ABB

R-3/D2 #55 –

October 1, 1993

Mr. Hal Eskridge
Manager of Regulatory Compliance
ABB Combustion Engineering Nuclear Fuel
P. O. Box 107
3300 State Road P
Hematite, MO 63047

Hal,

George France asked Len that we transmit "seismic analysis and related" to Mr. John P. Martin at the NRC. I have reviewed the documentation on the seismic aspects of the Kardex storage unit and have prepared the following summary, history and collection of documentation.

As with all the major construction in the Revitalization and Consolidation Projects (1988 through 1993) a major ABB-CE design requirement is the consideration of natural disaster including flood, wind, snow loading, tornados and earthquake. For the Kardex storage unit the primary concerns were tornado and earthquake. Concern about a tornado was eliminated with enclosure of the Kardex in a concrete block room (originally for temperature control) and adding a concrete slab roof.

Concern about earthquakes was addressed first by placing the Kardex and its enclosure room on a massive independent foundation. The Kardex itself was then reinforced with 120 additional braces reserved for a 30 foot high Kardex though this unit was only to be constructed 20 feet in height. This bracing configuration had been used in an earthquake resistant Kardex designed and analyzed for use in San Diego. To confirm the effectiveness of this treatment a seismic analysis of the Kardex was ordered from a southern California engineering firm that had done the analysis for the San Diego installation.

PROPRIETARY to ABB Combustion Engineering

TT-1

ABB Combustion Engineering Nuclear Fuel

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Based on the initial seismic review, 218 additional seismic bracing pieces were added to the Kardex frame in December 1992. As a precaution the local engineer that did the structural design and analysis for the earth quake resistant mezzanines in the building was asked to review the California seismic calculations. Over the next month an exchange developed between the two engineering firms that lead to further evolution of the seismic design to include 36 additional seismic braces.

The installation of the Kardex was completed with a total of 374 additional "seismic" braces, the blessing of two structural engineers working for different companies in different states, an on site inspection by our local NRC inspector and an on site inspection by an NRC reactor inspector with mechanical design expertise.

The following tables provide the history and documentation of the seismic analysis and construction of the Kardex. Copies of the listed documentation are attached. Because this is a unique application of high density uranium storage the attached tables and documentation are considered PROPRIETARY to ABB Combustion Engineering and should be treated as such.

Don Rohde
Project Manager
Manufacturing Technology
ABB Combustion Engineering

xc: Len Grossman w/o attachments
John Conant w/o attachments
Gary Kersteen w/o attachments
Jim Rode w/o attachments

Table 1. History of Seismic Analysis of Kardex Storage Unit

| | |
|---|---|
| 06/24/92 | Earthquake resistant footing for the Kardex was designed by John Hehmeyer P.E. of Metropolitan Engineering Co. (attachment #1) |
| 08/05/92 | License Amendment submitted to NRC that included the use of the Kardex storage unit. |
| 08/17/92 | At the request of Len Grossman of ABB, Shuler Business Systems (Kardex vendor) provided estimate for a seismic analysis of the Kardex units. (attachment #2) |
| 08/26/92 | Kardex unit was modified to have the bracing required for a 30 foot unit even though it was only 20 feet tall. This added 120 braces. |
| 09/14/92 | James Gavula, Reactor Inspector and George France, III Fuel Facility Inspector from the NRC inspect the installation of the Kardex frame at the Hematite site. The inspectors determined that the construction and installation of the Kardex was accomplished with sound engineering practices. It was agreed that additional channel nuts will be added to the bottom of the frame and that the unit will be anchored to the concrete base. Len Grossman of ABB promises that a seismic evaluation will be completed before the unit is put into operation. (cover letter and inspection report attachments #3 & #4) |
| 11/29/92 | At the request of Len Grossman of ABB, Mike Rabinovici of Eugene D. Birnbaum & Associates did the seismic analysis of the Kardex storage system. (attachment #5) |
| 12/29/92 | The suggested seismic bracing was add to the Kardex Unit frame. This involved 218 additional braces. |
| 01/19/93 | At the request of Len Grossman of ABB, John Hehmeyer P.E. of Metropolitan Engineering Co. reviewed the seismic analysis and found 13 areas that needed further review.(cover letter, areas needing review and markup of calculations, attachment #6) |
| 01/28/93 | Mike Rabinovici of Eugene D. Birnbaum & Associates respond to the 13 areas by adding spreaders, ties, braces and anchoring the unit to the floor. (attachment #7) |
| 02/01/93 | Mike Rabinovici of Eugene D. Birnbaum & Associates respond to questions about cross bracing the lower portion of the unit with an increase in the strength of the bolts in the tie plates. (attachment #8) |
| 02/03/93 | John Hehmeyer P.E. of Metropolitan Engineering Co. reviewed the response and accepted the added spreaders, ties, braces and anchoring the unit to the floor but still wanted cross bracing in the lower part of the front and rear of the unit. (attachment 9) |
| 09/13/93 | Visual inspection of Kardex confirms the installation of the 24 diagonal cross braces and 12 horizontal braces in lower portion of both the front and the rear of the unit. |

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Table 2. List of Attachments:

| | | |
|---|---|---|
| 1. | 06/30/92 | Footing Design by John Hehmeyer P.E. of Metropolitan Engineering Co. - 27 pages |
| 2. | 08/17/93 | Price Quotation from Shuler Business Systems, Inc - 1 page. |
| 3. | 10/05/92 | Cover letter from R. J. Caniano transmitting inspection report - 2 pages. |
| 4. | 10/05/92 | Inspection Report by James Gavula, Reactor Inspector and George France, III Fuel Facility Inspector from the NRC - 4 pages. |
| 5. | 11/29/92 | Calculations from Mike Rabinovici of Eugene D. Birnbaum & Associates - 13 pages. |
| 6. | 01/19/93 | Letter and attachments from John Hehmeyer P.E. of Metropolitan Engineering Co. - 13 pages. |
| 7. | 01/28/93 | Facsimile from Mike Rabinovici of Eugene D. Birnbaum & Associates - 10 pages |
| 8. | 02/01/93 | Facsimile from Mike Rabinovici of Eugene D. Birnbaum & Associates - 2 pages. |
| 9. | 02/03/93 | Letter, calculations and attachments from John Hehmeyer P.E. of Metropolitan Engineering Co - 10 pages. |

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Inter-Office Correspondence

To: Bob Klotz

Date: September 9, 1992

cc: John Conant (w/o attachments)
Len Grossman (w/o attachments)

From: Don Rohde

Location: Hematite

Subject: Foundation Design For Kardex

Attached are 24 pages of the design of the foundation to the Kardex. This information is proprietary to ABB and any distribution requires the prior approval of Len Grossman. Do not copy or give away this copy.

Don Rohde
Consolidation Project Manager

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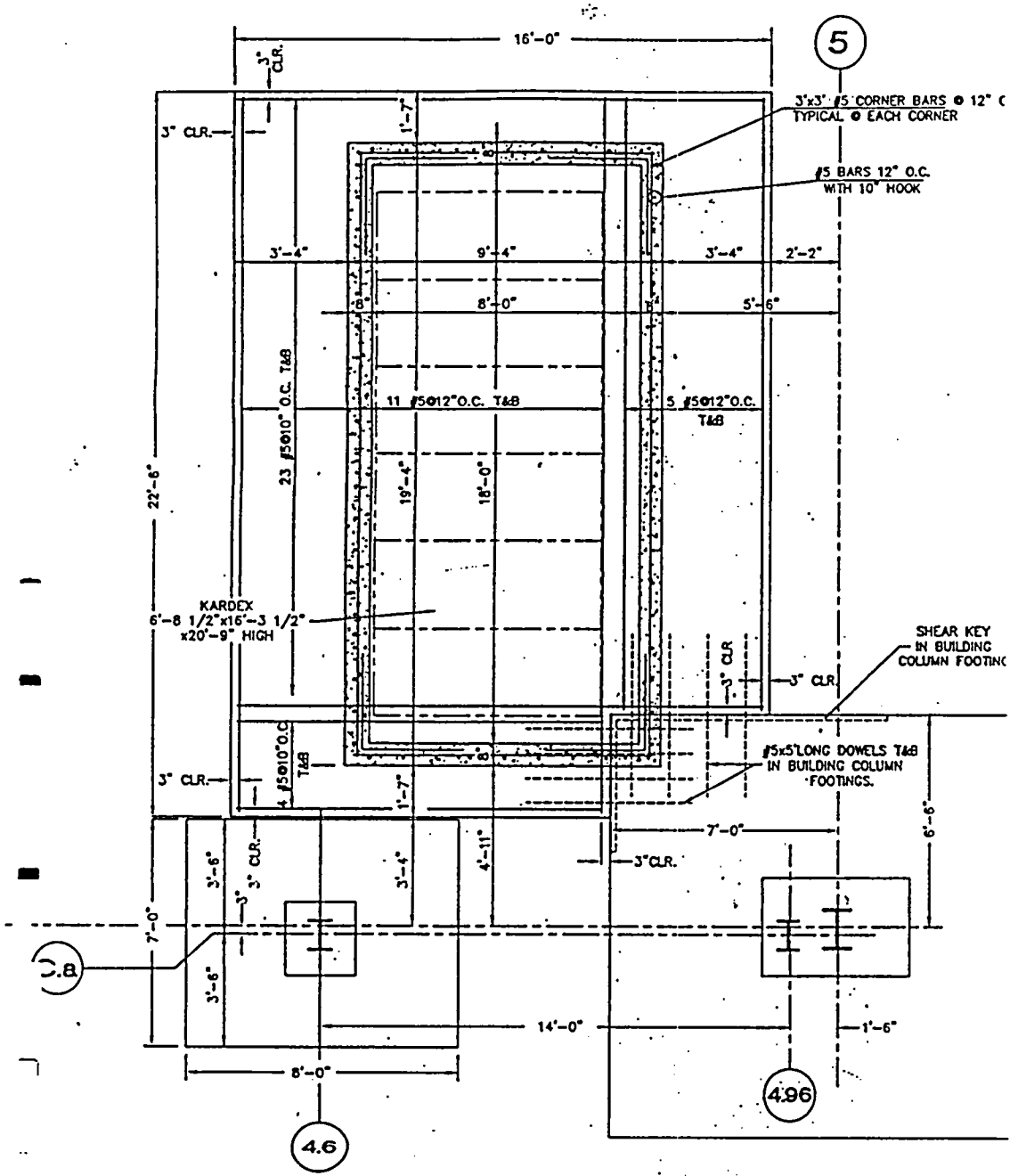
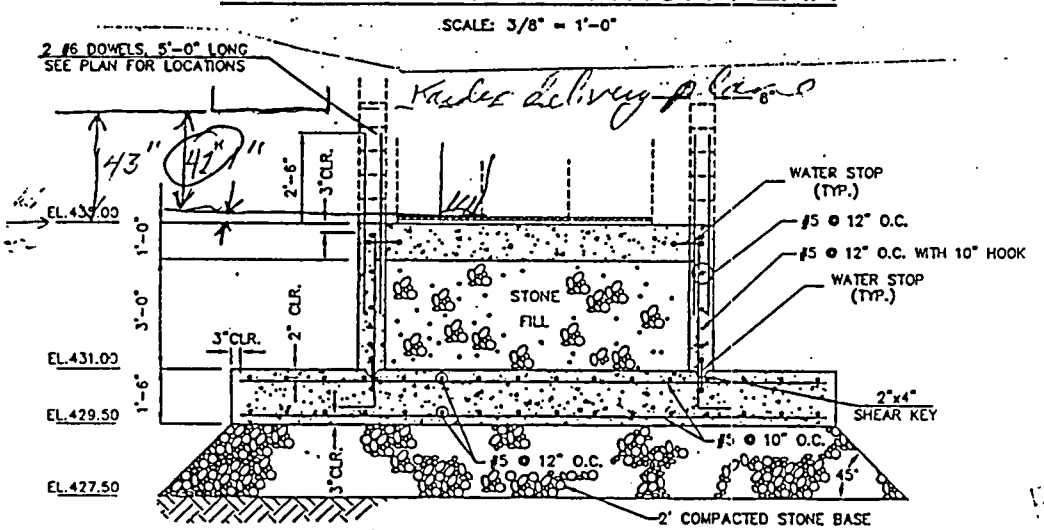



## KARDEX FOUNDATION PLAN

SCALE: 3/8" = 1'-0"




## KARDEX FOUNDATION

SCALE: 3/8" = 1'-0"

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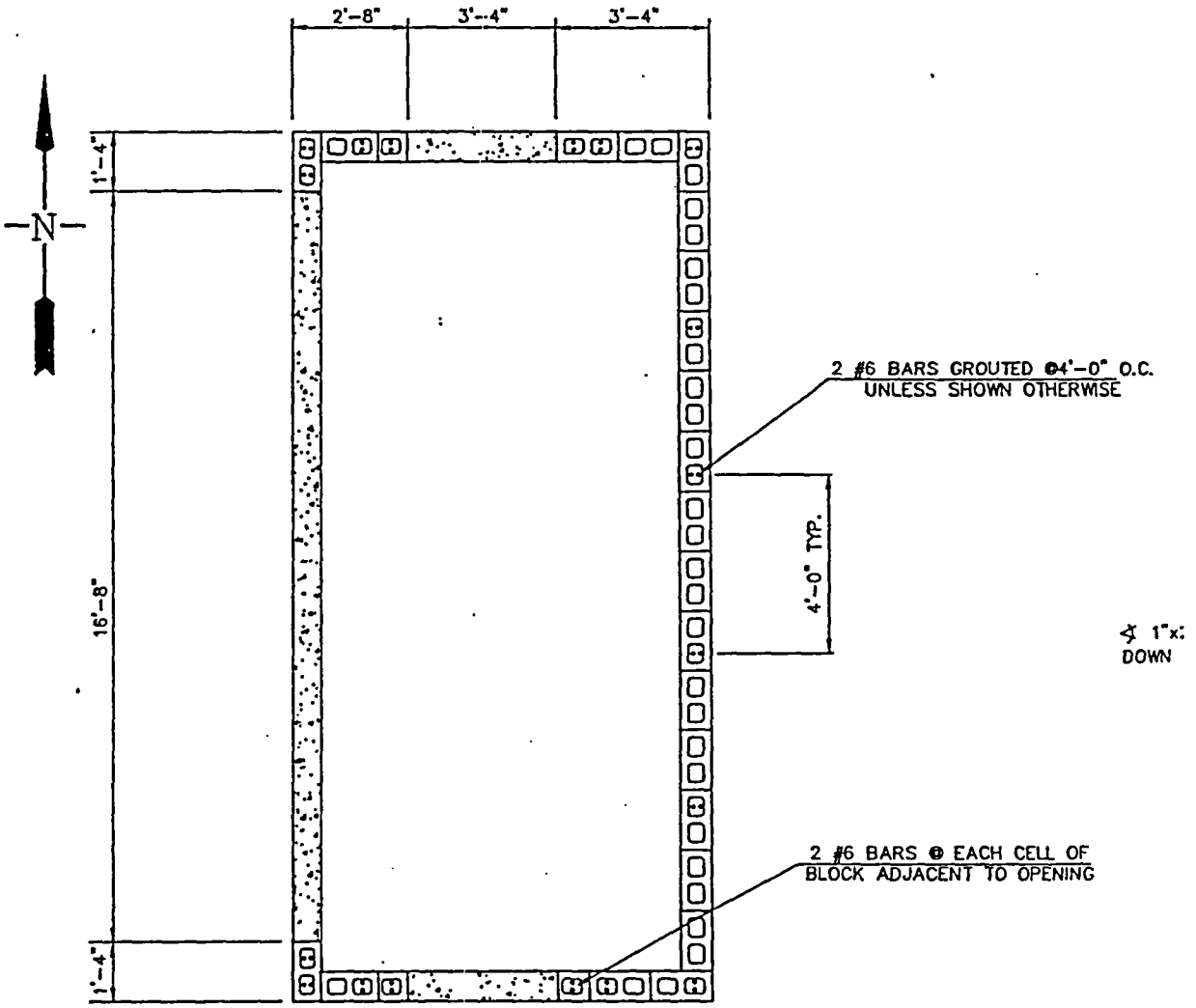
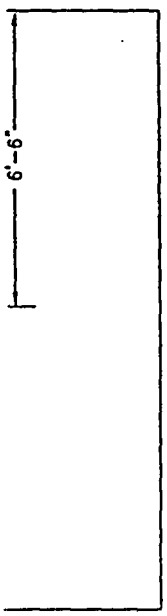
2 3 4 5

RS @ 12" O.C.
NER




HEAR KEY
I BUILDING
JMN FOOTING




1"x
DOWN

# KARDEX FOUNDATION CONCRETE BLOCK PLAN

SCALE: 3/8" = 1'-0"

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ABB COMBUSTION ENGINEERING

| METROPOLITAN ENGINEERING COMPANY | Design By JMH | Job No. 251.037 |
|---|---|---|
| Job ROD LOADING BLDG. BLDG. No. 230 | Checked By | Sheet 1 |
| For ABB/COMB. ENGR. | Date 30 JUN 92 | of |

## KARDEX ENCLOSURE & FOUNDATION

### DESIGN ASSUMPTIONS

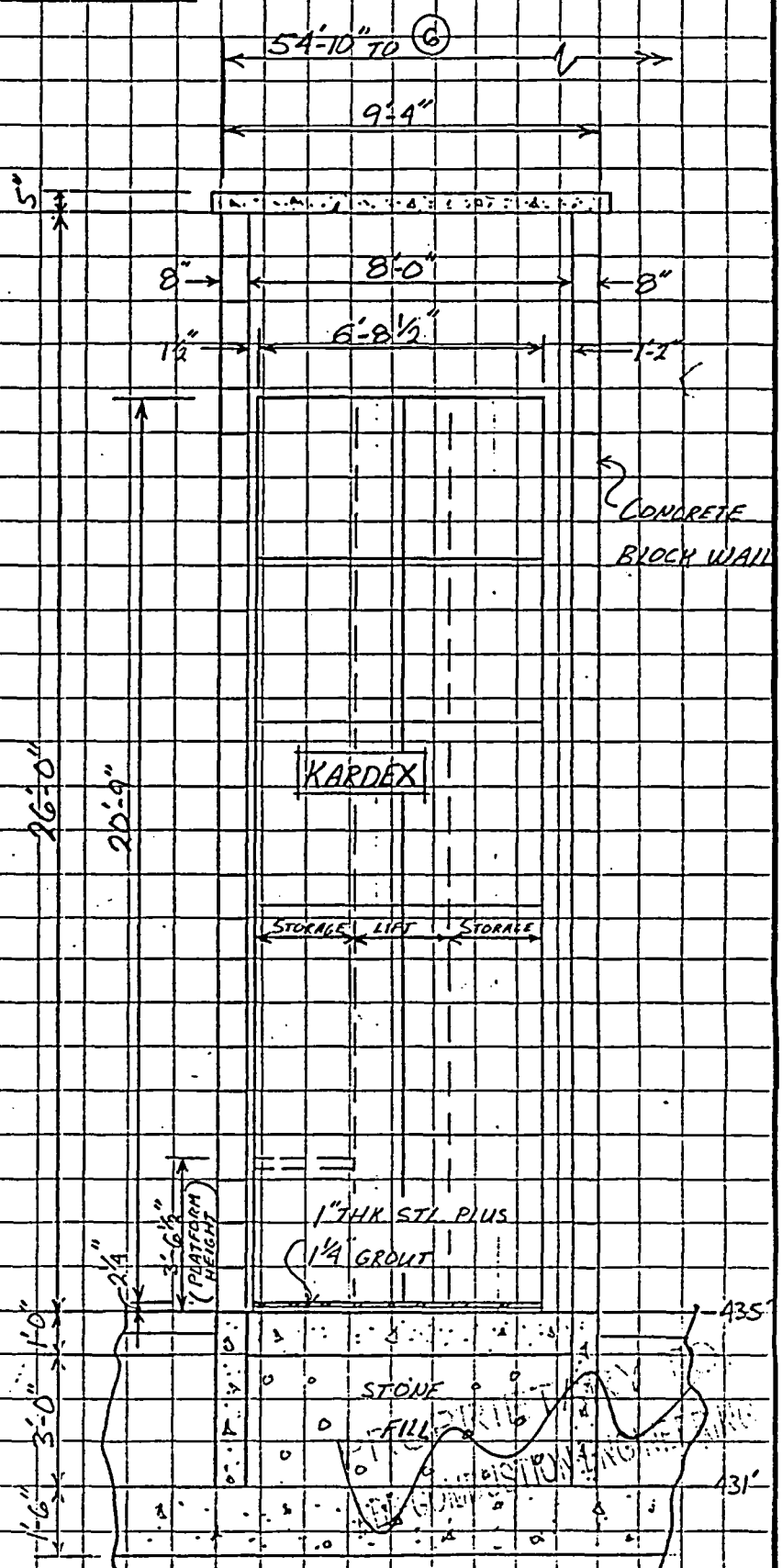
- IN PLAN, THE OUT-TO-OUT DIMENSIONS OF THE CONCRETE BLOCK WALLS ARE 9'-4" x 19'-4"
- 20% OF THE CONCRETE BLOCK CELLS ARE FILLED SOLID.
- MAX KARDEX PAYLOAD = 16,000#/MODULE
- KARDEX EQUIP. WEIGHT = 2350# + (70 PANS x 25#) = 4100#
- KARDEX WEIGHT AND FULL PAYLOAD ACT AT 0.5' ECCENTRICITY RELATIVE TO CENTERLINE OF FOOTING.
- CHECK 1/2 PAYLOAD ACTING AT GREATER ECCENTRICITIES

### SEISMIC LOADING

$V = 2.5 A_v I K C S W$

$= 2.5(0.2)(1.5)(1.33)(0.14)W$

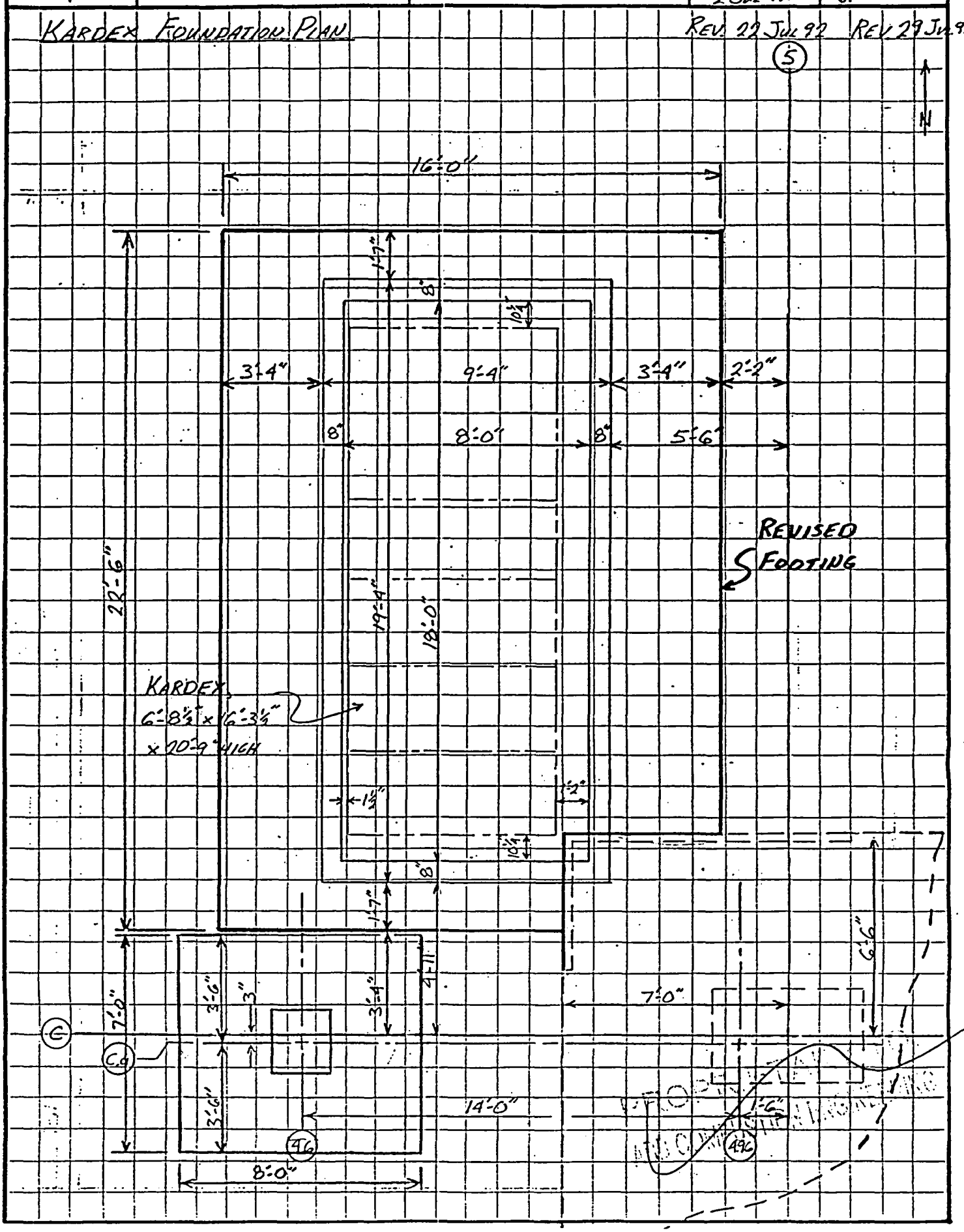
$= 0.140W$



| METROPOLITAN ENGINEERING COMPANY | Design By JMH | Job No. 251.037 |
|---|---|---|
| Job | Checked By | Sheet 2 |
| For | Date 2 JUL 92 | of |

KARDEX FOUNDATION PLAN

REV. 22 JUL 92 REV. 29 JUL 92



## SEISMIC LOADING

CONCRETE BLOCK ENCLOSURE -

$V = 2.5 A_v I K C S W$

$= 2.5(0.2)(1.5)(1.33)(0.14)W$

$= 0.140 W$

KARDEX EQUIPMENT -

TREAT AS A STORAGE RACK, USING BOCA 1113.10 FOR COMPONENTS. NOTE b OF TABLE 1113.10 APPLIES, SINCE THERE ARE A NUMBER OF STORAGE RACKS CONNECTED, WITH A MINIMUM OF 4 VERTICAL ELEMENTS.

$V = 2.5 A_v I K C S W$

$= 2.5(0.2)(1.5)(1.00)(0.2)W$

$= 0.15 W$, WHERE $W$ = DEAD LOAD PLUS 50% OF THE RACK-RATED CAPACITY.

## KARDEX DESIGN LOADS

EQUIPMENT WEIGHT = 2350# + (70 PANS × 25#) = 4100#/MODULE

RATED PAYLOAD CAPACITY = 16,000#/MODULE

DIMENSIONS = 16.3'W × 6.71'D × 20.75'H

(3) LOADING POSSIBILITIES, AS FOLLOW, WILL BE USED TO DESIGN THE FOUNDATION

### CASE "A" - FULLY LOADED KARDEX

$P = 6(4100 + 16{,}000) = 120{,}600^{\#}$

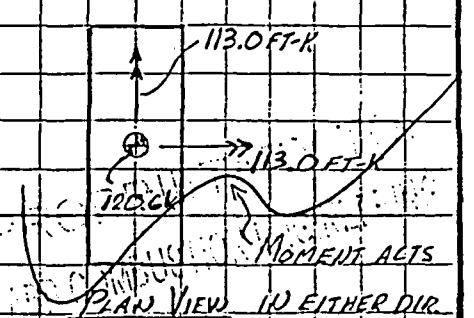
SEISMIC SHEAR, $V = 0.15(6)\left(4100 + \frac{16000}{2}\right)$

$= \underline{10{,}890^{\#}}$

OVERTURNING MOMENT, $M = 10{,}890\left(\frac{20.75'}{2}\right)$

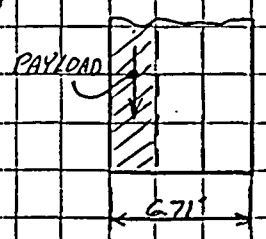
$= 112{,}980$ FT-LB

(AT BASE OF KARDEX)



CASE "B" - KARDEX W/ HALF PAYLOAD, LOADED AT FRONT

$P = 6\left(4100 + \frac{16000}{2}\right) = 72{,}600^{\#}$



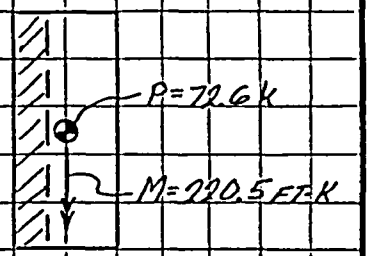

PAYLOAD ACTS AT ECCENTRICITY

$= \frac{1}{3}(6.71') = 2.24'$

OVERTURNING MOMENT,

$M = 112{,}980 + 6\left(\frac{16000}{2}\right)(2.24')$

$= 220{,}500$ FT-LB



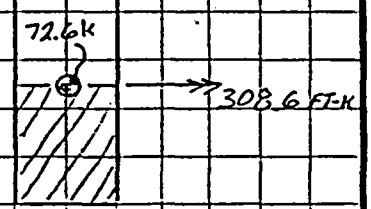

PLAN VIEW

CASE "C" - KARDEX W/ HALF PAYLOAD, LOADED AT END

$P = 72{,}600^{\#}$

PAYLOAD ECC. $= \frac{1}{4}(16.3') = 4.075'$

$M = 112{,}980 + 3(16000)(4.075) = 308{,}580$ FT-LB




## ENCLOSURE LOADS

### ROOF

ASSUME 5" THK CONC. W/ 4" OVERHANGS, 20 PSF LIVE LOAD

TOTAL W = 12.5 K (DL)
4.0 K (LL)

ROOF AREA $= (10')(20') = 200$ FT$^2$

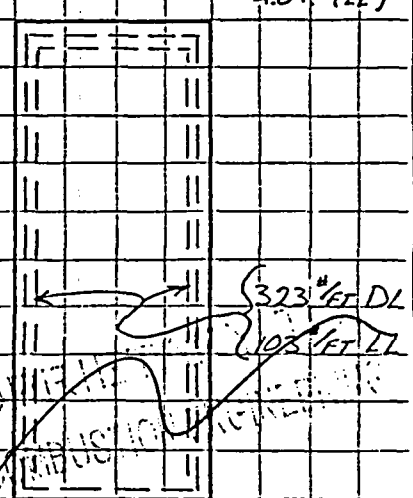
WEIGHT $= \left(\frac{5}{12}\right)(150^{\#}/\text{FT}^3)(200) = \underline{12{,}500^{\#}}$

$\frac{12{,}500}{2(19.33)} = 323^{\#}/\text{FT. OF WALL}$

LIVE LOAD $= (20^{\#}/\text{FT}^2)(200\text{ FT}^2) = \underline{4000^{\#}}$

$\frac{4000}{2(19.33)} = 103^{\#}/\text{FT OF WALL}$

(C.G. OF ROOF SLAB = 26.2' ABOVE FIN. FLR.)




ROOF PLAN

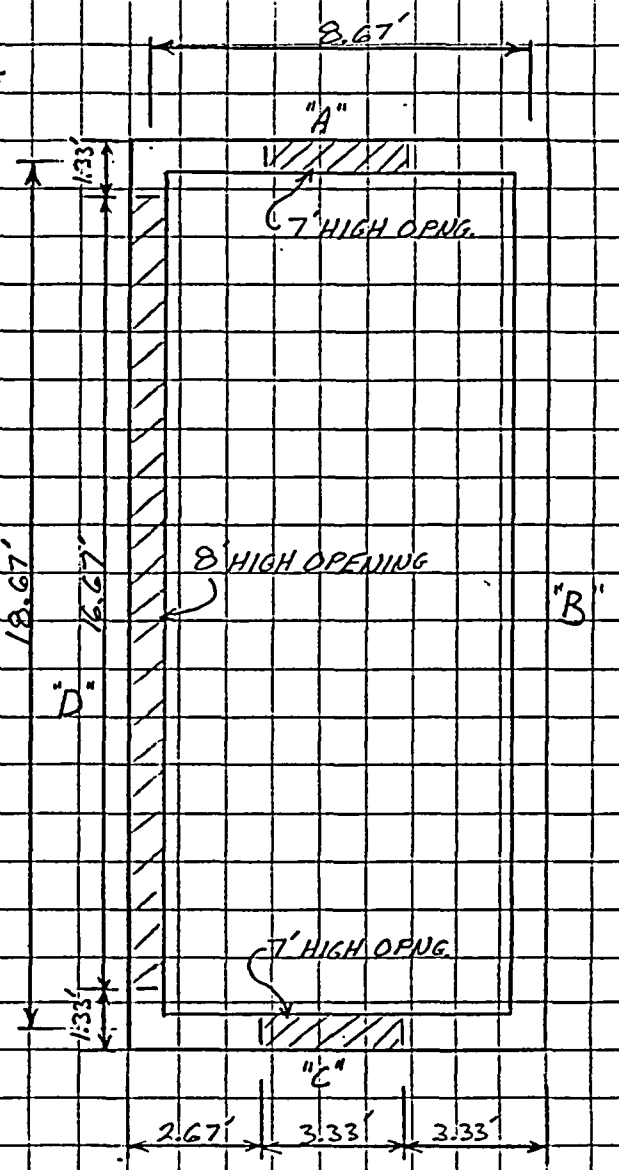
| METROPOLITAN ENGINEERING COMPANY | Design By JMH | Job No. 251.037 |
|---|---|---|
| Job | Checked By | Sheet 5 |
| For | Date 23 JUL 92 | of |

WALLS

ASSUME 8" CONC. BLOCK W/REINF. @ 24" O.C.

$A = 63.90\ in^2/FT$

$WEIGHT = (63.9/144)(150\#/FT^3) = 67\ PSF$




WALLS "A" & "C"

$AREA = (26')(8.67') - (7')(3.33')$

$= 225 - 23 = 202\ FT^2$

$WEIGHT = 202(67) = \underline{13{,}530\#}$

$C.G. = \dfrac{225(13') - 23(3.5)}{202}$

$= 14.1'$ ABOVE FIN. FLR.

