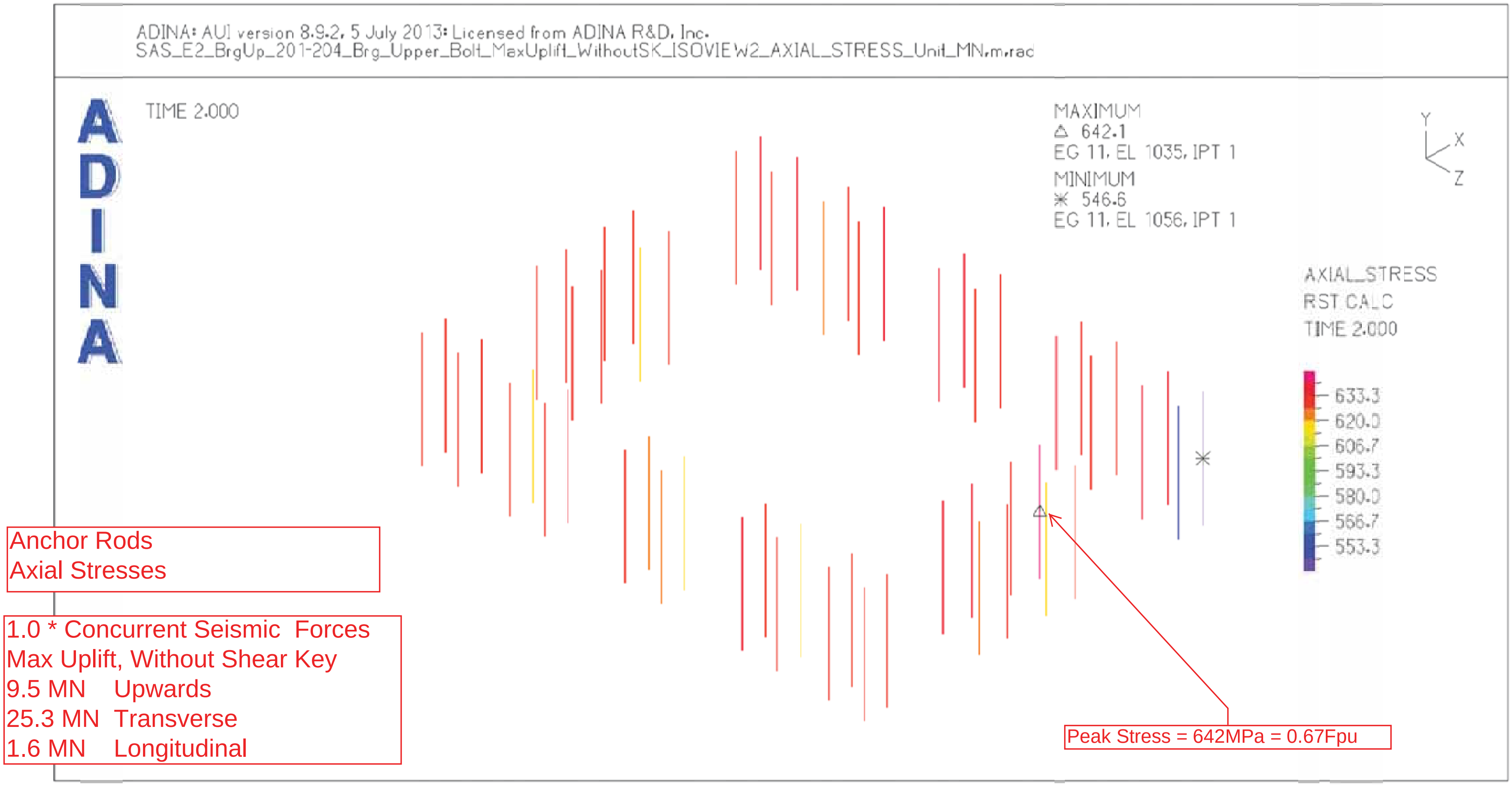

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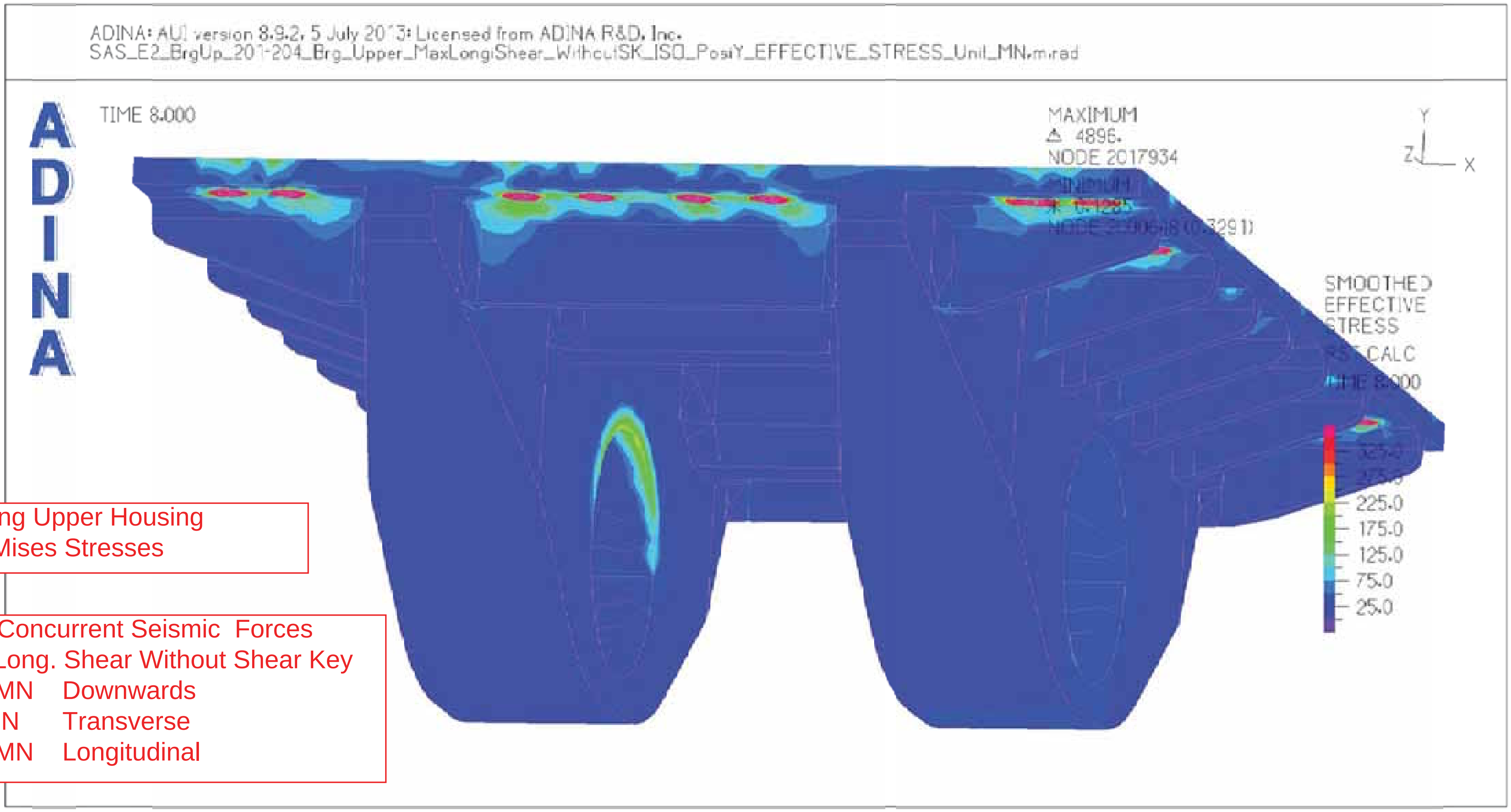
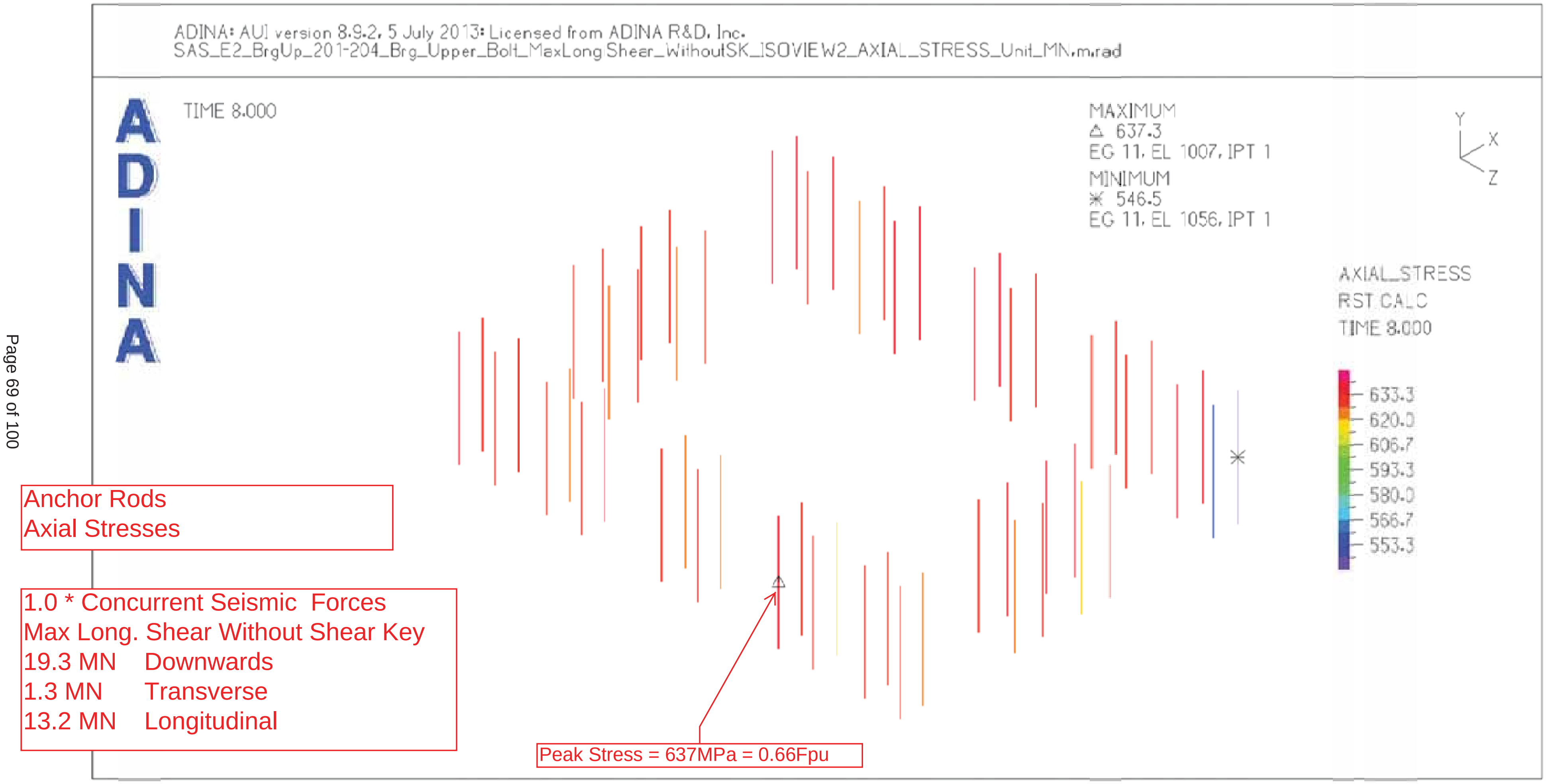


Bearing Upper Housing
Von Mises Stresses

1.0 * Concurrent Seismic Forces
Max Long. Shear Without Shear Key
19.3 MN Downwards
1.3 MN Transverse
13.2 MN Longitudinal

SAS_E2_BrgUp_201-204_Brg_Upper_MaxLongiShear_WithoutSK_ISO_PosiY_EFFECTIVE_STRESS



