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STMPO 182

SAN/0499-50
MDC G8502

10 MWe Solar Thermal
Central Receiver Pilot Plant
Solar Facilities Design Integration

PSS FINAL DESIGN CALCULATIONS
BOOK 7 OF 26--RECEIVER TOWER FOUNDATIONS
CONSTRUCTION PACKAGE 7A (RADL ITEM 7-8)

September 1980

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PREPARED FOR THE
U.S. DEPARTMENT OF ENERGY
SOLAR ENERGY
UNDER CONTRACT DE-AC-03-79SF10499

PREFACE

This document is provided by McDonnel Douglas Astronautics Company (MDAC) in accordance with Department of Energy Contract Number DE-AC03-79SF10499, Reports and Deliverables List (RADL Item 7-8). The report was prepared by Stearns-Roger Engineering Corporation under MDAC Subcontract Number 78012035.

The Plant Support Subsystem Final Design Calculations (RADL Item 7-8) are arranged in a twenty-six book volume as shown on the master Table of Contents.

Book 7 of this document is provided in support of the Receiver Tower Foundation, Construction Package No. 5A and includes structural design calculations, and reference sheets for trade study and drilled pier alternate. The calculations are supplemented by the design criteria and engineering data previously submitted by RADL 7-1, Final Soils Report.

Questions concerning this report should be directed to R.J. Perkins at (714) 896-3073.

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BOOK 25 - COLLECTOR FIELD ELECTRICAL, CONSTRUCTION PACKAGE 11A

Note: This document was previously submitted by MDAC Letter A3-228-EP-RJP-262, dated 7 March 1980 and therefore is not included in this submittal. Please transfer your copy to your RADL ITEM 7-8 file, marking it as BOOK 25 of 25.

BOOK-26-MDAC GENERAL ANALYSIS AND BACKGROUND DATA

NT-V-1

FORM 62.114
REV. 4.75

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PAGE 1

JOB NO. C-21700 DATE 7-23-79 BY MCC CH'K HJM

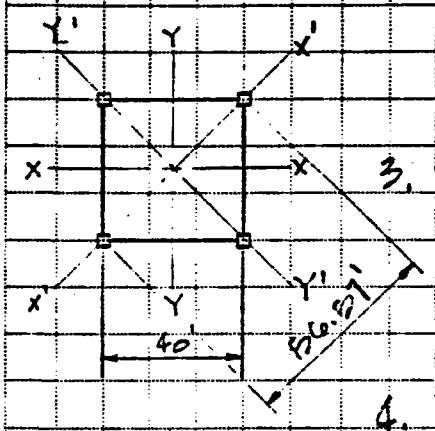
CUSTOMER MDAC PROJECT SOLAR ONE

SUBJECT FOUNDATION FOR RECEIVER TOWER - SPREAD FOOTING

REF: H.I.M's STEEL CALCULATION SHEETS P.279 THRU P.285

DATA: 1. TOTAL D.L. = 1049^K, OR $1049/4 = 262^K$/col.
" L.L. = 243^K, OR $243/4 = 61^K$/col.

2. WIND FORCE NORMAL TO X-X OR Y-Y AXIS:



H = 357.2^K TOTAL, OR $357.2/4 = 89.3^K$/col.
$V = \pm M/\ell = 50498/40x1 = \pm 631^K$/col.

3. WIND FORCE NORMAL TO X'-X' OR Y'-Y' AXIS (DIAGONAL):

H = 371.2^K TOTAL, OR $371.2/4 = 92.8^K$/col.
$V = \pm M/\ell = \pm 50951/56.57 = 901^K$

4. SEISMIC FORCE NORMAL TO X-X OR Y-Y AXIS:

H = 212^K TOTAL, OR $212/4 = 53^K$/col.
V = ± 488^K/col.

5. SEISMIC FORCE NORMAL TO X'-X' OR Y'-Y' AXIS (DIAGONAL)

H = 212^K TOTAL, OR $212/4 = 53^K$/col.
V = ± 608^K/col.

(SEISMIC NOT GOVERNING!)

MATERIALS: $f_c = 3000$ PSI
$f_y = 60{,}000$ PSI

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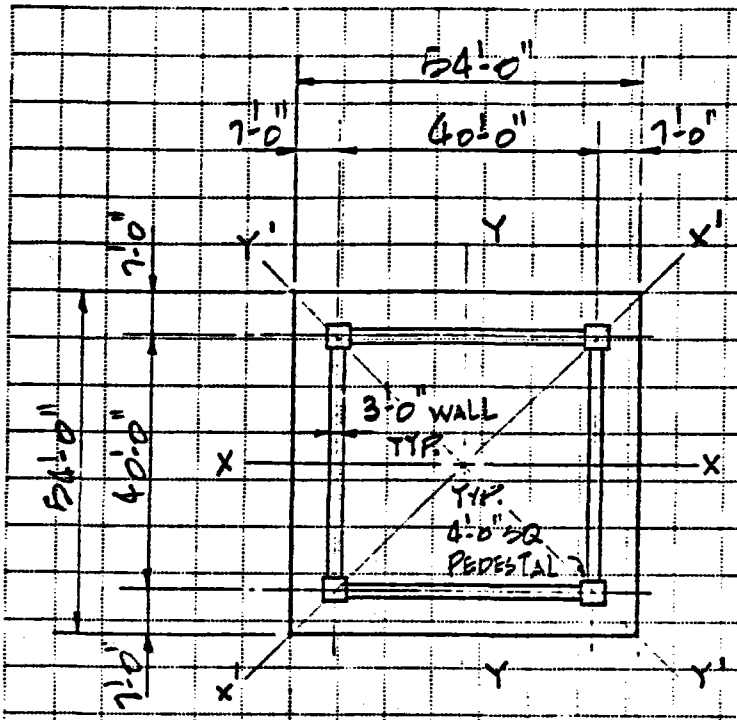
JOB NO. C-21700 DATE 7-23-79 BY CSC Rev. CH'K. HJM

CUSTOMER MDAC PROJECT SOLAR ONE

SUBJECT FOUNDATION FOR RECEIVER TOWER – MAT FOUNDATION



PLAN

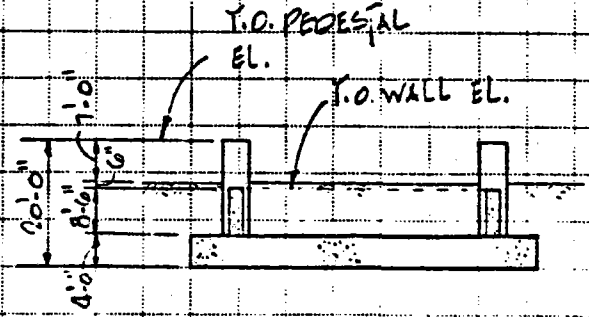
$I_x = I_y = I_{x'} = I_{y'} = 54^4/12 = 708588\ FT^4$

$S_x = S_y = 708588/27 = 26244\ FT^3$

$S_{x'} = S_{y'} = 708588/27\sqrt{2} = 18560\ FT^3$

WT. OF FDN.:

PEDESTALS	$4 \times 4 \times 16 \times 4 \times 0.15 =$	154^K
WALLS	$3 \times 36 \times 53 \times 4 \times 0.15 =$	2291^K
FDN. MAT	$54^2 \times 4 \times 0.15 =$	1750^K
	$\Sigma =$	2455^K



SECTION

WT. OF BACKFILL: (SOIL WT. = 130 #/CF)

$W = (54^2 \times 9 - 4^2 \times 4 \times 9 - 3 \times 36 \times 8.5 \times 4) \times .13$

$= 2420^K$

TOTAL WT. $= 2455 + 2420 = 4875^K$

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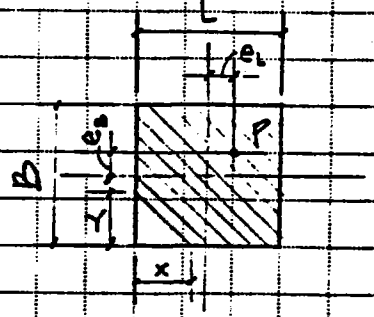
JOB NO. C-21700 DATE 7-23-79 BY CS Chang CH'K HJM

CUSTOMER MDAC PROJECT SOLAR ONE

SUBJECT FOUNDATION FOR RECEIVER TOWER

CASE (I): DIAGONAL WIND + D.L.+L.L.



$P = 1049 + 4875 + 243 = 6167^K$

$M_o = 50951 + 3712 \times 20 = 58375^{IK}$

$M_R = 6167 \times 27\sqrt{2} = 235479^{IK}$

FACTOR OF SAFETY $= 235479/58375 = 4.03 > 1.5$ O.K.!