WALL "B"

$AREA = (26')(18.67') = 485\ FT^2$

$WEIGHT = 485(67) = \underline{32{,}500\#}$

C.G. = 13' ABOVE FIN. FLR.

WALL "D"

$AREA = (26')(18.67') - (8')(16.67')$

$= 485 - 133 = 352\ FT^2$

$WEIGHT = 352(67) = \underline{23{,}580\#}$

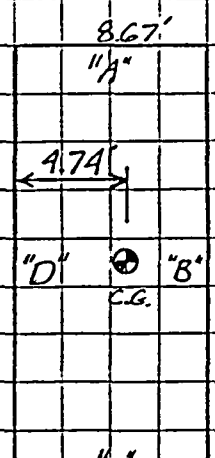
$C.G. = \dfrac{485(13') - 133(4')}{352} = 16.4'$ ABOVE FIN. FLR.

| METROPOLITAN ENGINEERING COMPANY | Design By JMH | Job No. 251.037 |
|---|---|---|
| Job | Checked By | Sheet 6 |
| For | Date 23 JUL 92 | of |

REV. 29 JUL 92

## COMBINED WALL & ROOF LOADS

| | W | $\bar{w}$ | $W\bar{w}$ | h | Wh |
|---|---|---|---|---|---|
| ROOF | 17.50k | 4.335' | 54.19 | 20.2' | 327.5 |
| WALL "A" | 13.53k | 4.335 | 58.65 | 14.1 | 190.8 |
| " "B" | 32.50k | 8.67 | 281.79 | 13.0 | 422.5 |
| " "C" | 13.53k | 4.335 | 58.65 | 14.1 | 190.8 |
| " "D" | 23.58k | 0 | 0 | 10.4 | 386.7 |
| | 95.64k | | 453.27 | | 1518.3 |




$$\bar{w} = \frac{453.27}{95.64} = 4.74'$$

$$h = \frac{1518.3}{95.64} = 15.88' \text{ (C.G. ABOVE FIN. FLR.)}$$

TOTAL SEISMIC SHEAR, $V = 0.140(95.64) = 13.4k$ (ACTING @ 15.88' ABOVE FIN. FLR.)

OVERTURNING MOMENT $= 13.4(15.88) = 212.8$ FT-K (SEISMIC ONLY)

## FOUNDATION LOADS (WEIGHT)

ASSUME 25' x 25' FOOTING

WALLS $= (54.7')(0.67')(4')(150\text{ PCF}) = 21{,}990^{\#}$

FLOOR SLAB $= [(25')(25') - (54.7')(0.67')](1.0')(150\text{ PCF})$ (ASSUME 1' SLAB INSIDE AND OUTSIDE)

$= (588\text{ FT}^2)(1.0')(150\text{ PCF}) = 88{,}200^{\#}$

STONE $= (588\text{ FT}^2)(3.0')(135\text{ PCF} \times 0.95) = 226{,}230^{\#}$

BASE SLAB $= (25')(25')(1.5')(150\text{ PCF}) = 140{,}620^{\#}$

TOTAL $= 477{,}040^{\#} = 477k$

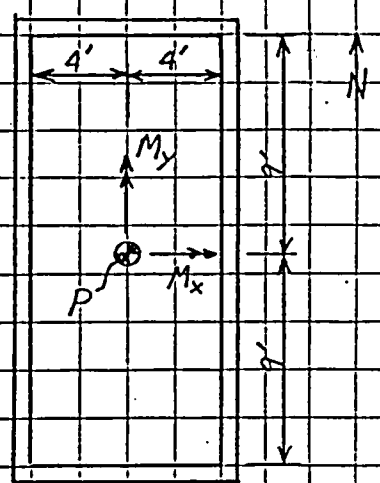
$$q_{FOUNDATION} = \frac{477k}{(25')(25')} = 0.763\text{ KSF}$$

NOTE:

FOR REVISED FOOTING DESIGN, GO TO SHEET 17

## LOAD SUMMARY FOR FOUNDATION DESIGN

SUMMARIZE ALL PREVIOUS LOADS, RELATIVE TO THE CENTROID OF THE KARDEX ENCLOSURE, WITH MOMENTS TAKEN ABOUT THE BASE OF THE FOOTING (EL. 429.5')




① KARDEX, FULLY LOADED

w/o SEISMIC:

$P = 120.6k$

$M_x = 0$

$M_y = 120.6(-0.52') = -62.7$ FT-K

ADD'L SEISMIC LOADS:

$P = 0$

$M_x = \pm(113.0 + 10.89k \times 5.69') = \pm 175.0$ FT-K

$= \pm 175.0$ FT-K (N-S EQ ONLY)

$M_y = \pm 175.0$ FT-K (E-W EQ ONLY)

② KARDEX, FRONT HALF LOADED

W/O SEISMIC:

$P = 72.6$ K

$M_x = 0$

$M_y = 6[4.1(-0.52') + 8.0(-0.52' - 2.24')] = -145.3$ FT-K

USE SAME SEISMIC ADD AS ABOVE.

③ KARDEX, REAR HALF LOADED

$P = 72.6$ K

$M_x = 0$

$M_y = 6[4.1(-0.52') + 8.0(-0.52 + 2.24')] = 69.8$ FT-K

USE SAME SEISMIC ADD AS ABOVE

④ KARDEX, ONE END LOADED

$P = 72.6k$

$M_x = 3(16.0)(\pm 4.075') = \pm 195.6$ FT-K

$M_y = 72.6(-0.52') = -37.8$ FT-K

USE SAME SEISMIC ADD AS ABOVE

⑥ ENCLOSURE

W/O SEISMIC:

$P = 95.64 + \overset{LL}{4.0} = 99.6\ K$

$M_x = 0$

$M_y = 95.64(0.405') = 38.7\ FT\text{-}K$

ADD'L. SEISMIC LOADS:

$P = 0$

$M_x = \pm(212.8 + 13.4 \times 5.5') = \pm 286.5\ FT\text{-}K$ (N-S EQ ONLY)

$M_y = \pm 286.5\ FT\text{-}K$ (E-W EQ ONLY)

CHECK SOIL BEARING PRESSURE FOR THE ASSUMED 25'x25' FOOTING

$$q = \frac{P}{A} \pm \frac{6M_x}{bd^2} \pm \frac{6M_y}{b^2d} = \frac{P}{25^2} \pm \frac{6M_x}{25^3} \pm \frac{6M_y}{25^3} =$$

VOID

GO TO SHT. 17

$$q_{MAX} = \frac{P}{625} + \frac{M_T}{2604}$$

$$q_{MIN} = \frac{P}{625} - \frac{M_T}{2604}$$

WHERE $M_T = |M_x| + |M_y|$

| LOAD COMBINATION | SEISMIC DIRECTION | P | $M_x$ | $M_y$ | $M_T$ | $q_{MAX}$ | $q_{MIN}$ |
|---|---|---|---|---|---|---|---|
| ① + ⑥ | NONE | 220.2 | 0 | -24.0 | 24.0 | 0.362 KSF | 0.343 KSF |
| ② + ⑥ | " | 172.2 | 0 | -106.6 | 106.6 | 0.316 KSF | 0.235 KSF |
| ③ + ⑥ | " | 172.2 | 0 | 108.5 | 108.5 | 0.317 KSF | 0.234 KSF |
| ④ + ⑥ | " | 172.2 | 195.6 | 0.9 | 196.5 | 0.351 KSF | 0.200 KSF |
| → ① + ⑥ | E-W | 220.2 | 0 | -485.5 | 485.5 | 0.539 KSF | 0.166 KSF |
| ② + ⑥ | E-W | 172.2 | 0 | -568.1 | 568.1 | 0.494 KSF | 0.057 KSF |
| ③ + ⑥ | E-W | 172.2 | 0 | 570.0 | 570.0 | 0.494 KSF | 0.057 KSF |
| ④ + ⑥ | N-S | 172.2 | 657.1 | 0.9 | 658.0 | 0.528 KSF | 0.023 KSF |

ABOVE PRESSURES DO NOT INCLUDE UNIFORM FOUNDATION PRESSURE OF 0.763 KSF

FULL KARDEX PAYLOAD, W/ SEISMIC, CONTROLS

$q_{MAX} = 0.539 + 0.763 = 1.302\ KSF$

$q_{NET} = 1.302 - \overset{PRELOAD}{3}(0.1\ PCF) = 1.002\ KSF < q_u = 1.5\ KSF$ OK

| METROPOLITAN ENGINEERING COMPANY | | Design By JMH | Job No. 251.037 |
|---|---|---|---|
| Job | For | Checked By | Sheet 9 THRU 16 |
| | | Date | of |

SHEETS 9 THRU 16 INTENTIONALLY LEFT BLANK

| METROPOLITAN ENGINEERING COMPANY | Design By JMH | Job No. 251.057 |
|---|---|---|
| Job | Checked By | Sheet 17 |
| For | Date 29 JUL 92 | of |

PER DISCUSSION WITH JOHN KOSTYSHOCK ON 28 JUL 92, I WILL REDESIGN THE FOOTING, ALLOWING HIGHER SOIL BEARING PRESSURES ON THE BASE OF THE FOOTING. IT IS ACCEPTABLE TO DESIGN FOR A NET ALLOWABLE BEARING PRESSURE OF 1500 PSF, WITH A 1/3 INCREASE FOR SEISMIC LOADS. IF I DESIGN TO A HIGHER BEARING PRESSURE THAN THIS, WE CAN OVEREXCAVATE AND BACKFILL WITH COMPACTED MATERIAL, USING THE COMPACTED MATERIAL TO DISTRIBUTE THE LOAD OVER A LARGER AREA.

I WILL ALSO DESIGN THE FOOTING, ASSUMING IT ACTS INDEPENDENTLY OF THE SC COLUMN FOOTING ALREADY IN PLACE.

## TRIAL FOOTING

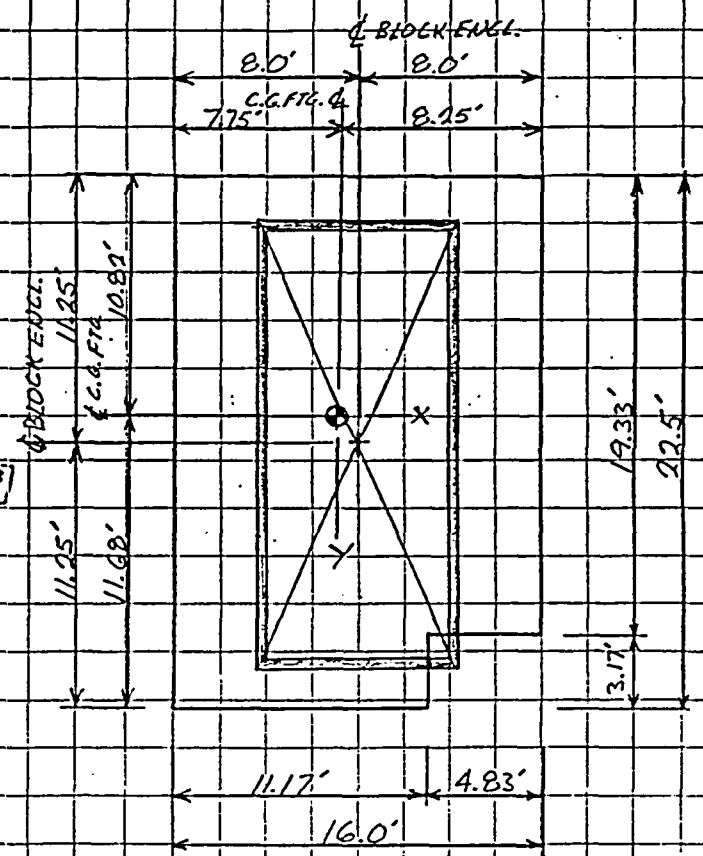
$$A = 16(22.5) - 4.83(3.17)$$
$$= 360 - 15.31$$
$$= 344.7\ FT^2$$

$$\bar{x} = \frac{360(8) - 15.31(13.58)}{344.7} = 7.75'$$

$$\bar{y} = \frac{360(11.25) - 15.31(20.92)}{344.7} = 10.82'$$

$$I_x = \frac{1}{3}\left[16(10.82)^3 + 11.17(11.68)^3 + 4.83(8.51)^3\right]$$
$$I_x = 13680\ FT^4$$

$$I_y = \frac{1}{3}\left[22.5(7.75)^3 + 19.33(8.25)^3 + 3.17(3.42)^3\right]$$
$$I_y = 7151\ FT^4$$




FROM PREVIOUS CALC'S, SHEET 8, ASSUME FULLY LOADED KARDEX, & EAST-WEST EARTHQUAKE CONTROL THE DESIGN.

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|---|---|---|
| Job | Checked By | Sheet 18 |
| For | Date 29 JUL 92 | of |

KARDEX;

$P = 120.6\,k$

$e_x = (8 - 0.52) - 7.75 = -0.27'$

$e_y = 11.25 - 10.82 = 0.43'$

$M_{EQ} = 175.0$ FT-K

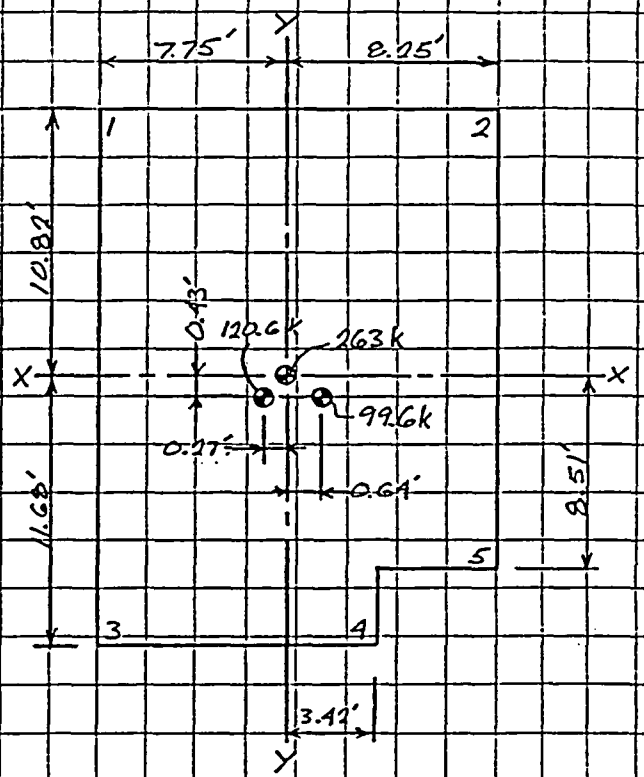
ENCLOSURE;

$P = 95.6 + 4.0 = 99.6\,k$

$e_x = \left(\frac{95.6(8.405) + 4(8.0)}{99.6}\right) - 7.75 = 0.64'$

$e_y = 0.43'$

$M_{EQ} = 286.5$ FT-K




FOOTING, WALLS, SLAB, SOIL;

$P = 0.763\,KSF\,(344.7\,FT^2) = 263\,k$

COMBINED;

$P = 120.6 + 99.6 + 263 = 483.2\,k$

$M_x = 120.6(0.43) + 99.6(0.43) = 94.7$ FT-K (+461.5 FT-K, N-S EQ)

$M_y = 99.6(0.64) - 120.6(0.27) = 31.2$ FT-K (+461.5 FT-K, E-W EQ)

SOIL BEARING PRESSURES;

$$q = \frac{P}{A} + \frac{(M_y)(x)}{I_y} + \frac{(M_x)(y)}{I_x} = \frac{483.2}{344.7} + \frac{M_y\,x}{7151} + \frac{M_x\,y}{13{,}680}$$

| CORNER | x | y | q' No EQ | q' N-S EQ | q' E-W EQ |
|---|---|---|---|---|---|
| 1 | -7.75' | -10.82' | 1.293 KSF | 0.928 KSF | 0.793 KSF |
| 2 | 8.25' | -10.82' | 1.363 KSF | 0.998 KSF | 1.895 KSF |
| 3 | -7.75' | 11.68' | 1.449 KSF | 1.843 KSF | 0.949 KSF |
| 4 | 3.42' | 11.68' | 1.498 KSF | 1.892 KSF | 1.718 KSF |
| 5 | 8.25' | 8.51' | 1.497 KSF | 1.789 KSF | 2.029 KSF |

w/o EQ; Max. $q_{NET} = 1.498 - 3'(0.100) = 1.198$ KSF (PRELOAD) $< 1.5$ KSF

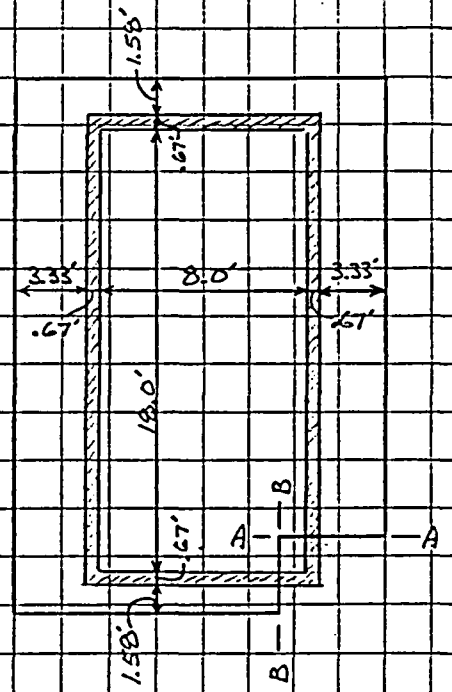
w/EQ; Max. $q_{NET} = 2.029 - 3'(0.100) = 1.729$ KSF $< 1.5 \times 1.33 = 2.0$ KSF

## FOOTING DESIGN

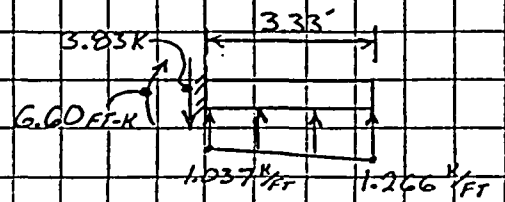
SECTION A-A: (E-W STEEL)

E-W EARTHQUAKE CONTROLS

NET $q_{EDGE} = 2.029 - 0.763$
$= 1.266$ KSF




AT FACE OF WALL,
$x = 4.97'$, $y = 8.51'$, $q = 1.800$ KSF
NET $q_{WALL} = 1.800 - 0.763 = 1.037$ KSF




TRY USING 15" DEEP FOOTING.
$d = 15" - 3" - 3/4" - 3/8" = 10.9"$

TRY $A_s = \frac{6.60(12)}{24(7/8)(10.9)} = 0.346 \text{ in}^2$

USING #5 @ 10", $A_s = 0.37 \text{ in}^2$, $nA_s = 9(0.37) = 3.33 \text{ in}^2$

$\frac{1}{2}(12)x^2 = 3.33(10.9 - x)$
$x^2 + 0.555x - 6.05 = 0 \Rightarrow x = 2.20" \Rightarrow A_{RM} = 10.9 - \frac{2.20}{3} = 10.2"$

$C = T = \frac{6.60(12)}{10.2} = 7.76$ K

$f_c = \frac{2(7.76)}{12(2.20)} = 0.588$ KSI $< 1.35$ KSI OK

$f_s = \frac{7.76}{0.37} = 21.0 < 24$ KSI OK

SHEAR, $f_v = \frac{3.83}{12(10.9)} = 0.029$ KSI $< 60$ PSI OK

SECTION B-B: (N-S STEEL)

N-S EARTHQUAKE CONTROLS

NET $q_{EDGE} = 1.892 - 0.763 = 1.129$ KSF

$V_{MAX} = 1.129(1.58') = 1.78$ K

$M_{MAX} = 1.129\left(\frac{1.58^2}{2}\right) = 1.41$ FT-K

BY INSPECTION, #5 @ 12" O.C. ARE OK

AREA WITHIN WALLS OF ENCLOSURE:

DESIGN AS A TWO WAY SLAB, 8'x18'

ASSUME UPWARD PRESSURE = 1.80 KSF

DOWNWARD LOAD = $\overset{\text{FNDN.}}{0.763 \text{ KSF}} + \frac{\overset{\text{KARDEX}}{120.6}}{8(18)} = 1.60$ KSF

NET UPWARD $q = 1.80 - 1.60 = 0.20$ KSF

$18'/8' = 2.25 \Rightarrow C_{18'} = 0.035$ & $C_{8'} = 0.106$

ACROSS 8' WIDTH, $M_{MAX} = 0.106(0.20)(8)^2 = 1.36$ FT-K

ALONG 18' LENGTH, $M_{MAX} = 0.035(0.20)(18)^2 = 2.27$ FT-K

BY INSPECTION USE #5 BARS @ 12" O.C. EACH WAY (TOP STL)

| METROPOLITAN ENGINEERING COMPANY | Design By JMH | Job No. 251037 |
|---|---|---|
| Job | Checked By | Sheet 20A |
| For | Date 24 AUG 92 | of |

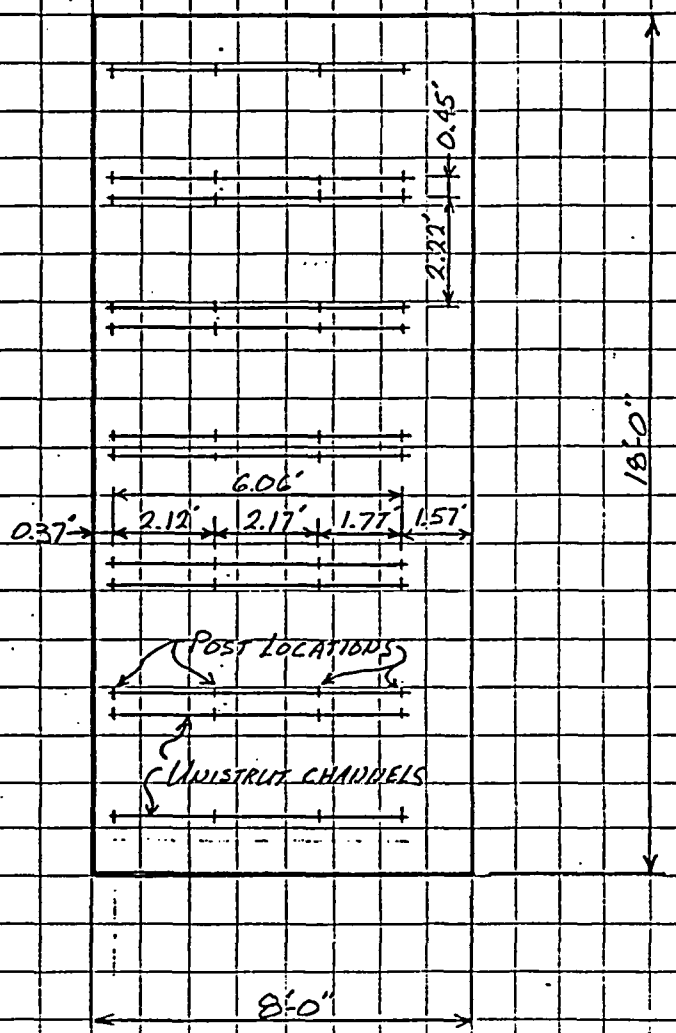
## SLAB DESIGN - KARDEX FLOOR LEVEL

KARDEX MODULE WEIGHS
4100# + 16,000 = 20,100#

POST LOAD = $\frac{20,100}{8}$ = 2510# (DL)

FROM PREVIOUS CALC'S,
OVERTURNING MOMENT =
112,980 FT-LB FOR ALL 6 MODULES

ADD'L POST LOAD = $\frac{112,980}{\frac{1}{2}(6.06')}$ = 1550# (EQ)




TOTAL EQUIP WEIGHT
= 6(20,100) = 120,600#
AT 0.6' ECCENTRICITY

SOIL BEARING PRESSURE (DL)
$= \frac{120,600}{18(8)} \pm \frac{6(120,600)(0.6)}{18(8)^2}$

= 838 ± 377
= 461 PSF MIN., 1215 PSF MAX.

SOIL BEARING PRESSURE (EQ)
$= \pm \frac{6(112980)}{18(8)^2}$

= ± 588 PSF

TO PREVENT TENSION IN SOIL (UPLIFT OF SLAB),
REQ'D. SLAB WEIGHT = 588 - 461 = 127 PSF  10" MIN. SLAB REQ'D.

$q_{MAX} = 1215 + 588 = 1803$ PSF

CONSERVATIVELY, DESIGNING SLAB FOR 1803 PSF OVER ENTIRE AREA,

$M_{MAX} = 1803\left(\frac{1.57^2}{2}\right) = 2222$ FT-LB/FT ← CONTROLS

OR $M_{MAX} = 1803\,\frac{(2.22+0.45)^2}{8} = 1610$ FT-LB/FT

TRY USING 10" SLAB,

$d = 12" - 3" - 3/4" - 3/8" = 7.88"$

$M = 2222$ FT-LB $= 26.7$ IN-K

$A_s = \frac{26.7}{24(7/8)(7.88)} = 0.161$ IN²/FT

USING #5 @ 12" O.C., $A_s = 0.31$ IN²/FT  OK BY INSPECTION

SHEAR:

$V_{MAX} = 1803(1.57') = 2830^{\#}$

$f_v = \frac{2830}{12(7.88)} = 30$ PSI < 60 PSI  OK

MAX. POST LOAD = 2510 + 1550 = 4060#

REQ'D BEARING AREA $= \frac{4060}{0.3(3000)} = 4.5$ IN²  (2.12" x 2.12" BRG. AREA)
∴ 4" x 12" SHIMS OK

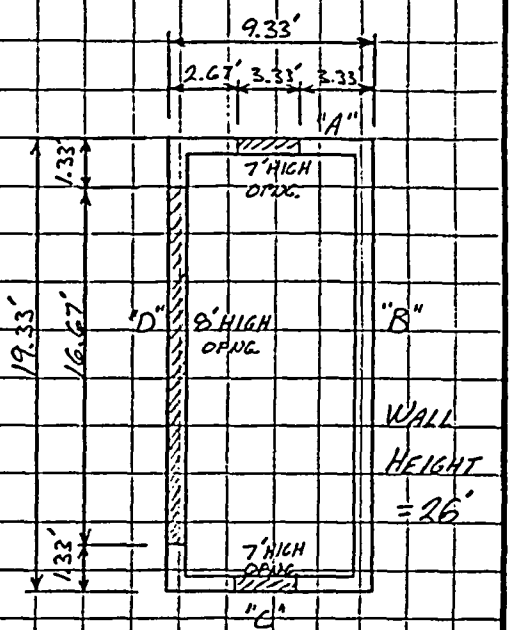
FOR PUNCHING SHEAR, USE $b_0 = 4(2.12 + 7.88) = 40"$

$f_v = \frac{4060}{40(7.88)} = 13$ PSI < 110 PSI  OK

## ENCLOSURE WALLS

FROM SHEET 4,

ROOF DL = 323 #/FT } ASSUME 3" ECCENTRICITY TO ℄ WALL
" LL = 103 #/FT }
426 #/FT (WALLS "B" & "D")




WALL WEIGHT = 67 PSF

SEISMIC LOAD = 0.140 W
= 0.140 (12,500#) = 1750# (TOTAL ROOF) } DESIGN OF SHEAR WALLS ONLY
= 0.140 (67) = 9.38 PSF (WALLS)

FOR PORTIONS OF BUILDINGS,
$F_p = 2.5 A_v I C_p W_p = 2.5(0.2)(1.5)(0.3) W_p = 0.225 W_p$
$= 0.225(67) = 15.1$ PSF (LATERAL WALL LOAD)

USE 8" CMU WALL, PARTIALLY GROUTED (48" O.C.)
$f'_m = 1350$ PSI $f_y = 60{,}000$ PSI

## WALL "B"

RE: "DESIGN OF REINFORCED MASONRY TALL SLENDER WALLS", PUBLISHED BY WESTERN STATES CLAY PRODUCTS ASSOCIATION.

1. LOADS

BASED ON GROUT @ 24" O.C. MAY BE CONSERVATIVE, BUT IT HELPS ACCOUNT FOR WGT. OF BOND BEAMS.

a. WEIGHT OF WALL = 67 PSF (GROUTED @ 48" O.C.)
$P_w = 67(26'/2) = 871$ #/FT (@ MID-HEIGHT)

$P_o = 426$ #/FT (ROOF LOAD)

CHECK AXIAL LOAD LIMITATION:
$\frac{P_w + P_o}{A_g} \le 0.04 f'_m$

$\frac{871 + 426}{57.0} = 22.8$ PSI $< .04(1350) = 54$ PSI OK

b. LATERAL LOAD
W = 15.1 PSF (SEISMIC)

c. FACTORED LOADS, $U = 0.75(1.4D + 1.7L + 1.87E)$

FACTORED WALL LOAD, $P_{wu} = 0.75(1.4)(871) = 915\ \#/FT$

" ROOF ", $P_{ou} = 0.75[(1.4)(323) + 1.7(103)] = 470\ \#/FT$

" VERTICAL ", $P_u = 1385\ \#/FT$

FACTORED SEISMIC LOAD, $w_u = 0.75(1.87)(15.1) = 21.2\ \#/FT^2$

2. ASSUME VERTICAL REINF STEEL, #5 @ 48" O.C.

$A_s = 0.31(12/48) = 0.0775\ IN^2/FT$

$\rho_g = \frac{A_s}{bt} = \frac{0.31}{48(7.625)} = 0.0008$ > 0.0007 MIN, < 0.0040 MAX OK

$d = t/2 = 7.625/2 = 3.81"$

$\rho = \frac{A_s}{bd} = \frac{0.31}{48(3.81)} = 0.00170$

$A_{se} = \frac{P_u + A_s f_y}{f_y} = \frac{1385 + 0.0775(60{,}000)}{60{,}000} = 0.101\ IN^2/FT$

$a = \frac{P_u + A_s f_y}{0.85 f'_m b} = \frac{1385 + 0.0775(60{,}000)}{0.85(1350)(12)} = 0.438"$ < 1.25" THK. OF FACE SHELL. (∴ NOT TEE)

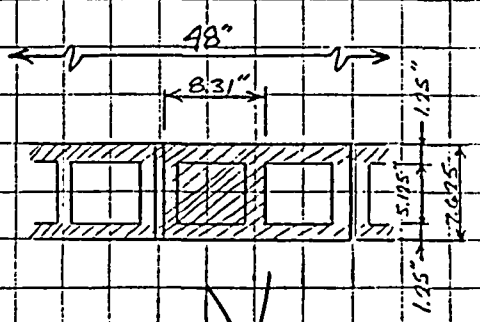
$c = \frac{a}{0.85} = \frac{0.438}{0.85} = 0.515"$

3. MODULUS OF ELASTICITY, $E_m$

$E_m = 1000 f'_m = 1000(1350) = 1{,}350{,}000\ PSI$

$n = \frac{E_s}{E_m} = \frac{29{,}000{,}000}{1{,}350{,}000} = 21.5$

$f_r = 2.5\sqrt{f'_m} = 2.5\sqrt{1350} = 91.9\ PSI$




$I_g = \frac{1}{12}[(48)(7.625)^3 - (48-8.31)(5.125)^3](12/48)$

$I_g = 332\ IN^4/FT$

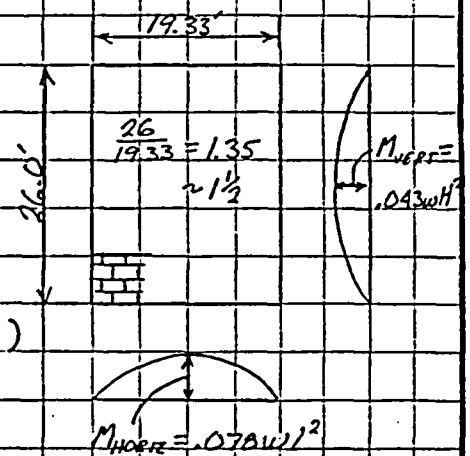
4. MOMENT AT CRACKING, $M_{cr}$

$M_{cr} = f_r\left(\frac{2I_g}{t}\right) = 91.9\left(\frac{2 \times 332}{7.625}\right) = 8003\ IN\text{-}LBS/FT$

$I_{cr} = nA_{se}(d-c)^2 + \frac{bc^3}{3} = 21.5(0.101)(3.81-0.515)^2 + \frac{12(0.515)^3}{3} = 24.1\ IN^4/FT$

5. CALCULATE MID-HEIGHT MOMENT AND LATERAL DEFLECTION UNDER SERVICE LOADS BY ITERATION PROCESS, USING PΔ METHOD.

USE FIG. 3-7 OF "CONCRETE MASONRY HANDBOOK", TO DETERMINE MOMENT IN WALL DUE TO SEISMIC LOADING




FIRST ITERATION, ASSUME $\Delta = 0.13''$

$$M_{s1} = 0.043 w H^2 + P_o\left(\frac{e}{2}\right) + (P_o + P_w)\Delta$$

$$= 0.043(15.1)(26)^2(12) + 426\left(\frac{3}{2}\right) + (426+871)(.13)$$

$$= 5267 + 639 + 169$$

$$= 6075 \text{ IN-LB} < M_{cr}$$

$$\Delta_{s1} = \frac{5M_s h^2}{48 E_m I_g} = \frac{5(6075)(26\times12)^2}{48(1{,}350{,}000)(332)} = 0.137''$$

SINCE $0.137'' \sim 0.13''$ ASSUMED, AND SINCE DEFLECTIONS ARE SO SMALL, THERE IS NO NEED TO CARRY THIS ANY FURTHER

6. STRENGTH CALCULATION, USING FACTORED LOADS AND PΔ METHOD

$$M_u = 0.043 w_u H^2 + P_{ou}\left(\frac{e}{2}\right) + (P_{ou} + P_{wu})\Delta_u$$

FIRST ITERATION, ASSUME $\Delta_u = 0.18''$

$$M_{u1} = 0.043(21.2)(26)^2(12) + 470\left(\frac{3}{2}\right) + 1385(0.18)$$

$$= 7395 + 705 + 249$$

$$= 8349 \text{ IN-LB} > M_{cr}$$

$$\Delta_{u1} = \frac{5M_{cr}h^2}{48E_m I_g} + \frac{5(M_u - M_{cr})h^2}{48E_m I_{cr}} = \frac{5(8003)(26\times12)^2}{48(1{,}350{,}000)(332)} + \frac{5(346)(26\times12)^2}{48(1{,}350{,}000)(24.1)} = 0.289''$$

SECOND ITERATION, $\Delta_u = 0.289''$

$$M_{u2} = 7395 + 705 + 1385(.289)$$

$$= 8500 \text{ IN-LB} \sim M_{u1} = 8349 \text{ IN-LB}$$

∴ DESIGN FOR $M_u = 8500$ IN-LB

$$M_n = A_{se} f_y \left(d - \frac{a}{2}\right) = 0.161(60{,}000)\left(3.81 - \frac{0.438}{2}\right) = 21{,}760 \text{ IN-LB}$$

$$\phi M_n = 0.5(21{,}760) = 10{,}880 \text{ IN-LB} > M_u = 8500 \quad \therefore \text{WALL IS OK}$$

NO SPECIAL INSPECTION

NOW CHECK HORIZONTAL BENDING IN WALL.