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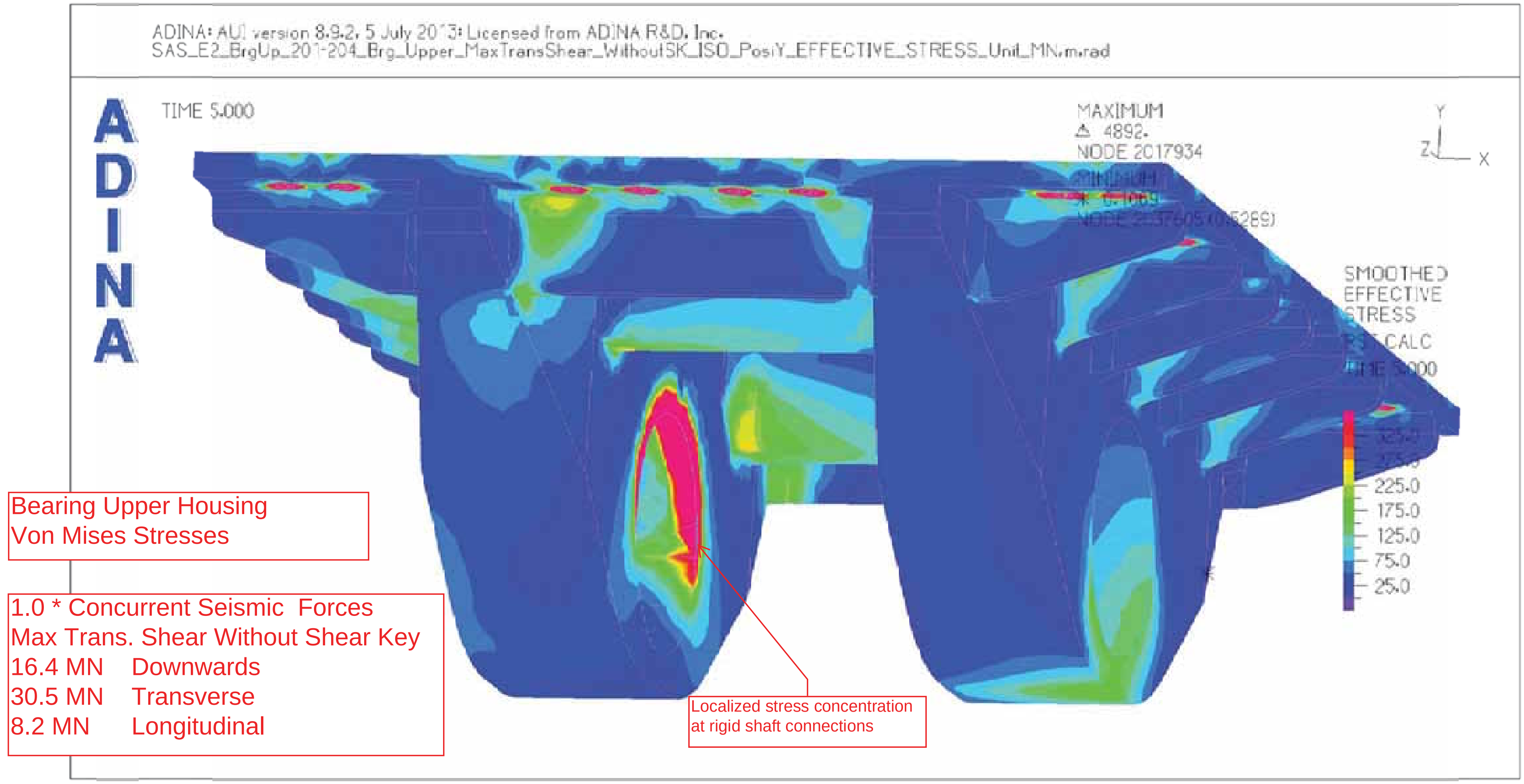

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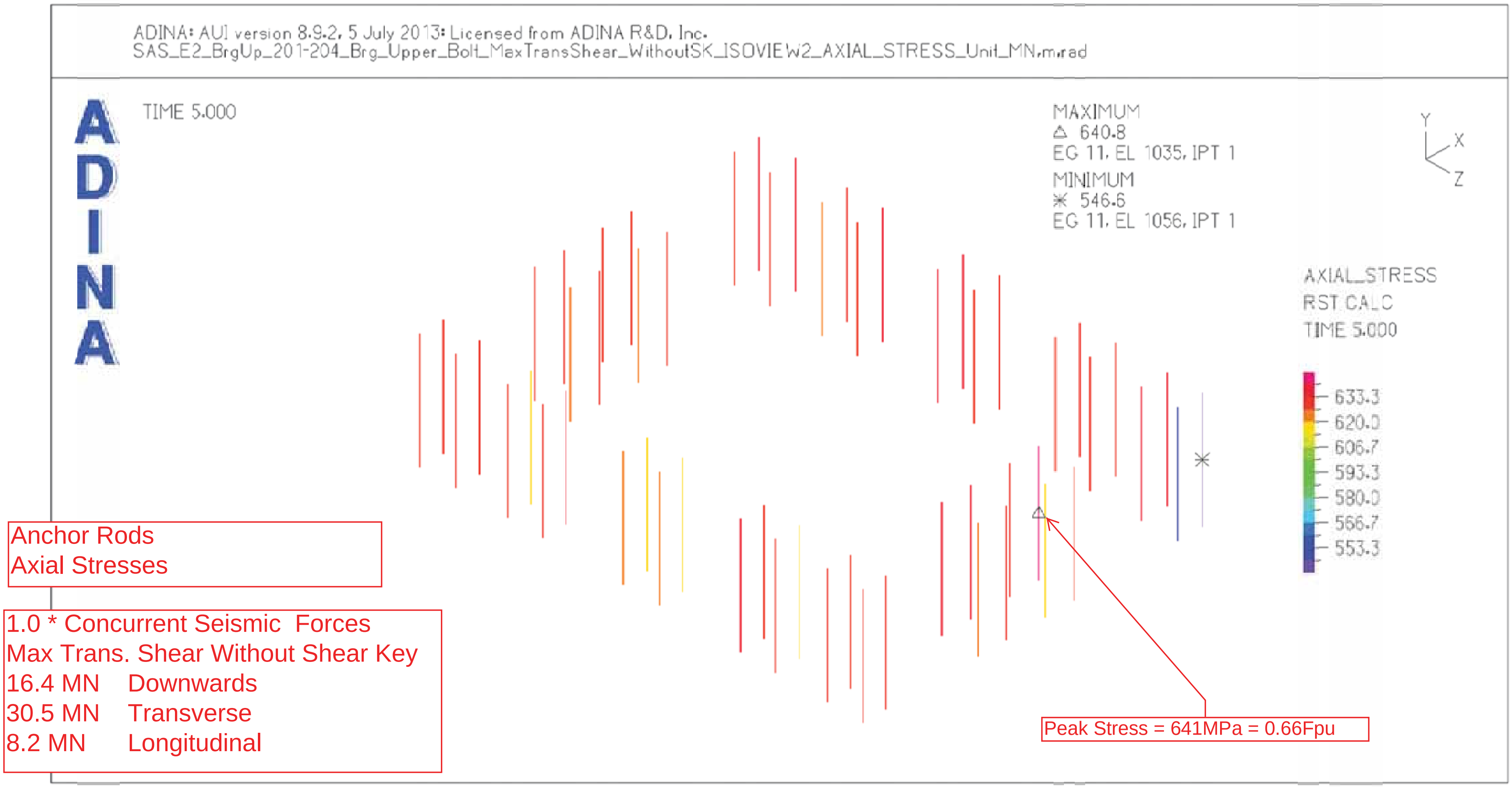

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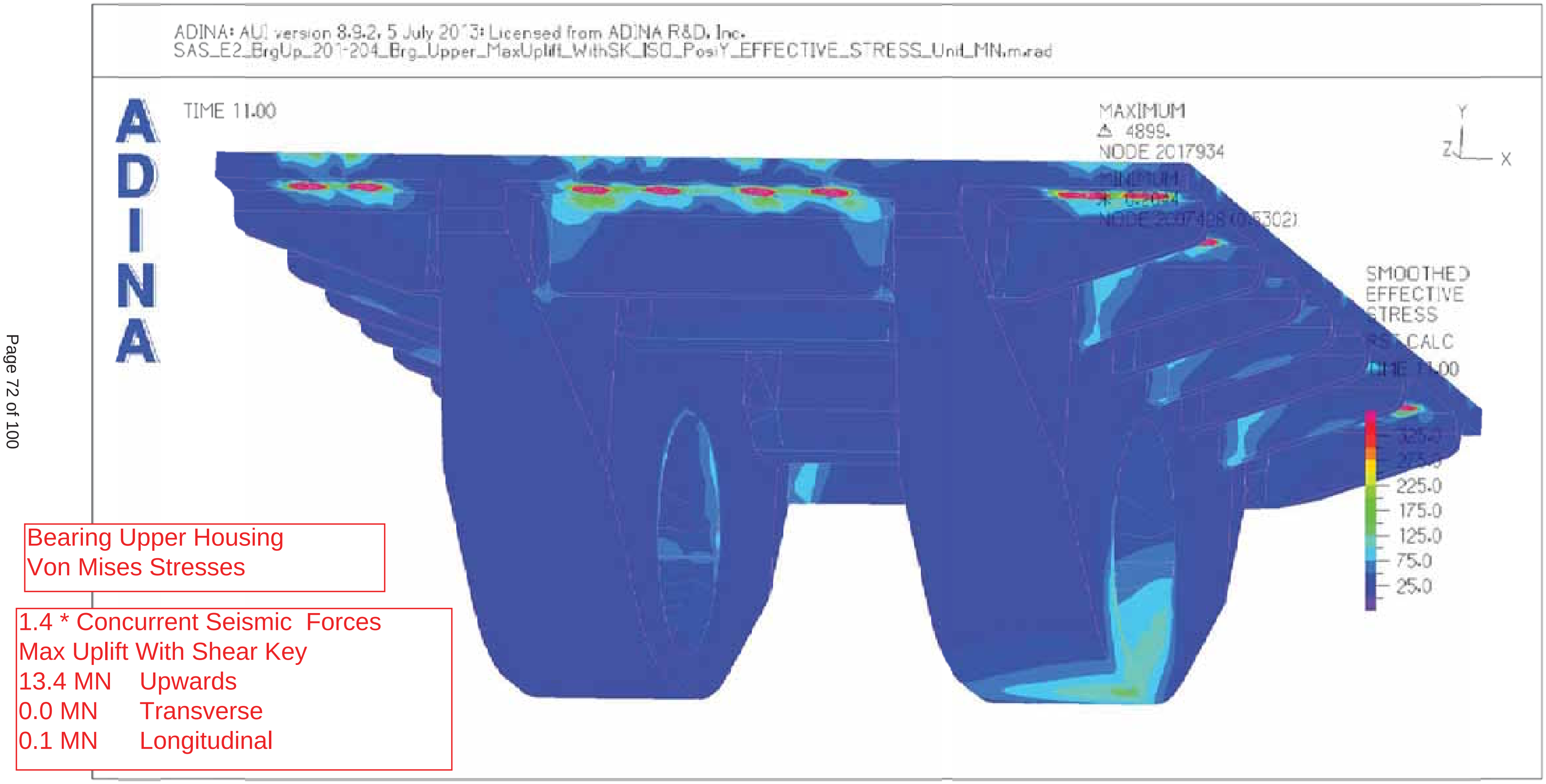

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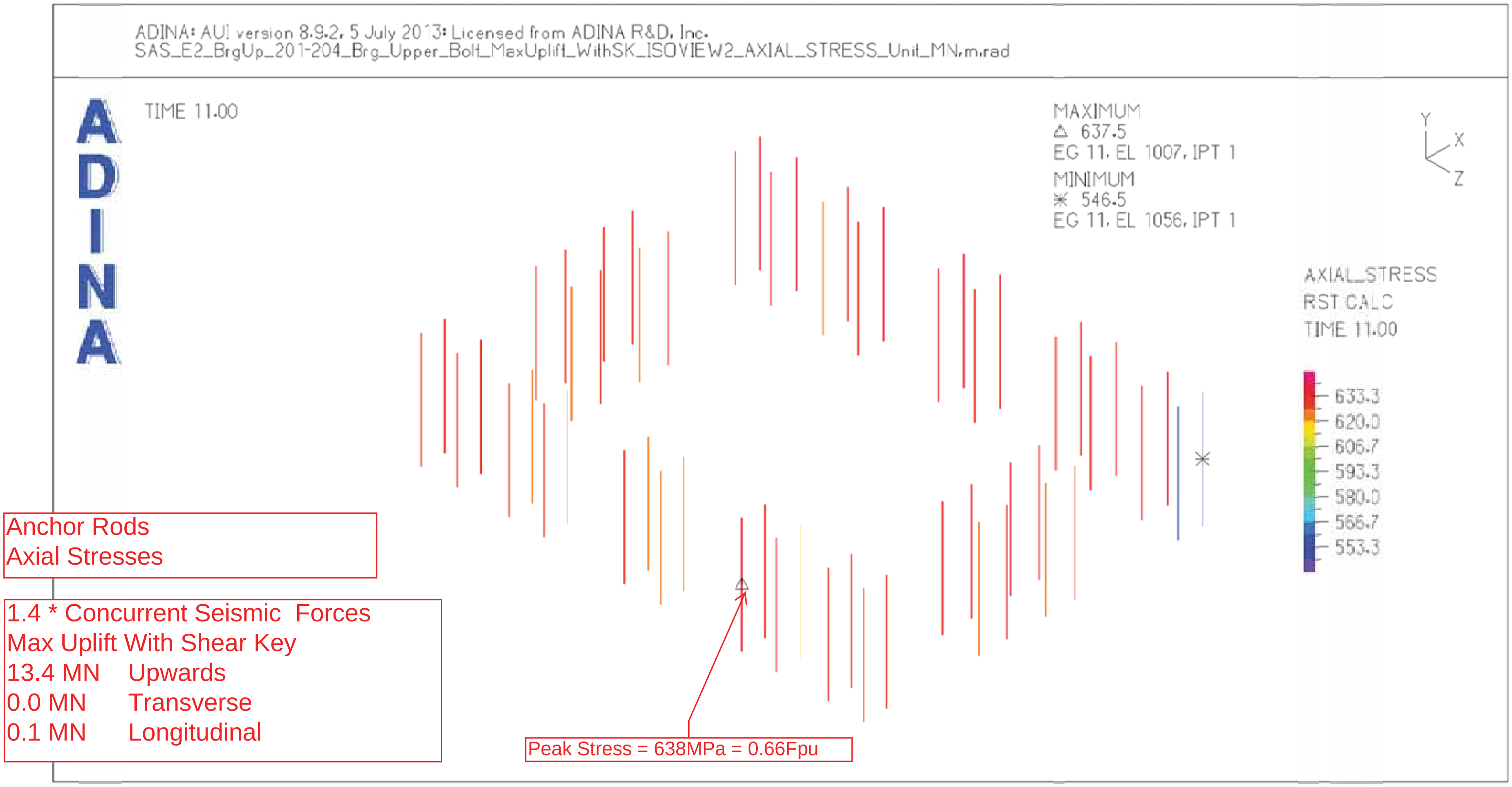

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Appendix C – Bearing Lower Housing FEM

ANALYSIS OF BEARING BOTTOM HOUSING FOR SEISMIC LOADS

Self-Anchored Suspension Bridge

San Francisco Oakland Bay Bridge East Span Seismic Safety Project

Caltrans Project No. 04-0120F4

T.Y. Lin International / Moffatt & Nichol Joint Venture

July 13, 2013

INTRODUCTION

The bearing bottom housing surrounds the spherical bushing assembly and transfers bearing loads to the bearing hold down assembly, see Figure 1.