$M_x = M_y = 58375 \times 0.707 = 41271$

REF. "FDN. DESIGN" BY WAYNE C. TEIG 1962
P. 133 FIG. C-14

$e_B = e_L = 41271/6167 = 6.69'$

$e_{B/B} = e_{L/L} = 6.69/54 = 0.124$

$\therefore K = 2.6$, $x = Y = 0.3L = 0.3B$

$p_{max} = KP/BL = 2.6 \times 6167/54^2 = 5.50$ KSF

$p_{net} = 5.50 - 13 \times 0.11 = 4.07$ KSF $< 5 \times 1.33 = 6.65$ KSF O.K.
(WOODWARD-CLYDE SOIL REPORT P.7)

CASE (Ia): DIAGONAL WIND + 75% D.L.

$P = 0.75 \times 1049 + 2455 = 3242^K$

$M_R = 3242 \times 27\sqrt{2} = 123,792^{IK}$

FACTOR OF SAFETY $= 123792/58375 = 2.1 > 1.5$ O.K.

FOR SOIL PRESSURE SEE P. 32a
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JOB NO. 21700 DATE 8-16-79 BY HJM CH'K

CUSTOMER MDAC PROJECT SOLAR ONE

SUBJECT FDN. RECEIVER TOWER

(I) $\frac{P}{A} = \frac{6167^K}{54^2} = 2.11$ Ksf

$\frac{M_x}{S} = \frac{41,271 \times 6}{54^3} = \pm 1.57$ "

$\frac{M_y}{S} = \pm 1.57$ "

$P_{max} \doteq 5.25$ Ksf ~ 5.5 (OK)

$(P_{min} = -1.03$ Ksf$)$ (N/A)

(Ia) $\frac{P}{A} = \frac{3,242}{54^2} = 1.11$ Ksf

$\frac{M_x}{S} = \pm 1.57$ "

$\frac{M_y}{S} = \pm 1.57$ "

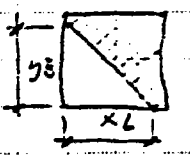
$\Sigma P = 4.25$ Ksf $[or\ -2.03$ Ksf$]$ (N/A)

$e_B = e_L = \frac{41,271}{3,242} = 12.73'$; $e_B/B = \frac{12.73}{54} = 0.24$

$\therefore K = 5.5$ $x = 0.95L$; $y = 0.95B$

$P_{max} = 5.5\,(3,242)\frac{1}{54^2} = 6.11$ Ksf

$P_{net} = 6.11 - 13\,(.11) = 4.68$ Ksf < 6.65 (OK)



FORM 62-114
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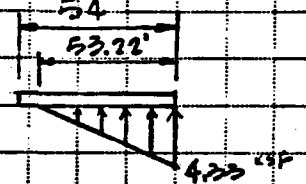
JOB NO. C-21700 DATE 7-23-79 BY GC Tsang CH'K HM

CUSTOMER MDAC PROJECT SOLAR ONE

SUBJECT FOUNDATION FOR RECEIVER TOWER

CASE (II): NORMAL WIND + D.L. + L.L.



$P = 6167^K$ (P.3)

$M_o = 50498 + 357.2 \times 20 = 57642^{IK}$

$M_R = 6167 \times 27 = 166509^{IK}$

FACTOR OF SAFETY $= 166509/57642 = 2.89 > 1.5$ O.K.

$e = M_o/P = 57642/6167 = 9.35' > \frac{1}{6} \times 54 = 9'$ RESULTANT OUTSIDE MID 1/3

$p_{max} = \frac{P}{A}\left(\frac{4P}{3b-6e}\right) = \frac{6167}{54^2}\left(\frac{4\times 54}{3\times 54 - 6\times 9.35}\right) = 4.31$ KSF

$p_{net} = 4.31 - 13\times 0.11 = 2.88$ KSF < 6.65 KSF O.K.!

CASE (IIa): NORMAL WIND + 75% D.L. (SEE P.4a)

CASE (I): D.L. + L.L.

$p_{max} = 6167/54^2 = 2.11$ KSF

$p_{net} = 2.11 - 13\times 0.11 = 0.68$ KSF < 5.0 KSF O.K.!

COMPARE TO ABOVE THREE CASES, CASE (I) IS FOR CHECKING OF SOIL BEARING PRESSURE ONLY, NOT PRACTICAL FOR DESIGN OF F.D. ∴ USE CASE (I) FOR FOUNDATION MAT DESIGN.

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REV. 4.75

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PAGE 9a

JOB NO. 21700 DATE 8-17-79 BY HJM CH'K.

CUSTOMER MDAC PROJECT SOLAR ONE

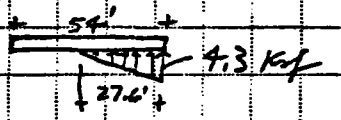
SUBJECT FDN. f. RECEIVER TOWER

(IIa): NORMAL WIND + DL (.75):

$P = 3,242^{k}$ (Pg. 3 CK. PRINT)

$e = \frac{M_{O.T.}}{P} = \frac{57,642}{3,242} = 17.8' > \frac{54'}{6} = 9'$ ∴ R → a.s. MID. ⅓

$a = \frac{54'}{2} - 17.8 = 9.2'$



$\max p = \frac{2 \times 3,242}{3 \times 9.2 \times 54} = 4.3\ Ksf < 5 \times 1.33 = 6.65$ (OK)

$M_{ST.} = 3,242 \times 27' = 87,534^{k}$

$S.F. = \frac{87,534}{57,642} = 1.52 > 1.5$ (OK)

FORM 62-114
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JOB NO. C-21100 DATE 7-23-79 BY CS C Chiang CH'K. HJM

CUSTOMER MDAC PROJECT SOLAR ONE

SUBJECT FOUNDATION FOR RECEIVER TOWER

FDN. DESIGN

(CASE (II))

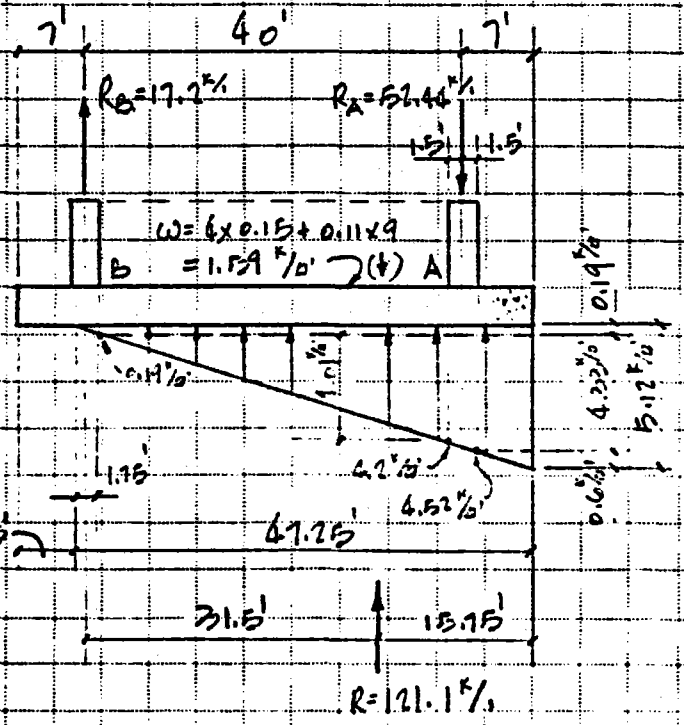
$P_u = [(1049+4875)\times 1.4 + 743\times 1.7]\times 0.75 = 6530^K$

$M_u = 57642\times 1.7\times 0.75 = 73194^{IK}$

$e = M_u/P_u = 73194/6530 = 11.25' > 1/6\times 54 = 9'$

$P_{u\,max} = \frac{6530}{54^2}\left(\frac{4\times 54}{3\times 54 - 6\times 11.25}\right) = 5.12\ K/F$

$a = (54/2 - 11.25)\times 3 = 47.25'$



$R = 5.12\times 47.25/2 = 121.1^K$

$R_A = \frac{121.1\times 31.5 - 1.59\times 54\times 20}{40}$

$= 52.44^K$

$R_B = 52.44 + 1.59\times 54 - 121.1$

$= 17.2^K$

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JOB NO. C-21700 DATE 7-23-79 BY DS Chang CH'K HJM

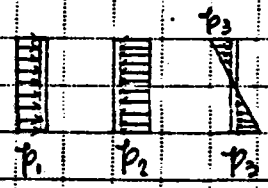
CUSTOMER MDAC PROJECT SOLAR ONE

SUBJECT FOUNDATION FOR RECEIVER TOWER

FDN. MAT

REF. BOOK: "MOMENTS AND REACTIONS FOR RECTANGULAR PLATES"
U.S. DEPT. OF THE INTERIOR, BUREAU OF RECLAMATION
P.40 & 41, FIGURES 34 & 35