FROM SHEET 23, $M = 0.078 w L^2$

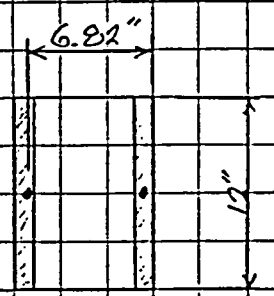
$= 0.078(15.1)(19.33)^2 = 440$ FT-LB / FT. OF WALL HGT.

USING DUR-O-WAL TRUSS JOINT REINF @ 8" O.C.

$A_s = \left(\frac{0.0346}{2}\right)\left(\frac{12}{8}\right) = 0.0260 \text{ in}^2/\text{FT}$ $\quad nA_s = 21.5(0.0260) = 0.559$

$d = 6.82''$

LOCATE NEUTRAL AXIS,




$\frac{1}{2}(12)x^2 = 0.559(6.82 - x)$

$x^2 + 0.0932x - 0.635 = 0 \Rightarrow x = 0.752''$

$ARM = 6.82 - \frac{0.752}{3} = 6.57''$

$C = T = 440(12)/6.57 = 804^{\#}$

$f_c = \frac{2(804)}{12(0.752)} = 178 \text{ PSI} < 225 \text{ PSI}$ OK

$f_s = \frac{804}{0.0260} = 30{,}920 \text{ PSI} < 30{,}000 \times 1.33$ EQ OK

∴ USE STANDARD DUR-O-WAL EVERY COURSE

NOW CHECK WALL "B" AS A SHEAR WALL (N-S SEISMIC LOAD)

ASSUME THE ROOF ACTS AS A RIGID DIAPHRAGM TO TIE THE WALLS TOGETHER. THE WALLS WILL THEN RESIST THE APPLIED SEISMIC LOADS IN PROPORTION TO THEIR RELATIVE RIGIDITIES.

FROM SHEET 6,

TOTAL SEISMIC SHEAR, $V = 13.4$ k, ACTING AT 15.88' ABOVE FIN. FLR

THE RESULTANT OF THE WALL AND ROOF LOADS IS LOCATED AT 4.74 + 0.33 = 5.07' IN FROM THE OUTSIDE FACE OF WALL "D"

## WALL RIGIDITY

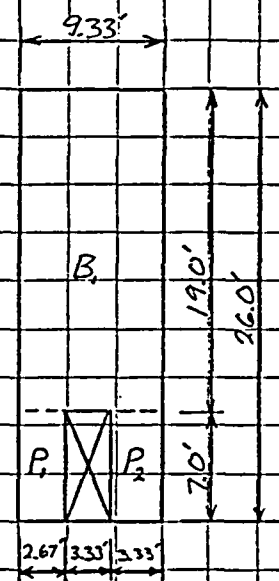
DETERMINE THE RELATIVE RIGIDITY OF THE WALLS, IN RESISTING SEISMIC SHEAR.

RE: "SEISMIC DESIGN FOR THE CIVIL PROFESSIONAL ENGRG. EXAMINATION".

FOR WALL FIXED TOP & BOTTOM, $R = 1/[.1(h/d)^3 + .3(h/d)]$

FOR CANTILEVER WALL, $R = 1/[.4(h/d)^3 + .3(h/d)]$

### WALL "A".




| | h | d | h/d | R | |
|---|---|---|---|---|---|
| $P_1$ | 7.0 | 2.67 | 2.62 | 0.387 | (FIXED) |
| $P_2$ | 7.0 | 3.33 | 2.10 | 0.643 | (FIXED) |
| $B_1$ | 19.0 | 9.33 | 2.04 | 0.250 | (CANTILEVER) |

$$\text{TOTAL RIGIDITY} = \frac{1}{\frac{1}{0.250} + \frac{1}{0.387 + 0.643}} = 0.201$$

CHECK WALL W/O OPENINGS:

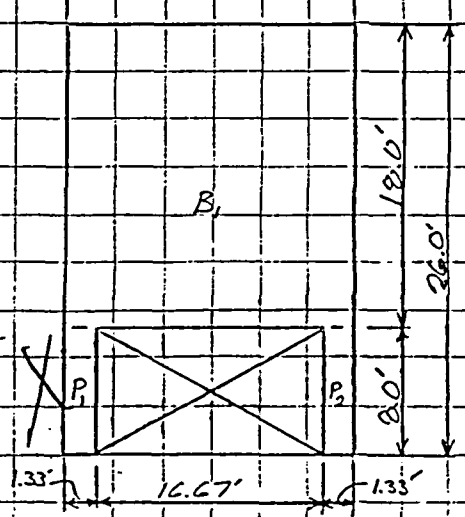
$R = 1/[.4(26/9.33)^3 + .3(26/9.33)] = 0.105$ ← CONTROLS

USE $R_A = 0.105$

### WALL "B" (NO OPENINGS)

$R_B = 1/[.4(26/19.33)^3 + .3(26/19.33)] = 0.555$

### WALL "D"




| | h | d | h/d | R | |
|---|---|---|---|---|---|
| $P_1$ | 8.0 | 1.33 | 6.02 | 0.0423 | (FIXED) |
| $P_2$ | 8.0 | 1.33 | 6.02 | 0.0423 | (FIXED) |
| $B_1$ | 18.0 | 19.33 | 0.931 | 1.661 | (CANTILEVER) |

$$\text{TOTAL RIGIDITY} = \frac{1}{\frac{1}{1.661} + \frac{1}{0.0423 + 0.0423}} = 0.0805$$

CONTROLS

W/O OPENINGS, $R = 0.555$

$R_D = 0.0805$

LOCATE CENTER OF RIGIDITY.

$$\overline{N}_R = \frac{0.555(9') + 0.0805(0.333')}{0.555 + 0.0805} = 7.90'$$

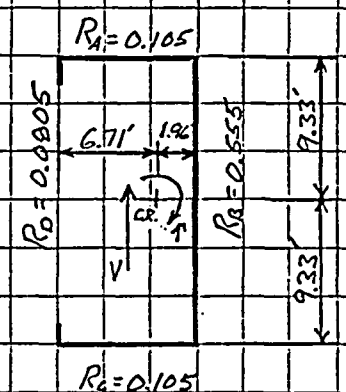
ECCENTRICITY = 7.90 − 5.07 = 2.83'

SEISMIC SHEAR, V = 13.4 k (RESULTANT @ 15.88' ABOVE FIN. FLR.)

TORSIONAL MOMENT, T = 13.4 (2.83') = 37.92 FT-K (N-S EQ. ONLY)

CALCULATE SHEAR FORCES IN EACH WALL

N-S EARTHQUAKE:




SHEAR ONLY:

$$V_B = 13.4\left(\frac{0.555}{0.555 + 0.0805}\right) = 11.7k \downarrow$$

$$V_D = 13.4\left(\frac{0.0805}{0.555 + 0.0805}\right) = 1.70k \downarrow$$

TORSION:

| WALL | R | d | Rd | $Rd^2$ | $V = \frac{T(Rd)}{\Sigma(Rd^2)}$ | |
|---|---|---|---|---|---|---|
| A | 0.105 | 9.33 | 0.980 | 9.14 | 1.55 k ← | |
| B | 0.555 | 1.96 | 1.088 | 2.13 | 1.72 k ↑ | USE 11.7k ↓ (NEGLECT NEGATIVE TORSIONAL STRESS) |
| C | 0.105 | 9.33 | 0.980 | 9.14 | 1.55 k → | |
| D | 0.0805 | 6.71 | 0.540 | 3.62 | 0.85 k ↓ | 0.85 + 1.7 = 2.55 k ↓ |
| | | | | 24.03 | | |

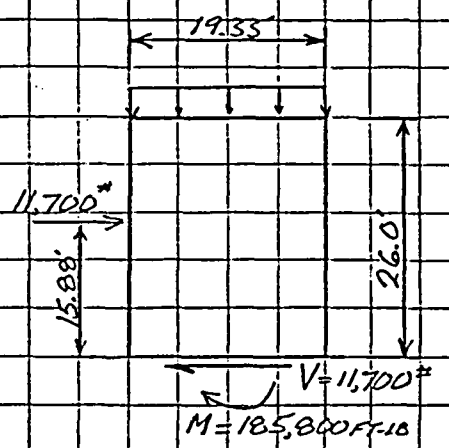
E-W EARTHQUAKE:

$$V_A = V_C = 13.4/2 = 6.7k$$

NOW, CHECK WALL "B" FOR SEISMIC SHEAR FORCES.

V = 11,700#

M = 11,700 (15.88') = 185,800 FT-LB




$l = 19.33(12) = 232''$

$d = 232 - 4 = 228''$ (#5 BAR IN END CELL)

$t = \underset{\text{FACE SHELL}}{2(1.25)} + \underset{\text{GROUTED CELLS}}{\frac{8.31(7.625-2\times1.25)}{48''}}$

$t = 3.39''$

$v = \frac{1.5V}{td} = \frac{1.5(11{,}700)}{3.39(228)} = 22.7\ PSI$

$\frac{M}{Vd} = \frac{185{,}800(12)}{11{,}700(228)} = 0.84$

ASSUMING NO SHEAR REINF, $v_m = 18.3\ PSI \times 1.33 = 24.3\ PSI$

$v = 22.7\ PSI < 24.3\ PSI$ OK ∴ SHEAR STRENGTH IS OK

CHECK OVERTURNING MOMENT;

$M = 185{,}800\ FT\text{-}LB$

TRY (1) #6 BAR IN END CELL

$A_s = 0.44\ in^2$

$nA_s = 21.5(0.44) = 9.46\ in^2$

$b = t = 2.5''$

$d = 228''$

LOCATE N.A.

$\frac{1}{2}(2.5)N^2 = 9.46(228 - N)$

$N^2 + 7.568N - 1726 = 0 \Rightarrow N = 37.93'' \Rightarrow ARM = 228 - \frac{37.93}{3} = 215''$

$C = T = \frac{185{,}800(12)}{215} = 10{,}370^{\#}$

$f_b = \frac{2(10{,}370)}{37.93(2.5)} = 219\ PSI < 225\ PSI \times 1.33$ OK

$f_s = \frac{10{,}370}{0.44} = 23{,}570\ PSI < 24{,}000\ PSI \times 1.33$ OK

∴ USE #6 VERT. BARS IN CORNER CELLS AND AT 48" MAX. SPACING IN BETWEEN.

WALL "D"

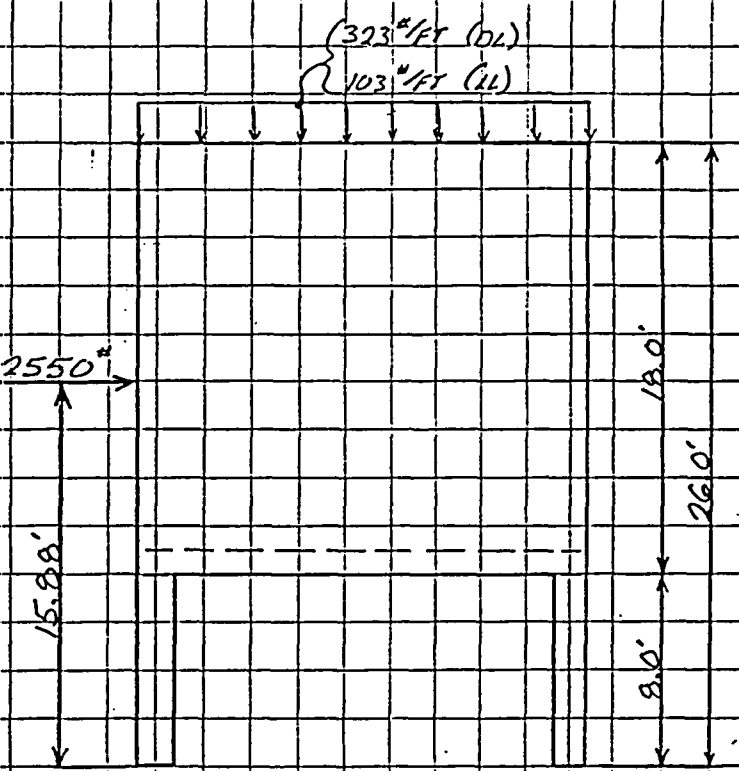
ROOF DL = 323 #/FT
" LL = 103 #/FT

WGT. OF WALL = 23,600#

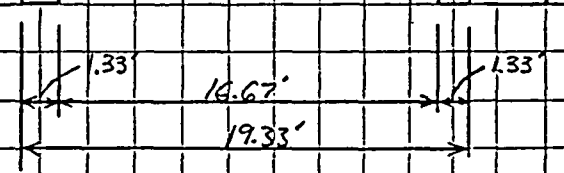
SEISMIC LOADS:

LATERAL WALL LOAD = 15.1 PSF
WALL SHEAR = 2550#

OVERTURNING MOMENT
= 2550 (15.88) = 40,490 FT-LB

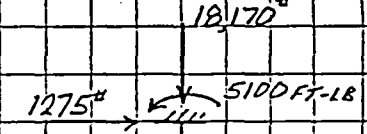



FIRST, CHECK THE BOTTOM 8' OF THE WALL, TREATING IT AS TWO COLUMNS.



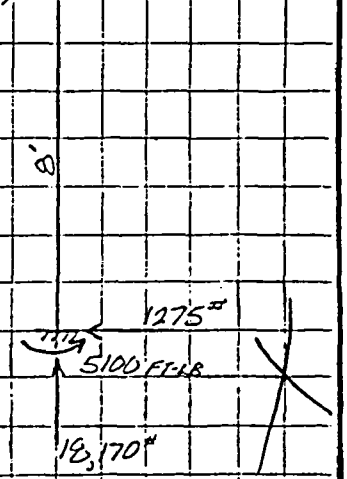

AXIAL LOAD PER COLUMN:

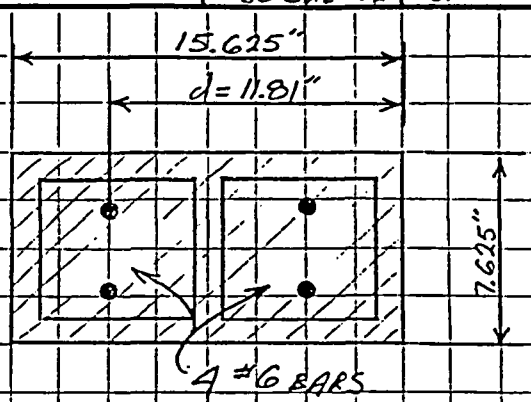
ROOF = $\frac{1}{2}(19.33')(323+103)$ = 4117#
WALLS = $\frac{1}{2}(23,600)$ = 11,800#
DUE TO M = 40,490/18' = 2249#
18,166#




$V = 2550/2 = 1275$ #/COL.

$M = \frac{1275(8)}{2} = 5100$ FT-LB






CHECK SHEAR:

$v = \frac{1.5V}{td} = \frac{1.5(1275)}{7.625(11.81)} = 21.2 \text{ PSI}$

$\frac{M}{Vd} = \frac{5100(12)}{1275(11.81)} = 4.06$

ASSUMING NO SHEAR REINF.,

$v_m = 17 \times 1.33 = 22.6 \text{ PSI} > 21.2 \text{ PSI}$ OK

CHECK AXIAL LOAD:

$P = 18{,}170^{\#}$

$A_g = 7.625(15.625) = 119.1 \text{ in}^2$

$A_s = 4(0.44) = 1.76 \text{ in}^2$ (4 #6 BARS)

$\rho_g = \frac{1.76}{119.1} = 0.0148$

$\text{ALLOW } P = A_g\left(.18 f'_m + .65 \rho_g f_s\right)\left[1 - \left(\frac{h}{40t}\right)^3\right]$

$= 119\left[.18(1350) + .65(.0148)(24000)\right]\left[1 - \left(\frac{8(12)}{40(15.625)}\right)^3\right]$

← (THE 7.625" WIDTH IS BRACED BY THE PERP. WALL)

$= 56{,}230^{\#}$

SINCE MIN. COLUMN DIMENSION IS 8", USE ½ $P_{ALLOW}$, PER UBC 2417(k)

$\therefore P_{ALLOW} = \frac{56230}{2} = 28{,}120^{\#} > P = 18{,}170^{\#}$

NOTE: THIS VALUE IS BASED UPON SPECIAL INSPECTION.

CHECK MOMENT:

$M = 5100 \times 12 = 61{,}200 \text{ IN-LB}$

$d = 11.81"$

$A_s = 2(0.44) = 0.88 \text{ in}^2$

$nA_s = 21.5(0.88) = 18.92 \text{ in}^2$

$\frac{1}{2}(7.625)x^2 = 18.92(11.81 - x)$

$x^2 + 4.963x - 58.61 = 0 \Rightarrow x = 5.566" \Rightarrow \text{ARM} = 11.81 - \frac{5.566}{3} = 9.95"$

$C = T = \frac{61,200}{9.95} = 6151^{\#}$

$f_b = \frac{2(6151)}{5.566(7.025)} = 290 \text{ PSI} < 445 \text{ PSI} \times 1.33$ (WITH INSPECTION) OK

$f_s = \frac{6151}{0.881} = 6990 \text{ PSI} < 24,000 \text{ PSI} \times 1.33$ OK

COMBINED AXIAL + BENDING:

$\frac{P}{P_{ALL}} + \frac{f_b}{F_b} = \frac{18,170}{28,120} + \frac{290}{445} = 1.30 < 1.33$ OK

NOTE THAT THIS DESIGN IS CONSERVATIVE FOR MANY REASONS, INCLUDING:

- I COULD HAVE DESIGNED THE COLUMN AS AN "L" SHAPE, USING 8" OF THE RETURN WALL, AS A FLANGE.
- THE INTERACTION FORMULA USED ABOVE FOR COMBINED AXIAL AND BENDING LOADS IS CONSERVATIVE

# SHULER BUSINESS SYSTEMS, INC. PRICE QUOTATION

Mr. Glen Schukei
Mr. Emil Parent
ASEA, BROWN & BOVERI

Date August 17,1992

In reply refer to Quotation No.

Gentlemen: We propose to furnish the material specified below at the prices quoted and under the conditions stated below and on the reverse side hereof.

Required by _____ Dept. _____ Approved by _____

| Item | Quantity | Size or Catalog No. | Description | Unit | Per | Price |
|---|---|---|---|---|---|---|
| | | | Seismic conditioning of the six modules, KARDEX Industriever 8000 Vertical Lift, Automated Storage and Retrieval System. This includes drawings by KARDEX on the 6 module system (to depict what additional structure and reinforcements will be supplied to each module) sent to an engineering firm in California to certify the drawings as Zone II, Importance factor of 1.5 Missouri Seismic Law.<br><br>Certification will take approximately 2 - 3 weeks.<br><br>If the certifying engineering firm does not add anything to the drawings, I will begin to figure the costs for the additional structure and reinforcement parts.<br><br>A.B.B. Hematite, Missouri, Shuler Business Systems, Inc. and Metropolitan Engineering Company are ready for installation of the 6 modules by the third or fourth week of September. | already existing drawings<br><br>4-6 weeks installation | | NO $4,800.00 work charges together plus added parts ~1200/160 |

probably no schedule effect - systems in SF got thru earthquake

Alternative brace to cement blocks

Terms - NET 30 DAYS F.O.B. _____ Transportation or Delivery Via _____

Subject to our credit department approval, this quotation is made for immediate acceptance and is subject to change without notice. If based on specially printed forms, it presupposes your acceptance of overruns or underruns not exceeding 10% of quantity ordered. Deliveries are subject to delays from fire, strikes, other causes beyond our control. We reserve the right to correct clerical errors. Orders resulting from this quotation are subject to the conditions printed on the reverse side of this sheet. Very truly yours,

SHULER BUSINESS SYSTEMS, INC.

This quotation is being submitted in duplicate for your convenience. To order the items listed, merely sign and return one copy signifying your acceptance.

By Sean M. O'Farrell

Sean O'Farrell

Accepted by _____

Office ~~2305 Weldon Parkway, St. Louis, MO 63146~~

Date _____

Telephone 314/434-4566

Write or Request Data Sheet for an detailed information on other profit producing business methods and equipment.

OCT 05 1992

Combustion Engineering, Inc.
ATTN: James A. Rode
Plant Manager
Hematite Nuclear Fuel Manufacturing
ABB CE Nuclear Fuel
P. O. Box 107, Highway P
Hematite, MO 63047

License No. SNM-33
Docket No. 70-0036

Dear Mr. Rode:

This refers to the announced special safety inspection conducted by Messrs. J. Gavula and G. France, III, of this office on September 14-16, 1992, of activities that affect your license amendment request for consolidating uranium manufacturing operations at your Hematite facility, under NRC Special Nuclear Material License No. SNM-33. This also references the discussion of our findings with Mr. L. Grossman, project manager of the consolidation operation, at the conclusion of the inspection, and the follow up discussion with Ms. B. Bieser, the project scheduler, by telephone on September 21, 1992.

The enclosed copy of our inspection report identifies areas examined during the inspection. As described in the report the emphasis of this inspection was the review of the installation of the uranium oxide storage and retrieval system.

Our evaluation of the uranium oxide storage unit has determined that the construction and installation to date has been accomplished with sound engineering practices. However, as discussed with Mr. Grossman during the inspection a concern was raised that the seismic load was not considered for the interaction between the walls and a free standing unit. As a safeguard and as agreed upon during the inspection, it is our understanding that additional bolts and channel nuts will be attached to the bottom of the frame and that the unit will be anchored to the concrete base, thus providing additional stability. It is also our understanding that a seismic evaluation will be obtained prior to placing the unit in operation. This evaluation along with a review of the additional anchoring of the unit will be reviewed during a future inspection.

In accordance with 10 CFR 2.790 of the Commission's regulations, a copy of this letter and the enclosed inspection report will be placed in the NRC Public Document Room.

We will gladly discuss any questions you have concerning this inspection.

Sincerely,

Original Signed by Roy J. Caniano

Roy J. Caniano, Acting Chief
Nuclear Materials Safety Branch

OCT 05 1992



Enclosure: Inspection Report
No. 70-0036/92004

cc w/enclosure:
Jeremiah W. (Jay) Nixon,
Missouri State Senator
Dr. Richard S. Siudek, President,
ABB CE Nuclear Fuel
Mr. S. B. Junkrans, Vice President,
Manufacturing Operations
Mr. A. E. Scherer, Vice President,
Regulatory Affairs
Mr. L. Grossman, Director, Manufacturing
Technology, Nuclear Fuel
Mr. C. B. Brinkman, Manager,
Washington Nuclear Operations
Mr. J. F. Conant, Manager,
Nuclear Materials Licensing
Mr. H. E. Eskridge, Manager, Nuclear Licensing,
Safety and Accountability
M. Tokar, NMSS/IMSB
DCD/DCB (RIDS)

| | | | |
|---|---|---|---|
| RIII | RIII | RIII | HQ NMSS |
| AMT ☒ YES | YES | | |
| France/bt | Gavula | Caniano | Tokar |
| 10/05/92 | 10/5/92 | 10/5/92 | 10/4/92 |

U.S. NUCLEAR REGULATORY COMMISSION

REGION III

Report No. 70-36/92004

License No. SNM-33
Docket No. 70-36

Licensee: Combustion Engineering, Inc.
Nuclear Power Systems
Windsor, CT 06095

Facility Name: Hematite Facility

Inspection At: Hematite, Missouri

Inspection Conducted: September 14-16, 1992

Inspectors: George M. France, III — 10/05/92
George M. France, III Fuel Facilities Inspector — Date

James A. Gavula — 10/5/92
James A. Gavula, Reactor Inspector — Date

Approved By: Roy J. Caniano — 10/5/92
Roy J. Caniano, Acting Chief, Nuclear Materials Safety Branch — Date

Inspection Summary

Inspection on September 14-16, 1992 (Report No. 70-0036/92004 (DRSS)) Areas Inspected: This was an announced inspection to observe the installation of a uranium oxide storage and retrieval system (Kardex unit). The inspectors also reviewed appropriate drawings and held discussions that were relevant to the design and installation of the Kardex unit.
Results: The inspector determined that the construction and installation of the unit was accomplished with sound engineering practices. The inspector also determined that strengthening the unit by adding bolts to the bottom frame, followed by anchoring the unit to the concrete base should provide a storage unit that is structurally adequate to perform its design function. However, a concern was identified that the seismic load was not considered for the interaction between the walls and a free standing unit. Kardex Systems design engineer agreed with the inspectors findings that it may be appropriate to anchor the unit to the concrete base to provide additional safety. The licensee's project manager concurred with this finding and will pursue anchoring the unit to the floor, followed by an appropriate seismic evaluation.

PROPRIETARY TO COMBUSTION ENGINEERING

## DETAILS

1. Persons Contacted

B. Bieser, Project Scheduler
E. Criddle, Health Physics Supervisor
*L. Grossman, Director, Manufacturing Technology, Nuclear Fuel; and Manager, Fuel Rod Loading Project
J. Rode, Plant Manager
D. Rohde, Project Manager

*Denotes licensee attendance at the exit meeting on September 16, 1992.

The inspector also interviewed representatives of the licensee's vendor, Kardex Office Systems.

2. Licensee Program

The Combustion Engineering facility at Hematite, Missouri, produces uranium dioxide ($UO_2$) fuel for the commercial nuclear power industry. Low enriched uranium hexafluoride ($UF_6$) limited to a maximum enrichment of 5% uranium-235 is received from Department of Energy (DOE) uranium enrichment/gaseous diffusion facilities in 2.5 ton, 30 inch diameter cylinders. The licensee processes $UF_6$ through a series of reactors (R-1, R-2, and R-3) where $UF_6$ is converted to an oxide powder. The powder is pelletized, shipped to a fuel fabricator and ultimately used for commercial fuel.

3. Background

On August 5, 1992, Combustion Engineering submitted an application to NMSS for a license amendment to Special Nuclear Material License No. SNM-33. Approval of this amendment application will enable the licensee to consolidate uranium manufacturing operations at their facility located in Hematite, MO. The operations will include an upgraded version of the basic rod loading and assembly manufacturing steps that were previously performed at their Windsor, CT operations under a different license. This consolidation will require the use of automated equipment to store, retrieve, and load $UO_2$ pellets into fuel rods. During this inspection, the inspectors examined engineering drawings and specifications, held discussions with the vendor representatives, and observed the partial assembly of a uranium oxide pellet storage and retrieval rack. The storage rack, a fully automated unit, manufactured by Kardex Office Systems, is capable of automating the storage and retrieval of more than 55 trays containing more than 5 tons of $UO_2$ pellets.

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ABB COMBUSTION ENGINEERING

4. Uranium oxide ($UO_2$) Storage and Retrieval System (KARDEX STORAGE UNIT)

The storage units appear to be of a general industrial design and are not built to any specific design code. In this application, six individual units are attached to each other to form a single structure. The licensee purchased a "seismic upgrade" package that added additional cross bracing to the standard units. According to the manufacturer, similar units have been installed in California and have been evaluated for seismic loading. Although the licensee had not purchased this evaluation, discussions with the project manager indicated that they would pursue obtaining the evaluation to assure the seismic adequacy of the structure.

Each unit is a bolted structure constructed from "unistrut" type open section members and formed thin gauge material. Outer vertical members approximately 20 feet long are attached to formed pan support brackets that are in turn attached to the internal vertical members. Outer members have lateral braces and cross bracing added. Due to the tray access requirements, internal members can not be cross braced, but do have "horizontal spreaders" at several vertical locations which will provide some lateral stability.

Shop welding was performed on two of the component details. Small diameter bolts were capacitor-discharge stud welded to the bottom of the pan supports for the horizontal spreader attachments. These welds appeared to be adequately performed. For the other component, angle brackets were welded to the bottom frame members. The design drawing specified 0.188 inch by 1.0 inch long fillet welds at six locations. Because of the component sizes, the fillet welds specified could not physically be made. The "as-constructed" weld was a groove weld with maybe a 0.10 inch throat due to the radius of the formed channel. In many cases the lengths of the welds measured in the field were approximately 0.75 inch instead of the 1.0 inch specified. During discussions, the Kardex design engineer stated that these welds were only performed to facilitate construction, and that the loads on these welds would be minimal since the connection would be in compression. For seismic installations, he stated that it may be appropriate to install the bolts and channel nuts to provide additional safety margin in these connections. This issue was communicated to the licensee's project manager who concurred with this approach and said they would have the additional bolts installed.

No anchorage details were specified for the unit. When questioned, the Kardex designer said it could either be anchored to the concrete slab or left to "float"; however, it depended on what the purchaser wanted. The unit will be enclosed by a partially reinforced masonry block wall which was evaluated for seismic loads. The evaluation of the walls did not consider any seismic interaction between the walls and a sliding unit. After discussions, the licensee stated that the units would be anchored to the floor.

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ABB COMBUSTION ENGINEERING

The building housing the Kardex unit was designed to BOCA (Building Official and Code Administration) National Building Code with a seismic zone 2 and a 1.5 Importance Factor. The foundation for the Kardex unit, which is independent of the building foundation, was also designed with these same parameters. The calculation for the Kardex foundation was reviewed by the NRC inspector and found to use conservative assumptions and appropriate methodology for the design.

Based on the observed construction details, in conjunction with the above mentioned refinements for equipment anchorage and bottom frame bolting, the NRC inspector considered the Kardex storage unit to be structurally adequate to perform its design function.

The vendor completed the assembly of three of the six units during the inspection. On September 21, 1992, via telecommunications the licensee's project scheduler indicated that the vendor had completed the assembly (w/metal skin) of all six units.

5. Exit Meeting

The inspectors met with those indicated in Section 1., of this report, at the conclusion of the onsite inspection to summarize the scope and findings of the inspection.

The licensee indicated that they would pursue attaching additional bolts and channel nuts to the base frame to strengthen the unit, anchor the unit to the concrete base, and evaluate the unit in accordance with the appropriate seismic zone.

Although the Kardex unit is not classified as proprietary, the vendors drawings are considered sensitive to manufacturing technology and therefore copies of such were not provided to the inspectors.

PROPRIETARY TO:
ABB COMBUSTION ENGINEERING

EUGENE D. BIRNBAUM & ASSOCIATES
Consulting Structural Engineers

SHEET NO. 1
JOB NO. 20613

JOB ABB COMBUSTION ENGINEERING NUCLEAR POWER HIGHWAY P- KARDEX INDUSTRIEVER 8000 - 6 UNITS
HEMATITE, MISSOURI 63047

KARDEX
BARNEY POOLE
(800) 234 3654 PH
(614) 3749300
(614) 373 7828 - FAX

UNIT _____ DESIGNER MR DATE 11-29-92
Δ 12-12-92

SIGNATURE IS VALID ONLY ON PRINT. A SIGNED COPY IS NOT TO BE REPRODUCED.