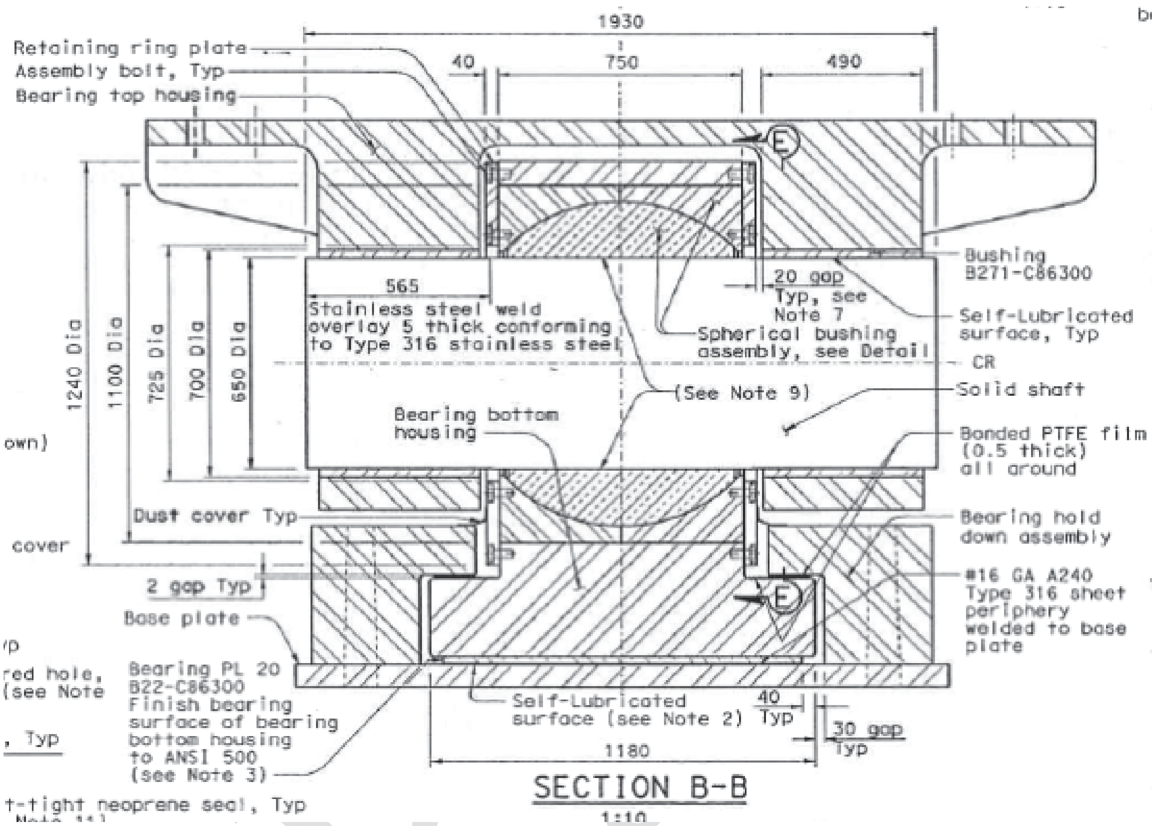


Figure 1, Bearing assembly showing the bearing bottom housing.

This report summarizes a series of analyses demonstrating the response of the bearing bottom housing to seismic loads.

LOADS

Bearing forces were extracted from a seismic (time history) analysis of the self-anchored suspension bridge including the bearings and shear keys. The total longitudinal, transverse, and vertical loads transferred from the westbound and eastbound box girders to Pier E2 were extracted from the analysis and distributed to the bearings and shear keys in accordance with the plans. The bearing loads are shown in Table 1.

Normal functioning of the bearing corresponds to the case “Shear Key Engaged”. The bearing is only required to carry vertical loads. These are either downwards—case C—or upwards—case U. Upwards loads are of greatest concern and are addressed in this report. A “safety factor” of 1.4 is applied to the calculated loads from the seismic analysis.

The bearing is also intended to function as a secondary mechanism to resist longitudinal and transverse loads should the shear keys fail. The three cases of greatest interest are those corresponding to the peak uplift on the bearing (case U), the peak transverse load (case T), and the peak longitudinal load (case L). In each case the orthogonal loads occurring simultaneously with the peak loads are also tabulated (and analyzed). These loads are applied with a "safety factor" of 1.0, since they are based on the conservative assumption that the shear key has failed.

Bearing Forces (SF=1.4)

Case	Case	Trans.	Long.	Vert.
Shear Key Engaged	C	0	310	81104
(Load Path A)	**U**	**0**	**108**	**-13355**

Bearing Forces (SF=1.0)

Case	Case	Trans.	Long.	Vert.
	C	10799	4770	57932
Shear Key Failed	**U**	**25287**	**1628**	**-9539**
(Load Path B – See Note)	**T**	**30496**	**8186**	**16441**
	L	**1340**	**13232**	**19255**

Note: The same seismic demands are conservatively assumed for Load Path C.

Table 1, Bearing Loads

MODEL

Finite Element Model

The behavior of the bearing bottom housing was evaluated using the finite element model shown in Figure 2. This model was created using ADINA.

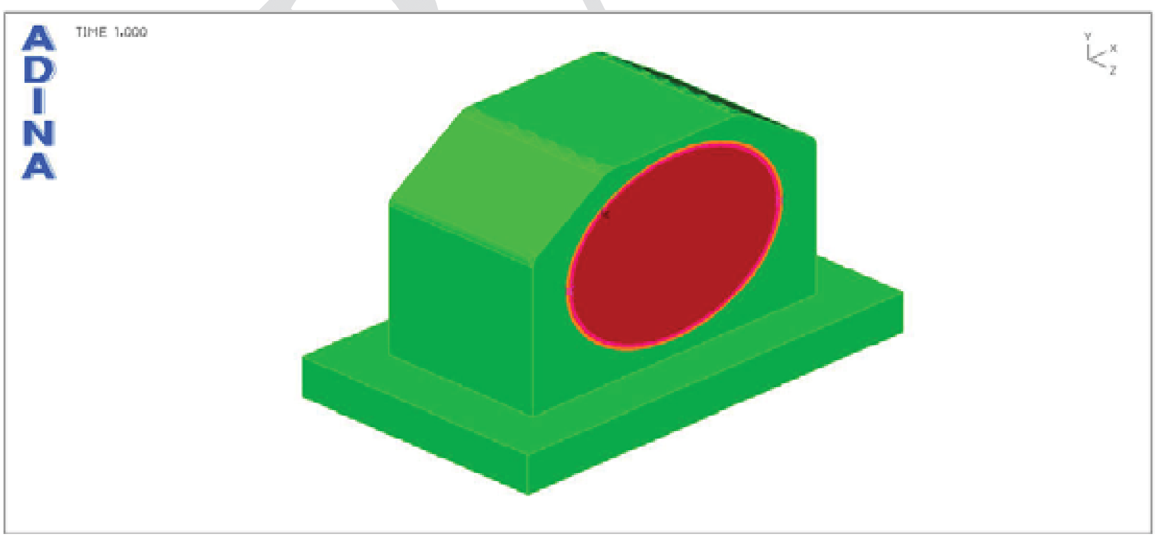


Figure 2, ADINA model of bottom bearing housing

The body of the bottom bearing housing is colored green in Figure 2. The spherical bushing assembly is colored red. The interface between the housing and the bushing was modeled with a contact surface able to transfer compression only.

Loads

For simplicity, longitudinal and vertical loads were distributed over the vertical faces of the spherical bushing assembly, as shown in Figure 3.

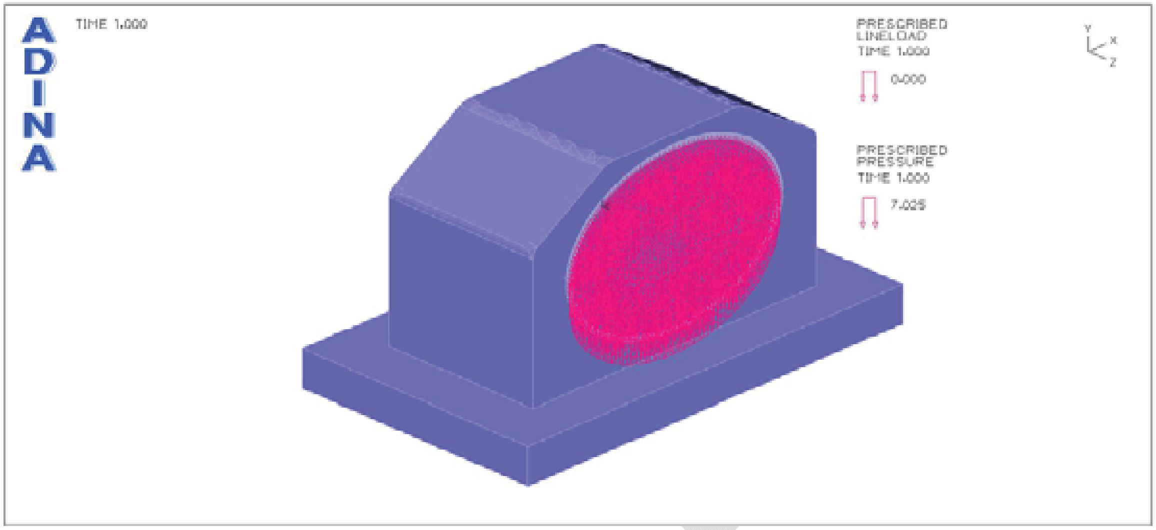


Figure 3, Application of vertical and longitudinal loads

Transverse loads are transferred to the bearing bottom housing through contact with the bearing upper housing on the side faces of both housings. This contact is complex. For simplicity, transverse loads were applied to the bearing bottom housing on the bottom half of the perimeter of the opening in the housing, as shown in Figure 4.

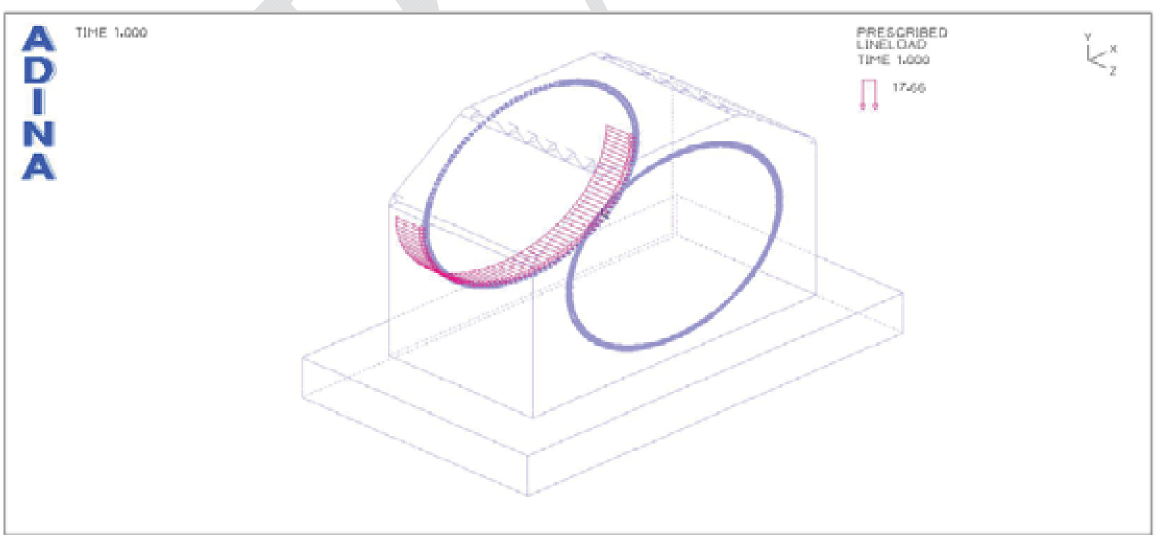


Figure 4, Application of transverse loads

Boundary Conditions

The bearing bottom housing is restrained through contact with the bearing hold down assembly. In lieu of modeling this contact, the restraint was modeled by fixed boundaries applied to the edges of the bearing bottom housing. The restrained edges were chosen to reflect the direction of the applied loads. The restrained boundaries used to resist uplift on the housing are shown in Figure 5.