$p_1 = 1.59 - 0.19 = 1.4$ KSF
$p_2 = p_3 = 4.01/2 = 2.01$ KSF



FOR $a/b = 37/37 = 1$

$M_1 = -0.05 \times 1.4 \times 37^2 = -95.83$ IK/'
$V_1 = -0.4389 \times 1.4 \times 37 = -22.74$ K/'

$M_2 = 0.05 \times 2.01 \times 37^2 = +137.58$ IK/'
$V_2 = 0.4389 \times 2.01 \times 37 = +32.64$ K/'

$M_3 = 0.0148 \times 2.01 \times 37^2 = +40.73$ IK/'
$V_3 = 0.1914 \times 2.01 \times 37 = +14.83$ K/'

$\Sigma M_u = 137.58 + 40.73 - 95.83 = 82.48$ IK/' ——
$\Sigma V_u = 32.64 + 14.83 - 22.74 = 24.73$ K/' ——

@ CANTILEVER SIDE, M & V @ FACE OF WALL "A"

$M_u = 4.33 \times 5.5^2/2 + (0.6 \times 5.5/2) \times 2 \times 5.5/3 - 1.4 \times 5.5^2/2 = 50.37$ IK/'
$V_u = (5.12 + 4.33) \times 5.5/2 - 1.59 \times 5.5 = 17.77$ K/'

@ CANTILEVER SIDE "B"

$M = 1.59 \times 5.5^2/2 = 24.05$ IK/'

@ MID. OF SLAB:

$Mu = (2.01 - 1.4) \times 0.0213 \times 37^2 = 17.77$ IK/'

FORM 62.114
REV. 4.75

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JOB NO. C-21700 DATE 7-23-79 BY [illegible] CH'K HJM

CUSTOMER MDAC PROJECT SOLAR ONE

SUBJECT FOUNDATION FOR RECEIVER TOWER

FDN. MAT (CONT.) - REBAR IN MAT:

$M_u = 82.48^{IK}/_{1}$ FOR b=12, d=43 ∴ F=1.85

$K_u = 82.48/1.85 = 45$ ∴ $a_u = 4.45$

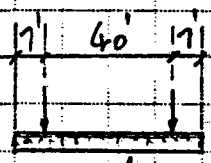
$A_s = 82.48/4.45 \times 43 = 0.4^{0}/_{1}$

USE # 8 @12" BOT. & # 8 @12" TOP EA WAY (OVER SIZE BAR FOR TEMPERATURE PURPOSE)

CHECK SHEAR:

$\phi V_c = 0.85 \times 2\sqrt{f'_c}\, bw\, d = 0.85 \times 2\sqrt{3000} \times 12 \times 43/1000 =$
$= 48.05^{K}/_{1} > 24.13^{K}/_{1}$ O.K. (SHEAR @ d DISTANCE OUT O.K.)

GRADE WALL DEPTH 12'-0" ABOVE d=12'-0"(144"), b=12", h=1'



TOP BAR $M_u = \frac{52.44 \times 40^2}{8} - \frac{52.44 \times 7^2}{2} = 9203^{IK}$

BOT. BAR $M_u = \frac{17.2 \times 40^2}{8} - \frac{17.2 \times 7^2}{2} = 3019^{IK}$

$F = bd^2/12000 = 36 \times 144^2/12000 = 62.2$

$K_u = 9203/62.2 = 133.9$ (TOP) ∴ $a_u = 4.35$ (ACI 10.5 USE)
$K_u = 3019/62.2 = 34.5$ (BOT.) ∴ $a_u = 4.45$ $A_s = 14.7 \times 1.33 = 19.55\,\square"$

TOP BAR $A_s = 9203/4.35 \times 144 = 14.7$ USE 13-#10, $A_s = 22.86\,\square"$ > 19.55 □"

BOT BAR $A_s = 3019/4.45 \times 144 = 4.71$ USE 6-#10. $A_s = 7.62\,\square"$ > 4.71 × 1.33 = 6.26 □"

CHECK SHEAR @ "d" DISTANCE OUT $V_u = 52.44(17-19/12) = 42.0^{K}$

$\phi V = 0.85 \times 2\sqrt{3000} \times 12 \times 144/1000 = 45.3^{K} > 42.0^{K}$ O.K.

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CUSTOMER MDAC PROJECT SOLAR ONE

SUBJECT FOUNDATION FOR RECEIVER TOWER

GRADE WALL (CONT.)

TRY #5 STIRRUPS @ 12"

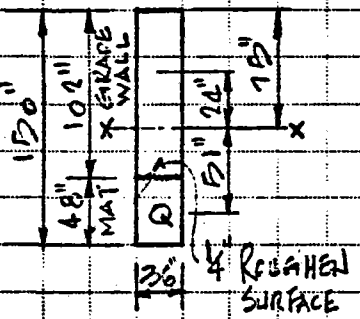
$A_v = 0.31 \times 2 = 0.62$ in²

$A_v = 50 b_w s / f_y = 50 \times 36 \times 12 / 60{,}000 = 0.36 < 0.62$ (GRADE 60)

OR $= 50 \times 36 \times 12 / 40{,}000 = 0.54 < 0.62$ (" " 40)

USE #5 STIRRUPS @ 12"

GRADE WALL CONN. TO MAT:



HORIZ. SHEAR: $V_u = 52.4 \times 37/2 = 969^K$

$I_x = 36 \times 150^3/12 = 1.01 \times 10^7$ IN⁴

$Q = 48 \times 36 \times 51 = 36 \times 102 \times 24 = 88128$ IN³

$S_u = VQ/Ib = \frac{969000 \times 88128}{1.01 \times 10^7 \times 36} = 235$ PSI

ACI-318-77 17.5.4.3 $S_{ALLOW} = 350$ PSI > 235 PSI O.K.

ACI-318-71 $V_{cc} = V_u/\phi b_w d = 969000/0.85 \times 36 \times 114 = 223$ PSI < 350 O.K.

FIX MOMENT TRANSFERED FROM PEDESTAL

$M = 89.3 \times 13.75 = 1228^{IK} < 3019^{IK}$ (P.7)

(T.O. PEDESTAL TO ℄ OF GRADE WALL = 13'-9")

BOTTOM & TOP BARS ARE ADEQUATE!

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JOB NO. C-21700 DATE 7-26-79 BY RLC/RWL CH'K HJM PAGE 9

CUSTOMER MDAC PROJECT SOLAR ONE

SUBJECT FOUNDATION FOR RECEIVER TOWER

PEDESTAL

SIZE 4'-0" SQ. (48" SQ) , $A_2 = 48^2 = 2304$ in²

LOADING CONDITIONS:

1. DL+LL

$P_u = 1.4 \times 262 + 1.7 \times 61 = 471^K$

$H_u = 0$

$M_u = 0$

2. DL+LL+WIND (DIAGONAL)

$P_u = 0.75(1.4 \times 262 + 1.7 \times 61 + 1.7 \times 90) = 1502^K$

$P_u = 0.75 \times 0.9 \times 262 - 1.3 \times 90 = -94^K$ (UPLIFT)

$H_u = 1.3 \times 92.8 = 121^K$

$M_u = 92.8 \times 1.3 \times 1.5 = 905^{IK}$

$\therefore M_{ux} = M_{uy} = 905 \times 0.707 = 640^{IK}$

CHECK CONC. BEARING:

SIZE OF PLATE = 2'-8" SQ (32" SQ) $A_1 = 32^2 = 1024$ in²

$F_p = 0.85 \phi f'_c \sqrt{A_2/A_1} = 0.85 \times 0.7 \times 3000 \sqrt{2304/1024} = 2673$ PSI

$f_p = (1502/1024) \times 1000 = 1467$ PSI < 2673 PSI O.K.!