OVER VIEW

2-14-92 THE INDUSTRIEVER 8000 IS AN ELECTROMECHANICAL DEVICE FOR STORING & RETRIEVING VARIOUS ITEMS. THE INDUSTRIEVER SHALL AUTOMATICALLY RETRIVE A REQUESTED TRAY AND PRESENT THIS TRAY TO AN ACCES AREA (SEE SIDE ELEV. ON SHT 4).
AFTER THE INITIATION OF A REQUEST THE UNIT SHALL ALSO AUTOMATICALLY RETURN THIS TRAY TO ITS STORAGE LOCATION BEFORE RETRIEVING THE NEXT REQUESTED STORAGE TRAY.
THE INDUSTRIEVER ARE CLOSED UNITS (6 UNITS FOR THIS JOB - SEE PLAN ON SHT 2) AND HAVE ALL THEIR MECHANICAL DEVICES INSIDE THE UNITS. BEING UNOCCUPIED MECHANICAL DEVICES THEY CAN ONLY BECOME HAZARDOUS DURING AN EARTHQUAKE DUE TO OVERTURNING OR STRUCTURAL FAILURE. ACCORDINGLY ONLY THE STRUCTURAL FRAMING SUPPORT IS CHECKED (THE MECHANICAL SYSTEM IS NOT CHECKED OR REVIEWED WITH THIS JOB)

LOADS - GIVEN BY KARDEX

DL = 2000#/UNIT x 6 UNITS = 12,000#
LL = 72 TRAYS x 215#/TRAY = 15480# USE 16000#/UNIT
16,000#/UNIT x 6 UNIT = 96000#

ENTIRE SYSTEM IS SUPPORTED ON A 1" STEEL PL RESTING ON A 12" THICK CONCRETE FOUNDATION $f'_c = 3000$ psi; (KARDEX FAX 11-13-92)

A NEW HORIZ BRACING WAS INSERTED @ FRONT ELEV. SEE SHT 3 Δ PER OUR PH. CONV. WITH BARNEY POOLE (12-9-92)

REGISTERED PROFESSIONAL ENGINEER
EUGENE D. BIRNBAUM
S 628
EXPIRES 9-30-95
STRUCTURAL
STATE OF CALIFORNIA

REF: KARDEX JOB# 384-74736
SHT 1 OF 9 — FRONT ELEV. (WITH OUTER PANELS)
SHT 2 OF 9 — REAR ELEV (WITH OUTER PANELS)
SHT 3 OF 9 — SIDE ELEV. (WITH OUTER PANELS)
SHT 4 OF 9 — FRONT-FRAME ELEVATION
SHT 5 OF 9 — REAR FRAME ELEV.
SHT 6 OF 9 — SIDE FRAME ELEV.
SHT 7 OF 9 — SIDE FRAME ELEVATION (BETWEEN MODULES)
SHT 8 OF 9 — MISC DETAILS
SHT 9 OF 9 — MISC DETAILS
SHT 10 OF 10 — SIDE BRACING - ELEVATION & DETAILS TO COME
DATED 10/92

PROPRIETARY TO: ABB COMBUSTION ENGINEERING

CALC'S 1 - 13
UBC - 1991
UBC STANDARD 27-11 / 1991

# EUGENE D. BIRNBAUM & ASSOCIATES

Consulting Structural Engineers

SHEET NO. 2

JOB NO. 20613

JOB ABB COMBUSTION ENGINEERING NUCLEAR POWER HIGHWAY P-KARDEX INDUSTRIEVER 8000 KARDEX

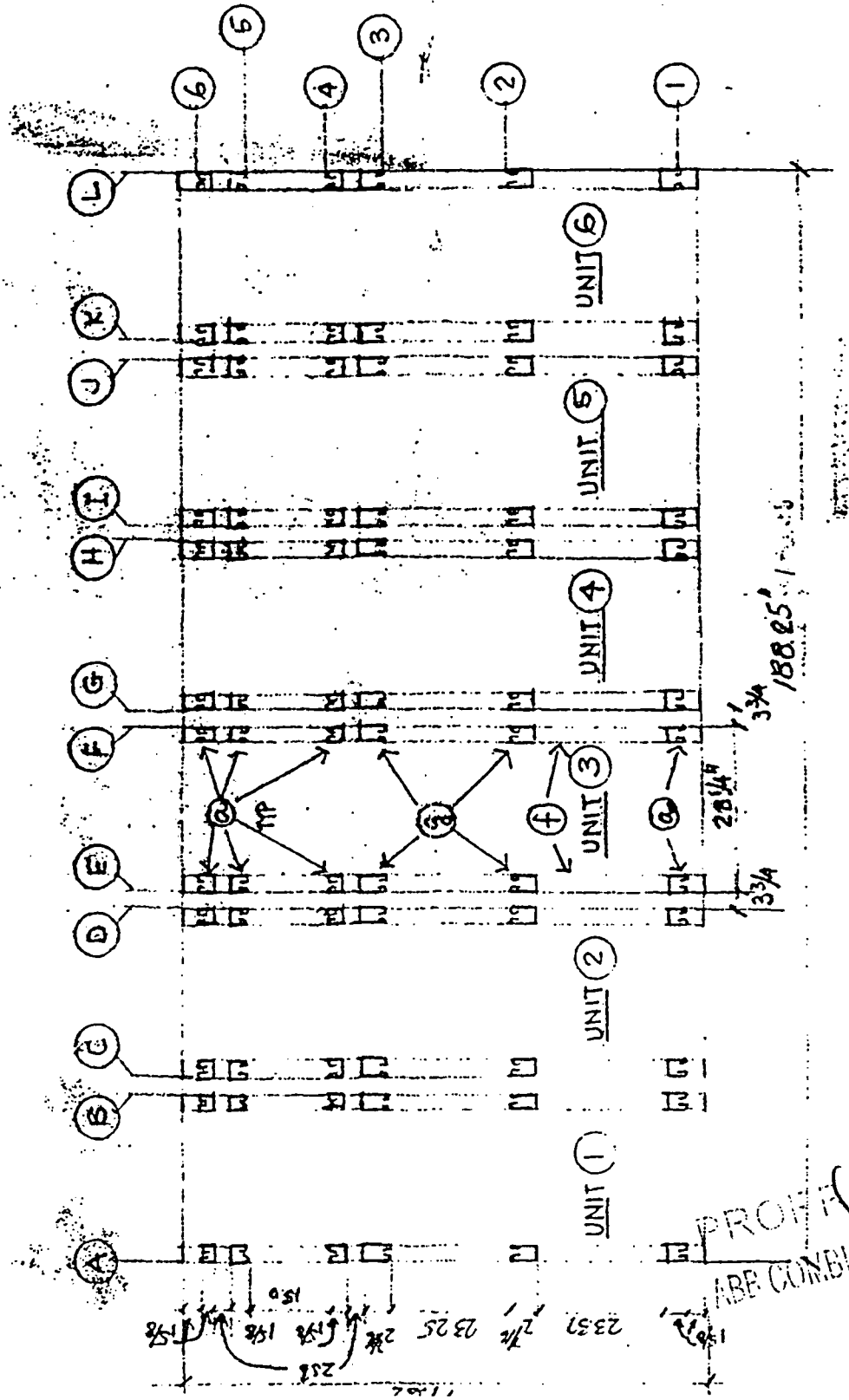
HEMATITE, MISSOURI 65047

UNIT _____ DESIGNER MR DATE 11-18-92

BARNEY POOLE
(800) 234 8654 / PHONE
(614) 374 9300
(614) 373 7888

SIGNATURE IS VALID ONLY ON PRINT. A SIGNED COPY IS NOT TO BE REPRODUCED.

HCK
REC FE
ROOT
2 —
STONE
FILL
CONCRETE




PROPRIETARY
ABB COMBUSTION ENGINEERING

EUGENE D. BIRNBAUM & ASSOCIATES
Consulting Structural Engineers

SHEET NO. 3
JOB NO. 20613

JOB ABB COMBUSTION ENG, NUCLEAR POWER HIGHWAY P-KARDEX INDUSTRIEVER 2000
HEMATITE, MISSOURI

UNIT _____ DESIGNER MR DATE 11-18-92
Δ 12-12-92

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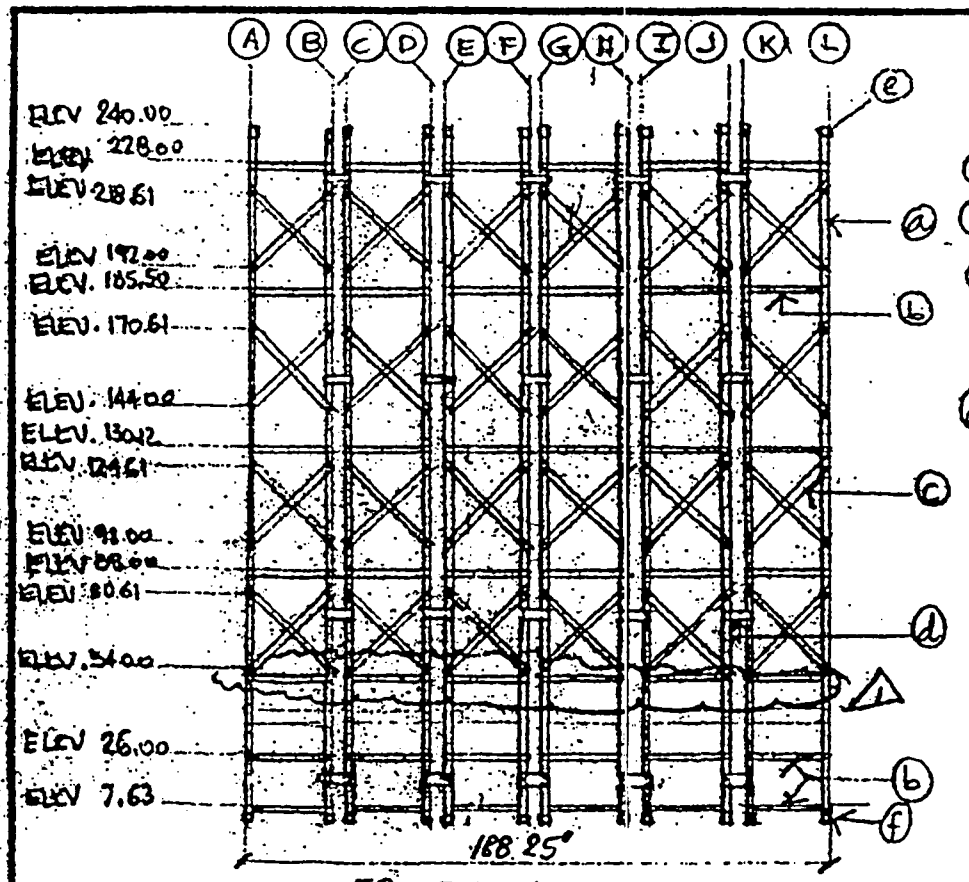
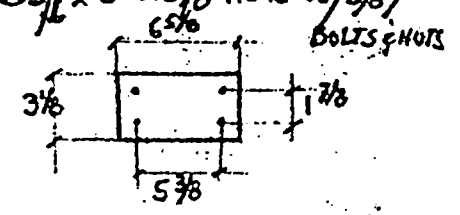
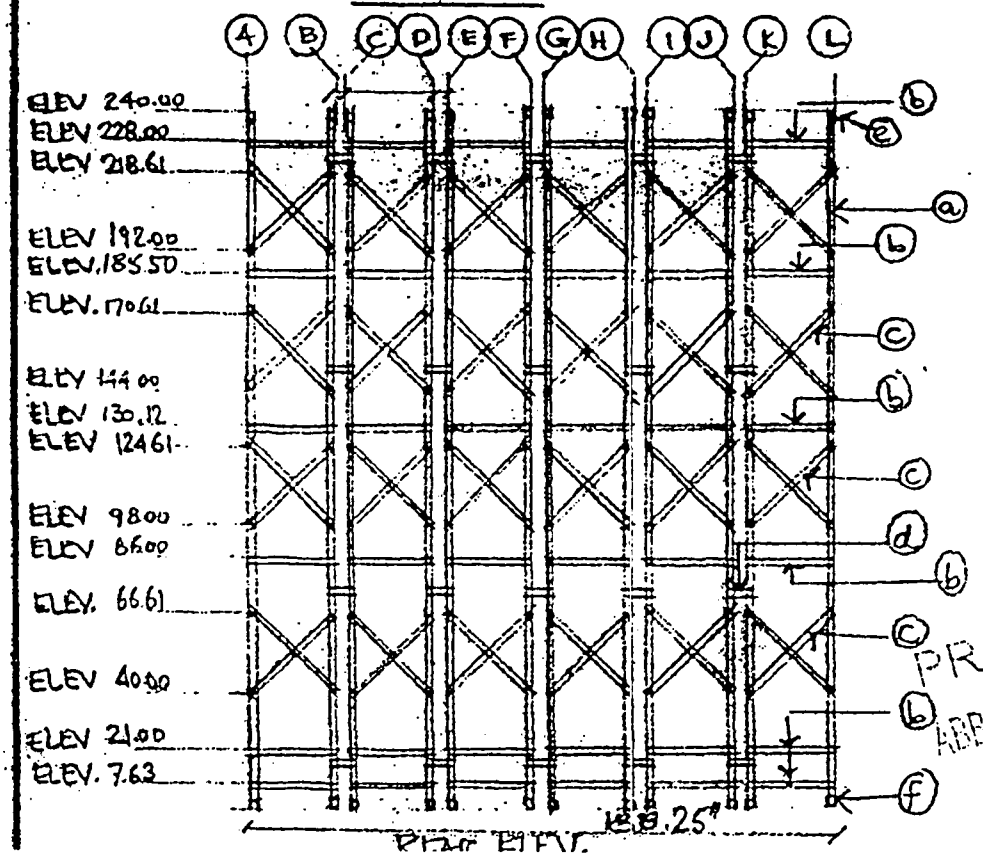



LEGEND:

ⓐ UPRIGHT ⊔ 1 5/8 x 1 5/8 x 12 ga
ⓑ HORIZ BRACING ⊔ 1 x 1 5/8 x 12 ga
ⓒ DIAGONALS. - 0.12 x 1 1/2 WITH 3/8"ϕ BOLTS, NUTS & WASHERS (TYP)
ⓓ 3/16 x 6 5/8 x 3 1/8 TIE ⊏ w/ 3/8"ϕ BOLTS & NUTS




ⓔ TOP HORIZ. ⊔ 1 5/8 x 1 5/8 x 12 ga
ⓕ BOTTOM HORIZ - ⊔ 1 5/8 x 1 5/8 x 12 ga




PROPRIETARY TO:
ABB COMBUSTION ENGINEERING

# EUGENE D. BIRNBAUM & ASSOCIATES

Consulting Structural Engineers

SHEET NO. 4

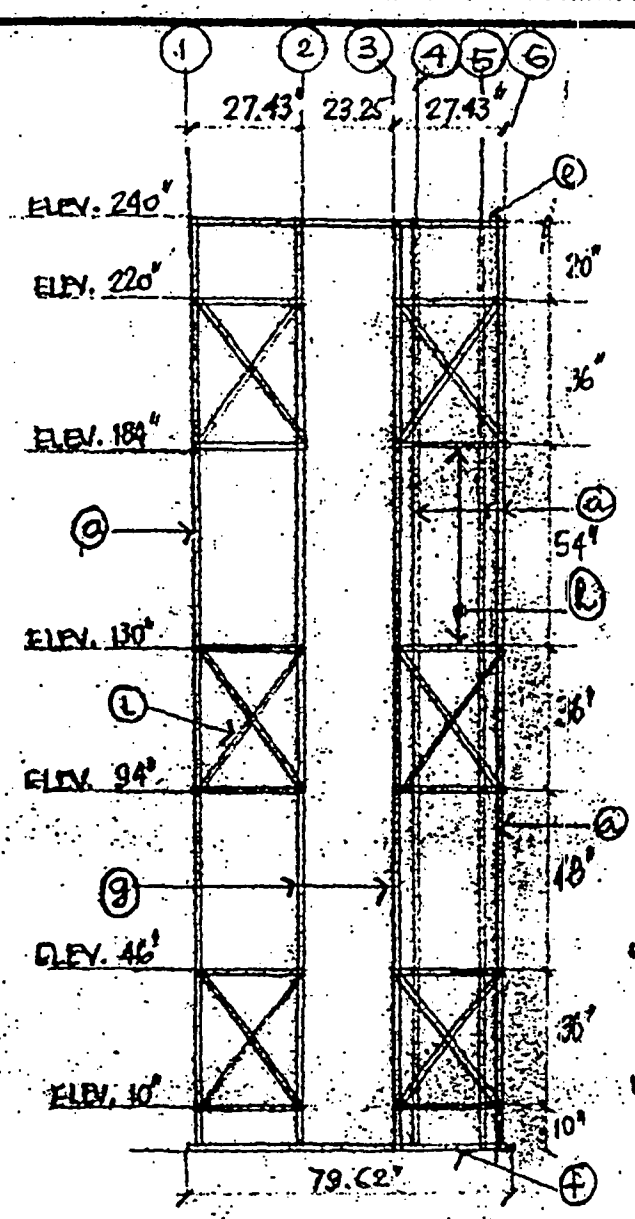
JOB NO. 20613

JOB ABB COMBUSTION ENG. NUCLEAR POWER HIGHWAY F-KARLEX INDUSTRIEVER 8000
HEMATITE MISSOURI

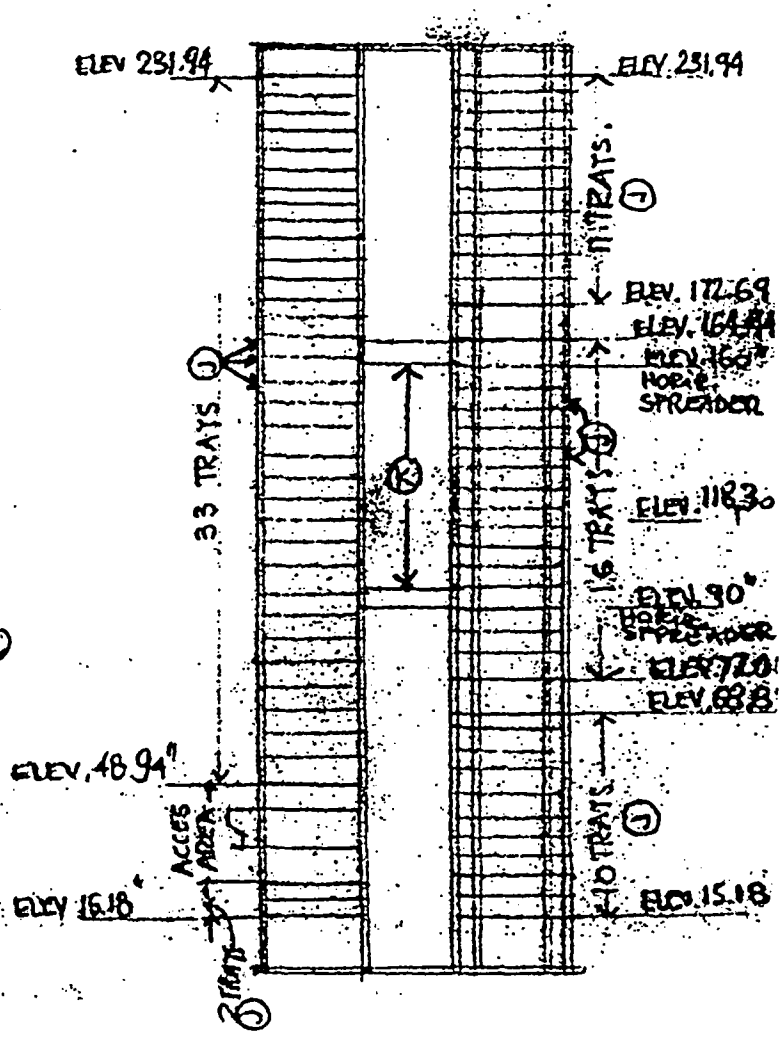
UNIT _____ DESIGNER MR DATE 11-26-92

SIGNATURE IS VALID ONLY ON PRINT. A SIGNED COPY IS NOT TO BE REPRODUCED.

1.43
3.25
1.43




SIDE ELEVATION
BRACING ELEVATION



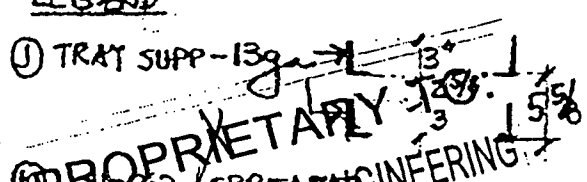

SIDE ELEVATION
TRAY ELEVATION [35 LEFT / 37 RIGHT]

LEGEND

ⓐ UPRIGHTS ⊔ 1 5/8 x 1 5/8 x 12ga
ⓔ TOP HORIZ ⊔ 1 5/8 x 1 5/8 x 12ga
ⓕ BOTT. HORIZ ⊔ 1 5/8 x 1 5/8 x 12 ga
ⓖ UPRIGHTS ⊔ 2 3/4 x 1 5/8 x 12ga
ⓗ HORIZ. BRACING ⊔ 1 x 1 5/8 x 12ga
Ⓛ DIAG. BRACING PL 0.12 x 1 1/2 w/ 3/8" ϕ BOLTS, NUTS & WASHERS

LEGEND

Ⓙ TRAY SUPP - 13ga




Ⓚ HORIZ. SPREADER

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LOADS

DL = 2 K/UNIT
LL = 16 K/UNIT } PER KARDEX

NOTE - ASSUME ALL LOAD TO BE ABOVE THE ACCES OPENING ALTHOUGH SOME ELECTRICAL PANELS & MECHANICAL DEVICES ARE BELOW THIS ELEV. (SEE SKETCH ON SHT 4.) → VERY CONSERVATIVE.

CHECK THE UPRIGHTS

DL SUPPORTED BY 12 COLUMNS
LL SUPPORTED BY EIGHT COLUMNS.

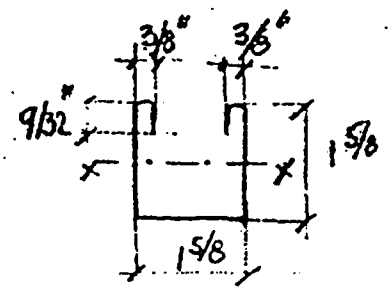
PER COLUMN

DL = 2/12 = 0.17 K/COLUMN

LL = 16/8 = 2 K/COLUMN

TOTAL 2.17 K/COL

P1000 [ 1 5/8 x 1 5/8 x 0.105 (OMISTROT) Fy = 42 KSI — COLUMN




t = 0.105"

$A_s = 0.56\ IN^2$

$S_x = 0.209\ IN^3$ $S_y = 0.294\ IN^3$

$r_x = 0.579$ $r_y = 0.655$

$\frac{KL}{r_x} = \frac{0.85 \times 48}{0.58} = 70.4 \rightarrow F_{axx} = 15.43\ KSI$

$F_{ex} = 30.14 \rightarrow F_{ex}$ [illegible] $= 34.4 \times 1.33 = 40.6$

$P_{ax} = 10.3^K$ $M_{xa} = 5.8^{IK}$ $M_{ya} = 7.4^{IK}$

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$SEISMIC = \frac{Z \cdot I \cdot C}{R_W}\left(DL + \frac{LL}{2}\right)$ UBC STANDARD 27-11 – MINIMUM FOUR COLUMNS IN ANY DIRECTION ON EACH COLUMN LINE DESIGNED TO RESIST HORIZ. FORCES

$Z = 0.15$ (SAINT LOUIS – SEISMIC ZONE 2A)

$I = 1.5$ (PER CLIENT REQUEST)

$C = 2.75$

$R_W = 6.0$ – 'X' BRACING

$V = \frac{0.15 \times 1.5 \times 2.75}{6}\left(DL + \frac{LL}{2}\right) = 0.103\left(DL + \frac{LL}{2}\right) = 0.103\left[2 + \frac{16}{2}\right] = 1.03^k$

USE $1.1^k$/CALC'S – PER UNIT

SEISMIC – (ANALYSIS PER ONE UNIT)

TRANSVERS – TAKEN BY TRANSV. POSTS (2x4) ON X-X DIR. (PER UNIT)

LONGITUDINAL – TAKEN BY REAR & FRONT POSTS (2x2) ON Y-Y DIR. (PER UNIT)

X – X DIR.

SEISMIC PER POST $= \frac{V \cdot LL}{8} = 0.1375^K$

$M = 0.1375 \times \frac{48}{2} = 3.3^{'K}$

COMBINED $\frac{2.11}{10.3} + \frac{0.85 \times 3.3}{\left(1 - \frac{2.11}{40.12}\right)5.3} = 0.211 + 0.56 = 0.77 < 1.33$ OK

Y – Y DIR.

SEISMIC PER POST $\Rightarrow \frac{1.1}{4} = 0.275^K$

$M = 0.275 \times \frac{54.6}{2} = 7.51^{'K}$ (80.6 – 26)

$\frac{Kl}{r_y} = \frac{0.85 \times 54.6}{0.655} = 70.9 \rightarrow F_a = 18.35 KSI$

$F_{cy} = 29.7 \rightarrow I_{cy}$ SETSHOR $= 29.7 \times 1.33 = 39.5$

$P_{ax} = 0.56 \times 18.35 = 10.3^k$

COMBINED

$\frac{2.2}{10.3} + \frac{0.85 \times 7.51}{\left(1 - \frac{2.2}{39.5}\right)7.4} = 0.214 + 0.913 = 1.13 < 1.33$ OK SEE NOTE ON SHT 7

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JOB ABB COMBUSTION ENGINEERING NUCLEAR POWER HIGHWAY 21 / INDUSTRI EVER 6000
HEMATITE, MISSOURI

UNIT _____ DESIGNER HR DATE 11-26-92

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NOTE - THE OUTER PANELS ON FRONT & REAR ELEVATION ARE PROVIDING ADDITIONAL SHEAR STRENGTH FOR THE REAR & FRONT STRUCTURAL FRAMING (SEE SHT 1 OF 9, 2 OF 9 AND DETAIL F-F ON SHT 9 OF 9)

CHECK POST ON SIDE BRACING FOR 54" DIST. BETWEEN BRACING (SEE SIDE ELEV. SIDE BRACING ON SHT 4)

TRIB LOAD $\Rightarrow \frac{H\ ABOVE}{H\ TOTAL} \times W = \frac{20 + 36 + 54}{240} \times W = \frac{110}{240} W = 0.46\ W$ (110)

DL = $2 \times 0.46 = 0.92^k$

LL = $16 \times 0.46 = 7.36^k$

TOTAL $8.28^k$

VERT/COL $= \frac{8.28}{8} = 1.04^k/col$

SEISMIC $\Rightarrow V = 0.103\left(0.92 + \frac{7.36}{2}\right) = 0.47^k$

PER COLUMN $\Rightarrow V = \frac{0.47}{4} = 0.12^k$ $\quad M_{COL} = 0.12 \times \frac{54}{2} = 3.24^{in\text{-}k}$

$\frac{KL}{r} = \frac{0.85 \times 54}{0.58} = 79.2 \Rightarrow F_a = 17.15$

$F_{ex} = 1.33 \times 23.8 = 31.65$

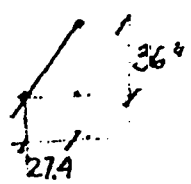
$P_a = 0.56 \times 17.15 = 9.6^k$

COMBINED

$$\frac{1.04}{9.6} + \frac{0.85 \times 3.24}{\left(1 - \frac{1.04}{31.65}\right)5.4} = 0.108 + 0.527 = 0.64 < 1.33 \quad \underline{OK}$$

CHECK BRACING ON SIDE ELEV. (SEE SHT 4)

GEOMETRY




$tg\,\alpha = \frac{36}{27.4} = 1.314 \rightarrow \alpha = 52.73^\circ \rightarrow \cos\alpha = 0.606$

$V = 1.1^k/UNIT \rightarrow V_{SIDE} = \frac{1.1}{2} = 0.55^k \rightarrow V_{EXTERIOR\ BRACING\ (SIDE)} = \frac{0.55}{2} = 0.28 \sim 0.3^k$

$P_{BRACE} = \frac{0.3}{0.606} = 0.5^k$ TENSION - EXT. ELEV.

$= 1.0^k$ TENSION - INT. ELEV.

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HEMATITE, MISSOURI

UNIT _____ DESIGNER HR DATE 11-27 92

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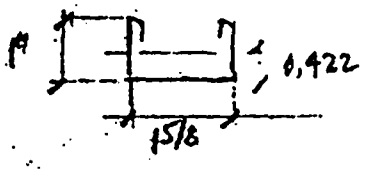
DIAGONAL → 1½ x 0.12

$P_{BRACE}$ (A gross) = 1.5 x 0.12 x 20 = 3.6 k

$P_{BRACE}$ (A NET) = [1.5 − (0.375 + 0.125)] 0.12 x 27 = 3.2 k ‖ GOVERN

$P_{BRACE}$ = 3.2 k ≫ 1.0 k TRANSV. BRACING ∴ OK

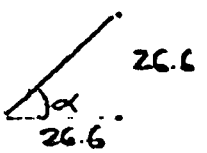
HORIZ BRACING → TAKEN BY UNISTRUT 1 x 1 5/8 x 12 GAG IN COMPR




A = 0.43 IN²
$I_x$ = 0.054 IN⁴ $I_y$ = 0.163 IN⁴
$S_x$ = 0.093 IN³ $S_y$ = 0.200 IN³
$r_x$ = 0.354 IN $r_y$ = 0.615 IN

$\frac{Kl}{r} = \frac{27.4}{0.35} = 78.3 \Rightarrow F_a = 17.26$ $P_a = 17.26 \times 0.43 = 7.42 \gg 0.6^k$ OK

CHECK BRACING ON FRONT & REAR ELEV
DIAGONALS
GEOMETRY




α = 45°

cos α = 0.707

V = 1.1 k/UNIT

$V_{SIDE} = \frac{1.1^k}{2} = 0.55^k$ $P_{BRACE} = \frac{0.55}{0.707} = 0.78^k < P_{a\,BRACE} = 3.2^k$ OK

DIAGONALS ARE OK

CHECK FRONT & REAR BRACING WITH ONLY 3 DIAGONALS FOR TOP TWO BRACINGS

a/ CHECK COLUMNS

TRIB LOAD = $\frac{\text{\# ABOVE}}{\text{\# TOTAL}} \times W = \frac{180}{240} W = 0.54\,W$

DL = 0.54 x 2 = 1.08 k
" 15.54 W = 8.64 k ‖ 9.72 k TOTAL

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EUGENE D. BIRNBAUM & ASSOCIATES
Consulting Structural Engineers

SHEET NO. 9
JOB NO. 20613

JOB ABB COMBUSTION ENG — NUCLEAR POWER HIGHWAY P — INDUSTRIENER 8000

UNIT _____ DESIGNER HR DATE 8-28-92

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$P_{VERT} = \frac{9.72}{8_K \text{ COLUMN}} = 1.22 \sim 1.3^K$

SEISMIC $= V = 0.103\left(1.1 + \frac{8.7}{2}\right) = 0.56^K \sim 0.6^K$

$P_{ER\ COL} = \frac{0.6^K}{4} = 0.15^K \qquad M_{COL} = 0.15 \times \frac{55.5}{2} = 4.16^{K'}$

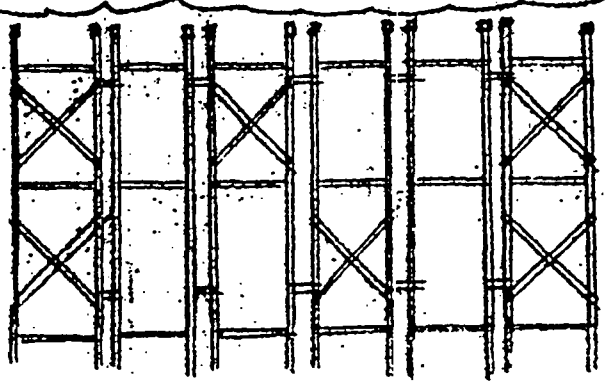
$\frac{KL}{r} = \frac{0.85 \times 55.5}{0.655} = 72 \rightarrow F_a = 18.19\ ksi$

$F_{ex} = 1.33 \times 28.8 = 38.32$

$P_a = 18.19 \times 0.56 = 10.2^K$

$\text{COMBINED} = \frac{1.3}{10.2} + \frac{0.85 \times 4.16}{\left(1 - \frac{1.3}{38.32}\right) 5.4} = 0.13 + 0.68 = 0.81 < 1.33$ OK

YOU MAY WAIVE 3 BRACINGS @ FIRST TWO TOP BRACINGS.



NOTE: THE THREE RETAINING BRACINGS ARE TAKEN THE ENTIRE SHEAR

$P_{BRACE} = \frac{0.15 \times 2 \times 3}{0.606} = 1.49^K < P_{a\ BRACE} = 3.2^K$ OK

$< P_{a\ BOLT} = 1.5^K$ OK

CHECK CONN.

REAR & FRONT

3/8"ϕ — A307 — @ 12 GA → 0.105"

$V_{BOLT} = 3.14 \times \frac{0.375^2}{4} \times 10 \times 1.33 = 1.5^K/BOLT$ SHEAR

$= 0.375 \times 0.105 \times \frac{2.22 \times 54}{222} \times 1.33 = 2.8^K/BOLT$ BEARING

UBC STANDARD 27-09/991

$P_{BOLT} = 1.5^K/BOLT > 0.78^K$ FRONT & REAR

$> 1.0^K$ SIDE ELEV.