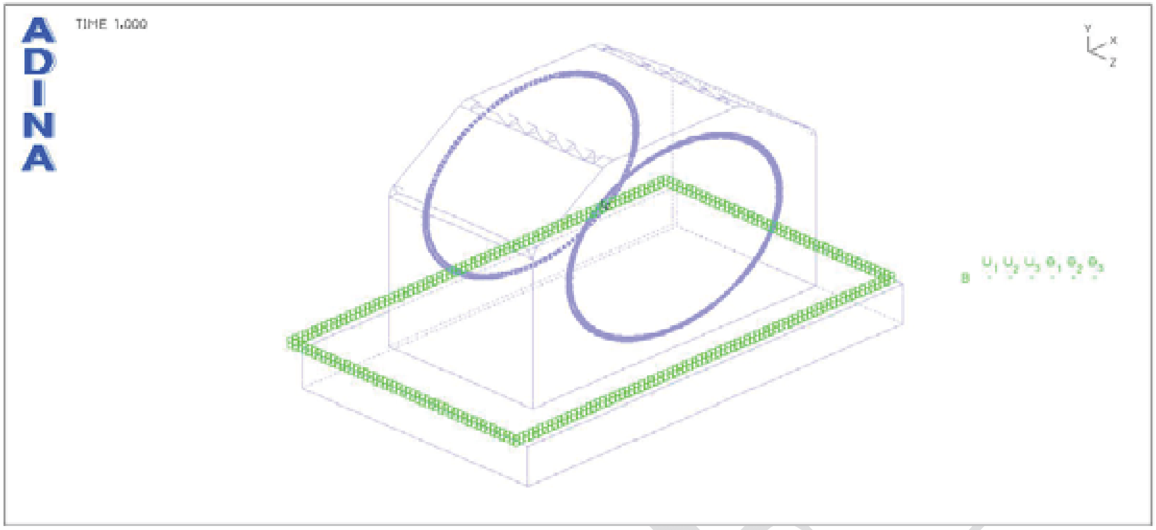


Figure 5, Boundary conditions used to analyze uplift

RESULTS

Maximum Uplift (Safety Factor = 1.4)

Assuming the shear key is functional, the loads on the bearing bottom housing are vertical. For the critical case of uplift on the bearing, the computed effective (von Mises) stresses in the housing are shown in Figure 6.

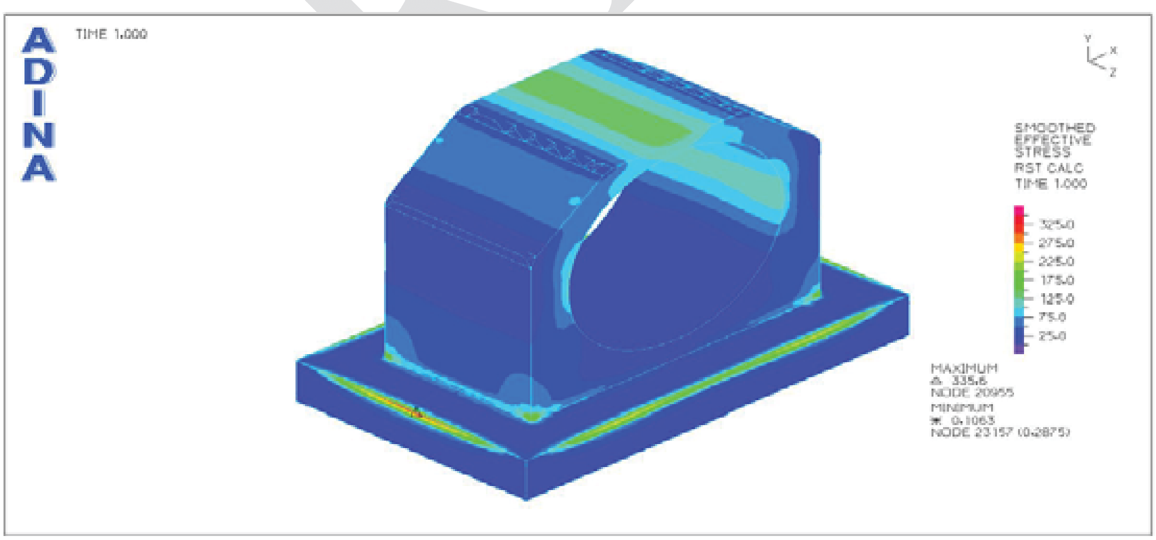


Figure 6, Effective stresses for maximum uplift (safety factor = 1.4)

The peak stresses in the body of the housing are about 175 MPa, which is well below the yield strength of the material of 550 MPa. Stresses on the restrained edges are also high. These overestimate the actual stresses because the contact of the housing with the hold down assembly will occur over some area rather than on an edge.

Maximum Uplift (Safety Factor = 1.0)

Assuming that the shear keys have failed, the bearings will resist longitudinal and transverse loads in addition to vertical loads. These loads are considered with a “safety factor” of 1.0. For the case of maximum uplift, the effective stresses are shown in Figure 7.

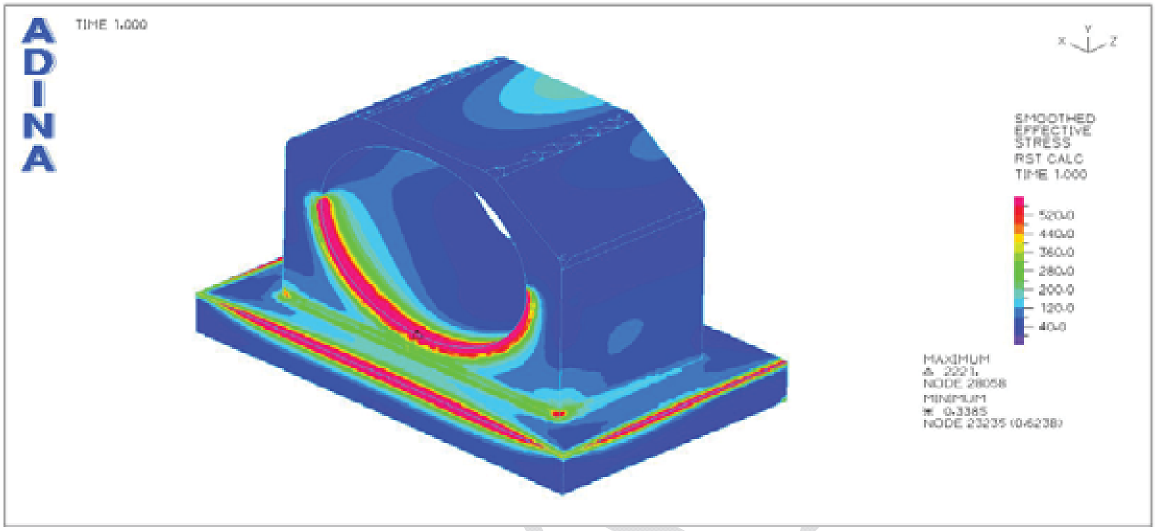


Figure 7, Effective stresses for maximum uplift (safety factor = 1.0)

There are high stresses around the bottom perimeter of the opening in the housing (where the spherical bushing assembly fits into the housing). This is due to the application of the transverse loads to the housing along this line. The stresses along this line overestimate the actual stresses in the housing because transverse loads will be applied over some contact area with the bearing top housing.

Aside from the aforementioned stress concentrations and those occurring along the restrained edges, the peak stresses in the housing are about 280 MPa.

Maximum Transverse Load (Safety Factor = 1.0)

Also assuming that the shear keys have failed, the effective stresses for the case of maximum transverse load are shown in Figure 8. Aside from stresses concentrations related to the (simplified) application of the loads and the boundary conditions, the peak stress in the housing is about 200 MPa.

Maximum Longitudinal Load (Safety Factor = 1.0)

Also assuming that the shear keys have failed, the effective stresses for the case of maximum longitudinal load are shown in Figure 9. Aside from stresses concentrations related to the (simplified) application of the loads and the boundary conditions, the peak stress in the housing is about 200 MPa.

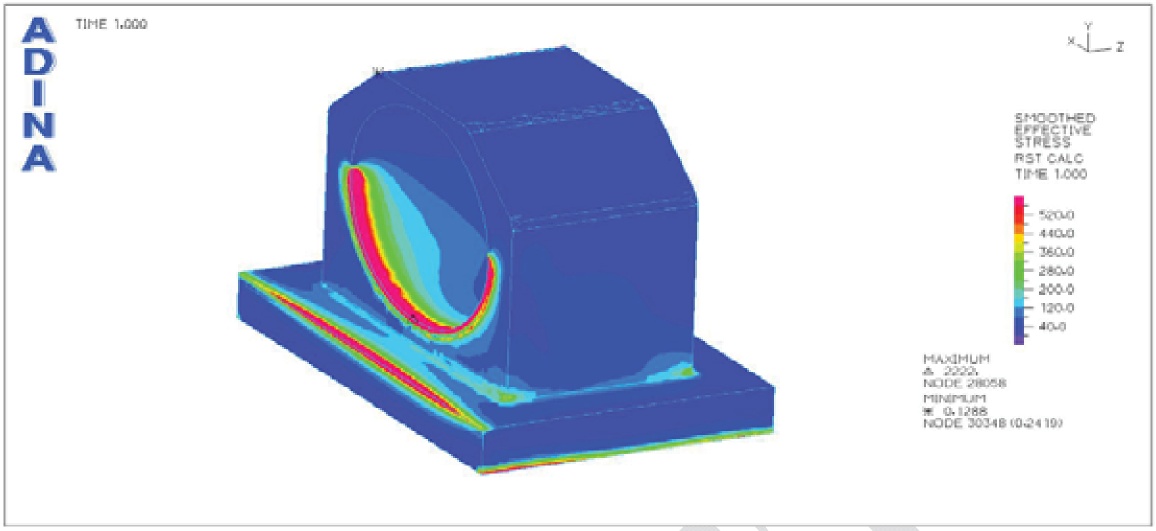


Figure 8, Effective stresses for maximum transverse load (safety factor = 1.0)

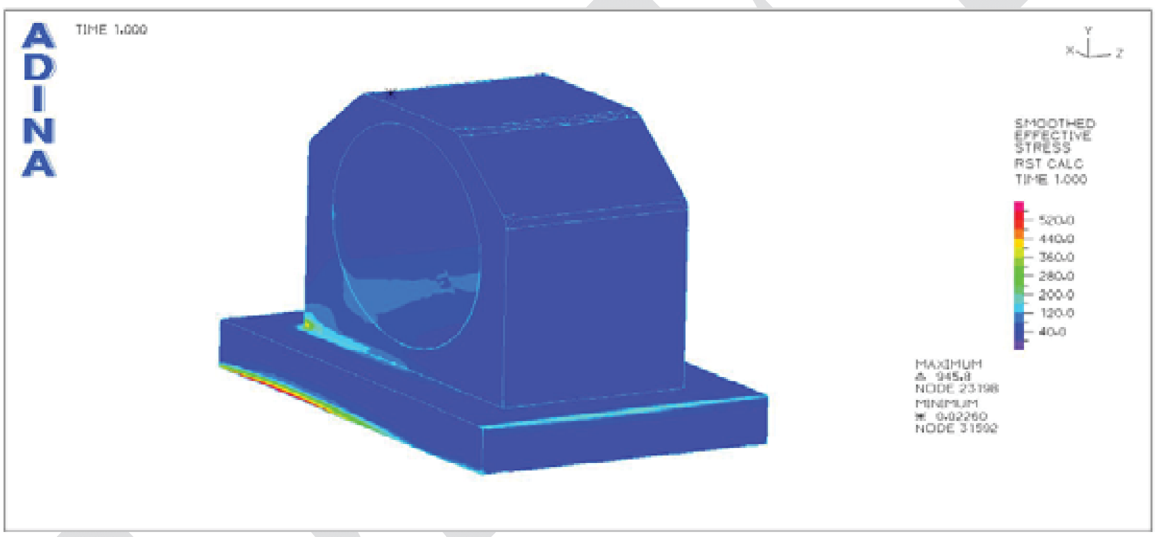


Figure 9, Effective stresses for maximum longitudinal load (safety factor = 1.0)

CONCLUSIONS

A series of finite element analyses were performed to determine the response of the bearing bottom housing to seismic loads. Of particular interest are the stresses induced by peak uplift and peak transverse and longitudinal loads (with orthogonal loads occurring simultaneously). In all cases, the effective stresses in the housing are less than the yield strength of the material (not counting stresses concentrations related to simplified load application and boundary conditions – these superficial concentrated stresses are of no concern).

Appendix D – Bearing Hold Down Assembly FEM

ANALYSIS OF BEARING LOWER HOUSING HOLD DOWN ASSEMBLY FOR SEISMIC LOADS

Self-Anchored Suspension Bridge

San Francisco Oakland Bay Bridge East Span Seismic Safety Project

Caltrans Project No. 04-0120F4

T.Y. Lin International / Moffatt & Nichol Joint Venture

July 15, 2013

INTRODUCTION

This study investigates the scenario of using only the permanent bearings to resist the seismic safety evaluation earthquake (SEE) load (without shear keys engaged – Load Path B and C).

