Re-Use Guidelines Appendices

Hangar 3 (Building No. 47)

NASA Ames Research Center
Moffett Field, California

August 30, 2006

Prepared for
Integrated Science Solutions, Inc.
Moffett Field, California

Prepared by
PAGE & TURNBULL, INC.
San Francisco, California

APPENDICES

The following appendices are provided under a separate cover:

a. Executive Summary of Building 46 by Rutherford and Chekene (1984)

b. Detailed Analysis Report, Volume 5 – Appendix B – Calculations: Building 46, 49, 88, 144, 146, Evaluation of Seismic Vulnerability of Structures at Naval Air Station – Moffett Field and Naval Auxiliary Landing Field – Crows Landing by Rutherford and Chekene (June 1985)

c. Hangar 2 Exerpts of Moffet Field Hangar Life Safety Evaluation by Moffet Field Development Project (February 1994).

d. Encompassing Synopsis of the Condition and Feasible Utility of Blimp Hangars 2 & 3 by Robert Dolci and Team (January 2000)

e. Hangars 2 & 3 Hazard Notice and Disclosure Report by NASA Ames Research Center (April 4, 2000)

f. An Initial Evaluation of Douglas Fir Wood Components in Hangars 2 and 3 at the NASA/Ames Research Center by Kevin A. Flynn and Christina H. Langford, University of California Forest Products Laboratory (March 2002)

g. Secretary of the Interior's Standards for the Treatment of Historic Properties

h. Selection of historic drawings obtained from the NASA Ames Research Center Engineering Documentation Center

Rutherford
&
Chekene 1984

EXECUTIVE SUMMARY OF BUILDING 46

This report describes the detailed seismic evaluation of structural and nonstructural elements, and decribes a method of structural strengthening, for Building 46 at N.A.S. Moffett Field. Building 46, Hangar 2, was originally a blimp hangar. It is framed with a wood roof on long span wood trussed arches, which are supported by a concrete frame. At the north and south ends, there are concrete and wood door structures, which are structurally separate from the hangar. A dynamic modal analysis was performed using the techniques given in the Evaluation Criteria in Section 1, Part H of this report.

The structural analysis indicates the concrete frames, concrete door towers, and connections of the longitudinal wood bracing are all overstressed. The repair scheme proposed is to strengthen the hangar by infilling the concrete frames with a concrete wall, adding a concrete diaphragm at the top of the frames, strengthening all the overstressed connections, and providing new concrete struts to brace the door towers. The estimated cost for this structural repair scheme is $2,400,000.

The nonstructural survey located many potential hazards to life safety and essential Navy functions. These include falling hazards from light fixtures and overturning hazards from shelving and lockers. The cost for bracing these elements is approximately $220,000. Thus the total estimated cost for structural and nonstructural repair is $2,620,000.

Results of Detailed Evaluation

The main structure of Building 46 was evaluated using Special Provisions for Large Hangars described in Section 1, Part H of this report. A full dynamic modal analysis was performed on the typical transverse arches. To reduce the number of members, the trusses of each arch were modeled as beam members. No simplification was made in modeling the members of the concrete base. Refer to Figure 46-4 for a sketch of the typical transverse arch and to Figure 46-5 for a sketch of the computer model used in analysis. Lumped masses were applied at each node.

Many analyses were performed in order to study the effects of various assumptions. One analysis was performed with the members of the concrete base assumed uncracked, and one with the base members assumed cracked. Another analysis was performed with the pile foundation assumed rigid, and another with the pile foundation modeled as a spring support. Member stresses were checked for Level 1 forces using the analysis which assumed the concrete base to be uncracked and the pile foundation to behave as a spring support.

In some modes of vibration, the predominant effect on the arch system was motion of the concrete base. In other modes, motion of the wood arch trusses was the predominant effect. For those modes where motion of the concrete base was predominant, damping of 5% was assumed for the response spectrum. Where motion of the wood arch trusses was predominant, damping of 10% was assumed. For Level 1 analysis, the loading condition used was dead load, plus horizontal earthquake load, plus 30% of vertical earthquake load. The vertical earthquake forces were assumed to be two-thirds of the horizontal earthquake forces at this site. The earthquake forces generated by the first sixteen modes of vibration of the structure were computed and combined using both the Square Root of the Sum of the Squares (RMS) method and the Complete Quadratic Combination (CQC) method.

In the longitudinal direction, the cross-bracing at the bottom chord of the arch trusses was modeled as a continuous beam with lumped masses at the nodes. A damping value of 5% was assumed for Level 1 analysis, and 10% was used for Level 2. The loading condition was the same as that used for the arch system. The earthquake forces generated by the first eight modes of vibration were combined using the same methods described above.

The concrete towers and the wood box beam framing the doors were checked by hand calculations. For Level 1 analysis, damping of 7% was assumed for east-west motion, while damping of 5% was assumed for north-south motion. The difference in damping between the two directions of motion is based on the different contributions expected from the wood box beam. For a summary of the Detailed Evaluation see Figure 46-15.

The stresses in the wood members of the typical transverse arch and longitudinal bracing truss were checked for both Level 1 and Level 2 forces. Under Level 2 forces all tension members were stressed below their computed yield capacity and all compression members were stressed below their elastic buckling capacities, thus no members were overstressed.

The field survey methodology includes a hazard rating from -9 to +8 for every element based on occupancy, element failure mode, support effectiveness, and essential function. A hazard rating of zero or less is intended to be acceptable. A hazard rating above zero is intended to designate elements which present a risk to life safety or to the Navy mission, or both.

The nonstructural field survey data for Building 46 is included in Volume 2 of the Detailed Analysis Report. The survey methodology is described in a separate report titled "Seismic Investigation of Nonstructural Elements, Survey Methodology."

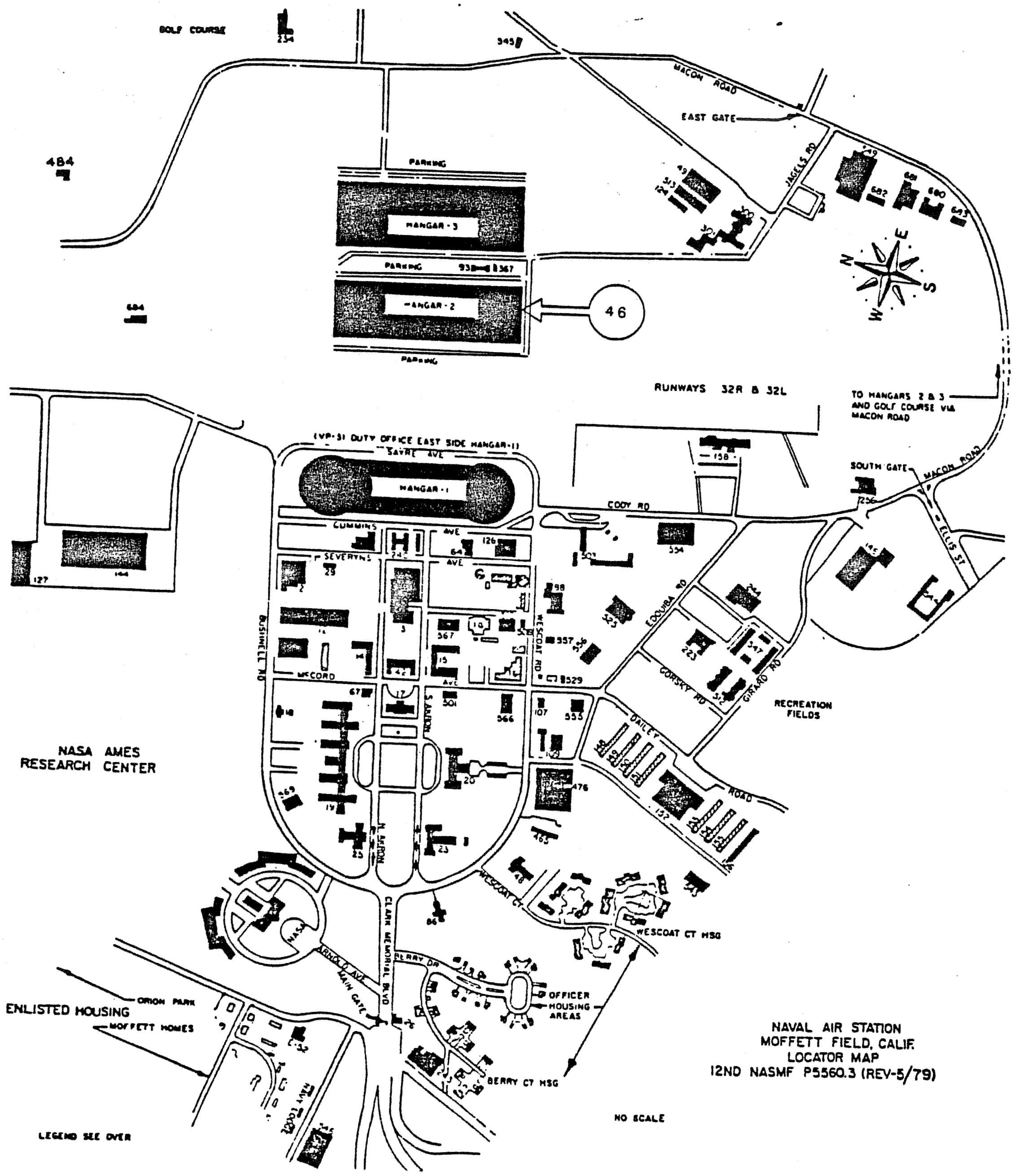
Estimated Repair Costs

The estimated cost for implementing the structural strengthening scheme delineated in this report for Building 46 is $2,400,000. The cost estimate for retrofitting all potential nonstructural hazards to life safety or essential function is $220,000. Thus the total cost estimate for the repair of the structural and nonstructural hazards is $2,620,000. This total cost is based on 1984 prices and does not include any factor for future escalation of prices.

The structural strengthening estimate is comprised of $1,550,000 for the strengthening of the hangar structure and $850,000 for bracing the door towers. The hangar strengthening estimate includes $1,000,000 for a new shear wall system to resist transverse seismic forces, and $550,000 for repairs to the longitudinal bracing trusses.

The nonstructural cost estimate may be reduced if a higher level of risk is considered acceptable. For example, retrofitting only those elements with a life safety or essential function hazard rating greater than 4 would cost an estimated $170,000 in Building 46. Retrofitting only life safety hazards rated above 4 would cost an estimated $150,000. Approximately one-third of the total nonstructural cost estimate is for securing light fixtures throughout the hangar.

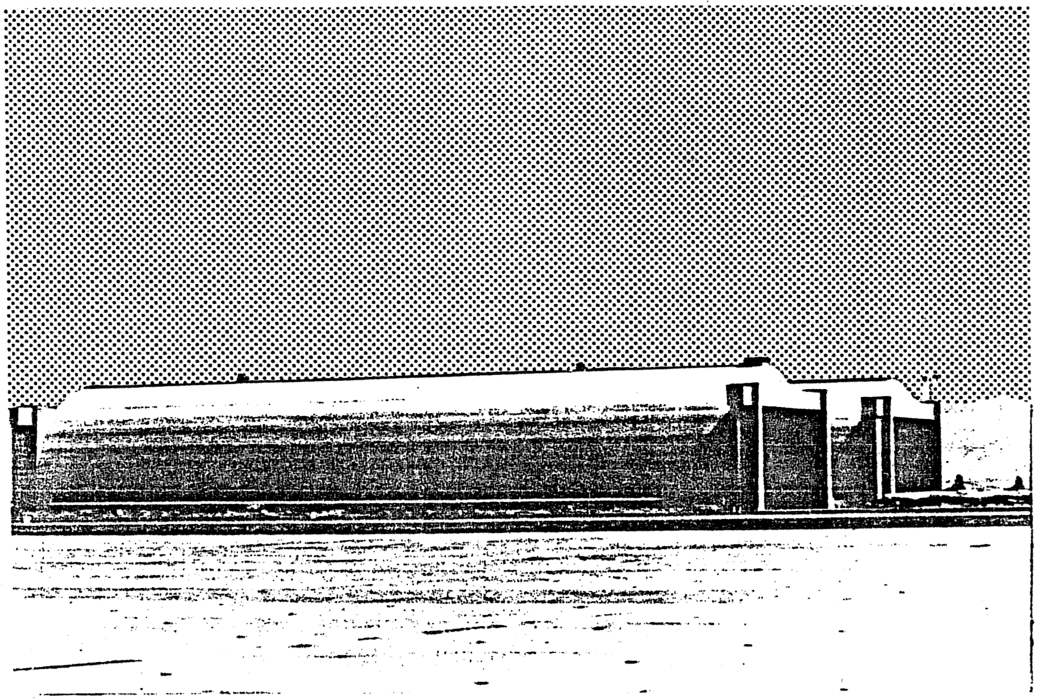
Since finishes were not removed during the walk-through nonstructural evaluation, certain portions of the utility lines, such as the entrance to the building and distribution above fixed ceiling spaces, could not be reviewed. The cost for any repairs required in those concealed spaces is not included in the above estimate. Thus the cost for a more detailed investigation and the repairs resulting would be in addition to the estimate above.



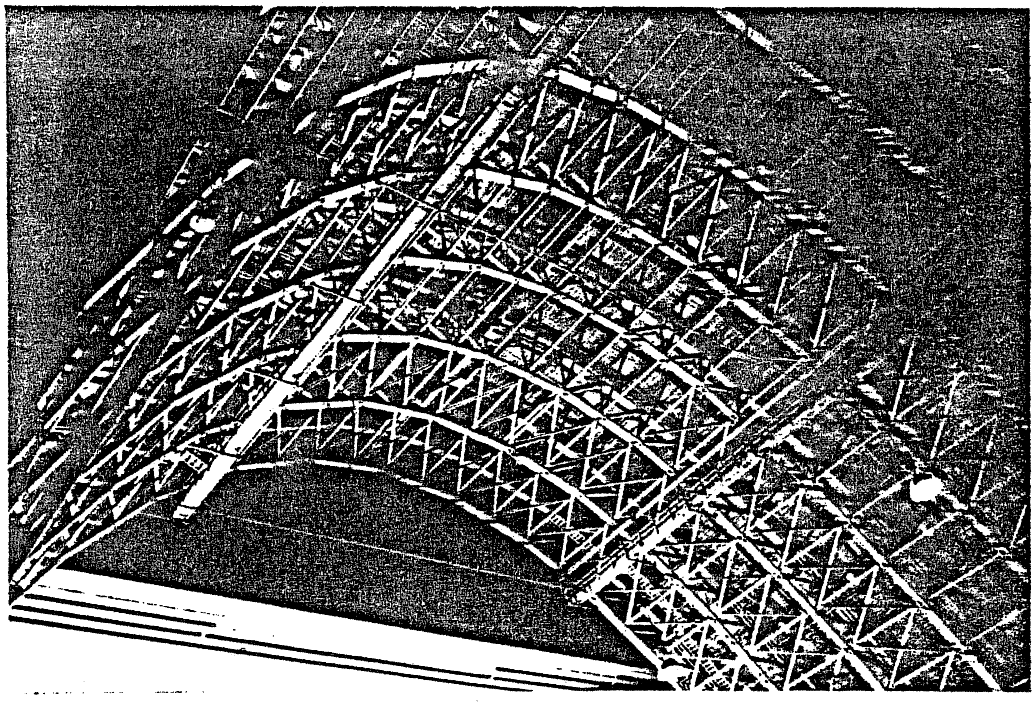
TITLE BUILDING LOCATION MAP

BLDG NO. 46	BLDG NAME HANGAR 2	BY J.U.	FIGUR
EVALUATION OF SEISMIC VULNERABILITY OF STRUCTURES - NAS MOFFETT FIELD		DATE DEC 84	46-

RUTHERFORD & CHEKENE CONSULTING ENGINEERS 487 BRYANT STREET SAN FRANCISCO 94107 TEL 415/391-3990



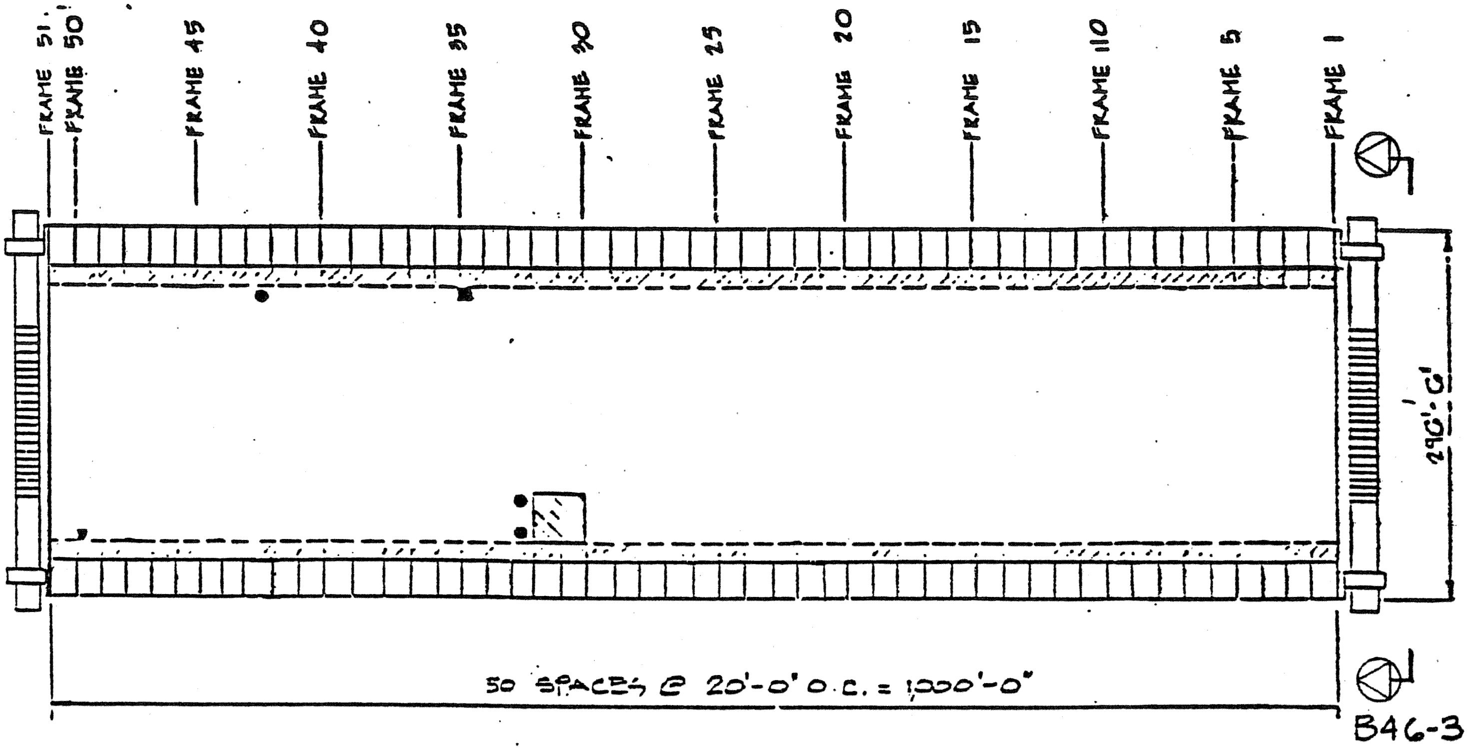
WEST SIDE BUILDINGS 46 & 47 - HANGARS



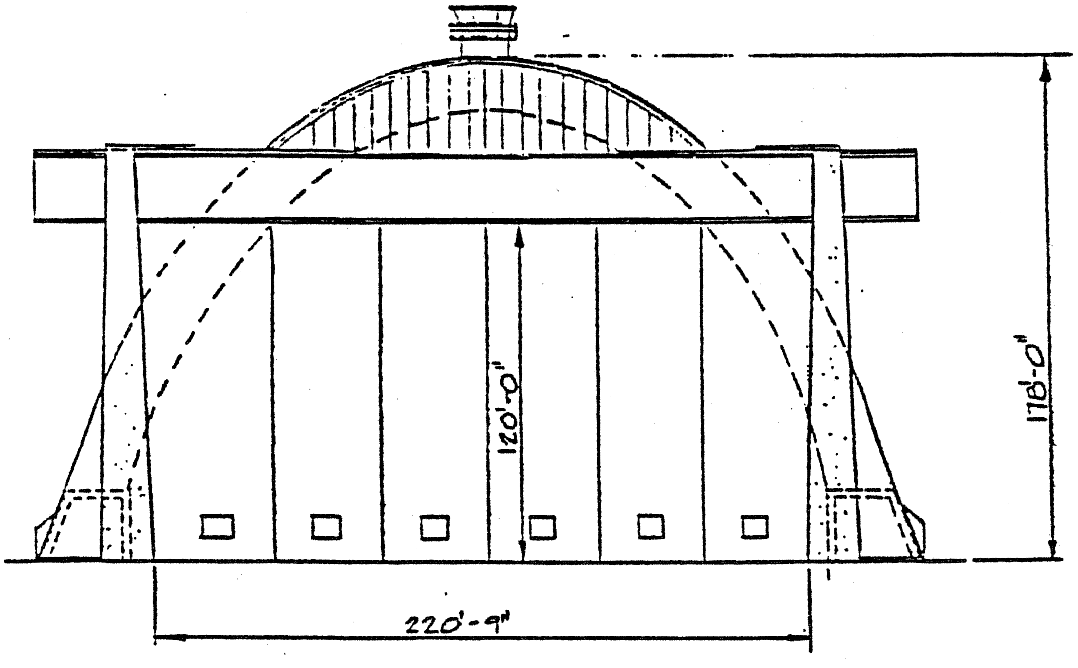
INTERIOR

TITLE BUILDING PHOTOGRAPHS

BLDG NO 46	BLDG NAME HANGAR	BY J.U.	FIGURE
EVALUATION OF SEISMIC VULNERABILITY OF STRUCTURES - NAS MOFFETT FIELD		DATE DEC 84	46-2



FLOOR PLAN A46-3

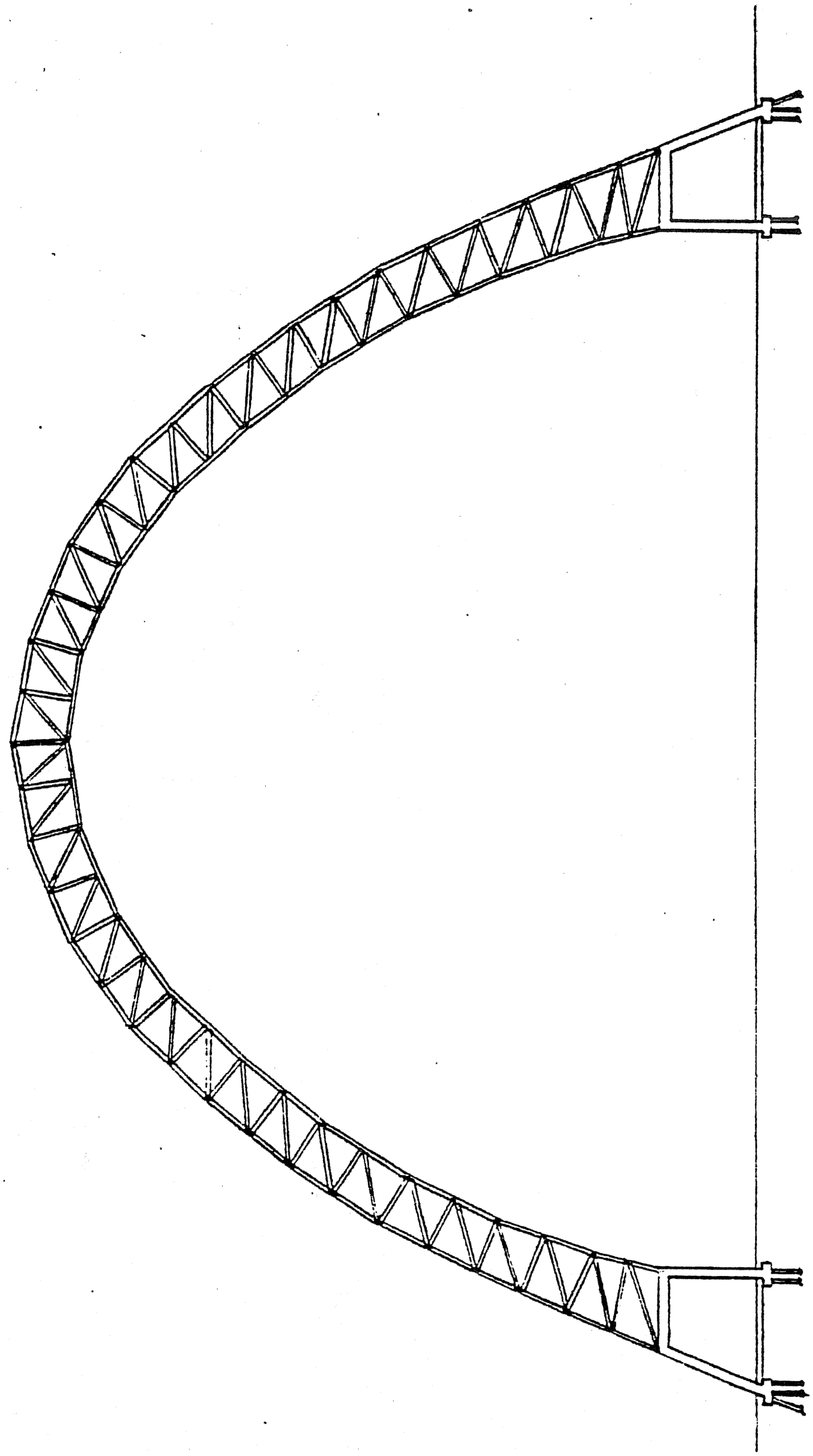


SOUTH ELEVATION B46-3

TITLE PLAN AND ELEVATION OF EXISTING STRUCTURE

BLDG NO. 46 BLDG NAME HANGAR 2 BY J.U. FIGURE 46-

EVALUATION OF SEISMIC VULNERABILITY OF STRUCTURES - NAS MOFFETT FIELD DATE DEC. 84



TYPICAL TRANSVERSE ARCH A 46-4

TITLE TYPICAL TRANSVERSE ARCH OF EXISTING STRUCTURE

BLDG NO. 46 BLDG NAME HANGAR 2

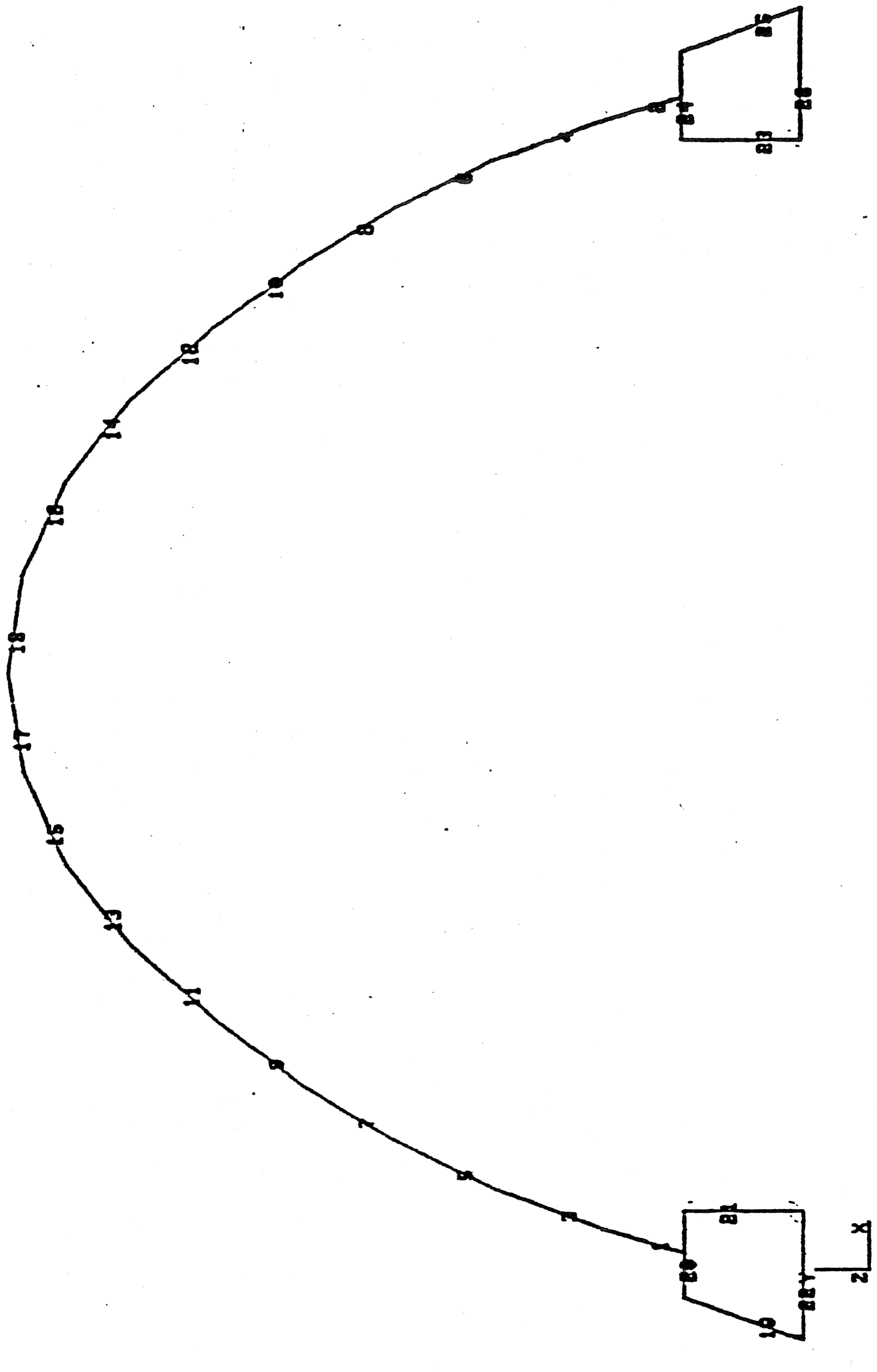
BY J.U.

FIGURE 46-

EVALUATION OF SEISMIC VULNERABILITY OF STRUCTURES - NAS MOFFETT FIELD

DATE DEC. 84

RUTHERFORD & CHEKENE CONSULTING ENGINEERS 487 BRYANT STREET SAN FRANCISCO 94107 TEL 415/391-3990

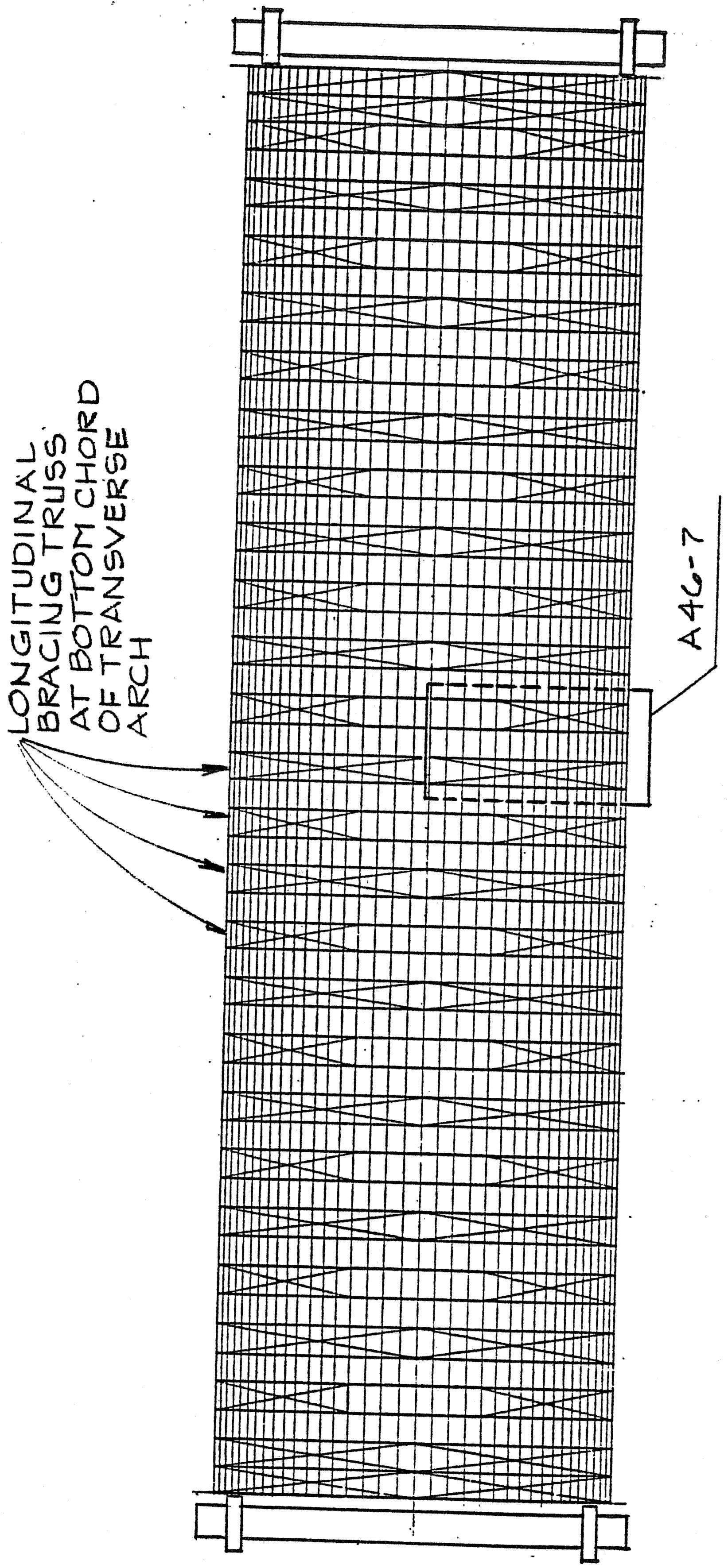


COMPUTER MODEL OF TYPICAL TRANSVERSE ARCH A 46-5

TITLE COMPUTER MODEL OF TYPICAL TRANSVERSE ARCH

BLDG NO. 46 BLDG NAME HANGAR 2 BY J.U. FIGURE 46-

EVALUATION OF SEISMIC VULNERABILITY OF STRUCTURES - NAS MOFFETT FIELD DATE DEC. 84



ROOF PLAN A46-6

TITLE ROOF PLAN OF EXISTING STRUCTURE

BLDG NO. 46 BLDG NAME HANGAR 2

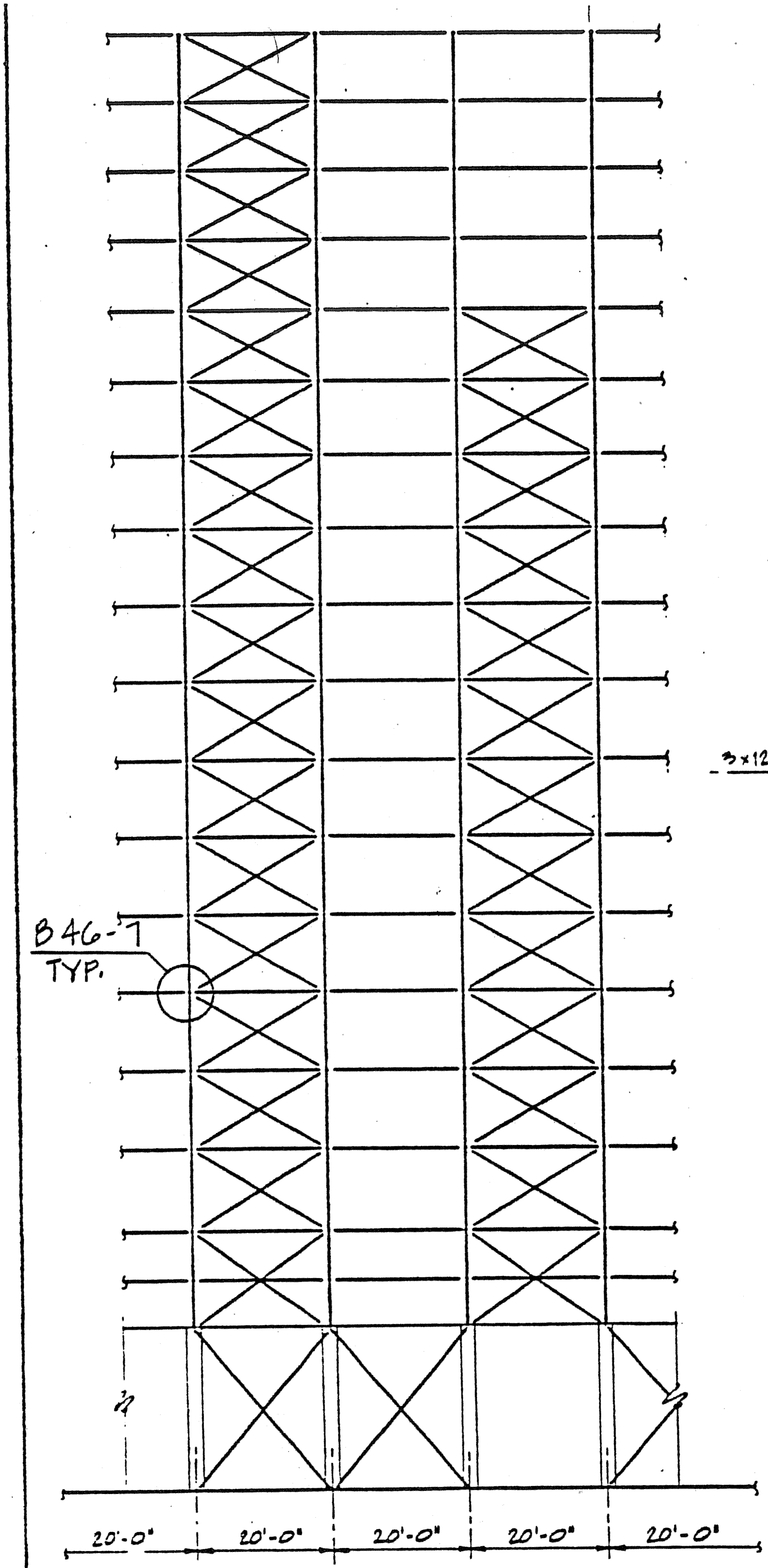
BY J.U.

EVALUATION OF SEISMIC VULNERABILITY OF STRUCTURES - NAS MOFFETT FIELD

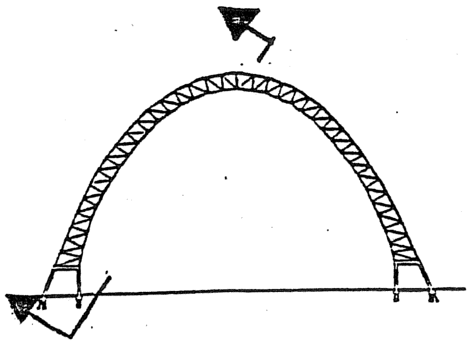
DATE DEC. 84

FIGURE 46-6

RUTHERFORD & CHEKENE CONSULTING ENGINEERS 487 BRYANT STREET



TYPICAL BRACING TRUSS A 46-7



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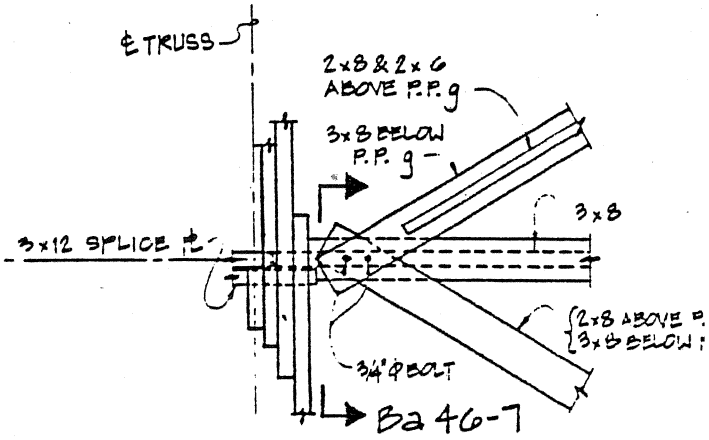
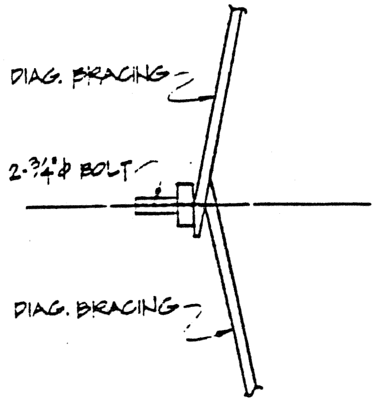


TYPICAL CONNECTION

DETAIL B 46-7

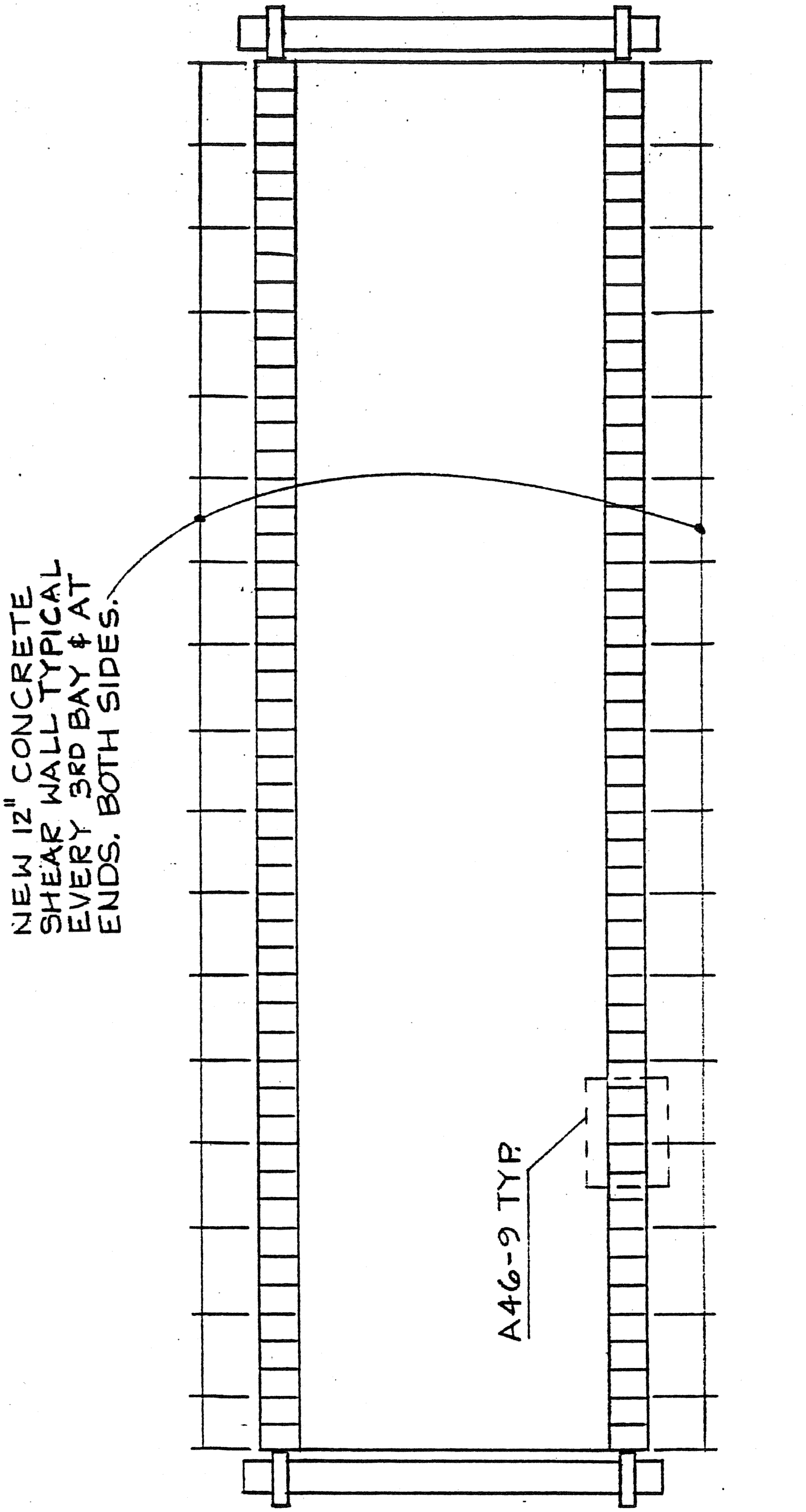


SECTION Ba 46-

TITLE TYPICAL BRACING TRUSS OF EXISTING STRUCTURE

BLDG NO. 46 | BLDG NAME HANGAR 2 | BY J.U. | FIGUR 46-

EVALUATION OF SEISMIC VULNERABILITY OF STRUCTURES - NAS MOFFETT FIELD | DATE DEC. 84

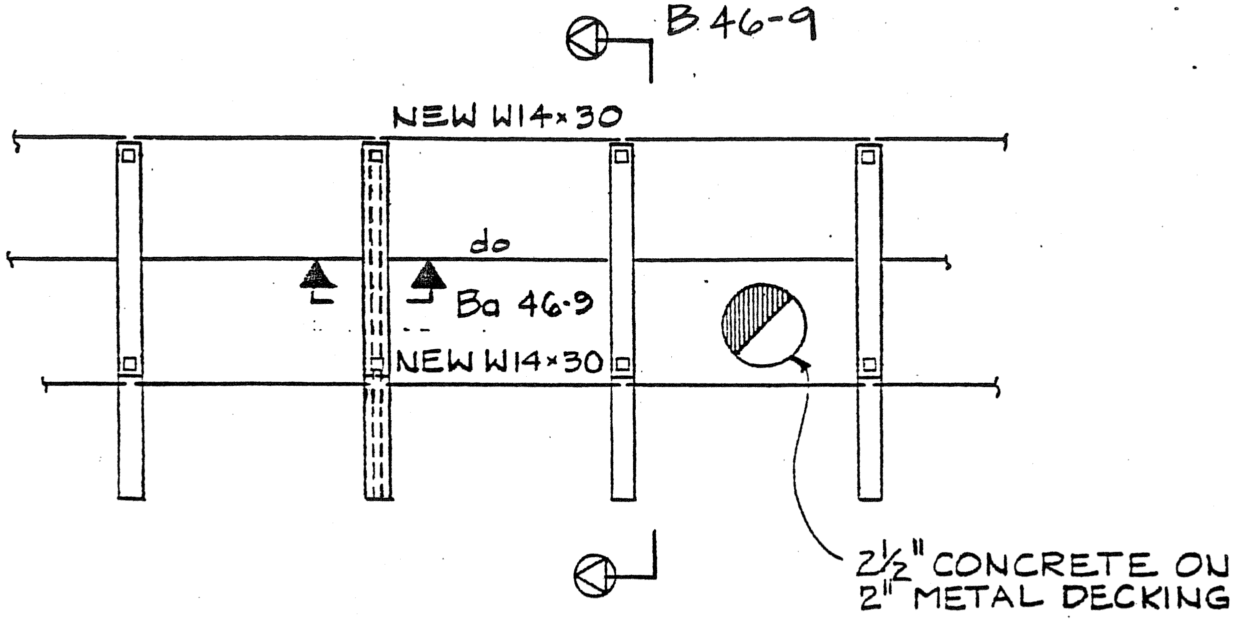


PLAN@BASE A46-8

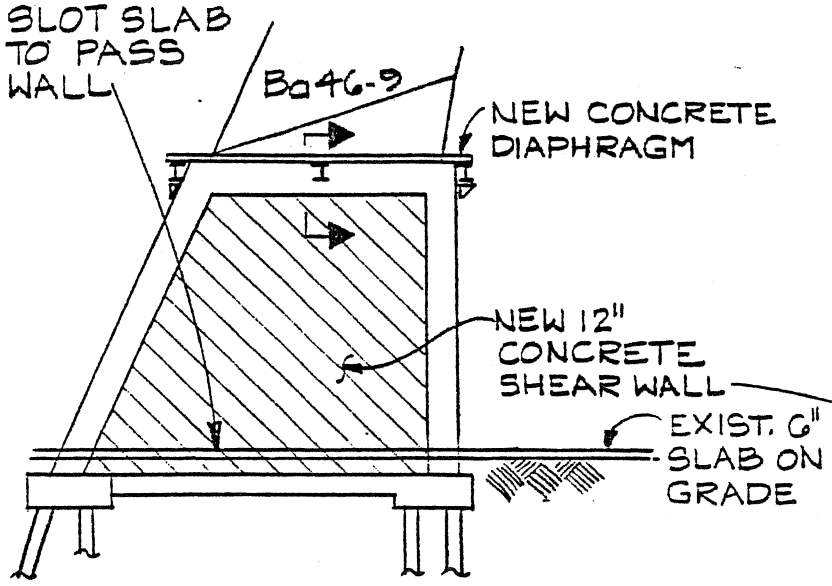
TITLE PLAN OF REPAIRED STRUCTURE

BLDG NO. 46 BLDG NAME HANGAR 2 BY J.U. FIGURE 46-

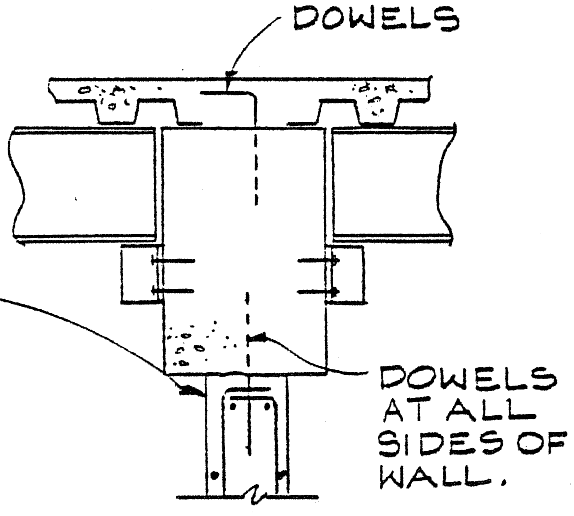
EVALUATION OF SEISMIC VULNERABILITY OF STRUCTURES - NAS MOFFETT FIELD DATE DEC. 84