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JOB ABB COMBUSTION ENG. NUCLEAR POWER HIGHWAY P.-KARNEX INDUSTRIES BLDG
HEMATITE, MISSOURI

UNIT _____ DESIGNER MR DATE 11-20-92

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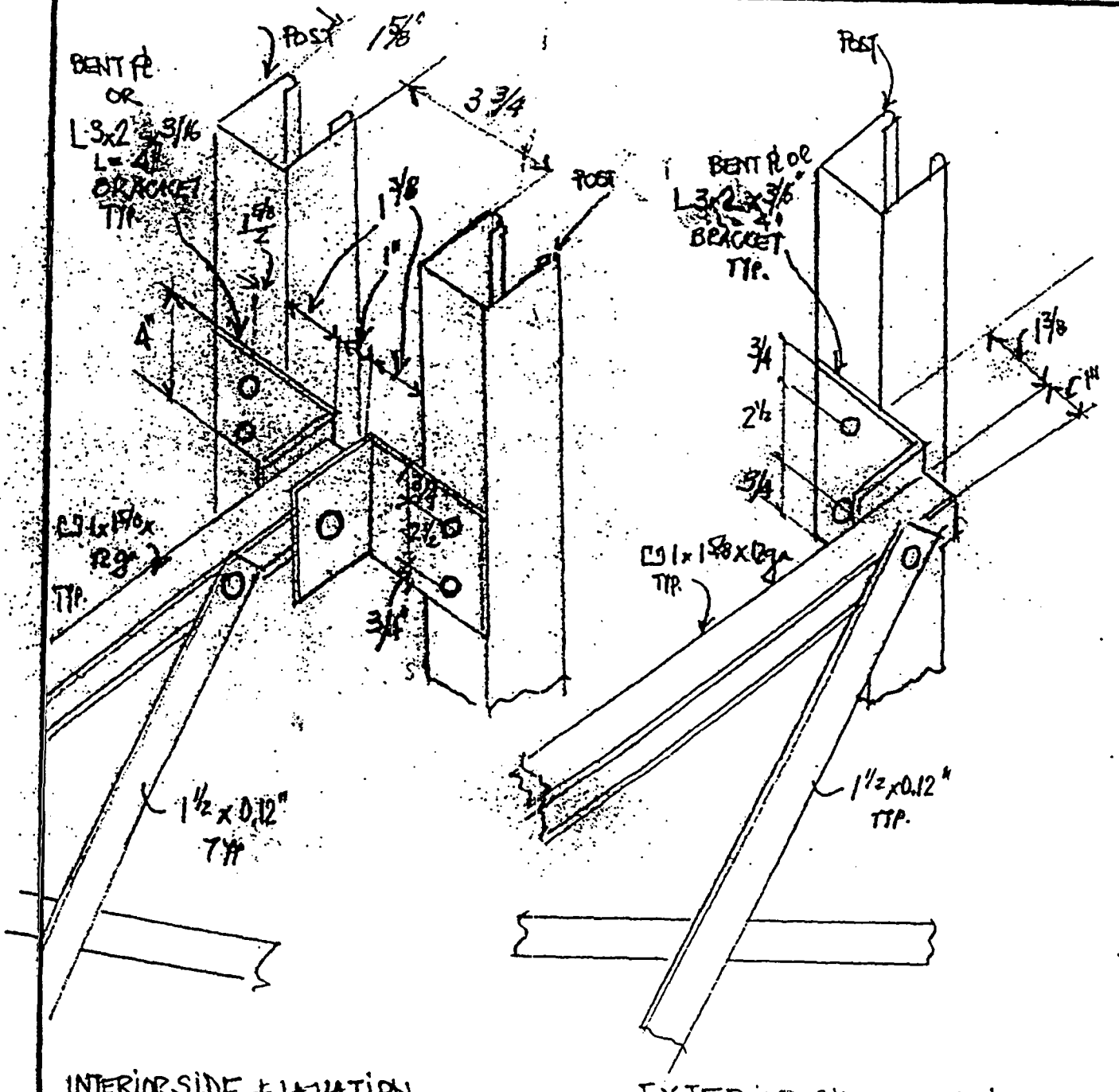


INTERIOR SIDE ELEVATION BETWEEN TWO UNITS

EXTERIOR SIDE ELEVATION

NOTE
ALL BOLTS 3/8"ϕ GRADE 5
ALL DIAGONALS — 1 1/2 x 0.12"
ALL HORIZ. BRACINGS — [ 1x1 5/8x12ga

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ATTACHEMENTS FOR SIDE ELEVATION BRACING

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UNIT _____ DESIGNER MR. DATE 11-28-92

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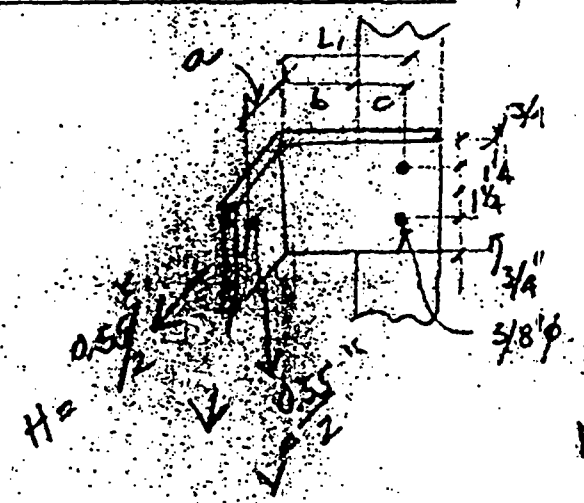
CHECK THE BRACKET @ SIDE ELEV SEE SHT 10

$F_y = 33$ KSI FOR BRACKET




GEOMETRY

$c = \frac{1\,5/8}{2} = 0.81$

$b = 1\,3/8 - 3/16 = 1.19$

$L_1 = \frac{1\,5/8 + 1\,3/8}{2} - 3/16 = 2.00$

$a_{MAX} = 1.25 - 0.1875 = 1.06$

$M_H = \frac{0.55}{2} \times 2 = 0.55^{IK}$

$M_V = \frac{0.55}{2} \times 1.06 = 0.29^{IK}$

SECT MODULUS

$S_H = 4 \times \frac{0.1875^2}{6} = 0.0234\ IN^3$

$S_{av} = \left[\frac{4^3}{12} - \frac{0.5^3}{12} \times 2 - 0.5\left(1.25 - \frac{0.1875}{2}\right)^2 \times 2\right] \frac{0.1875}{2} = 0.373\ IN^3$ $(0.375 + 0.125)$

$M_{aH} = 0.0234 \times 33 \times 0.75 \times 1.33 = 0.77^{IK}$

$M_{aV} = 0.373 \times 33 \times 0.66 \times 1.33 = 10.80^{IK}$

COMBINED $= \frac{0.55}{0.77} + \frac{0.29}{10.8} = 0.74 < 1.00$ OK

BRACKET - BENT PL 3 x 2 x 3/16 OR L 3 x 2 x 3/16 | L = 4" | OK

OPTION FOR SIDE BRACING

$F_y = 33$ KSI FOR TRAY SUPPORT

USE TRAY SUPPORT AS BRACING

FOR Q=1 ⇒ $\frac{b_{max}}{t} = \frac{76}{\sqrt{33}} = 13.3$ (BEND RADIUS)

$t = 0.09$ (13 GA) $b_{max} = (13.3 + 3) \times 0.09 = 1.47''$ (EFFECTIVE FROM 3" HEIGH

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UNIT _____ DESIGNER HR DATE 11-29-92

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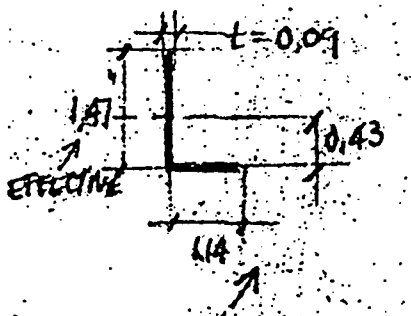



$t = 13\ GA$

$A = 0.23\ IN^2$

$y = \dfrac{1.47^2/2}{1.47 + (1.14 - 0.09)} = 0.43''$ $\quad c = 1.47 - 0.43 = 1.04''$

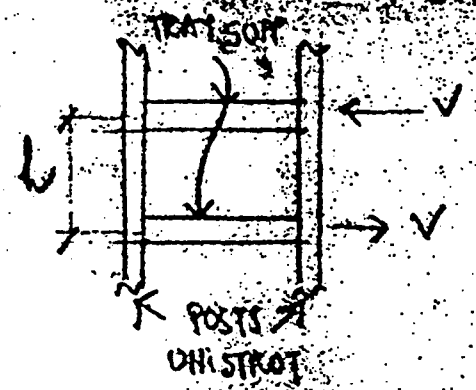
TRAY SUPPORT EFFECTIVE SECTION

$I_x = \left[\dfrac{1.47^3}{12} + 1.47\left(\dfrac{1.47}{2} - 0.43\right)^2 + (1.14 - 0.09)\left(0.43 - \dfrac{0.09}{2}\right)^2\right] t = 0.56t$

$I_x = 0.56 \times 0.09 = 0.0504\ IN^4$

$S_x = \dfrac{0.0504}{1.04} = 0.0482\ IN^3 \quad = M = 0.048 \times 33 \times 0.6 = \underline{\underline{0.95''^K}}$

THE SCHEME (TRAY SUPP. ACTS AS VIERENDEL)




M SUPPORT TRAY $= V \times h = 0.95''^K$

$V = \dfrac{1.1}{8} = 0.138^K/POST$ ← TOTAL SHEAR

$h_{MAX} = \dfrac{0.95 \times 1.33}{0.138} = 9.2''$

CHECK POST

$P = 8.2$

$M = 0.138 \times \dfrac{9.2}{2} = 0.64''^K$

$P_a = 10.3^K$ (U. CONSERVATIVE)

COMBINED $= \dfrac{8.2}{10.3} + \dfrac{0.64}{5.3} = 0.33 < 1.33$

$T_{BOLT} = \dfrac{1.33 \times 0.95''}{0.94} = 1.35^K < 1.5^K$ 3/8" ϕ BOLT

DIST. BETWEEN BOLT – TRAY SUPP TO POST – 0.94" (KATALOX STANDARD SUPP. TRAY DETAIL

(MAX DIST BETWEEN TRAY SUPP 9.2"
MIN 2 - 3/8" ϕ BOLT EACH SIDE (MIN 0.94"

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(IF THE ABOVE IS ACCOMPLISHED, FOR THOSE PARTICULAR AREAS YOU MAY OMMIT THE 'X' BRACING SHOWN ON DWG 4 (NOW YOU ... ONE BOLT ON ONE SIDE)

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## GENERAL STABILITY

### TRANSV. DIR. GOVERN

$O.T.M = 1.1 \times \frac{240}{2} \times 1.15 = 151.8$ SAY $- 160^{\text{'K}}$

$R.M = \left[(2+16) - \frac{1.1}{3}\right]\left(\frac{79 - 3.5 \times 2}{2}\right) = 634.8^{\text{'K}}$

∴ NO UPLIFT

**ANCHORAGE**

T = 0 (NO UPLIFT

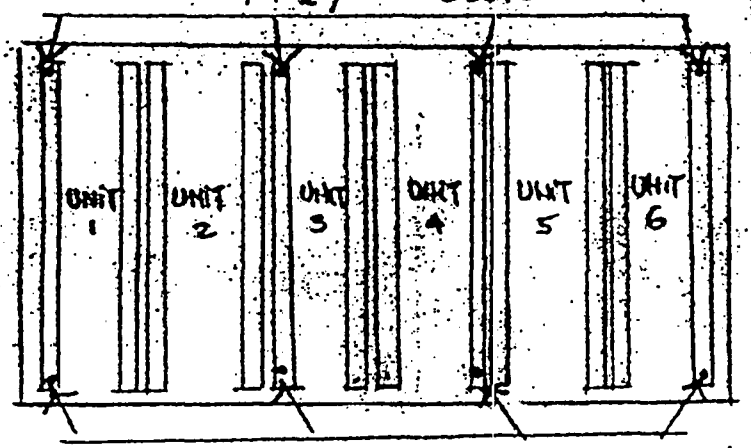
V = 6 × 1.1 = 6.6^K

USE 8 ANCH BOLTS

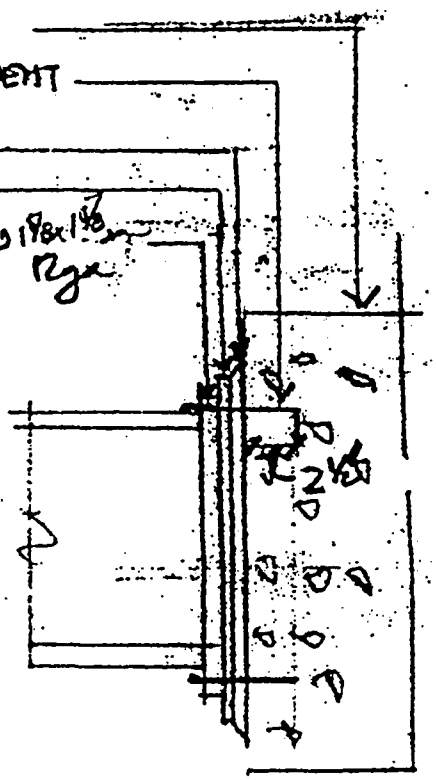
$V = \frac{6.6}{8} = 0.83^{K}$/SHEAR BOLT

× 4 - ½"φ - EXP. BOLTS

- 12" CONCRETE FTG
- ½"φ - 2½" EMBEDMENT IN CONCR. FTG
- ±1" GROUT
- 1" STEEL PL
- HORIZ. UNISTRUT ⊏ 1⅝ × 1⅝ Rgx




4 ½"φ - EXP. BOLT
2½" EMBEDM. IN CONCR FTG




PLAN

SECTION A-A

NOTE: USE ANY ICBO ½"φ EXP. BOLT - 2½" EMBEDM IN CONCRETE - APPROVED BY LOCAL CITY
EXAMPLE - RED HEAD (WEDGE) - ICBO 1372
- RAWL ANCH. BOLT - ICBO 1372
OR EQUIVALENT

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# METROPOLITAN ENGINEERING CO.

Consulting Engineers And Surveyors

7301 Metropolitan Blvd.
P.O. Box 400
Barnhart, Missouri 63012

Area Code 314
464-3860 — 467-3860
FAX No. 467-7480


January 19, 1993

Mr. Len Grossman
ABB Combustion Engineering Company
Highway P, Box 107
Hematite, MO 63047

Dear Mr. Grossman:

Pursuant to your request we have reviewed the seismic design calculations and appended Kardex drawing for the Kardex Unit in Building 230 as prepared by Eugene D. Birnbaum & Associates. We are appending herewith a copy of our review comments.

Should you have any questions please contact us.

Very truly yours,

**METROPOLITAN ENGINEERING COMPANY**

John M. Hehmeyer

John M. Hehmeyer, P.E.

JHM/tks

251.069


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ABB - COMBUSTION ENGINEERING
HIGHWAY "P"
HEMATITE, MISSOURI

KARDEX UNIT IN BUILDING 230
SEISMIC CALCULATIONS

SUMMARY OF SEISMIC DESIGN CALCULATION REVIEW:

Sheet 1 - The calculations should be sealed by a professional engineer, licensed in the state of Missouri.

- Seismic design is to be in accordance with The BOCA National Building Code/1990.

Sheet 4 - The unbraced length of the interior columns needs to be clarified. How often are these columns supported, to prevent buckling in the longitudinal direction?

- Drawing 6 of 10 shows horizontal spreaders at Elev. 110.81" and at Elev. 178.31". Do these spreaders provide adequate lateral support for the columns, and if so, are the columns strong enough with an unbraced length of 110.8"?

Sheet 6 - Using the BOCA/1990 equation for determining seismic shear, the design shear load is 1.1 kips/unit, which agrees with the value used in the calculations.

- The seismic loading creates an overturning moment in the frame, resulting in additional axial forces in the columns, which must be accounted for in the design.

- AISC Equation H1-1 is used to check the combined axial compression and bending strength of the columns. The denominator in the second term of this equation should use axial stress (ksi), instead of axial load (kips).

- The longitudinal frame analysis does not address bending in the bottom span of the columns. The base shear in the columns creates bending in the columns, below the first level of diagonal bracing. This appears to cause overstress in the columns at both the front and rear elevations.

Sheet 7 - Comments similar to sheet 6 comments.

- Need to review the interior columns, considering the large unbraced span in the longitudinal direction.

Sheet 9 - If half of the top bracing is to be omitted, the remaining braced frames must resist twice their normal seismic load.

- BOCA 1113.11.5 does not allow the 1.33 increase in allowable stress for connections in braced frames.

Sheet 13 - The longitudinal frame analysis indicates uplift can occur on individual columns. If each frame is not anchored to the slab, the frames must be interconnected to prevent uplift from occurring.

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Consulting Structural Engineers

SHEET NO. 1
JOB NO. 20613

JOB ABB COMBUSTION ENGINEERING NUCLEAR POWER HIGHWAY P - KARDEX INDUSTRIEVER 8000 - 6 UNITS
HEMATITE, MISSOURI 63047

UNIT _____ DESIGNER MR DATE 11-29-92
Δ 12-12-92

KARDEX
BARNET POOLE
(800) 239 9654 PH
(614) 374 9300
(614) 373 7888 - FAX

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OVERVIEW

THE INDUSTRIEVER 8000 IS AN ELECTROMECHANICAL DEVICE FOR STORING & RETRIEVING VARIOUS ITEMS. THE INDUSTRIEVER SHALL AUTOMATICALLY RETRIVE A REQUESTED TRAY AND PRESENT THIS TRAY TO AN ACCESS AREA (SEE SIDE ELEV ON SHT 4).
AFTER THE INITIATION OF A REQUEST THE UNIT SHALL ALSO AUTOMATICALLY RETURN THIS TRAY TO ITS STORAGE LOCATION BEFORE RETRIEVING THE NEXT REQUESTED STORAGE TRAY.
THE INDUSTRIEVER ARE CLOSED UNITS (6 UNITS FOR THIS JOB - SEE PLAN ON SHT 2) AND HAVE ALL THEIR MECHANICAL DEVICES INSIDE THE UNITS. BEING UNOCCUPIED MECHANICAL DEVICES THEY CAN ONLY BECOME HAZARDOUS DURING AN EARTHQUAKE DUE TO OVERTURNING OR STRUCTURAL FAILURE. ACCORDINGLY ONLY THE STRUCTURAL FRAMING SUPPORT IS CHECKED (THE MECHANICAL SYSTEM IS NOT CHECKED OR REVIEWED WITH THIS JOB).

LOADS - GIVEN BY KARDEX

DL = 2000#/UNIT x 6 UNITS = 12,000#
LL = TOTAL 215 TRAY LEAD + USE 16,000#/UNIT
16,000#/UNIT x 6 UNITS = 96000# (NO STEEL PL)
ENTIRE SYSTEM IS SUPPORTED ON A ~~(1" STEEL PL BEARING ON A~~
12" THICK CONCRETE FOUNDATION (f'c = 3000 psi) (KARDEX FAX 11/13/92)
AND ADD BEARING WALL DETAIL @ FRONT ELEV. SEE SHT 3 Δ PER OUR DISCUSSION WITH BARNET POOLE (12-9-92)

REF: KARDEX JOB # 384-74736
SHT 1 OF 9 - FRONT ELEV (WITH OUTER PANELS)
SHT 2 OF 9 - REAR ELEV (WITH OUTER PANELS)
SHT 3 OF 9 - SIDE ELEV (WITH OUTER PANELS)
SHT 4 OF 9 - FRONT FRAME ELEVATION
SHT 5 OF 9 - REAR FRAME ELEV.
SHT 6 OF 9 - SIDE FRAME ELEV.
SHT 7 OF 9 - SIDE FRAME ELEVATION (BETWEEN MODULES)
SHT 8 OF 9 - MISC DETAILS
SHT 9 OF 9 - MISC DETAILS
SHT 10 OF 10 - SIDE BRACE ELEVATION & DETAILS TO CORNER
DATED 10/92

PREPARED BY TO
BRIEF ENGINEERING

AISC - 9th EDITION

EUGENE D. BIRNBAUM & ASSOCIATES
Consulting Structural Engineers

SHEET NO. 2
JOB NO. 20813

JOB: ABB COMBUSTION ENGINEERING & NUCLEAR POWER HIGHWAY P - KARDEX INDUSTRIEVER 8000
HERMITAGE, MISSOURI 65047

UNIT: DESIGNER: MR DATE: 11-18-92

KARDEX
BARNEY POOLE
(800) 254 6654 / PN0116
(614) 374 9300
(614) 373 7888

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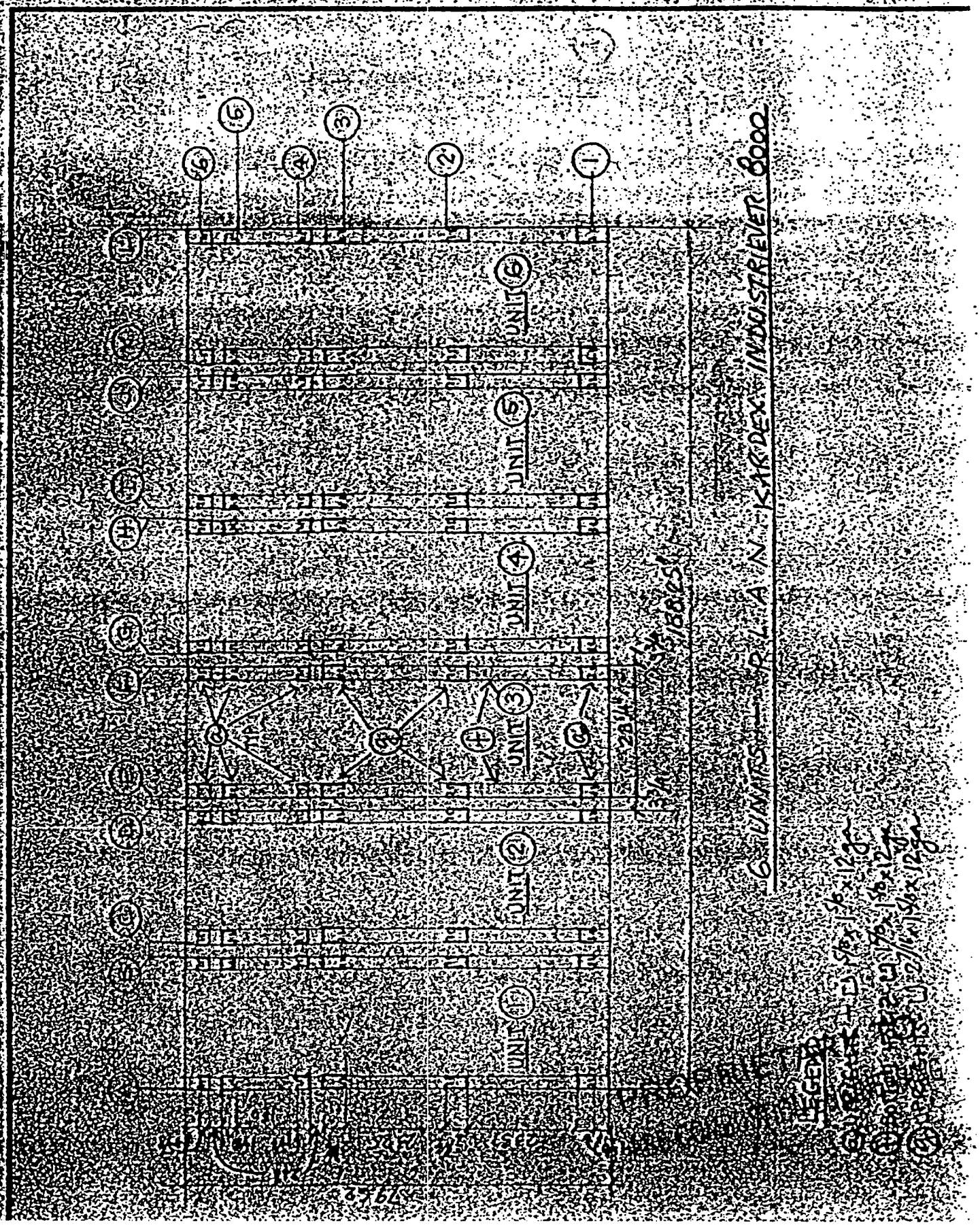

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SHEET NO. 3
JOB NO. 20613

JOB ABB COMBUSTION ENG. NUCLEAR POWER HIGHWAY P-KARDEX INDUSTRIES OVER 2000
HEMATITE, MISSOURI

UNIT _____ DESIGNER HR DATE 11-18-92
Δ 12-12-92

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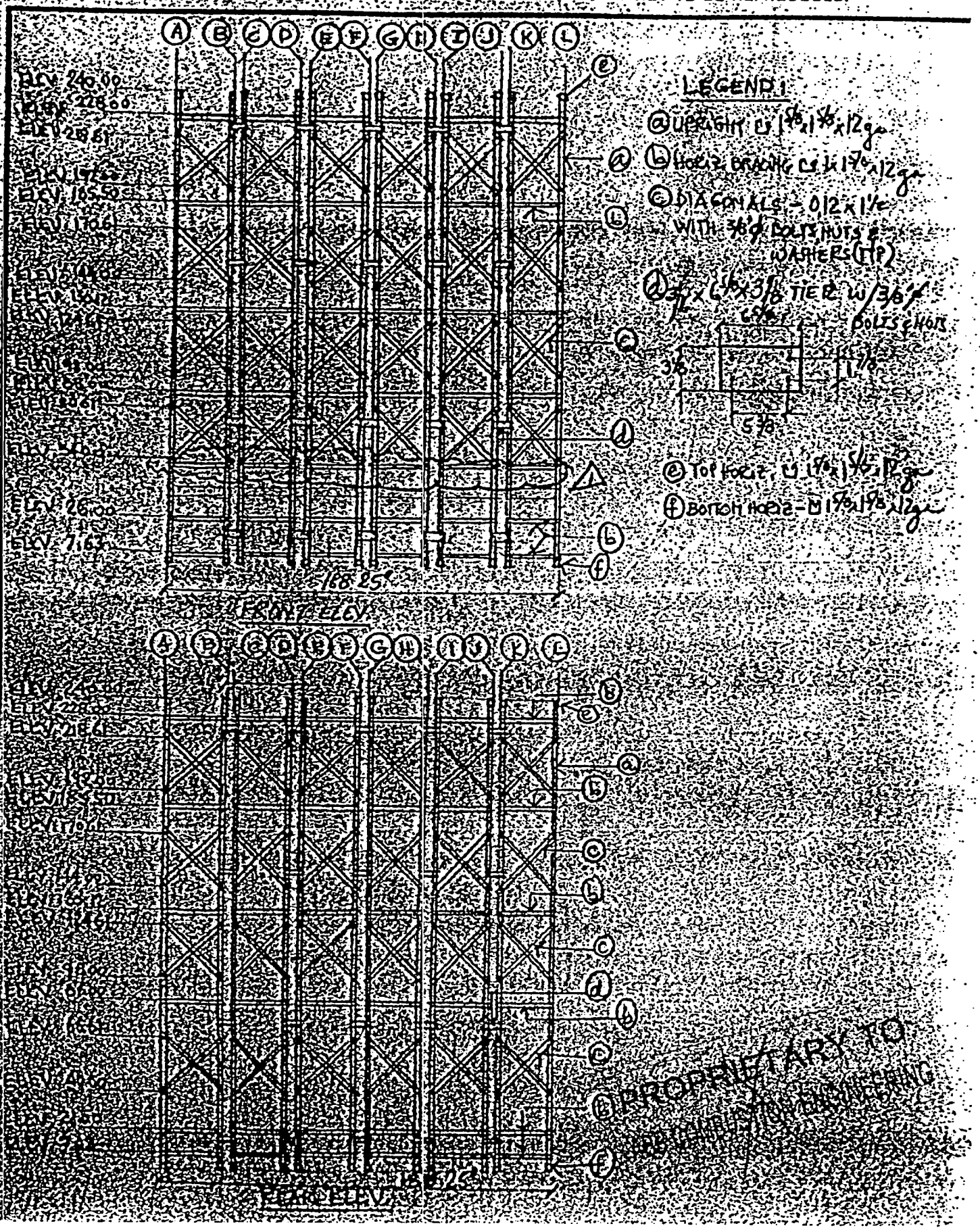


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Consulting Structural Engineers

SHEET NO. 4

JOB NO. 20613

FOR ABB COMBUSTION ENG. NUCLEAR POWER, HOBART P-KARREY INDUSTRIES EVER. BOND

HERCULANEUM, MISSOURI

UNIT _____ DESIGNER HR DATE 11-25-92

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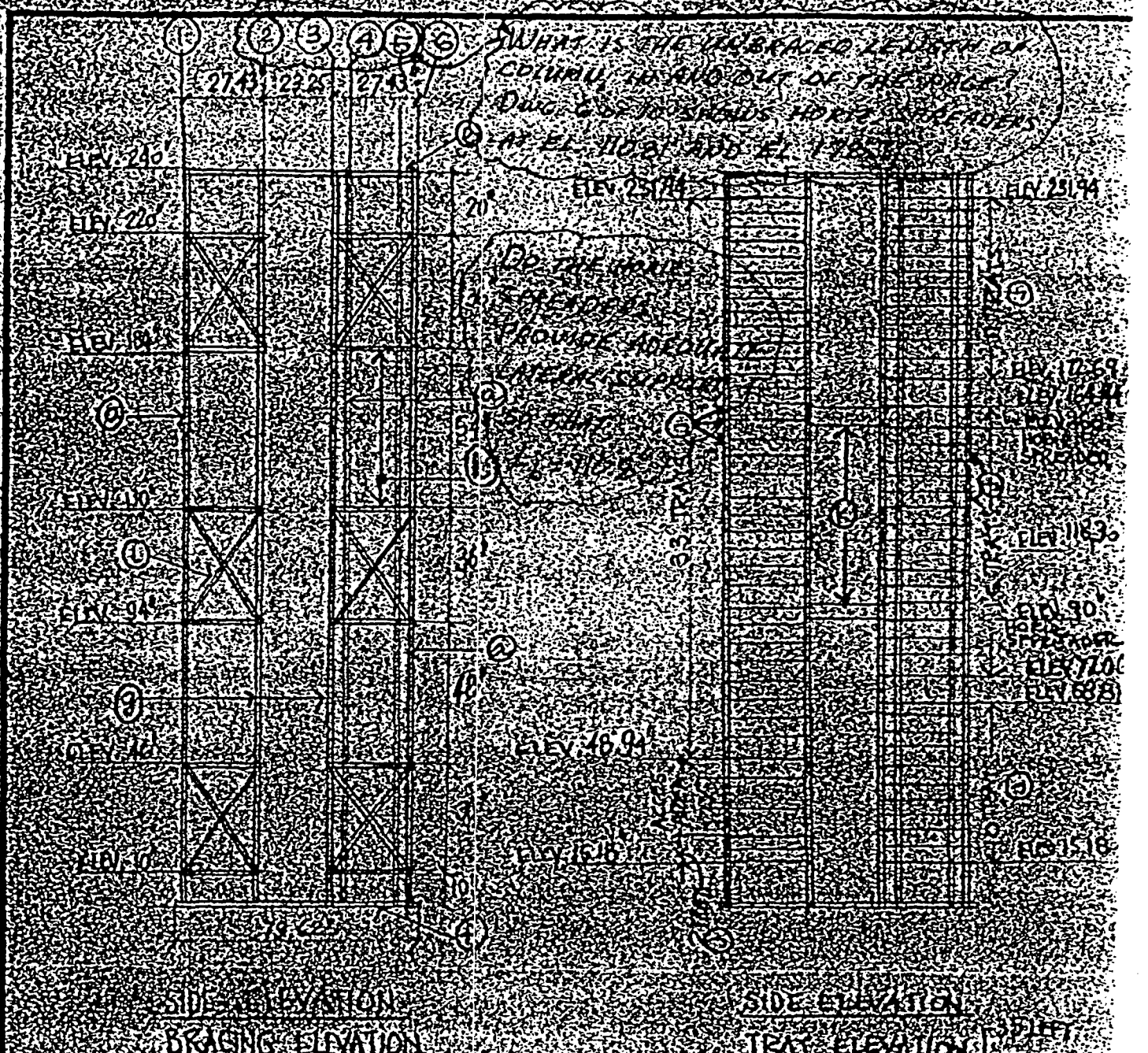

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Consulting Structural Engineers

SHEET NO. 5
JOB NO. 20613

JOB ABB COMBUSTION ENG. NUCLEAR POWER HIGHWAY - KARDEX INDUSTR. BOOO

UNIT _____ DESIGNER MR DATE 11-19-92

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LOADS

DL = 2 #/UNIT
LL = 16#/UNIT } PER KARDEX

NOTE - ASSUME ALL LOAD TO BE ABOVE THE ACCESS OPENING ALTHOUGH SOME ELECTRICAL PANELS & MECHANICAL DEVICES ARE BELOW THIS ELEV. (PER SECTION 6.11 SHT 4) AVERY CONSERVATIVE.

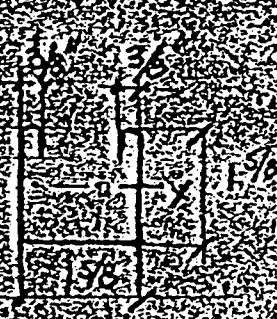
CHECK THE UPRIGHTS

DL SUPPORTED BY 12 COLUMNS
LL SUPPORTED BY 8 UPRIGHT COLUMNS

PER COLUMN

DL = 0.167 #/COLUMN
LL = 16 #/COLUMN
TOTAL = 21 #/COL

PROPOSE L 1 5/8 x 1 5/8 x 0.105 (UNISTRUT) Fy = 42 KSI - COLUMN




t = 0.105"

A = 0.36 IN²

Sx = 0.2091 IN³ Sy = 0.2941 IN³

Yx = 0.579" Yy = 0.655

$\frac{KL}{r} = \frac{0.85 \times 48}{1.058} = 70.4 \rightarrow F_{ax} = 18.49$ KSI

$F_{bx} = 30.14 \rightarrow F_{ex}$ (SEISMIC) = 30 KSI = 1.0

$F_{bx} = 10.35$ $M_{xa} = 6.8$ $M_{ya} = 7.4$

PROPRIETARY

EUGENE D. BIRNBAUM & ASSOCIATES
Consulting Structural Engineers

SHEET NO. 0
JOB NO. 20613

JOB ABB COMBUSTION ENGINEERING HOLLOW POWER HIGHWAY P – KARDEX INDUSTRIES, INC.
HEMATITE, MISSOURI 63047
KARDEX
BARNEY POOLE

UNIT _____ DESIGNER HR DATE 11-26-92

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SEISMIC = $\frac{Z I C}{R_W}\left(DL + \frac{LL}{2}\right)$ UBC STANDARD 27-11 – MINIMUM FOUR COLUMNS IN ANY DIRECTION ON EACH COLUMN LINE DESIGNED TO RESIST HORIZ. FORCES

$V = 2.5A_a I K C S W$
$A_a = 0.15$
$I = 1.5$
$K = 1.0$
$C/S = 0.2$
$W = 0.11W$

$Z = 0.15$ (SAINT LOUIS – SEISMIC ZONE 2A)
$I = 1.5$ (PER CLIENT REQUEST)
$C = 2.75$
$R_W = 6.0$ – 'X' BR. ACING

$V = \frac{0.15 \times 1.5 \times 2.75}{6}\left(DL + \frac{LL}{2}\right) = \left(\frac{0.103}{0.11}\right)\left(DL + \frac{LL}{2}\right) = \left(\frac{0.11}{0.103}\right)\left[2 + \frac{16}{2}\right] = \left(\frac{1.1^k}{1.03^k}\right)$

USE 1.1^k/CALC'S – PER UNIT

SEISMIC – (1.1 KIPS PER UNIT) – OK

TRANSVERS – TAKEN BY TRANSV. POSTS (2x4) ON X-X DIR. (PER UNIT)

LONGITUDINAL – TAKEN BY REAR & FRONT POSTS (2x2) ON Y-Y DIR. (PER UNIT)

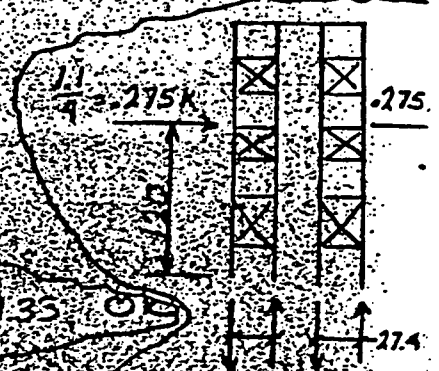
X – X DIR.