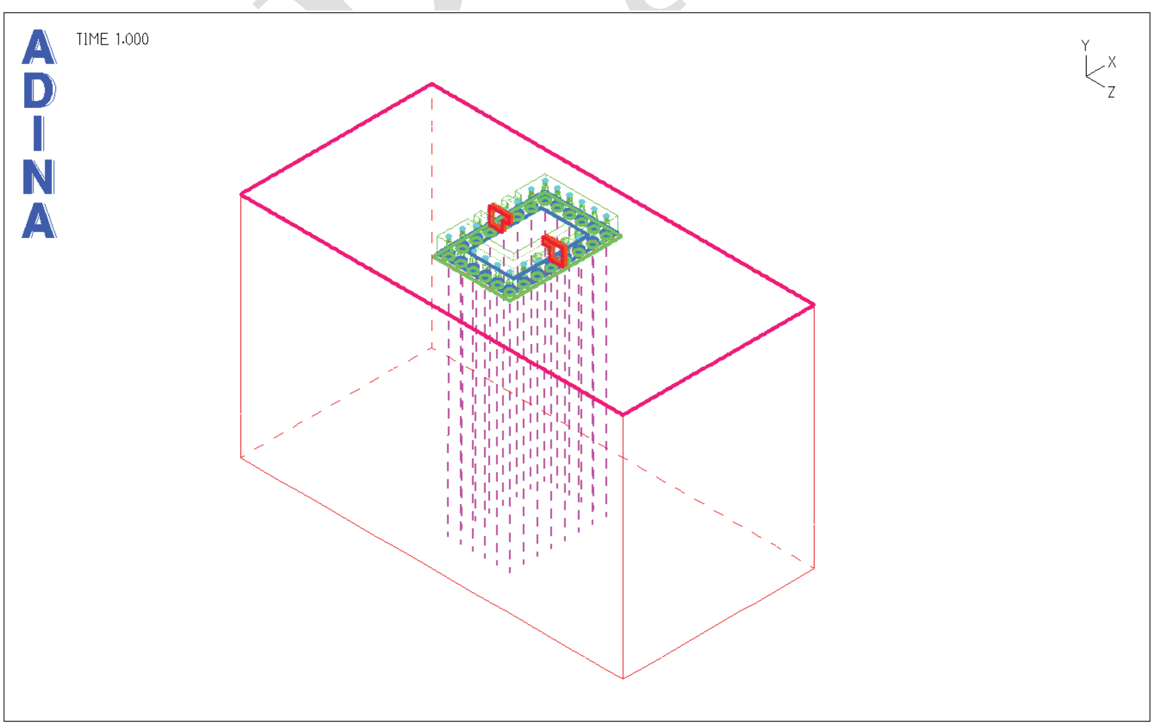
MODEL

The study is conducted with an analysis model developed in Adina. As shown in the figure below, the model includes the bearing hold down assembly and supporting concrete frame. Both are modeled as solid elements. A total of 24-A354BD of 3-inch diameter anchor bolts are modeled as truss elements, with both ends fixed to the concrete and the hold down assembly. The anchor bolts are assigned with initial tension strain that simulates installed pre-tension and are modeled with an initial tension equivalent to 0.7fpu per the plans.

The hold down assembly includes three pieces: one base plate and two top pieces which are held down by the anchor bolts. The two top pieces have a split interface at the transverse CL of the pier. The hold down assembly is modeled based on the as-built condition, which includes larger chamfer in each individual anchor bolt hole.

To ensure analysis efficiency and accuracy, only a portion of the concrete pier is modeled. The bottom of the concrete model is fixed.

The resistance at interface of all model components is only static friction based on the contact pressure. Bolt shear capacity is not considered across the interface and is conservative. The contact surface between the faces of the hold down assembly pieces uses a coefficient of 0.5 which corresponds to a Class B surface. The contact surface between the hold down assembly and the concrete pier uses a coefficient of friction of 0.67 for the as-built condition.



LOADS

Bearing forces were extracted from a seismic (time history) analysis of the self-anchored suspension bridge including the bearings and shear keys. The total longitudinal, transverse, and vertical loads transferred from the westbound and eastbound box girders to Pier E2 were extracted from the analysis and distributed to the bearings and shear keys in accordance with the plans. The bearing loads are shown in Table 1.

Normal functioning of the bearing corresponds to the case "Shear Key Engaged". The bearing is only required to carry vertical loads. These are either downwards—case C—or upwards—case U. Upwards loads are of greatest concern and are addressed in this report. A "safety factor" of 1.4 is applied to the calculated loads from the seismic analysis.

The bearing is also intended to function as a secondary mechanism to resist longitudinal and transverse loads should the shear keys fail. The three cases of greatest interest are those corresponding to the peak uplift on the bearing (case U), the peak transverse load (case T), and the peak longitudinal load (case L). In each case the orthogonal loads occurring simultaneously with the peak loads are also tabulated (and analyzed). These loads are applied with a "safety factor" of 1.0, since they are based on the conservative assumption that the shear key has failed.

Bearing Forces (SF=1.4)

Case	Case	Trans.	Long.	Vert.
Shear Key Engaged (Load Path A)	C	0	310	81104
	U	**0**	**108**	**-13355**

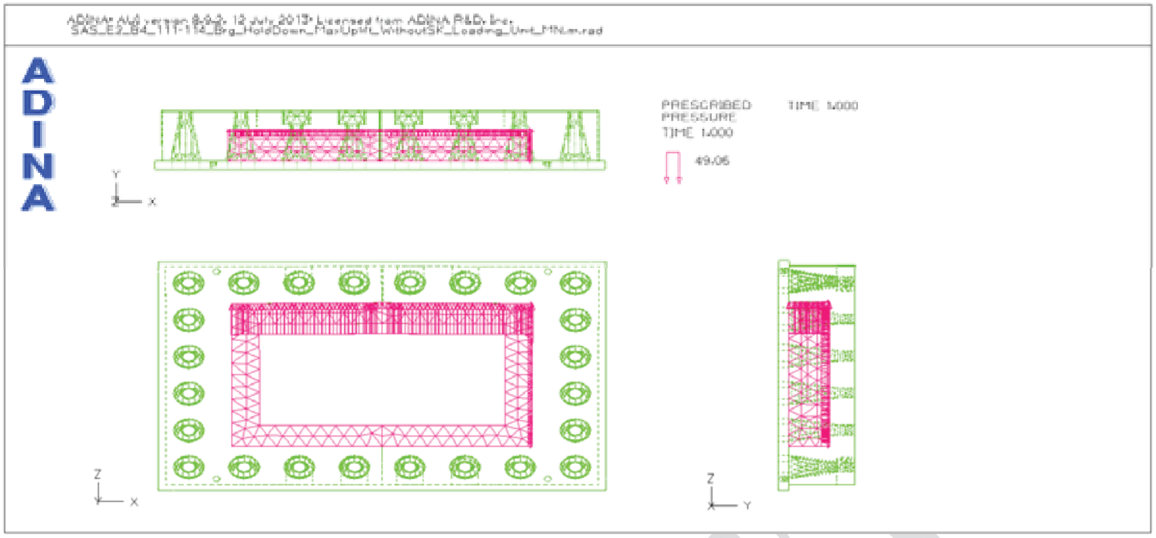
Bearing Forces (SF=1.0)

Case	Case	Trans.	Long.	Vert.
Shear Key Failed (Load Path B – See Note)	C	10799	4770	57932
	U	**25287**	**1628**	**-9539**
	T	**30496**	**8186**	**16441**
	L	**1340**	**13232**	**19255**

Note: The same seismic demands are conservatively assumed for Load Path C.

Table 1, Bearing Loads

The load is modeled as pressure loading applied at relevant surfaces, with some simplifications.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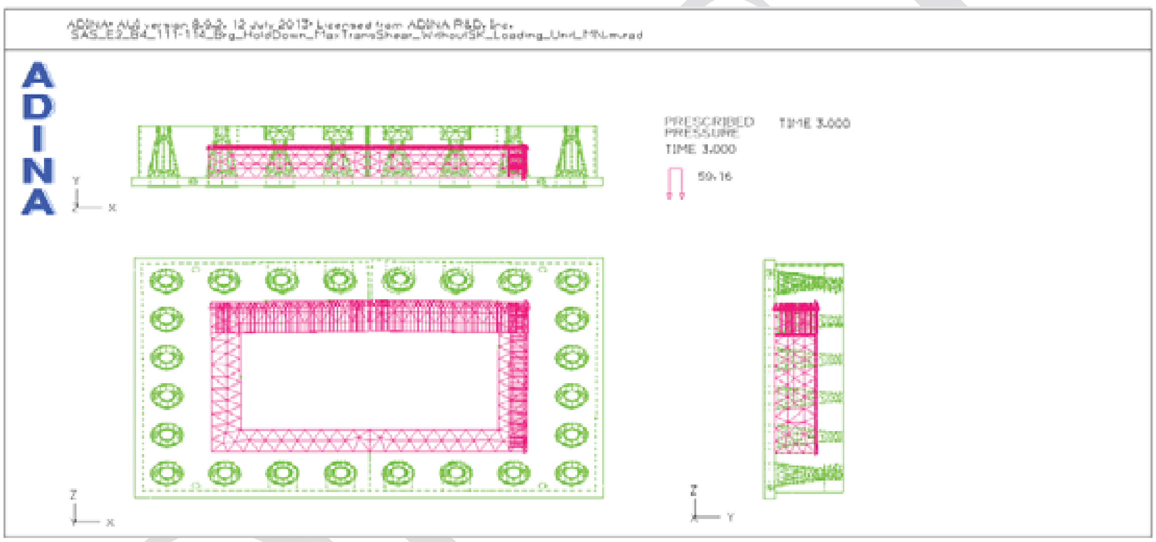
ADINA
PRESCRIBED PRESSURE
TIME 1.000
TIME 1.000
49.06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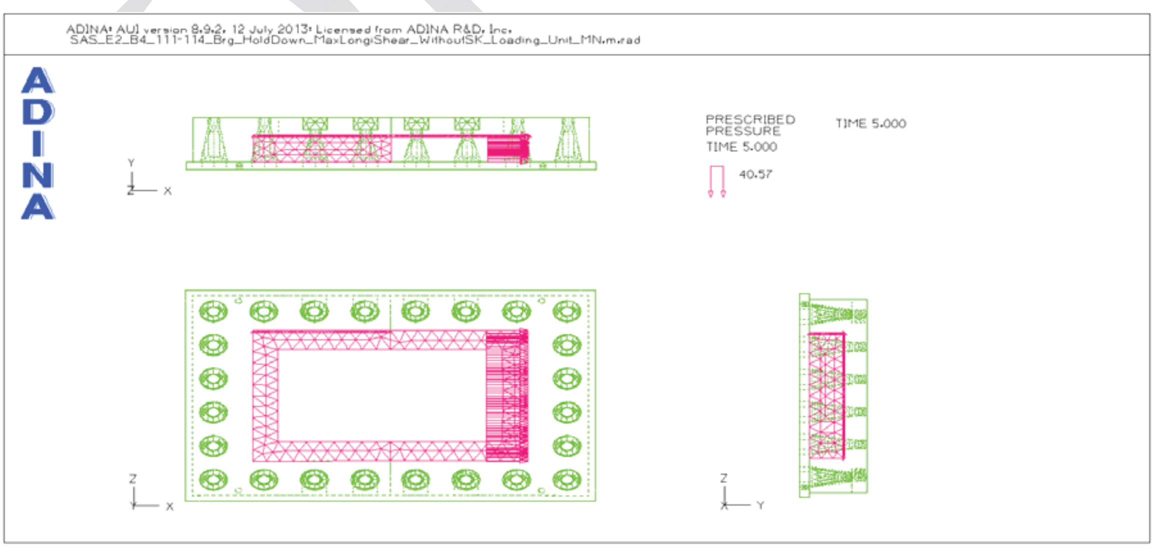
PRESCRIBED PRESSURE
TIME 3.000
TIME 3.000
59.16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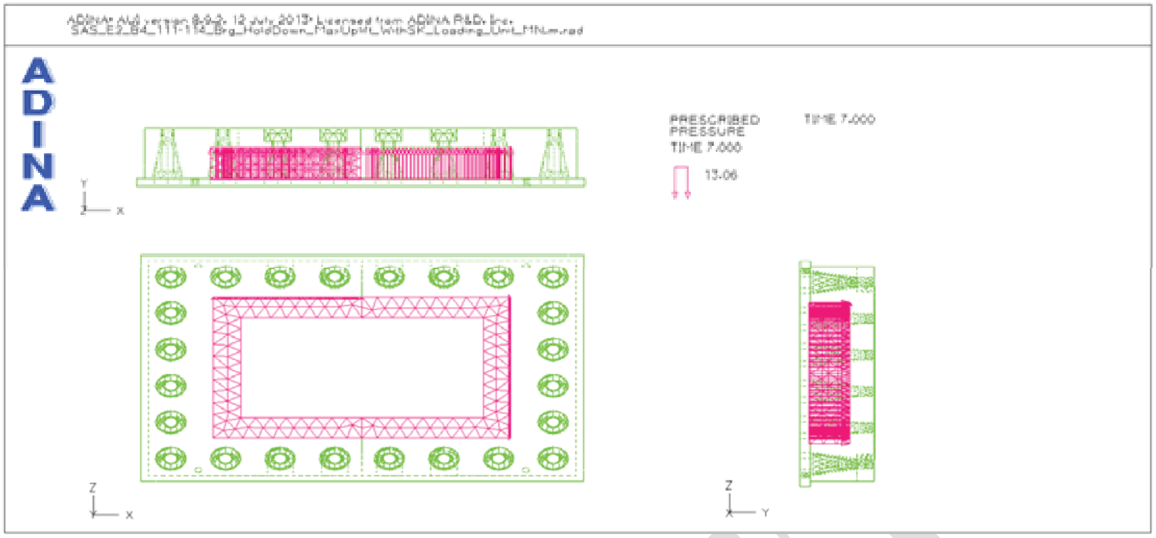
TIME 5.000
TIME 5.000
40.57