PLAN AT TOP OF CONCRETE BENTS A46-9



ELEVATION B46-9



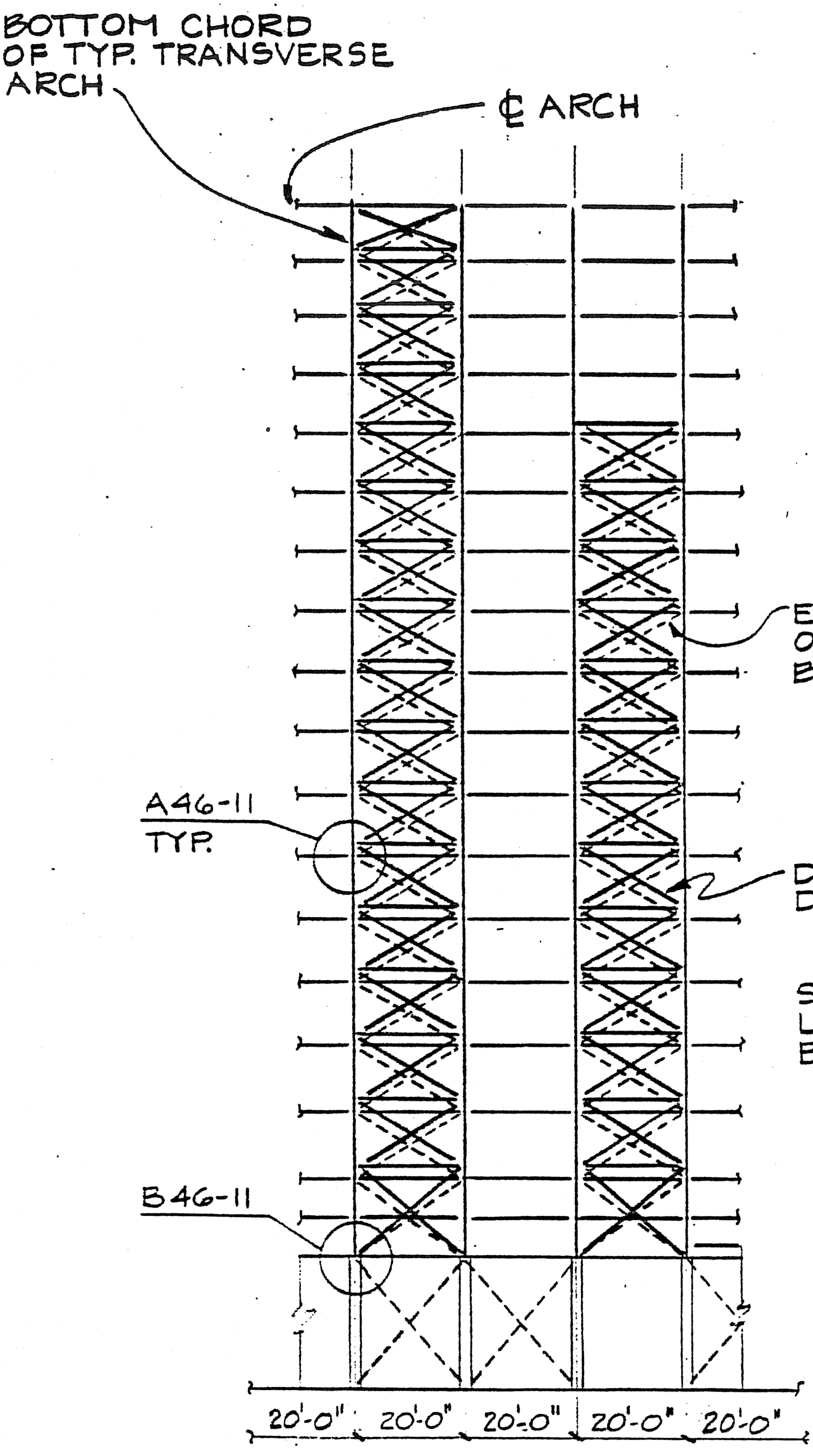
SECTION Ba46-9

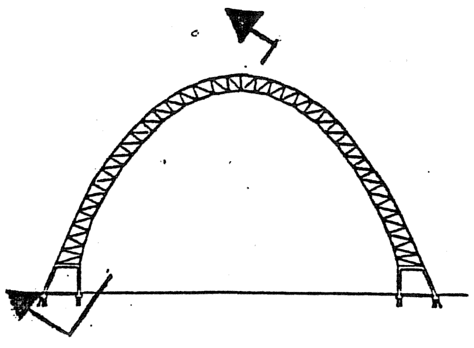
TITLE TYPICAL CONCRETE BENT REPAIRS

BLDG NO. 46 BLDG NAME HANGAR 2 BY J.U. FIGUR

EVALUATION OF SEISMIC VULNERABILITY OF STRUCTURES - NAS MOFFETT FIELD DATE DEC. 84 46·

RUTHERFORD & CHEKENE CONSULTING ENGINEERS 487 BRYANT STREET SAN FRANCISCO 94107 TEL 415/391-3990





KEY

ELEVATION A46-10

½ OF LONGITUDINAL BRACING TRUSS

TITLE LONGITUDINAL BRACING TRUSS REPAIRS

BLDG NO. 46	BLDG NAME HANGAR 2	BY J.U	FIGURE 46-1
EVALUATION OF SEISMIC VULNERABILITY OF STRUCTURES - NAS MOFFETT FIELD		DATE DEC. 84	

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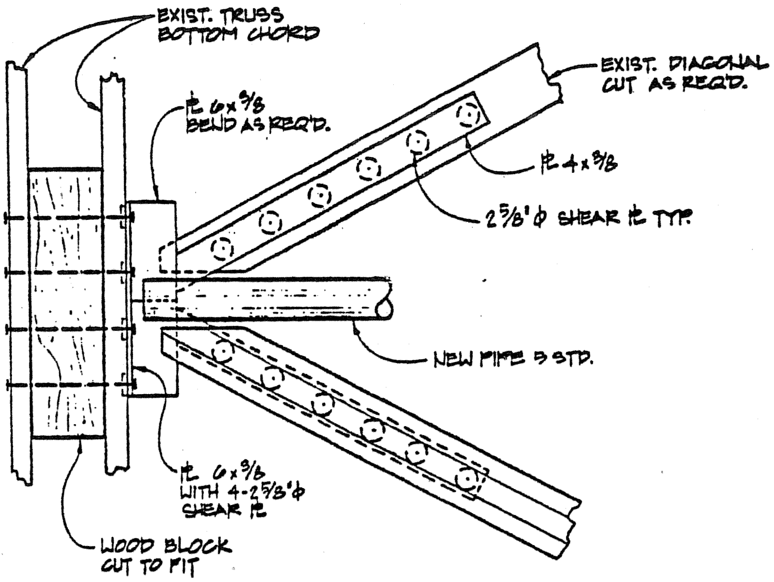
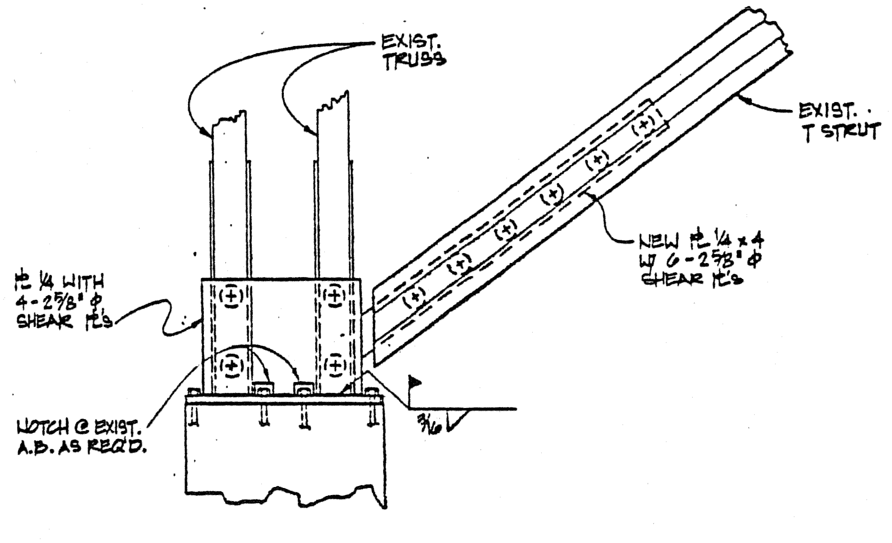


TYPICAL CONNECTION

DETAIL A·46-11



TYPICAL BASE CONNECTION

DETAIL B 46-11

TITLE NEW LONGITUDINAL BRACING TRUSS CONNECTIONS

BLDG NO. 46 | BLDG NAME HANGAR 2 | BY J.U. | FIGU

EVALUATION OF SEISMIC VULNERABILITY OF STRUCTURES - NAS MOFFETT FIELD | DATE DEC. 84 | 46-

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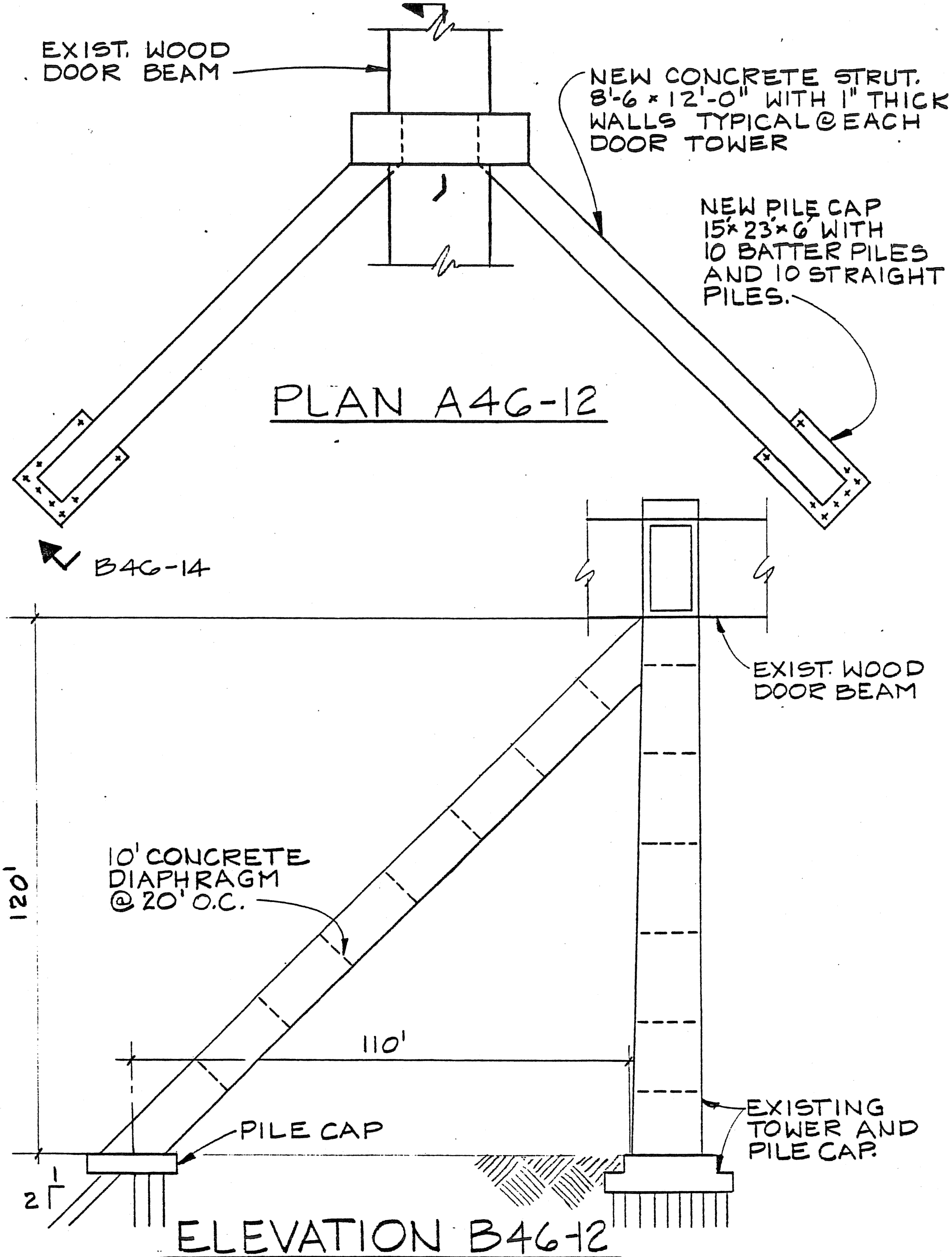


PLAN A46-12

ELEVATION B46-12

TITLE DOOR TOWER PLAN AND ELEVATION OF REPAIRED STRUCTUR

BLDG NO. 46 | BLDG NAME HANGAR 2 | BY J.U. | FIGU

EVALUATION OF SEISMIC VULNERABILITY OF STRUCTURES - NAS MOFFETT FIELD | DATE DEC. 84 | 46-

RESULTS OF DETAILED EVALUATION

			DIRECTION			
			TRANSVERSE		LONGITUDINAL	
		STATE OF STRUCTURE	EXISTING	STRENGTH.	EXISTING	STRENGTH.
LEVEL 1	PERIOD	ANALYSIS TYPE	COMP	EST	COMP	EST
		T sec	.72	.72	1.77	1.77
	SPECTRAL ACCEL. g		MODAL ANALYSIS	MODAL ANALYSIS	.17	.17
	DAMPING %		10	10	5	5
	RESULTS		NG	OK	NG	OK
LEVEL 2	PERIOD	ANALYSIS TYPE	COMP	EST	COMP	EST
		T sec	.72	.72	1.77	1.77
	SPECTRAL ACCEL. g		MODAL ANALYSIS	MODAL ANALYSIS	.21	.21
	DAMPING %		20	20	10	10
	RESULTS		NG	OK	NG	OK

ANALYSIS TYPES

HAND: HAND ANALYSIS
COMP: COMPUTER ANALYSIS
EST: ESTIMATED RESULTS

RESULTS

NG: STRENGTHENING REQUIRED
OK: ACCEPTABLE
NC: CONDITION DOES NOT GOVERN

HANGAR

TITLE RESULTS OF DETAILED EVALUATION - HANGAR

BLDG NO. 46 BLDG NAME HANGAR 2 BY J. U. FIGURE 46-1

EVALUATION OF SEISMIC VULNERABILITY OF STRUCTURES - NAS MOFFETT FIELD DATE DEC. 84

RESULTS OF DETAILED EVALUATION

			DIRECTION			
			TRANSVERSE		LONGITUDINAL	
		STATE OF STRUCTURE	EXISTING	STRENGTH.	EXISTING	STRENGTH.
LEVEL 1	PERIOD	ANALYSIS TYPE	HAND	EST	HAND	EST
		T sec	.68	.30	.78	.30
		SPECTRAL ACCEL. g	.29	.41	.24	.41
		DAMPING %	5	5	7	5
		RESULTS	NG	OK	NG	OK
LEVEL 2	PERIOD	ANALYSIS TYPE		EST		EST
		T sec		.41		41
		SPECTRAL ACCEL. g		.63		.63
		DAMPING %		10		10
		RESULTS	NC	OK	NC	OK

ANALYSIS TYPES

HAND: HAND ANALYSIS

COMP: COMPUTER ANALYSIS

EST: ESTIMATED RESULTS

RESULTS

NG: STRENGTHENING REQUIRED

OK: ACCEPTABLE

NC: CONDITION DOES NOT GOVERN

DOOR TOWERS

TITLE RESULTS OF DETAILED EVALUATION - DOOR TOWERS			
BLDG NO. 46	BLDG NAME HANGAR 2	BY J.U.	FIGUR 46-
EVALUATION OF SEISMIC VULNERABILITY OF STRUCTURES - NAS MOFFETT FIELD		DATE DEC. 84	

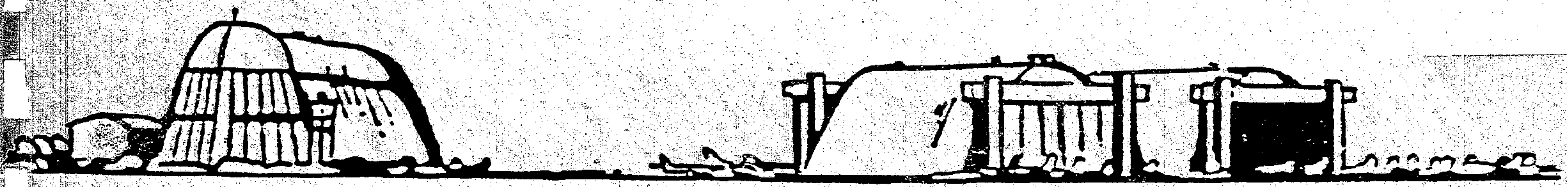
DETAILED ANALYSIS REPORT

VOLUME 5 - APPENDIX B - CALCULATIONS

BUILDINGS 46, 49, 88, 144, 146

EVALUATION OF SEISMIC VULNERABILITY OF STRUCTURES
AT
NAVAL AIR STATION-MOFFETT FIELD
AND
NAVAL AUXILIARY LANDING FIELD-CROWS LANDING

81002 S2
MOFFETT FIELD, NAS SEISMIC STUDY,COMPUTER FL.&
NONSTRUCT.
DAR VOL. 5, CALC BLDGS 46, 49, 88, 144,146



RUTHERFORD AND CHEKENE

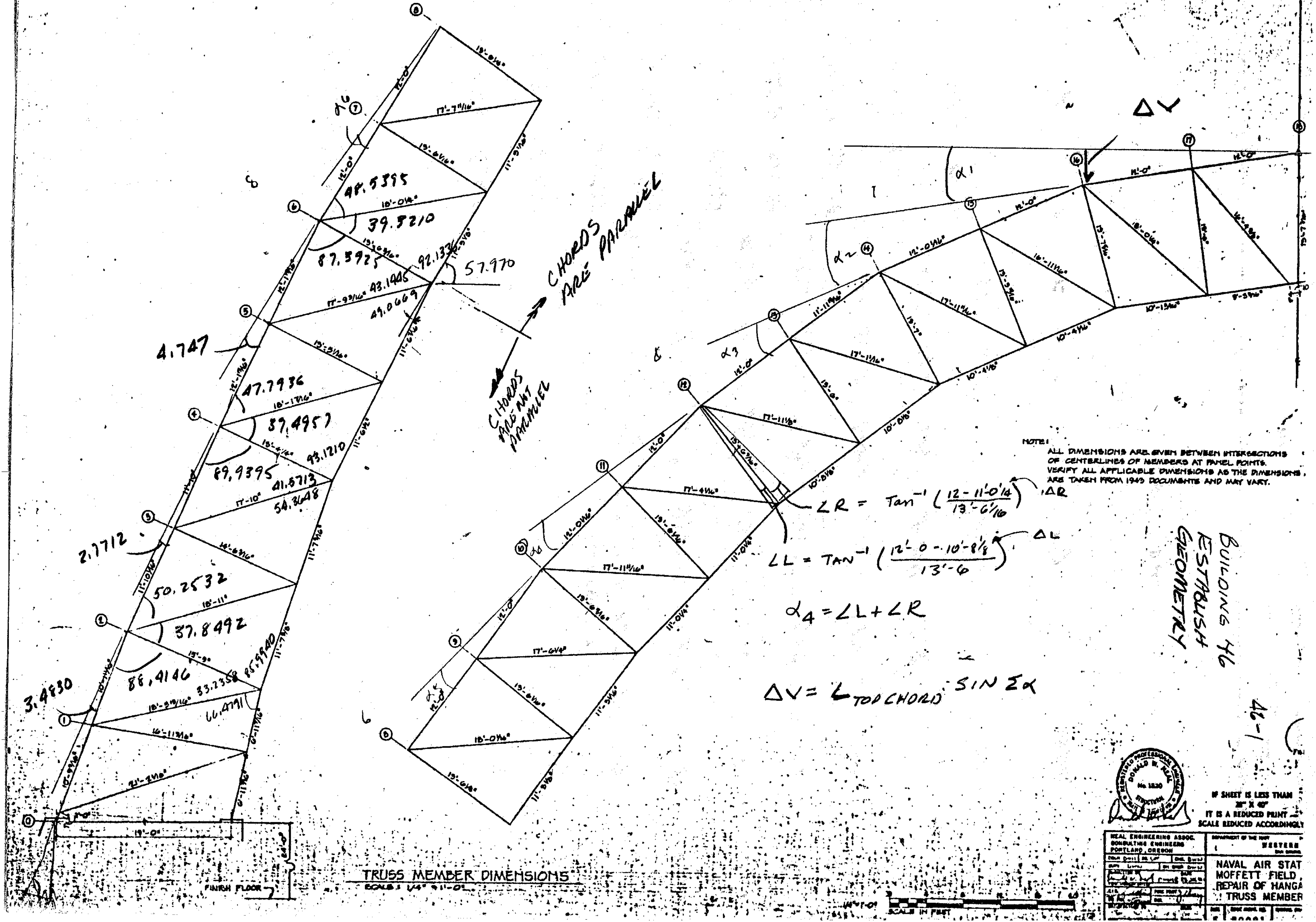
487 BRYANT STREET

SAN FRANCISCO, CA.

JUNE 1985

CALCULATIONS

BUILDING 46 - HANGAR 2



NOTE:
ALL DIMENSIONS ARE GIVEN BETWEEN INTERSECTIONS OF CENTERLINES OF MEMBERS AT PANEL POINTS.
VERIFY ALL APPLICABLE DIMENSIONS AS THE DIMENSIONS ARE TAKEN FROM 1943 DOCUMENTS AND MAY VARY.

$\angle R = Tan^{-1}\left(\frac{12-11'0\frac{1}{4}}{13'-6\frac{1}{16}}\right)$ ΔR

$\angle L = TAN^{-1}\left(\frac{12'0-10'-8\frac{1}{8}}{13'-6}\right)$ ΔL

$\alpha_4 = \angle L + \angle R$

$\Delta V = L_{TOP\,CHORD}\ SIN\ \Sigma\alpha$

BUILDING 46
ESTABLISH
GEOMETRY

46-1

TRUSS MEMBER DIMENSIONS
SCALE: 1/4" = 1'-0"

IF SHEET IS LESS THAN
30" X 40"
IT IS A REDUCED PRINT —
SCALE REDUCED ACCORDINGLY

NEAL ENGINEERING ASSOC.
CONSULTING ENGINEERS
PORTLAND, OREGON

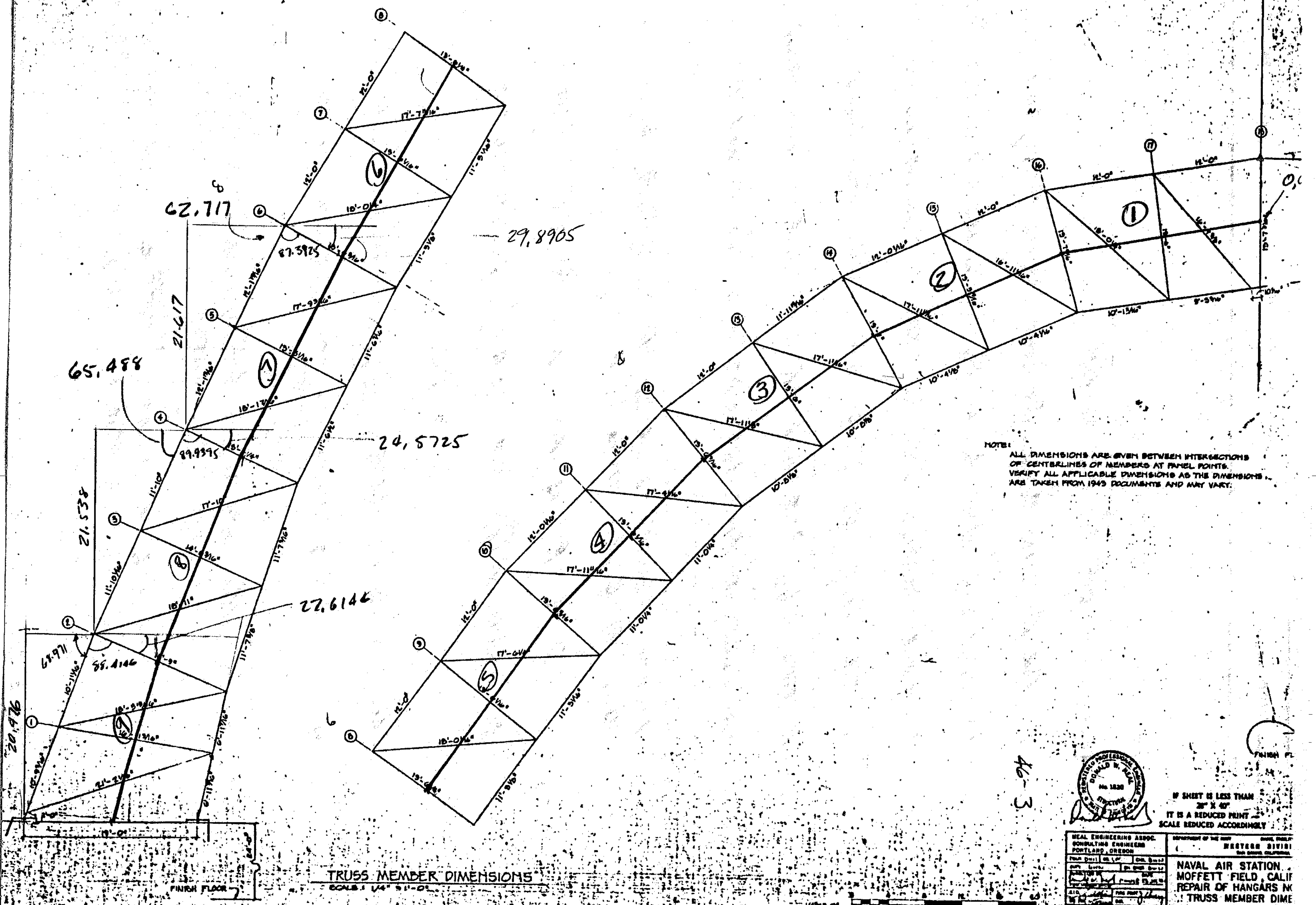
DEPARTMENT OF THE NAVY
WESTERN

NAVAL AIR STAT
MOFFETT FIELD
REPAIR OF HANGA
TRUSS MEMBER

TOP CHORD L'S

PANEL POINT	Δ_L	Δ_R	L_L	L_R	α	$\Sigma\alpha$	ΔY	$\Sigma\Delta Y$
18	-	1.8645	-	7.864	7.864			
						7.864	3.284	
16	1.859	1.6615	7.842	7.016	14.858			3.284
						22.722	9.272	
14	1.661	1.3177	7.019	5.575	12.594			12.556
						35.316	13.871	
12	1.323	.979	5.597	4.147	9.744			26.427
						45.060	16.992	
10	.984	.745	4.167	3.157	7.324			43.419
						52.384	19.011	
8	.740	.578	3.135	2.451	5.586			62.430
						57.970	20.347	
6	180 - 2 TRUSS L'S FROM LAW OF COSINES				4.747			82.777
						62.717	21.617	
4					2.771			104.394
						65.488	21.538	
2					3.483			125.932
						68.971	20.476	
0								146.408

FROM DWG $\Sigma\Delta V = 170'\text{-}4 - 24'\text{-}0 = 146'\text{-}4''$ ✓



TRUSS MEMBER DIMENSIONS

SCALE: 1/4" = 1'-0"

SCALE IN FEET

NOTE:
ALL DIMENSIONS ARE GIVEN BETWEEN INTERSECTIONS OF CENTERLINES OF MEMBERS AT PANEL POINTS. VERIFY ALL APPLICABLE DIMENSIONS AS THE DIMENSIONS ARE TAKEN FROM 1943 DOCUMENTS AND MAY VARY.

46-3

DONALD W. NEAL
No. 1830

IF SHEET IS LESS THAN
28" X 40"
IT IS A REDUCED PRINT
SCALE REDUCED ACCORDINGLY

NEAL ENGINEERING ASSOC.
CONSULTING ENGINEERS
PORTLAND, OREGON

DEPARTMENT OF THE NAVY
WESTERN DIVISI

NAVAL AIR STATION
MOFFETT FIELD, CALI
REPAIR OF HANGARS N
TRUSS MEMBER DIME

GEOMETRY OF ℄ OF TRUSS

FOR PARALLEL CHORD SECTION, NODES 6-18, THE LENGTH OF THE ℄ = ½ (TOP CHORD LENGTH + BOTT CHORD LENGTH). THE ∠ FROM THE HORIZONTAL IS THE SAME AS THE TOP CHORD. FOR NODES 0 THRU 6, THE END OF THE ℄ SECTIONS MUST BE LOCATED AND LENGTHS AND ∠'S COMPUTED

LOCATE END POINTS OF ℄ NODES 0, 2, 4, 6,
USE TOP CHORD NODE 0 AS 0,0.

∴ 0 ℄ P IS AT $X = 9/2 = 9.5'$ $Y = 0$

COORDINATE OF ② = $X = 20.476 / \text{TAN } 68.971 = 7.872$

$Y = 20.476$

X COORD OF 2 ℄ = $7.872 + \frac{15.75}{2} \text{COS } 22.6144 = 15.142$

Y $= 20.476 - \frac{15.75}{2} \text{SIN } 22.6144 = 17.448$

COORD OF ④ $X = 7.872 + 21.538 / \text{TAN } 68.488 = 17.693$
$Y = 20.476 + 21.538$ " $= 42.014$

COORD OF 4 ℄ $X = 17.693 + \frac{13.3542}{2} \text{COS } 24.5725 = 23.765$
$Y = 42.014 - 13.3542/2 \text{ SIN } 24.5725 = 39.2374$

DATE ____________

BY ________ CHKD. ________

SUBJECT ____________

RUTHERFORD & CHEKENE
STRUCTURAL ENGINEERS

JOB NO. ________

SHEET NO. 46-5

COORD OF 6

x = 17.693 + 21.617 / TAN 62.717 = 28.842
y = 42.014 + 21.617 = 63.631

COORD OF 6 ℄ x = 28.842 + 13.516/2 COS 29.8905 = 34.701
y = 63.631 − 13.516/2 SIN 29.8905 = 60.263

SUMMARY

NODE	x	y	IF O℄=0,0 x	y	Δx	ΔY	L
0 ℄	9.5	0	0	0	5.642	17.408	18.338
2 ℄	15.142	17.448	5.642	17.448	8.623	21.789	23.433
4 ℄	23.765	39.2374	14.265	39.2374	10.936	21.026	23.700
6 ℄	34.701	60.263	25.201	60.263			

GIVEN 6 @ x=25.201 y = 60.263

THEN L 6-8 = (24 + 22.849)/2 = 23.424

⑧ x℄ = 25.2014 23.424 COS 57.970 = 37.624
y = 60.263 + 23.424 SIN 57.970 = 80.121

	∡	Δx	Δy
L 8-10 = [24 + 22.516]/2 = 23.258	52.380	14.196	18.423
L 10-12 = [24.005 + 22.042]/2 = 23.024	45.060	16.263	16.297
L 12-14 = [23.995 + 21.354]/2 = 22.675	35.316	18.502	13.108
L 14-16 = [24.005 + 20.682)/2 = 22.344	22.722	20.610	8.631
L 16-18 = [24 + 20.276)/2 = 22.138	7.864	21.930	3.029

DATE ____________ RUTHERFORD & CHEKENE JOB NO. ____________

BY ________ CHKD. ________ STRUCTURAL ENGINEERS SHEET NO. 46 - 6

SUBJECT ____________

FINAL ℄ COORD

NODE	Δx	Δy	x	y	NODE	x	y
0E			0	0	0 W	258.25,	0
2E			5.642	17.448	24	252.608,	17.448
	8.623						
4E			14.265	39.237	4W	243.985,	39.257
	10.936						
6E			25.201	60.263	6W	233.049,	60.26
	12.423						
8E			37.624	80.121	8W	220.626,	80.12
	14.196	18.423					
10E			51.820	98.544	10W	206.430,	98.5
	16.263	16.297					
12E			68.083	114.841	12W	190.167,	114.84
	18.502	13.108					
14E			86.585	127.949	14W	171.665,	127.949
	20.610	8.631					
16E			107.195	136.580	16W	151.055,	136.58
	21.930	3.029					
18			129.125	139.609 ←			

$$x = 170.33 - \left[\frac{13.62}{2} + 24\right] = 139.523 \checkmark$$

FOR COMPUTER MODEL, CALCULATE COORDINATES OF TOP CHORD

NODE COORD.

0, 0, 0

2 7.872, 20.476

4 17.693, 42.014

6 28.842, 63.631

8 L=24' $\alpha = 57.970$ $\Delta y = 20.347$ $\Delta x = \frac{20.347}{\tan 57.97} = 12.729$ –

41.571, 83.978

10 $\alpha = 52.384$ $\Delta y = 19.011$ $\Delta x = 14.649$ ✓

56.220 102.989

12 $\alpha = 45.060$ $\Delta y = 16.992$ $\Delta x = 16.956$ ✓

73.176 119.981

14 $\alpha = 35.316$ $\Delta y = 13.871$ $\Delta x = 19.579$ ✓

92.755, 133.852

16 $\alpha = 22.722$ $\Delta y = 9.272$ $\Delta x = 22.142$ ✓

114.897 143.124

18 $\alpha = 7.864$ $\Delta y = 3.284$ $\Delta x = 23.776$

138.673 146.408 ✓

DATE
BY CHKD.
SUBJECT

RUTHERFORD & CHEKENE
STRUCTURAL ENGINEERS

JOB NO.
SHEET NO. 46-8

BOTTOM CHORD POINT, COMPUTE SIMILAR TO TOP CHORD,

I.E, NODES 18-6, USING PARALLEL CHORDS AND L'S CALC

NODES 6-0 LAW OF COSIGNS

CALL TOP OF BOTT. CHORD, 0, 0.

NODE	α	L	Δx	Δy	COORD
18					0, 0
	7.864	20.276 '	20.085	2.774	4
16					20.085, 2.774
	22.722	20.682	19.077	7.989	
14					39.162, 10.763
	35.316	21.350	17.424	12.344	
12					56.587, 23.107
	45.066	22.042	15.570	15.602	
10					72.156, 38.710
	52.384	22.516	13.743	17.835	
8					85.899 56.545
N	57.970	22.849	12.118	19.371	

NODE	Δα	Σα	L	Δx	Δy	COORD
						98.018 75.916
6						98.018, 75.916
	43450	62315	23.078	10.7223	20.4360	
4						108.740, 96.352
	9.0571	71.3721	23.2652	7.4315	22.0468	
2						116.172, 118.399
	5.7089	77.0810	13.9063	3.1~~0~~91	13.~~5~~543	
0				3.501	10.315	~~119.281~~ ~~131.953~~
						USE 119.673 USE 132.714

FROM OVERALL DIMS Y = 170.33 - 24 - 13.6198 = 132.7132

x = 138.673 - 19 = 119.673

Δ = .76"

0 ~ .392

LOCATE NODE 2 BOTTOM CHORD FROM TOP CHORD

2 TOP CHORD USING 0 TC AS 0,0, = 7.872, 20.476

2 BC ⇒ X @ 7.872 + 15.75 cos 22.6144 = 22.4110
Y @ 20.476 − 15.75 SIN 22.6144 = 14.4197

THE DIFFERENCE BETWEEN CALC'D FROM BOTTOM CHORD DIM'S & CALC'D FROM TOP CHORD DIM'S

X 3.411 − 3.109 = .30'
Y 14.4197 − 13.5543 = .8650'

≈ ERROR

THUS, THE LENGTH OF THE LAST SEGMENT IS

$$(3.411^2 + 14.4197^2)^{1/2} = 14.8176'$$

NOT 13.9063' AS SHOWN ON DWGS

DATE ____________

BY ________ CHKD. ________

SUBJECT ____________

RUTHERFORD & CHEKENE
STRUCTURAL ENGINEERS

JOB NO. ________

SHEET NO. 46-10

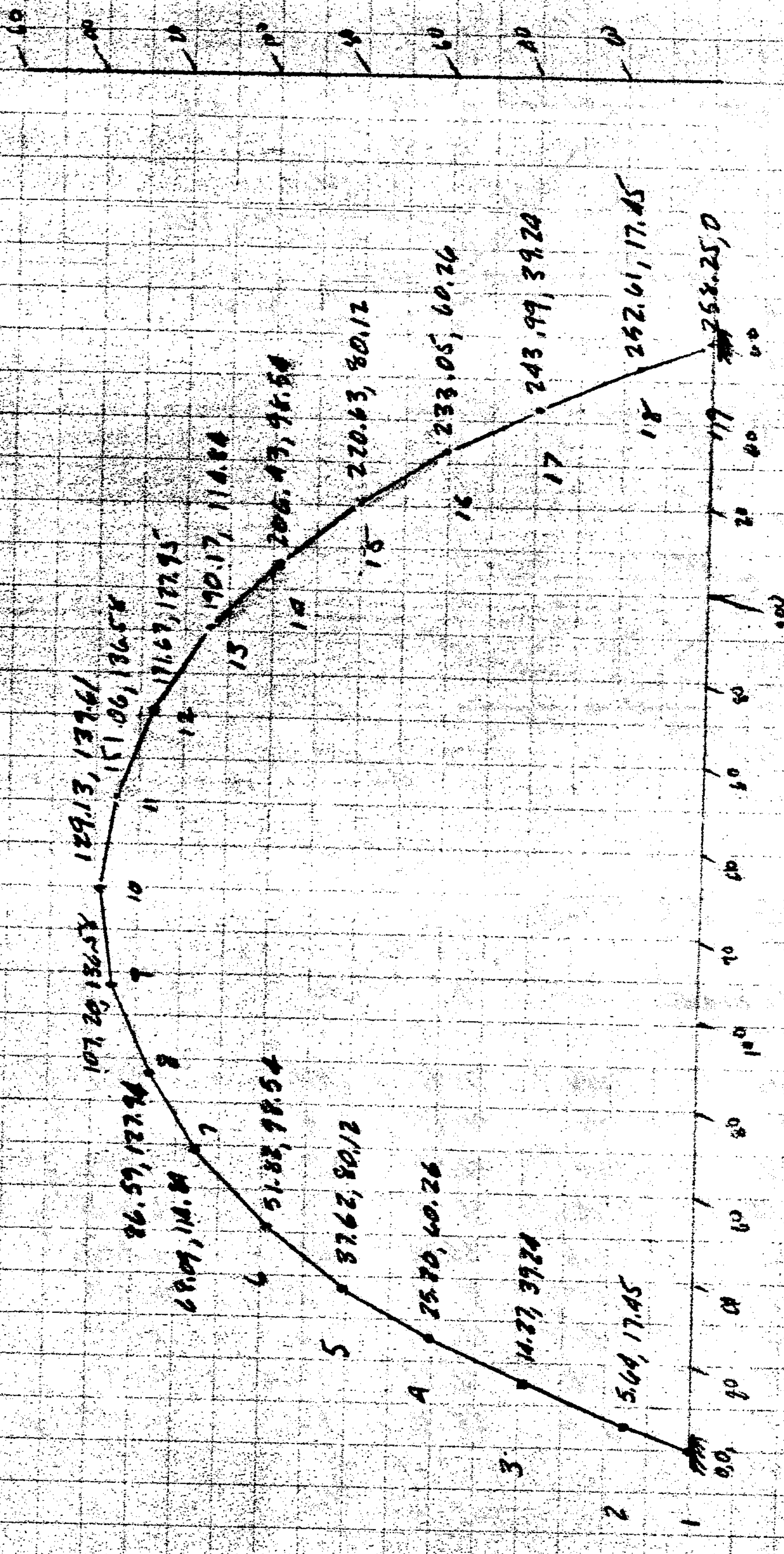
FINAL BOTTOM COORDINATES USING 0TC AS 0,0

NODE	X	Y	L
0BC	19.0	0	
			14.74
2BC	22.501	14.315	
			23.27
4BC	29.933	36.362	
			23.08
6BC	40.655	56.798	
			22.85
8BC	52.773	76.169	
			22.52
10BC	66.516	94.006	
			22.06
12BC	82.086	109.606	
			21.35
14BC	99.510	121.950	
			20.68
16BC	119.587	129.939	
			20.28
18BC	138.672	137.713	

RUTHERFORD & CHEKENE
STRUCTURAL ENGINEERS

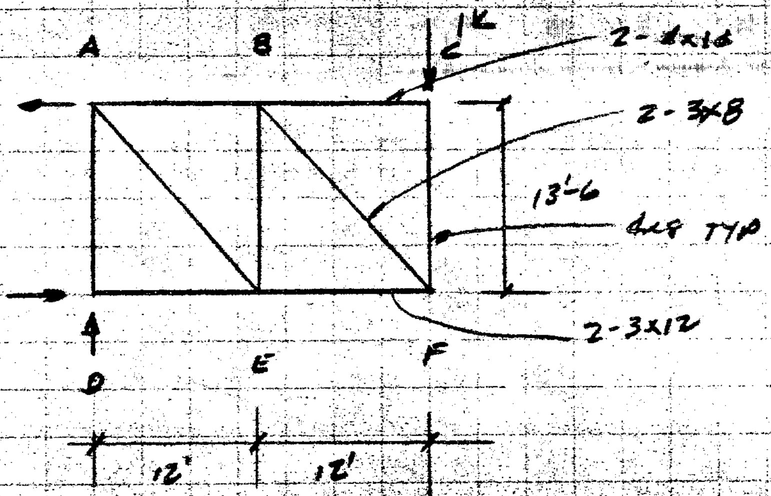
DATE ______
BY ______ CHKD. ______
SUBJECT ______

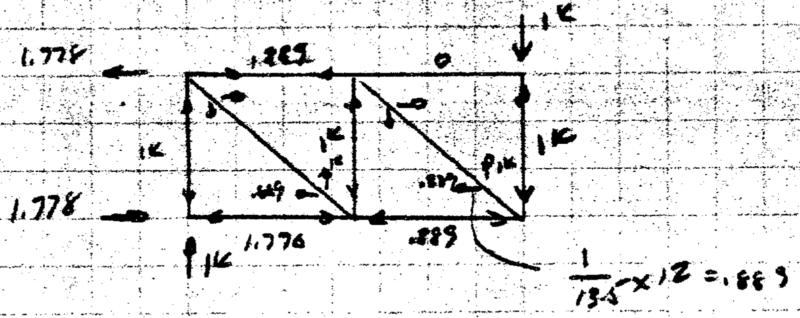
JOB NO. ______
SHEET NO. 46-11



Model Wood Truss

SECTION PROPERTIES NODES ⑥ THRU ⑩





$\Delta = \Sigma S^2 L/AE$

MEMBER	L	A	S	S^2L/A
AB	144	92.75	.889	1.227
BC	144	92.75	0	0
DE	144	56.25	1.778	8.093
EF	144	56.25	.889	2.023
AD	162	25.38	1.0	6.383
AE	217'	36.25	1.338	10.717
BE	162	25.38	1.0	6.383
BF	217'	36.25	1.338	10.717
CF	162	25.38	1.0	6.383

Δ BENDING = 11.343/E

Δ SHEAR = 40.583/E

$\Delta = 51.926$

IGNORING ΔCF

$\Delta_v = 34.20$

DATE ____________ **RUTHERFORD & CHEKENE** JOB NO. ____________

STRUCTURAL ENGINEERS

BY ________ CHKD. ________ SHEET NO. 46-13

SUBJECT ____________

SAY

$\Delta_{BENDING} = 11.343/E = 11.343/1,600 = .00709"$

$\Delta_{SHEAR} = 40.583/E = 40.583/1600 = .0254"$

$$\Delta_{BEND} = \frac{PL^3}{3EI_{EF}} \Rightarrow I_{EF} = \frac{PL^3}{3G\Delta_B} = \frac{1 \times 288^3}{3 \times 11.343} = \underline{702,000 \text{ IN}^4}$$