JOB NO. C-21100 DATE 7-26-79 BY CS CH'K HJM

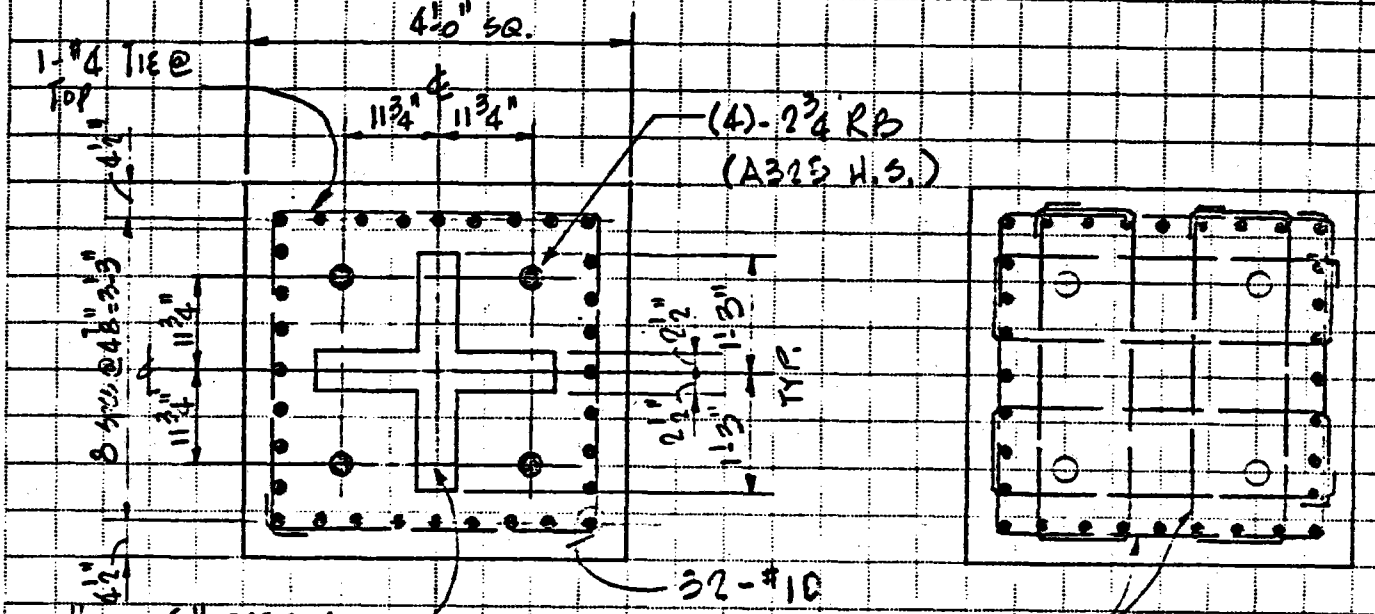
CUSTOMER MDAC PROJECT SOLAR ONE

SUBJECT FOUNDATION FOR RECEIVER TOWER

PEDESTAL

CASE (I): M_u + UPLIFT FORCE

$P_u = -994^K$, $M_{ux} = M_{uy} = 640^{IK}$, $\phi = 0.9$



$I_x = I_y = 18 \times 19.5^2 + 4 \times (14.63^2 + 9.75^2 + 4.88^2) = 8177$

$P_u = -994 / 0.9 = -1104^K$ (NEGLECT CONCRETE ACTION SINCE TENSION IS HIGH!)

$M_{ux} = M_{uy} = 640 / 0.9 = 711^{IK}$

$P_x = 1104/32 \pm \left(\frac{711 \times 12 \times 19.5}{8177}\right) \times 2$

$= 34.5^K \pm 40.7^K = 75.2^K$ (TENSION) MAX.

#10 BAR TENSION CAPACITY = $60 \times 1.27 = 76.2^K > 75.2^K$ O.K.!

JOB NO. C-21700 DATE 8-21-79 BY HJM CH'K.

CUSTOMER PROJECT

SUBJECT

PEDESTAL... $f'_c = 3.0$ ksi; $f_y = 60$ ksi

(I)... $T_u = -994^K$ uplift $\quad H_{ux} = H_{uy} = \frac{121}{1.414} = 85.5^K$

$M_{ux} = M_{uy} = 640^{IK}$

(II)... $P_u = 1502^K$

$M_{ux} = M_{uy} = 640^{IK} \quad H_{ux} = H_{uy} = 85.5^K$

REF: SP-7

$g = \frac{39}{48} = 0.8 \quad$ req $d = \sqrt{\frac{640}{4.0(.43)}} = 19" < 44"$ (OK)

(II) $K = \frac{1502}{3 \times 48 \times 48} = .217$

$K\frac{e}{t} = \frac{640(12) = M_{ux}}{3 \times 48 \times 48^2} = .023$

$\therefore P_t = 0.00$; USE 0.01 min

$A_s = 0.01\ (48)^2 = 23.0\ in^2$

For Comp. only:

ϕP_n (max) $= 0.80\ (0.9)\ [0.85\ (3.0)(2304 - 50) + 60\ (50)]$ (5748; 3000; 32-#11)

$= 6{,}300^K$

For one-way Bending only:

req $A_s = \frac{640}{4.2 \times 43.5} = 3.5\ in^2$ (smallest relat'g) $\rightarrow$ 3-#11 ($4.68\ in^2$)

For (Comp. - Bending f. two-way) only!

ϕP_n (max) $= (0.80)\ 0.9\ [5748 + 60(50 - 4.68 \times 2)]$ (2438)

$= 5{,}894^K > 1502^K$ (OK)

I) $T_u = \frac{994}{32 - 3(2)} = 38.2^K$/1 Lr.; #10: $f_{T_u} = \frac{38.2}{1.27} = 30.1$ ksi (OK)

(26 ← For Bending above!)

$\Sigma T = 901 - 262(.75) = 704^K$; #10: $f_T = 30.1 \frac{704}{994} = 21.3$ ksi (OK)

USE 48" SQ. w/ 32 - #10 ←

FORM 62-114
REV. 4-75

Stearns-Roger

JOB NO. C-21700 DATE 7-26-79 BY CSC Rang CH'K. HJM

CUSTOMER MIDAC PROJECT SOLAR ONE

SUBJECT FOUNDATION FOR RECEIVER TOWER

PEDESTAL

CASE (II) : Mu + DOWNWARD FORCE

$P_u = +1502^K$, $M_{ux} = M_{uy} = 640^{IK}$, $\phi = 0.7$

USE ACI 318-77 HAND BOOK VOLUME 2 - COLUMNS (P.129)

$\gamma = (48-9)/48 \approx 0.8$, $h = 48"$

$e_x/h = e_y/h = M_u/P_u h = 640 \times 12 / 1502 \times 48 = 0.107$

32-#10 $A = 32 \times 1.56 = 40.69\ in^2$

$\rho_g = 40.69/48^2 = 0.0176$

For $f'_c = 3$ ksi, $f_y = 60$ ksi

COLUMN 7.3.3 R3-60.75 $\phi P_{nx}/A_g = \phi P_{ny}/A_g = 2.0$

" 7.3.4 R3-60.90 " " " $= 2.0$

COLUMN 8.3 R3-60 $\phi P_o/A_g = 2.0$

$$\frac{1}{f_i/A_g} = \frac{1}{P_{nx}/A_g} + \frac{1}{P_{ny}/A_g} - \frac{1}{P_o/A_g} = \frac{1}{2.0} + \frac{1}{2.0} - \frac{1}{2.0} = 0.50$$

$\therefore f_i = A_g/0.50 = 48^2/0.50 = 4608^K > 1502^K$ O.K.

FORM 62-114
REV. 4-75

Stearns-Roger

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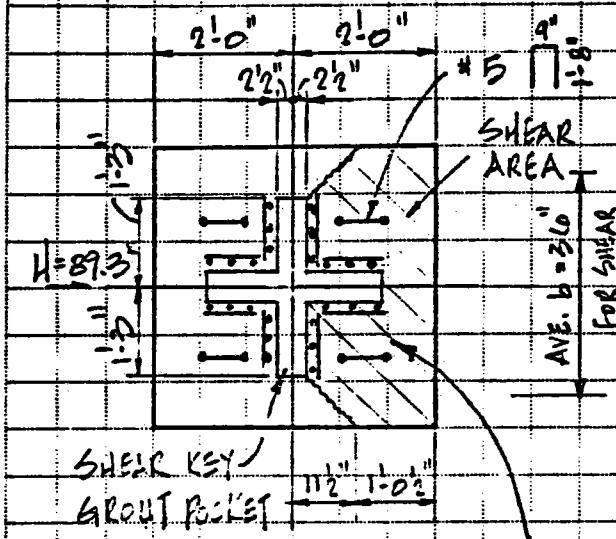
JOB NO. C-21700 DATE 7-26-79 BY OSC CH'K HJM

CUSTOMER MDAC PROJECT SOLAR ONE

SUBJECT FOUNDATION FOR RECEIVER TOWER

PEDESTAL (CONT.)