SEISMIC PER POST = $V = \frac{1.1}{8} = 0.1375^k$

$\left(P = 0.137 \times 48 = 6.37^k\right)$
$\left(P_{st} = 8 \times 4 \times 4 = 0.02^k\right)$

$M = 0.1375 \times \frac{48}{2} = 3.3^{k'}$

COMBINED $\frac{2.11^{k}}{10.3} + \frac{0.25 \times 3.3}{\left(1 - \frac{2.11}{40.1}\right)5.3} = \left(\frac{0.33}{0.211} + \frac{0.25}{0.95P}\right) = 0.77 < 1.33$ OK




Y – Y DIR.

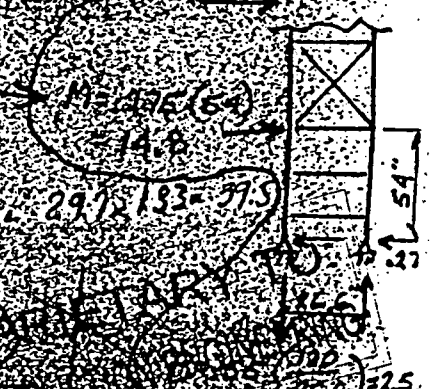
SEISMIC PER POST = $\frac{1.1}{4} = 0.275^k$ (BOX 6-26)

$\left(M = \frac{0.275 \times 54.0}{2} = 7.5^{k'}\right)$

$\frac{P_u}{A_n} = \frac{0.85 \times 51.6}{0.65} = 70.9 \rightarrow F_a = 18.35 \text{ KSI}$
$F_{cy} = 29.7 \rightarrow F_{cy}$ INCREASE $= 29.7 \times 1.33 = 39.5$

$P_{a_x} = 0.56 \times 18.35 = 10.3^k$

COMBINED




$\left(P = 2.1 + 7.5 = 9.6^k\right)$
$\left(P_{st} = 4.7 \times 2 = 9.4^k\right)$

$\frac{P}{10.3} + \frac{M_{st}}{\left(1 - \frac{P}{F_a}\right)F_b} = 0.93 + 0.91 = 1.84 > 1.33$ NG – SEE NOTE ON SHT. 7

$\left(F_b = 0.66 \times 0.75 = 0.5 \times 1.33 = 0.66^k\right)$

EUGENE D. BIRNBAUM & ASSOCIATES
Consulting Structural Engineers

SHEET NO. ____
JOB NO. 20613

ABB COMBUSTION ENGINEERING NUCLEAR POWER MECHANICAL / INDUSTRIES EVER 6000
HAZELWOOD, MISSOURI

DESIGNER HR DATE 11-26-92

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NOTE - THE OUTER PANELS ON FRONT & REAR ELEVATION ARE PROVIDING ADDITIONAL SHEAR STRENGTH FOR THE REAR & FRONT STRUCTURAL FRAMING (SEE SHT 1 OF 9, 2 OF 9 AND DETAIL F-F ON SHT 9 OF 9)

CHECK SIDE BRACING FOR 54" DIST. BETWEEN BRACING (SEE SIDE ELEV. ON SHT 4)

TRIB. LOAD → $\frac{H_{ADDED}}{H_{TOTAL}} \times W = \frac{20+36+54}{240} \times W = \frac{110}{240} W = 0.46W$

DL = 2 x 0.46 = 0.92 K

LL = 10 x 0.46 = 7.36 K

TOTAL = 8.28 K

VERT. COL. P = 8.28 = 1.04 K/COL

SEE HIC → V = (0.08)(1.92 + 7.36/2) = 0.51 K

PER COLUMN = V = 0.47 / (4.8) (0.12 / .06) (M COL = 0.12 x 54/2 = 3.24 IN-K)

TOTAL P = 1.04 + 2 (40 1/4 / 32.43) = 1.55 K
$f_a$ = 1.55/.56 = 2.77 KSI

Y6 = 0.85 x 54 / 0.58 = 79.2 → $F_a$ = 17.15
$F_{cx}$ = 1.33 x 23.8 = 31.65

$f_a$ = 0.56 x 17.15 = 9.6

COMBINED
1.04/9.6 + 0.85 x 3.24 / ((1 - 1.04/31.6) 5.4) = 0.108 + 0.527 = 0.64 < 1.33 OK

NEED TO REVIEW INTERIOR COLUMNS FOR $L_b$ = 111" ? (SEE SHEET 4)

CHECK BRACING ON SIDE ELEV. (SEE SHT 4)

GEO. HEIGHT

tg α = 36/24 = 1.5 → α = 52.73° → cos α = 0.606

Y = 11.5/UNIT → V SIDE = 11.5/2 x 0.55 = → V BRACKET (SIDE) = 0.55 K

PARTIAL 0.5 = 0.5 TENSION - EXT. LEV. 0.55 COMPRESSION

0.5 = 0.5 TENSION - INT. LEV.

ABY TO ENGINEERING

EUGENE U. BIRNBAUM

Consulting Structural Engineers

JOB NO. 20613

IBB COMBUSTION ETC. NUCLEAR POWER HIGHWAY 7 - INSPR. BLDG

TITE, MISSOURI

DESIGNER HR DATE 11-27-92

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DIAGONAL → 1½ x 0.12

$P_{BRACE}$ (A-y LOAD) = 1.5 x 0.12 x 20 = 3.6^k

$P_{BRACE}$ (A HOT) = [1.5 - (0.375 + 0.75)] 0.12 x 27 = 3.2^k || GOVERN

$P_{BRACE}$ = 3.2^k >> 1.0^k TRANSV. BRACING ∴ OK

ORIZ. BRACING → TAKEN BY UHISTRAT 1 x 1⅝ x 12GAGE H COLUMN

A = 0.43 IN²

$I_x$ = 0.054 IN⁴ $I_y$ = 0.163 IN⁴

$S_x$ = 0.093 IN³ $S_y$ = 0.200 IN³

$r_x$ = 0.354 IN $r_y$ = 0.615 IN

$\frac{KL}{r}$ = $\frac{27.4}{0.35}$ = 78.3 → $F_a$ = 17.26 $P_a$ = 17.26 x 0.43 = 7.42 >> 0.6^k OK

CHECK BRACING ON FRONT & REAR ELEV

DIAGONALS

GEOMETRY

α = 45°

cos α = 0.707

V = 1.1^k / UNIT

$V_{DIAG}$ = $\frac{1.1}{2}$ = 0.55^k $P_{BRACE}$ = $\frac{0.55}{0.707}$ = 0.78^k < $P_a$ = 3.2^k OK

BRACE

∴ DIAGONALS ARE OK

OPTN FRONT & REAR BRACING WITH ONLY 3 DIAGONALS FOR TOP

TWO BRACINGS

OF THE COLUMNS

TOTAL LOAD = 1.6 x 1.4 x 180 = 1008 W = 0.54 W

DL = 0.54 x 1008 = 544 ^k || 9.72 ^k = 10.7 ^k

LL = 0.54 x 16 = 8.64 ^k

PROPRIETARY TO

ENGINEERING

EUGENE D. BIRNBAUM & ASSOCIATES
Consulting Structural Engineers

SHEET NO. 7
JOB NO. 2063

JOB ABB COMBUSTION ENG — NUCLEAR POWER HISTORY P-INDUSTRIES 8000

UNIT _____ DESIGNER HR DATE 8-28-92

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$P_{VERT} = \frac{9.72}{8 \text{ COLUMNS}} = 1.22 \sim 1.9^k$

$P_{SEISMIC} = V = 0.103\left(1.1 + \frac{9.7}{2}\right) = 0.56^k \sim 0.6^k$

$P_{PER\ COL} = \frac{9.6}{4} = 0.15^k$ $\quad M_{COL} = 0.15 \times \frac{55.5}{2} = 4.16^{k'} \times 2$

SINCE BRACED UNIT SUPPORTS SEISMIC LOAD OF 2 UNITS

$\frac{KL}{r} = \frac{0.85 \times 55.5}{10.55} = 72 \rightarrow F_a = 18.19\ ksi$

$F_{bx} = 1.33 \times 28.8^k = 38.32$

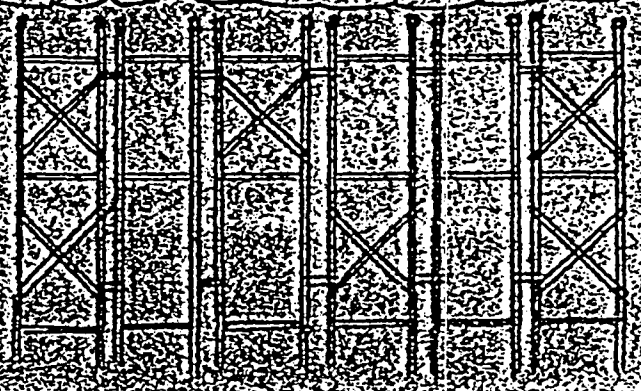
$P_a = 18.19 \times 0.56 = 10.2^k$

COMBINED $= \frac{1.32}{10.2} + \frac{0.85 \times 4.16}{\left(1 - \frac{1.32}{38.32}\right) 54} = 0.13 + 0.68 = 0.81 < 1.33$ OK

$\times 2$ $\quad 1.49 \times 1.33$ N.G.

(NO HAY WAVE 3 BRACING @ FIRST TWO TOP BRACINGS)

(NO)



(NOTE: THE THREE BETTAHHH BRACINGS ARE TAKEN THE ENTIRE SHEAR)

$P_{BRACE} = \frac{0.15 \times 2 \times 3}{0.606} = 1.49^k < P_{a\ BRACE} = 3.2^k$ OK

$< P_{A\ BOLT} = 1.5^k$ OK

CHECK CONN.

BRACE & FRONT

$f_{bf} = \frac{1.49}{12.6A} = 0.105^k$

(BOCA 1113.11.5 DOES NOT ALLOW THE 1.33 INCREASE FOR CONNECTIONS IN BRACED FRAMES)

$V_{BOLT} = 3.14 \times \frac{.375^2}{4} \times 10 \times 1.33 = 1.5^k/BOLT$ < SHEAR || GOVERN

$= 0.375 \times 0.105 \times \frac{2.22 \times 54}{2.02} \times 1.33 = 2.8^k/BOLT$ BEARING

OBS STANDARD

JT-69/79 $\quad P_{BOLT} = 1.5^k/BOLT > 0.78^k$ FROM FOR 1992

$1.1^k/BOLT > 1.0^k$ SIDE ELEV.

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Consulting Structural Engineers

SHEET NO. 10
JOB NO. 20613

JOB ABB COMBUSTION ENG. NUCLEAR POWER HIGHWAY P. - KAMEX INDUSTRIES BLDG.
HEMATITE, MISSOURI

UNIT _____ DESIGNER MR DATE 11-20-92

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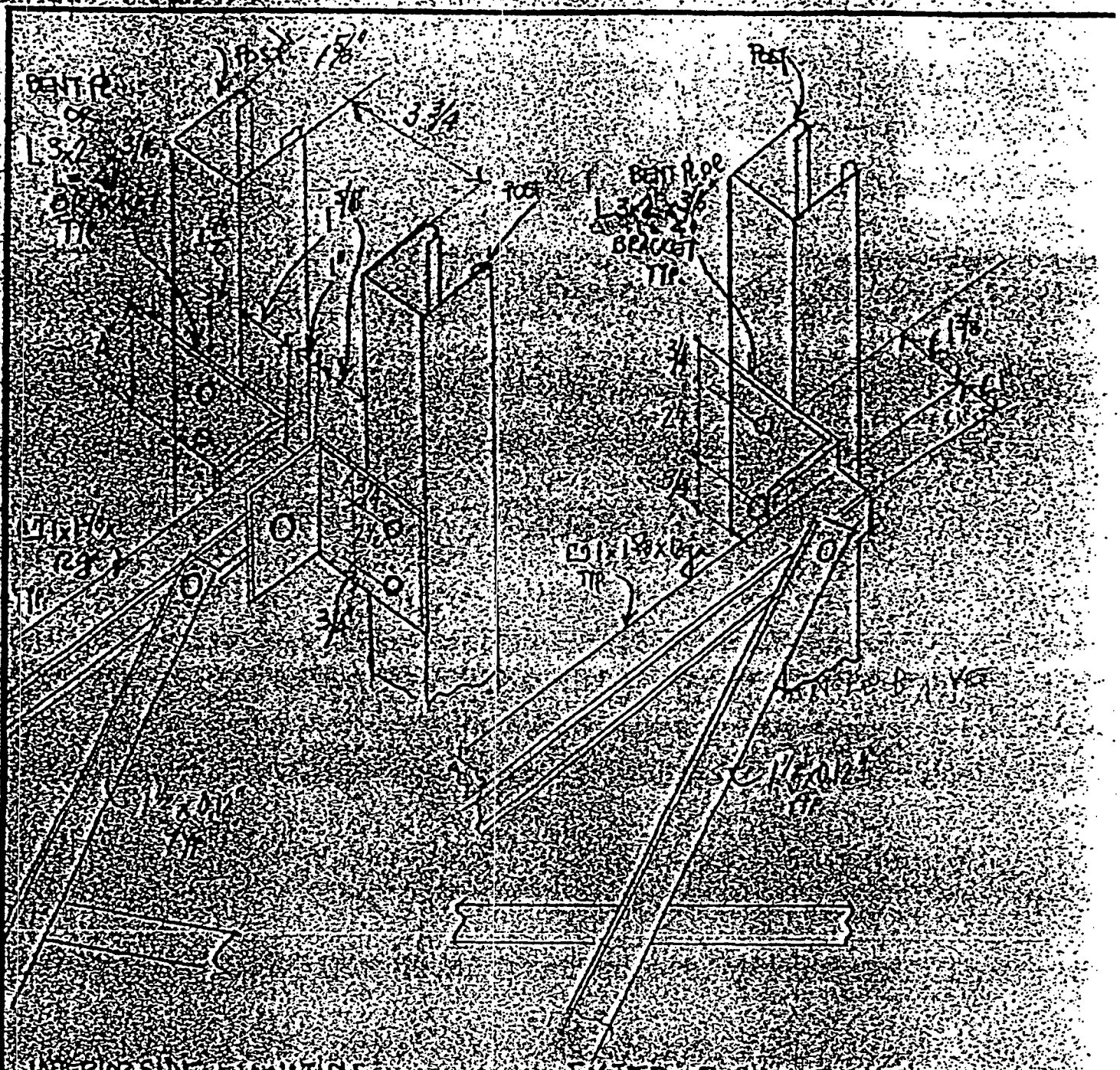


Note:
All Bolts = 5/8" ø Grade 5
All Diagonals = 1/2" ø 12"
All Knee Braces = L 1x1x1/8

ATTACHMENTS FOR SIDE ELEVATION BRACING

STRUCTURAL ENGINEERING

THIS DRAWING IS ONLY ON PAPER. A PAPER COPY IS NOT TO BE REPRODUCED

ABB COMBUST ENG. HUCHAR FOWLER ASHOKY? - KATALOX PO. 5000

DESIGNED HR DATE 11-29-92

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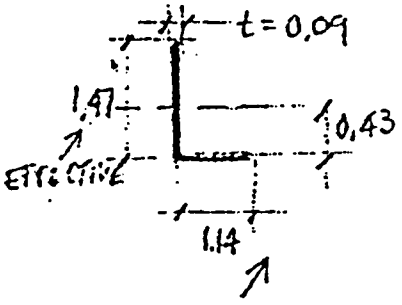



$t = 13\ GA$

$A = 0.23\ IN^2$

$y = \dfrac{1.47^2/2}{1.47 + (1.14 - 0.09)} = 0.43''$ $\quad c = 1.47 - 0.43 = 1.04''$

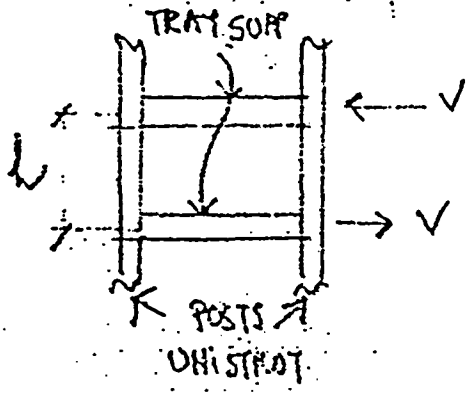
TRAY SUPPORT EFFECTIVE SECTION

$I_x = \left[\dfrac{1.47^3}{12} + 1.47\left(\dfrac{1.47}{2} - 0.43\right)^2 + (1.14 - 0.09)\left(0.43 - \dfrac{0.09}{2}\right)^2\right] t = 0.56t$

$I_x = 0.56 \times 0.09 = 0.0504\ IN^4$

$S_x = \dfrac{0.0504}{1.04} = 0.0482\ IN^3 \quad = M = 0.048 \times 33 \times 0.6 = \underline{\underline{0.95''K}}$

THE SCHEME (TRAY SUPP. ACTS AS VIERENDEL)




M SUPPORT TRAY $= V \times h = 0.95^{BK}$

$V = \dfrac{1.1}{8} = 0.138^{K}/POST$ ← TOTAL SHEAR

$h_{MAX} = \dfrac{0.95 \times 1.33}{0.138} = 9.2''$

CHECK POST

$P = 2.2$

$M = 0.138 \times \dfrac{9.2}{2} = 0.64^{BK}$

$P_a = 10.3^K$ (U. CONSERVATIVE)

COMBINED $= \dfrac{2.2}{10.3} + \dfrac{0.64}{5.3} = 0.33 < 1.33$

$T_{BOLT} = \dfrac{1.33 \times 0.95''}{0.94} = 1.35^K < 1.5^K$ 3/8" ϕ BOLT

DIST. BETWEEN BOLT – TRAY SUPP TO POST – 0.94" (KATALOX STANDARD SUPP. TRAY DETAIL

(MAX DIST. BETWEEN TRAY SUPP 9.2"
MIN 2 - 3/8" ϕ BOLT EACH SIDE CONTRARY TO:

PROPRIETARY
ABB COMBUSTION ENGINEERING

IF THE ABOVE IS ACCOMPLISHED, FOR THOSE BACKWARDLAR AREAS YOU MAY OMMIT THE "X" BRACING SHOWN ON SHT 4 (NOW YOU HAVE ONLY ONE BOLT ON ONE SIDE)

ABB - COMBUST. ENG. INDUSTR. POWER BIGHOUSE - [illegible]

DESIGNED MR DATE 11-29-9[illegible]

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THE LONGITUDINAL ANALYSIS ON PAGE 6 INDICATES UPLIFT CAN OCCUR ON INDIVIDUAL COLUMNS, SINCE EACH UNIT WAS ANALYZED INDEPENDENTLY.
∴ IF EACH FRAME IS NOT ANCHORED TO SLAB, SHOW THAT THE FRAMES ARE ADEQUATELY INTERCONNECTED, TO PREVENT UPLIFT FROM OCCURRING.

## GENERAL STABILITY

TRANSV. DIR. GOVERN

$O.T.M = 1.1 \times \frac{240}{2} \times 1.15 = 151.8$ ~~[illegible]~~ − 160 ft-k

$R.M = \left[(2+16) - \frac{1.1}{3}\right]\left(\frac{79 - 3.5 \times 2}{2}\right) =$ 634.5 ft-k

NO UPLIFT

ANCHORAGE

T = 0 (NO UPLIFT

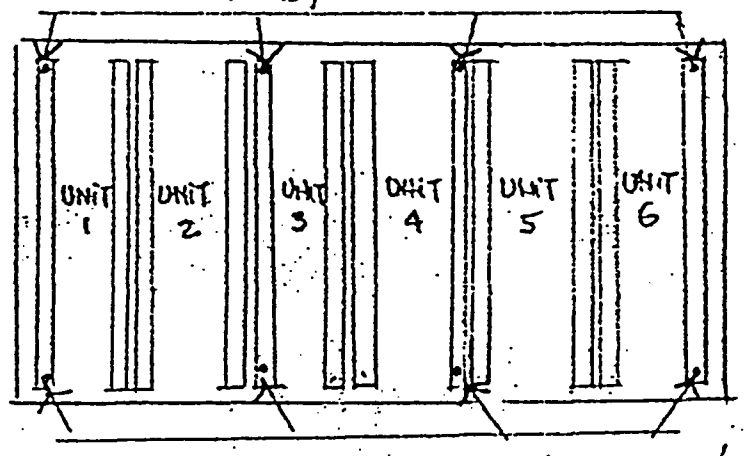
$V = 6 \times 1.1 = 6.6^k$

USE 8 ANCH BOLTS

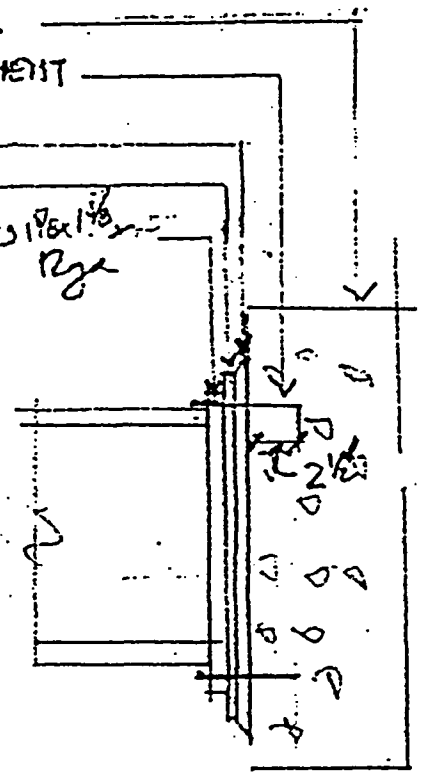
$V = \frac{6.6}{8} = 0.83^k$/SHEAR BOLT

- 12" CONCRETE FTG
- 1½"φ − 2½" EMBEDMENT IN CONCR. FTG
- ±1" GROUT
- 1" STEEL PL
- HORIZ. UNISTRUT ⊏ 1⅝"x1⅝"

× 4 − ½"φ-EXP BOLTS




4½"φ-EXP. BOLT
2½" EMBEDM. IN CONCR FTG




PLAN

SECTION A-A

NOTE: USE ANY ICBO ½"φ EXP. BOLT − 2½" EMBEDM. IN CONCRETE − APPROVED BY LOCAL CITY
EXAMPLE − RED HEAD (DEWALT) − ICBO 1372
− RAWL ANCH. BOLT − ICBO 4514
OR EQUIVALENT

PROPRIETARY TO:
ABB COMBUSTION ENGINEERING

Post-it™ brand Fax Transmittal Memo 7672

| | | | |
|---|---|---|---|
| To MR. DON RODE / LEN GROSSMAN | | No. of Pages 10 | Today's Date 1-28-93 Time 2:25 |
| Company ABB CENP | | From SEAN O'FARRELL | |
| Location HEMATITE, MISSOURI | | Company SHULER BUS. SYSTEMS, KAROCK SYSTEMS | |
| Fax # 314-937-7955 | Telephone # 314-296-5640 x345 | Location ST. LOUIS, MISSOURI | Dept Charge |
| | | Fax # 314-434-4569 | Telephone # 314-434-4566 |

Comments

Original Disposition: ☐ Destroy ☐ Return ☐ Call for pickup

Dear Don,

I hope this answers the questions and comments you have concerning the seismic calculations. I am ready to proceed with the amended calculations as soon as ABB and Metropolitan Engineering agree this meets seismic certifications...

Very Truly yours

Sean

Sean O'Farrell

EUGENE D. BIRNBAUM AND ASSOCIATES
Consulting Structural Engineers
1626 SILVERLAKE BOULEVARD
LOS ANGELES, CALIFORNIA 90026
PHONE 213-663-9218
FAX 213-663-7309

**FACSIMILE TRANSMISSION**

TO: SHULER BUSINESS SYSTEMS INC.

Attn: SEAN O'FARRELL

Phone (314) 434 4566

Fax (314) 434 4569

JOB NO. 20613

DATE 1-28-93

FROM: MIKE RABINOVICI

SUBJECT: ABB COMBUSTION ENGINEERING HIGHWAY P - HEMATITE MISSOURI

MESSAGE MR SEAN O'FARRELL

ATTACHED YOU HAVE CC-1 TO CC-6, SK-1, SK-2 & SHT3 ORIGINAL CALCS WITH THE NEW HORIZ BRACINGS AT ELEV. 40' → OUR CORRECTIONS ON ABBCENP'S COMMENTS.

FIRST → THE LOAD → 16,000# YOUR CLIENT IS ASKING FOR SEEMS TO BE UNREALISTIC BECAUSE THE VOLUM (INCLUDING THE HON OCCUPIED SPACE!) IS (FOR THE 2 TOWERS / AT EACH UNIT) $\frac{\sqrt{27.5 \times 25 \times 21.5 \times 2}}{12 \times 12 \times 12} = .171$ CUFT

DENSITY (K) 16000 / .171 = 94#/CU FT → FROM OUR EXPERIENCE THIS DENSITY IS LESS THAN 17 ½ ON AN AVERAGE BASIS. — SEE COMMENTS ON SHT CC-1 PLEASE

WHAT WE ADDED → TRANSVERS & LONGITUDINAL HORIZ. SPREADERS → PER SK-1

→ TIE RE → PER SK-2

→ NEW HORIZ. BRACINGS AT REAR ELEV. → PER SHT3 CALCS REVISED

→ ANCHORAGE TO FLOOR - ALL FRAMES ANCHORED → PER CC-6

I BELIEVE THAT THE ABOVE SHOULD ANSWER ON ALL THE QUESTIONS ABBCENP WERE ASKING FOR

PLEASE CALL ME OR BARNEY POOLE (RADLEY) FOR ANY INSTALLATION PROBLEMS

INCLUDING THIS SHEET, THERE ARE 10 TOTAL SHEETS IN THIS TRANSMISSION

Mike

KINDLY CONTACT US IF THE TRANSMISSION IS INCOMPLETE

PROPRIETARY TO: ABB COMBUSTION ENGINEERING

HEMATITE MISSOURI 63047

UNIT _____ DESIGNER PJR DATE 1-25-93

SHULER BUSINESS SYSTEMS, INC { JEAN O'HARRA (314) 434 4566 (314) 434 4569

BARNEY POOLE (800) 234 3654 (614) 324 9300 (614) 373 7888 FAX

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COMMENTS ON ABB CEN'P SEISMIC DESIGN REVIEW – LETTER OF 01-20-93

SHEET 1 – PER OUR AGREEMENT WITH OUR CLIENT (BARNEY POOLE – FROM KACPED PRIOR TO GET THE JOB, IT WAS CONFIRMED THAT A STRUCTURAL CALIFORNIA SEAL IS SATISFACTORY FOR THIS JOB. IF THIS IS NOT ANY MORE VALID WE CAN SEAL THE JOB BY A PROFESSIONAL ENGINEER LICENSED IN THE STATE OF MISSOURI FOR AN ADDITIONAL ±$300.

– WE DESIGNED PER UBC STANDARD 27-11 – FOR STEEL STORAGE RACK WHICH MEETS BOCA NATIONAL BUILDING CODE 1990 SEISMIC REQUIREMENTS AS WELL (AS YOU MENTIONED IN YOUR COMMENTS SHT 6 FIRST PARAGRAPH. THE BASE SHEAR IS STILL THE SAME)

– PLEASE SEE OUR COMMENTS ON LOADS – SHT CC-4

SHEET 4 – THE HORIZONTAL SPREADERS ARE SUPPORTS FOR THE INTERIOR LONGITUDINAL COLUMNS. THE SEISMIC LATERAL FORCE IS TAKEN BY REAR & FRONT ELEVATION ALREADY CHECKED ON SHT 6 (SEE FURTHER COMMENTS ON SHT 6 AS WELL) VIA VIERENDEL ACTION OF SPREADERS, TRAY SUPPORTS – EVERY 5½' & TRANSV. HORIZ. BRACINGS

CHECK INTERIOR COLUMNS – LONGIT. DIR.

TOP PORTION ⇒ (240 – 1.625) – 178.31 = 60.06"

V. CONSERVATIVE

$\frac{KL}{r} = \frac{1.2 \times 60}{0.655} = 110 \rightarrow F_a = 12.16$ ksi

$P_a = 0.56 \times 12.16 = 6.8^k$  $P_a$ SEISMIC $= 6.8 \times 1.33 = 9.04^k$

VERT. LOAD @ ELEV. 178.31 ⇒ $P = \frac{60}{240} W = 0.25 W = 0.25 \left(\frac{2+16}{8 \text{ COL.}}\right) = 0.56^k$

FROM OVERTURNING $V = 0.103 \times \left(\frac{2 + 16/2}{8}\right) \times 0.25 = 0.033 \sim 0.04$

SEISMIC REACTION ON POST ⇒ $P_s = \frac{2 \times 0.04 \times 60\frac{1}{2}}{25} = 0.09^k \sim 0.1^k$

$P = 0.56^k < 6.8^k$ OR $P_{SEISMIC} = 0.56^k + 0.1^k = 0.66^k < 9.04^k$

THE VERT. FORCE HAS A TRIANGULAR DISTRIBUTION SO THE REAL FORCE IS ±½ FROM THE ABOVE $\left(\frac{0.56^k}{2} \text{ & } \frac{0.1^k}{2}\right)$

INTERMED. PORTION $(178.3 - 110.81) = 67.5'$

$\frac{KL}{r} = \frac{1.2 \times 67.5}{0.655} = 123.4 \rightarrow F_a = 9.79$ Ksi

$P_a = 0.56 \times 9.79 = 5.48^k$  $P_a$ SEISMIC $= 5.48 \times 1.33 = 7.3^k$

PROPRIETARY TO ABB COMBUSTION ENGINEERING

EUGENE D. BIRNBAUM & ASSOCIATES
Consulting Structural Engineers

SHEET NO. 2-C
JOB NO. 20613

JOB ABB COMBUSTION ENGINEERING HIGHWAY P-

UNIT _____ DESIGNER HR DATE 1-26-93

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VERT LOAD @ ELEV. 110 ⇒ $P = \frac{60+67.5}{240} W = 0.53 w = 0.53 \frac{(2+16)}{8 \text{ COL.}} = 1.2^k$

FROM OVERTURNING $V = 0.103 \frac{(2+16/2)}{8 \text{ COL.}} \times 0.53 = 0.07^k$

SEISMIC REACTION ON POST $= 2 \times \frac{0.07 \times 127.5/2}{25} = 0.36^k \approx 0.4^k$

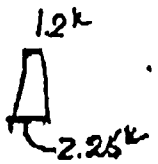
$P = 1.2^k < 5.48^k$ $\quad P_{SEISMIC} = 1.2 + 0.4 = 1.6^k < 7.3^k$

SAME REMARK FOR TRIANGULAR DISTRIB. OF VERT. FORCE

LOWER PORTION — 110.8' ELEVATION

$\frac{KL}{r} = \frac{(110.8 - 1.62)1.2}{0.655} = 200 \rightarrow F_a = 3.73$

$P_a = 3.73 \times 0.56 = 2.1^k$




VERT LOAD @ ELEV. 110.8 → $1.2^k$

VERT LOAD @ ELEV 0 → $P = \frac{2+16}{8} = 2.25^k$

AVERAGE LOAD ⇒ $P = \frac{1.2+2.25}{2} = 1.73^k < 2.1^k$

HOWEVER WE DECIDED TO PUT THREE MORE SPREADERS ON FRONT SIDE & TWO MORE ON REAR SIDE SEE ATTACHED SKETCH SK-1 & DWG 6 REVISED. PLEASE NOTICE THAT ALL INTERIOR COLUMNS ARE TIED WITH 4 - TIE PL $6^{5/8} \times 3\frac{1}{8} \times 3/16$ WITH 3/8"Ø BOLTS & NUTS AS THEY ARE ON FRONT & REAR ELEVATION.

CHECK FOR NEW CONFIGURATION — SEE SK-1 INTERIOR LONGIT. COLUMNS.