I BASED ON Ad^2

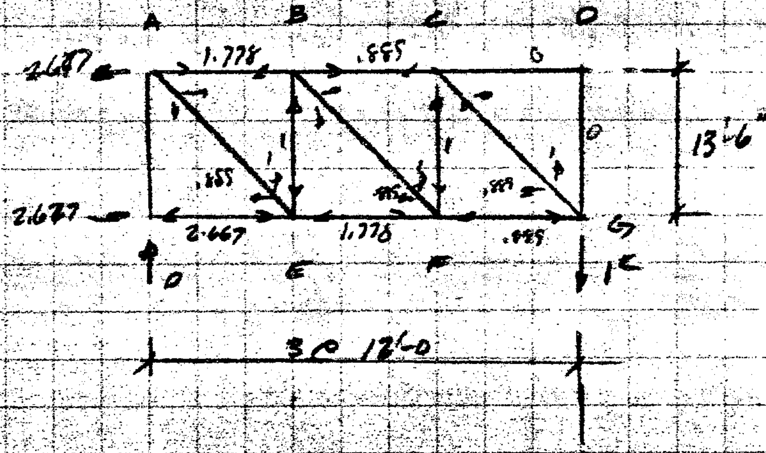
A	y	$A\bar{y}$
92.75 × 0		0
56.25 × 162		9113
149		9113

$I = 92.75 \times 61.16^2 + 56.25 \times 100.89^2 = 918,925$

$\bar{y} = 61.16"$ FROM TOP

$$\Delta_Y = \frac{VL}{A_{Y_{EF}} G} = \frac{VL}{A \frac{E}{2.4}} \Rightarrow A_{EFF_Y} = \frac{VL}{\Delta G} = \frac{1 \times 288}{\frac{34.20}{E} \times \frac{E}{2.4}} = 20.21 \text{ IN}^2$$

STIFFNESS OF 3 BAYS



MEMBER	L	A	S	S^2L/A
AB	144	92.25	1.778	4.908
BC	144	"	.889	1.227
CD	144	"	0	0
DE	144	56.25	2.667	18.209
EF	144	"	1.778	8.093
FG	144	"	.889	2.023
AD	162	25.38	1.0	6.383
BE	162	"	1.0	6.383
CF	162	"	1.0	6.383
DG	162	"	0	0
AE	217	36.25	1.338	10.717
BF	217	"	1.338	10.717
CG	217	"	1.338	10.717
				75.043

BENDING DEFL
34.460

SHEAR DEFL
51.3

$$\Delta_B = 1\times(36\times12)^3 / 3EI = 54.46/E \Rightarrow I = 780,000\ IN^4$$

$$\Delta_V = 1\times 36\times12 / A_V \times \frac{E}{2.4} = \frac{51.3}{E} \Rightarrow A_V = 20.2\ IN^2$$

USE $\Sigma Ad^2 = 90,$

DATE ______
BY ______ **CHKD.** ______
SUBJECT ______

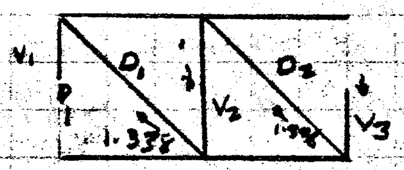
JOB NO. ______
SHEET NO. 46-15

COMPUTE MEMBER PROP'S

SEG	TC	BC	h_{AVG}	A_{TC}	A BC	$\bar{Y}$ FROM T.C.	I	A
0-2	2-4x14	2-4x14	16.96	92.75	92.75	101.8"	1,920,000 IN^4	185.5
2-4	2-4x14	2-4x14	14.55	92.75	92.75	87.3"	1,410,000	185.5
4-6	2-4x14	2-3x14	13.42	92.75	66.25	67.1"	1,000,000	159
⇒ 6-8	2-4x14	2-3x14	13.5	92.75	66.25	67.5"	1,010,000	159
8-10	2-4x14	2-3x12	13.5	92.75	56.25	61.16"	919,000	149
10-12	2-3x14	2-3x12	13.5	66.25	56.25	74.39	798,000	122.5
12-14	2-3x12	2-3x12	13.5	56.25	56.25	81.0"	738,000	112.5
14-16	2-3x14	2-3x12	13.5	56.25	56.25	81.0	738,000	112.5
16-18	2-3x14	2-3x12	13.5	66.25	56.25	74.39	798,000	122.5

COMPUTE MEMBER PROP'S

SIMPLE AREA



BAY 4-6

MEMBER	SIZE	A	L	S	S^2L/A	
V_1	6x10	52.25	80.13	1.0	1.53	
V_2	6x8	41.25	161	1.0	3.90	Σ 19.31
V_3	6x8	41.25	81.1	1.0	1.97	
D_1	2-4x10	64.75	217.4	1.338	6.01	$A_v = \frac{1 \times 288}{\frac{19.31}{2.6}} = 35$
D_2	2-4x8	64.75	213.2	1.338	5.90	

BAY 6-8

V_1	6x8	41.25	81.1	1.0	1.97	$\Sigma = 27.37$
V_2	4x12	39.38	162.1	1.0	4.12	
V_3	4x8	25.38	81.1	1.0	3.20	$A_v = \frac{288 \times 2.4}{27.37} = 24.3$
D_1	2-4x8	50.75	216.0	1.338	7.62	
D_2	2-3x8	36.25	211.7	1.338	10.46	

BAY 8-10

V_1	4x8	25.38	81.1	1.0	3.20	$\Sigma = 33.84$
V_2	4x8	"	162	1.0	6.38	
V_3	4x8	"	81.2	1.0	3.20	$A_v = \frac{288 \times 2.4}{33.84} = 20.4$
D_1	2-3x8	36.25	216	1.338	10.67	
D_2	2-3x8	"	210.3	1.338	10.39	

BAY 10-12

MEMBER	SIZE	A	L	S	S^2L/A
V_1	4x8	25.38	81.2	1.0	3.20
V_2	4x8	"	162	1.0	6.38
V_3	4x10	32.38	81.3	1.0	2.51
D_1	2-3x8	36.25	215.7	1.338	10.65
D_2	2-3x8	"	208.1	1.338	10.28

$\Sigma = 33.02$

$A_v = 288 \times 2.4 / 33.02 = 20.9$

BAY 12-14

V_1	4x10	32.38	81.3	1.0	2.51
V_2	4x10	"	162	1.0	5.00
V_3	4x10	"	81.5	1.0	2.52
D_1	2-3x8	36.25	215.1	1.338	10.62
D_2	2-3x8	"	205.1	1.338	10.13

$\Sigma = 30.78$

$A_v = 22.5 \text{ IN}^2$

BAY 14-16

V_1	4x10	32.38	81.5	1.0	2.52
V_2	4x8	25.38	161.9	1.0	6.38
V_3	4x8	"	81.7	1.0	3.22
D_1	2-3x8	36.25	215.7	1.338	10.65
D_2	2-3x8	"	203.1	1.338	10.03

$\Sigma = 32.8$

$A_v = 21.1$

BAY 16-18

V_1	4x8	25.38	81.7	1.0	3.22
V_2	4x8	25.38	162	1.0	6.38
V_3	4x8	"	81.7	1.0	3.22
D_1	2-3x8	36.25	216.3	1.338	10.68
D_2	2-3x8	"	196.4	1.336	9.70

$\Sigma = 33.2$

$A_v = 20.8 \text{ IN}^2$

BAY 0-2

MEMBER	SIZE	A	L	S	S^2L/A
V_1	CONCRETE				0
V_2	6x10	74.25	203.6	1.0	2.74
V_3	6x14	74.25	94.5	1.0	1.27
D_1	2-4x16	106.75	254.1	1.338	4.26
D_2	2-4x12	78.75	221.9	1.338	5.05

$\Sigma = 13.3$

$$A_v = \frac{1 \times 220 \times 2.4}{13.3} = 39.7\ \text{IN}^2$$

$$L = (5.642^2 + 17.448^2)^{1/2} = 18.34' = 220''$$

BAY 2-4

V_1	6x10	74.25	94.5	1.0	1.27
V_2	6x10	52.25	174.6	1.0	3.34
V_3	6x10	"	80.1	1.0	1.53
D_1	2-4x12	78.75	227	1.338	5.16
D_2	2-4x10	64.75	210.0	1.338	5.92

Σ 17.22

$$A_v = \frac{281.2 \times 2.4}{17.22} = 39.2\ \text{IN}^2$$

$$L = \left[(14.265 - 5.642)^2 + (59.237 - 17.448)^2\right]^{1/2} = 23.43 = 281.2''$$

SUMMARY

SEGMENT	A_v	I_o	A
0-2	39.7	1,920,000	185.5
2-4	39.2	1,410,000	185.5
4-6	35.8	1,000,000	159.0
6-8	25.3	1,010,000	159.0
8-10	20.4	919,000	149.0
10-12	20.5	798,000	122.5
12-14	22.5	758,000	112.5
14-16	21.1	738,000	112.5
16-18	20.8	798,000	122.5

REVISE ℄ COORDINATES USING TRUSS ORIGIN AS

X = 9.227 + 1½ = 18.727
Y = = 24"

NODE	X	Y
0 ℄	18.727	24.0
2	24.369	41.448
4	32.992	63.237
6	43.928	84.263
8	56.351	104.121
10	70.547	122.544
12	86.810	138.841
14	105.312	151.949
16	125.922	160.580
18	147.852	163.609
16	169.782	160.580
14	190.392	151.949
12	208.894	138.841
10	225.157	122.544
8	239.353	104.121
6	251.776	84.263
4	267.712	63.237
2	271.335	41.448
0	276.977	24.0

MASS	TRUSS	2-4x14	22.2
		2-3x14	16.1
		2-3x8	8.8
			47.1 #/'
	DECK	3#/□	
	2x T&G	4.4#/□	
	JOISTS	2#/□	
	PURLINS	.4	
		9.8	

9.8 — 10 #/□ × 20' = 200 #/LF

SAY 250 #/' × 24' = 6000#

BOTTOM CHORD POINT, COMPUTE SIMILAR TO TOP CHORD,

I.E., NODES 18-6, USING PARALLEL CHORDS AND L'S CALC

NODES 6-0 LAW OF COSINES

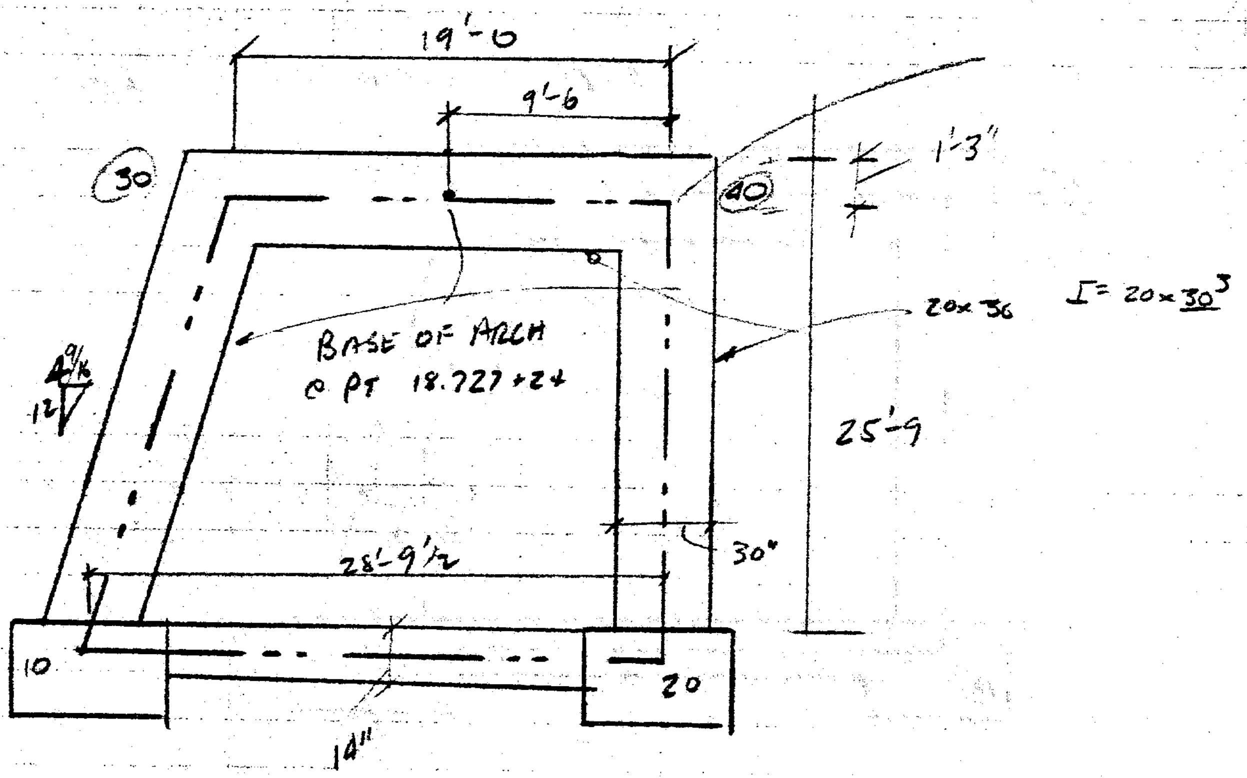
CALL TOP OF BOTT. CHORD, 0, 0.

NODE	α	L	Δx	Δy	COORD	
18					138.2799 0, 0	131.957
	7.864	20.276 ✓	20.085	2.774		+
16					118.909 ~~20.085~~, ~~2.774~~	129.178
	22.722	20.682	19.077	7.989		
14					99.179 ~~39.162~~, ~~10.763~~	121.1671
	35.316	21.354	17.424	12.344		
12					81.6935 ~~56.587~~, ~~23.107~~	105.64
	45.066	22.042	15.570	15.602	66.4216	90.1017
10					66.1239 ~~72.156~~, ~~38.710~~	75.2451
	52.384	22.516	13.743	17.835 52.678	52.3609	76.265
8					~~85.899~~ 56.545	75.4081
	57.970	22.849	17.118 17.118	19.371		19

N NODE	Δα	Σα	L	Δx	Δy		
6				10.7223 ✓	40.5601	98.018, 75.916 = 40.2627 → ~~98.018~~, ~~75.916~~	56.0371
	43450	62315	23.078	10.7223	20.4360	29.5430	51.0042
4					29.8378	~~108.740~~, ~~96.352~~	36.4
	9.0571	71.3721	23.2656	7.4868 ✓ 7.4315	22.0468	13.5543	
2				3All	22All	~~116.172~~, ~~118.399~~	14A
	5.7089	77.0810	13.9063 ✓	~~3.1091~~	13.5543		
0						19 119.281 .58	131.953

FROM OVERALL DIMS Y = 170.33 - 24 - 13.6198 = 132.7155

COORDINATES OF BASE BENT



Point 40

$x = 18.727 + 9.5 = 28.227$
$Y = \quad = 24.0$

$$\begin{array}{r} .785 \\ 28.227 \\ \hline 29.012 \\ -9.5 \\ \hline 19.512 \end{array}$$

Point 20

$x = 28.227$
$Y = 24 + 1.25 - 25.75 - .58 = -1.08$

Point 10 $X = 28.227 - 28.79 - \frac{4.563}{12} \times \frac{7}{12} = -.785'$

$Y = \quad = -1.08$

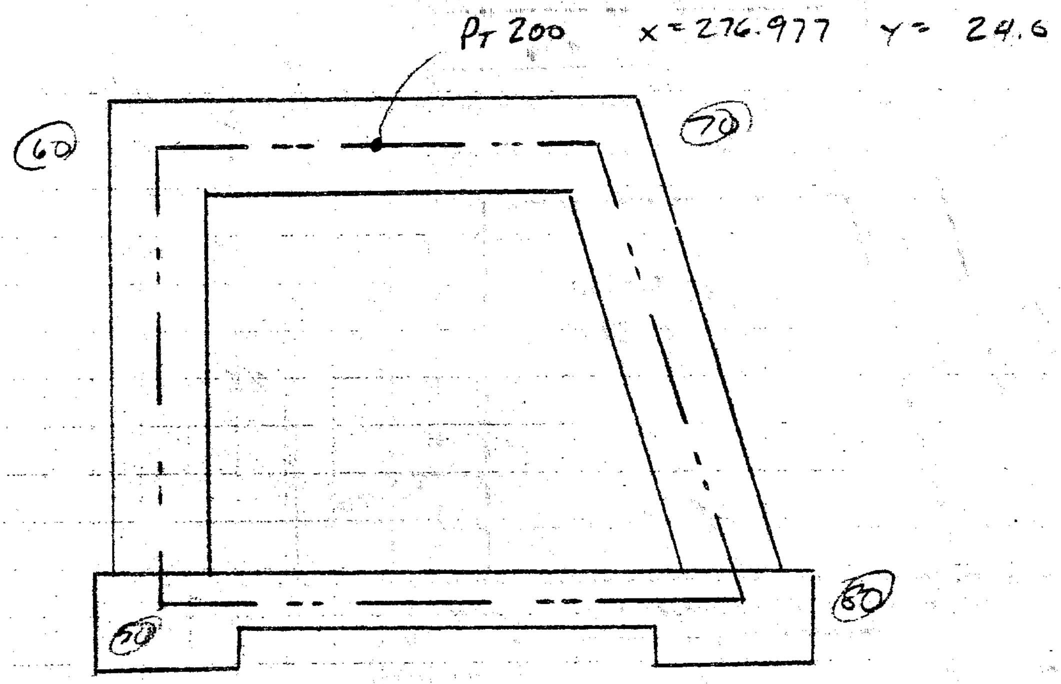
Point 30 $x = -.785 + \frac{4.563}{12} \times 25.08 = 8.752$

$Y = 24$

DATE ____________ **RUTHERFORD & CHEKENE** JOB NO. ____________

BY ______ CHKD. ______ *STRUCTURAL ENGINEERS* SHEET NO. 46-22

SUBJECT ____________________



POINT 60 x = 276.977 − 9.5 = 267.477
Y = 24.0

POINT 70 x = 276.977 + [18.727 − 8.752] = 286.952
Y = 24.0

POINT 50 x = 267.477
Y = −1.08

POINT 80 x = 267.477 + .785 + 28.227 = 296.489
Y = −1.08

MASS AT 60, CONCR BEAM WEIGHS $600^{in^2}/144 \times .15 = 625^{\#}/'$

W CONCR = [25.08/2 + 19/2] × .625 = 13.78 k
W WOOD = 6k/2×2 = 1.5 W TOT = 15.3 k

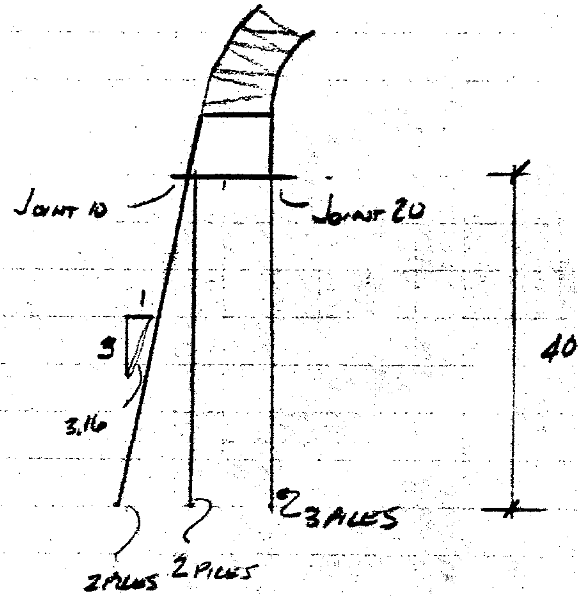
@ 70 W CONCR = [26.83 + 19]/2 × .625 = 14.3 k
W ROOF = 1.5 = W TOT = 15.8

SP1147A

DATE 2-25-85
BY JU. CHKD.
SUBJECT MOFFETT FIELD
JOB NO.
SHEET NO. 46-23

ADD SPRING AT BASE

1. PILES ARE 15" SQ, 2500 p.s.i CONC.
   a. ASSUME PILES ARE 40' LONG
   b. ASSUME PILES ARE FIXED AT MIDHEIGHT



$\Delta = PL/AE$

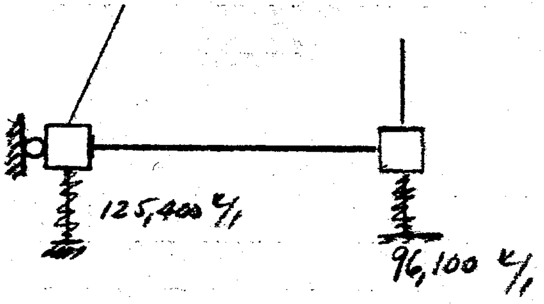
$K = \frac{P}{\Delta} = \frac{AE}{L}$

$A = 15^2 = 225 \text{ IN}^2 = 1.563$ Ø
$E = 57{,}000\sqrt{2500} = 2{,}850$ K.S.I
$= 410{,}000$ K/Ø
$L = 20'$

$K_{@10} = \left[2 + 2\times\frac{3}{3.16}\right] \times \frac{1.563\times 410{,}000}{20}$
$= 125{,}000$ K/1

$K_{@20} = 3\times 1.563\times 410{,}000/20$
$= 96{,}100$ K/1

∴ BASE MODEL



BUILDING 46
LEVEL 1 ANALYSIS
MODES 2,3,4 @ 5% DAMPING (BASE MODES)
REMAINDER @ 10% DAMPING

BASE UNCRACKED WITH SPRINGS

```
                  XXXXXXXXXXXX     XXXXXXXXXXXXX      XXXXXXXXXXXX
                 XXXXXXXXXXXX     XXXXXXXXXXXXX      XXXXXXXXXXXX
                XXXX             XXXX     XXXX      XXXX
               XXXX             XXXX     XXXX      XXXX
              XXXXXXXX         XXXXXXXXXXXXX      XXXX
             XXXXXXXX         XXXXXXXXXXXXX      XXXX
            XXXX             XXXX     XXXX      XXXX
           XXXX             XXXX     XXXX      XXXX
          XXXXXXXXXXXX     XXXX     XXXX      XXXXXXXXXXXX
         XXXXXXXXXXXX     XXXX     XXXX      XXXXXXXXXXXX

         XXXXXXXXXXXX    XXXXXXXXX         XXXX    XXXX      XXXX
        XXXXXXXXXXXX   XXXXXXXXXXX        XXXX    XXXXX     XXXX
       XXXX           XXX      XXX       XXXX    XXXXXX    XXXX
      XXXX                   XXXX       XXXX    XXXXXXX   XXXX
     XXXXXXXX              XXXX        XXXX    XXXX XXX  XXXX
    XXXXXXXX             XXXX         XXXX    XXXX  XXX XXXX
   XXXX                XXXX          XXXX    XXXX   XXXXXXX
  XXXX               XXXX           XXXX    XXXX    XXXXXX
 XXXXXXXXXXXX      XXXXXXXXXXXX    XXXX    XXXX     XXXXX
XXXXXXXXXXXX      XXXXXXXXXXXX    XXXX    XXXX      XXXX

              (E2IN VERSION 13.4   -   19MAR82)
```

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-------------------
P R O G R A M   D O C U M E N T S
-------------------

1) USERS MANUAL - V13.4 UPDATES AVAILABLE, NO CHARGE, REQUEST COPIES FROM EAC
2) EXAMPLE PROBLEM MANUAL
3) THEORETICAL MANUAL (IN PREPARATION)

---------------------------
N E W   F E A T U R E S   I N   T H I S   R E L E A S E
---------------------------

1) HARMONIC RESPONSE ANALYSIS (E2HRA)
2) RANDOM BASE INPUT (E2RBI) - CONTACT EAC FOR USE AND THEORY OF E2HRA/E2RBI
3) REVISED CYCLIC SYMMETRY - USE DESCRIBED IN *CONSTRAINTS* UPDATE
4) VELOCITY AND ACCELERATION ADDED AS RESPONSE SPECTRUM NODE OUTPUT OPTIONS
5) E2PLOT COMPLETELY UPDATED WITH SEVERAL NEW FEATURES
6) A POSITIVE ENTRY FOR (FSHIFT) ON THE *EIGENVALUES* CARD CAN NOW BE USED
   TO ACCELERATE CONVERGENCE IN SOME PROBLEMS

-----------------
E R R O R S   C O R R E C T E D
-----------------

ALL ERRORS WHICH COULD HAVE GIVEN INCORRECT RESULTS ARE LISTED.
A COMPLETE TABULATION OF CORRECTED ERRORS CAN BE OBTAINED FROM EAC.

1) POST-PROCESSORS USING *TAPE15* CREATED BY A DIRECT INTEGRATION RUN WOULD
   RECOVER INCORRECT (MZ) RESULTS AT END-2 OF BEAMS
2) STURM-SEQUENCE-ONLY USING *TAPE12* TO RESTART OVER-ESTIMATED THE NUMBER
   OF EIGENVALUES BELOW THE INPUT FREQUENCY
3) MODAL PARTICIPATION FACTORS COMPUTED USING SKEWED MASSES WERE INCORRECT
   IN MODE SUPERPOSITION AND EIGENVALUES-ONLY JOBS
4) THE ENTRY MADE FOR (IRBM) DEFINED THE NUMBER OF RIGID BODY MODES EXCLUDED
   IN RESPONSE SPECTRUM EVEN IF IT EXCEEDED THE TRUE NUMBER
5) RESPONSE SPECTRUM SHELL RESULTS WERE NOT TRANSFORMED THROUGH THE PROPER
   STRESS REFERENCE ANGLE FOR SHELLS EXACTLY EQUIVALENT TO THEIR PREDECESSORS
   AND HAVING NON-ZERO ENTRIES FOR (IVEC)

ANY QUESTIONS OR COMMENTS SHOULD BE DIRECTED TO -

ENGINEERING ANALYSIS CORPORATION
25200 NARBONNE AVENUE
LOMITA, CA     90717
PHONE- (213) 530-EASE
```

```
/- - - - -    E A S E 2   C A R D   I M A G E   L I S T I N G   - - - - -/
....+...10....+...20....+...30....+...40....+...50....+...60....+...70....+...80

EASE2            5   00                                                          EASE2      1
 NAS MOFFETT FIELD                                                               EASE2      2
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46                                         EASE2      3
NODES                                                                            NODES      1
   10         -.785      -1.08                                                   NODES      2
   20        28.227      -1.08                                                   NODES      3
   30         8.752      24.00                                                   NODES      4
   40        28.227      24.00                                                   NODES      5
   50       267.477     -1.08                                                    NODES      6
   60        296.489     -1.08                                                   NODES      7
   70        267.477     24.00                                                   NODES      8
   80        286.952     24.00                                                   NODES      9
  100         18.727    24.000                                                   NODES     10
  102         24.369    41.448                                                   NODES     11
  104         32.992    63.237                                                   NODES     12
  106         43.928    84.263                                                   NODES     13
  108         56.351   104.121                                                   NODES     14
  110         70.547   122.544                                                   NODES     15
  112         86.810   138.841                                                   NODES     16
  114        105.312   151.949                                                   NODES     17
  116        125.922   160.580                                                   NODES     18
  118        147.852   163.609                                                   NODES     19
  200        276.977      24.0                                                   NODES     20
  202        271.335    41.448                                                   NODES     21
  204        262.712    63.237                                                   NODES     22
  206        251.776    84.263                                                   NODES     23
  208        239.353   104.121                                                   NODES     24
  210        225.157   122.544                                                   NODES     25
  212        208.894   138.841                                                   NODES     26
  214        190.392   151.949                                                   NODES     27
  216        169.782   160.580                                                   NODES     28
RESTRAINTS              000000                                                   RESTRAIN   1
   10RSD000                        125000.                                       RESTRAIN   2
   200SD000                        96100.                                        RESTRAIN   3
   500SD000                        96100.                                        RESTRAIN   4
   60RSD000                        125000.                                       RESTRAIN   5
CONSTRAINTS                                                                      CONSTRAI   1
   12   IC  100   30   40                                                        CONSTRAI   2
   12   IC  200   70   80                                                        CONSTRAI   3
MATERIALS                                                                        MATERIAL   1
    1TRUSS                          233000.      0.2                             MATERIAL   2
    2CONCR                         410400.    0.3                                MATERIAL   3
SECTIONS                                12.                                      SECTIONS   1
    1    1     185.5               1920000.            39.7                      SECTIONS   2
               102.                  -102.                                       SECTIONS   3
    2    1     185.5               1410000.            39.2                      SECTIONS   4
               87.3                  -87.3                                       SECTIONS   5
    3    1     159.0               1000000.            35.8                      SECTIONS   6
               67.1                  -93.9                                       SECTIONS   7
    4    1     159.0               1010000.            25.3                      SECTIONS   8

....+...10....+...20....+...30....+...40....+...50....+...60....+...70....+...80
```

```
/- - - - -     E A S E 2   C A R D   I M A G E   L I S T I N G    - - - - -/
....+...10....+...20....+...30....+...40....+...50....+...60....+...70....+...80

               67.5              -94.5                                            SECTIONS   9
    5    1     149.0             919000.               20.4                       SECTIONS  10
               61.2              -100.8                                           SECTIONS  11
    6    1     122.5             798000.               20.9                       SECTIONS  12
               74.4              -87.6                                            SECTIONS  13
    7    1     112.5             739000.               22.5                       SECTIONS  14
               81.0               -81.0                                           SECTIONS  15
    8    1     112.5             738000.               21.1                       SECTIONS  16
               81.0               -81.0                                           SECTIONS  17
    9    1     122.5             798000.               20.8                       SECTIONS  18
               74.4              -87.6                                            SECTIONS  19
   10    1   600.              45000.                 600.                        SECTIONS  20
               15.0                -15.0                                          SECTIONS  21
   11    1  168.                   2744.              168.                        SECTIONS  22
                7.                -7.                                             SECTIONS  23
BEAMS                                                                             BEAMS      1
    1  100  102    1    1    *              1  100                                BEAMS      2
    3  102  104    1    2    *              1  100                                BEAMS      3
    5  104  106    1    3    *              1  100                                BEAMS      4
    7  106  108    1    4    *              1  100                                BEAMS      5
    9  108  110    1    5.   *              1  100                                BEAMS      6
   11  110  112    1    6    *              1  100                                BEAMS      7
   13  112  114    1    7    *              1  100                                BEAMS      8
   15  114  116    1    8    *              1  100                                BEAMS      9
   17  116  118    1    9    *                                                    BEAMS     10
   18  118  216    1    9    *                                                    BEAMS     11
   19   10   30    2   10    *                                                    BEAMS     12
   20   30   40    2   10    *                                                    BEAMS     13
   21   40   20    2   10  -10                                                    BEAMS     14
   22   10   20    2   11    *                                                    BEAMS     15
   23   50   70    2   10  -10                                                    BEAMS     16
   24   70   80    2   10    *                                                    BEAMS     17
   25   60   80    2   10    *                                                    BEAMS     18
   26   50   60    2   11    *                                                    BEAMS     19
DYNAMIC JOB                 32.2                                                  DYNAMIC    1
MASSES              .031056                                                       MASSES     1
  102           6.0       6.0                                              8    2 MASSES     2
  202           6.0       6.0                                              7    2 MASSES     3
   30          16.       16.0                                                     MASSES     4
   40          16.       16.0                                                     MASSES     5
   70          16.0       16.                                                     MASSES     6
   80          16.0      16.0                                                     MASSES     7
EIGENVALUES       16   12    1                                                    EIGENVAL   1
SPECTRUM           1    8    2                                                    SPECTRUM   1
SHOCK TABLE        1   18    2  32.2                                              SHOCK      1
                                                                                  SHOCK      2
     0.20    0.154      0.25     0.179      0.33     0.189      0.50     0.244    SHOCK      3
     1.00    0.371     1.11      0.389      1.25     0.401      1.43     0.422    SHOCK      4
     1.67    0.483      2.00     0.528      2.50     0.750      3.33     0.826    SHOCK      5
    3.60     0.816      3.70     0.632      5.00     0.620      6.67      .575    SHOCK      6

....+...10....+...20....+...30....+...40....+...50....+...60....+...70....+...80
```

```
/- - - - -    E A S E 2   C A R D   I M A G E   L I S T I N G   - - - - -/
....+...10....+...20....+...30....+...40....+...50....+...60....+...70....+...80

     10.00     0.474     20.00     0.366                                          SHOCK       7
RESPONSE CASE      1                    CASE 1 - SRSS METHOD                      RESPONSE    1
    1                 0.5                                                         RESPONSE    2
RESPONSE CASE      2    2     .90         ¬/CASE 2 - CLOSELY SPACED MOJES         RESPONSE    1
    1                 0.5                                                         RESPONSE    2
RESPONSE CASE      3    7     .02        CASE 3 - CQC METHOD                      RESPONSE    1
    1                 0.5                                                         RESPONSE    2
RESPONSE CASE      4                     SRSS VERTICAL SEISMIC                    RESPONSE    1
         1                          0.33                                          RESPONSE    2
RESPONSE CASE      5    2            .90 CSM VERTICAL SEISMIC                     RESPONSE    1
         1                          0.33                                          RESPONSE    2
RESPONSE CASE      6    7           0.02 CQC VERTICAL SEISMIC                     RESPONSE    1
         1                         0.33                                           RESPONSE    2
RESPONSE CASE      7                     SRSS 1.0*HORIZ SIES + 0.3*VERT SEIS      RESPONSE    1
    1    1                 0.5      0.11                                          RESPONSE    2
RESPONSE CASE      8                     SRSS .3*HORIZ SEIS + 1.0*VERT SEIS       RESPONSE    1
    1    1                0.17      0.33                                          RESPONSE    2
RSA OUTPUT                                                                        RSA OUTP    1
 NODE                                                                             RSA OUTP    2
 BEAM      E1PX E1VY E1MZ E2MZ E1S1 E1S2 E2S1 E2S2                                RSA OUTP    3

(ENTER A (*) IN CC14 OF THE EASE2 SEPARATOR TO SUPPRESS THE CARD IMAGE LISTING)
```

```
M A S T E R   C O N T R O L   P A R A M E T E R S

 NAS MOFFETT FIELD
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46                                                                PAGE     1
                                                                                                         18 MAR 83
MASTER ECHO PRINT CONTROL                 = (      )      SPS    (CC    15)
  EQ. *, SUPPRESS ECHO PRINT IN ALL
         DATA SECTIONS

SOLUTION MODE CONTROL                     = (     5)      IMODE  (CC 16-20)
  EQ. 1, STATIC SOLUTION
  EQ. 2, EIGENVALUE SOLUTION ONLY
  EQ. 3, TIME-HISTORY ANALYSIS USING
         MODE SUPERPOSITION
  EQ. 4, TIME HISTORY ANALYSIS USING
         DIRECT INTEGRATION
  EQ. 5, RESPONSE SPECTRUM ANALYSIS

STIFFNESS MATRIX RESTART CONTROL          = (     0)      IRSTR1 (CC    24)
  EQ. 1, PROGRAM EXPECTS TO READ THE
         DECOMPOSED STIFFNESS MATRIX
         FROM DISK FILE TAPE12

EIGENVALUES/EIGENVECTORS RESTART CONTROL  = (     0)      IRSTR2 (CC    25)
  EQ. 1, PROGRAM EXPECTS TO READ
         EIGENVALUES AND EIGENVECTORS
         FROM DISK FILE TAPE13

NODE RESEQUENCING CONTROL                 = (     2)      IBAND  (CC 26-30)
  EQ. 0, INTERNAL NODE NUMBERS ASSIGNED
         IN ASCENDING NODE ORDER
  EQ. 1, INTERNAL NODE NUMBERS ASSIGNED
         SEQUENTIALLY AS NODES ARE
         ENCOUNTERED DURING INPUT
  EQ. 2, INTERNAL NODE NUMBERS ASSIGNED
         TO PRODUCE A REDUCED BANDWIDTH
         USING  *GPS*  ALGORITHM
  BLANK, DEFAULT SET TO 2

MAXIMUM CORE FOR EASE2 EXECUTION          = (375000)      ICORE  (CC 35-40)
  BLANK, DEFAULT SET TO 375000
  LT. 100000B, RESET TO 100000B
```

```
INPUT  NODE  DATA

 NAS MOFFETT FIELD                                                                                                                  PAGE     2
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46                                                                                            18 MAR 83

                                                                 ---   G E N E R A T I O N   ---
NODE SYSTEM  COORDINATES OF THE FIRST NODE   THICK-                     PERCENT  2ND-LEVEL    COORDINATES OF THE LAST NODE   NODE
 NO  /TYPE      X1-ORD     X2-ORD    X3-ORD    NESS  NUMBER  INC  CHANGE        CODE      X1-ORD     X2-ORD    X3-ORD  COUNT

  10   0/        -.785     -1.080     0.000    0.00                                                                          1
  20   0/       28.227     -1.080     0.000    0.00                                                                          2
  30   0/        8.752     24.000     0.000    0.00                                                                          3
  40   0/       28.227     24.000     0.000    0.00                                                                          4
  50   0/      267.477     -1.080     0.000    0.00                                                                          5
  60   0/      296.489     -1.080     0.000    0.00                                                                          6
  70   0/      267.477     24.000     0.000    0.00                                                                          7
  80   0/      286.952     24.000     0.000    0.00                                                                          8
 100   0/       18.727     24.000     0.000    0.00                                                                          9
 102   0/       24.369     41.448     0.000    0.00                                                                         10
 104   0/       32.992     63.237     0.000    0.00                                                                         11
 106   0/       43.928     84.263     0.000    0.00                                                                         12
 108   0/       56.351    104.121     0.000    0.00                                                                         13
 110   0/       70.547    122.544     0.000    0.00                                                                         14
 112   0/       86.810    138.841     0.000    0.00                                                                         15
 114   0/      105.312    151.949     0.000    0.00                                                                         16
 116   0/      125.922    160.580     0.000    0.00                                                                         17
 118   0/      147.852    163.609     0.000    0.00                                                                         18
 200   0/      276.977     24.000     0.000    0.00                                                                         19
 202   0/      271.335     41.448     0.000    0.00                                                                         20
 204   0/      262.712     63.237     0.000    0.00                                                                         21
 206   0/      251.776     84.263     0.000    0.00                                                                         22
 208   0/      239.353    104.121     0.000    0.00                                                                         23
 210   0/      225.157    122.544     0.000    0.00                                                                         24
 212   0/      208.894    138.841     0.000    0.00                                                                         25
 214   0/      190.392    151.949     0.000    0.00                                                                         26
 216   0/      169.782    160.580     0.000    0.00                                                                         27
```

```
R E S T R A I N E D   N O D E S

 NAS MOFFETT FIELD
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46                                                                                PAGE     3
                                                                                                                        18 MAR 83
GENERAL RESTRAINT CODE APPLIED TO ALL NODES   (000000)          SGCODE (CC 25-30)

   NODE      BOUNDARY    /TRANSLATIONAL COMPONENT VALUES/    / ROTATIONAL COMPONENT  VALUES /   G E N E R A T I O N   NODE
  NUMBER        CODES     (X OR R)    (Y OR S)    (Z OR T)     (X OR R)    (Y OR S)    (Z OR T)   NUMBER   INCREMENT   COUNT

     10      RSD 000     0.          .125E+06  0.           0.          0.          0.            0           1         1
     20      0SD 000     0.          .961E+05  0.           0.          0.          0.            0           1         2
     50      0SD 000     0.          .961E+05  0.           0.          0.          0.            0           1         3
     60      RSD 000     0.          .125E+06  0.           0.          0.          0.            0           1         4
```

```
C O N S T R A I N E D   N O D E S

 NAS MOFFETT FIELD
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46

                                        N O D E   N U M B E R S   L E N G T H S   (IC  CONSTRAINTS)   G E N E R A T I O N
   CONSTRAINT      CONSTRAINT         DEPENDENT   INDEPENDENT     NODES I-J   NODES J-K   NODES I-K    NUMBER   INCREMENTS
    DIRECTION            TYPE               (J)     (I)    (K)       L(IJ)       L(JK)       L(IK)              (J)  (I)  (K)    COUNT

           12              IC               100      30     40      9.9750      9.5000     19.4750          0    1    0    0        1
           12              IC               200      70     80      9.5000      9.9750     19.4750          0    1    0    0        2
```

```
M A T E R I A L   P R O P E R T I E S

 NAS MOFFETT FIELD                                                                                                              PAGE     5
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46                                                                                         18 MAR 83

MATERIAL     MATERIAL                              WEIGHT         ELASTIC        POISSON.S      EXPANSION
  NUMBER   DESCRIPTION     TEMPERATURE             DENSITY         MODULUS            RATIO    COEFFICIENT

       1         TRUSS      0.             0.                    .2330E+06      .2000E+00      0.
       2         CONCR      0.             0.                    .4104E+06      .3000E+00      0.
```

```
B E A M   S E C T I O N   P R O P E R T I E S                                                                                    PAGE      6
                                                                                                                                 18 MAR 83
 NAS MOFFETT FIELD
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46

SPECIAL SECTIONS FLAG                          (          )           SS=    (CC 22-25)
SCALE FACTOR  -  DIVIDE AREAS BY (FLU)**2,
MOMENTS BY (FLU)**4 AND COORDINATES BY (FLU) (  12.00000)             FLJ    (CC 31-40)

                                                                                            C O O R D I N A T E S      F O R
SECTION   SECTION   M O M E N T S    O F   I N E R T I A    S H E A R    A R E A S       S T R E S S   E V A L U A T I O N
NUMBER      AREA          I(Y)            I(Z)        J(X)         A(Y)          A(Z)         Y1/Z1     Y2/Z2     Y3/Z3     Y4/Z4

     1  .1855E+03     0.           .1920E+07   0.            .3970E+02 0.                   .10E+03-.10E+030.
                                                                                           0.       0.        0.
     2  .1855E+03     0.           .1410E+07   0.            .3920E+02 0.                   .87E+02-.87E+020.
                                                                                           0.       0.        0.
     3  .1590E+03     0.           .1000E+07   0.            .3580E+02 0.                   .67E+02-.94E+020.
                                                                                           0.       0.        0.
     4  .1590E+03     0.           .1010E+07   0.            .2530E+02 0.                   .68E+02-.95E+020.
                                                                                           0.       0.        0.
     5  .1490E+03     0.           .9190E+06   0.            .2040E+02 0.                   .61E+02-.10E+030.
                                                                                           0.       0.        0.
     6  .1225E+03     0.           .7980E+06   0.            .2090E+02 0.                   .74E+02-.88E+020.
                                                                                           0.       0.        0.
     7  .1125E+03     0.           .7380E+06   0.            .2250E+02 0.                   .81E+02-.81E+020.
                                                                                           0.       0.        0.
     8  .1125E+03     0.           .7380E+06   0.            .2110E+02 0.                   .81E+02-.81E+020.
                                                                                           0.       0.        0.
     9  .1225E+03     0.           .7980E+06   0.            .2080E+02 0.                   .74E+02-.88E+020.
                                                                                           0.       0.        0.
    10  .6000E+03     0.           .4500E+05   0.            .6000E+03 0.                   .15E+02-.15E+020.
                                                                                           0.       0.        0.
    11  .1680E+03     0.           .2744E+04   0.            .1680E+03 0.                   .70E+01-.70E+010.
                                                                                           0.       0.        0.
```

```
B E A M   E L E M E N T S

NAS MOFFETT FIELD
RESPONSE SPECTRUM ANALYSIS OF HANGAR 46                                                                                          PAGE     7
                                                                                                                                  18 MAR 83

   BEAM    NODE  NODE      MATL     SECTION    LOCAL AXIS      MEMBER-END-      - G E N E R A T I O N -
  NUMBER     1     2      NUMBER     NUMBER    ORIENTATION    RELEASE CODES    /1ST LEVEL/ /2ND LEVEL/   TEMPE-    ELEMENT    BAND-
                                               VECTOR/NODE    END-1    END-2   NUMBER  INC NUMBER  INC   RATURE     LENGTH    WIDTH

       1    100   102        1          1          *           000      000        1  100      0    1      0.0       18.34        9
       2    200   202                                                                                    0.0       18.34        8
       3    102   104        1          2          *           000      000        1  100      0    1      0.0       23.43        6
       4    202   204                                                                                    0.0       23.43        6
       5    104   106        1          3          *           000      000        1  100      0    1      0.0       23.70        6
       6    204   206                                                                                    0.0       23.70        6
       7    106   108        1          4          *           000      000        1  100      0    1      0.0       23.42        6
       8    206   208                                                                                    0.0       23.42        6
       9    108   110        1          5          *           000      000        1  100      0    1      0.0       23.26        6
      10    208   210                                                                                    0.0       23.26        6
      11    110   112        1          6          *           000      000        1  100      0    1      0.0       23.02        6
      12    210   212                                                                                    0.0       23.02        6
      13    112   114        1          7          *           000      000        1  100      0    1      0.0       22.67        6
      14    212   214                                                                                    0.0       22.67        6
      15    114   116        1          8          *           000      000        1  100      0    1      0.0       22.34        6
      16    214   216                                                                                    0.0       22.34        6
      17    116   118        1          9          *           000      000        0    1      0    1      0.0       22.14        6
      18    118   216        1          9          *           000      000        0    1      0    1      0.0       22.14        6
      19     10    30        2         10          *           000      000        0    1      0    1      0.0       26.83        9
      20     30    40        2         10          *           000      000        0    1      0    1      0.0       19.48        6
      21     40    20        2         10             -10      000      000        0    1      0    1      0.0       25.08        9
      22     10    20        2         11          *           000      000        0    1      0    1      0.0       29.01        6
      23     50    70        2         10             -10      000      000        0    1      0    1      0.0       25.08        9
      24     70    90        2         10          *           000      000        0    1      0    1      0.0       19.47        6
      25     60    80        2         10          *           000      000        0    1      0    1      0.0       26.83        9
      26     50    60        2         11          *           000      000        0    1      0    1      0.0       29.01        6
```

```
 NAS MOFFETT FIELD
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46

FLAG CONTROLLING THE METHOD USED TO
CREATE THE SYSTEM MASS MATRIX                  =  (      0)           IELMS  (CC 16-20)
  EQ. 0, ELEMENT MASSES ARE NOT USED,
         ALL MASS DATA MUST BE INPUT IN
         THE  *MASSES*  DATA SECTION
  EQ. 1, ELEMENT MASSES ARE USED,  ANY DATA
         GIVEN IN THE  *MASSES*  DATA SECTION
         WILL AUGMENT THE ELEMENT-BASED MATRIX

ACCELERATION OF GRAVITY                        =  (      .32200E+02) FGEE   (CC 21-30)

FLAG FOR PRINTING THE SYSTEM MASS MATRIX       =  (      0)           IMPRT  (CC 31-35)
  EQ. 0, NO
  EQ. 1, YES
```

```
M A S S E S

 NAS MOFFETT FIELD
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46                                                                                          PAGE     9
                                                                                                                                  18 MAR 83
MASS COEFFICIENTS SCALE FACTOR              = (      .31056E-01) FMASSF (CC 21-30)