CHECK SHEAR @ KEY

ASSUME SHEAR AREA = $(30+48)\times\frac{21.5}{2} - 12.5\times5$
$= 776$ □"

$H_u = 89.3\times1.7\times0.75 = 113.9^{K}$

$v_u = 113900/0.85\times776 = 172.7^{KSI} > 2\sqrt{f_c'} = 110^{KSI}$

∴ SHEAR REINF. REQ'D

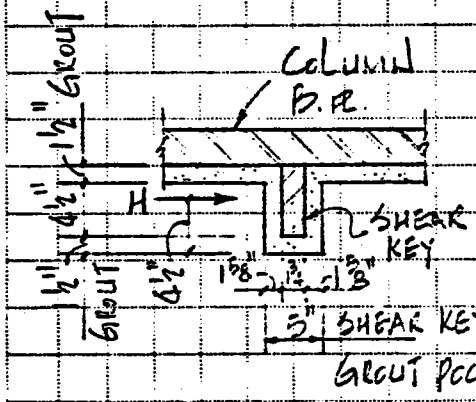
ALLOWABLE FRICTION SHEAR $= 0.2 f_c'$
$= 6000^{PSI} > 172.7^{PSI}$

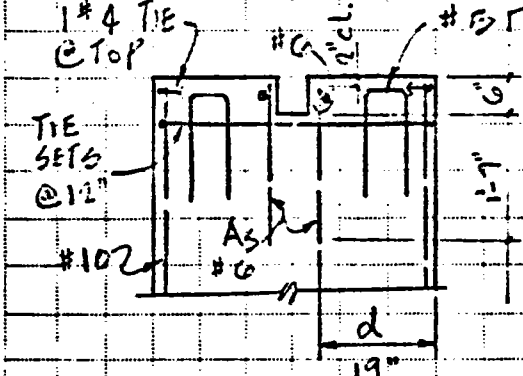
$A_{vf} = V_u/\phi f_y \mu$, $\mu = 1.4$, $\phi = 0.85$

$\therefore A_{vf} = 113.9/0.85\times60\times1.4 = 1.60$ □"

$A_s = M_u/\phi f_y jd = \frac{113.9\times4.5}{0.9\times60\times0.9\times19} = 0.526$ □" (ACI 11.9.7)

$A_{s(MIN.)} = \frac{0.04\times f_c' bd}{f_y} = \frac{0.04\times3\times36\times19}{60} = 1.37$ □"





BUT SINCE $A_h = 0.5A_s$, $A_h + A_s = A_{vf}$ (ACI 11.9.4)

$\therefore A_s = \frac{2}{3}A_{vf} = 1.6\times\frac{2}{3} = 1.07$ □" < 1.37 □"
$A_h = \frac{1}{3}A_{vf} = 0.54$ □"

A_s : USE 6-#6 = 2.64 □" > 1.37 □"
A_h : USE 4-#5 = 1.24 □" > 0.54 □"

$\rho_v = (A_s + A_h)/bd = (2.64+1.24)/36\times19 = 0.006$
$.15 < 0.2 f_c'/f_y = 0.01$ MAX. (ACI 11.9.5)

BEARING: $P_u = \frac{113900}{(30-5)6} = 760$ PSI
O.K.!

Stearns-Roger

FORM 62-114
REV. 4-75

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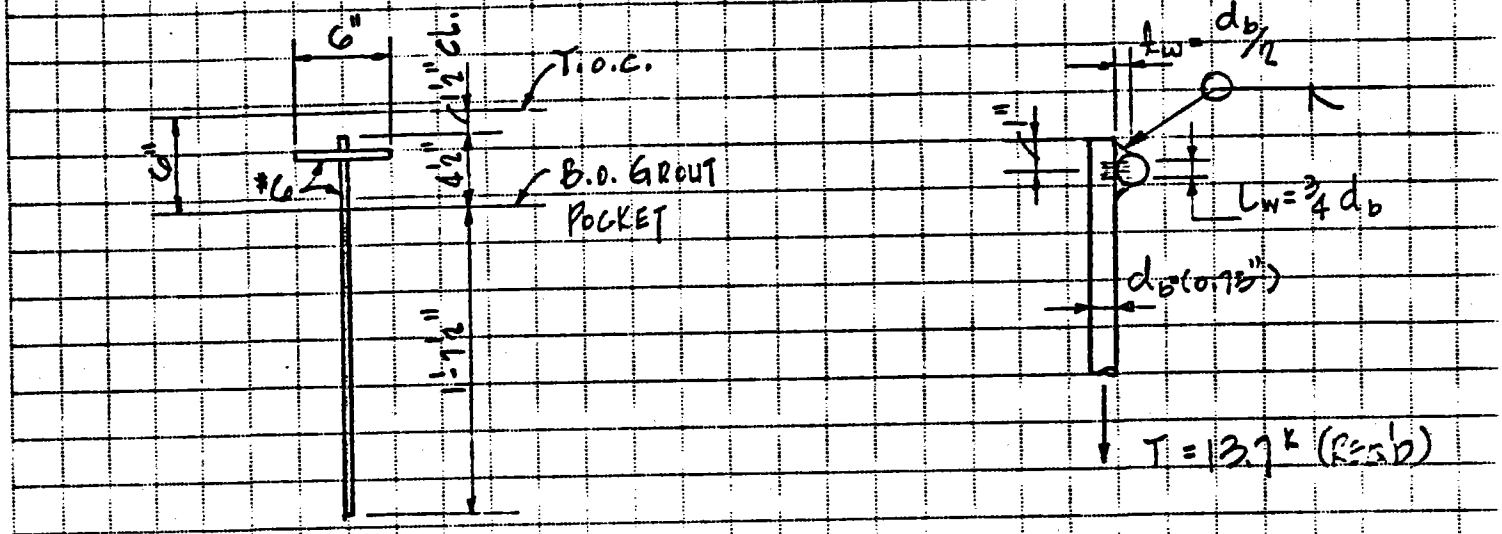
JOB NO. C-21700 DATE 8-7-79 BY CSChang CH'K. HJM

CUSTOMER MDAC PROJECT SOLAR ONE

SUBJECT FOUNDATION FOR RECEIVER TOWER



REF. BOOK "PCI DESIGN HAND BOOK" SECTION 6.1.18

ACTUAL AREA REQ'D = 1.37 in^2

ACTUAL FORCE PER BAR (6 BARS) $T = 1.37 \times 60 / 6 = 13.7^K$

CAPACITY OF WELDED CONNECTION:

$W_c = \phi 2.5 L_w t_w$ 4 SIDES

$= (0.7 \times 2.5 \times 0.75^3/_2) \times 4$

$= 14.77^K > 13.7^K$ O.K.

L_w = LENGTH OF WELD = 0.75×0.75

t_w = WELD SIZE = $0.75/2$

$\phi = 0.7$

CAPACITY OF "T" BAR BEARING

$T_b = F_b \Sigma A$

$= 0.85 \times 0.7 \times 3.0 \times 2 \times 3.94$

$= 14.07^K > 13.7^K$

$F_b = 0.85 \phi f'_c \sqrt{A_2/A_1}$ $\left(\sqrt{A_2/A_1} \geq 2\right)$

$\Sigma A = 0.75 \times (6 - 0.75) = 3.94$ in^2

FORM 62.114
REV. 4.75

Stearns-Roger

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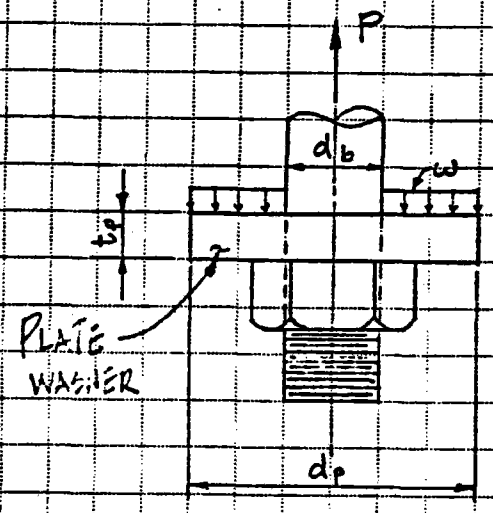
JOB NO. C-21700 DATE 8-20-79 BY CSC CH'K HJM

CUSTOMER MDAC PROJECT SOLAR ONE

SUBJECT FOUNDATION FOR RECEIVER TOWER

DESIGN OF ANCHOR BOLT & WASHER

MATERIAL: 1. ANCHOR BOLT ($2\frac{3}{4}$" ø A325 H.S. BOLTS) $F_t = 40$ KSI
2. ø WASHER A36 STEEL (PER R. OWEN) $F_b = 27$ KSI



TENSILE STRESS AREA $A_{ts} = 4.93$ □" (AISC 4-12th)

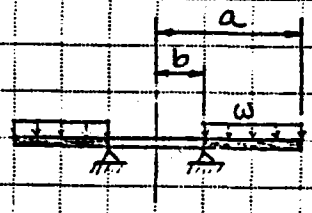
$P = 4.93 \times 40 = 197.2^K$

ALLOWABLE BEARING STRESS FOR ø WASHER = $f'_c = 3.0$ KSI (CONC. ULTIMATE COMPRESSIVE STRE...)