CONCLUSIONS

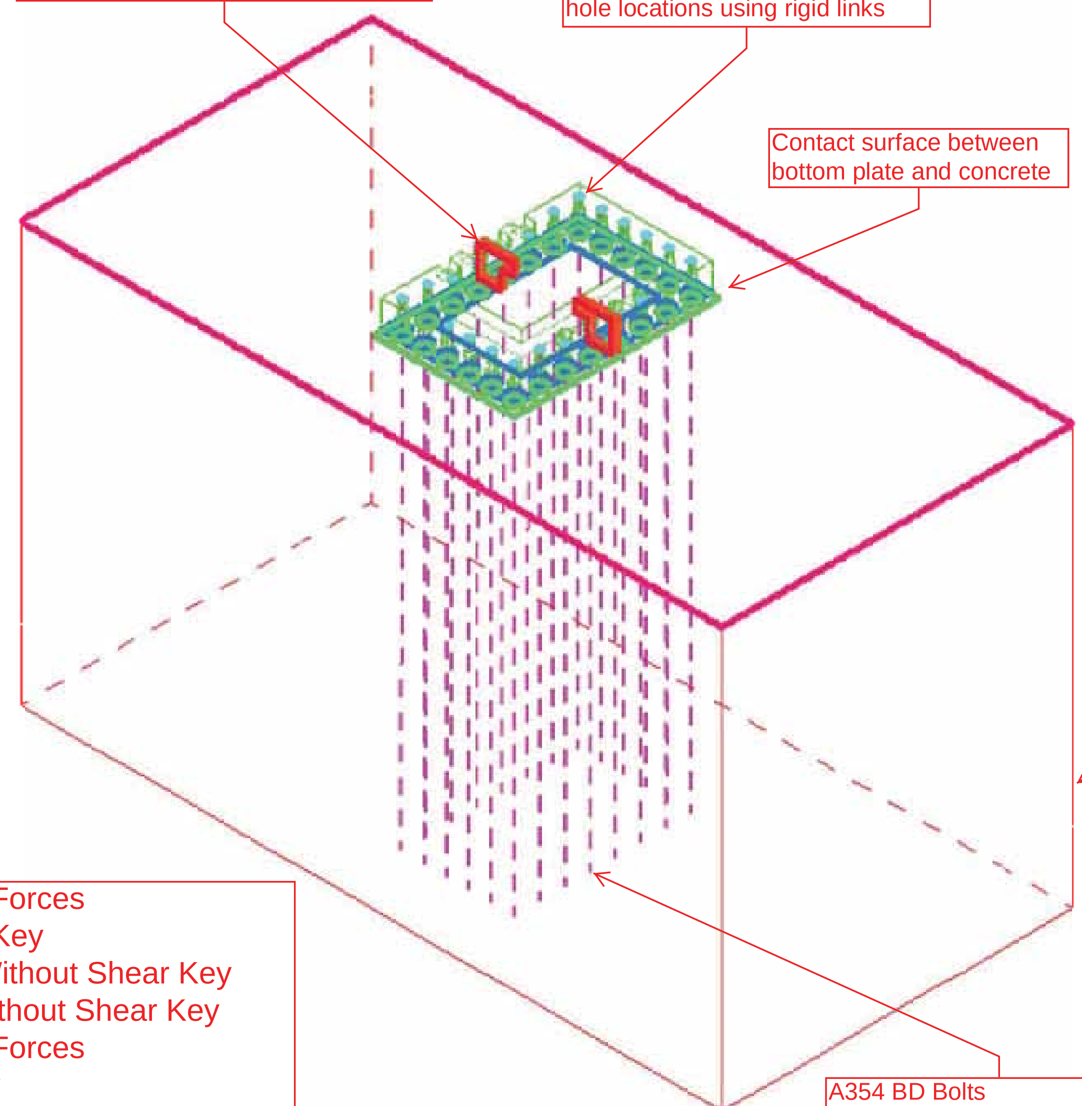
A series of finite element analyses were performed to determine the response of the bearing lower housing hold down assembly to seismic loads. Of particular interest are the stresses induced by peak uplift and peak transverse and longitudinal loads (with orthogonal loads occurring simultaneously). The analysis results are presented graphically for the four most critical load cases in Appendix A. The following can be concluded:

- Load Path A:
  - Case U: The effective stresses are less than yield.
- Load Path B:
  - Case L: The effective stresses are less than yield.
  - Case T: Localized yielding is expected at the edges where contact between the lower housing and the hold down assembly occurs. Note that the magnitude of the effective stresses are magnified by the simplified load application and boundary conditions.
  - Case U: Localized yielding may be expected at the corners where contact between the lower housing and the hold down assembly occurs. Note that the magnitude of the effective stresses are magnified by the simplified load application and boundary conditions.

For Load Path B (Case T and Case U), minor damage to the bearing lower housing hold down assembly is expected under the extreme event of SEE if all the shear keys failed. However, it is important to note that for Load Path C, the Transverse Shear at the Pier E2 Bent is shared among the four bearings (B1, B2, B3 and B4) and Shear Keys (S3 and S4) thereby reducing the demand by about a factor of 4/6, thereby reducing the stresses close to yield.

TIME 1.000

Friction Coefficients:
Steel-Steel = 0.50
Steel-Concrete = 0.67



Pressure loads applied to interior faces of bearing hold down to simulate seismic loads transferred from lower housing. Simplified linear and uniform distribution used.

Model Scope

1.0 * Concurrent Seismic Forces
Max Uplift, Without Shear Key
Max Longitudinal Shear, Without Shear Key
Max Transverse Shear, Without Shear Key
1.4 * Concurrent Seismic Forces
Max Uplift, With Shear Key

model overview

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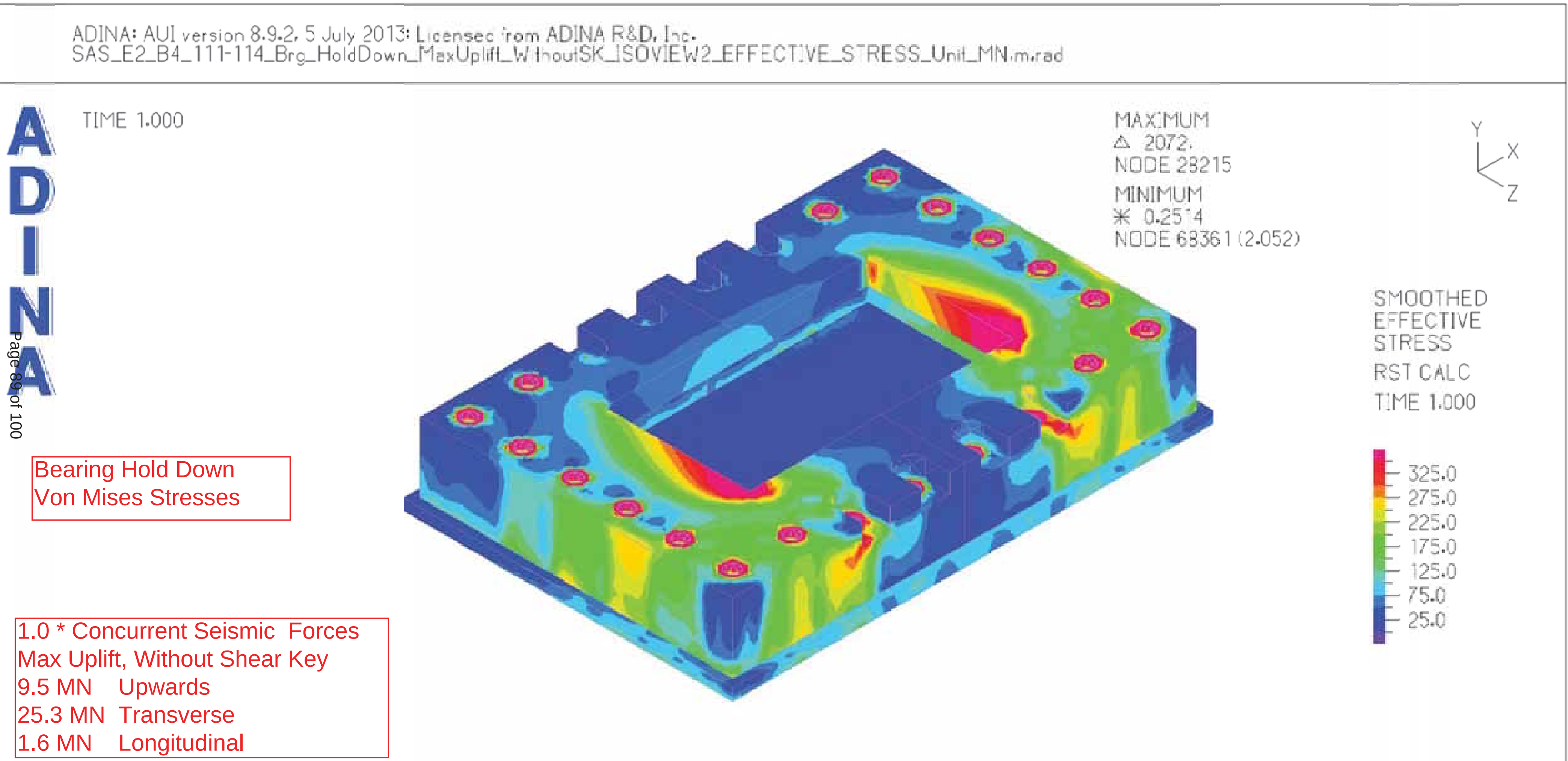

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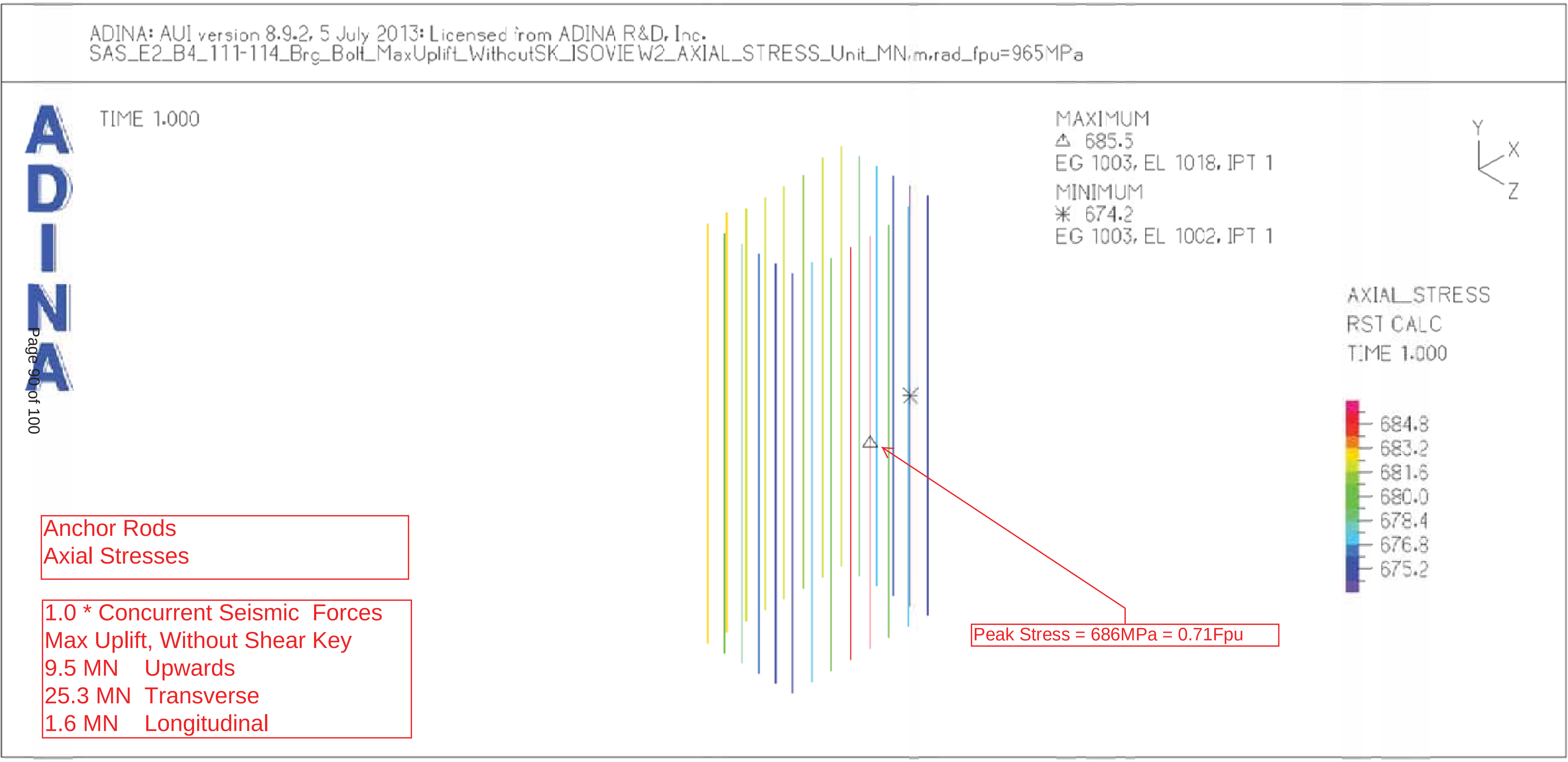