                                                      (X OR R)   (Y OR S)   (Z OR T)   (X OR R)   (Y OR S)   (Z OR T)
  NODE    SKEW    REST-    CONS-    REPEAT    TRANSLA-   TRANSLA-   TRANSLA-  ROTATIONAL ROTATIONAL ROTATIONAL  *GENERATION*
 NUMBER  SYSTEM   RAINT    TRAINT     NODE   TION MASS  TION MASS  TION MASS       MASS       MASS       MASS  NUMBER   INC COUNT
    102                                        6.00000    6.00000    0.00000    0.00000    0.00000    0.00000       8     2     1
    104                                                                                                                        2
    106                                                                                                                        3
    108                                                                                                                        4
    110                                                                                                                        5
    112                                                                                                                        6
    114                                                                                                                        7
    116                                                                                                                        8
    118                                                                                                                        9
    202                                        6.00000    6.00000    0.00000    0.00000    0.00000    0.00000       7     2    10
    204                                                                                                                       11
    206                                                                                                                       12
    208                                                                                                                       13
    210                                                                                                                       14
    212                                                                                                                       15
    214                                                                                                                       16
    216                                                                                                                       17
     30                                       16.00000   16.00000    0.00000    0.00000    0.00000    0.00000       0     1    18
     40                                       16.00000   16.00000    0.00000    0.00000    0.00000    0.00000       0     1    19
     70                                       16.00000   16.00000    0.00000    0.00000    0.00000    0.00000       0     1    20
     80                                       16.00000   16.00000    0.00000    0.00000    0.00000    0.00000       0     1    21
                                             ----------  ----------  ----------
GLOBAL CONCENTRATED MASS SUMS                .16600E+03  .16600E+03 0.
```

```
E I G E N V A L U E S   C O N T R O L   V A R I A B L E S

 NAS MOFFETT FIELD
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46

TOTAL NUMBER OF LOWEST EIGENVALUES/VECTORS
TO BE CALCULATED (AND/OR USED) IN THIS JOB = (    16)          IP     (CC 16-20)

NUMBER OF EIGENVECTORS TO BE PRINTED       = (    12)          IPT    (CC 21-25)

EIGENVECTOR PRINT NORMALIZATION CODE       = (     0)          I0     (CC    27)
  EQ. 0, MASS NORMALIZED
  EQ. 1, NORMALIZED TO UNITY

EIGENVECTOR COMPONENT TYPE CONTROL         = (     0)          I1     (CC    28)
  EQ. 0, USE NODAL POINT INPUT SYSTEM
  EQ. 1, USE GLOBAL CARTESIAN  SYSTEM

EIGENVECTOR COMPONENT FORMAT CONTROL       = (     0)          I2     (CC    29)
  EQ. 0, USE EXPONENTIAL FORMAT
  GT. 0, USE FLOATING POINT FORMAT

TAPE15 FILE CONTROL PARAMETER              = (     1)          I3     (CC    30)
  EQ. 1, EIGENVALUES/VECTORS SAVED ON TAPE15
  EQ. 2, ELEMENT TRANSFORMS  SAVED ON TAPE15
  EQ. 3, SAVE EIGENSYSTEM AND ELEMENT DATA

FLAG FOR PRINTING SUPPLEMENTARY OUTPUT
DURING THE EIGENVALUE EXTRACTION PHASE     = (     0)          IX     (CC    32)
  EQ. 1, PRINT SUPPLEMENTARY OUTPUT
  EQ. 2, PRINT DURING LAST TWO CYCLES ONLY

FLAG CONTROLING SUBSPACE ITERATION USAGE   = (     1)          II     (CC    33)
  EQ. 1, USE SUBSPACE ITERATION
  EQ. 2, USE DETERMINANT SEARCH

FLAG FOR COMPUTING THE PHYSICAL
ERROR BOUNDS FOR THE ( 16) EIGENVALUES     = (     0)          IE     (CC    34)

FLAG DIRECTING THE PROGRAM TO PERFORM STURM
SEQUENCE CHECK                             = (     0)          IS     (CC    35)

RIGID-BODY-MODES FLAG                      = (     0)

TOTAL NUMBER OF WORKING VECTORS TO BE USED
IN THE SUBSPACE ITERATION SOLUTION         = (    24)          IQ     (CC 41-45)

MAXIMUM NUMBER OF ITERATIONS ALLOWED PRIOR
TO SOLUTION TERMINATION/WRAP-UP            = (     8)          ITMAX  (CC 46-50)

HIGHEST FREQUENCY TO BE CALCULATED         = (      .10000E+11) FQMAX  (CC 51-60)

CONVERGENCE TOLERANCE REQUIRED FOR
ALL OF THE ( 16) EIGENVALUES               = (      .10000E-02) FQTOL  (CC 61-70)

SHIFT VALUE (U) IN (RADIANS/T)**2 UNITS,
MO   ED EIGENPROBLEM WILL BE (K - U*M)     = (      0.          SHIFT  (CC 71-80)
```

```
S P E C T R U M   A N A L Y S I S   C O N T R O L

 NAS MOFFETT FIELD
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46                                                                          PAGE    11
                                                                                                                   18 MAR 83

NUMBER OF GROUND SHOCK SPECTRA TABLES        = (      1)          INTBL  (CC 16-20)
NUMBER OF SPECTRUM ANALYSIS RESPONSE CASES   = (      8)          IRCS   (CC 21-25)
COMBINATION METHOD FOR X,Y,Z MODAL MAXIMA    = (      2)          ICMA   (CC 26-30)
  EQ. 0, ABSOLUTE SUM
  EQ. 1, ROOT-SUM-SQUARES
  EQ. 2, ALGEBRAIC SUM
```

```
S H O C K   S P E C T R U M

 NAS MOFFETT FIELD
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46

SPECTRUM TABLE NUMBER                        = (      1)          ITABL  (CC 16-20)
NUMBER OF INPUT PAIRS IN THIS TABLE          = (     18)          IPTS   (CC 21-25)
TYPE OF INPUT SPECTRUM                       = (      2)          ISTY   (CC 26-30)
  EQ. 0, DISPLACEMENT
  EQ. 1, VELOCITY
  EQ. 2, ACCELERATION
SCALE FACTOR FOR ORDINATE VALUES             = (       .32200E+02) FSORD  (CC 31-40)

NUMBER OF FIELDS TO READ ON SPECTRUM CARDS   = (      8)          IFEL   (CC 41-45)

SPECTRUM DATA FORMAT    =  ((1X,F9.0,7F10.0)                    ) SFNFMT (CC 46-80)


SPECTRUM NUMBER   1 --

    CARD          1    1    2    2    3    3    4    4    5    5    6    6    7    7    8
  COLUMNS....5....0....5....0....5....0....5....0....5....0....5....0....5....0....5....0

               0.20      0.154      0.25     0.179      0.33     0.189      0.50     0.244
               1.00      0.371     1.11      0.389      1.25     0.401      1.43     0.422
               1.67      0.483      2.00     0.528      2.50     0.750      3.33     0.826
              3.60       0.816      3.70     0.632      5.00     0.620      6.67     .575
              10.00      0.474     20.00     0.366
```

```
R E S P O N S E   C A S E   C O N T R O L    (RESPONSE CASE   1)

 NAS MOFFETT FIELD                                                                                                    PAGE    13
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46                                                                              18 MAR 83

SPECTRUM ANALYSIS CASE NUMBER                = (      1)            ICASE  (CC 16-20)

COMBINATION METHOD FOR MODAL COMPONENTS      = (      0)            IMC    (CC 21-25)
  EQ. 0, ROOT-SUM-SQUARES
  EQ. 1, ABSOLUTE SUM
  EQ. 2, CLOSELY-SPACED MODES
  EQ. 3, IMPACT METHOD
  EQ. 4, NRL METHOD
  EQ. 5, NRC 10 PCT METHOD
  EQ. 6, NRC DOUBLE SUM
  EQ. 7, CQC METHOD

PARAMETER ASSOCIATED WITH COMBINATION METHOD= (     0.           ) FCM    (CC 31-40)


CASE 1 - SRSS METHOD


TABLE NUMBER FOR X-DIRECTION SHOCK           = (      1)            ISTX   (CC  2- 5)
TABLE NUMBER FOR Y-DIRECTION SHOCK           = (      0)            ISTY   (CC  6-10)
TABLE NUMBER FOR Z-DIRECTION SHOCK           = (      0)            ISTZ   (CC 11-15)

SCALE FACTOR FOR X-DIRECTION SHOCK           = (       .50000E+00) FACX   (CC 21-30)
SCALE FACTOR FOR Y-DIRECTION SHOCK           = (       .10000E+01) FACY   (CC 31-40)
SCALE FACTOR FOR Z-DIRECTION SHOCK           = (       .10000E+01) FACZ   (CC 41-50)
```

```
R E S P O N S E   C A S E   C O N T R O L    (RESPONSE CASE   2)

 NAS MOFFETT FIELD
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46

SPECTRUM ANALYSIS CASE NUMBER              = (      2)          ICASE  (CC 16-20)

COMBINATION METHOD FOR MODAL COMPONENTS    = (      2)          IMC    (CC 21-25)
  EQ. 0, ROOT-SUM-SQUARES
  EQ. 1, ABSOLUTE SUM
  EQ. 2, CLOSELY-SPACED MODES
  EQ. 3, IMPACT METHOD
  EQ. 4, NRL METHOD
  EQ. 5, NRC 10 PCT METHOD
  EQ. 6, NRC DOUBLE SUM
  EQ. 7, CQC METHOD

PARAMETER ASSOCIATED WITH COMBINATION METHOD= (      .90000E+00) FCM    (CC 31-40)


  ¬/CASE 2 - CLOSELY SPACED MODES

TABLE NUMBER FOR X-DIRECTION SHOCK         = (      1)          ISTX   (CC  2- 5)
TABLE NUMBER FOR Y-DIRECTION SHOCK         = (      0)          ISTY   (CC  6-10)
TABLE NUMBER FOR Z-DIRECTION SHOCK         = (      0)          ISTZ   (CC 11-15)

SCALE FACTOR FOR X-DIRECTION SHOCK         = (      .50000E+00) FACX   (CC 21-30)
SCALE FACTOR FOR Y-DIRECTION SHOCK         = (      .10000E+01) FACY   (CC 31-40)
SCALE FACTOR FOR Z-DIRECTION SHOCK         = (      .10000E+01) FACZ   (CC 41-50)
```

```
R E S P O N S E   C A S E   C O N T R O L     (RESPONSE CASE   3)

 NAS MOFFETT FIELD                                                                                                PAGE    15
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46                                                                           18 MAR 83

SPECTRUM ANALYSIS CASE NUMBER                 = (      3)              ICASE  (CC 16-20)

COMBINATION METHOD FOR MODAL COMPONENTS       = (      7)              IMC    (CC 21-25)
  EQ. 0, ROOT-SUM-SQUARES
  EQ. 1, ABSOLUTE SUM
  EQ. 2, CLOSELY-SPACED MODES
  EQ. 3, IMPACT METHOD
  EQ. 4, NRL METHOD
  EQ. 5, NRC 10 PCT METHOD
  EQ. 6, NRC DOUBLE SUM
  EQ. 7, CQC METHOD

PARAMETER ASSOCIATED WITH COMBINATION METHOD= (      .20000E-01) FCM    (CC 31-40)


 CASE 3 - CQC METHOD


TABLE NUMBER FOR X-DIRECTION SHOCK            = (      1)              ISTX   (CC  2- 5)
TABLE NUMBER FOR Y-DIRECTION SHOCK            = (      0)              ISTY   (CC  6-10)
TABLE NUMBER FOR Z-DIRECTION SHOCK            = (      0)              ISTZ   (CC 11-15)

SCALE FACTOR FOR X-DIRECTION SHOCK            = (      .50000E+00) FACX   (CC 21-30)
SCALE FACTOR FOR Y-DIRECTION SHOCK            = (      .10000E+01) FACY   (CC 31-40)
SCALE FACTOR FOR Z-DIRECTION SHOCK            = (      .10000E+01) FACZ   (CC 41-50)
```

```
R E S P O N S E   C A S E   C O N T R O L    (RESPONSE CASE   4)

 NAS MOFFETT FIELD
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46

SPECTRUM ANALYSIS CASE NUMBER               = (      4)           ICASE  (CC 16-20)

COMBINATION METHOD FOR MODAL COMPONENTS     = (      0)           IMC    (CC 21-25)
  EQ. 0, ROOT-SUM-SQUARES
  EQ. 1, ABSOLUTE SUM
  EQ. 2, CLOSELY-SPACED MODES
  EQ. 3, IMPACT METHOD
  EQ. 4, NRL METHOD
  EQ. 5, NRC 10 PCT METHOD
  EQ. 6, NRC DOUBLE SUM
  EQ. 7, CQC METHOD

PARAMETER ASSOCIATED WITH COMBINATION METHOD= (      0.          ) FCM    (CC 31-40)


 SRSS VERTICAL SEISMIC


TABLE NUMBER FOR X-DIRECTION SHOCK          = (      0)           ISTX   (CC  2- 5)
TABLE NUMBER FOR Y-DIRECTION SHOCK          = (      1)           ISTY   (CC  6-10)
TABLE NUMBER FOR Z-DIRECTION SHOCK          = (      0)           ISTZ   (CC 11-15)

SCALE FACTOR FOR X-DIRECTION SHOCK          = (       .10000E+01) FACX   (CC 21-30)
SCALE FACTOR FOR Y-DIRECTION SHOCK          = (       .33000E+00) FACY   (CC 31-40)
SCALE FACTOR FOR Z-DIRECTION SHOCK          = (       .10000E+01) FACZ   (CC 41-50)
```

```
R E S P O N S E   C A S E   C O N T R O L     (RESPONSE CASE   5)

 NAS MOFFETT FIELD                                                                                             PAGE    17
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46                                                                        18 MAR 83

SPECTRUM ANALYSIS CASE NUMBER                = (      5)            ICASE  (CC 16-20)

COMBINATION METHOD FOR MODAL COMPONENTS      = (      2)            IMC    (CC 21-25)
  EQ. 0, ROOT-SUM-SQUARES
  EQ. 1, ABSOLUTE SUM
  EQ. 2, CLOSELY-SPACED MODES
  EQ. 3, IMPACT METHOD
  EQ. 4, NRL METHOD
  EQ. 5, NRC 10 PCT METHOD
  EQ. 6, NRC DOUBLE SUM
  EQ. 7, CQC METHOD

PARAMETER ASSOCIATED WITH COMBINATION METHOD= (       .90000E+00) FCM    (CC 31-40)


 CSM VERTICAL SEISMIC


TABLE NUMBER FOR X-DIRECTION SHOCK           = (      0)            ISTX   (CC  2- 5)
TABLE NUMBER FOR Y-DIRECTION SHOCK           = (      1)            ISTY   (CC  6-10)
TABLE NUMBER FOR Z-DIRECTION SHOCK           = (      0)            ISTZ   (CC 11-15)

SCALE FACTOR FOR X-DIRECTION SHOCK           = (       .10000E+01) FACX   (CC 21-30)
SCALE FACTOR FOR Y-DIRECTION SHOCK           = (       .33000E+00) FACY   (CC 31-40)
SCALE FACTOR FOR Z-DIRECTION SHOCK           = (       .10000E+01) FACZ   (CC 41-50)
```

```
R E S P O N S E   C A S E   C O N T R O L     (RESPONSE CASE   6)

 NAS MOFFETT FIELD
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46

SPECTRUM ANALYSIS CASE NUMBER                = (      6)            ICASE  (CC 16-20)

COMBINATION METHOD FOR MODAL COMPONENTS      = (      7)            IMC    (CC 21-25)
  EQ. 0, ROOT-SUM-SQUARES
  EQ. 1, ABSOLUTE SUM
  EQ. 2, CLOSELY-SPACED MODES
  EQ. 3, IMPACT METHOD
  EQ. 4, NRL METHOD
  EQ. 5, NRC 10 PCT METHOD
  EQ. 6, NRC DOUBLE SUM
  EQ. 7, CQC METHOD

PARAMETER ASSOCIATED WITH COMBINATION METHOD= (       .20000E-01) FCM    (CC 31-40)


 CQC VERTICAL SEISMIC


TABLE NUMBER FOR X-DIRECTION SHOCK           = (      0)            ISTX   (CC  2- 5)
TABLE NUMBER FOR Y-DIRECTION SHOCK           = (      1)            ISTY   (CC  6-10)
TABLE NUMBER FOR Z-DIRECTION SHOCK           = (      0)            ISTZ   (CC 11-15)

SCALE FACTOR FOR X-DIRECTION SHOCK           = (       .10000E+01) FACX   (CC 21-30)
SCALE FACTOR FOR Y-DIRECTION SHOCK           = (       .33000E+00) FACY   (CC 31-40)
SCALE FACTOR FOR Z-DIRECTION SHOCK           = (       .10000E+01) FACZ   (CC 41-50)
```

```
R E S P O N S E   C A S E   C O N T R O L     (RESPONSE CASE   7)

 NAS MOFFETT FIELD
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46

SPECTRUM ANALYSIS CASE NUMBER                = (      7)          ICASE  (CC 16-20)

COMBINATION METHOD FOR MODAL COMPONENTS      = (      0)          IMC    (CC 21-25)
  EQ. 0, ROOT-SUM-SQUARES
  EQ. 1, ABSOLUTE SUM
  EQ. 2, CLOSELY-SPACED MODES
  EQ. 3, IMPACT METHOD
  EQ. 4, NRL METHOD
  EQ. 5, NRC 10 PCT METHOD
  EQ. 6, NRC DOUBLE SUM
  EQ. 7, CQC METHOD

PARAMETER ASSOCIATED WITH COMBINATION METHOD= (      0.         ) FCM    (CC 31-40)


 SRSS 1.0*HORIZ SIES + 0.3*VERT SEIS

TABLE NUMBER FOR X-DIRECTION SHOCK           = (      1)          ISTX   (CC  2- 5)
TABLE NUMBER FOR Y-DIRECTION SHOCK           = (      1)          ISTY   (CC  6-10)
TABLE NUMBER FOR Z-DIRECTION SHOCK           = (      0)          ISTZ   (CC 11-15)

SCALE FACTOR FOR X-DIRECTION SHOCK           = (      .50000E+00) FACX   (CC 21-30)
SCALE FACTOR FOR Y-DIRECTION SHOCK           = (      .11000E+00) FACY   (CC 31-40)
SCALE FACTOR FOR Z-DIRECTION SHOCK           = (      .10000E+01) FACZ   (CC 41-50)
```

```
R E S P O N S E   C A S E   C O N T R O L     (RESPONSE CASE   8)

 NAS MOFFETT FIELD
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46

SPECTRUM ANALYSIS CASE NUMBER                 = (     8)          ICASE  (CC 16-20)

COMBINATION METHOD FOR MODAL COMPONENTS       = (     0)          IMC    (CC 21-25)
  EQ. 0, ROOT-SUM-SQUARES
  EQ. 1, ABSOLUTE SUM
  EQ. 2, CLOSELY-SPACED MODES
  EQ. 3, IMPACT METHOD
  EQ. 4, NRL METHOD
  EQ. 5, NRC 10 PCT METHOD
  EQ. 6, NRC DOUBLE SUM
  EQ. 7, CQC METHOD

PARAMETER ASSOCIATED WITH COMBINATION METHOD= (     0.          ) FCM    (CC 31-40)


 SRSS .3*HORIZ SEIS + 1.0*VERT SEIS


TABLE NUMBER FOR X-DIRECTION SHOCK            = (     1)          ISTX   (CC  2- 5)
TABLE NUMBER FOR Y-DIRECTION SHOCK            = (     1)          ISTY   (CC  6-10)
TABLE NUMBER FOR Z-DIRECTION SHOCK            = (     0)          ISTZ   (CC 11-15)

SCALE FACTOR FOR X-DIRECTION SHOCK            = (      .17000E+00) FACX  (CC 21-30)
SCALE FACTOR FOR Y-DIRECTION SHOCK            = (      .33000E+00) FACY  (CC 31-40)
SCALE FACTOR FOR Z-DIRECTION SHOCK            = (      .10000E+01) FACZ  (CC 41-50)
```

```
R E S P O N S E   S P E C T R U M   A N A L Y S I S   ( R S A )   O U T P U T

 NAS MOFFETT FIELD
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46

FLAG FOR SAVING STRESS/DISPLACEMENT
TRANSFORMATIONS ON DISC                    = (     0)          IS     (CC    20)
FLAG FOR SAVING SYSTEM MODAL
DISPLACEMENTS ON DISC                      = (     0)          ID     (CC    25)
  EQ. 0, NOTHING WRITTEN
  EQ. 1, WRITE TAPE15 DISC FILE

CONTROL FOR PRINTING OF SUMMARY LINE       = (     0)          IPSL   (CC 26-30)
  EQ. 0, MAXIMUM RESULTANT
  EQ. 1, SUM  OF RESULTANTS
  EQ. 2, ROOT-SUM-SQUARE


  OUTPUT   FORMAT     O U T P U T   R E Q U E S T   Q U A N T I T I E S
 CATEGORY  CONTROL     COL.1 COL.2 COL.3 COL.4 COL.5 COL.6 COL.7 COL.8

    NODE         0     XT    YT    ZT    XR    YR    ZR
                         D     D     D     D     D     D

    BEAM         0     E1    E1    E1    E2    E1    E1    E2    E2
                         PX    VY    MZ    MZ    S1    S2    S1    S2
```

```
NAS MOFFETT FIELD
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46

S U M M A R Y   (DYNAMIC ANALYSIS)

NUMBER OF NODES                                       27

NUMBER OF BEAMS                                       26
NUMBER OF MEMBRANES                                    0
NUMBER OF SHELLS                                       0
NUMBER OF SOLIDS                                       0
NUMBER OF PIPES                                        0

INITIAL NODAL BANDWIDTH                               14
  FINAL NODAL BANDWIDTH                                3

RMS BANDWIDTH                                          6

NUMBER OF DELETED    DEGREES OF FREEDOM               81
NUMBER OF RESTRAINED  DEGREES OF FREEDOM               6
NUMBER OF CONSTRAINED DEGREES OF FREEDOM               6

EIGENVALUE ALGORITHM  = (SUBSPACE ITERATION)
NUMBER OF EIGENVALUES REQUESTED                       16
SUBSPACE ORDER                                        24
EIGENVECTOR BLOCKING FACTOR FOR REDUCTION              9

NUMBER OF MASS DEGREES OF FREEDOM                     42

NUMBER OF EQUATIONS                                   75
BANDWIDTH (DEGREES OF FREEDOM)                         9
```

```
C O R E   A L L O C A T I O N   (DYNAMIC JOB)

 NAS MOFFETT FIELD
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46

                          NUMBER OF      /S U B S P A C E     I T E R A T I O N/
MAXIMUM CORE TO BE      EIGENVALUES       - - - - - - - -     - - - - - - - - - -
ALLOTTED FOR EASE2     AVAILABLE BY      NUMBER OF   NUMBER OF   NUMBER OF VEC-
EXECUTION (*ICORE*      DETERMINANT      EQUATIONS   EQUATION     TORS REDUCED
ENTRY, EASE2 CARD)           SEARCH      PER BLOCK     BLOCKS     CONCURRENTLY

            150000              ALL              9          9               24

CORE ALLOCATION IS BASED ON THE LAST LINE PRINTED.
THE MAXIMUM NUMBER OF EIGENVALUES WHICH COULD BE
EXTRACTED AT THIS CORE VALUE IS ( 42).

***  N O T E  **
CONVERGENCE WILL OCCUR IN ONE ITERATION IF THE SUBSPACE ORDER (EIGENVALUES CARD, IQ, CC 41-45)
IS SET EQUAL TO THE NUMBER OF MASS DEGREES OF FREEDOM ( 42).
```

```
                             XXXXXXXXXXXX    XXXXXXXXXXXX    XXXXXXXXXXXX
                            XXXXXXXXXXXX    XXXXXXXXXXXX    XXXXXXXXXXXX
                           XXXX            XXXX    XXXX    XXXX
                          XXXX            XXXX    XXXX    XXXX
                         XXXXXXXX        XXXXXXXXXXXX    XXXX
                        XXXXXXXX        XXXXXXXXXXXX    XXXX
                       XXXX            XXXX    XXXX    XXXX
                      XXXX            XXXX    XXXX    XXXX
                     XXXXXXXXXXXX    XXXX    XXXX    XXXXXXXXXXXX
                    XXXXXXXXXXXX    XXXX    XXXX    XXXXXXXXXXXX

         XXXXXXXXXXXX    XXXXXXXXXXXX    XXXXXXXXXXXX    XXXXXXXXXXXX     XXXXXXXXXX
        XXXXXXXXXXXX    XXXXXXXXXXXX    XXXXXXXXXXXX    XXXXXXXXXXXX    XXXXXXXXXXXX
       XXXX            XXXX    XXXX    XXXX            XXXX            XXX      XXX
      XXXX            XXXX    XXXX    XXXX            XXXX                    XXXX
     XXXXXXXX        XXXXXXXXXXXX    XXXXXXXXXXXX    XXXXXXXX              XXXX
    XXXXXXXX        XXXXXXXXXXXX    XXXXXXXXXXXX    XXXXXXXX            XXXX
   XXXX            XXXX    XXXX            XXXX    XXXX              XXXX
  XXXX            XXXX    XXXX            XXXX    XXXX            XXXXX
 XXXXXXXXXXXX    XXXX    XXXX    XXXXXXXXXXXX    XXXXXXXXXXXX    XXXXXXXXXXXX
XXXXXXXXXXXX    XXXX    XXXX    XXXXXXXXXXXX    XXXXXXXXXXXX    XXXXXXXXXXXX

                        (EASE2 VERSION 13.4  -  19MAR82)
```

```
STARTING SUBSPACE INFORMATION

NAS MOFFETT FIELD
RESPONSE SPECTRUM ANALYSIS OF HANGAR 46                                                        PAGE     1
                                                                                                18 MAR 83

COMPOSITION OF THE ( 24) WORKING VECTORS

    TOTAL NUMBER OF WORKING VECTORS                    +( 24)   IQ
    NUMBER OF INITIAL VECTORS READ FROM TAPE           -(  0)   IPO
    NUMBER OF USER-SUPPLIED GUYAN VECTORS              -(  0)   IGUYAN
    NUMBER OF RANDOMLY SELECTED VECTORS                +(  0)   IRANDOM
    NUMBER OF VECTORS SELECTED BY M/K RATIOS           +( 23)   IMOK
    RESERVED VECTOR                                    -(  1)   I1
                                                       ------
    NUMBER OF VECTORS TO BE SELECTED
     BY THE PROGRAM                                    =( 23) = IQ-IPO-IGUYAN+IRANDOM+IMOK-I1

EQUATION NUMBER CORRESPONDING TO THE NON-ZERO ELEMENT IN EACH OF THE ( 23) PROGRAM-SELECTED TRIAL VECTORS

   VECTOR   DEGREE OF FREEDOM

       1                8
       2                7
       3               13
       4               16
       5               17
       6               19
       7               22
       8               25
       9               35
      10               32
      11               29
      12               38
      13               41
      14               44
      15               47
      16               52
      17               49
      18               61
      19               58
      20               55
      21               65
      22               68
      23               67
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A U X I L I A R Y   D A T A   C O M P U T E D   D U R I N G   E A C H   I T E R A T I O N

 NAS MOFFETT FIELD
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46

ITERATION NUMBER                      = ( 1)
SWEEPS REQUIRED FOR DIAGONALIZATION = (10)
EIGENVALUES AND (CONVERGENCE TOLERANCE)

(  1 -  5)  .757581E+02( .100E+01)  .323320E+03( .100E+01)  .467966E+03( .100E+01)  .501513E+03( .100E+01)  .917944E+03( .100E+01)
(  6 - 10)  .124595E+04( .100E+01)  .172001E+04( .100E+01)  .264100E+04( .100E+01)  .314275E+04( .100E+01)  .405619E+04( .100E+01)
( 11 - 15)  .538721E+04( .100E+01)  .671587E+04( .100E+01)  .820513E+04( .100E+01)  .952332E+04( .100E+01)  .111140E+05( .100E+01)
( 16 - 20)  .118646E+05( .100E+01)  .124749E+05( .100E+01)  .128827E+05( .100E+01)  .186521E+05( .100E+01)  .188492E+05( .100E+01)
( 21 - 24)  .233454E+05( .100E+01)  .537566E+05( .100E+01)  .908069E+05( .100E+01)  .908879E+05( .100E+01)

ITERATION NUMBER                      = ( 2)
SWEEPS REQUIRED FOR DIAGONALIZATION = ( 6)
EIGENVALUES AND (CONVERGENCE TOLERANCE)

(  1 -  5)  .755540E+02( .270E-02)  .323024E+03( .916E-03)  .467248E+03( .154E-02)  .499441E+03( .415E-02)  .904287E+03( .151E-01)
(  6 - 10)  .123033E+04( .127E-01)  .169463E+04( .150E-01)  .231919E+04( .139E+00)  .283242E+04( .110E+00)  .386723E+04( .489E-01)
( 11 - 15)  .520971E+04( .341E-01)  .657304E+04( .217E-01)  .795486E+04( .315E-01)  .894740E+04( .644E-01)  .101368E+05( .964E-01)
( 16 - 20)  .109358E+05( .849E-01)  .116829E+05( .678E-01)  .123465E+05( .434E-01)  .128459E+05( .452E+00)  .169534E+05( .112E+00)
( 21 - 24)  .185728E+05( .257E+00)  .185769E+05( .189E+01)  .782395E+05( .161E+00)  .902595E+05( .696E-02)

ITERATION NUMBER                      = ( 3)
SWEEPS REQUIRED FOR DIAGONALIZATION = ( 6)
EIGENVALUES AND (CONVERGENCE TOLERANCE)

(  1 -  5)  .755540E+02( .325E-07)  .323024E+03( .799E-07)  .467247E+03( .449E-06)  .499440E+03( .133E-05)  .904250E+03( .407E-04)
(  6 - 10)  .123030E+04( .290E-04)  .169430E+04( .191E-03)  .231270E+04( .281E-02)  .282969E+04( .966E-03)  .385524E+04( .311E-02)
( 11 - 15)  .520252E+04( .138E-02)  .656767E+04( .817E-03)  .793660E+04( .230E-02)  .835469E+04( .709E-01)  .945242E+04( .724E-01)
( 16 - 20)  .108332E+05( .947E-02)  .116812E+05( .143E-03)  .122288E+05( .963E-02)  .125540E+05( .232E-01)  .153659E+05( .103E+00)
( 21 - 24)  .185699E+05( .159E-03)  .185705E+05( .349E-03)  .565151E+05( .384E+00)  .889003E+05( .153E-01)

ITERATION NUMBER                      = ( 4)
SWEEPS REQUIRED FOR DIAGONALIZATION = ( 6)
EIGENVALUES AND (CONVERGENCE TOLERANCE)

(  1 -  5)  .755540E+02( .187E-12)  .323024E+03( .173E-11)  .467247E+03( .291E-11)  .499440E+03( .750E-11)  .904250E+03( .147E-08)
(  6 - 10)  .123030E+04( .895E-09)  .169430E+04( .720E-07)  .231268E+04( .885E-05)  .282967E+04( .408E-05)  .385502E+04( .563E-04)
( 11 - 15)  .520238E+04( .263E-04)  .656751E+04( .250E-04)  .793507E+04( .192E-03)  .830217E+04( .633E-02)  .942717E+04( .268E-02)
( 16 - 20)  .108294E+05( .355E-03)  .116812E+05( .287E-05)  .122176E+05( .916E-03)  .125377E+05( .130E-02)  .152324E+05( .876E-02)
( 21 - 24)  .185697E+05( .680E-05)  .185699E+05( .279E-04)  .363320E+05( .556E+00)  .822273E+05( .812E-01)

ITERATION NUMBER                      = ( 5)
SWEEPS REQUIRED FOR DIAGONALIZATION = ( 6)
EIGENVALUES AND (CONVERGENCE TOLERANCE)

(  1 -  5)  .755540E+02( .782E-13)  .323024E+03( .124E-11)  .467247E+03( .510E-11)  .499440E+03( .708E-11)  .904250E+03( .168E-08)
(  6 - 10)  .123030E+04( .844E-09)  .169430E+04( .629E-07)  .231268E+04( .430E-08)  .282967E+04( .273E-08)  .385502E+04( .110E-06)
( 11 - 15)  .520238E+04( .486E-07)  .656751E+04( .854E-07)  .793506E+04( .129E-05)  .829921E+04( .356E-03)  .942540E+04( .187E-03)
( 16 - 20)  .108291E+05( .287E-04)  .116812E+05( .123E-06)  .122165E+05( .925E-04)  .125357E+05( .164E-03)  .152189E+05( .891E-03)
( 21 - 24)  .185697E+05( .945E-06)  .185698E+05( .870E-05)  .291859E+05( .245E+00)  .634578E+05( .296E+00)
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S U B S P A C E   I T E R A T I O N   R E S U L T S

 NAS MOFFETT FIELD                                                                                                    PAGE    3
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46                                                                             18 MAR 83

SUBSPACE ITERATION EIGENVALUE ANALYSIS PERFORMED USING A SHIFT VALUE OF ( 0.          ).
RELATIVE TOLERANCE ( .10000E-02) ACHIEVED AFTER (  5) CYCLES OF ITERATION.

              CONVERGED EIGENVALUES                                   UNCONVERGED EIGENVALUES
   ROOT     BEFORE SHIFT IS APPLIED    CONVERGENCE        ROOT      BEFORE SHIFT IS APPLIED    CONVERGENCE
  NUMBER     (RADIANS/UNIT TIME)**2     TOLERANCE        NUMBER      (RADIANS/UNIT TIME)**2     TOLERANCE

      1         .75553962710364E+02     .78245E-13          23         .29185904637496E+05     .24485E+00
      2         .32302416544263E+03     .12388E-11          24         .63457761107228E+05     .29578E+00
      3         .46724738943152E+03     .50998E-11
      4         .49944024102531E+03     .70802E-11
      5         .90425028678185E+03     .16772E-08
      6         .12302961376685E+04     .84449E-09
      7         .16943019572561E+04     .62893E-07
      8         .23126819341187E+04     .42998E-08
      9         .28296736114702E+04     .27326E-08
     10         .38530198587028E+04     .11046E-06
     11         .52023806443090E+04     .48584E-07
     12         .65675055353305E+04     .85355E-07
     13         .79350594515619E+04     .12904E-05
     14         .82992123675842E+04     .35593E-03
     15         .94254045941756E+04     .18702E-03
     16         .10829088663086E+05     .28654E-04
     17         .11681201744745E+05     .12324E-06
     18         .12216477625899E+05     .92462E-04
     19         .12535652791977E+05     .16441E-03
     20         .15218854500175E+05     .89123E-03
     21         .18569730567210E+05     .94487E-06
     22         .18569772898894E+05     .87003E-05
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E I G E N V A L U E   T A B L E

 NAS MOFFETT FIELD
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46

  ROOT    E I G E N V A L U E S   CIRCULAR FREQUENCY           FREQUENCY            PERIOD
 NUMBER  (RADIANS/UNIT TIME)**2  (RADIANS/UNIT TIME)   (CYCLES/UNIT TIME)   (TIME/ONE CYCLE)

    1      .75553962710364E+02         .869218E+01               1.3834            .722855
    2      .32302416544263E+03         .179729E+02               2.8605            .349593
    3      .46724738943152E+03         .216159E+02               3.4403            .290674
    4      .49944024102531E+03         .223482E+02               3.5568            .281150
    5      .90425028678185E+03         .300708E+02               4.7859            .208947
    6      .12302961376685E+04         .350756E+02               5.5825            .179133
    7      .16943019572561E+04         .411619E+02               6.5511            .152646
    8      .23126819341187E+04         .480904E+02               7.6538            .130654
    9      .28296736114702E+04         .531947E+02               8.4662            .118117
   10      .38550198587028E+04         .620888E+02               9.8817            .101197
   11      .52023806443090E+04         .721275E+02              11.4795            .087112
   12      .65675055353305E+04         .810401E+02              12.8979            .077532
   13      .79350594515619E+04         .890790E+02              14.1774            .070535
   14      .82992123675842E+04         .911000E+02              14.4990            .068970
   15      .94254045941756E+04         .970845E+02              15.4515            .064719
   16      .10829088663086E+05         .104063E+03              16.5621            .060379
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N O D E / E Q U A T I O N   C O R R E S P O N D E N C E   T A B L E

 NAS MOFFETT FIELD
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46

THE TABLE RELATES REFERENCED EQUATIONS TO EXTERNAL DEGREES OF FREEDOM

 EQUATION      NODE      NODAL
   NUMBER    NUMBER        DOF

        8        30          2
        7        30          1
       13       102          1
       16       104          1
       17       104          2
       19       106          1
       22       108          1
       25       110          1
       35       116          2
       32       114          2
       29       112          2
       38       118          2
       41       216          2
       44       214          2
       47       212          2
       52       208          1
       49       210          1
       61       202          1
       58       204          1
       55       206          1
       65        80          2
       68        70          2
       67        70          1
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E I G E N V E C T O R S                                                                                          PAGE    6
                                                                                                                 18 MAR 83
 NAS MOFFETT FIELD
 RESPONSE SPECTRUM ANALYSIS OF HANGAR 46

NOTE -  FOR CYLINDRICAL SYSTEMS (X*,Y*) CORRESPOND TO RADIAL AND TANGENTIAL
COMPONENTS REFERENCED TO THE INITIAL THETA COORDINATE OF THE NODE.

                COORDINATE          X (OR X*)     Y (OR Y*)     Z (OR Z*)     X (OR X*)     Y (OR Y*)     Z (OR Z*)
 NODE           SYSTEM EIGEN-     TRANSLATIONAL TRANSLATIONAL TRANSLATIONAL   ROTATIONAL    ROTATIONAL    ROTATIONAL
NUMBER     NUMBER/TYPE VECTOR       COMPONENT     COMPONENT     COMPONENT     COMPONENT     COMPONENT     COMPONENT

  10           0/0      1          .5498E-18     .1257E-02     0.            0.            0.             .4730E-03
                        2          .2416E-17     .3341E-02     0.            0.            0.            -.1217E-01
                        3         -.3956E-17    -.3611E-02     0.            0.            0.             .3210E-01
                        4         -.3045E-17    -.1923E-02     0.            0.            0.             .3025E-01
                        5         -.1054E-18     .1883E-02     0.            0.            0.             .1376E-01
                        6          .1794E-18     .2540E-02     0.            0.            0.             .1472E-01
                        7          .3297E-18     .1668E-02     0.            0.            0.             .5932E-02
                        8          .2108E-17     .6091E-02     0.            0.            0.             .1109E-01
                        9          .7450E-18     .1131E-02     0.            0.            0.            -.2223E-02
                       10         -.9030E-18    -.3007E-02     0.            0.            0.            -.6797E-02
                       11         -.6341E-18    -.2442E-02     0.            0.            0.            -.5938E-02
                       12          .1498E-17     .4128E-02     0.            0.            0.             .6003E-02

  20           0/0      1         -.1479E-03    -.1544E-02     0.            0.            0.             .3984E-03
                        2          .2650E-02    -.3841E-02     0.            0.            0.            -.1211E-01
                        3         -.7147E-02     .4693E-02     0.            0.            0.             .3168E-01
                        4         -.6794E-02     .1916E-02     0.            0.            0.             .2978E-01
                        5         -.3180E-02    -.2526E-02     0.            0.            0.             .1340E-01
                        6         -.3268E-02     .5951E-02     0.            0.            0.             .1432E-01
                        7         -.1468E-02    -.6399E-02     0.            0.            0.             .5725E-02
                        8         -.2489E-02     .6086E-02     0.            0.            0.             .1059E-01
                        9          .6504E-03     .1054E-01     0.            0.            0.            -.2220E-02
                       10          .1565E-02     .5440E-02     0.            0.            0.            -.6506E-02
                       11          .1477E-02     .6278E-02     0.            0.            0.            -.5689E-02
                       12         -.1463E-02    -.3262E-02     0.            0.            0.             .5672E-02

  30           0/0      1         -.5428E-02     .6137E-02     0.            0.            0.            -.2873E-03
                        2          .2249E+00    -.7460E-01     0.            0.            0.            -.8680E-04
                        3         -.5817E+00     .2092E+00     0.            0.            0.            -.7818E-03
                        4         -.5441E+00     .2004E+00     0.            0.            0.            -.1108E-02
                        5         -.2409E+00     .9759E-01     0.            0.            0.            -.1085E-02
                        6         -.2627E+00     .1080E+00     0.            0.            0.            -.4566E-03
                        7         -.9894E-01     .4298E-01     0.            0.            0.            -.1020E-02
                        8         -.1925E+00     .9289E-01     0.            0.            0.            -.6326E-03
                        9          .3433E-01    -.9357E-02     0.            0.            0.             .9152E-03
                       10          .1129E+00    -.5263E-01     0.            0.            0.             .1116E-02
                       11          .9791E-01    -.4509E-01     0.            0.            0.             .1089E-02
                       12         -.9846E-01     .5078E-01     0.            0.            0.            -.1001E-02

  40           0/0      1         -.5080E-02    -.3726E-02     0.            0.            0.            -.2999E-03
                        2          .2258E+00    -.9120E-02     0.            0.            0.            -.4060E-03
                        3         -.5826E+00     .1095E-01     0.            0.            0.            -.3529E-04
                        4         -.5446E+00     .4278E-02                   0.            0.            -.4301E-03
                        5         -.2403E+00    -.6243E-02                   0.            0.            -.8262E-03
                        6          .252           141A                                                        2E-0
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             COORDINATE              X (OR X*)       Y (OR Y*)       Z (OR Z*)       X (OR X*)       Y (OR Y*)       Z (OR Z*)
   NODE          SYSTEM EIGEN-   TRANSLATIONAL   TRANSLATIONAL   TRANSLATIONAL      ROTATIONAL      ROTATIONAL      ROTATIONAL
 NUMBER     NUMBER/TYPE VECTOR       COMPONENT       COMPONENT       COMPONENT       COMPONENT       COMPONENT       COMPONENT

                            11       .9714E-01       .1520E-01   0.              0.              0.                  .1003E-02
                            12      -.9720E-01      -.7928E-02   0.              0.              0.                 -.9537E-03

     50             0/0      1      -.1479E-03       .1544E-02   0.              0.              0.                  .3984E-03
                             2      -.2550E-02      -.3841E-02   0.              0.              0.                  .1211E-01
                             3      -.7147E-02      -.4693E-02   0.              0.              0.                  .3168E-01
                             4       .6794E-02       .1915E-02   0.              0.              0.                 -.2978E-01
                             5      -.3180E-02       .2532E-02   0.              0.              0.                  .1340E-01
                             6       .3268E-02       .5957E-02   0.              0.              0.                 -.1432E-01
                             7       .1468E-02      -.6436E-02   0.              0.              0.                 -.5726E-02
                             8      -.2489E-02      -.6095E-02   0.              0.              0.                  .1059E-01
                             9       .6507E-03      -.1055E-01   0.              0.              0.                 -.2220E-02
                            10      -.1564E-02       .5383E-02   0.              0.              0.                  .6504E-02
                            11       .1475E-02      -.6223E-02   0.              0.              0.                 -.5688E-02
                            12       .1462E-02      -.3172E-02   0.              0.              0.                 -.5670E-02

     60             0/0      1       .5498E-18      -.1257E-02   0.              0.              0.                  .4730E-03
                             2      -.2416E-17       .3341E-02   0.              0.              0.                  .1217E-01
                             3      -.3956E-17       .3611E-02   0.              0.              0.                  .3210E-01
                             4       .3045E-17      -.1923E-02   0.              0.              0.                 -.3025E-01
                             5      -.1049E-18      -.1884E-02   0.              0.              0.                  .1376E-01
                             6      -.1809E-18       .2543E-02   0.              0.              0.                 -.1472E-01
                             7      -.3200E-18       .1648E-02   0.              0.              0.                 -.5932E-02
                             8       .2106E-17      -.6086E-02   0.              0.              0.                  .1109E-01
                             9       .7432E-18      -.1127E-02   0.              0.              0.                 -.2224E-02
                            10       .9152E-18      -.3032E-02   0.              0.              0.                  .6797E-02
                            11      -.6915E-18       .2436E-02   0.              0.              0.                 -.5936E-02
                            12      -.1516E-17       .4165E-02   0.              0.              0.                 -.6003E-02

     70             0/0      1      -.5080E-02       .3726E-02   0.              0.              0.                 -.2999E-03
                             2      -.2258E+00      -.9120E-02   0.              0.              0.                  .4060E-03
                             3      -.5926E+00      -.1095E-01   0.              0.              0.                 -.3531E-04
                             4       .5446E+00       .4277E-02   0.              0.              0.                  .4301E-03
                             5      -.2403E+00       .6256E-02   0.              0.              0.                 -.8269E-03
                             6       .2520E+00       .1419E-01   0.              0.              0.                  .2060E-03
                             7       .9845E-01      -.1558E-01   0.              0.              0.                  .9180E-03
                             8      -.1908E+00      -.1456E-01   0.              0.              0.                 -.5303E-03
                             9       .3463E-01      -.2546E-01   0.              0.              0.                  .8283E-03
                            10      -.1120E+00       .1305E-01   0.              0.              0.                 -.1022E-02
                            11       .9715E-01      -.1506E-01   0.              0.              0.                  .9975E-03
                            12       .9718E-01      -.7712E-02   0.              0.              0.                  .9506E-03

     80             0/0      1      -.5428E-02      -.6137E-02   0.              0.              0.                 -.2873E-03
                             2      -.2249E+00      -.7460E-01   0.              0.              0.                  .8680E-04
                             3      -.5817E+00      -.2092E+00   0.              0.              0.                 -.7819E-03
                             4       .5441E+00       .2004E+00   0.              0.              0.                  .1108E-02
                             5      -.2409E+00      -.9759E-01   0.              0.              0.                 -.1085E-02
                             6       .2627E+00       .1090E+00   0.              0.              0.                  .4563E-03
                             7       .9894E-01       .4291E-01   0.              0.              0.                  .1022E-02
                             8      -.1925E+00      -.9287E-01   0.              0.              0.                 -.6312E-03
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NAS MOFFETT FIELD
RESPONSE SPECTRUM ANALYSIS OF HANGAR 46

                COORDINATE               X (OR X*)      Y (OR Y*)      Z (OR Z*)      X (OR X*)      Y (OR Y*)      Z (OR Z*)
   NODE            SYSTEM EIGEN-   TRANSLATIONAL  TRANSLATIONAL  TRANSLATIONAL     ROTATIONAL     ROTATIONAL     ROTATIONAL
  NUMBER      NUMBER/TYPE VECTOR       COMPONENT      COMPONENT      COMPONENT      COMPONENT      COMPONENT      COMPONENT