ELEV. 212.06 & 155.81' OK BY INSP PER THE ABOVE

ELEV 99.56 → VERT. LOAD ⇒ $P = \frac{139}{240} \times W = 0.58 \frac{(2+16)}{8} = 1.3^k$/POST

FROM OVERTURNING ⇒ BASE SHEAR $V = 0.103 \frac{(2+16/2)}{8} \times 0.58 = 0.075^k$/POST

SEISMIC REACTION ON POST $= \frac{0.075 \times 2 \times 141/2}{25} = 1.42^k$

$\frac{KL}{r} = \frac{1.2 \times 56.25}{0.655} = 103 \Rightarrow F_a = 13.4$ ksi

$P_a = 13.4 \times 0.56 = 7.5^k$ $\quad P_a$ SEISMIC $= 7.5 \times 1.33 = 9.97^k$ $\quad 1.72^k + 1.42^k = 3.14^k$

ELEV. 54.56 → VERT. LOAD $= \frac{184}{240} w = 0.77 \frac{2+16}{8} = 1.73^k$

BASE SHEAR ⇒ $V = 0.103 \frac{(2+16/2)}{8} \times 0.77 = 0.099^k$/POST

SEISMIC REACTION ON POST $= \frac{0.099 \times 2 \times 184/2}{25} = 0.73^k$

PROPRIETARY: ABB COMBUSTION ENGINEERING

EUGENE D. BIRNBAUM & ASSOCIATES
Consulting Structural Engineers

SHEET NO. CC-3
JOB NO. 20813

JOB ABB COMBUSTION ENGINEERING HAMMAYT
HEMATITE, MISSOURI

UNIT _____ DESIGNER MR DATE 1-26-93

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$\frac{KL}{r} = \frac{1.2 \times 45}{0.655} = 82.5 \rightarrow F_a \Rightarrow 16.78$ KSI

$P_a = 0.56 \times 16.78 = 9.4^k$ $P_a$ SEISMIC $= 9.4 \times 1.33 = 12.5^k \gg 1.73 + 0.73 = 2.46^k$

ELEV. 20.81 → VERT LOAD = WE TOTAL LOAD $P = \frac{2+16}{8} = 2.25^k$/POST

BASE SHEAR $= 0.103 \left(\frac{2+16/2}{8}\right) = 0.129^k$/POST

SEISMIC REACTION ON POST $= \frac{2 \times 0.129 \times 21 8/2}{25} = 1.1^k$

$\frac{KL}{r} = \frac{1.2 \times 53.55}{0.655} = 61.5 \rightarrow F_a = 19.57$ KSI

$P_a = 0.56 \times 19.57 = 10.96^k$ $P_a$ SEISMIC $= 10.96 \times 1.33 = 14.6 \gg 2.25 + 1.1 = 3.35^k$ OK

THEODORE GALAMBOS IN HIS "GUIDE TO STABILITY DESIGN CRITERIA FOR METAL STRUCTURES" LATEST (4th) EDITION RECOMMEND FOR A LAT. SUPPORT → TO BE ABLE TO CARRY 1% FROM ITS VERTICAL CAPACITY. OUR OFFICE IS USING 1.5% → 5% SPRING PER CAPACITY → $2.25 \times 1.5\% = 0.0338^k$

OR SEISMIC $= 3.35^k \times 1.5\% = 0.05^k$ OR $\frac{0.05}{1.33} = 0.0375^k$ @ PL PL – OK BY INSP

SHT 6

YOUR TWO REMARKS ARE CORRECT:

XX

SEISMIC REACTION ON POST CONSERVATIVE – THIS IS REFERING TO TOTAL LOAD PER ENTREUHIT { THE AREA INVESTIGATED IS BETWEEN ELEV 94' & 46'

$P_s = \frac{0.137 \times 2 \times 194/2}{27} = 0.99^k \sim 1.0^k$ $f_a = \frac{3.17}{0.55} = 5.66$

$P_v = 2.17^k$ $M = 3.3^{HK}$ $M_m = 5.3^{HK}$

$P = \frac{2.17 + 1.0}{10.3} + \frac{0.85 \times 3.3}{\left(1 - \frac{5.66}{40.1}\right) 5.3} = 0.308 + 0.616 = 0.92 < 1.33$ STILL OK

Y-Y REAR & FRONT ELEV. CARRING THE ENTIRE SEISMIC

CHECK BELOW BRACING

FRONT ELEV. BETWEEN 54' & 26' ELEV. → $l = 28'$

BASE SHEAR/POST → $V = 0.275^k$

$M = 0.275 \times \frac{28}{2} = 3.85^{HK}$

$\frac{Kl}{r_y} = \frac{0.85 \times 28}{0.655} = 36.4 \sim 37 \rightarrow F_a = 22.4$ KSI
$F_{ex} = 110 \times 1.33 = 146.3$

$P_a = 22.4 \times 0.56 = 12.54^k$ $M_{pl} = 7.4^{HK}$

PROPRIETARY TO:
ABB COMBUSTION ENGINEERING

Consulting Structural Engineers

JOB No. 20013

JOB ABB COMBUSTION ENGINEERING HIGHWAY P
HEMATITE, MISSOURI

UNIT _____ DESIGNER MR DATE 1-26-93

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SEISMIC REACTION ON POST

USE - CONSERVATIVE - ENTIRE BASE SHEAR/POST = V = 0.275 K

$P_s = \frac{2 \times 0.275 \times 214/2}{25} = 2.35^K$ $\quad f_a = \frac{2.35 + 2.12}{0.56} = 7.91$

COMBINED

$$\frac{4.52}{12.54} + \frac{0.85 \times 3.85}{\left(1 - \frac{7.91}{146.3}\right)7.4} = 0.36 + 0.47 = 0.83 < 1.33 \text{ OK}$$

REAR ELEV. BETWEEN ELEV 66.61 & 21.00 $\ell = 46.6'$ } NEGLECT THE HORIZ. SPREADER @ 54.57' ELEV - CONSERVATIVE

USE - CONSERV. - ENTIRE BASE SHEAR/POST = V = 0.275 K

$M = 0.275 \times \frac{46}{2} = 6.35^{IK}$

$\frac{KL}{r} = \frac{0.85 \times 46.6}{0.655} = 60.5 \rightarrow F_a = 19.7$ Ksi

$F'_{ey} = 41.0 \times 1.33 = 54.53$

$P_a = 19.7 \times 0.56 = 11.03^K$

$P_s = 2.35^K$ $\quad P_V = 2.17^K$ $\quad P_{TOTAL} = 4.52^K$ $\quad f_a = 7.91$ Ksi

COMBINED

$$\frac{4.52}{11.0} + \frac{0.85 \times 6.35}{\left(1 - \frac{7.91}{54.5}\right)7.4} = 0.41 + 0.85 = 1.26 < 1.33 \text{ OK}$$

NOTE: AS WE MENTIONED BEFORE, OUR APPROACH IS CONSIDERING THE LOAD ON THE LOWER ELEVATION BEING ON TOP OF THE COLUMN WHICH IS VERY CONSERVATIVE. EVEN SO 1.26 IS TO CLOSE TO 1.33 ⇒ INSERT ONE MORE HORIZ BRACING ON ELEV. 40' - (SEE SHT 3 - ATTACHED - WITH THE NEW BRACING SHOWN)

GENERAL COMMENTS ON LOADS

THE LOAD → 16 000# THE CLIENT IS ASKING FOR, SEEMS TO BE UNREALISTIC BIG - THE VOLUM (INCLUDING THE NON OCCUPIED SPACE) IS (FOR THE TWO TOWERS/AREA OF UNITS)

$V = 2 \times \frac{27.5' \times 25' \times 215}{12 \times 12 \times 12} = 171$ CUFT

THE DENSITY (INCL. THE NON OCCUPIED VOLUM) $= \frac{16000}{171} = 94^{\#}/\text{CUFT}$

BECAUSE IT IS DIFFICULT TO FIT THE TRAY DIMENSIONS IN WIDTH, DEPTH & HEIGHT PLUS THE 1' MIN ROOM TO MOVE THE TRAY, USUALLY THE OCCUPIED VOLUM IS LESS THAN 1/2 TOTAL VOLUM. → FROM OUR EXPERIENCE THE REAL DENSITY FOR THIS JOB SHOULD BE (ON AN AVERAGE BASIS) LESS THA

PROPRIETARY
ABB COMBUSTION ENGINEERING

# EUGENE D. BIRNBAUM & ASSOCIATES

Consulting Structural Engineers

SHEET No. CC-5
JOB No. 20619

JOB ABB COMBUSTION ENGINEERING HIGHWAY P
HEMATITE, MISSOURI

UNIT _____ DESIGNER HR DATE 1-28-93

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SHT 7

CHECK POST ON SIDE BRACING FOR 54' DIST. BETWEEN BRACINGS. - (SEE SHT 4 ORIG. CALC)

$P_{VERT\ COL} = 1.04^k/COL$ (SEE SHT 4 - CONSIDERING THE LOAD AT LOWER ELEV. BEING ON TOP OF THE COLUMN!)

BASE SHEAR - 0.47 K/UNIT AT 8 COLUMNS. (SEE SHT 7 ORIG. CALC'S)

PER COL $= \frac{0.47}{8} = 0.12^k$ $\quad H = 0.12 \times \frac{54}{2} = 3.24^{\prime k}$ | SHT 7

SEISMIC REACTION ON POST $P_S = \frac{2 \times 0.12 \times 110/2}{27} = 0.49^k$

SHT 7 | $F_a = 1715$ KSI $\quad P_a = 9.6^k$

$F_{ex} = 3165 \quad P = P_V + P_A = 1.04 + 0.49^k = 1.53^k \quad f_a = \frac{1.53}{0.56} = 2.73$ KSI

COMBINED

$$\frac{1.53}{9.6} + \frac{0.85 \times 3.24}{\left(1 - \frac{2.73}{31.65}\right)5.4} = 0.16 + 0.66 = 0.82 < 1.33 \text{ OK}$$

INTERIOR LONGIT COL. ALREADY CHECKED BEFORE -

SHT 8-9

KARDEX ALREADY PROVIDED ALL THE BRACINGS PER ORIG. DRAWINGS. SO THIS IS ACADEMIC NOW

TRIB LOAD = 0.54 W. SEE SHT 8 | DL = 1.08 K LL = 8.64 K

BASE SHEAR @ THIS LEVEL = $V = 0.103\left(1.08 + \frac{8.64}{2}\right) = 0.56^k$/TO 4 COLUMNS

PER COL $\Rightarrow V = \frac{0.56}{4} = 0.14^k/COL \rightarrow$ FOR 12 COLUMNS/REAR OR FRONT ELEV. $\rightarrow$ BASE SHEAR $V = 0.14 \times 12 = 1.68^k$

PER ONE BRACE $P = \frac{1.68}{3 \times 0.606} = 0.92^k < P_a$ BRACE $= 3.2^k$ OK WITH 3 BRACING

$< P_a$ BOLT $= 1.1^k$ OK

CHECK CONN REAR FRONT & SIDES

UBC STANDARD 27-09-91

3/8" A307 - @ 12 GA $\rightarrow$ 0.105" WITH WASHERS (IN ORIGINAL CALC'S OMITTED)

$V_{BOLT} = 3.14 \times \frac{0.375^2}{4} \times 10 = 1.10^k$/BOLT SHEAR

$= 0.375 \times 0.105 \times \frac{3.0 \times 54}{2.22} = 2.87^k$/BOLT BEARING

$P_{BOLT}$ $1.1^k$/BOLT $> 0.78^k$ FRONT & REAR ELEV. | OK

$> 1.1^k$ SIDE ELEV.

PROPRIETARY TO ABB COMBUSTION ENGINEERING

EUGENE D. BIRNBAUM & ASSOCIATES
Consulting Structural Engineers

SHEET NO. CC-6
JOB NO. 20613

JOB ABB COMBUSTION ENGINEERING HAGERSTOWN

UNIT _____ DESIGNER MK DATE 1-28-93

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SHT 13

GENERAL STABILITY

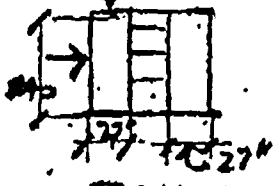
LONGITUDINAL – ALL POSTS ARE INTERCONNECTED & NO UPLIFT OCCURS.

TRANSV. DIR. GOVERN

VERT LOAD = DL = 2K
LL = 16
TOTAL = 18K

4 BRACING SYSTEMS } PER UNIT ⇒ PER BRACING $\frac{18}{4} = 4.5^K$

BASE SHEAR/BRACING SYSTEM = $V = \frac{1.1^K}{4} = 0.275^K$



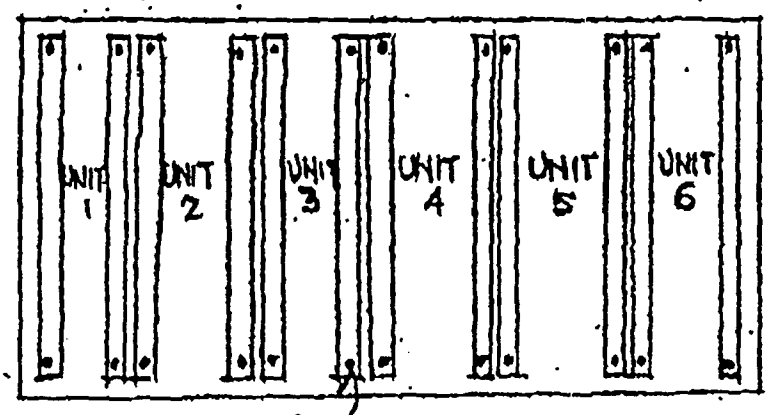
TRANSV. ELEV.

O.T.M = $0.275 \times \frac{240}{2} \times 1.15 = 40^{IK}$

R.M = $\left(4.5 - \frac{0.275}{3}\right) 27/2 = 59.5^{IK}$

NO UPLIFT.

TO BE ON THE SIDE THE CONTRACTOR DECIDED TO ANCHOR EACH FRAME




SEE SECTION A-A ON SHT 13 CALC'S. BUT 3/8"ϕ MCH. BOLTS INSTEAD OF 1/2"ϕ

3/8"ϕ EXP. BOLTS – 2½ EMBEDM. IN CONCR. FTG – TYP.

PLAN

NOTE: USE ANY ICBO – 3/8"ϕ EXP. BOLTS – 2½" EMBEDMENT IN CONCRETE APPROVED BY LOCAL CITY
EXAMPLE = RED HEAD WEDGE – ICBO 1372 X TO:
= R. MOL ANCH. BOLT ICBO 454
OR EQ. / WILLSON

PROPERTY OF ABB COMBUSTION ENGINEERING

SHT CC-1 TO CC-6 AND SK-1 & SK-2 ARE PART OF THE CALCULATION PACKAGE

EUGENE D. BIRNBAUM & ASSOCIATES
Consulting Structural Engineers

SHEET NO. SK-1
JOB NO. 20613

JOB ABB COMBUSTION ENGINEERING HIGHWAY P-KARDEX INDUSTRIES HEMATITE, MISSOURI

UNIT _____ DESIGNER MR DATE 1-26-93

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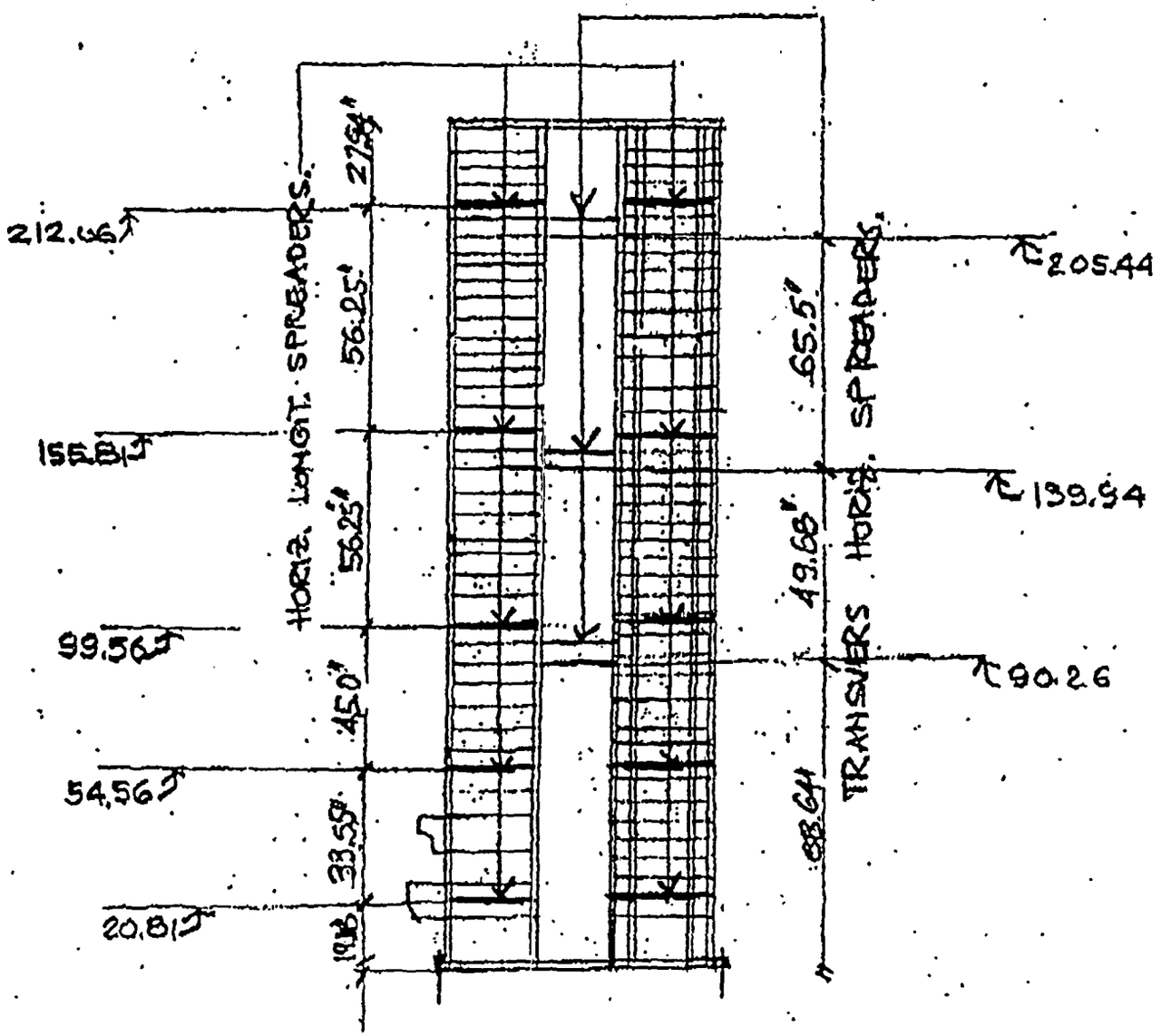


NEW LOCATION FOR: HORIZ. LONGIT. SPREADERS
TRANSVERS LONGIT. SPREADERS.

SEE DWG 6 OF 10

PROPRIETARY TO:
ABB COMBUSTION ENGINEERING

# EUGENE D. BIRNBAUM & ASSOCIATES

Consulting Structural Engineers

SHEET NO. SK-2

JOB NO. 20613

JOB ABB COMBUSTION ENG. NUCLEAR POWER HIGHWAY-KARAEX INDUSTRIAL PARK HEMATITE MISSOURI

UNIT _____ DESIGNER MR DATE 1-26-93

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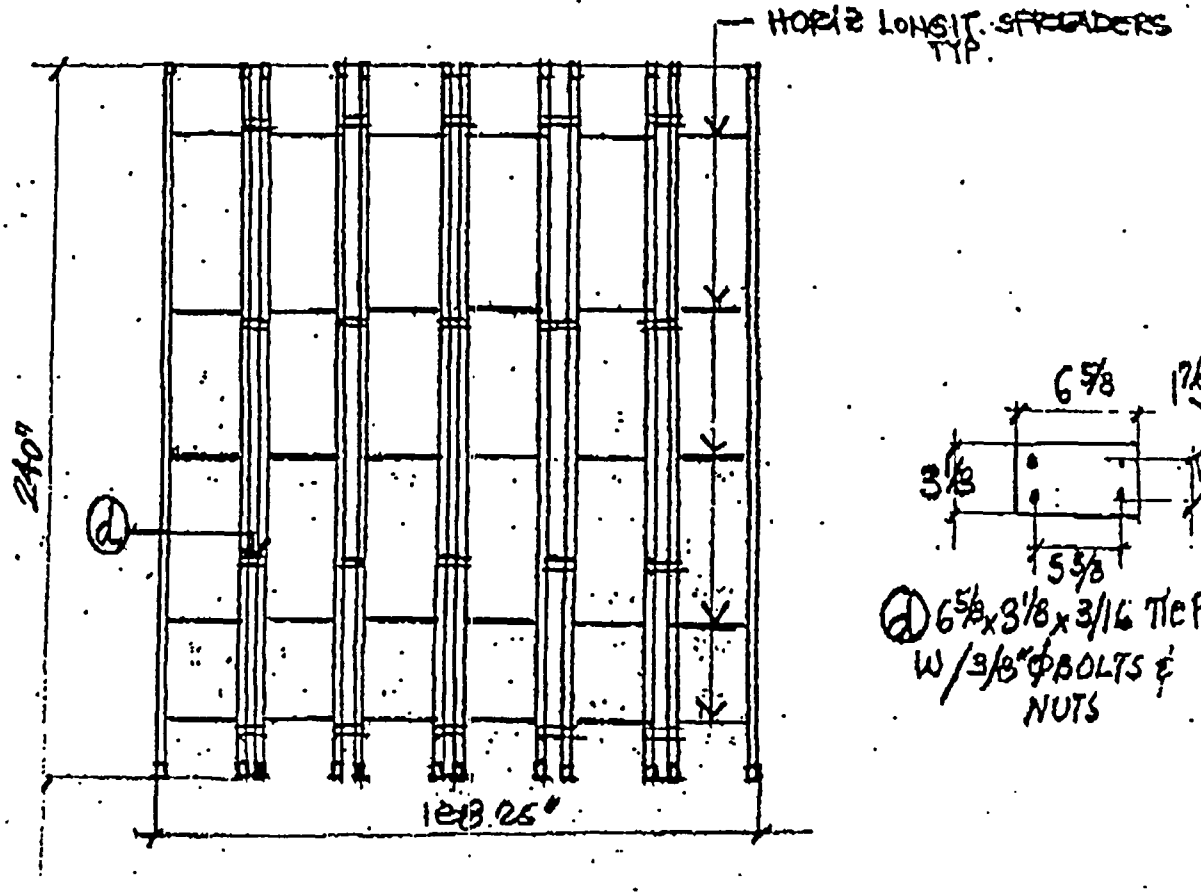


TIE PL ELEVATION FOR LONGIT. INTERIOR COLUMNS

TIE PL ELEV. SAME AS IN REAR & FRONT ELEV.

PROPRIETARY TO:
ABB COMBUSTION ENGINEERING

EUGENE D. BIRNBAUM & ASSOCIATES
Consulting Structural Engineers

SHEET NO. 3
JOB NO. 20613

JOB ABB COMBUSTION ENG. NUCLEAR POWER HIGHWAY, P-KARDEX INDUSTRIES EVER ADDED
HEMATITE, MISSOURI

UNIT _____ DESIGNER HR DATE 11-18-92 Δ 12-12-92 Δ 1-26-93 CORR.

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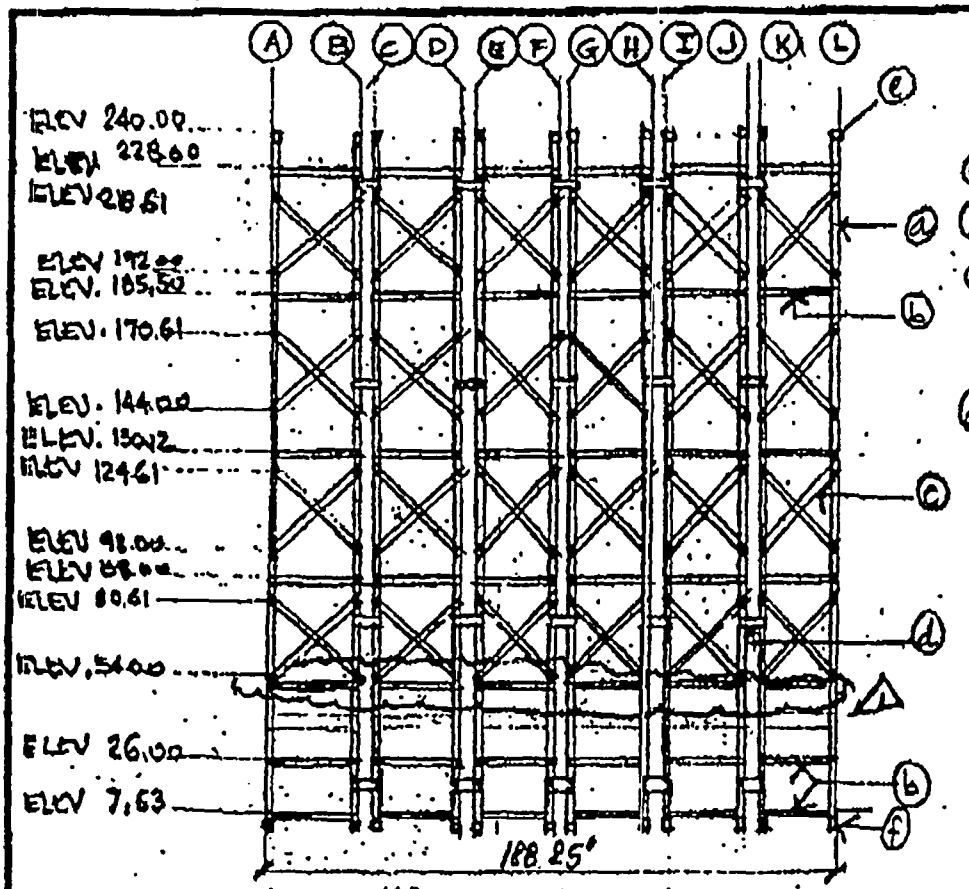
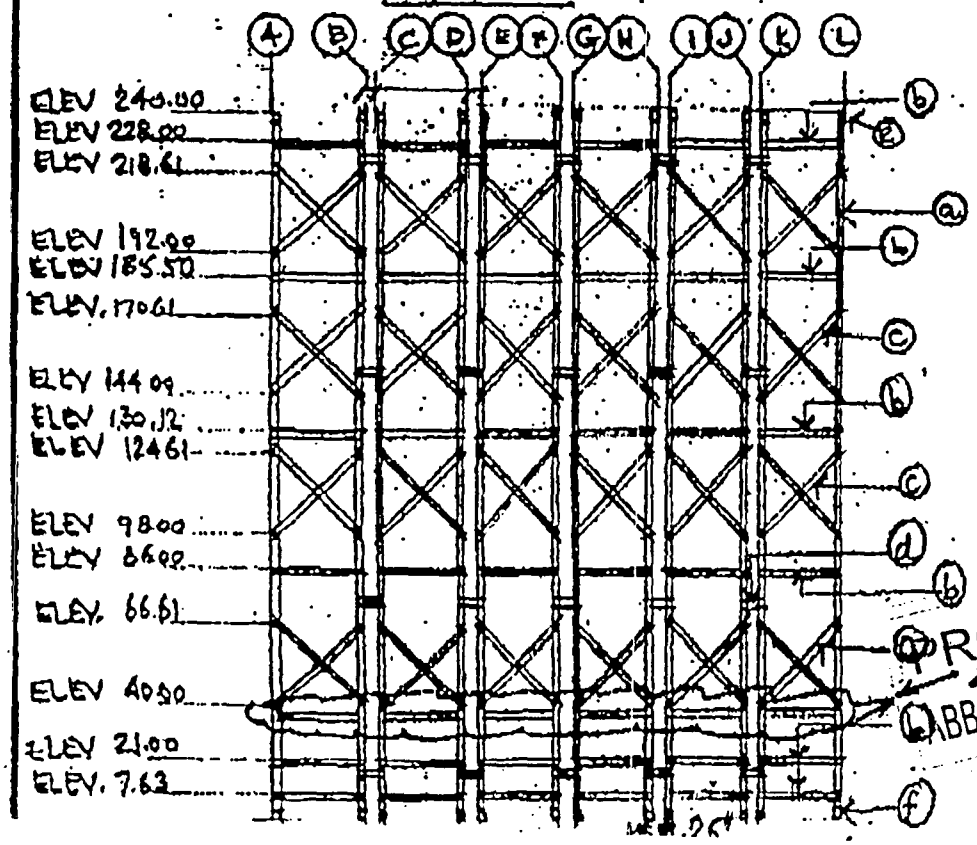



FRONT ELEV.



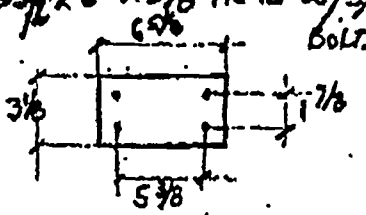

LEGEND 1

ⓐ UPRIGHT ⊔ 1 5/8 x 1 5/8 x 12 ga

ⓑ HORIZ. BRACING ⊔s 1 x 1 5/8 x 12 ga

ⓒ DIAGONALS. – 0.12 x 1 1/2 WITH 3/8 ϕ BOLTS, NUTS & WASHERS (TYP)

ⓓ 3/16 x 6 5/8 x 3 1/8 TIE PL w/ 3/8 ϕ BOLTS & NUTS




ⓔ TOP HORIZ. ⊔ 1 5/8 x 1 5/8, 12 ga

ⓕ BOTTOM HORIZ – ⊔ 1 5/8 x 1 5/8 x 12 ga

PROPRIETARY TO:
ABB COMBUSTION ENGINEERING

A-1

EUGENE D. BIRNBAUM AND ASSOCIATES
*Consulting Structural Engineers*
1626 SILVERLAKE BOULEVARD
LOS ANGELES, CALIFORNIA 90026
PHONE 213-663-9218
FAX 213-663-7309

**FACSIMILE TRANSMISSION**

TO: METROPOLITAN ENG. CO
Attn: MR. JOHN HEHMEYER
Phone (314) 464 3860
Fax: (314) 467 7480

JOB NO. 20 613
DATE 2-1-93
FROM: MIKE RABINOVICI
SUBJECT: ABB COMBUSTION ENG. HIGHWAY P. KARDEX INDUSTR. 8000

MESSAGE DEAR JOHN

PER OUR PHONE CONV OF 1/29-93:

a/ I TALKED TO KARDEX

- "X" BRACING NO FEASIBLE BETWEEN 7.63 & 26 ELEV.
- THE TIE ABOVE ELEV. 26.00 FRONT ELEV – INTERFERES WITH ACCESS AREA.

b/ TO INCREASE THE HOR. CAPACITY PROVIDED BY THE TIE – WE SHALL USE 3/8" ø A325 TYPE N (GRADE 5) BOLTS FOR THE LOWER TIE ELEV.

c/ ATTACHED YOU HAVE SHT CC S9 – FRONT & REAR ELEV. ENGINEERED FOR THE ABOVE FOR YOUR REVIEW

d/ IF YOU STILL FEEL UNCOMFORTABLE WE CAN INSERT ONE MORE TIE ON REAR ELEV. ABOVE 21" ELEV.

IF YOU HAVE ANY OTHER QUESTION PLEASE CALL ME

PROPRIETARY TO:
SIN. ENGINEERING
ABB COMBUSTION
mike

INCLUDING THIS SHEET, THERE ARE

EUGENE D. BIRNBAUM & ASSOCIATES
Consulting Structural Engineers

SHEET NO. CC3a
JOB NO. 20613

JOB ABB COMBUSTION ENGINEERING HIGHWAY P

A-2

UNIT _____ DESIGNER HR DATE 2-1-93

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REAR & FRONT ELEV. – RECHECK BOTTOM PORTION BELOW 'X' BRACING

12/2 = 162
62

USE 3/8"ϕ A325 TYP 'N' BOLTS INSTEAD OF A307 BOLT FOR THE LOWER TIE PL ONLY – A SPECIAL NOTE FOR THE ABOVE ON THE DWGS. SHOULD BE WRITTEN

BOLT CAPACITY

SHEAR = $3.14 \times \frac{0.375^2}{4} \times 20 = 2.2^k$/BOLT  1 GOVERN

BEARING = $0.375 \times 0.105 \times \frac{3.0 \times 54}{2.22} = 2.87^k$/BOLT

MOMENT CAPACITY DELIVERED BY THE TIE PL

1.88'  $M = 2.2 \times 1.875 = 4.125^{'k}$

CHECK FRONT ELEV. BETWEEN ELEV 52.5 & 22.5" (℄ OF TIE PL)

BASE SHEAR = /POST → V = 0.275^k/POST

INSTEAD OF 0.85  $M = 0.275 \times \frac{30}{2} = 4.125^{'k}$  USE 4.5^{'k}!

$\frac{Kl}{r_y} = \frac{1.0 \times 30}{0.655} = 45.8 \rightarrow F_a = 21.48$ KSI

$F_{ex} = 71.21 \times 1.33 = 94.7$

$P_a = 21.48 \times 0.56 = 12.03^k$  $M_{ay} = 7.4^{'k}$

$P = 2.17^k$
$P_s = 2.35^k$  $f_a = 7.91$ | SEE CC-4

COMBINED

$\frac{4.52}{12.03} + \frac{0.85 \times 4.5}{\left(1 - \frac{7.91}{94.7}\right) 7.4} = 0.38 + 0.56 = 0.94 < 1.33$

STILL BIG MARGIN

REAR ELEV. BETWEEN ELEV 38.5 & 18.5" (℄ TIE PL)

SAME BASE SHEAR – OK BY INSP. PER FRONT ELEV.

PROPRIETARY TO:
ABB COMBUSTION ENGINEERING

Kardex

# METROPOLITAN ENGINEERING CO.

Consulting Engineers And Surveyors

7301 Metropolitan Blvd.
P.O. Box 400
Barnhart, Missouri 63012

Area Code 314
464-3860 — 467-3860
FAX No. 467-7480

February 3, 1993

Mr. Len Grossman
ABB Combustion Engineering Company
Highway P, Box 107
Hematite, MO 63047

Re: Kardex Design
Calculation Review

Dear Mr. Grossman:

I have reviewed the response from Eugene D. Birnbaum & Associates, regarding my comments on the seismic design calculations for the Kardex unit. This response was received by fax on January 28, 1993.

Many of my initial concerns have been relieved with the addition of extra material, including new horizontal spreaders, new horizontal bracing, and anchors on every frame.

Two areas still concern me, however; those being the lower 54" of the front frame, and the lower 40" of the rear frame. These areas contain no diagonal bracing to assist in transferring the lateral seismic forces down to the foundation. Without the diagonal bracing, the frames will not react as trusses, as they do in the upper portion, but rather as rigid frames, with all lateral load being resisted by bending of the columns.

I called Mike Rabinovici, the engineer who performed the calculations for Eugene D. Birnbaum & Associates, on January 29, 1993 to discuss this matter. After much discussion, I felt that Mr. Rabinovici had acknowledged the problem. He pointed out there are some reduncies in the framing which he had not accounted for, most notably the tie plates used to interconnect the units. I agreed that the tie plates are of benefit, but that it was difficult to quantify the added benefit. It was agreed that Mr. Rabinovici would talk to Kardex to find out what type of additional bracing could be installed, and then send me revised calculations.

I received a two page fax from Mr. Rabinovici on February 1, 1993, responding to our phone conversation. This transmittal is included in Attachment A, for your information. In this response, the only modification made was a change to high strength bolts in the lower tie plate connections. A calculation sheet was provided.