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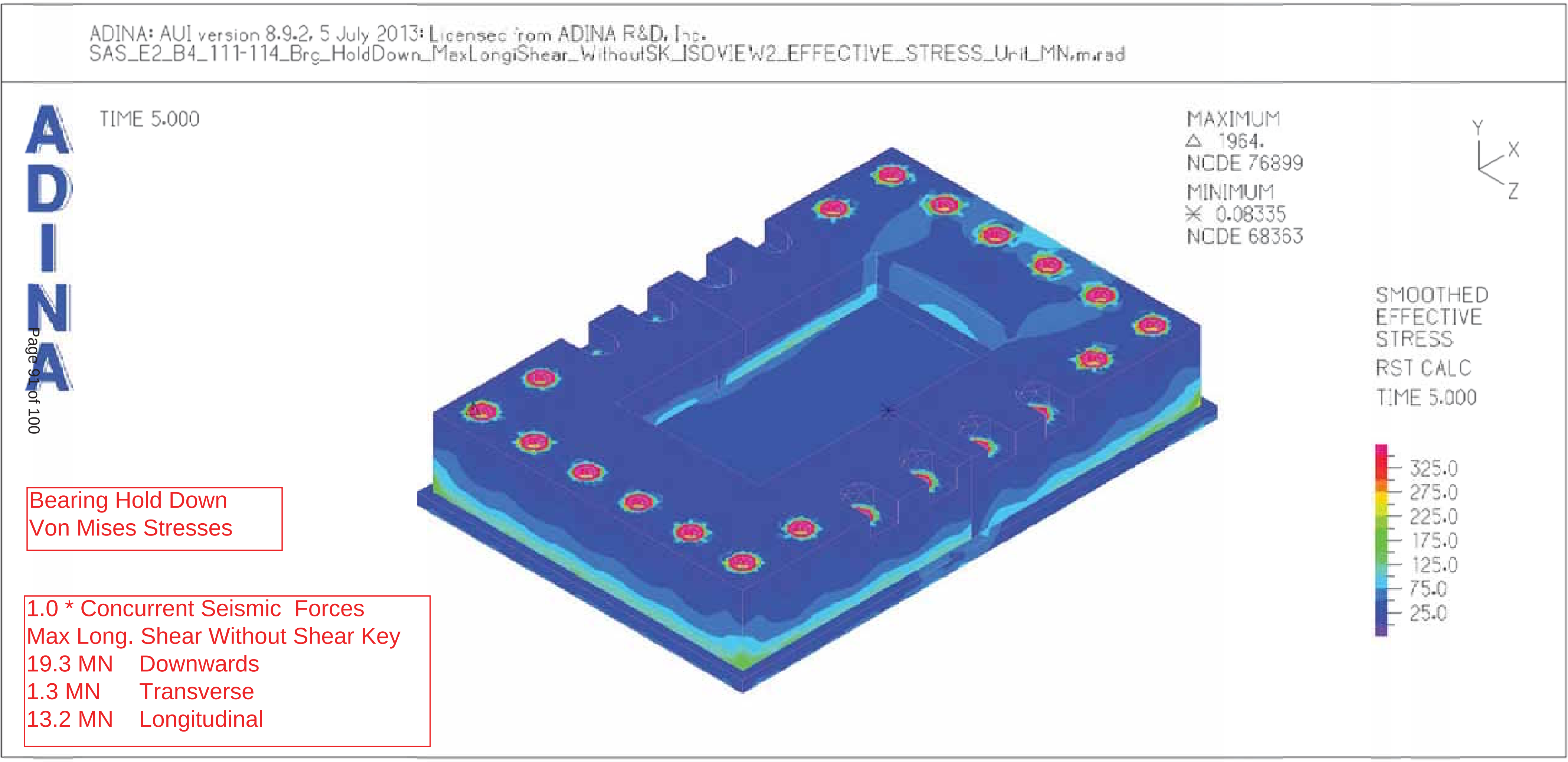
SAS_E2_B4_111-114_Brg_Bolt_MaxUplift_WithoutSK_ISOVIEW2_AXIAL_STRESS



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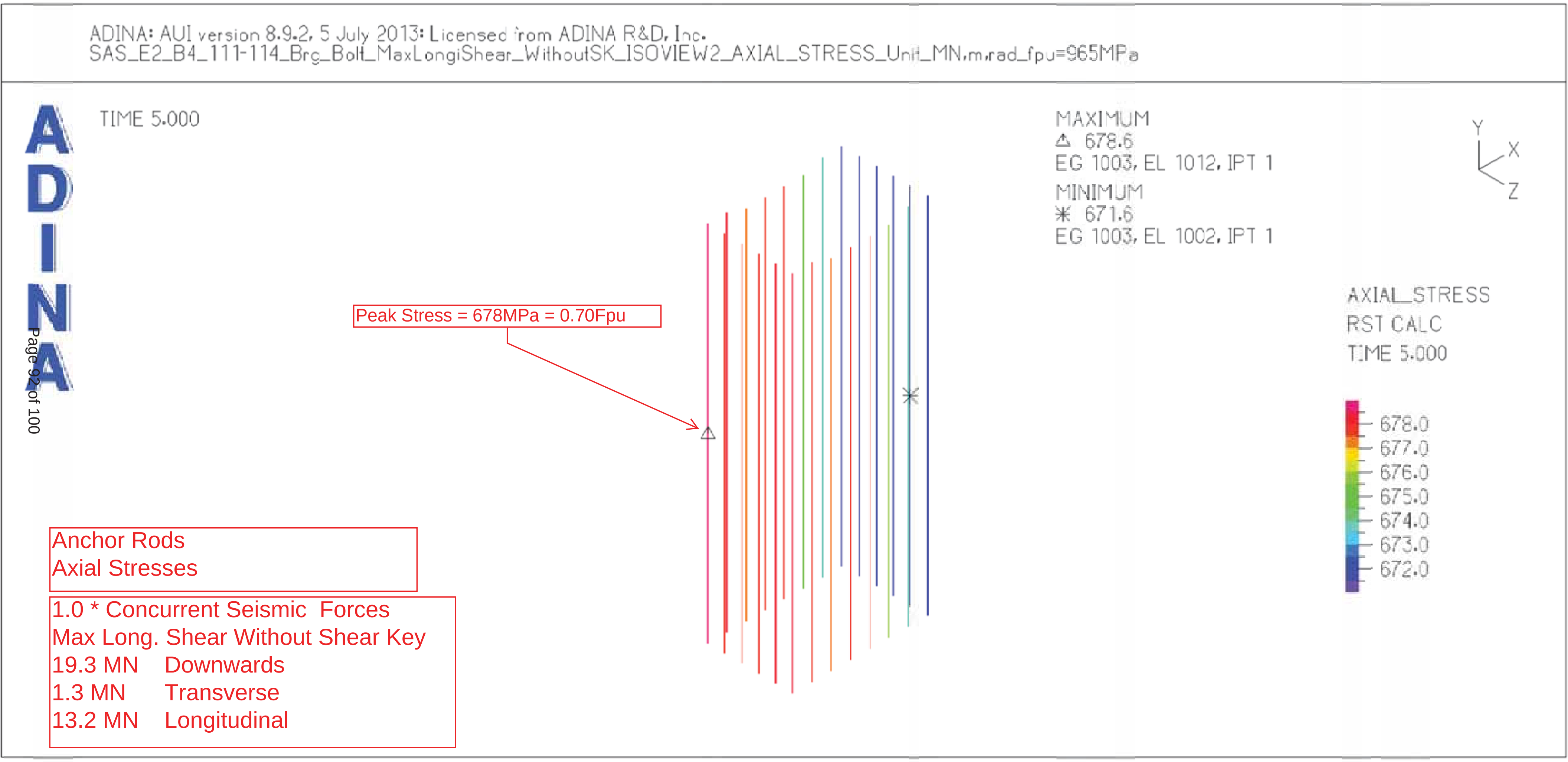

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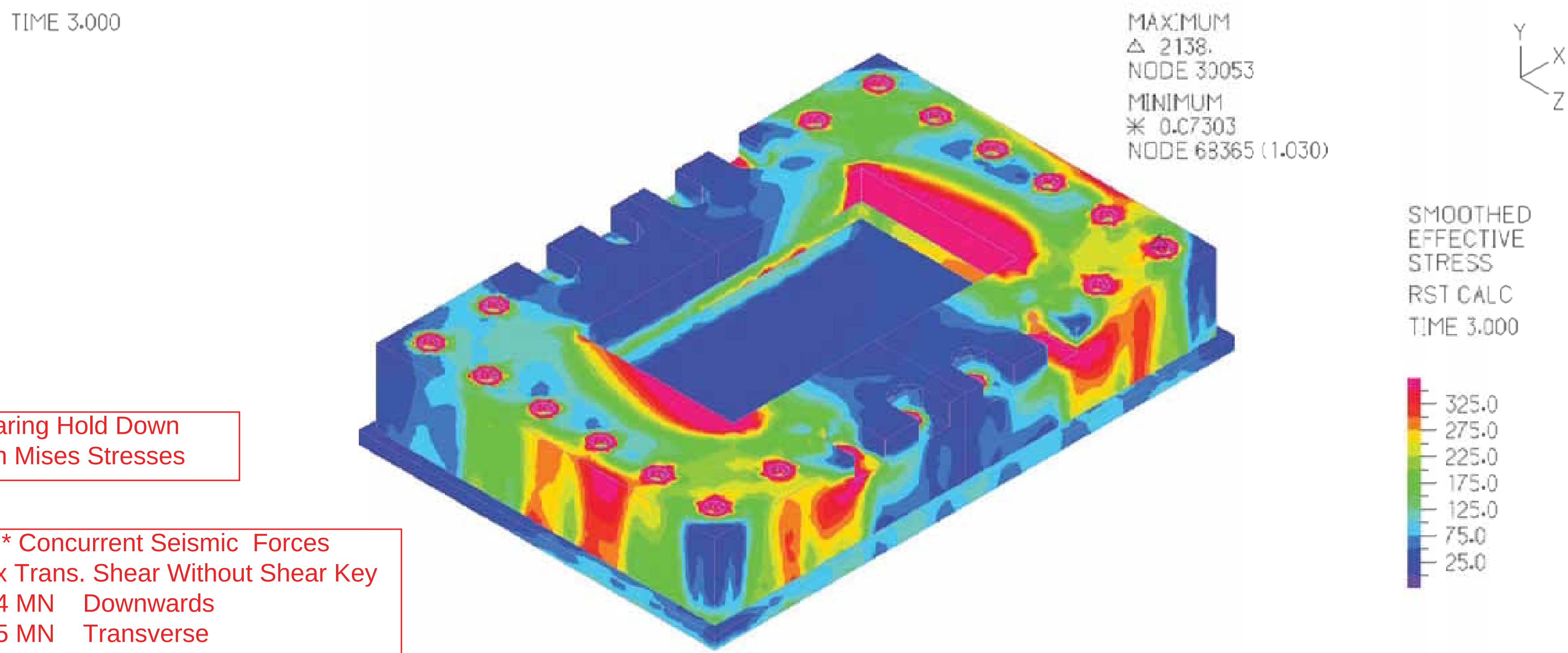

Bearing Hold Down
Von Mises Stresses

1.0 * Concurrent Seismic Forces
Max Trans. Shear Without Shear Key
16.4 MN Downwards
30.5 MN Transverse
8.2 MN Longitudinal

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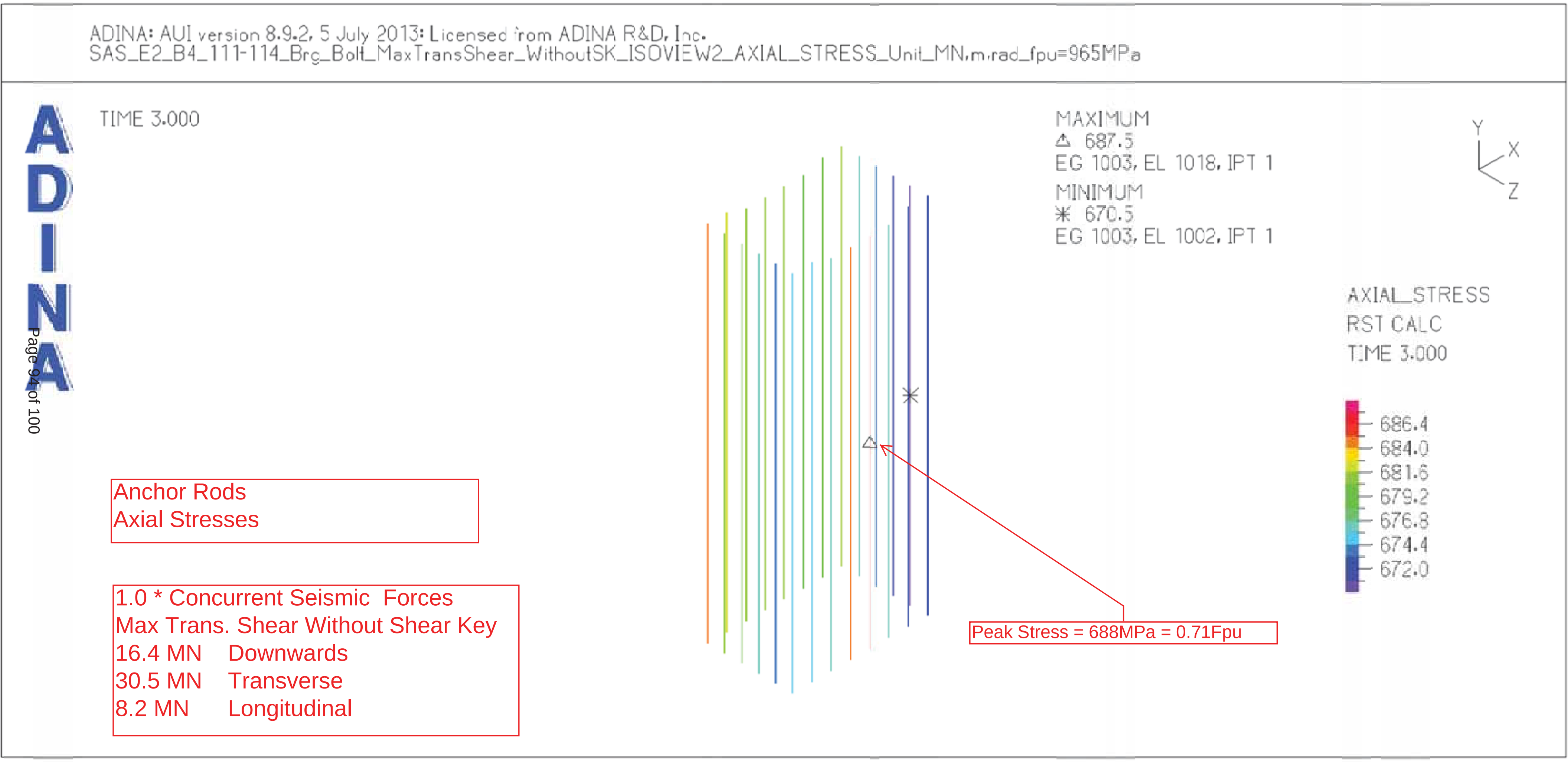
SAS_E2_B4_111-114_Brg_HoldDown_MaxTransShear_WithoutSK_ISOVIEW2_EFFECTIVE_STRESS