                               9      .3433E-01      .9369E-02     0.             0.             0.               .9165E-03
                              10     -.1129E+00     -.5271E-01     0.             0.             0.             -.1113E-02
                              11      .9791E-01      .4508E-01     0.             0.             0.               .1084E-02
                              12      .9845E-01      .5090E-01     0.             0.             0.               .9973E-03

    100              0/0       1     -.5250E-02      .1085E-02     0.             0.             0.             -.5064E-03
                               2      .2254E+00     -.4106E-01     0.             0.             0.               .3362E-02
                               3     -.5822E+00      .1077E+00     0.             0.             0.             -.1018E-01
                               4     -.5443E+00      .9996E-01     0.             0.             0.             -.1007E-01
                               5     -.2406E+00      .4441E-01     0.             0.             0.             -.5331E-02
                               6     -.2523E+00      .5996E-01     0.             0.             0.             -.4819E-02
                               7     -.9868E-01      .1303E-01     0.             0.             0.             -.3002E-02
                               8     -.1916E+00      .5276E-01     0.             0.             0.             -.4023E-02
                               9      .3449E-01      .8463E-02     0.             0.             0.               .1786E-02
                              10      .1124E+00     -.1892E-01     0.             0.             0.               .3379E-02
                              11      .9751E-01     -.1421E-01     0.             0.             0.               .3096E-02
                              12     -.9781E-01      .2071E-01     0.             0.             0.             -.3014E-02

    102              0/0       1      .5733E-01     -.1753E-01     0.             0.             0.             -.2746E-02
                               2      .2972E+00     -.5716E-01     0.             0.             0.             -.3761E-03
                               3     -.4958E+00      .7412E-01     0.             0.             0.             -.7902E-02
                               4     -.3653E+00      .3483E-01     0.             0.             0.             -.1067E-01
                               5      .3020E-01     -.4203E-01     0.             0.             0.             -.9386E-02
                               6     -.1202E+00      .7048E-01     0.             0.             0.             -.4038E-02
                               7      .2057E+00     -.1079E+00     0.             0.             0.             -.7783E-02
                               8      .7489E-01      .5411E-01     0.             0.             0.             -.4761E-02
                               9     -.2521E+00      .1731E+00     0.             0.             0.               .5933E-02
                              10     -.3535E+00      .1347E+00     0.             0.             0.               .6488E-02
                              11     -.4167E+00      .1637E+00     0.             0.             0.               .5095E-02
                              12      .4591E+00     -.1396E+00     0.             0.             0.             -.3639E-02

    104              0/0       1      .1962E+00     -.6614E-01     0.             0.             0.             -.5143E-02
                               2      .4402E+00     -.1040E+00     0.             0.             0.             -.2933E-02
                               3     -.3724E+00      .2615E-01     0.             0.             0.             -.6291E-02
                               4     -.9613E-01     -.8030E-01     0.             0.             0.             -.1102E-01
                               5      .4224E+00     -.1943E+00     0.             0.             0.             -.1009E-01
                               6      .2570E-03      .9648E-01     0.             0.             0.             -.8984E-03
                               7      .5981E+00     -.2902E+00     0.             0.             0.             -.7055E-02
                               8      .2890E+00      .8207E-01     0.             0.             0.             -.4172E-03
                               9     -.5787E+00      .3832E+00     0.             0.             0.               .3363E-02
                              10     -.6757E+00      .2632E+00     0.             0.             0.             -.8586E-03
                              11     -.6300E+00      .2597E+00     0.             0.             0.             -.4514E-02
                              12      .5380E+00     -.1451E+00     0.             0.             0.               .7344E-02

    106              0/0       1      .3482E+00     -.1470E+00     0.             0.             0.             -.6351E-02
                               2      .5691E+00     -.1584E+00     0.             0.             0.             -.1751E-02
                               3     -.2835E+00     -.3835E-01     0.             0.             0.             -.5722E-02
                               4      .1649E+00     -.2251E+00     0.             0.             0.             -.9137E-02
                               5      .6776E+00     -.3215E+00     0.             0.             0.             -.3142E-02
                               6     -.2683E-01      .1997E+00     0.             0.             0.               .3899E-02
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              COORDINATE               X (OR X*)      Y (OR Y*)      Z (OR Z*)      X (OR X*)      Y (OR Y*)      Z (OR Z*)
  NODE            SYSTEM EIGEN-     TRANSLATIONAL  TRANSLATIONAL  TRANSLATIONAL    ROTATIONAL     ROTATIONAL     ROTATIONAL
 NUMBER      NUMBER/TYPE VECTOR       COMPONENT      COMPONENT      COMPONENT      COMPONENT      COMPONENT      COMPONENT

                              7        .7168E+00     -.3829E+00     0.             0.             0.              .2971E-02
                              8        .1829E+00      .2681E+00     0.             0.             0.              .6639E-02
                              9       -.5090E+00      .4442E+00     0.             0.             0.             -.7445E-02
                             10       -.3137E+00      .7890E-01     0.             0.             0.             -.1302E-01
                             11       -.3847E-01     -.2994E-01     0.             0.             0.             -.1391E-01
                             12       -.2054E+00      .2594E+00     0.             0.             0.              .1174E-01

   108               0/0      1        .5114E+00     -.2453E+00     0.             0.             0.             -.5707E-02
                              2        .6131E+00     -.1734E+00     0.             0.             0.              .2124E-02
                              3       -.1542E+00     -.1194E+00     0.             0.             0.             -.5275E-02
                              4        .3491E+00     -.3482E+00     0.             0.             0.             -.5036E-02
                              5        .6345E+00     -.2896E+00     0.             0.             0.              .6289E-02
                              6       -.1755E+00      .3804E+00     0.             0.             0.              .6041E-02
                              7        .3822E+00     -.2066E+00     0.             0.             0.              .1164E-01
                              8       -.1445E+00      .5920E+00     0.             0.             0.              .6218E-02
                              9        .5448E-01      .1860E+00     0.             0.             0.             -.1198E-01
                             10        .4577E+00     -.3900E+00     0.             0.             0.             -.8785E-02
                             11        .6524E+00     -.4354E+00     0.             0.             0.             -.3271E-02
                             12       -.5474E+00      .4722E+00     0.             0.             0.             -.2911E-02

   110               0/0      1        .6302E+00     -.3324E+00     0.             0.             0.             -.3539E-02
                              2        .5173E+00     -.8672E-01     0.             0.             0.              .6893E-02
                              3       -.5153E-01     -.2114E+00     0.             0.             0.             -.3954E-02
                              4        .3867E+00     -.3849E+00     0.             0.             0.              .4128E-03
                              5        .2742E+00     -.9578E-02     0.             0.             0.              .1287E-01
                              6       -.3237E+00      .5874E+00     0.             0.             0.              .4755E-02
                              7       -.1945E+00      .1963E+00     0.             0.             0.              .1098E-01
                              8       -.2755E+00      .8050E+00     0.             0.             0.             -.2374E-02
                              9        .5564E+00     -.1028E+00     0.             0.             0.             -.4348E-02
                             10        .4753E+00     -.3802E+00     0.             0.             0.              .7339E-02
                             11        .7572E-01      .3689E-01     0.             0.             0.              .9260E-02
                             12        .5015E+00     -.3458E+00     0.             0.             0.             -.6438E-02

   112               0/0      1        .6730E+00     -.3692E+00     0.             0.             0.             -.1775E-03
                              2        .3186E+00      .1254E+00     0.             0.             0.              .1038E-01
                              3        .1017E-01     -.2768E+00     0.             0.             0.             -.1323E-02
                              4        .2811E+00     -.2897E+00     0.             0.             0.              .5312E-02
                              5       -.1322E+00      .3912E+00     0.             0.             0.              .1159E-01
                              6       -.3303E+00      .7095E+00     0.             0.             0.              .8791E-03
                              7       -.4500E+00      .3705E+00     0.             0.             0.             -.4287E-03
                              8        .3590E-01      .6151E+00     0.             0.             0.             -.1215E-01
                              9        .4227E+00      .1382E+00     0.             0.             0.              .6726E-02
                             10       -.2433E+00      .3602E+00     0.             0.             0.              .1186E-01
                             11       -.5191E+00      .6493E+00     0.             0.             0.             -.4219E-03
                             12        .4158E+00     -.2811E+00     0.             0.             0.              .8484E-02

   114               0/0      1        .6475E+00     -.3263E+00     0.             0.             0.              .3391E-02
                              2        .1229E+00      .4135E+00     0.             0.             0.              .1025E-01
                              3        .5118E-02     -.2711E+00     0.             0.             0.              .2008E-02
                              4        .1280E+00     -.8987E-01     0.             0.             0.              .7005E-02
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           COORDINATE            X (OR X*)     Y (OR Y*)     Z (OR Z*)     X (OR X*)     Y (OR Y*)     Z (OR Z*)
 NODE         SYSTEM EIGEN-  TRANSLATIONAL TRANSLATIONAL TRANSLATIONAL    ROTATIONAL    ROTATIONAL    ROTATIONAL
NUMBER   NUMBER/TYPE VECTOR      COMPONENT     COMPONENT     COMPONENT     COMPONENT     COMPONENT     COMPONENT

                          5     -.3155E+00     .6333E+00  0.            0.            0.             .2178E-02
                          6     -.2136E+00     .6868E+00  0.            0.            0.            -.2393E-02
                          7     -.2780E+00     .7467E-01  0.            0.            0.            -.1195E-01
                          8      .4373E+00     .1733E+00  0.            0.            0.            -.1335E-01
                          9      .9683E-01     .6842E+00  0.            0.            0.             .4494E-02
                         10     -.4522E+00     .6669E+00  0.            0.            0.            -.3163E-02
                         11     -.8548E-01     .5442E-01  0.            0.            0.            -.1308E-01
                         12     -.2626E+00     .6013E+00  0.            0.            0.             .4277E-02

  116             0/0     1      .5949E+00    -.1934E+00  0.            0.            0.             .5971E-02
                          2      .1498E-01     .6778E+00  0.            0.            0.             .6123E-02
                          3     -.3573E-01    -.1705E+00  0.            0.            0.             .4680E-02
                          4      .2547E-01     .1244E+00  0.            0.            0.             .4635E-02
                          5     -.2679E+00     .4921E+00  0.            0.            0.            -.8493E-02
                          6     -.8023E-01     .5708E+00  0.            0.            0.            -.2448E-02
                          7     -.3395E-01    -.5811E+00  0.            0.            0.            -.1133E-01
                          8      .6063E+00    -.1023E+00  0.            0.            0.            -.7157E-02
                          9      .8220E-01     .7620E+00  0.            0.            0.            -.9740E-02
                         10     -.1208E+00    -.8309E-01  0.            0.            0.            -.1137E-01
                         11      .2741E+00    -.7366E+00  0.            0.            0.            -.1977E-02
                         12     -.1020E+00     .7196E-01  0.            0.            0.            -.9380E-02

  118             0/0     1      .5691E+00    -.1173E-08  0.            0.            0.             .6839E-02
                          2     -.3463E-07     .7850E+00  0.            0.            0.             .4172E-09
                          3     -.6004E-01     .5147E-07  0.            0.            0.             .5624E-02
                          4      .2134E-06     .2164E+00  0.            0.            0.            -.2767E-08
                          5     -.2044E+00     .1315E-05  0.            0.            0.            -.1274E-01
                          6     -.3840E-05     .5058E+00  0.            0.            0.             .4832E-07
                          7      .2743E-04    -.9249E+00  0.            0.            0.            -.3383E-06
                          8      .6092E+00    -.5745E-05  0.            0.            0.            -.3581E-02
                          9      .1888E+00    -.4824E-05  0.            0.            0.            -.1738E-01
                         10      .6748E-04    -.6969E+00  0.            0.            0.            -.7980E-06
                         11      .1889E+00     .2957E-04  0.            0.            0.             .8848E-02
                         12     -.1018E-03    -.8756E+00  0.            0.            0.             .1190E-05

  200             0/0     1     -.5250E-02    -.1085E-02  0.            0.            0.            -.5064E-03
                          2     -.2254E+00    -.4106E-01  0.            0.            0.            -.3362E-02
                          3     -.5822E+00    -.1077E+00  0.            0.            0.            -.1018E-01
                          4      .5443E+00     .9996E-01  0.            0.            0.             .1007E-01
                          5     -.2406E+00    -.4440E-01  0.            0.            0.            -.5332E-02
                          6      .2523E+00     .5997E-01  0.            0.            0.             .4819E-02
                          7      .9869E-01     .1296E-01  0.            0.            0.             .3003E-02
                          8     -.1916E+00    -.5276E-01  0.            0.            0.            -.4021E-02
                          9      .3448E-01    -.8468E-02  0.            0.            0.             .1788E-02
                         10     -.1124E+00    -.1903E-01  0.            0.            0.            -.3376E-02
                         11      .9752E-01     .1427E-01  0.            0.            0.             .3088E-02
                         12      .9780E-01     .2088E-01  0.            0.            0.             .3009E-02

                  0/0     1      .5733E-01     .1753E-01                0.            0.            -.2746E-02
                          2     -.2972E+00    -.5716E-01                0.            0.             .3761E-03
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              COORDINATE         X (OR X*)      Y (OR Y*)      Z (OR Z*)       X (OR X*)      Y (OR Y*)      Z (OR Z*)
  NODE           SYSTEM EIGEN- TRANSLATIONAL  TRANSLATIONAL  TRANSLATIONAL    ROTATIONAL     ROTATIONAL     ROTATIONAL
 NUMBER     NUMBER/TYPE VECTOR     COMPONENT      COMPONENT      COMPONENT     COMPONENT      COMPONENT      COMPONENT

                            3    -.4958E+00     -.7412E-01     0.             0.             0.            -.7902E-02
                            4     .3553E+00      .3483E-01     0.             0.             0.             .1067E-01
                            5     .3020E-01      .4204E-01     0.             0.             0.            -.9387E-02
                            6     .1202E+00      .7049E-01     0.             0.             0.             .4038E-02
                            7    -.2057E+00     -.1080E+00     0.             0.             0.             .7784E-02
                            8     .7489E-01     -.5413E-01     0.             0.             0.            -.4760E-02
                            9    -.2521E+00     -.1731E+00     0.             0.             0.             .5934E-02
                           10     .3535E+00      .1345E+00     0.             0.             0.            -.6487E-02
                           11    -.4168E+00     -.1635E+00     0.             0.             0.             .5092E-02
                           12    -.4592E+00     -.1393E+00     0.             0.             0.             .3637E-02

   204             0/0      1     .1862E+00      .6614E-01     0.             0.             0.            -.5143E-02
                            2    -.4402E+00     -.1040E+00     0.             0.             0.             .2933E-02
                            3    -.3724E+00     -.2615E-01     0.             0.             0.            -.6291E-02
                            4     .9613E-01     -.8030E-01     0.             0.             0.             .1102E-01
                            5     .4224E+00      .1943E+00     0.             0.             0.            -.1009E-01
                            6    -.2530E-03      .9649E-01     0.             0.             0.             .8984E-03
                            7    -.5981E+00     -.2903E+00     0.             0.             0.             .7055E-02
                            8     .2890E+00     -.8210E-01     0.             0.             0.            -.4168E-03
                            9    -.5787E+00     -.3832E+00     0.             0.             0.             .3364E-02
                           10     .6758E+00      .2631E+00     0.             0.             0.             .8586E-03
                           11    -.6300E+00     -.2596E+00     0.             0.             0.            -.4515E-02
                           12    -.5381E+00     -.1448E+00     0.             0.             0.            -.7344E-02

   206             0/0      1     .3482E+00      .1470E+00     0.             0.             0.            -.6351E-02
                            2    -.5691E+00     -.1584E+00     0.             0.             0.             .1751E-02
                            3    -.2935E+00      .3835E-01     0.             0.             0.            -.5722E-02
                            4    -.1549E+00     -.2251E+00     0.             0.             0.             .9137E-02
                            5     .6776E+00      .3215E+00     0.             0.             0.            -.3142E-02
                            6     .2683E-01      .1997E+00     0.             0.             0.            -.3900E-02
                            7    -.7168E+00     -.3829E+00     0.             0.             0.            -.2970E-02
                            8     .1829E+00     -.2681E+00     0.             0.             0.             .6639E-02
                            9    -.5090E+00     -.4443E+00     0.             0.             0.            -.7445E-02
                           10     .3138E+00      .7885E-01     0.             0.             0.             .1302E-01
                           11    -.3853E-01      .3003E-01     0.             0.             0.            -.1391E-01
                           12     .2053E+00      .2594E+00     0.             0.             0.            -.1174E-01

   208             0/0      1     .5114E+00      .2453E+00     0.             0.             0.            -.5707E-02
                            2    -.6131E+00     -.1734E+00     0.             0.             0.            -.2124E-02
                            3    -.1542E+00      .1194E+00     0.             0.             0.            -.5275E-02
                            4    -.3491E+00     -.3482E+00     0.             0.             0.             .5036E-02
                            5     .6345E+00      .2896E+00     0.             0.             0.             .6289E-02
                            6     .1755E+00      .3804E+00     0.             0.             0.            -.6041E-02
                            7    -.3822E+00     -.2065E+00     0.             0.             0.            -.1164E-01
                            8    -.1944E+00     -.5920E+00     0.             0.             0.             .6218E-02
                            9     .5449E-01     -.1860E+00     0.             0.             0.            -.1198E-01
                           10    -.4577E+00     -.3899E+00     0.             0.             0.             .8786E-02
                           11     .6524E+00      .4354E+00     0.             0.             0.            -.3271E-02
                           12     .5475E+00      .4721E+00     0.             0.             0.             .2911E-02

   210             0/0      1     .6302E+00      .3324E+00     0.             0.             0.            -.3539E-02
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           COORDINATE                 X (OR X*)      Y (OR Y*)      Z (OR Z*)       X (OR X*)      Y (OR Y*)      Z (OR Z*)
  NODE          SYSTEM EIGEN-      TRANSLATIONAL  TRANSLATIONAL  TRANSLATIONAL     ROTATIONAL     ROTATIONAL     ROTATIONAL
 NUMBER    NUMBER/TYPE VECTOR          COMPONENT      COMPONENT      COMPONENT      COMPONENT      COMPONENT      COMPONENT

                            2       -.5173E+00     -.8672E-01     0.             0.             0.             -.6893E-02
                            3       -.5153E-01      .2114E+00     0.             0.             0.             -.3954E-02
                            4       -.3867E+00     -.3849E+00     0.             0.             0.             -.4128E-03
                            5        .2742E+00      .9573E-02     0.             0.             0.              .1287E-01
                            6        .3237E+00      .5874E+00     0.             0.             0.             -.4755E-02
                            7        .1945E+00      .1963E+00     0.             0.             0.             -.1098E-01
                            8       -.2755E+00     -.8049E+00     0.             0.             0.             -.2373E-02
                            9        .5564E+00      .1029E+00     0.             0.             0.             -.4348E-02
                           10       -.4754E+00     -.3801E+00     0.             0.             0.             -.7338E-02
                           11        .7695E-01     -.3695E-01     0.             0.             0.              .9259E-02
                           12       -.5014E+00     -.3460E+00     0.             0.             0.              .6437E-02

   212            0/0       1        .6730E+00      .3692E+00     0.             0.             0.             -.1775E-03
                            2       -.3186E+00      .1254E+00     0.             0.             0.             -.1038E-01
                            3        .1017E-01      .2768E+00     0.             0.             0.             -.1323E-02
                            4       -.2811E+00     -.2897E+00     0.             0.             0.             -.5312E-02
                            5       -.1322E+00     -.3912E+00     0.             0.             0.              .1159E-01
                            6        .3303E+00      .7095E+00     0.             0.             0.             -.8792E-03
                            7        .4499E+00      .3905E+00     0.             0.             0.              .4291E-03
                            8        .3588E-01     -.6151E+00     0.             0.             0.             -.1215E-01
                            9        .4227E+00     -.1382E+00     0.             0.             0.              .6726E-02
                           10        .2431E+00      .3603E+00     0.             0.             0.             -.1186E-01
                           11       -.5190E+00     -.6494E+00     0.             0.             0.             -.4231E-03
                           12       -.4157E+00     -.2812E+00     0.             0.             0.             -.8486E-02

   214            0/0       1        .6475E+00      .3263E+00     0.             0.             0.              .3391E-02
                            2       -.1229E+00      .4135E+00     0.             0.             0.             -.1025E-01
                            3        .5119E-02      .2711E+00     0.             0.             0.              .2008E-02
                            4       -.1280E+00     -.8987E-01     0.             0.             0.             -.7005E-02
                            5       -.3155E+00     -.6333E+00     0.             0.             0.              .2178E-02
                            6        .2135E+00      .6968E+00     0.             0.             0.              .2393E-02
                            7        .2780E+00      .7466E-01     0.             0.             0.              .1195E-01
                            8        .4373E+00     -.1733E+00     0.             0.             0.             -.1335E-01
                            9        .9681E-01     -.6842E+00     0.             0.             0.              .4495E-02
                           10        .4322E+00      .6669E+00     0.             0.             0.              .3163E-02
                           11       -.8537E-01     -.5448E-01     0.             0.             0.             -.1308E-01
                           12        .2526E+00      .6014E+00     0.             0.             0.             -.4277E-02

   216            0/0       1        .5949E+00      .1934E+00     0.             0.             0.              .5971E-02
                            2       -.1498E-01      .6778E+00     0.             0.             0.             -.6123E-02
                            3       -.3573E-01      .1705E+00     0.             0.             0.              .4680E-02
                            4       -.2547E-01      .1244E+00     0.             0.             0.             -.4635E-02
                            5       -.2579E+00     -.4721E+00     0.             0.             0.             -.8493E-02
                            6        .8023E-01      .5708E+00     0.             0.             0.              .2448E-02
                            7        .3398E-01     -.5811E+00     0.             0.             0.              .1133E-01
                            8        .6063E+00      .1023E+00     0.             0.             0.             -.7157E-02
                            9        .8219E-01     -.7620E+00     0.             0.             0.             -.9740E-02
                           10        .1208E+00     -.8314E-01     0.             0.             0.              .1137E-01
                           11        .2741E+00      .7366E+00     0.             0.             0.             -.1979E-02
                           12        .1019E+00      .7204E-01     0.             0.             0.              .9382E-02
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M A S S   N O D A L   P A R T I C I P A T I O N   F A C T O R S

NAS MOFFETT FIELD                                                                 PAGE    13
RESPONSE SPECTRUM ANALYSIS OF HANGAR 46                                           18 MAR 83

  MODE        GLOBAL X        GLOBAL Y        GLOBAL Z
 NUMBER       DIRECTION       DIRECTION       DIRECTION

    1      -.145538E+01     .287949E-08     0.
    2       .171267E-07    -.300473E+00     0.
    3       .169330E+01    -.359305E-06     0.
    4      -.143130E-06     .225384E+00     0.
    5       .231207E-01    -.770903E-05     0.
    6       .253967E-05    -.144610E+01     0.
    7      -.159521E-04     .483241E+00     0.
    8      -.182162E+00     .104072E-04     0.
    9      -.525522E-01     .109880E-04     0.
   10      -.238649E-04    -.732827E-01     0.
   11       .266994E-01    -.968340E-04     0.
   12       .352579E-04    -.634945E-01     0.
   13      -.207821E-01    -.318578E-03     0.
   14       .135648E-03    -.790956E+00     0.
   15       .125674E-03    -.128678E+00     0.
   16       .175534E-01     .298148E-03     0.
```

$M = \frac{W}{g} = \frac{166^{k}}{32.2} = 5.155$ k-sec²/ft

mmp²/m

		K	Y	S_a	
T	S_a				
.723	.215	.411	0	.0884	1
.35		—	.0175		2
.29	.3177	.556		.1766	3
.78		—	.0099		4
		—		.265	5
			.4057		6
.15		.006	.0353		7
			.0010		10
			.1212		14
			.0032		15
		.973	.604		

$\sqrt{\Sigma^2} = .0884$

.1766

.198 $S = .198 \times 166/2 = 16.45$ k

[illegible] 166 = 44

22 k

```
X     XX   XXXXXX   XXXXXXX   XXXXXXXX
XX    XX  XX    XX  XX    XX  XX
XXX   XX  XX    XX  XX    XX  XX
XXXX  XX  XX    XX  XX    XX  XXXXX
XX XX XX  XX    XX  XX    XX  XX
XX  XXXX  XX    XX  XX    XX  XX
XX   XXX  XX    XX  XX    XX  XX
XX    XX  XX    XX  XX    XX  XX
XX    XX   XXXXXX   XXXXXXX   XXXXXXXX


X      X     XX     XX    XX   XXXXXX   X      X     XX
XX    XX    XXXX     XX  XX      XX     XX    XX    XXXX
XXX  XXX   XX  XX     XXXX       XX     XXX  XXX   XX  XX
XXXXXXXX  XX    XX     XX        XX     XXXXXXXX  XX    XX
XX XX XX  XX    XX    XXXX       XX     XX XX XX  XX    XX
XX    XX  XXXXXXXX   XX  XX      XX     XX    XX  XXXXXXXX
XX    XX  XX    XX  XX    XX     XX     XX    XX  XX    XX
XX    XX  XX    XX  XX    XX     XX     XX    XX  XX    XX
XX    XX  XX    XX  XX    XX   XXXXXX   XX    XX  XX    XX
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NAS MOFFETT FIELD
RESPONSE SPECTRUM ANALYSIS OF HANGAR 46

  NODE   RESPONSE X(OR R)-TRANS Y(OR S)-TRANS Z(OR T)-TRANS  X(OR R)-ROT   Y(OR S)-ROT   Z(OR T)-ROT
 NUMBER      CASE  DISPLACEMENT  DISPLACEMENT  DISPLACEMENT DISPLACEMENT  DISPLACEMENT  DISPLACEMENT

   10          1   .202563E-18   .237478E-03  0.            0.            0.            .154042E-02
               2   .202563E-18   .237481E-03  0.            0.            0.            .154043E-02
               3   .202674E-18   .237673E-03  0.            0.            0.            .154036E-02
               4   .223950E-19   .335876E-04  0.            0.            0.            .187995E-03
               5   .223952E-19   .335928E-04  0.            0.            0.            .187996E-03
               6   .227208E-19   .337545E-04  0.            0.            0.            .188888E-03
               7   .202700E-18*  .237742E-03* 0.            0.            0.            .154170E-02*
               8   .724209E-19   .874498E-04  0.            0.            0.            .556462E-03
     (MAXIMUM)     .202700E-18   .237742E-03  0.            0.            0.            .154170E-02

   20          1   .343226E-03   .300768E-03  0.            0.            0.            .152008E-02
               2   .343227E-03   .300791E-03  0.            0.            0.            .152008E-02
               3   .343203E-03   .300998E-03  0.            0.            0.            .152003E-02
               4   .417516E-04   .559567E-04  0.            0.            0.            .184838E-03
               5   .417519E-04   .560098E-04  0.            0.            0.            .184839E-03
               6   .419381E-04   .564959E-04  0.            0.            0.            .185756E-03
               7   .343508E-03*  .301346E-03* 0.            0.            0.            .152133E-02*
               8   .123941E-03   .116570E-03  0.            0.            0.            .548885E-03
     (MAXIMUM)     .343508E-03   .301346E-03  0.            0.            0.            .152133E-02

   30          1   .279004E-01   .100637E-01  0.            0.            0.            .527677E-04
               2   .279004E-01   .100637E-01  0.            0.            0.            .527689E-04
               3   .278998E-01   .100627E-01  0.            0.            0.            .527269E-04
               4   .339585E-02   .127242E-02  0.            0.            0.            .585980E-05
               5   .339587E-02   .127245E-02  0.            0.            0.            .586050E-05
               6   .341329E-02   .127643E-02  0.            0.            0.            .576893E-05
               7   .279234E-01*  .100727E-01* 0.            0.            0.            .528039E-04*
               8   .100756E-01   .365059E-02  0.            0.            0.            .188737E-04
     (MAXIMUM)     .279234E-01   .100727E-01  0.            0.            0.            .528039E-04

   40          1   .279438E-01   .712485E-03  0.            0.            0.            .388028E-04
               2   .279438E-01   .712540E-03  0.            0.            0.            .388039E-04
               3   .279433E-01   .713032E-03  0.            0.            0.            .388000E-04
               4   .339719E-02   .133141E-03  0.            0.            0.            .421463E-05
               5   .339721E-02   .133271E-03  0.            0.            0.            .421473E-05
               6   .341486E-02   .134435E-03  0.            0.            0.            .413805E-05
               7   .279667E-01*  .713866E-03* 0.            0.            0.            .388282E-04*
               8   .100900E-01   .276422E-03  0.            0.            0.            .138498E-04
     (MAXIMUM)     .279667E-01   .713866E-03  0.            0.            0.            .388282E-04

   50          1   .343226E-03   .300760E-03  0.            0.            0.            .152008E-02
               2   .343227E-03   .300783E-03  0.            0.            0.            .152008E-02
               3   .343201E-03   .300990E-03  0.            0.            0.            .152003E-02
               4   .417513E-04   .560350E-04  0.            0.            0.            .184837E-03
               5   .417516E-04   .560924E-04  0.            0.            0.            .184838E-03
               6   .419378E-04   .565786E-04  0.            0.            0.            .185755E-03
               7   .343508E-03*  .301340E-03* 0.            0.            0.            .152133E-02*
               8   .123941E-03   .116605E-03  0.            0.            0.            .548885E-03
     (MAXIMUM)     .343508E-03   .301340E-03  0.            0.            0.            .152133E-02

   60          1   .202562E-18   .237477E-03  0.            0.            0.            .154042E-02
               2   .202563E-18   .237480E-03  0.            0.            0.            .154043E-02
               3   .202674E-18   .237672E-03  0.            0.            0.            .154036E-02
               4   .223977E-19   .336050E-04  0.            0.            0.            .187995E-03
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NAS MOFFETT FIELD
RESPONSE SPECTRUM ANALYSIS OF HANGAR 46

  NODE   RESPONSE X(OR R)-TRANS Y(OR S)-TRANS Z(OR T)-TRANS  X(OR R)-ROT  Y(OR S)-ROT  Z(OR T)-ROT
 NUMBER      CASE DISPLACEMENT  DISPLACEMENT  DISPLACEMENT  DISPLACEMENT DISPLACEMENT DISPLACEMENT

                5  .223982E-19   .336094E-04  0.            0.           0.           .187996E-03
                6  .227237E-19   .337732E-04  0.            0.           0.           .188888E-03
                7  .202700E-18*  .237741E-03* 0.            0.           0.           .154170E-02*
                8  .724216E-19   .874563E-04  0.            0.           0.           .556462E-03
       (MAXIMUM)   .202700E-18   .237741E-03  0.            0.           0.           .154170E-02

   70           1  .279438E-01   .712466E-03  0.            0.           0.           .388027E-04
                2  .279438E-01   .712521E-03  0.            0.           0.           .388039E-04
                3  .279433E-01   .713012E-03  0.            0.           0.           .387999E-04
                4  .339718E-02   .133331E-03  0.            0.           0.           .421464E-05
                5  .339720E-02   .133471E-03  0.            0.           0.           .421465E-05
                6  .341485E-02   .134636E-03  0.            0.           0.           .413809E-05
                7  .279667E-01*  .713851E-03* 0.            0.           0.           .388281E-04*
                8  .100900E-01   .276508E-03  0.            0.           0.           .138498E-04
       (MAXIMUM)   .279667E-01   .713851E-03  0.            0.           0.           .388281E-04

   80           1  .279004E-01   .100637E-01  0.            0.           0.           .527684E-04
                2  .279004E-01   .100637E-01  0.            0.           0.           .527695E-04
                3  .278999E-01   .100627E-01  0.            0.           0.           .527276E-04
                4  .339585E-02   .127246E-02  0.            0.           0.           .585956E-05
                5  .339587E-02   .127249E-02  0.            0.           0.           .586039E-05
                6  .341329E-02   .127648E-02  0.            0.           0.           .576870E-05
                7  .279234E-01*  .100727E-01* 0.            0.           0.           .528045E-04*
                8  .100756E-01   .365061E-02  0.            0.           0.           .188739E-04
       (MAXIMUM)   .279234E-01   .100727E-01  0.            0.           0.           .528045E-04

  100           1  .279226E-01   .516471E-02  0.            0.           0.           .492550E-03
                2  .279226E-01   .516472E-02  0.            0.           0.           .492552E-03
                3  .279221E-01   .516456E-02  0.            0.           0.           .492458E-03
                4  .339654E-02   .677827E-03  0.            0.           0.           .598471E-04
                5  .339655E-02   .677835E-03  0.            0.           0.           .598477E-04
                6  .341409E-02   .680326E-03  0.            0.           0.           .600036E-04
                7  .279456E-01*  .516965E-02* 0.            0.           0.           .492954E-03*
                8  .100830E-01   .188228E-02  0.            0.           0.           .177839E-03
       (MAXIMUM)   .279456E-01   .516965E-02  0.            0.           0.           .492954E-03

  102           1  .249001E-01   .421455E-02  0.            0.           0.           .519155E-03
                2  .249002E-01   .421478E-02  0.            0.           0.           .519161E-03
                3  .249116E-01   .421745E-02  0.            0.           0.           .518754E-03
                4  .288378E-02   .736071E-03  0.            0.           0.           .535600E-04
                5  .288381E-02   .737555E-03  0.            0.           0.           .535601E-04
                6  .292018E-02   .745064E-03  0.            0.           0.           .528985E-04
                7  .249187E-01*  .422168E-02* 0.            0.           0.           .519462E-03*
                8  .894372E-02   .161094E-02  0.            0.           0.           .184460E-03
       (MAXIMUM)   .249187E-01   .422168E-02  0.            0.           0.           .519462E-03

  104           1  .305480E-01   .863975E-02  0.            0.           0.           .729932E-03
                2  .305486E-01   .864013E-02  0.            0.           0.           .729932E-03
                3  .305713E-01   .864169E-02  0.            0.           0.           .729500E-03
                4  .359213E-02   .125363E-02  0.            0.           0.           .508156E-04
                5  .359214E-02   .125496E-02  0.            0.           0.           .508190E-04
                6  .360136E-02   [illegible]  0.                         0.           [illegible]
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NAS MOFFETT FIELD                                                                                                PAGE    17
RESPONSE SPECTRUM ANALYSIS OF HANGAR 46                                                                         18 MAR 83

  NODE    RESPONSE X(OR R)-TRANS Y(OR S)-TRANS Z(OR T)-TRANS   X(OR R)-ROT    Y(OR S)-ROT    Z(OR T)-ROT
 NUMBER       CASE  DISPLACEMENT  DISPLACEMENT  DISPLACEMENT  DISPLACEMENT   DISPLACEMENT   DISPLACEMENT

   106           1   .470144E-01   .190905E-01  0.            0.             0.             .865468E-03
                 2   .470147E-01   .190911E-01  0.            0.             0.             .865474E-03
                 3   .470349E-01   .190877E-01  0.            0.             0.             .865050E-03
                 4   .463981E-02   .224937E-02  0.            0.             0.             .486022E-04
                 5   .464010E-02   .225072E-02  0.            0.             0.             .486174E-04
                 6   .462108E-02   .226224E-02  0.            0.             0.             .482142E-04
                 7   .470399E-01*  .191052E-01* 0.            0.             0.             .865620E-03*
                 8   .166447E-01   .686946E-02  0.            0.             0.             .298246E-03
     (MAXIMUM)       .470399E-01   .191052E-01  0.            0.             0.             .865620E-03

   108           1   .665590E-01   .322200E-01  0.            0.             0.             .779732E-03
                 2   .665591E-01   .322204E-01  0.            0.             0.             .779742E-03
                 3   .665715E-01   .322113E-01  0.            0.             0.             .779336E-03
                 4   .516967E-02   .346978E-02  0.            0.             0.             .561310E-04
                 5   .516989E-02   .347001E-02  0.            0.             0.             .561429E-04
                 6   .513678E-02   .347557E-02  0.            0.             0.             .554672E-04
                 7   .665814E-01*  .322408E-01* 0.            0.             0.             .779956E-03*
                 8   .232131E-01   .114912E-01  0.            0.             0.             .270986E-03
     (MAXIMUM)       .665814E-01   .322408E-01  0.            0.             0.             .779956E-03

   110           1   .814795E-01   .441414E-01  0.            0.             0.             .495136E-03
                 2   .814797E-01   .441415E-01  0.            0.             0.             .495138E-03
                 3   .814835E-01   .441256E-01  0.            0.             0.             .494832E-03
                 4   .494932E-02   .473546E-02  0.            0.             0.             .672111E-04
                 5   .495053E-02   .473680E-02  0.            0.             0.             .672211E-04
                 6   .489843E-02   .471831E-02  0.            0.             0.             .666286E-04
                 7   .814962E-01*  .441696E-01* 0.            0.             0.             .495643E-03*
                 8   .281417E-01   .157374E-01  0.            0.             0.             .181267E-03
     (MAXIMUM)       .814962E-01   .441696E-01  0.            0.             0.             .495643E-03

   112           1   .869756E-01   .495264E-01  0.            0.             0.             .680238E-04
                 2   .869757E-01   .495266E-01  0.            0.             0.             .681495E-04
                 3   .869748E-01   .495055E-01  0.            0.             0.             .679176E-04
                 4   .376196E-02   .558801E-02  0.            0.             0.             .835560E-04
                 5   .376366E-02   .558901E-02  0.            0.             0.             .835635E-04
                 6   .370851E-02   .556645E-02  0.            0.             0.             .829174E-04
                 7   .869847E-01*  .495614E-01* 0.            0.             0.             .735048E-04
                 8   .298100E-01   .177420E-01  0.            0.             0.             .866978E-04*
     (MAXIMUM)       .869847E-01   .495614E-01  0.            0.             0.             .866978E-04

   114           1   .836872E-01   .441347E-01  0.            0.             0.             .448795E-03
                 2   .836872E-01   .441349E-01  0.            0.             0.             .448809E-03
                 3   .836868E-01   .441140E-01  0.            0.             0.             .448646E-03
                 4   .200823E-02   .609436E-02  0.            0.             0.             .886393E-04
                 5   .200829E-02   .609454E-02  0.            0.             0.             .886583E-04
                 6   .197777E-02   .610490E-02  0.            0.             0.             .875832E-04
                 7   .836898E-01*  .441814E-01* 0.            0.             0.             .449766E-03*
                 8   .285244E-01   .161961E-01  0.            0.             0.             .176467E-03
     (MAXIMUM)       .836898E-01   .441814E-01  0.            0.             0.             .449766E-03

   116           1   .769082E-01   .262998E-01  0.            0.             0.             .803671E-03
                 2   .769082E-01   .263001E-01  0.            0.             0.             .803680E-03
                 3   .769111E-01*  .262866E-01  0.            0.             0.             .803317E-03
                 4   .641231E-03   .688503E-02  0.            0.             0.             .576365E-04
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NAS MOFFETT FIELD
RESPONSE SPECTRUM ANALYSIS OF HANGAR 46

  NODE   RESPONSE X(OR R)-TRANS Y(OR S)-TRANS Z(OR T)-TRANS   X(OR R)-ROT    Y(OR S)-ROT   Z(OR T)-ROT
 NUMBER      CASE  DISPLACEMENT  DISPLACEMENT  DISPLACEMENT  DISPLACEMENT  DISPLACEMENT  DISPLACEMENT

               5    .643329E-03   .688580E-02  0.            0.            0.            .576447E-04
               6    .636877E-03   .691926E-02  0.            0.            0.            .567800E-04
               7    .769085E-01   .263998E-01* 0.            0.            0.            .803901E-03*
               8    .261566E-01   .112855E-01  0.            0.            0.            .279261E-03
      (MAXIMUM)     .769111E-01   .263998E-01  0.            0.            0.            .803901E-03

   118         1    .736146E-01   .131895E-06  0.            0.            0.            .924066E-03
               2    .736147E-01   .154573E-06  0.            0.            0.            .924073E-03*
               3    .736194E-01*  .142065E-06  0.            0.            0.            .923637E-03
               4    .300805E-06   .741155E-02  0.            0.            0.            .487812E-08
               5    .335009E-06   .741263E-02  0.            0.            0.            .531291E-08
               6    .305580E-06   .744631E-02* 0.            0.            0.            .592067E-08
               7    .736146E-01   .247049E-02  0.            0.            0.            .924066E-03
               8    .250290E-01   .741154E-02  0.            0.            0.            .314183E-03
      (MAXIMUM)     .736194E-01   .744631E-02  0.            0.            0.            .924073E-03

   200         1    .279226E-01   .516470E-02  0.            0.            0.            .492552E-03
               2    .279226E-01   .516471E-02  0.            0.            0.            .492553E-03
               3    .279221E-01   .516455E-02  0.            0.            0.            .492460E-03
               4    .339653E-02   .677896E-03  0.            0.            0.            .598460E-04
               5    .339655E-02   .677903E-03  0.            0.            0.            .598465E-04
               6    .341409E-02   .680399E-03  0.            0.            0.            .600024E-04
               7    .279456E-01*  .516964E-02* 0.            0.            0.            .492955E-03*
               8    .100830E-01   .188230E-02  0.            0.            0.            .177840E-03
      (MAXIMUM)     .279456E-01   .516964E-02  0.            0.            0.            .492955E-03

   202         1    .249001E-01   .421453E-02  0.            0.            0.            .519155E-03
               2    .249002E-01   .421476E-02  0.            0.            0.            .519161E-03
               3    .249116E-01   .421743E-02  0.            0.            0.            .518754E-03
               4    .288376E-02   .736302E-03  0.            0.            0.            .535597E-04
               5    .288379E-02   .737807E-03  0.            0.            0.            .535598E-04
               6    .292016E-02   .745316E-03  0.            0.            0.            .528983E-04
               7    .249187E-01*  .422167E-02* 0.            0.            0.            .519462E-03*
               8    .894371E-02   .161104E-02  0.            0.            0.            .184460E-03
      (MAXIMUM)     .249187E-01   .422167E-02  0.            0.            0.            .519462E-03

   204         1    .305481E-01   .863975E-02  0.            0.            0.            .729932E-03
               2    .305486E-01   .864013E-02  0.            0.            0.            .729932E-03
               3    .305713E-01   .864168E-02  0.            0.            0.            .729500E-03
               4    .359211E-02   .125383E-02  0.            0.            0.            .508156E-04
               5    .359212E-02   .125518E-02  0.            0.            0.            .508190E-04
               6    .360134E-02   .126498E-02  0.            0.            0.            .500873E-04
               7    .305715E-01*  .864985E-02* 0.            0.            0.            .730128E-03*
               8    .109900E-01   .319391E-02  0.            0.            0.            .253326E-03
      (MAXIMUM)     .305715E-01   .864985E-02  0.            0.            0.            .730128E-03

   206         1    .470145E-01   .190909E-01  0.            0.            0.            .865468E-03
               2    .470147E-01   .190911E-01  0.            0.            0.            .865474E-03
               3    .470349E-01   .190877E-01  0.            0.            0.            .865050E-03
               4    .463981E-02   .224940E-02  0.            0.            0.            .486023E-04
               5    .464010E-02   .225075E-02  0.            0.            0.            .486176E-04
               [illegible]    .[illegible]108E[illegible]   .2[illegible]E-0[illegible]  [illegible]                        [illegible]      .[illegible]6E-[illegible]
               [illegible]    [illegible]             [illegible]                                                     .[illegible]0E-[illegible]
```

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NAS MOFFETT FIELD
RESPONSE SPECTRUM ANALYSIS OF HANGAR 46

  NODE   RESPONSE X(OR R)-TRANS Y(OR S)-TRANS Z(OR T)-TRANS   X(OR R)-ROT    Y(OR S)-ROT    Z(OR T)-ROT
 NUMBER      CASE  DISPLACEMENT  DISPLACEMENT  DISPLACEMENT  DISPLACEMENT   DISPLACEMENT   DISPLACEMENT

  208          1   .665590E-01   .322200E-01  0.             0.             0.             .779732E-03
               2   .665591E-01   .322204E-01  0.             0.             0.             .779742E-03
               3   .665715E-01   .322113E-01  0.             0.             0.             .779336E-03
               4   .516968E-02   .346971E-02  0.             0.             0.             .561310E-04
               5   .516990E-02   .346994E-02  0.             0.             0.             .561429E-04
               6   .513680E-02   .347549E-02  0.             0.             0.             .554671E-04
               7   .665814E-01*  .322408E-01* 0.             0.             0.             .779956E-03*
               8   .232131E-01   .114912E-01  0.             0.             0.             .270986E-03
     (MAXIMUM)     .665814E-01   .322408E-01  0.             0.             0.             .779956E-03

  210          1   .814795E-01   .441413E-01  0.             0.             0.             .495136E-03
               2   .814797E-01   .441415E-01  0.             0.             0.             .495138E-03
               3   .814835E-01   .441256E-01  0.             0.             0.             .494832E-03
               4   .494931E-02   .473539E-02  0.             0.             0.             .672110E-04
               5   .495053E-02   .473673E-02  0.             0.             0.             .672210E-04
               6   .489842E-02   .471824E-02  0.             0.             0.             .666284E-04
               7   .814962E-01*  .441696E-01* 0.             0.             0.             .495643E-03*
               8   .281417E-01   .157374E-01  0.             0.             0.             .181267E-03
     (MAXIMUM)     .814962E-01   .441696E-01  0.             0.             0.             .495643E-03

  212          1   .869756E-01   .495264E-01  0.             0.             0.             .680239E-04
               2   .869757E-01   .495266E-01  0.             0.             0.             .681496E-04
               3   .869748E-01   .495055E-01  0.             0.             0.             .679197E-04
               4   .376195E-02   .558798E-02  0.             0.             0.             .835559E-04
               5   .376364E-02   .558898E-02  0.             0.             0.             .835634E-04
               6   .370851E-02   .556641E-02  0.             0.             0.             .829174E-04
               7   .869847E-01*  .495614E-01* 0.             0.             0.             .735049E-04
               8   .298100E-01   .177419E-01  0.             0.             0.             .866977E-04*
     (MAXIMUM)     .869847E-01   .495614E-01  0.             0.             0.             .866977E-04

  214          1   .836872E-01   .441347E-01  0.             0.             0.             .448795E-03
               2   .836872E-01   .441349E-01  0.             0.             0.             .448809E-03
               3   .836868E-01   .441140E-01  0.             0.             0.             .448646E-03
               4   .200822E-02   .609438E-02  0.             0.             0.             .886392E-04
               5   .200829E-02   .609455E-02  0.             0.             0.             .886582E-04
               6   .197777E-02   .610491E-02  0.             0.             0.             .875831E-04
               7   .836898E-01*  .441814E-01* 0.             0.             0.             .449766E-03*
               8   .285244E-01   .161961E-01  0.             0.             0.             .176467E-03
     (MAXIMUM)     .836898E-01   .441814E-01  0.             0.             0.             .449766E-03

  216          1   .769082E-01   .262998E-01  0.             0.             0.             .803671E-03
               2   .769082E-01   .263001E-01  0.             0.             0.             .803680E-03
               3   .769111E-01*  .262866E-01  0.             0.             0.             .803317E-03
               4   .641272E-03   .688503E-02  0.             0.             0.             .576365E-04
               5   .643363E-03   .688581E-02  0.             0.             0.             .576447E-04
               6   .636904E-03   .691926E-02  0.             0.             0.             .567799E-04
               7   .769085E-01   .263978E-01* 0.             0.             0.             .803901E-03*
               8   .261566E-01   .112853E-01  0.             0.             0.             .279261E-03
     (MAXIMUM)     .769111E-01   .263998E-01  0.             0.             0.             .803901E-03
```