$$P = \frac{\pi}{4}(d_p^2 - d_b^2) f'_c$$

$$\therefore d_p = \sqrt{\frac{4P}{\pi f'_c} + d_b^2}$$

$$= \sqrt{\frac{4 \times 197.2}{3.14 \times 3.0} + 2.75^2} = 9.56 \text{ □"} \quad (\text{USE } 9\tfrac{3}{4}\text{" SQ. OR ROUND})$$



REF: ROARK, 4th EDITION, TABLE X, CASE 16, P. 221

ø WASHER THICKNESS = t_p
$F_b = 27$ KSI
Δ = MAX. ALLOWABLE DEFLECTION = .001"

$a = d_p/2 = 9.75/2 = 4.88$"
$b = d_b/2 = 2.75/2 = 1.38$"

NOTE: THE FOLLOWING SOLUTION IS BASED ON THIN-PLATE THEORY. IN ORDER TO COMPENSATE FOR THE INACCURACY OF THE SOLUTION, THE PLATE IS CONSIDERED SUPPORTED OF THE FACE OF THE BOLT RATHER THAN AT THE CENTER OF THE BEARING SURFACE PROVIDED BY THE NUT. [17]

FORM 62-114
REV. 4-75

Stearns-Roger

JOB NO. C-21700 DATE 8-20-79 BY [illegible] CH'K. HJM

CUSTOMER MDAC PROJECT SOLAR ONE

SUBJECT FOUNDATION FOR RECEIVER TOWER

DESIGN OF ANCHOR BOLT & WASHER (CONT.)

$$\omega = P/\pi(a^2-b^2) = 191.2/3.14(4.88^2-1.38^2) = 2.87 \text{ KSI}$$

ν = POISSON'S RATIO = 0.25

$m = 1/\nu = 4$, $E = 29{,}000$ KSI

THICKNESS REQ'D TO SATISFY ALLOWABLE STRESS:

$$\frac{t}{r} = \left\{\frac{3\omega\left[a^4\left(2.0\log\frac{a}{b}-1\right)+4a^2b^2+3b^4\right]}{16F_b'(a^2-b^2)}\right\}^{1/2}$$

$$= \left\{\frac{3\times 2.87\left[4.88^4\left(2.0\log\frac{4.88}{1.38}-1\right)+4\times 4.88^2\times 1.38^2+3\times 1.38^4\right]}{16\times 27\times(4.88^2-1.38^2)}\right\}^{1/2}$$

$$= (2.22)^{1/2} = 1.5"$$

THICKNESS REQ'D TO SATISFY ALLOWABLE DEFLECTION:

$$t = \left\{\frac{9\omega}{1.424\times10^6\delta}\left[31a^4+21b^4-52a^2b^2-\frac{260}{3}a^2b^2\log\frac{a}{b}+\frac{400a^4b^2}{3(a^2-b^2)}\left(\log\frac{a}{b}\right)^2\right]\right\}^{1/3}$$

$$= \left\{\frac{9\times 1.87}{1.424\times10^6\times 0.001}\left[31\times 4.88^4+21\times 1.38^4-52\times 4.88^2\times 1.38^2-\frac{260}{3}\times 4.88^2\times 1.38^2\log\frac{4.88}{1.38}\right.\right.$$

$$\left.\left.+\frac{400}{3}\times\frac{4.88^4\times 1.38^2}{(4.88^2-1.38^2)}\left(\log\frac{4.88}{1.38}\right)^2\right]\right\}^{1/3}$$

$$= (52.61)^{1/3} = 3.75" \longleftarrow \text{GOVERN}$$

USE $3\frac{3}{4}" \times 9\frac{3}{4}" \times 0'-9\frac{3}{4}"$ ℄ WASHER

FORM 62.114
REV. 4.75

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JOB NO. C-21700 DATE 5-24-79 BY CSC Kang CH'K

CUSTOMER MDAC PROJECT SOLAR ONE

SUBJECT FOUNDATION FOR RECEIVER TOWER - TRADE STUDY

CONCRETE QUANTITIES:

1. FOR SPREAD FOOTING:

PEDESTAL :	4x4x16 x 4	=	1024 CF.
GRADE BEAM :	3x8.5x36x4	=	3672
MAT :	54x54x4	=	11664
		Σ =	16360 CF.

OR 16360/27 = 606 CY.

2. DRILLED PIER FDN:

PEDESTAL :	4x4x7.5x4	=	480 CF.
PIER CAP :	16x16x5x4	=	5120
GRADE BEAM :	3x5x24x4	=	1440
PIER (48"ϕ) :	$\frac{3.14 \times 4^2}{4} \times 45 \times 16$	=	9048
		Σ =	16088 CF.

OR = 16088/27 = 596 CY.

RF – R-2

FORM 62.114
REV. 4.75

Stearns-Roger

PAGE

JOB NO. 2700 DATE 5/29/79 BY PARKER CH'K

CUSTOMER MD&E/DOE PROJECT SOLAR ONE

SUBJECT REVOLVER TOWER FOUNDATION TRADE STUDY

ESTIMATED CONSTRUCTION COST COMPARISON

Ref: MEANS BUILDING CONSTRUCTION COST DATA – 1975
(Since we are only interested in relative costs – the date of this data should not be a problem)

CONCRETE IN PLACE	MAT FOUNDATION		DRILLED PIER FOUND.	
	QTY	COST	QTY	COST
A. PEDESTAL #186/cy	38 cy	$7,050	18 cy	$3,310
B. GRADE WALLS #104/cy	136 cy	14,140	53 cy	5,550
C. FOUND. MAT $57/cy	432 cy	24,620	—	—
D. PIER CAP $58/cy	—	—	190 cy	11,000
E CAISSON *$41.98/lf	—	—	800 lf	32,800
		$45,810		$52,660

USE → MAT FOUNDATION

* FOR Caissons, reduce figure of $400/ft by 15% since this figure from MEANS includes O&P, but the others do not.