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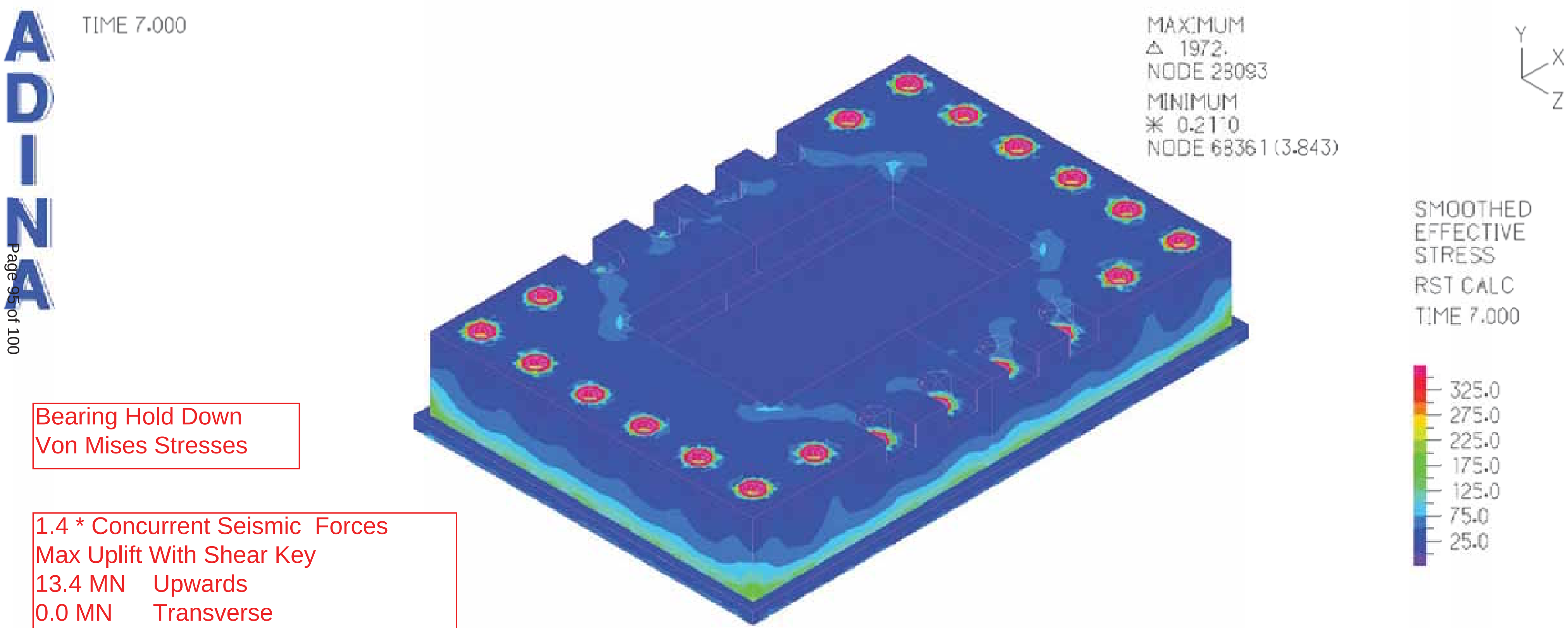

Bearing Hold Down
Von Mises Stresses

1.4 * Concurrent Seismic Forces
Max Uplift With Shear Key
13.4 MN Upwards
0.0 MN Transverse
0.1 MN Longitudinal

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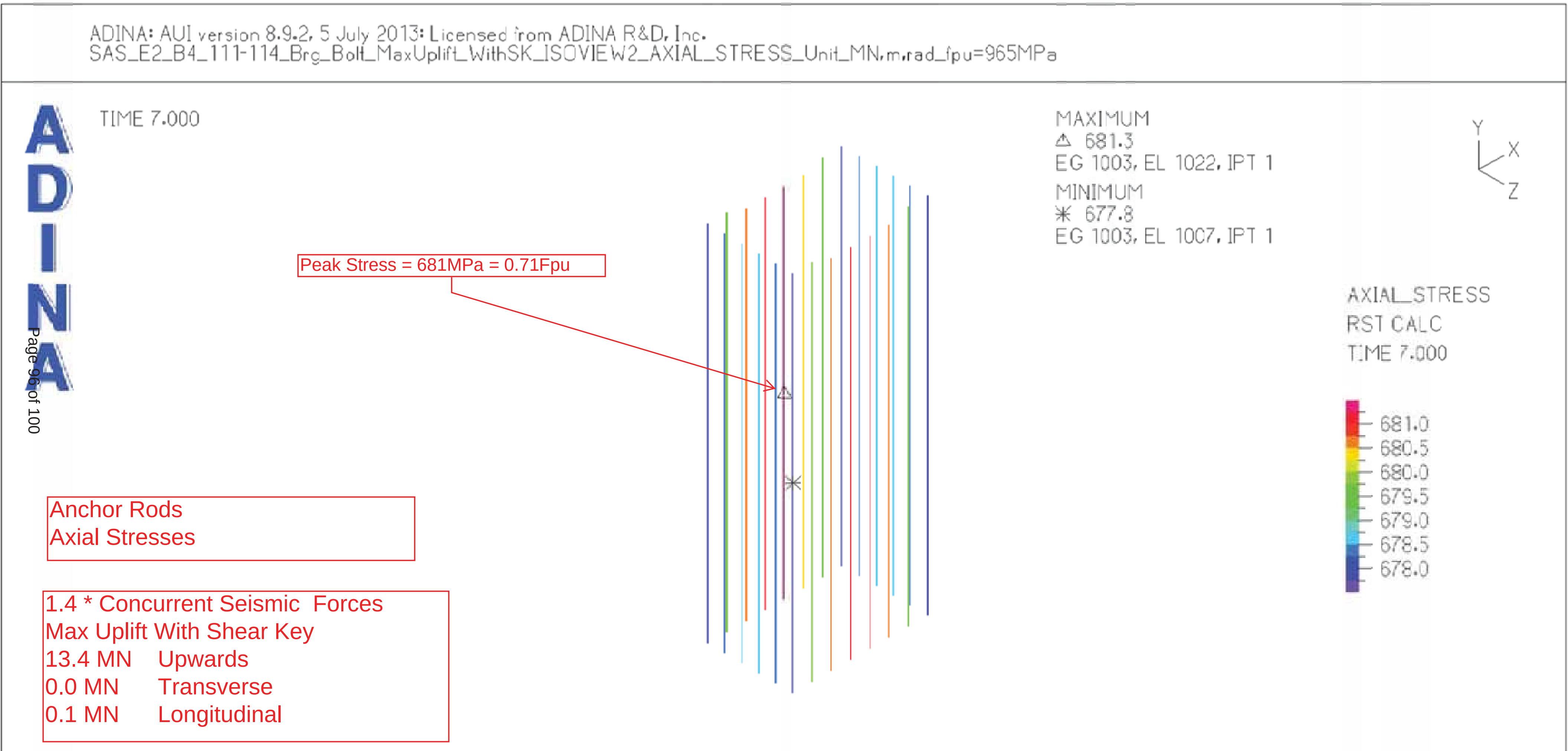

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SAS_E2_B4_111-114_Brg_Bolt_MaxUplift_WithSK_ISOVIEW2_AXIAL_STRESS

Appendix E – Pier E2 Push-Over Analysis

The superstructure supports at Pier E2 were developed with four (4) shear keys resisting the horizontal forces and four (4) bearings carrying the vertical loads. This design is based on the 1998 recommendation of the Seismic Safety Peer Review Panel (SSPRP) to have horizontal load carrying members separate and independent from the vertical load carrying members.

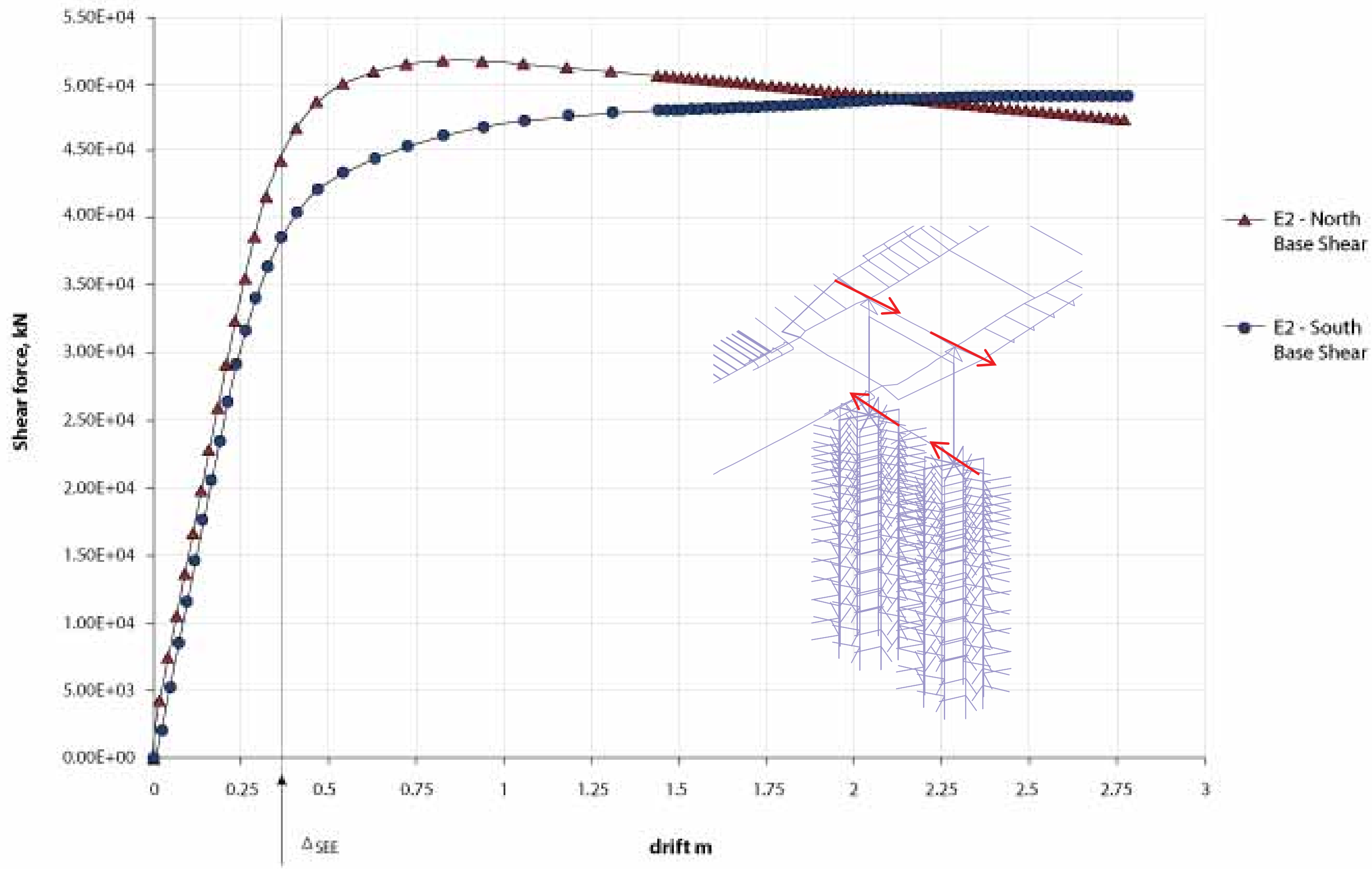
The shear keys were designed for the larger of:

- 1.4 times the Safety Evaluation Earthquake (from Time History Analysis)
- 1.15 times pushover strength of Pier E2 using maximum feasible material over-strength properties (f'ce = 1.7f'c for concrete and fye = 1.3fy for rebar)

The 100% design considered prestressing the shear key stub down to the crossbeam and utilized shear friction to resist design horizontal force. The large prestressing force is required to provide adequate friction force as well as preventing any uplift, and this necessitated the use of large diameter, high-strength anchor rods.

Seismic Demand			Design Shear (Max of 1.4 SEE or 1.15 Pushover)		
Total Shear at Bent E2	Time History (Max of 6 SEE)	Pushover (PO) (1.7f'c, 1.3fy)	1.4 SEE	1.15 PO	Governing Load Case
Longitudinal Shear	50 MN	48 MN	70 MN	55 MN	70 MN
Transverse Shear	120 MN	110 MN	168 MN	127 MN	168 MN

Pier E2: Transverse Push-Over (Base Shear)



Pier E2: Longitudinal Push-Over (Base Shear)