NAS MOFFETT FIELD
RESPONSE SPECTRUM ANALYSIS OF HANGAR 46

```
XXXXXXX   XXXXXXXX     XX     X      X
XX    XX  XX          XXXX    XX    XX
XX    XX  XX         XX  XX   XXX  XXX
XXXXXXX   XXXXX     XX    XX  XXXXXXXX
XX    XX  XX        XX    XX  XX XX XX
XX    XX  XX        XXXXXXXX  XX    XX
XX    XX  XX        XX    XX  XX    XX
XX    XX  XX        XX    XX  XX    XX
XXXXXXX   XXXXXXXX  XX    XX  XX    XX

X      X     XX     XX    XX   XXXXXX   X      X     XX
XX    XX    XXXX     XX  XX      XX     XX    XX    XXXX
XXX  XXX   XX  XX     XXXX       XX     XXX  XXX   XX  XX
XXXXXXXX  XX    XX     XX        XX     XXXXXXXX  XX    XX
XX XX XX  XX    XX    XXXX       XX     XX XX XX  XX    XX
XX    XX  XXXXXXXX   XX  XX      XX     XX    XX  XXXXXXXX
XX    XX  XX    XX  XX    XX     XX     XX    XX  XX    XX
XX    XX  XX    XX  XX    XX     XX     XX    XX  XX    XX
XX    XX  XX    XX  XX    XX   XXXXXX   XX    XX  XX    XX
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$\frac{P}{A} +$ [illegible]

Max Arch Stress
= 43.77 k/ф
= 304 p.s.i.
Arch O.K.

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NAS MOFFETT FIELD
RESPONSE SPECTRUM ANALYSIS OF HANGAR 46                                                                              PAGE    21
                                                                                                                   18 MAR 83
  BEAM  RESPONSE        END 1          END 1          END 1          END 2         END 1          END 1          END 2          END 2
 NUMBER     CASE      X-THRUST        Y-SHEAR       Z-MOMENT       Z-MOMENT    PT. 1 STRESS   PT. 2 STRESS   PT. 1 STRESS   PT. 2 STRESS

    1          1    .540542E+01    .814673E+01    .436049E+03    .293321E+03    .437128E+02   -.364567E+02    .303891E+02    .237031E+02
               2    .543362E+01    .814789E+01    .436055E+03    .293322E+03    .437130E+02    .364603E+02    .303913E+02    .237082E+02
               3    .541510E+01    .815266E+01    .436299E+03    .293448E+03    .437408E+02    .364753E+02    .304061E+02    .237103E+02
               4    .683266E+01    .135181E+01    .468341E+02    .273363E+02    .697175E+01    .668057E+01    .505771E+01    .657879E+01
               5    .683731E+01    .135239E+01    .468378E+02    .273398E+02    .697312E+01    .668817E+01    .506965E+01    .658238E+01
               6    .687899E+01    .133925E+01    .467593E+02    .273440E+02    .694684E+01    .675457E+01    .507389E+01    .662491E+01
               7    .586561E+01    .815918E+01*   .436328E+03*   .293463E+03*   .437745E+02*   .365247E+02*   .304358E+02*   .238043E+02*
               8    .707548E+01*   .308215E+01    .155478E+03    .103408E+03    .164163E+02    .140809E+02    .115037E+02    .104033E+02
     (MAXIMUM)      .707548E+01    .815918E+01    .436328E+03    .293463E+03    .437745E+02    .365247E+02    .304358E+02    .238043E+02

    2          1    .540559E+01    .814676E+01    .436049E+03    .293322E+03    .437129E+02    .364567E+02    .303891E+02    .237031E+02
               2    .543379E+01    .814791E+01    .436056E+03    .293322E+03    .437132E+02    .364603E+02    .303914E+02    .237081E+02
               3    .541527E+01    .815269E+01    .436299E+03    .293448E+03    .437409E+02    .364753E+02    .304061E+02    .237102E+02
               4    .683458E+01    .135180E+01    .468331E+02    .273357E+02    .697294E+01    .668157E+01    .505930E+01    .657994E+01
               5    .683942E+01    .135237E+01    .468366E+02    .273390E+02    .697422E+01    .668928E+01    .507144E+01    .658347E+01
               6    .688104E+01    .133925E+01    .467581E+02    .273434E+02    .694810E+01    .675567E+01    .507563E+01    .662610E+01
               7    .586602E+01    .815921E+01*   .436329E+03*   .293463E+03*   .437747E+02*   .365247E+02*   .304359E+02*   .238043E+02*
               8    .707736E+01*   .308215E+01    .155478E+03    .103408E+03    .164168E+02    .140814E+02    .115045E+02    .104040E+02
     (MAXIMUM)      .707736E+01    .815921E+01    .436329E+03    .293463E+03    .437747E+02    .365247E+02    .304359E+02    .238043E+02

    3          1    .553151E+01    .667614E+01    .293321E+03    .139287E+03    .350766E+02    .278602E+02    .183918E+02    .119485E+02
               2    .555713E+01    .667672E+01    .293322E+03    .139303E+03    .350782E+02    .278644E+02    .183960E+02    .119518E+02
               3    .554086E+01    .667976E+01    .293448E+03    .139319E+03    .350952E+02    .278693E+02    .184013E+02    .119477E+02
               4    .679209E+01    .109311E+01    .273363E+02    .213291E+02    .512845E+01    .681223E+01    .349155E+01    .733647E+01
               5    .679569E+01    .109333E+01    .273398E+02    .213403E+02    .513960E+01    .681663E+01    .350568E+01    .733846E+01
               6    .683492E+01    .107995E+01    .273440E+02    .209642E+02    .513783E+01    .685734E+01    .356299E+01    .732597E+01
               7    .597688E+01    .668607E+01*   .293463E+03*   .139468E+03*   .351182E+02*   .279526E+02*   .184286E+02*   .121961E+02*
               8    .704764E+01*   .251938E+01    .103408E+03    .519389E+02    .129819E+02    .116676E+02    .716193E+01    .838614E+01
     (MAXIMUM)      .704764E+01    .668607E+01    .293463E+03    .139468E+03    .351182E+02    .279526E+02    .184286E+02    .121961E+02

    4          1    .553153E+01    .667614E+01    .293322E+03    .139287E+03    .350766E+02    .278602E+02    .183918E+02    .119485E+02
               2    .555716E+01    .667672E+01    .293322E+03    .139303E+03    .350783E+02    .278644E+02    .183960E+02    .119518E+02
               3    .554089E+01    .667976E+01    .293448E+03    .139319E+03    .350953E+02    .278693E+02    .184013E+02    .119477E+02
               4    .679156E+01    .109309E+01    .273357E+02    .213291E+02    .512840E+01    .681156E+01    .349122E+01    .733603E+01
               5    .679517E+01    .109331E+01    .273390E+02    .213404E+02    .513960E+01    .681596E+01    .350539E+01    .733801E+01
               6    .683435E+01    .107994E+01    .273434E+02    .209643E+02    .513781E+01    .685662E+01    .356271E+01    .732548E+01
               7    .597684E+01    .668608E+01*   .293463E+03*   .139468E+03*   .351182E+02*   .279526E+02*   .184286E+02*   .121961E+02*
               8    .704713E+01*   .251937E+01    .103408E+03    .519390E+02    .129819E+02    .116673E+02    .716178E+01    .838575E+01
     (MAXIMUM)      .704713E+01    .668604E+01    .293463E+03    .139468E+03    .351182E+02    .279526E+02    .184286E+02    .121961E+02

    5          1    .563734E+01    .541325E+01    .139287E+03    .115628E+02    .206125E+02    .185411E+02    .635145E+01    .348411E+01
               2    .565986E+01    .541327E+01    .139303E+03    .116668E+02    .206169E+02    .185416E+02    .637284E+01    .348448E+01
               3    .564654E+01    .541432E+01    .139319E+03    .115607E+02    .206226E+02    .185414E+02    .636147E+01    .348563E+01
               4    .660784E+01    .708626E+00    .213291E+02    .217923E+02    .401805E+01    .915833E+01    .474379E+01    .871081E+01
               5    .661065E+01    .709310E+00    .213403E+02    .218168E+02    .403037E+01    .916074E+01    .475123E+01    .871790E+01
               6    .664721E+01    .705544E+00    .209642E+02    .212845E+02    .409594E+01    .912803E+01    .483288E+01    .864429E+01
               7    .605290E+01    .541840E+01*   .139468E+03*   .136551E+02    .206559E+02*   .187907E+02*   .654530E+01*   .453538E+01
               8    .688025E+01*   .197221E+01    .519389E+02    .221440E+02*   .807836E+01    .111182E+02    .521216E+01    .879097E+01*
     (MAXIMUM)      .688025E+01    .541840E+01    .139468E+03    .221440E+02    .206559E+02    .187907E+02    .554530E+01    .879097E+01

    6          1    .563786E+01    .541325E+01    .139287E+03    .115628E+02    .206124E+02    .185411E+02    .635138E+01    .348403E+01
               2    .565978E+01    .541327E+01    .139303E+03    .116668E+02    .206169E+02    .185416E+02    .637278E+01    .348440E+01
               3    .564647E+01    .541432E+01    .139319E+03    .115607E+02    .206225E+02    .185414E+02    .636141E+01
               4    .660621E+01
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NAS MOFFETT FIELD
RESPONSE SPECTRUM ANALYSIS OF HANGAR 46

  BEAM   RESPONSE      END 1        END 1        END 1        END 2         END 1         END 1         END 2         END 2
 NUMBER      CASE     X-THRUST     Y-SHEAR     Z-MOMENT     Z-MOMENT   PT. 1 STRESS  PT. 2 STRESS  PT. 1 STRESS  PT. 2 STRESS

                5   .660892E+01  .709291E+00  .213404E+02  .218167E+02  .402828E+01  .915964E+01  .474925E+01  .871692E+01
                6   .664547E+01  .705536E+00  .209643E+02  .212843E+02  .409397E+01  .912679E+01  .483072E+01  .864333E+01
                7   .605263E+01  .541840E+01* .139468E+03* .136551E+02  .206559E+02* .187907E+02* .654508E+01* .453513E+01
                8   .687867E+01* .197220E+01  .519390E+02  .221438E+02* .807739E+01  .111173E+02  .521029E+01  .879008E+01*
        (MAXIMUM)   .687867E+01  .541840E+01  .139468E+03  .221438E+02  .206559E+02  .187907E+02  .654508E+01  .879008E+01

    7           1   .543918E+01  .436581E+01  .115628E+02  .925667E+02  .620331E+01  .321809E+01  .789079E+01  .188425E+02
                2   .545789E+01  .436710E+01  .116658E+02  .925693E+02  .622114E+01  .322073E+01  .790274E+01  .188456E+02
                3   .544653E+01  .436485E+01  .115607E+02  .925440E+02  .621188E+01  .321907E+01  .788879E+01  .188429E+02
                4   .626162E+01  .670790E+00  .217923E+02  .206084E+02  .444403E+01  .841510E+01  .579689E+01  .701199E+01
                5   .626282E+01  .672723E+00  .218168E+02  .206097E+02  .444958E+01  .841812E+01  .579742E+01  .701367E+01
                6   .630019E+01  .656721E+00  .212845E+02  .203216E+02  .453235E+01  .834732E+01  .584923E+01  .698159E+01
                7   .582589E+01  .437153E+01* .136551E+02  .928212E+02* .637771E+01* .426897E+01  .812393E+01* .189869E+02*
                8   .652899E+01* .162890E+01  .221440E+02* .376196E+02  .491911E+01. .848592E+01* .538761E+01  .949793E+01
        (MAXIMUM)   .652899E+01  .437153E+01  .221440E+02  .928212E+02  .637771E+01  .848592E+01  .812393E+01  .189869E+02

    8           1   .543908E+01  .436581E+01  .115628E+02  .925667E+02  .620323E+01  .321798E+01  .789071E+01  .188425E+02
                2   .545778E+01  .436709E+01  .116668E+02  .925693E+02  .622105E+01  .322062E+01  .790266E+01  .188456E+02
                3   .544643E+01  .436485E+01  .115607E+02  .925440E+02  .621180E+01  .321895E+01  .788871E+01  .188429E+02
                4   .626037E+01  .670790E+00  .217922E+02  .206084E+02  .444235E+01  .841450E+01  .579573E+01  .701114E+01
                5   .626150E+01  .672722E+00  .218167E+02  .206097E+02  .444793E+01  .841744E+01  .579622E+01  .701275E+01
                6   .629885E+01  .656718E+00  .212843E+02  .203216E+02  .453059E+01  .834664E+01  .584799E+01  .698067E+01
                7   .582564E+01  .437153E+01* .136551E+02  .928212E+02* .637751E+01* .426875E+01  .812376E+01* .189869E+02*
                8   .652778E+01* .162890E+01  .221438E+02* .376196E+02  .491758E+01  .848532E+01* .638655E+01  .949730E+01
        (MAXIMUM)   .652778E+01  .437153E+01  .221438E+02  .928212E+02  .637751E+01  .848532E+01  .812376E+01  .189869E+02

    9           1   .517750E+01  .304035E+01  .925667E+02  .162716E+03  .709996E+01  .218620E+02  .151172E+02  .349066E+02
                2   .519244E+01  .304113E+01  .925693E+02  .162735E+03  .711175E+01  .218639E+02  .151182E+02  .349070E+02
                3   .518310E+01  .303856E+01  .925440E+02  .162653E+03  .709854E+01  .218605E+02  .151089E+02  .348977E+02
                4   .582474E+01  .666190E+00  .206084E+02  .212965E+02  .577401E+01  .731371E+01  .689544E+01  .563507E+01
                5   .582475E+01  .667289E+00  .206097E+02  .213010E+02  .577403E+01  .731393E+01  .689591E+01  .563512E+01
                6   .586497E+01  .647411E+00  .203216E+02  .209317E+02  .582964E+01  .727408E+01  .689270E+01  .566475E+01
                7   .552957E+01  .304845E+01* .928212E+02* .162871E+03* .735620E+01* .219975E+02* .152909E+02* .349571E+02*
                8   .608493E+01* .122979E+01  .376196E+02  .592809E+02  .625830E+01  .104279E+02  .860028E+01  .131381E+02
        (MAXIMUM)   .608493E+01  .304845E+01  .928212E+02  .162871E+03  .735620E+01  .219975E+02  .152909E+02  .349571E+02

   10           1   .517744E+01  .304035E+01  .925667E+02  .162716E+03  .709989E+01  .218620E+02  .151171E+02  .349066E+02
                2   .519237E+01  .304113E+01  .925693E+02  .162735E+03  .711168E+01  .218638E+02  .151181E+02  .349070E+02
                3   .518304E+01  .303856E+01  .925440E+02  .162653E+03  .709847E+01  .218605E+02  .151089E+02  .348977E+02
                4   .582447E+01  .666195E+00  .206084E+02  .212965E+02  .577375E+01  .731353E+01  .689521E+01  .563485E+01
                5   .582448E+01  .667300E+00  .206097E+02  .213010E+02  .577377E+01  .731372E+01  .689565E+01  .563497E+01
                6   .586467E+01  .647426E+00  .203216E+02  .209318E+02  .582935E+01  .727387E+01  .689244E+01  .566453E+01
                7   .552948E+01  .304845E+01* .928212E+02* .162871E+03* .735611E+01* .219975E+02* .152908E+02* .349571E+02*
                8   .608467E+01* .122979E+01  .376196E+02  .592809E+02  .625806E+01  .104278E+02  .860009E+01  .131380E+02
        (MAXIMUM)   .608467E+01  .304845E+01  .928212E+02  .162871E+03  .735611E+01  .219975E+02  .152908E+02  .349571E+02

   11           1   .482186E+01  .128184E+01  .162716E+03  .189888E+03  .214009E+02  .359517E+02  .259500E+02  .409444E+02
                2   .483235E+01  .128304E+01  .162735E+03  .189892E+03  .214023E+02  .359521E+02  .259517E+02  .409456E+02
                3   .482533E+01  .128023E+01  .162653E+03  .189795E+03  .213902E+02  .359416E+02  .259346E+02  .409285E+02
                4   .540016E+01  .501432E+00  .212965E+02  .180850E+02  .824551E+01  .615375E+01  .840212E+01  .513668E+01
                5   .540045E+01  .504886E+00  .213010E+02  .181188E+02  .825006E+01  .616292E+01  .840632E+01  [illegible]
                6   .544177E+01  .493175E+00  [illegible]  .176091E+02  .823219E+01  .620178E+01  [illegible]  [illegible]
                7   [illegible]  [illegible]  [illegible]  [illegible]  [illegible]  [illegible]  [illegible]  [illegible]
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NAS MOFFETT FIELD
RESPONSE SPECTRUM ANALYSIS OF HANGAR 46                                                                                          PAGE    23
                                                                                                                              18 MAR 83
  BEAM   RESPONSE        END 1         END 1         END 1         END 2          END 1          END 1          END 2          END 2
 NUMBER      CASE      X-THRUST      Y-SHEAR       Z-MOMENT      Z-MOMENT    PT. 1 STRESS   PT. 2 STRESS   PT. 1 STRESS   PT. 2 STRESS

   12          1     .482183E+01   .128184E+01   .162716E+03   .189888E+03   .214008E+02    .359517E+02    .259499E+02    .409444E+02
               2     .483232E+01   .128304E+01   .162735E+03   .189892E+03   .214023E+02    .359522E+02    .259516E+02    .409456E+02
               3     .482531E+01   .128023E+01   .162653E+03   .189795E+03   .213902E+02    .359416E+02    .259346E+02    .409285E+02
               4     .540040E+01   .501425E+00   .212965E+02   .180850E+02   .824572E+01    .615424E+01    .840235E+01    .513698E+01
               5     .540068E+01   .504875E+00   .213010E+02   .181188E+02   .825027E+01    .616320E+01    .840655E+01    .515207E+01
               6     .544203E+01   .493162E+00   .209318E+02   .176090E+02   .823240E+01    .620213E+01    .336087E+01    .523783E+01
               7     .514689E+01   .129269E+01*  .162871E+03*  .189984E+03*  .215766E+02*   .350101E+02*   .261006E+02*   .409801E+02*
               8     .564375E+01*  .664356E+00   .592809E+02   .670470E+02   .109971E+02    .136854E+02    .121838E+02    .148386E+02
      (MAXIMUM)      .564375E+01   .129269E+01   .162871E+03   .189984E+03   .215766E+02    .360101E+02    .261006E+02    .409801E+02

   13          1     .418806E+01   .107013E+01   .189888E+03   .167206E+03   .311519E+02    .410004E+02    .269654E+02    .356286E+02
               2     .419384E+01   .107591E+01   .189892E+03   .167211E+03   .311519E+02    .410010E+02    .269676E+02    .366296E+02
               3     .418946E+01   .106936E+01   .189795E+03   .167110E+03   .311347E+02    .409831E+02    .269480E+02    .366105E+02
               4     .508516E+01   .737591E+00   .180850E+02   .982228E+01   .899407E+01    .523170E+01    .768163E+01    .571555E+01
               5     .508698E+01   .741597E+00   .181188E+02   .983976E+01   .900630E+01    .525532E+01    .768501E+01    .572323E+01
               6     .512281E+01   .723646E+00   .176091E+02   .965049E+01   .893689E+01    .533228E+01    .768053E+01    .580545E+01
               7     .451806E+01   .109801E+01*  .189984E+03*  .167238E+03*  .312958E+02*   .410374E+02*   .270867E+02*   .366781E+02*
               8     .528075E+01*  .822447E+00   .670470E+02   .576924E+02   .138952E+02    .148895E+02    .119609E+02    .137027E+02
      (MAXIMUM)      .528075E+01   .109801E+01   .189984E+03   .167238E+03   .312958E+02    .410374E+02    .270867E+02    .366781E+02

   14          1     .418806E+01   .107013E+01   .189888E+03   .167206E+03   .311519E+02    .410004E+02    .269654E+02    .366286E+02
               2     .419384E+01   .107591E+01   .189892E+03   .167211E+03   .311519E+02    .410010E+02    .269676E+02    .366296E+02
               3     .418946E+01   .106936E+01   .189795E+03   .167110E+03   .311347E+02    .409831E+02    .269480E+02    .366105E+02
               4     .508504E+01   .737591E+00   .180850E+02   .982220E+01   .899402E+01    .523138E+01    .768139E+01    .571552E+01
               5     .508677E+01   .741597E+00   .181188E+02   .983968E+01   .900612E+01    .525505E+01    .768485E+01    .572306E+01
               6     .512271E+01   .723692E+00   .176090E+02   .965055E+01   .893687E+01    .533196E+01    .768036E+01    .580538E+01
               7     .451805E+01   .109801E+01*  .189984E+03*  .167238E+03*  .312958E+02*   .410374E+02*   .270867E+02*   .366781E+02*
               8     .528063E+01*  .822446E+00   .670470E+02   .576924E+02   .138951E+02    .148894E+02    .119608E+02    .137026E+02
      (MAXIMUM)      .528063E+01   .109801E+01   .189984E+03   .167238E+03   .312958E+02    .410374E+02    .270867E+02    .366781E+02

   15          1     .298275E+01   .310250E+01   .167206E+03   .979915E+02   .281304E+02    .353433E+02    .150630E+02    .222049E+02
               2     .298466E+01   .310265E+01   .167211E+03   .980106E+02   .281311E+02    .353449E+02    .150633E+02    .222099E+02
               3     .298281E+01   .310094E+01   .167110E+03   .979280E+02   .281133E+02    .353243E+02    .150523E+02    .221920E+02
               4     .493773E+01   .845136E+00   .982228E+01   .197761E+02   .747271E+01    .556759E+01    .664083E+01    .799586E+01
               5     .494376E+01   .845246E+00   .983976E+01   .197981E+02   .747293E+01    .558250E+01    .664967E+01    .801107E+01
               6     .496494E+01   .825716E+00   .965049E+01   .195106E+02   .745818E+01    .564363E+01    .670075E+01    .795363E+01
               7     .340673E+01   .311527E+01*  .167238E+03*  .982129E+02*  .282405E+02*   .353920E+02*   .152248E+02*   .223643E+02*
               8     .504097E+01*  .135165E+01   .576924E+02   .387443E+02   .121374E+02    .132438E+02    .838624E+01    .109969E+02
      (MAXIMUM)      .504097E+01   .311527E+01   .167238E+03   .982129E+02   .282405E+02    .353920E+02    .152248E+02    .223643E+02

   16          1     .298276E+01   .310250E+01   .167206E+03   .979915E+02   .281304E+02    .353433E+02    .150630E+02    .222049E+02
               2     .298467E+01   .310265E+01   .167211E+03   .980106E+02   .281312E+02    .353449E+02    .150633E+02    .222099E+02
               3     .298282E+01   .310094E+01   .167110E+03   .979280E+02   .281133E+02    .353243E+02    .150524E+02    .221920E+02
               4     .493741E+01   .845134E+00   .982220E+01   .197759E+02   .747200E+01    .556701E+01    .663996E+01    .799550E+01
               5     .494310E+01   .845243E+00   .983968E+01   .197979E+02   .747238E+01    .558181E+01    .564894E+01    .801056E+01
               6     .496442E+01   .825711E+00   .965055E+01   .195103E+02   .745755E+01    .564298E+01    .669979E+01    .795333E+01
               7     .340665E+01   .311527E+01*  .167238E+03*  .982129E+02*  .282405E+02*   .353919E+02*   .152248E+02*   .223642E+02*
               8     .504046E+01*  .135165E+01   .576924E+02   .387442E+02   .121370E+02    .132436E+02    .838555E+01    .109966E+02
      (MAXIMUM)      .504046E+01   .311527E+01   .167238E+03   .982129E+02   .282405E+02    .353919E+02    .152248E+02    .223642E+02

   17          1     .109917E+01   .442635E+01   .979915E+02   .125058E-02   .145572E+02    .198265E+02    .129208E+01    .129209E+01
               2     .109934E+01   .442722E+01   .980106E+02   .127439E-02   .145593E+02    .198310E+02    .129228E+01    .129228E+01
               3     .109899E+01   .442349E+01   .979280E+02   .126375E-02   .145475E+02    .198140E+02    .129188E+01    .129188E+01
               4     .492148E+01   .388470E+00   .197761E+02   .271264E+02   .585699E+01    .764920E+01    .384047E+01    .903760E+01
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NAS MOFFETT FIELD                                                                                                    PAGE    24
RESPONSE SPECTRUM ANALYSIS OF HANGAR 46                                                                              18 MAR 83

  BEAM   RESPONSE        END 1          END 1          END 1          END 2          END 1          END 1          END 2          END 2
 NUMBER     CASE        X-THRUST       Y-SHEAR        Z-MOMENT       Z-MOMENT    PT. 1 STRESS   PT. 2 STRESS   PT. 1 STRESS   PT. 2 STRESS

              5       .492589E+01    .395068E+00    .197981E+02    .271279E+02*   .586781E+01    .766370E+01    .587120E+01    .905412E+01*
              6       .493633E+01*   .377213E+00    .195106E+02    .266834E+02    .590312E+01    .759064E+01    .591443E+01*   .891678E+01
              7       .197462E+01    .442825E+01*   .982129E+02*   .904189E+01    .146875E+02*   .199898E+02*   .233647E+01    .327785E+01
              8       .493562E+01    .155429E+01    .387443E+02    .271263E+02    .766818E+01    .101956E+02    .585692E+01    .904824E+01
      (MAXIMUM)       .493633E+01    .442825E+01    .982129E+02    .271279E+02    .146875E+02    .199898E+02    .591443E+01    .905412E+01

   18         1       .109918E+01    .442635E+01    .125058E-02    .979915E+02    .129210E+01    .129209E+01    .145572E+02    .198265E+02
              2       .109935E+01    .442722E+01    .127439E-02    .980106E+02    .129229E+01    .129229E+01    .145593E+02    .198309E+02
              3       .109900E+01    .442349E+01    .126375E-02    .979280E+02    .129189E+01    .129189E+01    .145475E+02    .198140E+02
              4       .492120E+01    .388445E+00    .271264E+02    .197759E+02    .584017E+01    .903736E+01    .585649E+01    .764907E+01
              5       .492555E+01    .395024E+00    .271279E+02*   .197979E+02    .587080E+01    .905389E+01*   .586737E+01    .766352E+01
              6       .493605E+01*   .377182E+00    .266834E+02    .195103E+02    .591413E+01*   .891654E+01    .590253E+01    .759059E+01
              7       .197454E+01    .442825E+01*   .904189E+01    .982129E+02*   .233640E+01    .327778E+01    .146875E+02*   .199898E+02*
              8       .493534E+01    .155428E+01    .271263E+02    .387442E+02    .585663E+01    .904800E+01    .766780E+01    .101955E+02
      (MAXIMUM)       .493605E+01    .442825E+01    .271279E+02    .982129E+02    .591413E+01    .905389E+01    .146875E+02    .199898E+02

   19         1       .322442E+02    .517592E+01    .170057E+02    .121876E+03    .162234E+02    .696192E+01    .650319E+02    .758085E+02
              2       .322446E+02    .517593E+01    .170057E+02    .121877E+03    .162234E+02    .696200E+01    .650321E+02    .758085E+02
              3       .322706E+02    .517555E+01    .170048E+02    .121867E+03    .162311E+02    .695664E+01    .550183E+02    .758118E+02
              4       .450659E+01    .630749E+00    .207092E+01    .148535E+02    .176716E+01    .143617E+01    .841135E+01    .883099E+01
              5       .450726E+01    .630754E+00    .207094E+01    .148536E+02    .176720E+01    .143648E+01    .841168E+01    .883114E+01
              6       .453107E+01    .633502E+00    .208056E+01    .149178E+02    .179284E+01    .142239E+01    .842174E+01    .889416E+01
              7       .322792E+02*   .518019E+01*   .170197E+02*   .121977E+03*   .162341E+02*   .697836E+01*   .650923E+02*   .758656E+02*
              8       .118531E+02    .186943E+01    .614152E+01    .440197E+02    .579211E+01    .276867E+01    .236567E+02    .272457E+02
      (MAXIMUM)       .322792E+02    .518019E+01    .170197E+02    .121977E+03    .162341E+02    .697836E+01    .650923E+02    .758656E+02

   20         1       .556153E+01    .126836E+02    .121876E+03    .125136E+03    .693292E+02    .710868E+02    .729670E+02    .712038E+02