RF-R-3

FORM 62.114
REV. 4.75

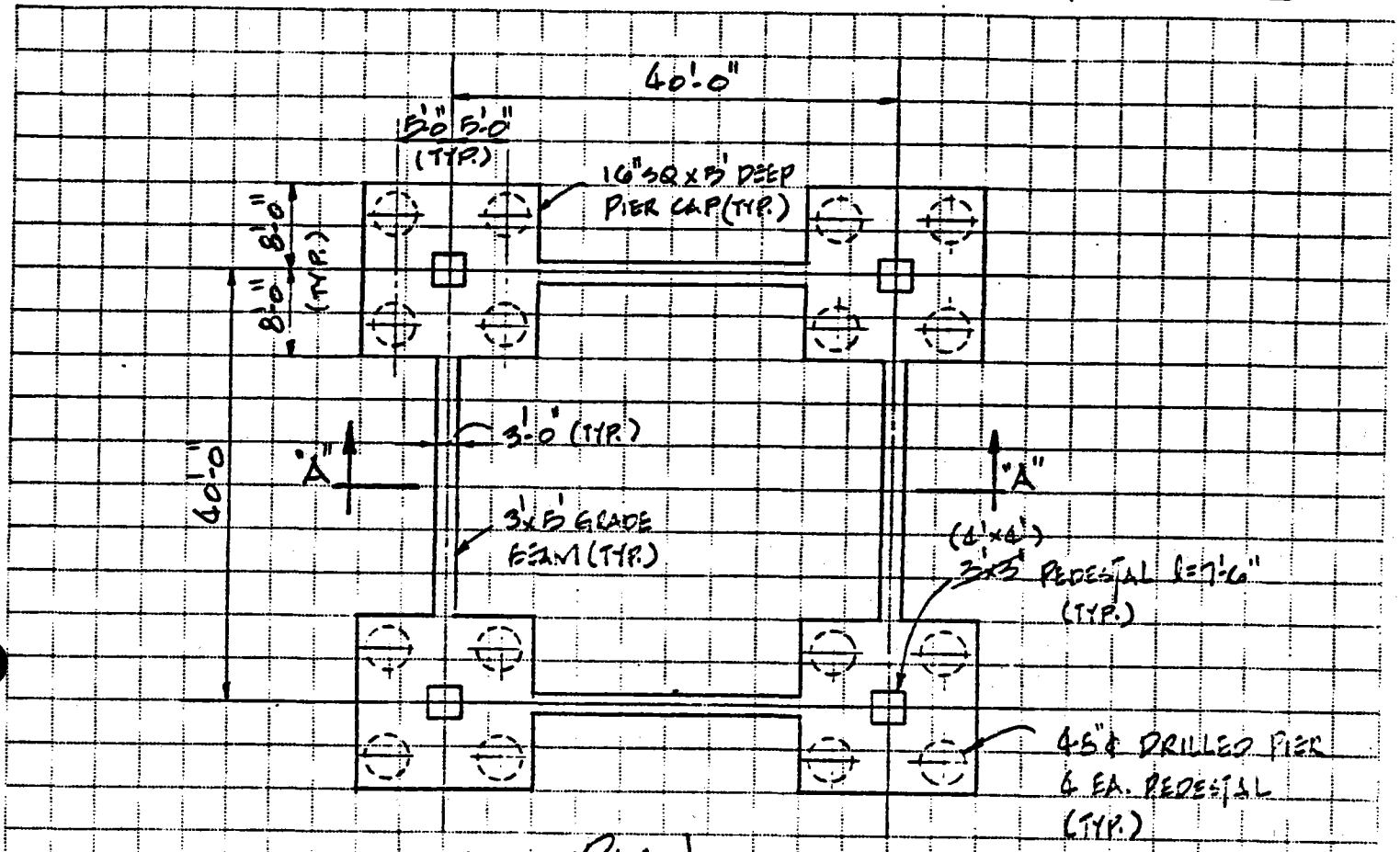
Stearns-Roger

PAGE 1

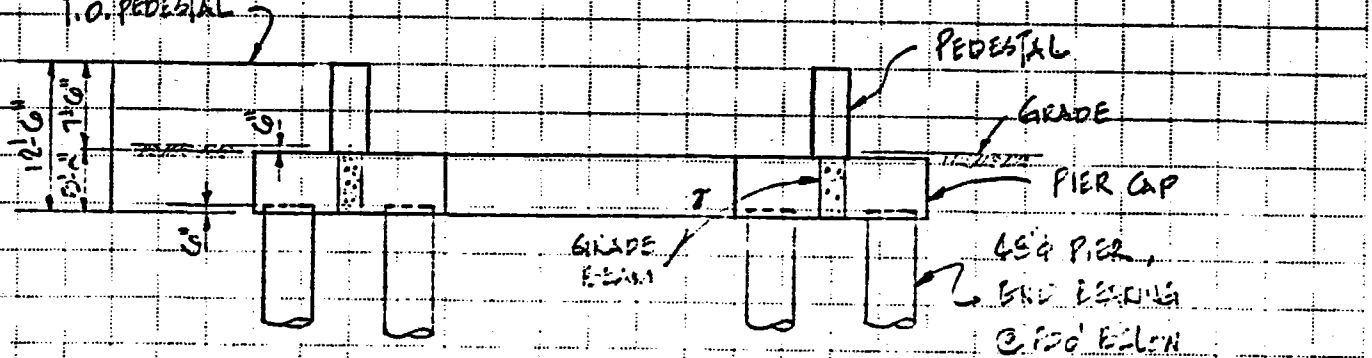
JOB NO. C-21700 DATE 5-24-79 BY [illegible] CH'K

CUSTOMER MDAC PROJECT SOLAR ONE

SUBJECT FOUNDATION FOR RECEIVER TOWER - DRILLED PIER



PLAN



SECTION "A"-"A"

FORM 62.114
REV. 4.75

Stearns-Roger

JOB NO. C-21700 DATE 5-24-79 BY C.S.Chang CH'K

CUSTOMER MDAC PROJECT SOLAR ONE

SUBJECT FOUNDATION FOR RECEIVER TOWER - DRILLED PIER

MAX. UPLIFT @ DIAGONAL WIND

P = 0.75 D.L. + WIND
= 0.75 x 977/4 - 993 = (-)810^K

USE SAFETY FACTOR = 1.5 & NEGLECT ONE-THIRD INCREASE

∴ MAX. UPLIFT FORCE P = -810 x 1.5 = (-)1215^K

MAX. DOWNWARD FORCE @ DIAGONAL WIND

P = D.L. + L.L. + WIND
= (977 + 1960)/4 + 993 = 1286^K

ALLOW ONE-THIRD INCREASE FOR COMBINE WT WIND

∴ MAX. DOWNWARD FORCE P = 1286 x 0.75 = 965^K

P = 965^K > D.L.+L.L. ONLY = (977+1960)/4 = 293^K

∴ WIND LOAD GOVERNS!

TRY 4-45'ϕ PIERS, SPACING @ 10' APART.

FROM WOODWARD-CLYDE CONSULTANTS' SOIL REPORT:

ALLOWABLE AXIAL PIER CAPACITY FIG. 1, USE INTERPOLATING VALUE FOR 45ϕ PIER, SINCE THE FIG. GIVE VALUE ONLY FOR 36"ϕ, 54"ϕ & 60"ϕ PIERS.

* VALUE ON FIG. 1 NOT INCLUDED WT. OF PIER. (SEE TELEPHONE CONVERSATION FROM C.S. CHANG OF S-R TO Dr. KUL BHUSHAN OF WOODWARD-CLYDE CONSULTANTS DATE 5-23-79)

FORM 62.114
REV. 4-75

Stearns-Roger

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JOB NO. C-21700 DATE 5-24-79 BY CSCheng CH'K

CUSTOMER MDAC PROJECT SOLAR ONE

SUBJECT FOUNDATION FOR RECEIVER TOWER - DRILLED PIER

WT OF 4E" ϕ PIER $l = 50' - 5.5' = 44.5'$, $W = \frac{3.14 \times 4^2}{4} \times 44.5 \times 0.15 = 84^K$

DIFFERENT WT. BETWEEN CONC. & SOIL FOR THIS PIER $W = 84 \times \frac{150-110}{150} = 22^K$

WT. OF PIER CAP $= 16^2 \times 5 \times 0.15 = 192^K$ / EA. COLUMN.

WT. OF GRADE BEAM $= 24 \times 2 \times 5 \times 0.15 = 36^K$ / EA. COLUMN.

WT. OF PEDESTAL $= 3^2 \times 7.5 \times 0.15 = 10^K$

ADDITIONAL WT. @ EA. COLUMN $= 192 + 36 + 10 = 238^K$ (NOT INCL. PILE WT.)

ALLOWABLE AXIAL CAPACITY INTERPOLATING FROM FIG. 1 (PER EA. PILE)

UPLIFT FORCE $= 280^K$

COMPRESSION $= 400^K$

END BEARING $= 400^K - 280^K = 120^K$

FIND EFFICIENCY OF FRICTION PIER GROUP:

REF. BOOK: "PILE FOUNDATION" BY R.D. CHELLIS SECOND EDITION

P. 137 CONVERSE-LABARRE METHOD

$$\text{EFFICIENCY} = 1 - \phi\left[\frac{(n-1)m + (m-1)n}{90mn}\right] = 1 - 21.5\left[\frac{2+2}{90 \times 2 \times 2}\right] = 0.76$$

WHERE m = NUMBER OF ROWS = 2
n = NUMBER OF PIER IN A ROW = 2
ϕ = ARC TAN (d/s), IN DEGREES $= \tan^{-1}(4/10) = 21.5°$
d = DIAMETER OF PIER = 4'
s = SPACING OF PIER CENTERS. = 10'

FORM 62.114
REV. 4.75

Stearns-Roger

PAGE 4

JOB NO. C-21700 DATE 5-24-79 BY CS CH'K

CUSTOMER MDAC PROJECT SOLAR ONE

SUBJECT FOUNDATION FOR RECEIVER TOWER - DRILLED PIER

ALLOWABLE AXIAL CAPACITY PER EA. PIER @ PIER GROUP:

UPLIFT: $280 \times 0.76 = 213^K$

COMPRESSION: $280 \times 0.76 + 120 = 333^K$

ACTUAL FORCE IN EA. PIER

UPLIFT: $(1215 - 238)/4 - 84 = 160^K < 213^K$ O.K!

COMPRESSION: $(965 + 238)/4 + 27 = 323^K < 333^K$ O.K!

STMPO 182

Department of Energy
San Francisco Operations Office
1333 Broadway
Oakland, California 94612

Reply To: DOE Solar One Project Office
P.O. Box 366
Daggett, CA 92327

SEP 2 8 1984

Mr. Robert L. Gervais
Solar One Project Office
McDonnell Douglas Astronautics Corp.
P.O. Box 366
Daggett, CA 92327

Subject: Contractor Clearance of Contract DE-AC03-79SF10499
Solar One Reports for DOE/TIC Inclusion.

Dear Bob:

Enclosed are copies of covers and title pages of eight reports prepared by McDonnell Douglas Astronautics Corporation for the Solar One Project under the above referenced contract. In preparation for delivery of these documents to DOE/TIC, I have prepared a SAN form 70 "Request for Patent Clearance" and a DOE form RA-426 "Recommendations for Announcement and Distribution of Documents" for each document.