PROPRIETARY TO
ABB COMBUSTION ENGINEERING

which determined the moment capacity of the tie plate, but the actual applied moment in the tie plate was not established. The calculations also reviewed the column design, but as in the original calculations, bending across the full unbraced height was not addressed.

The structural response of the entire front or rear frame is difficult to determine by hand calculations. The frame consists of six separate frames, one per module, interconnected by rigid tie plates. I set up a simple computer model, using "STRESS Plus", to analyze the front frame. Attachment B contains a brief overview of this model along with the calculated forces carried by a few select members. The lower tie plate connections between the first and second modules, and between the fifth and sixth modules are the worst areas, but all of the lower tie plate connections are a problem.

Sheet B-5 contains a brief review of the tie plate connections. The tie plate itself experiences a moment of 14.7 in-k, but its allowable moment is only 4.125 in-k, a substantial difference. The column review indicates that the channels are strong enough in pure bending, or in pure compression, but are overstressed during the combined bending and compression state which exists.

In summary, I am still concerned about the structural adequacy of the front and rear frames of the Kardex. In my opinion, additional reinforcement, such as diagonal bracing, is required in the lower portions of these frames.

Should you have any questions, please contact me.

Very truly yours,

**METROPOLITAN ENGINEERING COMPANY**

John M. Hehmeyer, P.E.

JMH/mlg
251.069

PROPRIETARY TO:
ABB COMBUSTION ENGINEERING

A-1

EUGENE D. BIRNBAUM AND ASSOCIATES
*Consulting Structural Engineers*
1626 SILVERLAKE BOULEVARD
LOS ANGELES, CALIFORNIA 90026
PHONE 213-663-9218
FAX 213-663-7309

**FACSIMILE TRANSMISSION**

TO: METROPOLITAN ENG. CO
Attn: MR. JOHN HEHMEYER
Phone (314) 464 3860
Fax: (314) 467 7480

JOB NO. 20 613
DATE 2-1-93
FROM: MIKE RABINOVICI
SUBJECT: ABB COMBUSTION ENG. HICOMYP. KARDEX INDUSTR. 8000

MESSAGE DEAR JOHN

PER OUR PHONE CONV OF 1/29-93:

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- THE TIE ABOVE ELEV. 26 NO FRONT ELEV – INTERFERES WITH ACCESS AREA.

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c/ ATTACHED YOU HAVE SHT CC S9 – FRONT & REAR ELEV. ENGINEERED TIE TIE

THE ABOVE FOR YOUR REVIEW

d/ IF YOU STILL FEEL UNCOMFORTABLE WE CAN INSERT ONE MORE TIE TIE ON REAR ELEV. ABOVE 21" ELEV.

IF YOU HAVE ANY OTHER QUESTION PLEASE CALL ME

PROPRIETARY TO: SIMULATION ENGINEERING ABB COMBUSTION

INCLUDING THIS SHEET, THERE ARE

EUGENE D. BIRNBAUM & ASSOCIATES
Consulting Structural Engineers

SHEET NO. CC3a
JOB NO. 20613

JOB ABB COMBUSTION ENGINEERING HIGHWAY P

A-2

UNIT _____ DESIGNER HR DATE 2-1-93

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REAR & FRONT ELEV – RECHECK BOTTOM PORTION BELOW 'X' BRACING

12/2 = 62
62

USE 3/8"ϕ A325 TYP 'N' BOLTS INSTEAD OF A307 BOLT FOR THE LOWER TIE PL ONLY – A SPECIAL NOTE FOR THE ABOVE ON THE DWGS. SHOULD BE WRITTEN

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$P = 2.17^k$  $f_a = 7.91$ | SEE CC-4

$P_s = 2.35^k$

COMBINED

$\frac{4.52}{12.03} + \frac{0.85 \times 4.5}{\left(1 - \frac{7.91}{94.7}\right) 7.4} = 0.38 + 0.56 = 0.94 < 1.33$

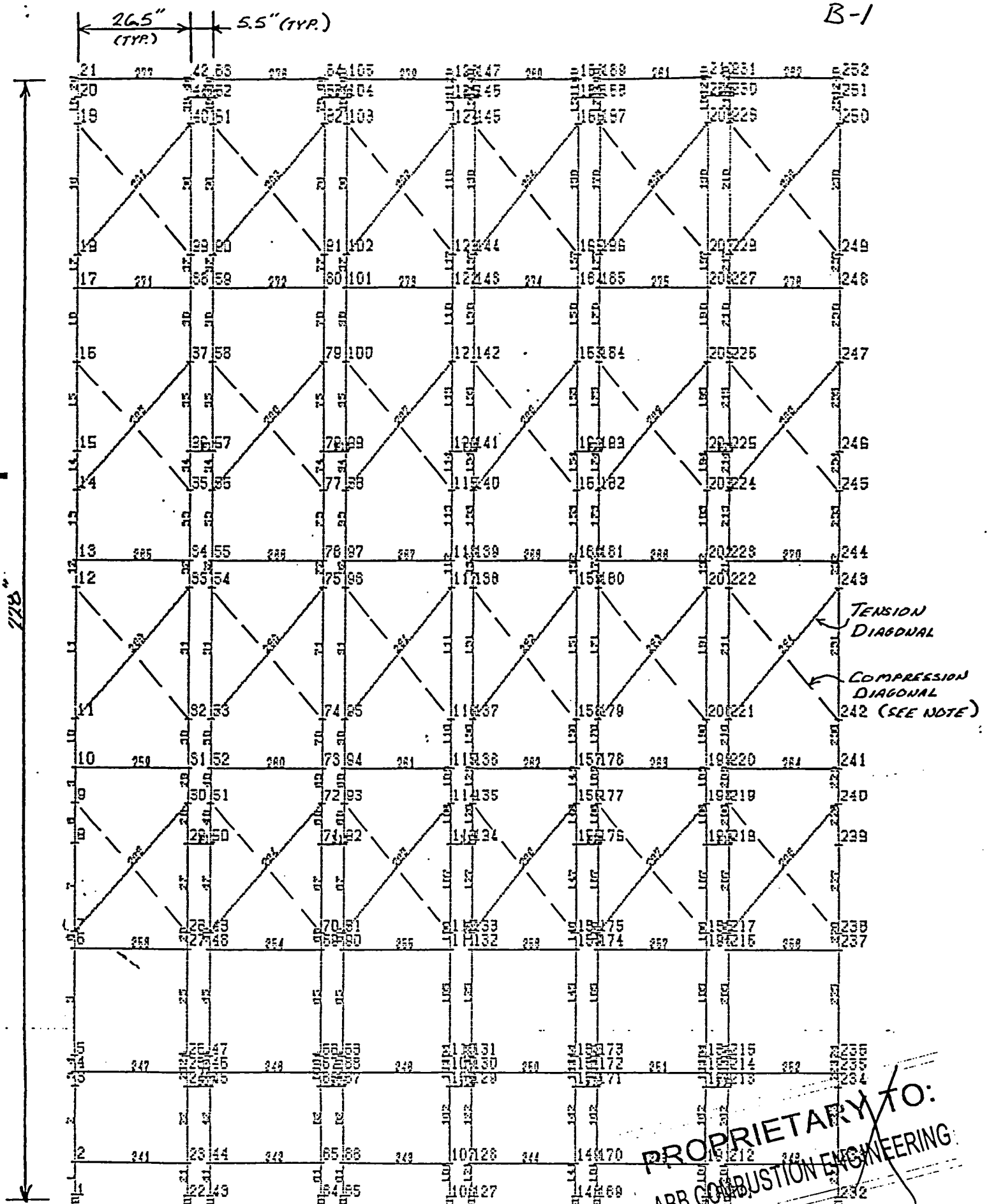
STILL BIG MARGIN

REAR ELEV. BETWEEN ELEV 38.5 & 18.5" (TIE PL)

SAME BASE SHEAR – OK BY INSP. PER FRONT ELEV.

PROPRIETARY TO:
ABB COMBUSTION ENGINEERING

B-1




KARDEX FRAME (FRONT ELEVATION)

SCALE = 30.000

NOTE:

FLAT BAR DIAGONALS GOOD IN TENSION ONLY.

: COMPRESSION DIAGONALS NOT USED

PROPRIETARY TO:
ABB COMBUSTION ENGINEERING

KARDEX FRAME

```
STRUCTURE KARDEX FRAME
* ABB/COMBUSTION ENGINEERING - ROD LOADING FACILITY
TRACE
TABULATE ALL
VERIFY

TYPE PLANE FRAME
NUMBER OF JOINTS  252
NUMBER OF MEMBERS 326
NUMBER OF SUPPORTS 12
NUMBER OF LOADINGS  1
```

**NOTE:**

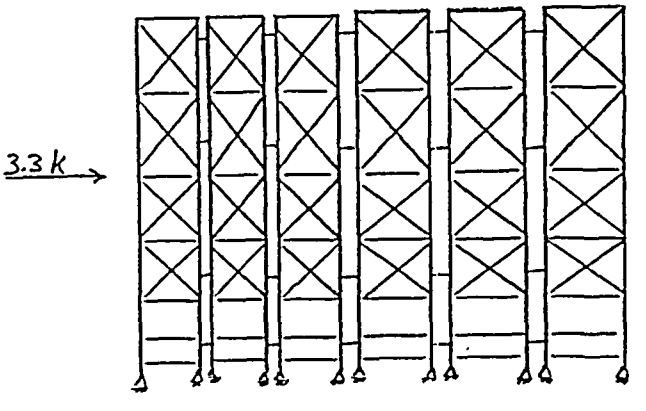
THIS IS ONLY A PARTIAL PRINT-OUT OF THE INPUT AND OUTPUT DATA, INTENDED TO PROVIDE A QUICK OVERVIEW OF THE PROBLEM.

```
SUPPORT RELEASES
  1 22 43 64 85 106 127 148 169 190 211 232 MOMENT Z

MEMBER RELEASES
 241 THRU 306 START MOMENT Z
 241 THRU 306 END MOMENT Z

MEMBER PROPERTIES PRISMATIC
   1 THRU 282  AX  0.56  IZ 0.239      *CHANNEL
 283 THRU 306  AX  0.18  IZ 0.034      *STRAP
 307 THRU 326  AX  0.59  IZ 0.477      *TIE PLATE

CONSTANTS E 29000. ALL
PLOT STRUCTURE

LOADING 1   SEISMIC LOAD
  MEMBER LOADS
    1 THRU 240  FORCE Y UNIFORM  W -0.001206

SOLVE
```

SECTION & MATERIAL PROPERTIES FROM EUGENE D. BIRNBAUM & ASSOCIATES CALCULATIONS.

SEISMIC LOAD = (1.1 k/UNIT)(6 UNITS)(1/2) = 3.3 k @ FRONT OR REAR FRAME.

UNIFORM LOAD = $\frac{3.3k}{(12\ \text{cols})(228'')}$ = 0.001206 k/IN (PER COLUMN)




PROPRIETARY TO:
ABB COMBUSTION ENGINEERING

KARDEX FRAME

LOADING 1 SEISMIC LOAD

~~~ MEMBER END FORCES ~~~

| MEMBER | JOINT | AXIAL FORCE | SHEAR FORCE | BENDING MOMENT |
|---|---|---|---|---|
| 21 | 22 | -3.413 | -.023 | .000 |
| | 23 | 3.413 | .032 | -.212 |
| 22 | 23 | -3.413 | .568 | .212 |
| | 24 | 3.413 | -.549 | 8.376 |
| 23 | 24 | 1.301 | .693 | 6.330 |
| | 25 | -1.301 | -.689 | -4.257 |
| 24 | 25 | 1.301 | .350 | 4.257 |
| | 26 | -1.301 | -.347 | -3.211 |
| 41 | 43 | 2.963 | .301 | .000 |
| | 44 | -2.963 | -.292 | 2.265 |
| 42 | 44 | 2.963 | .321 | -2.265 |
| | 45 | -2.963 | -.303 | 7.060 |
| 43 | 45 | -1.751 | .159 | 4.161 |
| | 46 | 1.751 | -.156 | -3.689 |
| 44 | 46 | -1.751 | .244 | 3.689 |
| | 47 | 1.751 | -.240 | -2.963 |
| 181 | 190 | -2.757 | .322 | .000 |
| | 191 | 2.757 | -.313 | 2.424 |
| 182 | 191 | -2.757 | .288 | -2.424 |
| | 192 | 2.757 | -.270 | 6.714 |
| 183 | 192 | 1.536 | .299 | 4.326 |
| | 193 | -1.536 | -.295 | -3.435 |
| 184 | 193 | 1.536 | .280 | 3.435 |
| | 194 | -1.536 | -.277 | -2.600 |
| 201 | 211 | 3.201 | -.002 | .000 |
| | 212 | -3.201 | .011 | -.052 |
| 202 | 212 | 3.201 | .564 | .052 |
| | 213 | -3.201 | -.546 | 8.475 |
| 203 | 213 | -1.093 | .517 | 4.099 |
| | 214 | 1.093 | -.513 | -2.554 |
| 204 | 214 | -1.093 | .199 | 2.554 |
| | 215 | 1.093 | -.195 | -1.963 |

PROPRIETARY TO:
ABB COMBUSTION ENGINEERING
~~~

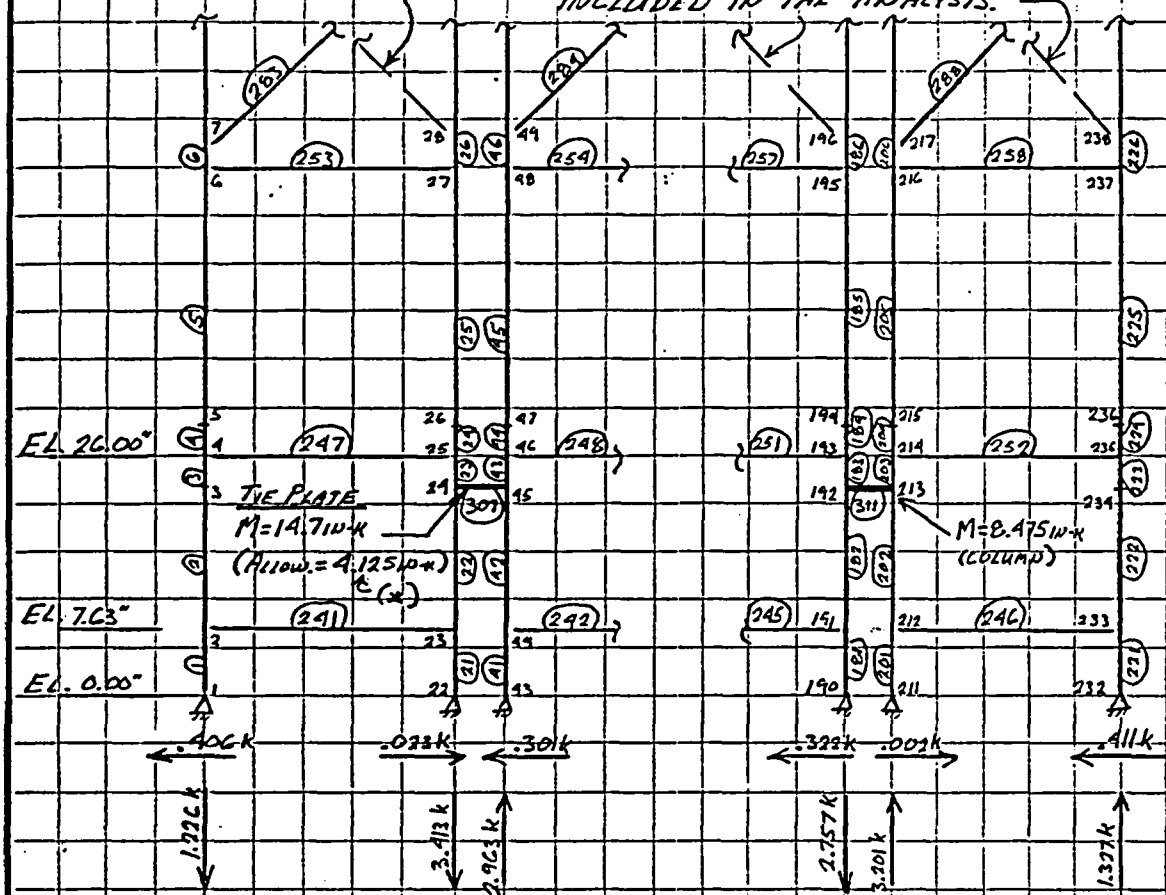
KARDEX FRAME

| MEMBER | JOINT | AXIAL FORCE | SHEAR FORCE | BENDING MOMENT |
|---|---|---|---|---|
| 241 | 2 | -.600 | .000 | .000 |
| | 23 | .600 | .000 | .000 |
| 242 | 44 | .029 | .000 | .000 |
| | 65 | -.029 | .000 | .000 |
| 245 | 170 | .025 | .000 | .000 |
| | 191 | -.025 | .000 | .000 |
| 246 | 212 | .575 | .000 | .000 |
| | 233 | -.575 | .000 | .000 |
| 247 | 4 | .339 | .000 | .000 |
| | 25 | -.339 | .000 | .000 |
| 248 | 46 | .088 | .000 | .000 |
| | 67 | -.088 | .000 | .000 |
| 251 | 172 | .015 | .000 | .000 |
| | 193 | -.015 | .000 | .000 |
| 252 | 214 | -.314 | .000 | .000 |
| | 235 | .314 | .000 | .000 |
| 307 | 24 | .143 | -4.714 | -14.705 |
| | 45 | -.143 | 4.714 | -11.221 |
| 311 | 192 | .029 | -4.294 | -11.040 |
| | 213 | -.029 | 4.294 | -12.574 |

~~~ SUPPORT REACTIONS ~~~

| JOINT | FORCE X | FORCE Y | MOMENT Z |
|---|---|---|---|
| 1 | -.406 | -1.226 | .000 |
| 22 | .023 | -3.413 | .000 |
| 43 | -.301 | 2.963 | .000 |
| 64 | -.325 | -2.781 | .000 |
| 85 | -.303 | 2.704 | .000 |
| 106 | -.325 | -2.682 | .000 |
| 127 | -.305 | 2.654 | .000 |
| 148 | -.324 | -2.624 | .000 |
| 169 | -.303 | 2.635 | .000 |
| 190 | -.322 | -2.757 | .000 |
| 211 | .002 | 3.201 | .000 |
| 232 | -.411 | 1.327 | .000 |

STOP

PROPRIETARY TO:
ABB COMBUSTION ENGINEERING
~~~

| METROPOLITAN ENGINEERING COMPANY | Design By JMH | Job No. 251.069 |
|---|---|---|
| Job: KARDEX FRAME REVIEW — For: ABB | Checked By | Sheet B-5 of |
| | Date 3 FEB 93 | |

NOTE- COMPRESSION DIAGONALS ARE NOT INCLUDED IN THE ANALYSIS.




PARTIAL DIAGRAM- LOWER FRAME

COLUMN REVIEW- MEMBERS 1 THRU 240 ($F_y$ = 42 ksi)

$M_{max}$ = 8.475 IN-K  $M_{ya}$ = 7.4 IN-K (*)

$\times 1.33 = 9.84$ IN-K (SEISMIC)

$P_{EARTHQUAKE}$ = 3.2 k

$P_{DEAD+LIVE}$ = 2.2 k (*)

5.4 k (TOTAL AXIAL LOAD) $\Rightarrow f_a = \frac{P}{A} = \frac{5.4}{0.56} = 9.64$ KSI

$\frac{KL}{r_y} = \frac{0.85(18.4")}{0.655} = 23.9 \rightarrow F_a = 23.6$ KSI  $F'_{ey} = 261 \times 1.33 = 347$ KSI

COMBINED: $\frac{9.64}{23.6} + \frac{0.85(8.475)}{\left(1-\frac{9.64}{347}\right)(7.4)} = 0.41 + 1.00 = 1.41 \leq 1.33$ N.G.

AND $\frac{9.64}{0.60(42)} + \frac{8.475}{7.4} = 0.38 + 1.15 = 1.53 > 1.33$ N.G.

(*) - INDICATES INFORMATION TAKEN FROM "EUGENE D. BIRNBAUM & ASSOC." CALCULATIONS.

PROPRIETARY TO: ABB COMBUSTION ENGINEERING

Consulting Structural Engineers

JOB NO. 20613

JOB ABB COMBUSTION ENG. NUCLEAR POWER HIGHWAY F-MARTEX INDUSTRIEVER 2000
HEMATITE, MISSOURI

UNIT _____ DESIGNER HR DATE 11-18-92

△2 1-26-93 CORR.

△1 12-12-92

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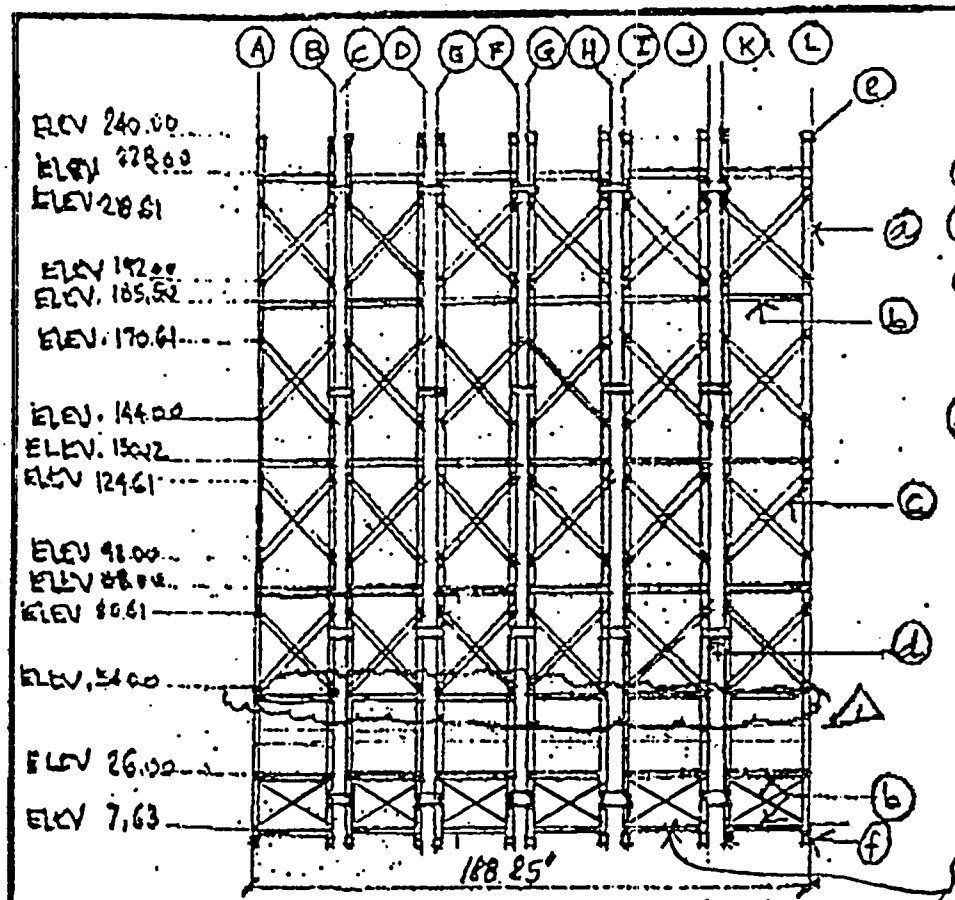
B-6



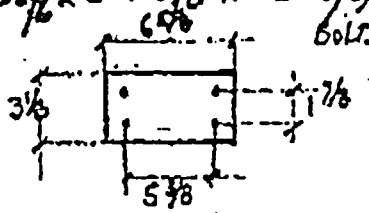

LEGEND:

ⓐ UPRIGHT ⊔ 1 5/8 x 1 5/8 x 12 ga

ⓑ HORIZ. BRACING ⊔ 1 x 1 5/8 x 12 ga

ⓒ DIAGONALS - 0.12 x 1 1/2 WITH 3/8 ϕ BOLTS, NUTS & WASHERS (TYP)

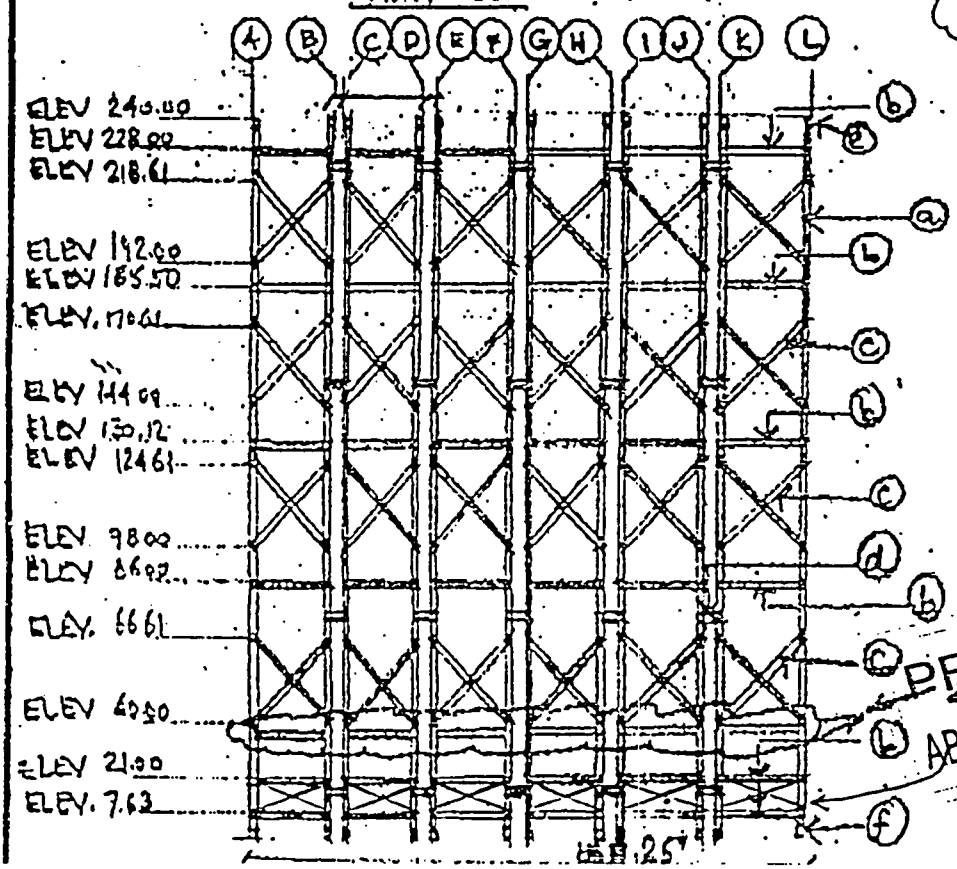
ⓓ 3/16 x C 5/8 x 3 5/8 TIE PL W/ 3/8 ϕ BOLTS & NUTS




ⓔ TOP HORIZ. ⊔ 1 5/8 x 1 5/8, 12 ga

ⓕ BOTTOM HORIZ - ⊔ 1 5/8 x 1 5/8 x 12 ga

RECOMMENDED BRACING ADD




RECOMMENDED BRACING ADD

PROPRIETARY TO: ABB COMBUSTION ENGINEERING

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JOB ABB COMBUSTION ENG. NUCLEAR POWER H...
HEMATITE, MISSOURI

UNIT 1 DESIGNER HR

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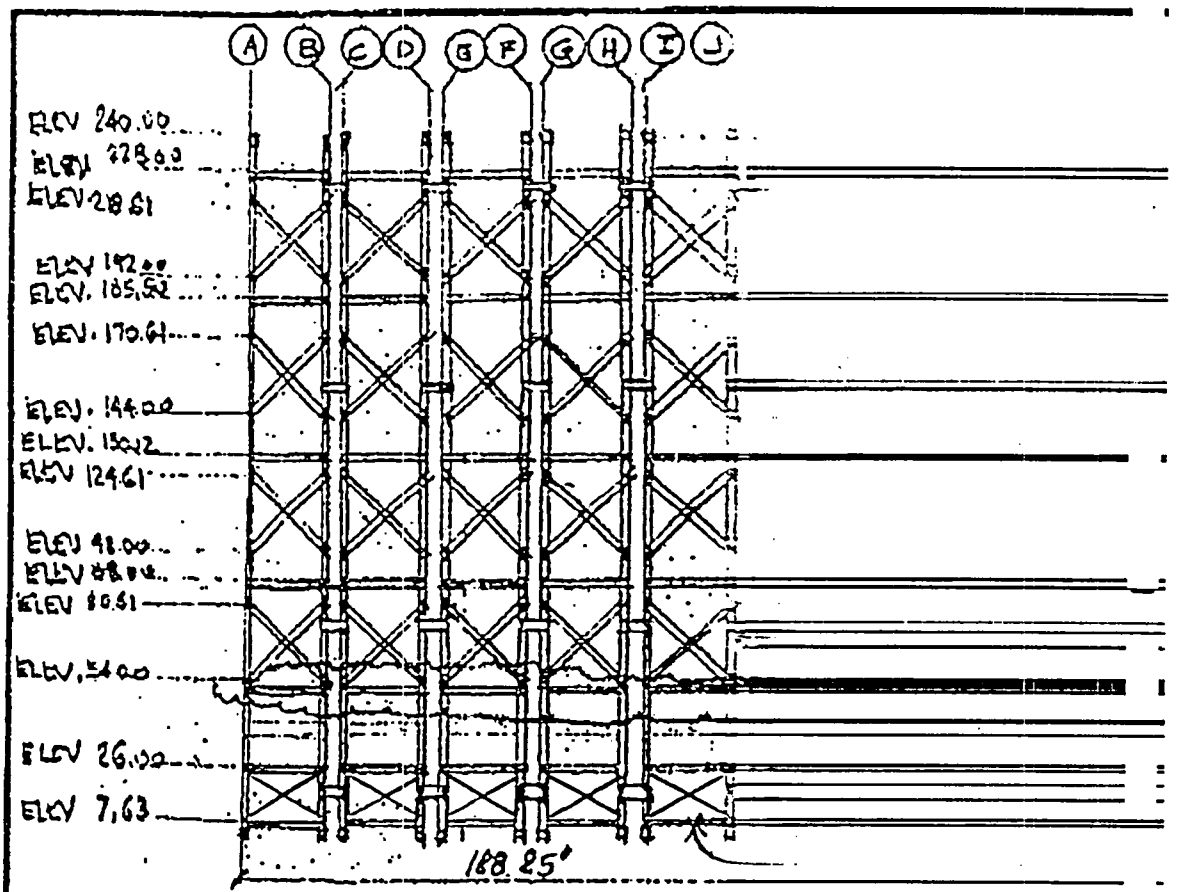

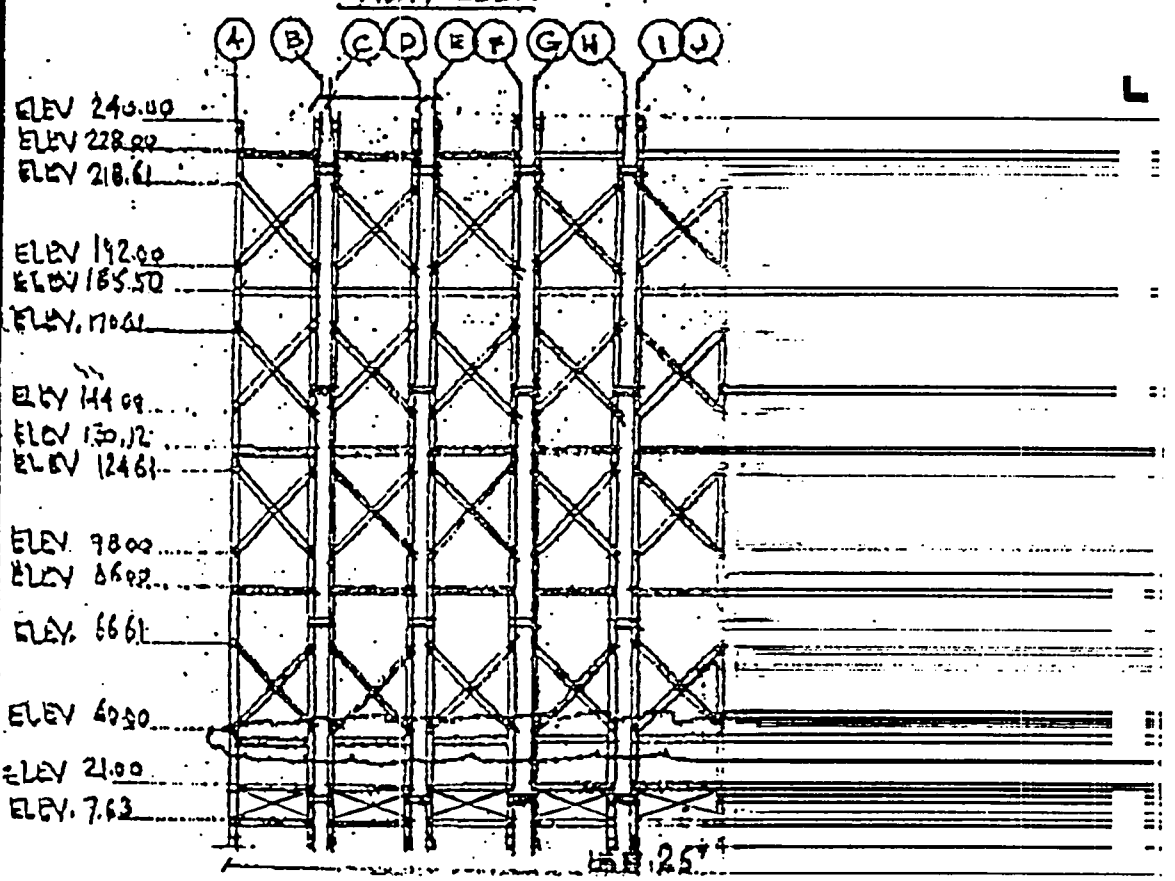
FRONT ELEV.