              2       .556161E+01    .126836E+02    .121877E+03    .125136E+03    .693293E+02    .710869E+02    .729671E+02    .712039E+02
              3       .556609E+01    .126826E+02    .121867E+03    .125127E+03    .693224E+02    .710831E+02    .729635E+02    .711972E+02
              4       .825356E+00    .154433E+01    .148535E+02    .152224E+02    .853478E+01    .858101E+01    .879426E+01    .874630E+01
              5       .825568E+00    .154434E+01    .148536E+02    .152225E+02    .853489E+01    .858103E+01    .879428E+01    .874640E+01
              6       .828312E+00    .155109E+01    .149178E+02    .152898E+02    .856690E+01    .862287E+01    .883797E+01    .878028E+01
              7       .556833E+01*   .126940E+02*   .121977E+03*   .125239E+03*   .693875E+02*   .711443E+02*   .730258E+02*   .712634E+02*
              8       .206320E+01    .458059E+01    .440197E+02    .451874E+02    .250694E+02    .256476E+02    .263213E+02    .257408E+02
      (MAXIMUM)       .556833E+01    .126940E+02    .121977E+03    .125239E+03    .693875E+02    .711443E+02    .730258E+02    .712634E+02

   21         1       .280766E+02    .566444E+01    .125136E+03    .169292E+02    .768715E+02    .676178E+02    .698792E+01    .152366E+02
              2       .280788E+02    .566445E+01    .125136E+03    .169293E+02    .768716E+02    .676181E+02    .698819E+01    .152369E+02
              3       .280982E+02    .566405E+01    .125127E+03    .169284E+02    .768735E+02    .676059E+02    .698277E+01    .152429E+02
              4       .526283E+01    .689049E+00    .152224E+02    .205908E+01    .980495E+01    .779820E+01    .777679E+00    .232363E+01
              5       .526806E+01    .689052E+00    .152225E+02    .205909E+01    .980503E+01    .779857E+01    .779379E+00    .232422E+01
              6       .531434E+01    .692125E+00    .152898E+02    .206881E+01    .985235E+01    .782999E+01    .787187E+00    .233962E+01
              7       .281314E+02*   .566909E+01*   .125239E+03*   .169431E+02*   .769409E+02*   .676678E+02*   .699272E+01*   .152563E+02*
              8       .107006E+02    .204546E+01    .451874E+02    .611315E+01    .279149E+02    .242766E+02    .249993E+01    .567770E+01
      (MAXIMUM)       .281314E+02    .566909E+01    .125239E+03    .169431E+02    .769409E+02    .676678E+02    .699272E+01    .152563E+02

   22         1       .566444E+01    .116968E+01    .170057E+02    .169292E+02    .701088E+02    .798189E+02    .794817E+02    .697719E+02
              2       .566445E+01    .116969E+01    .170057E+02    .169293E+02    .701089E+02    .798190E+02    .794819E+02    .697720E+02
              3       .566405E+01    .116962E+01    .170048E+02    .169284E+02    .701052E+02    .798146E+02    .794777E+02    .697685E+02
              4       .689048E+00    .142355E+00    .207092E+01    .205908E+01    .853838E+01    .971957E+01    .966733E+01    .8[illegible]17E+01
              5       .689052E+00    .142356E+00    .207094E+01    [illegible]5909E+01    .853844E+01    .971964E+01    .966739E+01    .8[illegible]2E+01
                      .[illegible]25E[illegible]  .1[illegible]E+0[illegible]  .208[illegible]01  [illegible]688[illegible]1  [illegible]823[illegible]  .[illegible]0E+[illegible]  .97[illegible]+01  [illegible]
                                                                                                                   .79[illegible]+02*      9829[illegible]2*
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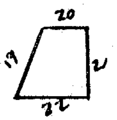

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NAS MOFFETT FIELD                                                                                                          PAGE    25
RESPONSE SPECTRUM ANALYSIS OF HANGAR 46                                                                                   18 MAR 83

  BEAM  RESPONSE        END 1        END 1        END 1        EVD 2        END 1        END 1        END 2        END 2
 NUMBER     CASE     X-THRUST      Y-SHEAR     Z-MOMENT     Z-MOMENT  PT. 1 STRESS PT. 2 STRESS PT. 1 STRESS PT. 2 STRESS

    23         1  .280759E+02  .566444E+01  .169292E+02  .125136E+03  .152364E+02  .698808E+01  .676181E+02  .768713E+02
               2  .280780E+02  .566445E+01  .169293E+02  .125136E+03  .152367E+02  .698835E+01  .676184E+02  .768714E+02
               3  .280974E+02  .566406E+01  .169284E+02  .125127E+03  .152427E+02  .698294E+01  .676062E+02  .768733E+02
               4  .527045E+01  .689043E+00  .205907E+01  .152222E+02  .232491E+01  .779779E+00  .779781E+01  .980563E+01
               5  .527611E+01  .689047E+00  .205908E+01  .152223E+02  .232556E+01  .782249E+00  .779820E+01  .980569E+01
               6  .532239E+01  .692121E+00  .206880E+01  .152897E+02  .234097E+01  .789405E+00  .782958E+01  .985307E+01
               7  .281308E+02* .566910E+01* .169431E+02* .125239E+03* .152561E+02* .699291E+01* .676681E+02* .759408E+02*
               8  .109041E+02  .204546E+01  .611315E+01  .451874E+02  .567815E+01  .250063E+01  .242766E+02  .279151E+02
      (MAXIMUM)   .281308E+02  .566910E+01  .169431E+02  .125239E+03  .152561E+02  .699291E+01  .676681E+02  .769408E+02

    24         1  .556152E+01  .126836E+02  .125136E+03  .121876E+03  .729670E+02  .712038E+02  .693292E+02  .710869E+02
               2  .556159E+01  .126836E+02  .125136E+03  .121877E+03  .729671E+02  .712039E+02  .693293E+02  .710870E+02
               3  .556608E+01  .126827E+02  .125127E+03  .121867E+03  .729635E+02  .711972E+02  .693225E+02  .710832E+02
               4  .825853E+00  .154432E+01  .152222E+02  .148534E+02  .879413E+01  .874631E+01  .853481E+01  .858089E+01
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               6  .828851E+00  .155108E+01  .152897E+02  .149177E+02  .883783E+01  .878030E+01  .856694E+01  .862275E+01
               7  .556833E+01* .126940E+02* .125239E+03* .121977E+03* .730259E+02* .712635E+02* .693876E+02* .711444E+02*
               8  .206339E+01  .458059E+01  .451874E+02  .440197E+02  .263213E+02  .257408E+02  .250695E+02  .256476E+02
      (MAXIMUM)   .556833E+01  .126940E+02  .125239E+03  .121977E+03  .730259E+02  .712635E+02  .693876E+02  .711444E+02

    25         1  .322441E+02  .517592E+01  .170057E+02  .121876E+03  .162234E+02  .696192E+01  .650320E+02  .758085E+02
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               3  .322705E+02  .517555E+01  .170048E+02  .121867E+03  .162311E+02  .695665E+01  .650184E+02  .758118E+02
               4  .450889E+01  .630745E+00  .207092E+01  .148534E+02  .176724E+01  .143689E+01  .841175E+01  .883066E+01
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      (MAXIMUM)   .322791E+02  .518017E+01  .170197E+02  .121977E+03  .162341E+02  .697838E+01  .650924E+02  .758656E+02

    26         1  .566444E+01  .116967E+01  .169292E+02  .170057E+02  .794818E+02  .697719E+02  .701089E+02  .798189E+02
               2  .566445E+01  .116969E+01  .169293E+02  .170057E+02  .794819E+02  .697720E+02  .701090E+02  .798190E+02
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               7  .566910E+01* .117065E+01* .169431E+02* .170197E+02* .795471E+02* .698293E+02* .701666E+02* .798846E+02*
               8  .204546E+01  .422403E+00  .611315E+01  .614162E+01  .287009E+02  .251946E+02  .253201E+02  .288264E+02
      (MAXIMUM)   .566910E+01  .117065E+01  .169431E+02  .170197E+02  .795471E+02  .698293E+02  .701666E+02  .798846E+02
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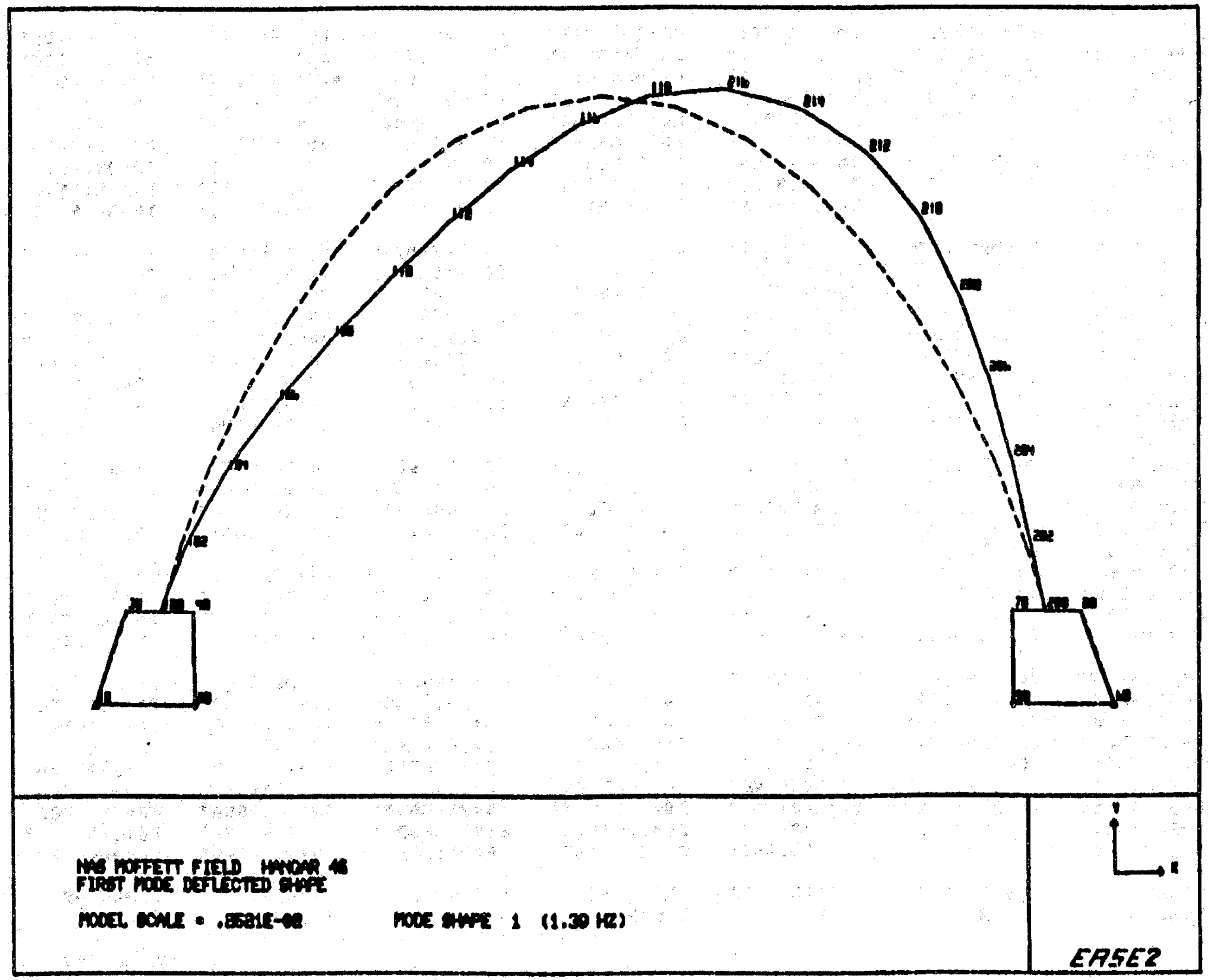
SPRINGS
UNCR BASE

PLOT 1 (PAPER SIZE 11.7 X 9.4)

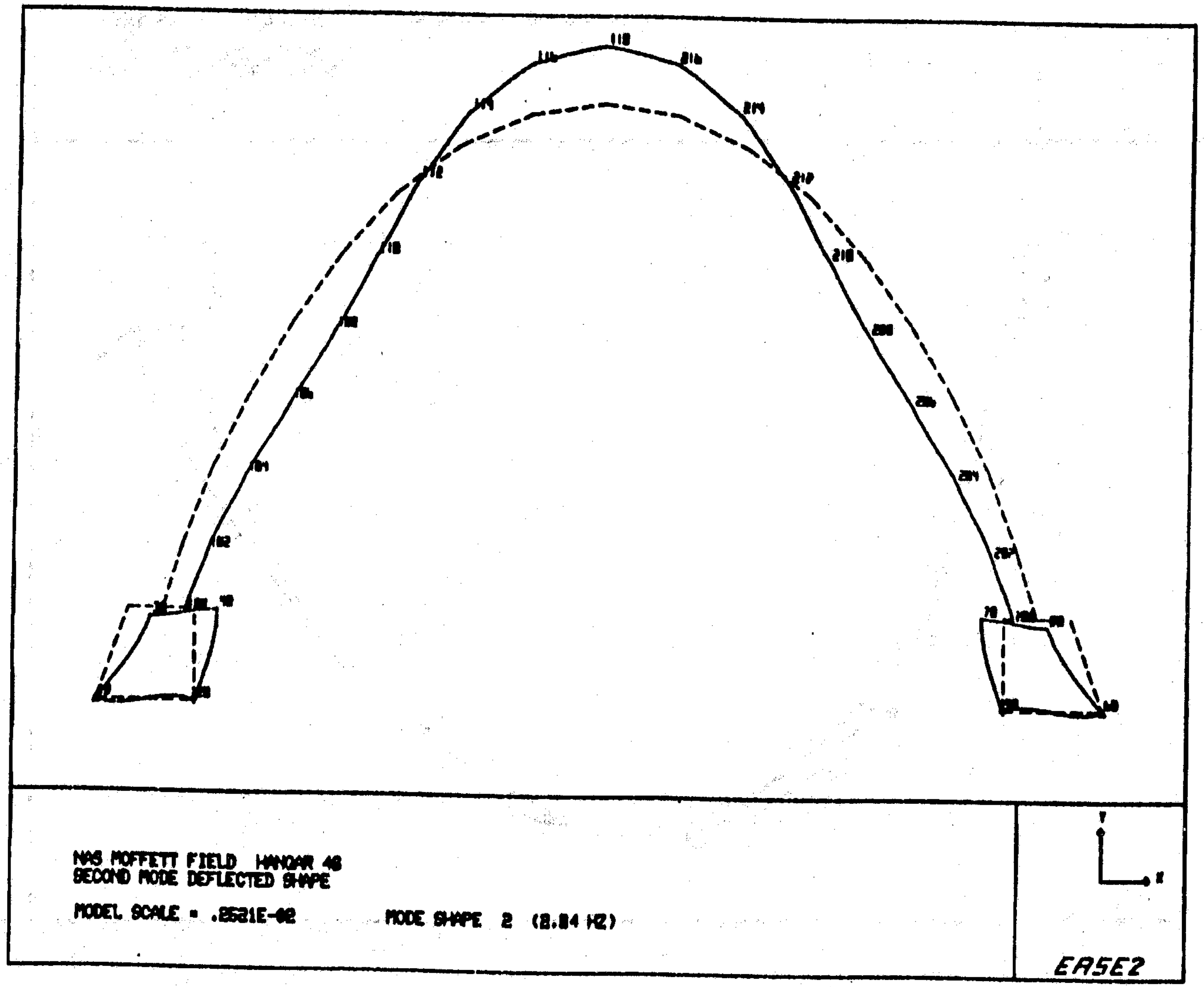


NAS MOFFETT FIELD HANGAR 46
FIRST MODE DEFLECTED SHAPE

MODEL SCALE = .8581E-02 MODE SHAPE 1 (1.30 HZ)

E2PLOT VIEW 1-1 83/02/25 16.08.06.

PLOT 2 (PAPER SIZE 11.7 X 9.4)



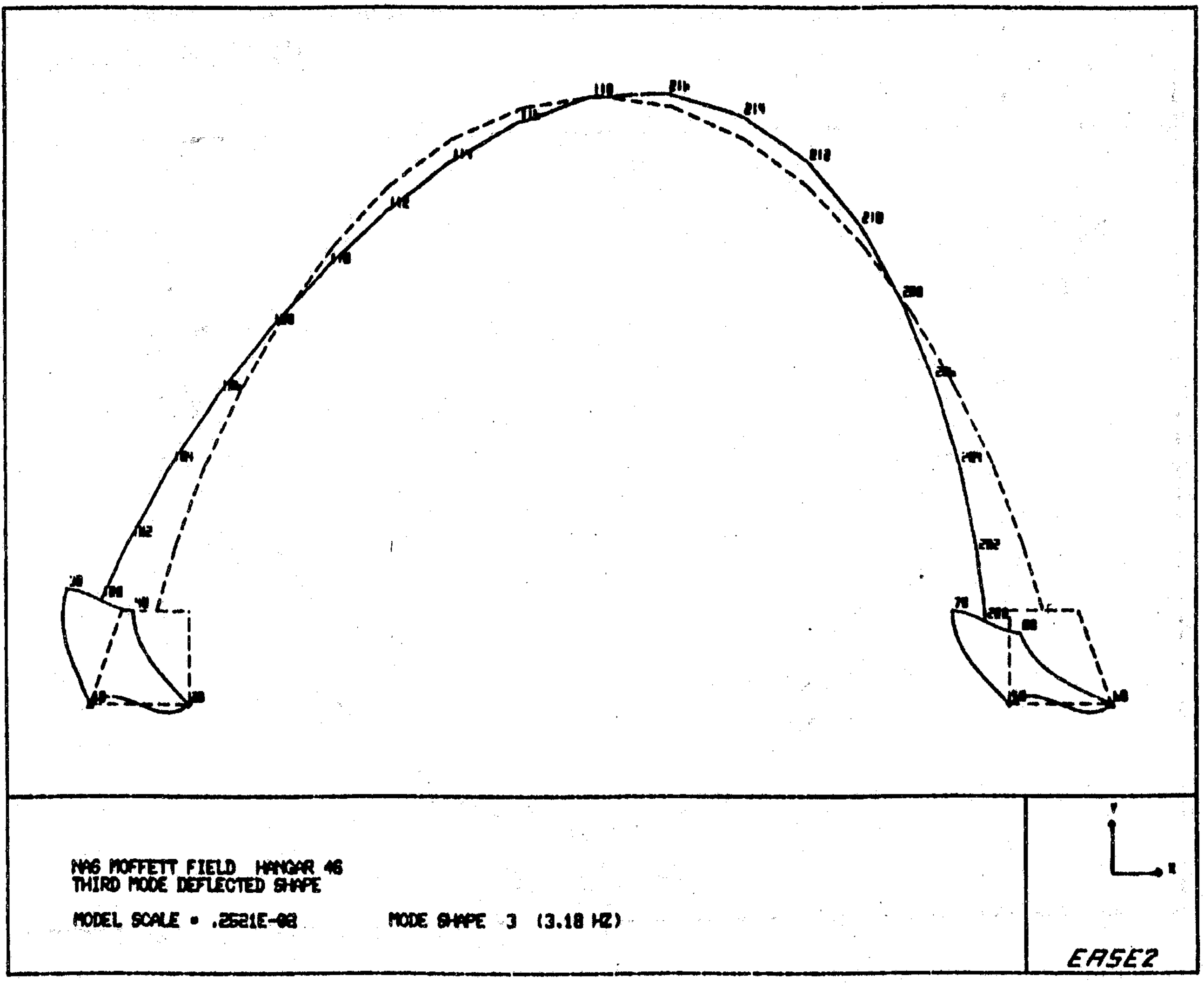
NAS MOFFETT FIELD HANGAR 46
SECOND MODE DEFLECTED SHAPE

MODEL SCALE = .2521E-02 MODE SHAPE 2 (2.84 HZ)

EA5E2

E2PLOT VIEW 1-2 83/02/25 16.08.06.

PLOT 3 (PAPER SIZE 11.7 X 9.4)



NAS MOFFETT FIELD HANGAR 46
THIRD MODE DEFLECTED SHAPE

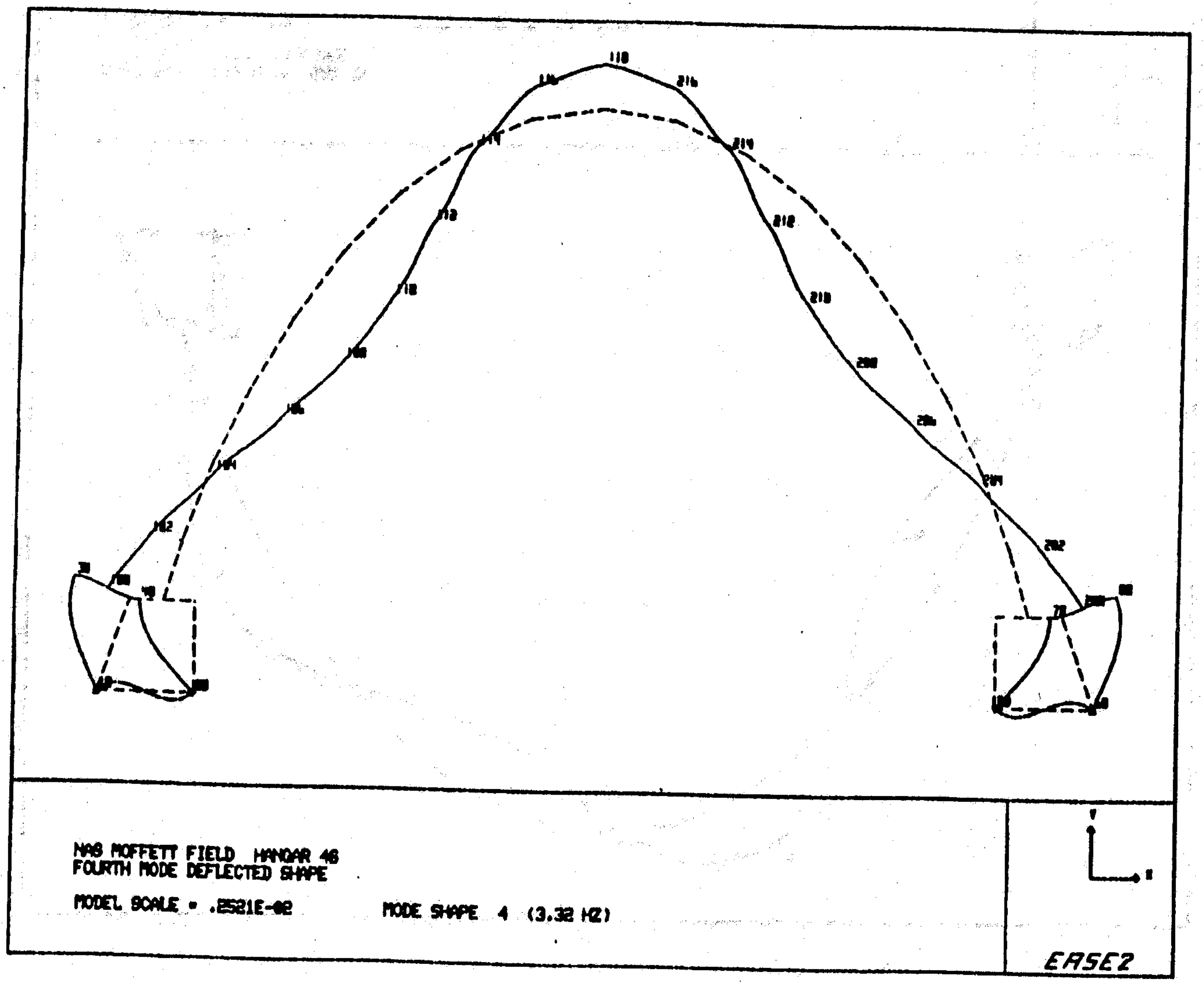
MODEL SCALE = .2521E-08 MODE SHAPE 3 (3.18 HZ)

EASE2

EZPLOT VIEW 1-3 83/02/25 16.06.08.

C

PLOT 4 (PAPER SIZE 11.7 X 9.4)

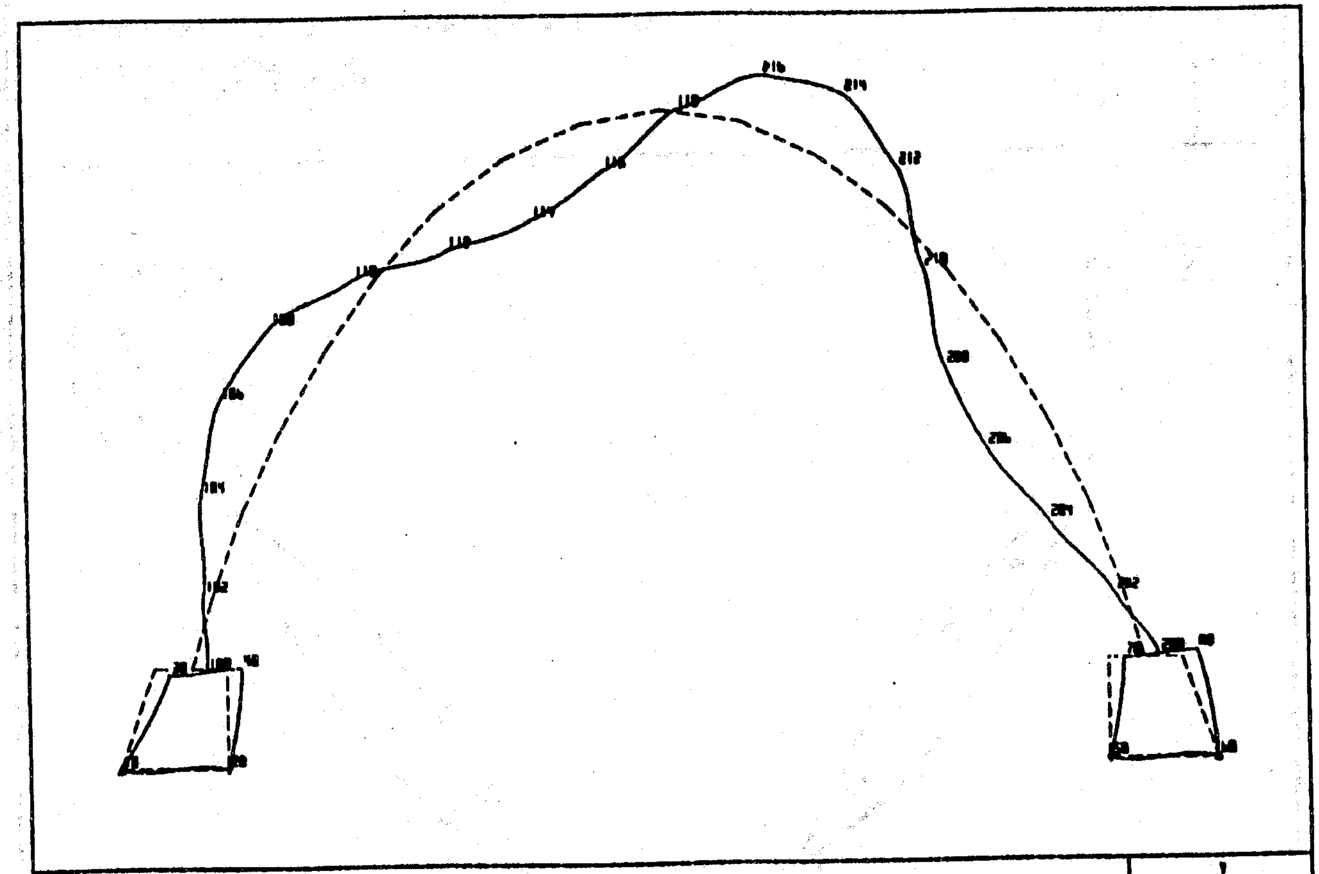


NAS MOFFETT FIELD HANGAR 46
FOURTH MODE DEFLECTED SHAPE

MODEL SCALE = .2521E-02 MODE SHAPE 4 (3.32 HZ)

EZPLOT VIEW 1-4 83/02/25 16.06.06.

PLOT 5 (PAPER SIZE 11.7 X 9.4)



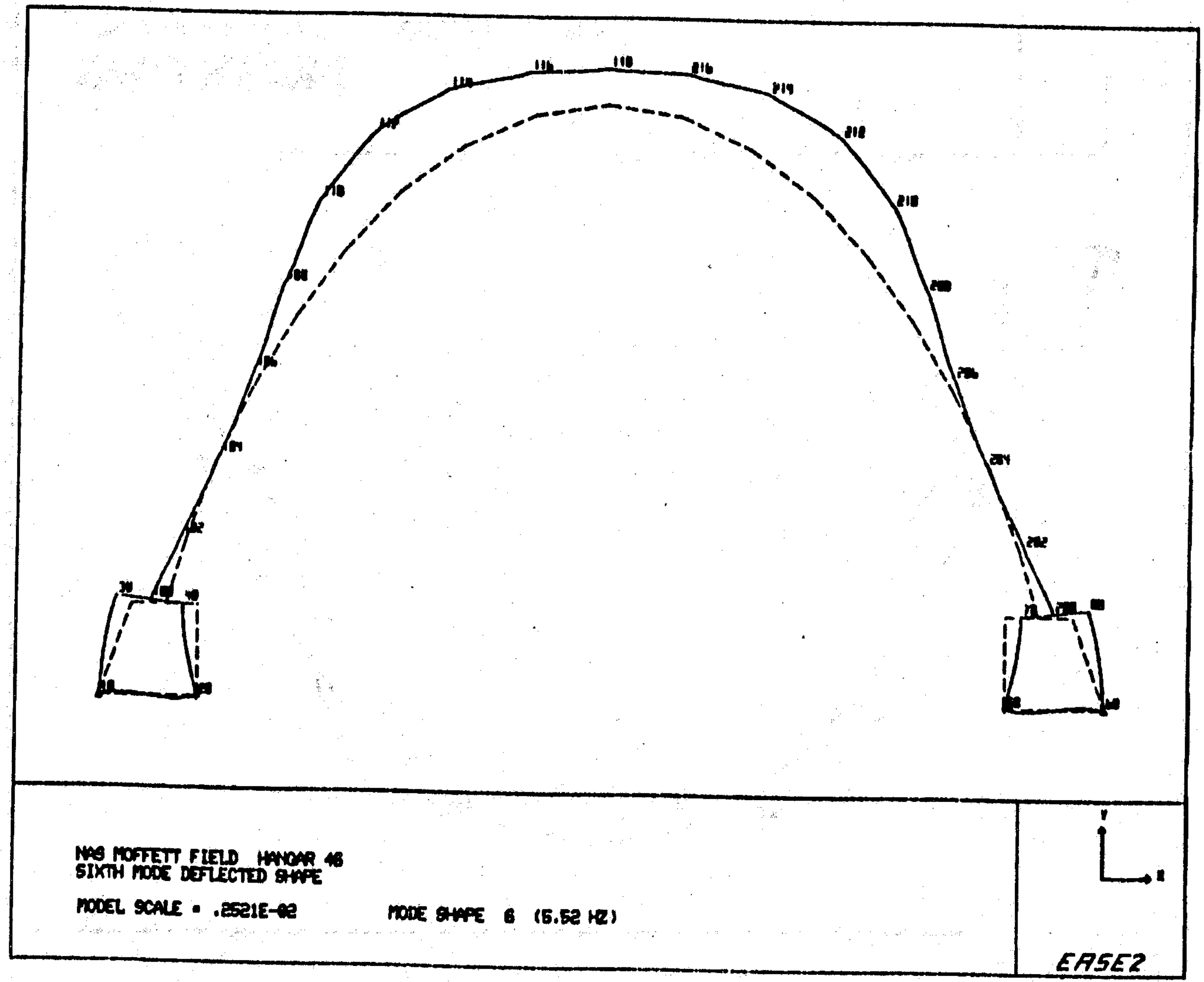
NAS MOFFETT FIELD HANGAR 46
FIFTH MODE DEFLECTED SHAPE

MODEL SCALE = .2521E-02 MODE SHAPE 5 (4.74 HZ)

EASE2

E2PLOT VIEW 1-5 83/02/25 16.06.06.

PLOT 6 (PAPER SIZE 11.7 X 9.4)

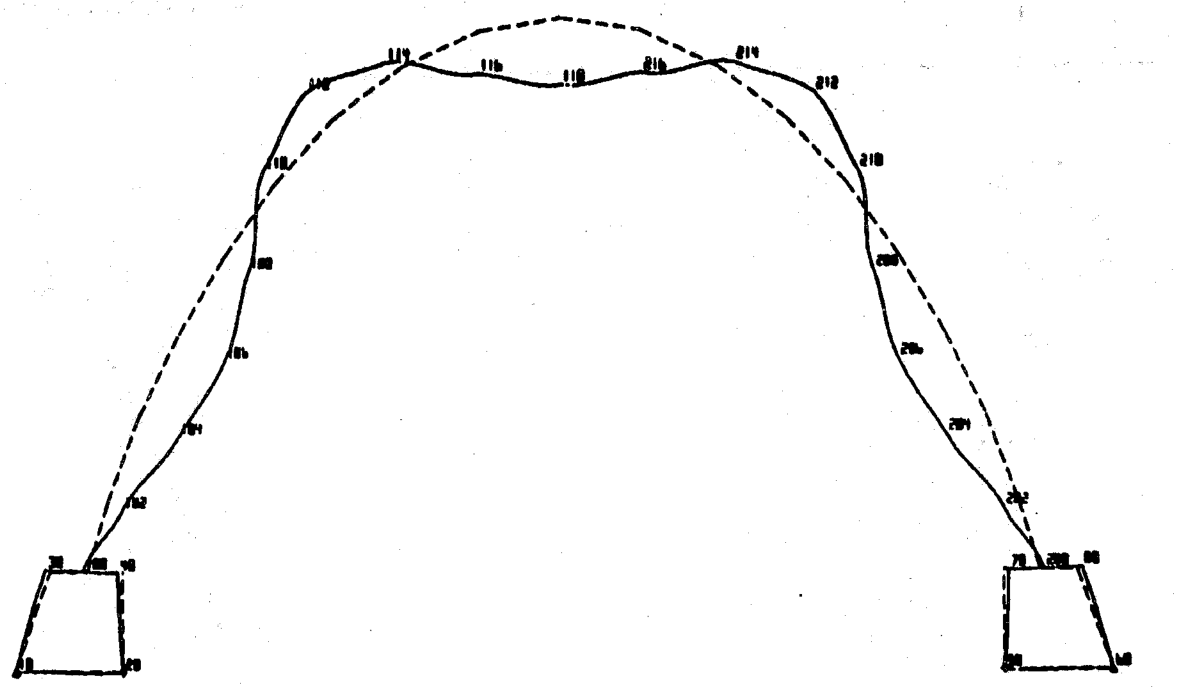


NAS MOFFETT FIELD HANGAR 46
SIXTH MODE DEFLECTED SHAPE

MODEL SCALE = .2521E-02 MODE SHAPE 6 (5.52 HZ)

EZPLOT VIEW 1-6 83/02/25 16.06.06.

PLOT 7 (PAPER SIZE 11.7 X 9.4)



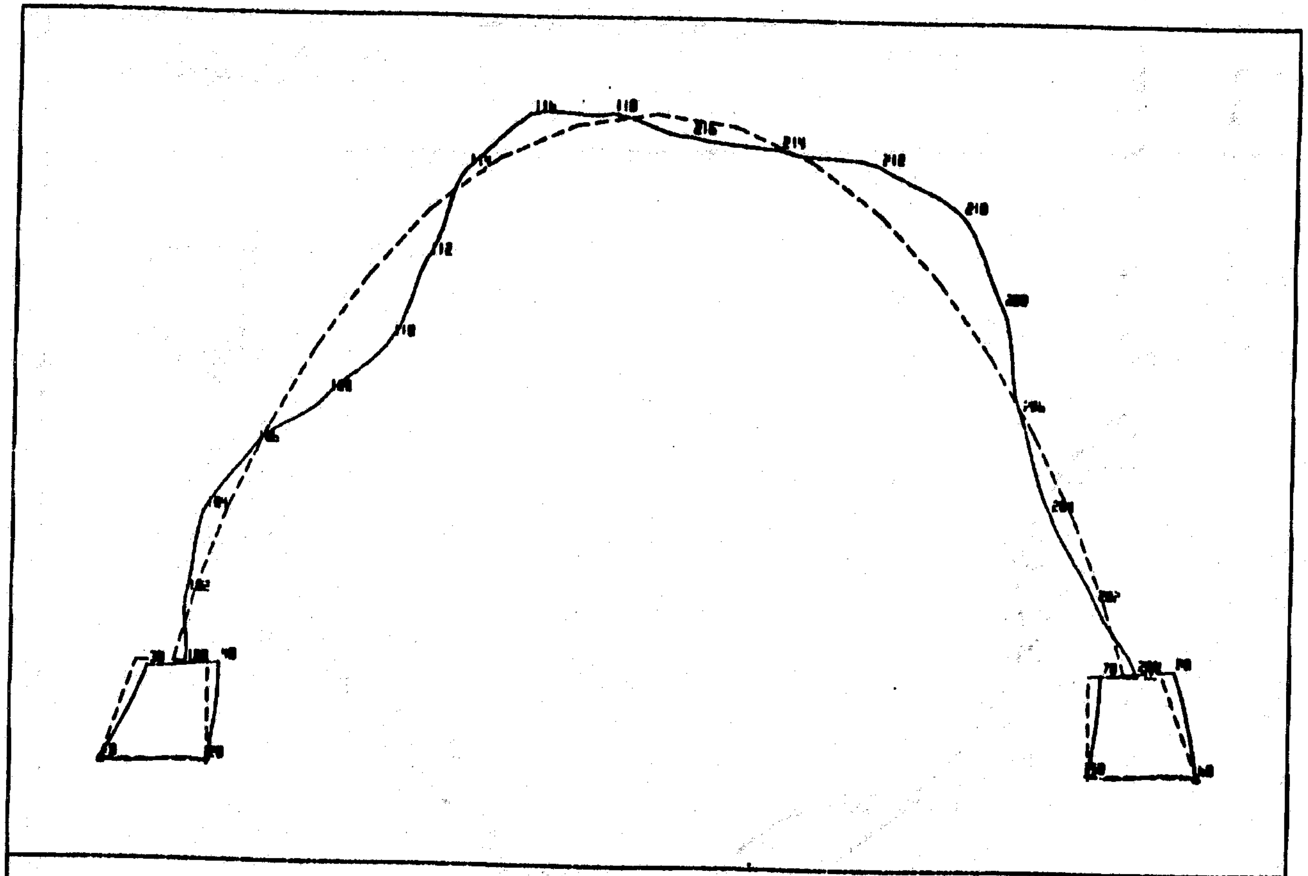
NAS MOFFETT FIELD HANGAR 46
SEVENTH MODE DEFLECTED SHAPE

MODEL SCALE = .2521E-02 MODE SHAPE 7 (6.56 HZ)

EASE2

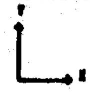
EZPLOT VIEW 1-7 83/02/25 16.06.06.

PLOT 8 (PAPER SIZE 11.7 X 9.4)



NAS MOFFETT FIELD HANGAR 46
EIGTH MODE DEFLECTED SHAPE

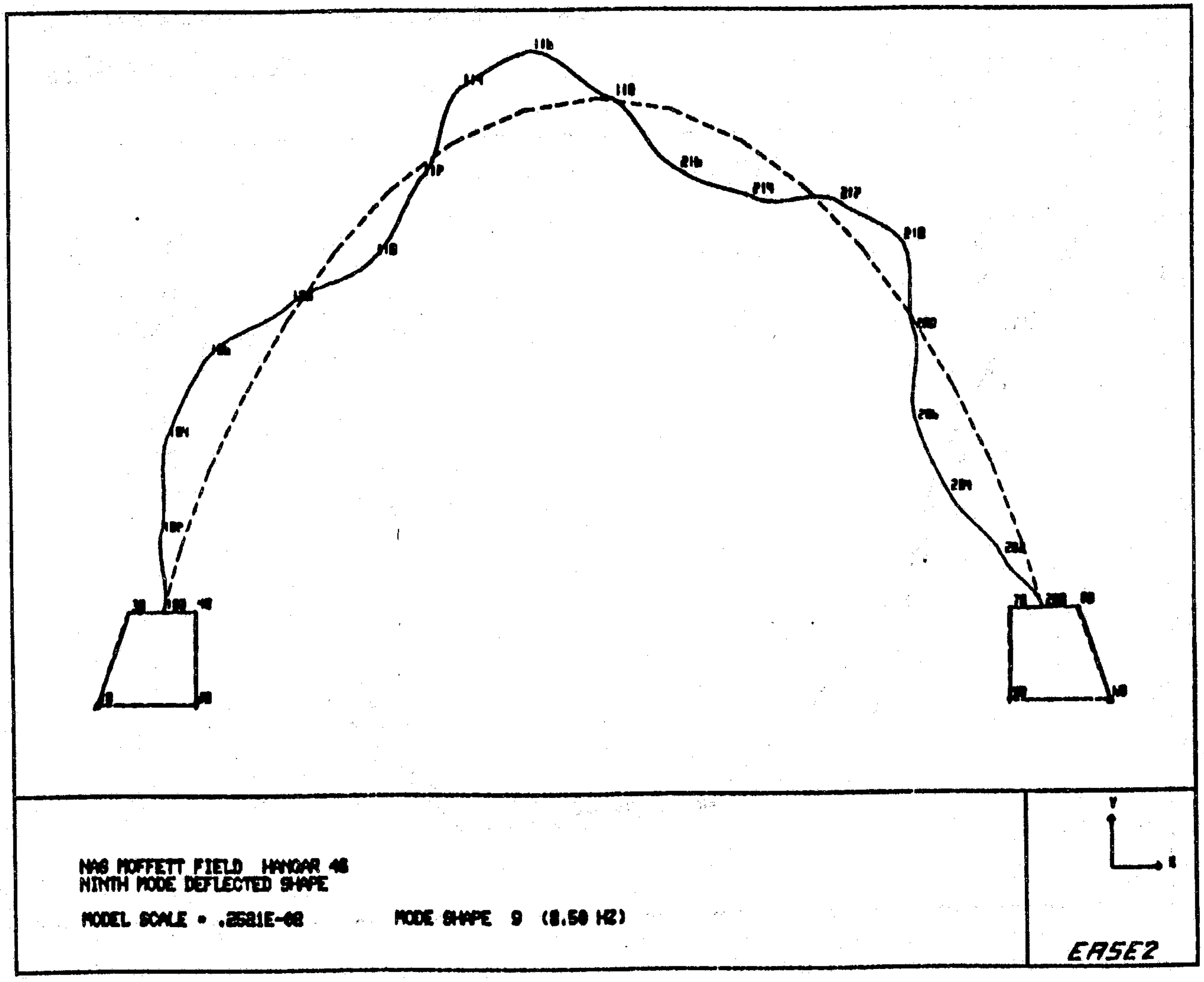
MODEL SCALE = .2521E-02 MODE SHAPE 8 (7.62 HZ)



EASE2

EZPLOT VIEW 1-8 83/02/25 16.06.06.

PLOT 9 (PAPER SIZE 11.7 X 9.4)



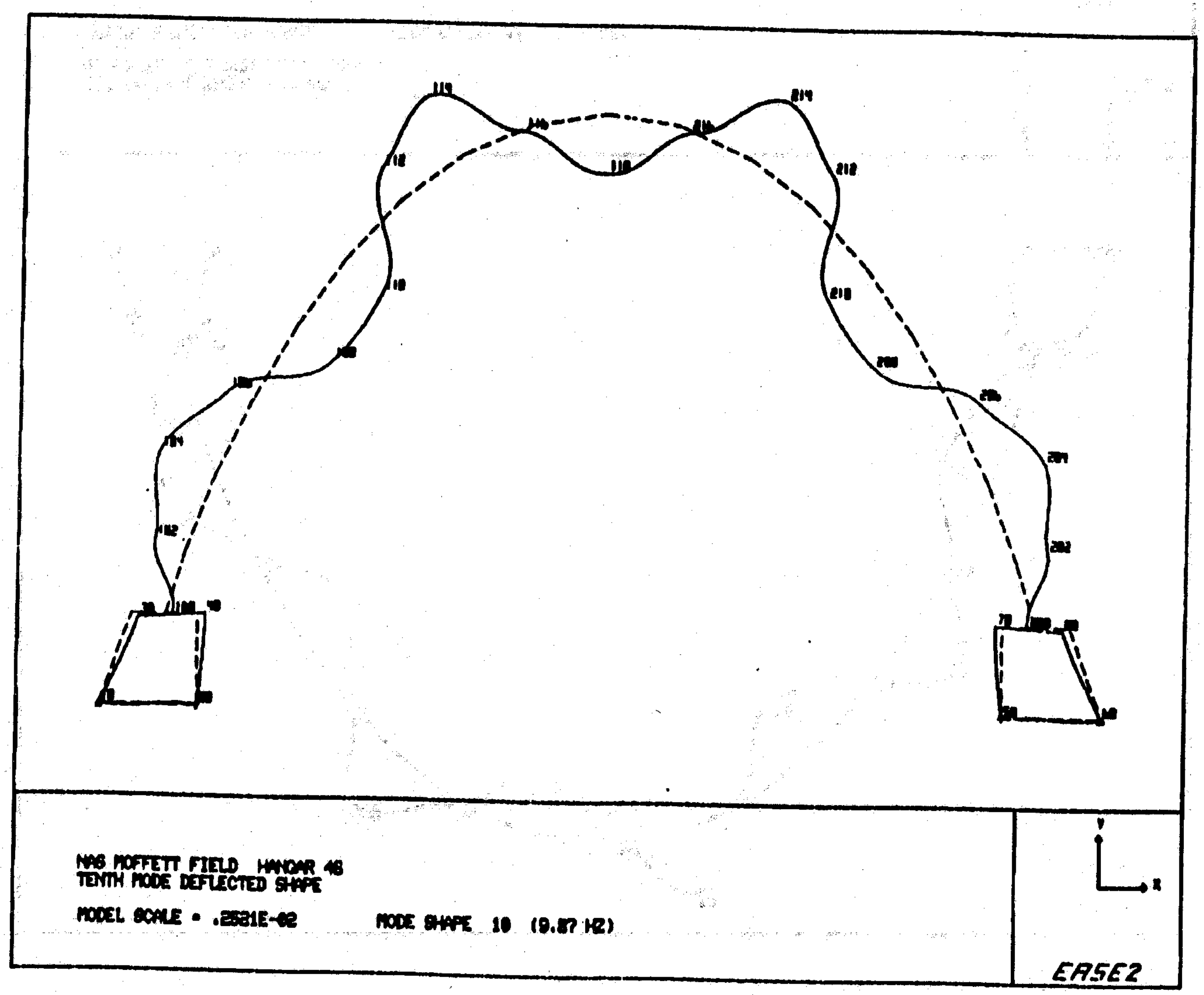
NAS MOFFETT FIELD HANGAR 46
NINTH MODE DEFLECTED SHAPE

MODEL SCALE = .2581E-08 MODE SHAPE 9 (0.50 HZ)

EASE2

E2PLOT VIEW 1-9 83/02/25 16.06.06.

PLOT 10 (PAPER SIZE 11.7 X 9.4)

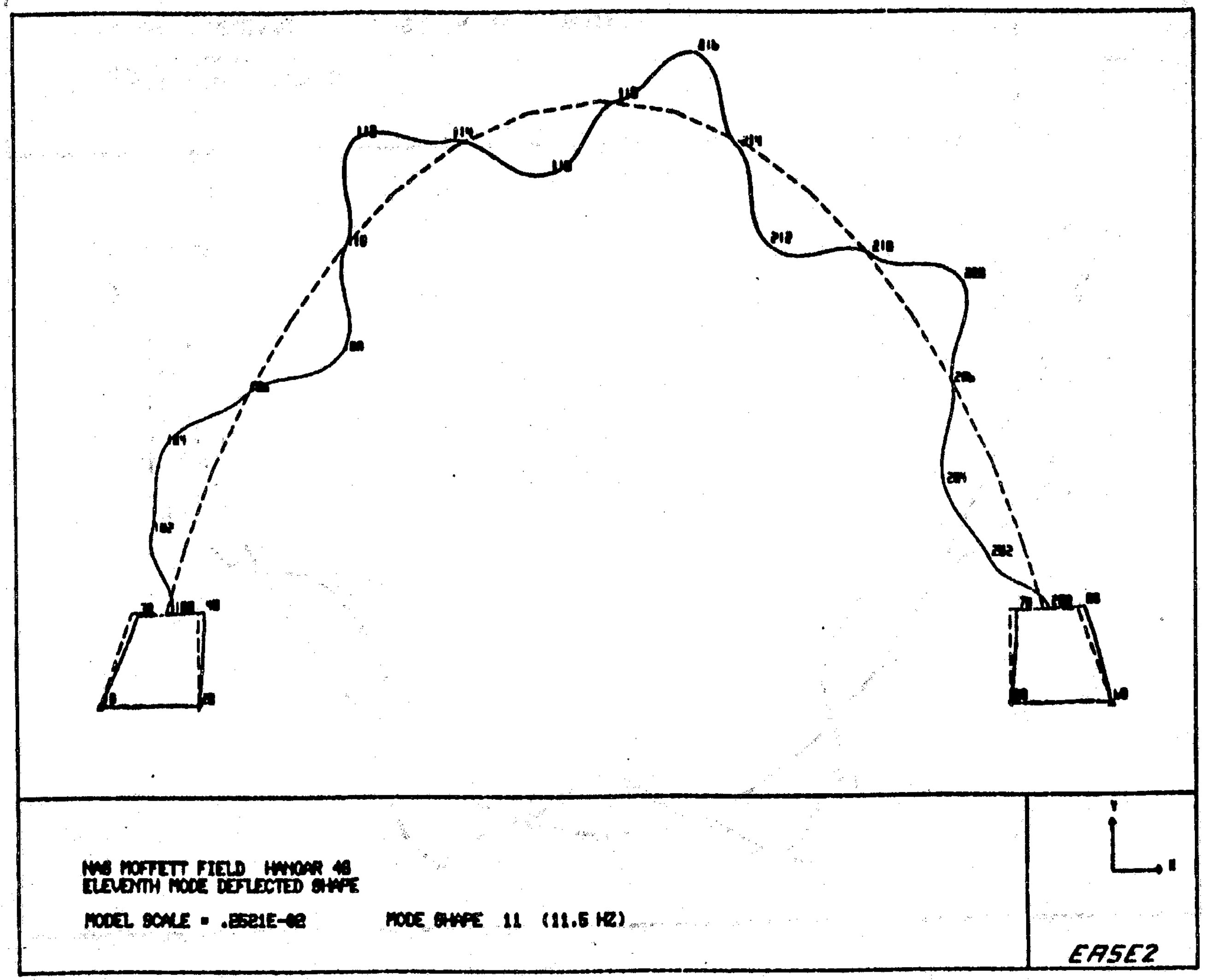


NAS MOFFETT FIELD HANGAR 46
TENTH MODE DEFLECTED SHAPE

MODEL SCALE = .2521E-02 MODE SHAPE 10 (9.87 HZ)

EEPLOT VIEW 1-10 83/02/25 16.06.06.

PLOT 11 (PAPER SIZE 11.7 X 9.4)



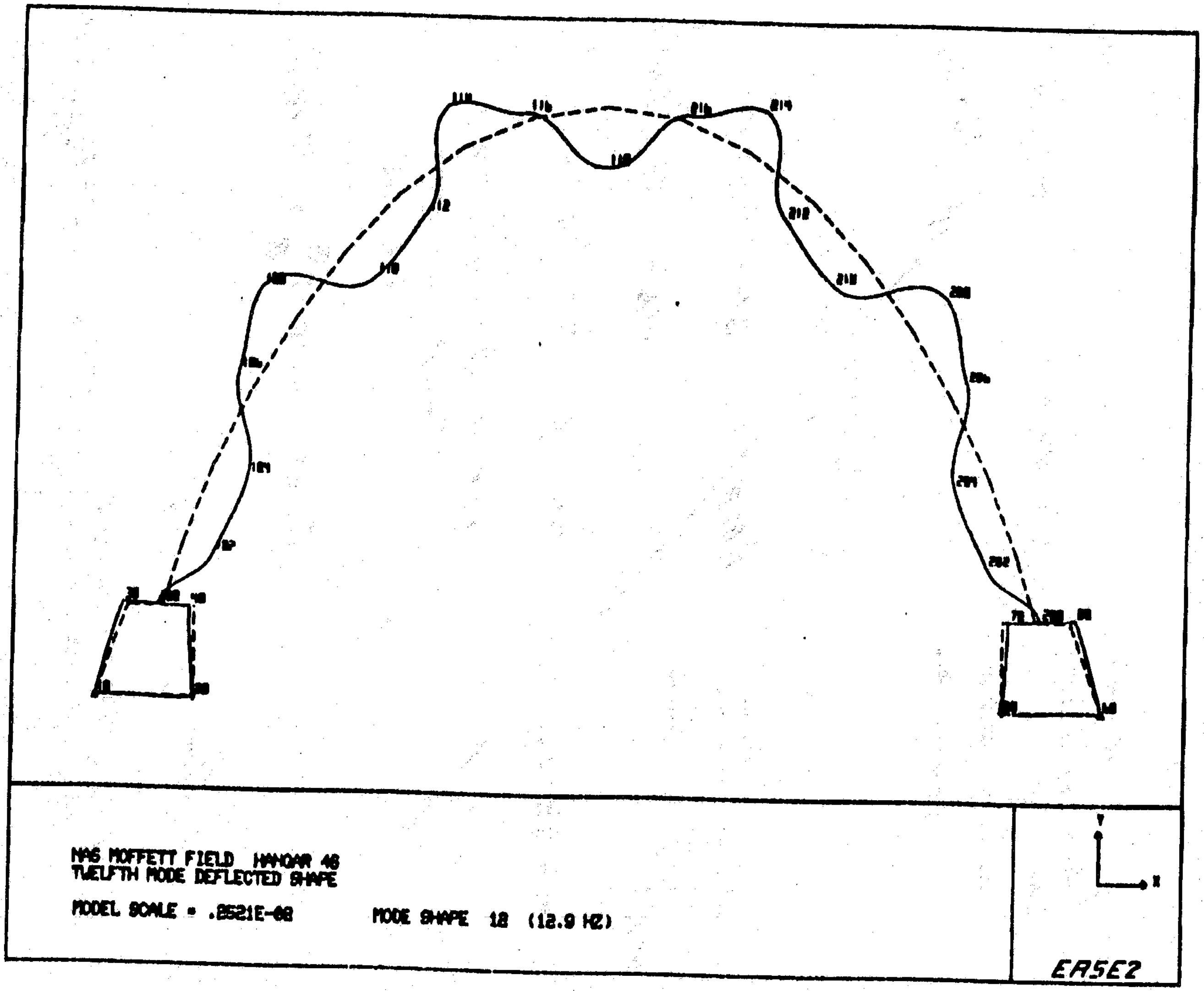
NAS MOFFETT FIELD HANGAR 46
ELEVENTH MODE DEFLECTED SHAPE

MODEL SCALE = .8521E-02 MODE SHAPE 11 (11.5 HZ)

EASE2

EZPLOT VIEW 1-11 83/02/25 16.06.06.

PLOT 12 (PAPER SIZE 11.7 X 9.4)



NAS MOFFETT FIELD HANGAR 46
TWELFTH MODE DEFLECTED SHAPE

MODEL SCALE = .2521E-08 MODE SHAPE 12 (12.9 HZ)

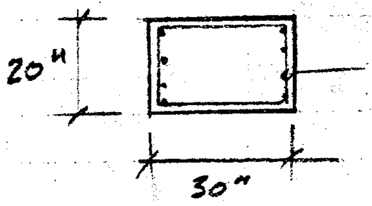
ER5E2

E2PLOT VIEW 1-12 83/02/25 16.06.06.

REVISE BASE FRAME USING CRACKED SECTION PROP'S

NOT USED

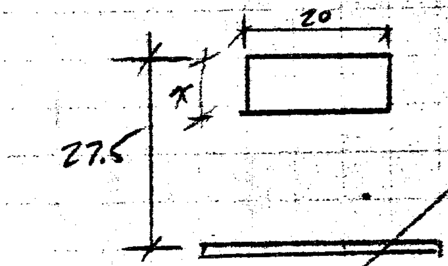
COLUMNS



4 #6's EA. FACE $A_s = 3.53$

$\rho = 3.53/600 = .0059$

$n = 30{,}000/2850 = 10$



$nA_s = 10 \times 3.53/2 = 17.7\ IN^2$

$d = 30 - 2 - 3/8 = 27\tfrac{1}{2}$ SAY

$20x \cdot \frac{x}{2} = 17.7 \times [27.5 - x]$

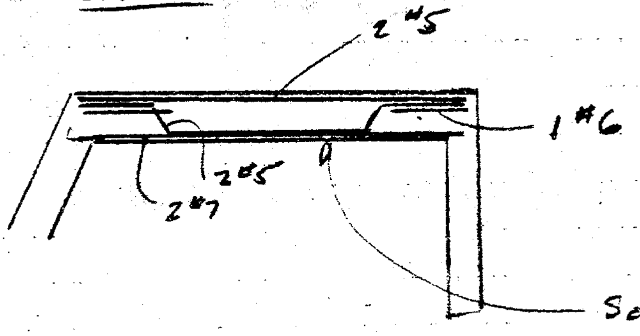
$10x^2 + 17.7x - 487 = 0$

$x^2 + 1.77x - 48.7 = 0$

$x = 6.15''$

$I_{CR} = 20 \times 6.15^3/3 + 17.7 \times (27.5 - 6.15)^2 = 9618$

BEAM



$W = \frac{20 \times 30}{144} \times .15 = 625^{k}/'$

$M^- = \frac{WL^2}{24} = \frac{.625 \times 19^2}{24} = 9.4^{1k}$

SECTION UNDERREINFORCED •

AT COL.

SECTION CAPACITY, 2 #7's $A_s = 1.20$

$a = 1.2 \times 33/.85 \times 2.5 \times 20 = .93''$

$M_u = .9 \times 33 \times 1.2\,[27.5 - .93/2]/12 = 80^{1k}$

$M_{APPLIED} = 125^{1k}$ EQ

LEVEL 1 EQ $\xi = 5\%$

• 56% 0.9

CAPACITY OF COLUMN IN BENDING (MEMB 19521)

$A_S = 4 \# 6's = 1.77 \text{ IN}^2$

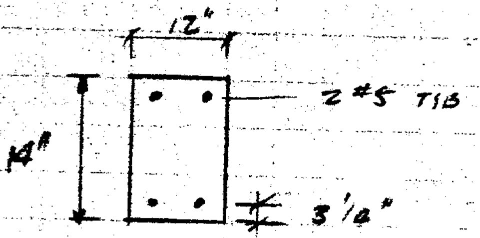
$a = 1.77 \times 33 / .85 \times 2.5 \times 20 = 1.37 \text{ IN}^2$

$M_U = .9 \times 33 \times 1.77 \left[27.5 - 1.37/2 \right] / 12 = 113^{\text{ 1K}}$ @ ULT

$M_{APPLIED_{EQ.}} = 125^{\text{ 1K}}$ 11% O.S.

LEVEL 1 EQ 9'-5%

CRACKED SECTION OF GRADE BEAM



$n A_s = 10 \times .61 = 6.1$

$12 \times \frac{x^2}{2} = 6.1 [10.75 - x]$

$6x^2 + 6.1x - 65.6 = 0$

$x = 2.84''$

$I = 12 \times 2.84^3/3 + 6.1 [10.75 - 2.84]^2 = 473 \text{ IN}^4$

CAPACITY $a = .61 \times 33 / .85 \times 12 \times 2.5 = .79''$

$M_U = .9 \times 61 \times 33 \left[10.75 - \frac{.72}{2} \right] / 12 = 15.6^{\text{ 1K}}$

● $M_{APPLIED} = 17^{\text{ 1K}}$ 9% O.S.

LEVEL 1 EQ.

DATE 2-20-00

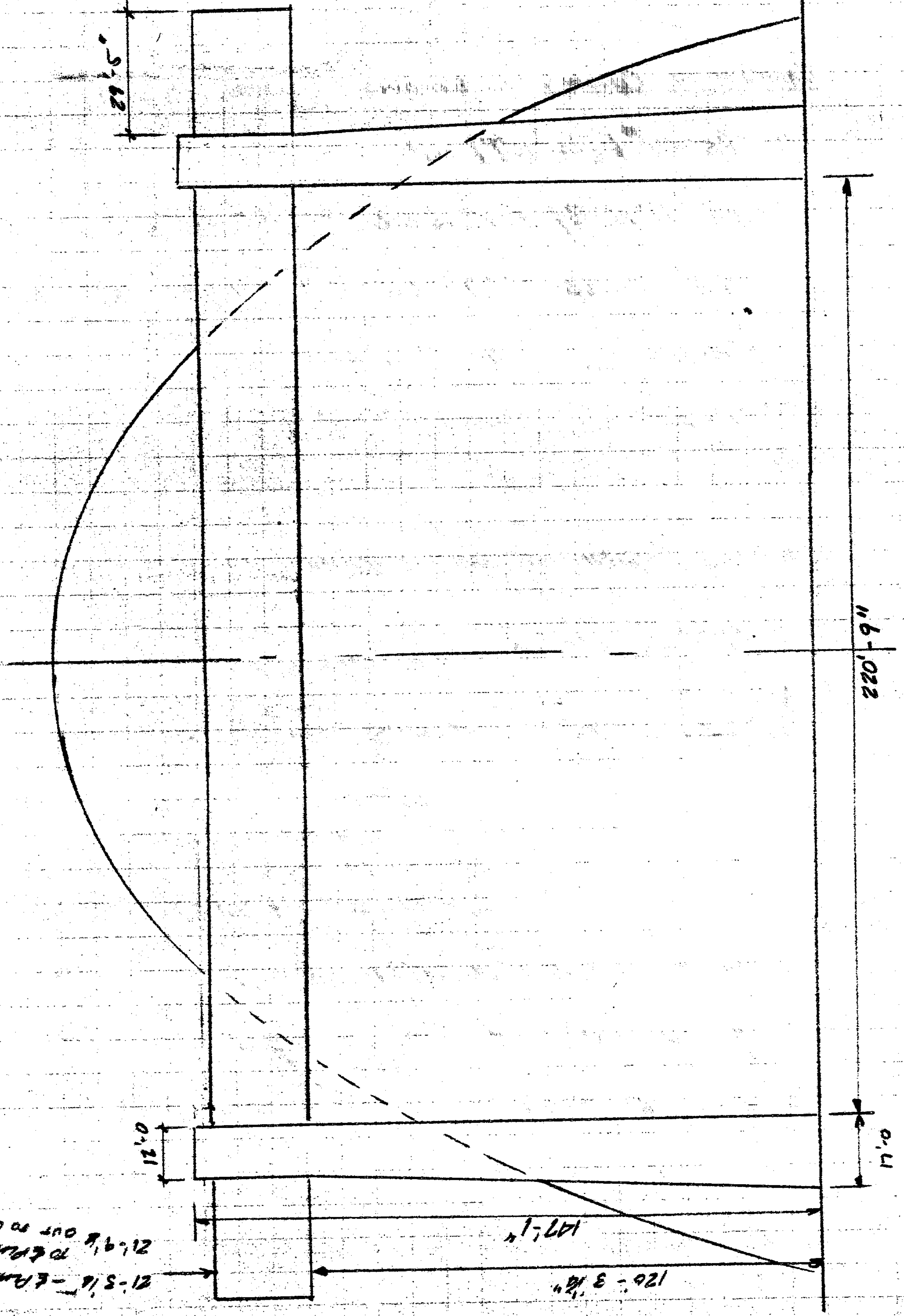
BY JU CHKD.

SUBJECT Hangar 46 Door Structure

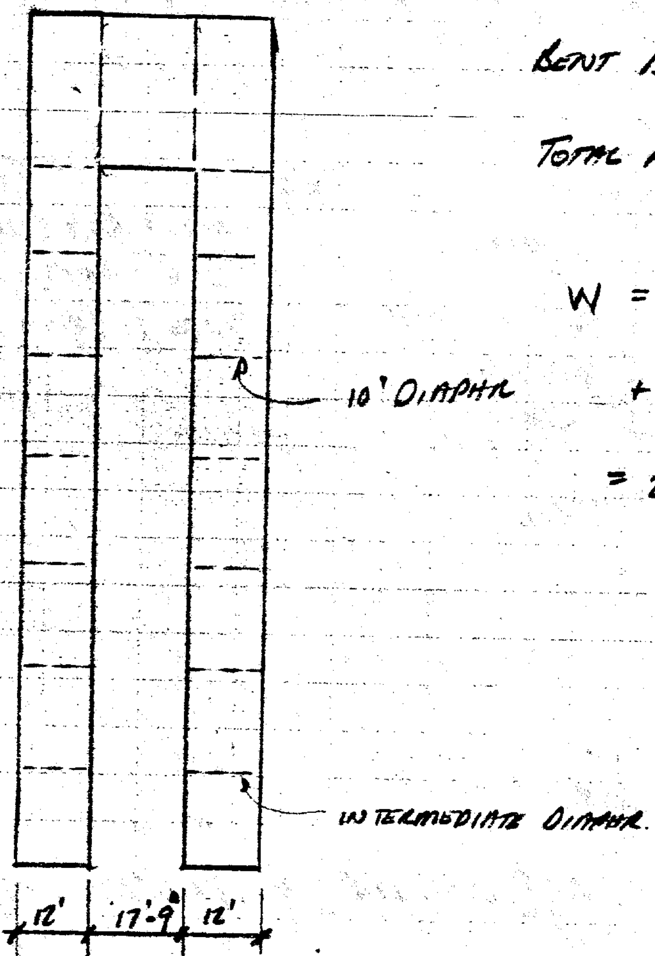
RUTHERFORD & CHEKENE
STRUCTURAL ENGINEERS

JOB NO. 0106D-46

SHEET NO. 46-26



DOORWAY BENT



WEIGHT OF DOORWAY BENT,

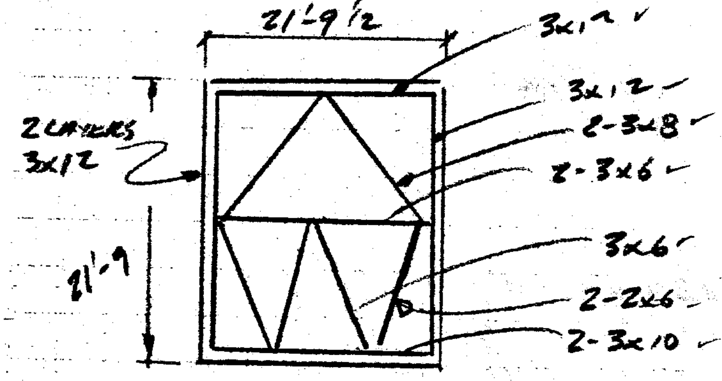
BENT IS 12" THICK

TOTAL A = 24 × 2 × 147.08 + 17.75 × 2 × 27
+ 4 × 12 × 27 + 4 × 120 × 14.5 = 16,270

$$W = 16270 \times .15 + 2 \times 6 \times 12 \times 14.5 \times \frac{10}{12} \times .15$$

$$+ 2 \times 12 \times 41.75 \times \frac{10}{12} \times .15$$

= 2440# + 261 + 125 = 2826 K EA



INTERIOR BRACING AT 7'-1 c.c.

WT/LF -

$$\text{SHEATHING} = 2[21.75 + 21.79] \times \frac{5}{12} \times 35\ \#/LF$$

= 1,270 #/1

INTERNAL BRACING

3x12	= 6.84 #/1 × 21 × 3 =	431#
3x10	= 5.62 × 21 × 2 =	236
3x8	= 2 × 2 × 4.41 × 14.8 =	262
3x6	= 3.34 [2×21 + 2×11.7] =	219
2x6	= 2.00 [2×2×11.7] =	94
		1242

$$W/LF = \frac{1242}{7.08}$$

= 175 #/1

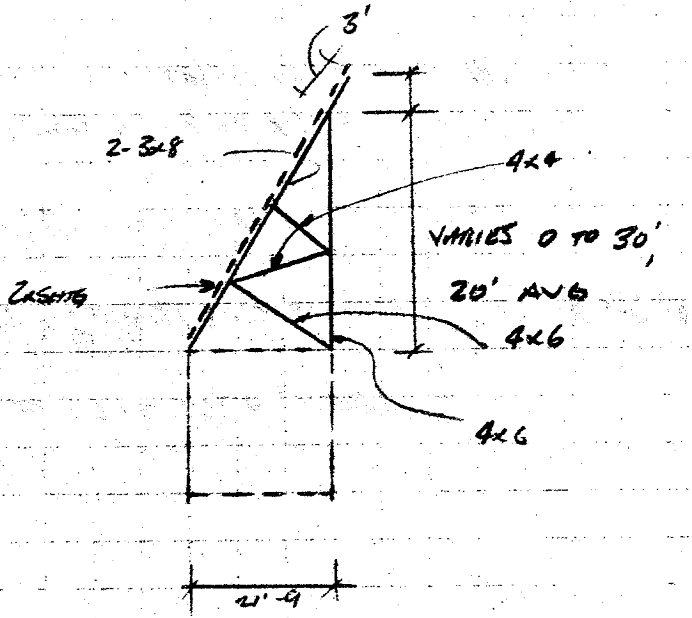
DATE 5-1-02
BY JU CHKD.
SUBJECT Hangar 46

RUTHERFORD & CHEKENE
STRUCTURAL ENGINEERS

JOB NO. 01028-46
SHEET NO. 46-28

BOX BEAM AT DOORS.

A-FRAME OVER BEAM, FRAMES OCCUR AT 7'-1", 19 TOTAL



Wt $4\times4 = 2.97\times[10' + 15'] = 7$
$4\times6 = 4.68\,[15' + 20'] = 17$
$3\times8 = 4.41\,[2\times29.5] = 260$
SHTG $= 32.5\times\frac{1.5}{12}\times7.1\times35 = 101$
1522

TOTAL WT BOX BEAM =

$$W = \overset{279.6'}{[220.75 + 2\times29.42]}\,[1270 + 175] + 19\times1522 = 406,900^{\#}$$

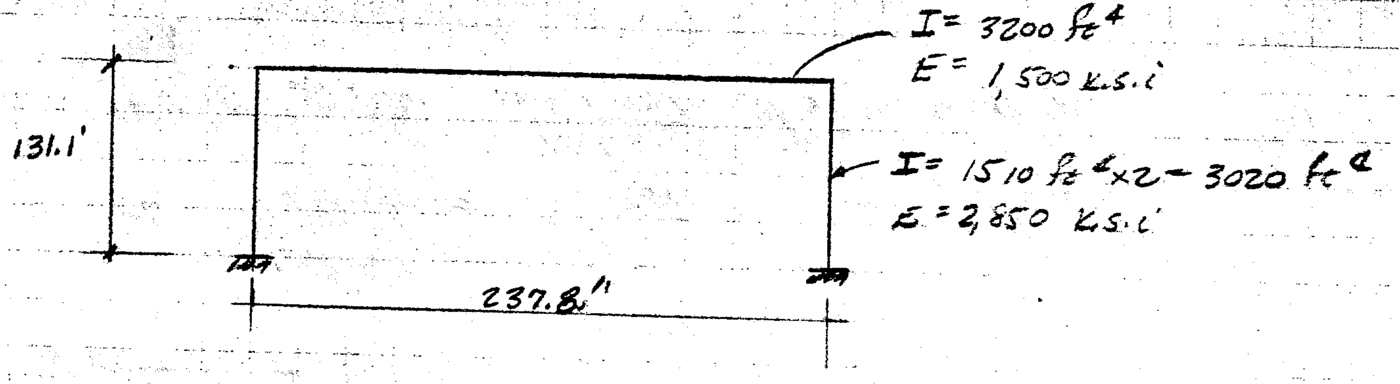
USE $W = 410^{K}$

$W_{TOT}/LF = 410/279.6 = 1.466^{K}/LF$

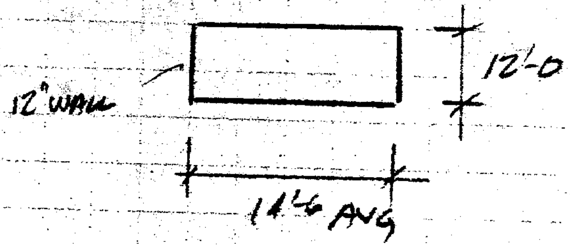
TOTAL WEIGHT
PYLONS = $2826\times2 = 5652$
BEAM $+\ 410$
6062

SP1147A

ESTIMATE STIFFNESS OF DOOR LONGIT



I OF BENT

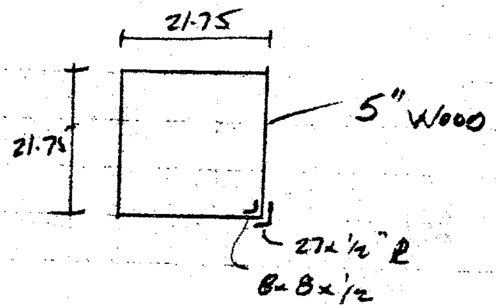


$$I = 2 \times 1 \times \frac{14.5^3}{12} + 2 \times 11 \times 1 \left[\frac{13.5}{2}\right]^2$$

$$= 508 + 1002 = 1510 \text{ ft}^4$$

$$E = 57{,}000\sqrt{2500} = 2{,}850 \text{ k.s.i}$$

I OF BOX BEAM



$$A_s = 27 \times .5 + 16 \times .5 = 21.5 \text{ in}^2$$

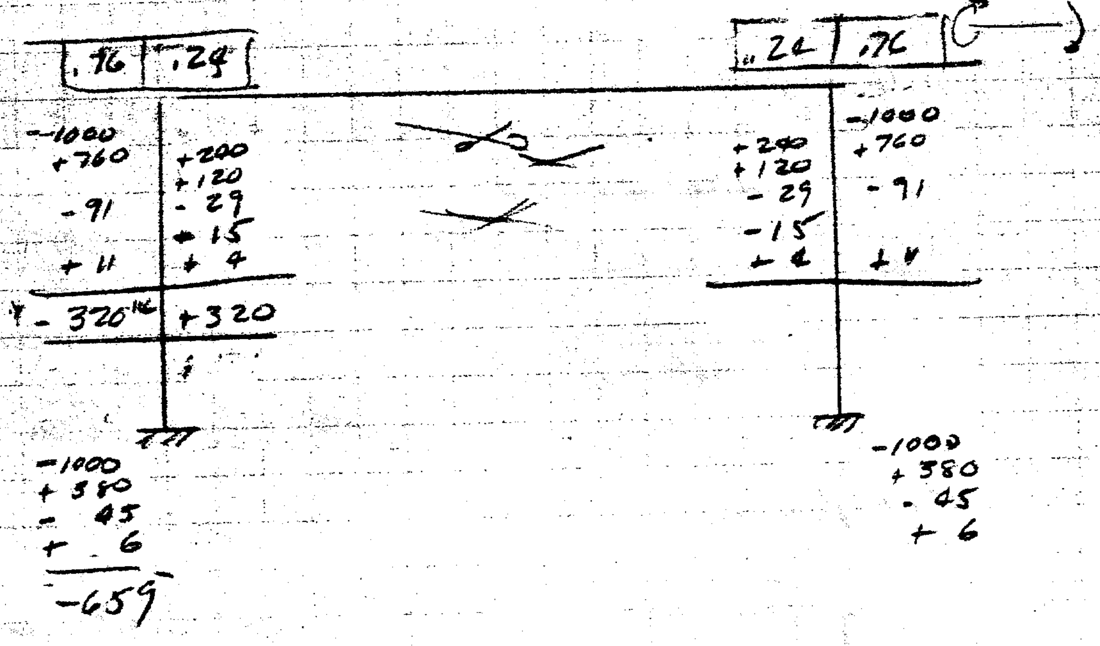
$$n A_s = \frac{29}{1.5} \times 21.5 = 415 \text{ in}^2 = 2.89 \boxed{}$$

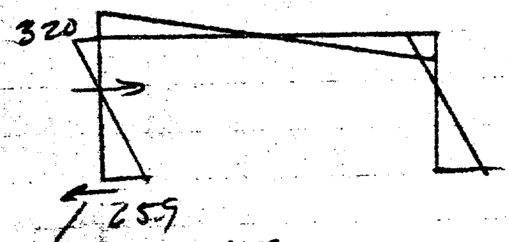
$$I = .42 \times \frac{21.75^3}{12} + 2 \times [21.75 \times .42 + 2.89]\left[\frac{21.7}{2}$$

$$= 360 + 2844 = 3204 \text{ ft}^4$$

F.E.M $M = \frac{6EI\Delta}{L^2}$, FOR OUR CASE USE M = 1000

				K/ΣK
K BEAM	= EI/L =	$\frac{1500 \times 3200}{237.8}$	= 20,185	.24
K COL	=	$\frac{2850 \times 3020}{134.1}$	= 65,652	.76
			85,837	



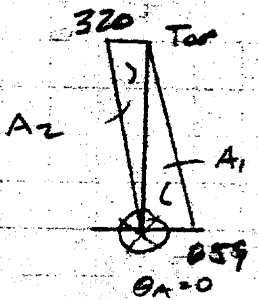


659

$V = \left[\frac{659}{659+320}\right] \times 131.1 = 7.47^k$

V TOTAL = 7.47 × 2
= 14.94k

CALC LATERAL DEFLECTION $P = 14.94^{k}$



$$A_1 = \frac{1}{EI}\left[659 \times \frac{131}{2}\right] = 43,200/EI$$

$$A_2 = \frac{1}{EI}\left[320 \times \frac{131}{2}\right] = 21,000/EI$$

$$\Delta_{TOP} = \frac{1}{2,850 \times 144 \times 3020}\left[43,200 \times \frac{2}{3}[131.1] - 21,000 \times \frac{131.1}{3}\right]$$

$$= .0023 \text{ ft} = .028 \text{ IN}$$

$$K = \frac{14.94}{.028} = 540 \; ^{k}/_{in}$$

$$W = \left[\frac{2826}{2} \times 2 + 410\right] = 3236^{k} \checkmark$$

½ OF BENTS

$$T = 2\pi\sqrt{\frac{M}{K}} = 2\pi\left(\frac{3236}{32.2 \times 12 \times 540}\right)^{1/2} = .78 \text{ SEC}$$

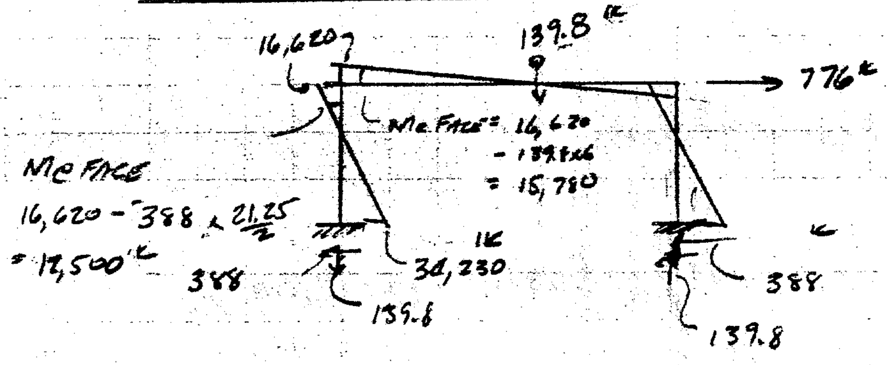
SEISMIC LOAD

USING ½ EQ @ 7% DAMPING,

	FULL E.Q.		
	5%	7%	10%
.7 sec	.567	.517	.443
.78 sec		.481	.409
.85 sec	.520	.472	.401

$$V = .24 \times 3236 = 776. \checkmark$$

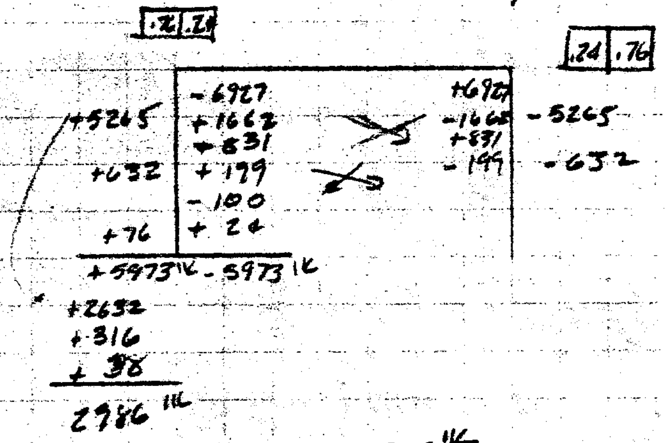
LATERAL ANALYSIS



Mc FACE
16,620 - 388 x 21.25/2
= 12,500 'k

EQ. 776 k

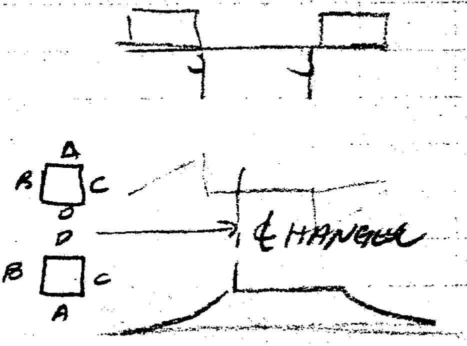
DEAD LOAD $M_{FIX} = WL \times \frac{L}{12} = 1.47^{k}/_{1} \times 237.8^2/12 = 6927$ kft.

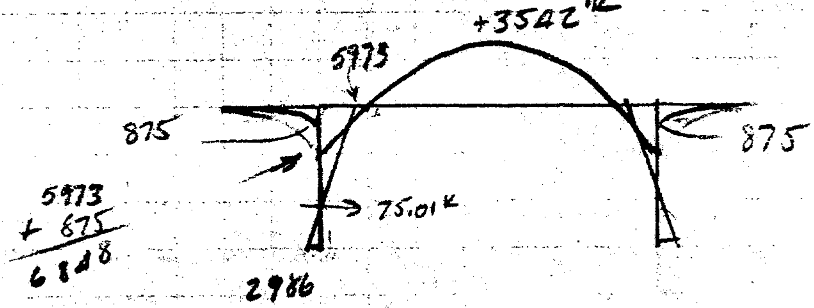


$M_{SIMPLE} = 1.47 \times 237.8^2/8$
$= 10,590$ 'k

$M_{CANT} = 1.47 \times \frac{345^2}{2}$
$= 875$ 'k

$M_{TOT} =$





Mc FACE = 5973 - 75.01k 2/2 = 5185 'k

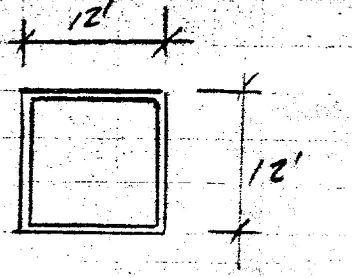
DESIGN BEAM FOR M = 15,780 + 6848
= 22,630 'k

BENT TOP, [5185 ± 12500] /2 = 8,840 'k (-3657)
2 LEGS

BENT BOTTOM [34,230 ± 2990] /2 = 18,610 'k/PIER (-15,620)

LONGIT SEISMIC - CHECK MOMENT ONLY, AXIAL EFFECTS ARE SMALL

FORCES AT TOP OF PIER $M_{APPLIED} = \underline{8840}$ 'K



USING FLANGE ONLY (FACE B)

As	20 #8's	15.70
	8 #8's	6.28
		21.98

$F_y = 33$ k.s.i
$f'_c = 2500$ p.s.i

$$a = \frac{21.98 \times 33}{.85 \times 2.5 \times 144} = 2.37$$

$$M_u = .9 \times 21.98 \times 33 \left[138 - 2.37/2\right]/12 = 7440 \text{ 'K} \checkmark$$

IF SIDEWALL STEEL IS USED

$$A_s = 21.98 + 2 \times [9 \#8's \times 2] = 50.26 \text{ in}^2$$

$$d' = [21.98 \times 138 + 28.3 \times 78]/50.26 = 104.3''$$

$$a = \frac{50.26 \times 33}{.85 \times 2.5 \times 144} = 5.42''$$

$$M_u = .9 \times 41.5 \times 33 \left[104.3 - 5.42/2\right]/12 = 10{,}430 \text{ 'K} \checkmark \text{ O.K.}$$

SHEAR APPLIED = $[75.01 + 388]$ / 4 WALLS = 116 K/LEG

CAPACITY $v_c = 2\sqrt{2500} = 100$ p.s.i
$V_c = .85 \times .8 \times 12 \times 144 \times .1 = 118^K$

$$A_v = \frac{\overset{v_s}{(v_u - v_c)}\, b_w S}{F_y}$$

$$v_s = \frac{A_v F_y}{b_w S} \times b_w \times d = \frac{\overset{4's@18}{.26} \times 33}{12} \times 144 \times .85 = \underline{88^K}$$

206^K OK

TOP OF PIER, FACE C.

$M_{APPLIED} = 3657^{1K}$

USING FLANGE ONLY

$A_S = 8\ \#8's = 6.28$

$12\ \#7's = 7.22$

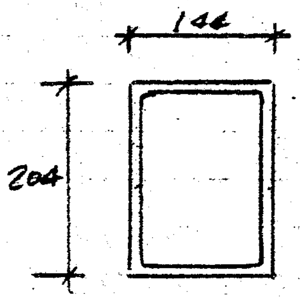
$8\ \#6's = 3.53$

$17.03\ IN^2$

$M_U \approx \frac{17.03}{21.98} \times 7440 = 5764$ O.K

BOTTOM OF PIER, FACE C - FLANGE ONLY

$M_{APPLIED} = 18,610^{1K}$



$A_S = 20\ \#6 = 8.84\ IN^2$

$8\ \#7 = 6.28$

$15.12\ IN^2$

$a = \frac{15.12 \times 33}{.85 \times 2.5 \times 144} = 1.63''$

$M_U = .9 \times 33 \times 15.12\ [198 - 1.63/2] / 12 = 7,380^{1K}$

USING SIDE WALLS - 9 BARS. EA. FACE

As	d	
15.12	198	= 2994
SAY 36 #6 = 15.92	138	2197
31.04		5191

$a = \frac{33 \times 31.04}{.85 \times 2.5 \times 144} = 3.35\ IN$

$\bar{d} = \frac{5191}{31.04} = 167$

$M_U = .9 \times 33 \times 31.04 \left[167 - \frac{3.35}{2}\right] / 12 = 12,700^{1K}$ N.G.

USING SIDE WALLS - 14 BARS EA FACE

$a = 39.88 \times 33 / .85 \times 2.5 \times 144 = 4.3\ IN$

	As	d	As d
	15.12	198	2994
64 #6's	24.76	108	2674
	39.88		5668

$M_U = .9 \times 33 \times 39.88\ [142 - 4.3/2] / 12$

$= 13,800^{1K}$ N.G 35% O.S.

204 - 12 - 7x12

$\bar{d} = 142$

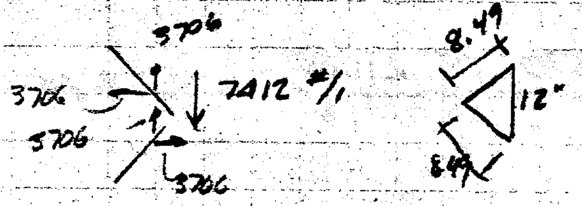
BOX BEAM

$M_{APPLIED} = 22,630^{1k}$

$V_{APPLIED} = 1.47 \times \frac{237.8}{2} + 139.8 = 315^{k}$ D+E

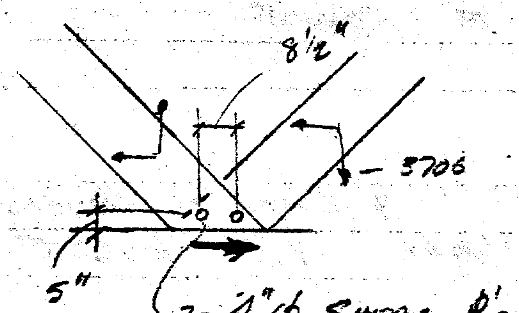
$f_V = \frac{V}{A} = \frac{315,000}{2 \times 21.25} = 7,412$ #/LF

SHEAR IS CARRIED BY DOUBLE SHEATHING ½ IN COMPRESSION ½ IN TENSION

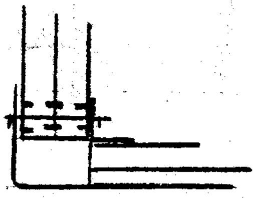


STRESS IN WOOD = $\frac{3706}{2.625 \times 8.49}$ = 166 p.s.i. AXIAL

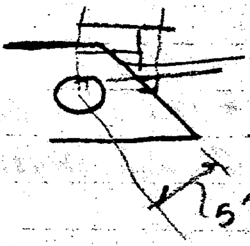
AT BASE



2- 4"φ SHEAR R's
EA. SIDE, 2 4"φ
SPLIT RINGS IN CENTER



END DISTANCE PROVIDED



END DIST = $5\sqrt{2} - 1 = 6"$ ∴ 100% COMP
89% TENS

$V/S.R = .89 \times 3200 = 2850^{\#}$

$\therefore \quad V_{MAX} = 2850 \times \underbrace{2}_{\text{2 RINGS}} \times \overset{\text{2 MEMBERS}}{2} = 11{,}400^{\#}/,$

CHECK NET SECTION

$A_{TOTAL} = 2.5 \times 11.25 = 28.13$

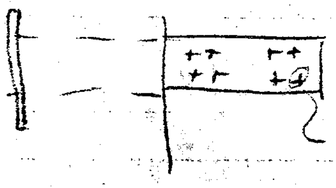
$A_{S.R.}$ 2 FACES $= \quad = \underline{-6.25}$

21.88 IN^2

$f_T = \dfrac{3706\sqrt{2} \times 11.25}{21.88 \quad 12} = 224$ p.s.i ✓

WEB. O.K.

END CONN TO TOWER



8 - 1¼" ϕ BOLTS IN DOUBLE SHEAR

V_{MAX} CAP = 16 × 24.5 = 392) × 2 = 784 ② VERT.

$V = 22{,}650 / \underbrace{21.25 \times 2}_{\text{2 SIDES}} = 532^{k}$ O.K.

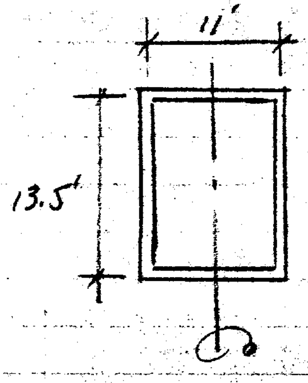
SUMMARY LONGIT. SEIS.

1. M @ TOP OF PIER O.K., SHEAR O.K.
2. BOTTOM OF PIER N.G. CAP = 13,800 ^{1k}, M_{MAX} = 18,610 ^{1k}
3. WOOD BOX APPEARS O.K, CONN'S MUST BE CHECKED

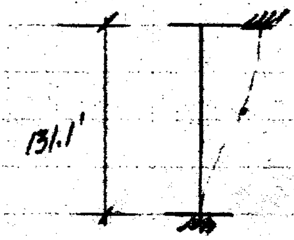
SEISMIC ⊥ TO DOORS   DOORS WEIGH $72^k/\text{LEAF} \times 6 = 432^k$

ESTIMATE PERIOD $W = 3236 + \frac{432}{2} = 3452^k$

$W/\text{PYLON} = 3452^k/2 = 1726^k$



$$I = 14.5 \times 1 \times 2\left[11/2\right]^2 + 1 \times \frac{10^3}{12} \times 2 =$$
$$= 877 + 166 = 1043 \text{ ft}^4$$



$$\Delta = 2\left[\frac{V \times (L/2)^3}{3EI}\right] = 2\left[\frac{1 \times (131.1/2)^3}{3 \times 2850 \times 144 \times 1043}\right]$$

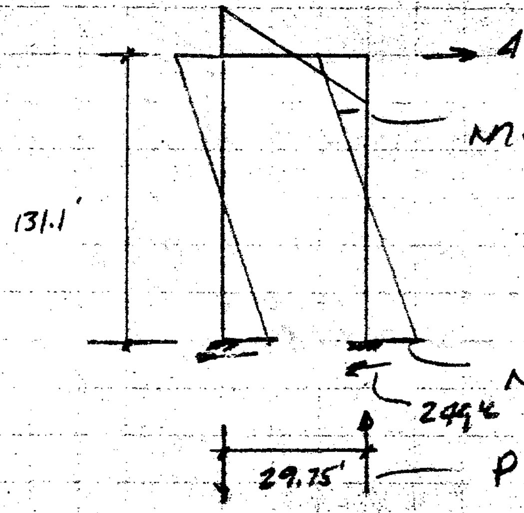
$$k = \frac{1}{\Delta} = 2280^k/\text{FT}$$
$$= 190^k/''$$

$$T = 2\pi\sqrt{M/k} = 2\pi\sqrt{\frac{\overset{W/\text{LEG}}{1726^k/2}}{32.2\,\frac{\text{ft}}{\text{sec}^2} \times 2280\,\frac{k}{F}}} = .68 \text{ sec.}$$

USING 1/2 EQ @ 5% DAMPING

	FULL EQ.
T	B=5%
.60	.618
.68	.577
.70	.567

$$V_{BASE}/\text{PYLON} = \frac{.577}{2} \times 1726 = 498^k/\text{PYLON}$$



$M @ \text{FACE} = 16320 - \frac{29.25}{2} \times 249 = 12,678^{\prime K}$

$M = 249 \times \frac{131.1}{2} = \underline{16,320}^{\prime K}$

$P = \frac{16320 \times 2}{29.75} = 1097^{K}$

CHECK BASE

MOMENT CAPACITY USING FLANGES ONLY

As 34 #6's + 2 #7's = 15.02 + 4.21 = 19.23 in^2

$d = 138''$ $b = 17 \times 12 = 204''$

$a = 19.23 \times 33 / .85 \times 2.5 \times 204 = 1.47''$

$M_u = .9 \times 19.23 \times \frac{33}{12} \left(138 - \frac{1.47}{2}\right) = \underline{6533}^{\prime K}$

ADD SIDE WALLS

	As	d	As d
FLANG	19.23	138"	2654
WALL 36 #6	15.91	78"	1241
	35.14		3895

$\bar{d} = 111''$

$d = 144 - 12'' - 4.5 \times 12 = 78''$

$a = 35.14 \times 33 / .85 \times 2.5 \times 204 = 2.68''$

$M_u = .9 \times 35.14 \times \frac{33}{12} \left(111 - \frac{2.68}{2}\right) = 9537^{\prime K}$ N.G.

CHECK SHEAR

BASE V APPLIED = 249^k

CAPACITY OF SIDE WALLS $= \dfrac{.85 \times 2\sqrt{2500}}{1000} \times \overset{d}{144} \times \overset{t}{12} \times \overset{\text{2 WALLS}}{2} = 293^k$

SHEAR O.K.

CHECK SHEAR IN BOX BEAM V = 1097^k

$$V_c = .85 \times .1 \times [\overset{18.58}{22.58 - 4}] \times 12 \times 2 \times 12 = 455^k$$

$$V_s = .85 \times 2 [\underset{\text{4's C12}}{.39} \times 33 \times 18.58 \times \cancel{12}] / \cancel{12} = \underline{407^k}$$

$$862^k$$

SUMMARY - PIERS HAVE INSUFFICIENT MOMENT CAPACITY AT BASE, (CAP = 9537, M = 16320)

- APPLIED MOMENT AT TOP OF BEAM IS SAME AS BASE, AVAILABLE SECTION IS LESS ∴ TOP OF PIER N.G.

- SHEAR IN PIERS O.K, SHEAR IN TOP BEAM N.G.

(CHECK M IN BOX BEAM)

DATE ____________
BY ________ CHKD. ________
SUBJECT Hangar 46

RUTHERFORD & CHEKENE
STRUCTURAL ENGINEERS

JOB NO. ____________
SHEET NO. 46 - 40

TRUSS - WORST LOADED MEMBER

- BEAM No 1 M_{max} FOR $1.0\,H + 0.3\,V = 436^{\prime k}$

$P = 5.9^{k}$

STRESS COMPUTED $= 43.77$ K/□

$\sigma = 43.77 \times \frac{1000}{144} = 304$ p.s.i ✓ ok

D.L. ONLY $M = 63.7^{\prime k}$

$P = 54.7^{k}$

$\therefore M_{TOT} = 500^{\prime k}$

$P_{TOT} = 60.6^{k}$ $\Rightarrow P_{TOT} = \frac{60.6}{2} + \frac{500 \times 12}{2 \times 102} = 59.7$

ON 2-4×14, $A = 92.75\ in^2$

$f_c = 59{,}700 / 92.75 = 643$ p.s.i ✓.

CHECK TENSION = $P = 54.7 - 5.9 = 48.8^{k}$

$M = 436 + 63.7 = 500^{\prime k}$

$\therefore T = \frac{48.8}{2} - \frac{500 \times 12}{204} = -5.01^{k}$

5^{k} TENS O.K

$A_{NET} = 92.75 - 4 \times 6.51 = 66.7\ in^2$

$f_{c\,NET} = 59.7/66.7 = 894$ p.s.i

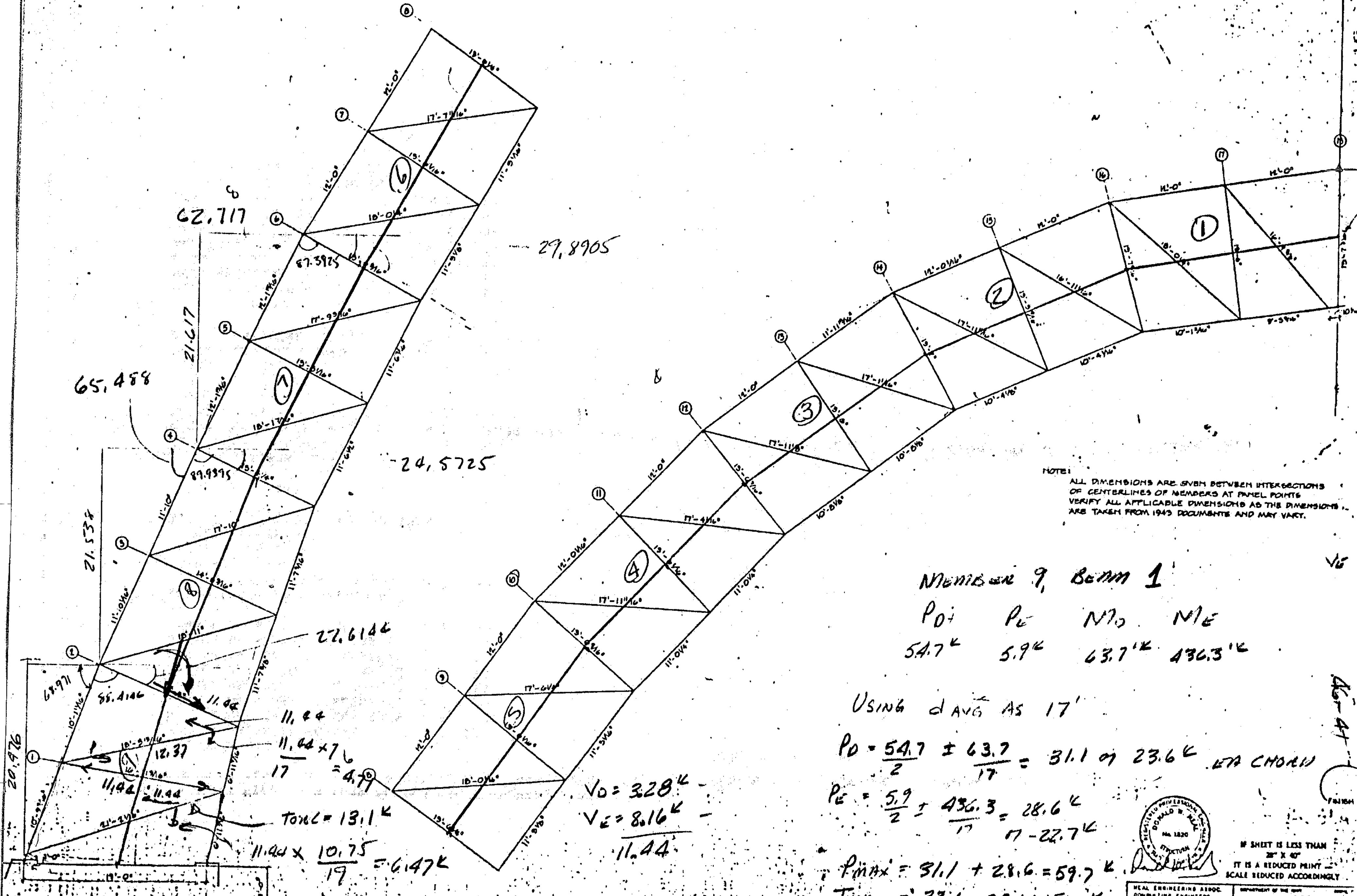
$F_{T\,NET} = 5{,}000/66.7 = 75$ p.s.i ✓

-24 S.R., 12 PAIRS, CAP $= 4.9^{k}$ EA $\times 12 = 58.8^{k}$

D+E CAP $= 58.8 \times 1.33 = 78.2^{k}$ o.k

SPLIT RINGS OK

SP11477A



NOTE:
ALL DIMENSIONS ARE GIVEN BETWEEN INTERSECTIONS OF CENTERLINES OF MEMBERS AT PANEL POINTS
VERIFY ALL APPLICABLE DIMENSIONS AS THE DIMENSIONS ARE TAKEN FROM 1943 DOCUMENTS AND MAY VARY.

Member 9, Beam 1

P_D	P_E	M_D	M_E
54.7 k	5.9 k	63.7 'k	436.3 'k

Using d_{AVG} as 17'

$P_D = \frac{54.7}{2} \pm \frac{63.7}{17} = 31.1$ or 23.6^k EA CHORD

$P_E = \frac{5.9}{2} \pm \frac{436.3}{17} = 28.6^k$ or -22.7^k

$P_{MAX} = 31.1 + 28.6 = 59.7^k$

$T_{MAX} = 23.6 - 28.6 = 5.0^k$

TRUSS MEMBER DIMENSIONS

SCALE: 1/4" = 1'-0"

DONALD W. NEAL No. 1820 STRUCTURAL

IF SHEET IS LESS THAN 28" X 40" IT IS A REDUCED PRINT — SCALE REDUCED ACCORDINGLY

NEAL ENGINEERING ASSOC.
CONSULTING ENGINEERS
PORTLAND, OREGON

DEPARTMENT OF THE NAVY
WESTERN DI

NAVAL AIR STATION
MOFFETT FIELD, CA
REPAIR OF HANGARS
TRUSS MEMBER D

AG-41

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B E G I N   E 2 C O M B

 NAS MOFFETT FIELD - HANGAR 46 TYPICAL TRANSVERSE ARCH
 LOAD COMBINATION DEAD + 1.0 * HORIZ. EQ. + 0.3 * VERT. EQ.

CONTROL PARAMETERS
    NUMBER OF NODAL POINTS          = (   27)
    NUMBER OF BEAM     ELEMENTS     = (   26)
    NUMBER OF MEMBRANE ELEMENTS     = (    0)
    NUMBER OF SHELL    ELEMENTS     = (    0)
    NUMBER OF SOLID    ELEMENTS     = (    0)
    NUMBER OF PIPE     ELEMENTS     = (    0)
    NUMBER OF STATIC LOAD CASES     = (    1)
    NUMBER OF R.S.A. CASES          = (    8)

STATIC ANALYSIS COMBINATION DATA
    STATIC COMBINATION METHOD       = (    1)
      EQ.0, S.R.S.S.
      EQ.1, ABSOLUTE
      EQ.2, ALGEBRAIC
    STATIC LOAD CASE SCALE FACTORS

             1.0000

R.S.A. COMBINATION DATA
    R.S.A. CASE NUMBER              = (    7)
    R.S.A. CASE SCALE FACTOR        = (    .1000E+01)
    MODAL COMBINATION METHOD        = (    0)
      EQ.0, S.R.S.S.
      EQ.1, ABSOLUTE
      EQ.2, C.S.M.
    NUMBER OF MODES USED            = (   16)
    C.S.M. FREQUENCY RATIO          = (    .1000E+01)

PRINT OUTPUT REQUESTS
    NODE DISPLACEMENTS              = (    1)
    NODE REACTIONS                  = (    1)
    BEAM     RESULTS                = (    1)
    MEMBRANE RESULTS                = (    0)
    SHELL    RESULTS                = (    0)
    SOLID    RESULTS                = (    0)
    PIPE     RESULTS                = (    0)
      EQ.0, SUPPRESS PRINTCUT
      EQ.1, PRINT IF APPLICABLE
```