Please have the appropriate MDAC personnel complete and sign these forms. As agreed, SAN form 70 should be forwarded to SAN/OPC by your office with copies of the completed SAN form 70 and the transmittal letter being sent to me. The completed DOE form RA-426 should be sent directly back to me.

The documents covered by this letter are:

Primary Document No.	Secondary No.	Brief Title
DOE/SF/10499-T91	STMPO 176	PSS Design Calculations (Book 1 of 26)
DOE/SF/10499-T92	STMPO 177	PSS Design Calculations (Book 2 of 26)
DOE/SF/10499-T93	STMPO 178	PSS Design Calculations (Book 3 of 26)
DOE/SF/10499-T95	STMPO 180	PSS Design Calculations (Book 5 of 26)
DOE/SF/10499-T96	STMPO 181	PSS Design Calculations (Book 6 of 26)
DOE/SF/10499-T97	STMPO 182	PSS Design Calculations (Book 7 of 26)
DOE/SF/10499-T98	STMPO 183	PSS Design Calculations (Book 8 of 26)
DOE/SF/10499-T99	STMPO 184	PSS Design Calculations (Book 9 of 26)

If you should have any questions or concerns please do not hesitate to contact me by telephone at, (619) 254-2672.

Sincerely,

S.D. Elliott, Jr., Director
DOE Solar One Project Office

SDE/aks
Project File: CCC008.RNO(SA3:)

Encl: Eight Document Covers W/forms 70 and RA-426

cc: Roger Gaither, SAN/OPC
W.D. Matheny, DOE/TIC
Mike Lopez, DOE/SAN (FGS)
Mary Soderstrum, B&McD

SAN FORM 75 10/80

DEPARTMENT OF ENERGY
SAN FRANCISCO OPERATIONS OFFICE

CONTRACTOR REQUEST FOR PATENT CLEARANCE
FOR RELEASE OF UNCLASSIFIED DOCUMENT

Prime Contract No.	DE-AC03-79SF10499
Subcontract No.	(N/A)
Report No.	(STMPO 182) DOE/SF/10499-T97
Date of Report	September 1980
Name & Phone No. of DOE Technical Representative	S.D. Elliott, Jr. (619) 254-2672

TO: Roger S. Gaither, Asst. Chief for Prosecution
Office of Patent Counsel/Livermore Office
P.O. Box 808, L-376
Livermore, California 94550

FROM: McDonnell Douglas Corporation
3855 Lakewood Blvd.
Long Beach, CA 90846

1. Document Title: Plant Support Subsystem Final Design Calculations (Book 7 of 26)

2. Type of Document: ☒ Technical Report, ☐ Conference Paper, ☐ Journal Article, ☐ Abstract or Summary, ☐ Copy of Oral Presentation, ☐ Other (please specify): _____

3. In order to meet a publication schedule or submission deadline, patent clearance by (Routine) would be desired.

SENDER IS TO CHECK BOX #4 OR #5 BELOW.

☐ 4. I have reviewed (or have had reviewed by technically knowledgeable personnel) this document for possible inventive subject matter (Subject Inventions) and that no inventions or discoveries (Subject Inventions) are deemed to be disclosed in this document except as stated below:

a. Attention should be directed to pages _____ of this document.

b. This document describes matter relating to an invention:

i. Contractor Invention Docket No. _____.
ii. A disclosure of the invention was submitted to DOE on _____ (date)
iii. A disclosure of the invention will be submitted shortly _____ (approximate date)
iv. A waiver of DOE's patent rights to the contractor:
☐ has been granted, ☐ has been applied for; or ☐ will be applied for _____ (date)

☐ 5. This document is being submitted, but no review has been made of this document for possible inventive subject matter.

6. Remarks: Provide copy of clearance to: Solar One Project Office
P.O. Box 366, Daggett, CA 92327

Reviewing/Submitting Official: Name (Print/Type) _____
Title _____
Signature _____ Date _____

TO: INITIATOR OF REQUEST

FROM: ASSISTANT CHIEF FOR PROSECUTION
Office of Patent Counsel/Livermore Office

☐ No patent objection to above-identified release.

☐ Please defer release until advised by this office.

Signed _____ Date Mailed _____

DOE OFFICE OF PATENT COUNSEL (OPC)

DOE Form RA-426
(10/80)

U.S. DEPARTMENT OF ENERGY

OMB NO. 038-R0190

DOE AND MAJOR CONTRACTOR RECOMMENDATIONS FOR ANNOUNCEMENT AND DISTRIBUTION OF DOCUMENTS

See Instructions on Reverse Side

1. DOE Report No.	2. Contract No.	3. Subject Category No.
DOE/SF/10499-T97 (STMPO 182)	DE-AC03-79SF10499	UC-62, 62c, 62d

4. Title

Plant Support Subsystem Final Design Calculations (Book 7 of 26)

5. Type of Document ("x" one)

☒ a. Scientific and technical report

☐ b. Conference paper: Title of conference _____

_____ Date of conference _____

Exact location of conference _____ Sponsoring organization _____

☐ c. Other (specify planning, educational, impact, market, social, economic, thesis, translations, journal article manuscript, etc.)

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S.D. Elliott, Jr., Director, DOE Solar One Project Office

Organization

P.O. Box 366, Daggett, CA 92327 (619) 254-2672

Signature	Date

DOE/SF/10499-T97
STMPO 182
SAN/0499-50
MDC G8502

10 MWe Solar Thermal
Central Receiver Pilot Plant

SOLAR FACILITIES DESIGN INTEGRATION

PSS FINAL DESIGN CALCULATIONS
BOOK 7 OF 26--RECEIVER TOWER FOUNDATIONS
CONSTRUCTION PACKAGE 7A (RADL ITEM 7-8)

September 1980

WORK PERFORMED UNDER CONTRACT
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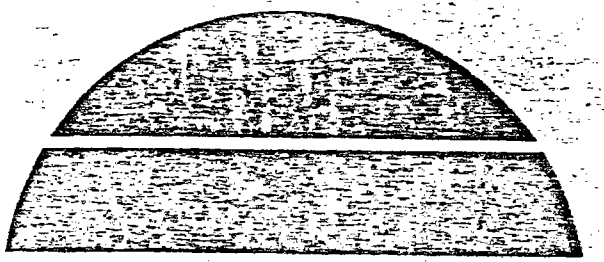

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PREPARED FOR THE
U.S. DEPARTMENT OF ENERGY
SOLAR ENERGY
UNDER CONTRACT DE-AC-03-79SF10499

H009-M-956

DOE Form RA-426
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U.S. DEPARTMENT OF ENERGY

OMB NO. 038-R0190

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1. DOE Report No.	2. Contract No.	3. Subject Category No.
DOE/SF/10499-T97 (SIMPO 182)	DE-AC03-79SF10499	UC-62, 62c, 62d

4. Title

Plant Support Subsystem Final Design Calculations (Book 7 of 26)

5. Type of Document ("x" one)

☒ a. Scientific and technical report

☐ b. Conference paper: Title of conference _____

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DEPARTMENT OF ENERGY
SAN FRANCISCO OPERATIONS OFFICE

CONTRACTOR REQUEST FOR PATENT CLEARANCE
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Prime Contract No.	DE-AC03-79SF10499
Subcontract No.	(N/A)
Report No.	(SIMPO 182) DOE/SF/10499-T97
Date of Report	September 1980
Name & Phone No. of DOE Technical Representative	S.D. Elliott, Jr. (619) 254-2672

TO: Roger S. Gaither, Asst. Chief for Prosecution
Office of Patent Counsel/Livermore Office
P.O. Box 808, L-376
Livermore, California 94550

FROM: McDonnell Douglas Corporation
3855 Lakewood Blvd.
Long Beach, CA 90846

1. Document Title: Plant Support Subsystem Final Design Calculations (Book 7 of 26)

2. Type of Document: ☒ Technical Report, ☐ Conference Paper, ☐ Journal Article, ☐ Abstract or Summary, ☐ Copy of Oral Presentation, ☐ Other (please specify): _____

3. In order to meet a publication schedule or submission deadline, patent clearance by (Routine) would be desired.

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Reviewing/Submitting Official: Name (Print/Type) John P. Scholl
Title Asst. Chief Patent Counsel, MDC (MS 122-23)
Signature _____ Date 8 Nov 84

TO: INITIATOR OF REQUEST

FROM: ASSISTANT CHIEF FOR PROSECUTION
Office of Patent Counsel/Livermore Office

☐ No patent objection to above-identified release.

☐ Please defer release until advised by this office.