BUILDING 46 LEVEL 1 EARTHQUAKE
CHECK FOR D+E

} LG 100 1 & 2   MODES 2, 3, 4   5% DAMPING, OTHERS 10% DAMPING

```
N O D E   D I S P L A C E M E N T S

NAS MOFFETT FIELD - HANGAR 46 TYPICAL TRANSVERSE ARCH
LOAD COMBINATION DEAD + 1.0 * HORIZ. EQ. + 0.3 * VERT. EQ.

 NODE  LOAD           X-            Y-            Z-            X-            Y-            Z-
NUMBER CASE     DISPLACEMENT  DISPLACEMENT  DISPLACEMENT     ROTATION      ROTATION      ROTATION

   10 ST          .19934E-18    .37494E-03   0.            0.            0.            .29541E-03
      RS   7      .20270E-18    .23774E-03   0.            0.            0.            .15417E-02
      CB          .40204E-18    .61269E-03   0.            0.            0.            .18371E-02
   20 ST          .68307E-04    .37598E-03   0.            0.            0.            .30806E-03
      RS   7      .34351E-03    .30135E-03   0.            0.            0.            .15213E-02
      CB          .41181E-03    .67733E-03   0.            0.            0.            .18294E-02
   30 ST          .56063E-02    .91296E-03   0.            0.            0.            .88083E-05
      RS   7      .27923E-01    .10073E-01   0.            0.            0.            .52804E-04
      CB          .33530E-01    .10986E-01   0.            0.            0.            .61612E-04
   40 ST          .57098E-02    .90933E-03   0.            0.            0.            .56952E-05
      RS   7      .27967E-01    .71387E-03   0.            0.            0.            .38828E-04
      CB          .33677E-01    .16232E-02   0.            0.            0.            .44523E-04
   50 ST          .68307E-04    .37598E-03   0.            0.            0.            .30806E-03
      RS   7      .34351E-03    .30134E-03   0.            0.            0.            .15213E-02
      CB          .41182E-03    .67732E-03   0.            0.            0.            .18294E-02
   60 ST          .19934E-18    .37494E-03   0.            0.            0.            .29541E-03
      RS   7      .20270E-18    .23774E-03   0.            0.            0.            .15417E-02
      CB          .40204E-18    .61269E-03   0.            0.            0.            .18371E-02
   70 ST          .57098E-02    .90933E-03   0.            0.            0.            .56952E-05
      RS   7      .27967E-01    .71385E-03   0.            0.            0.            .38828E-04
      CB          .33677E-01    .16232E-02   0.            0.            0.            .44523E-04
   80 ST          .56063E-02    .91296E-03   0.            0.            0.            .88083E-05
      RS   7      .27923E-01    .10073E-01   0.            0.            0.            .52805E-04
      CB          .33530E-01    .10986E-01   0.            0.            0.            .61613E-04
  100 ST          .56593E-02    .20409E-04   0.            0.            0.            .93571E-04
      RS   7      .27946E-01    .51697E-02   0.            0.            0.            .49295E-03
      CB          .33605E-01    .51901E-02   0.            0.            0.            .58652E-03
  102 ST          .75131E-02    .27306E-02   0.            0.            0.            .64949E-04
      RS   7      .24919E-01    .42217E-02   0.            0.            0.            .51946E-03
      CB          .32432E-01    .71523E-02   0.            0.            0.            .58441E-03
  104 ST          .89497E-02    .64912E-02   0.            0.            0.            .93797E-04
      RS   7      .30572E-01    .86499E-02   0.            0.            0.            .73013E-03
      CB          .39521E-01    .15141E-01   0.            0.            0.            .82392E-03
  106 ST          .76767E-02    .11701E-01   0.            0.            0.            .17597E-03
      RS   7      .47040E-01    .19105E-01   0.            0.            0.            .86562E-03
      CB          .54717E-01    .30806E-01   0.            0.            0.            .10416E-02
  108 ST          .47155E-02    .17694E-01   0.            0.            0.            .23420E-03
      RS   7      .66581E-01    .32241E-01   0.            0.            0.            .77996E-03
      CB          .71297E-01    .49934E-01   0.            0.            0.            .10142E-02
  110 ST          .11240E-02    .24547E-01   0.            0.            0.            .26376E-03
      RS   7      .81496E-01    .44170E-01   0.            0.            0.            .49564E-03
      CB          .82620E-01    .68717E-01   0.            0.            0.            .75940E-03
  112 ST          .16271E-02    .32043E-01   0.            0.            0.            .25544E-03
      RS   7      .86985E-01    .49561E-01   0.            0.            0.            .73505E-04
      CB          .88612E-01    .81604E-01   0.            0.            0.            .32895E-03
  114 ST          .27554E-02    .39009E-01   0.            0.            0.            .20160E-03
      RS   7      .83690E-01    .44181E-01   0.            0.            0.            .44977E-03
      CB          .86445E-01    .83190E-01   0.            0.            0.            .65136E-03
  116 ST          .20095E-02    .44175E-01   0.            0.            0.            .10854E-03
      RS   7      .76908E-01    .26400E-01   0.            0.            0.            .80390E-03
      CB          .78918E-01    .70575E-01   0.            0.            0.            .91244E-03
  118 ST          .15836E-13    .46080E-01   0.            0.            0.            .88037E-16
      RS   7      .73619E-01    .24705E-02   0.            0.            0.            .92407E-03
```

```
NODE DISPLACEMENTS

NAS MOFFETT FIELD - HANGAR 46 TYPICAL TRANSVERSE ARCH
LOAD COMBINATION DEAD + 1.0 * HORIZ. EQ. + 0.3 * VERT. EQ.

  NODE   LOAD          X-            Y-            Z-              X-            Y-              Z-
 NUMBER  CASE     DISPLACEMENT  DISPLACEMENT  DISPLACEMENT     ROTATION      ROTATION        ROTATION

   200  ST          .56593E-02    .20409E-04   0.              0.            0.             .93571E-04
        RS    7     .27946E-01    .51696E-02   0.              0.            0.             .49296E-03
        CB          .33605E-01    .51900E-02   0.              0.            0.             .58653E-03
   202  ST          .75131E-02    .29306E-02   0.              0.            0.             .64949E-04
        RS    7     .24919E-01    .42217E-02   0.              0.            0.             .51946E-03
        CB          .32432E-01    .71523E-02   0.              0.            0.             .58441E-03
   204  ST          .89497E-02    .64912E-02   0.              0.            0.             .93797E-04
        RS    7     .30572E-01    .86499E-02   0.              0.            0.             .73013E-03
        CB          .39521E-01    .15141E-01   0.              0.            0.             .82392E-03
   206  ST          .76767E-02    .11701E-01   0.              0.            0.             .17597E-03
        RS    7     .47040E-01    .19105E-01   0.              0.            0.             .86562E-03
        CB          .54717E-01    .30806E-01   0.              0.            0.             .10416E-02
   208  ST          .47155E-02    .17694E-01   0.              0.            0.             .23420E-03
        RS    7     .66581E-01    .32241E-01   0.              0.            0.             .77996E-03
        CB          .71297E-01    .49934E-01   0.              0.            0.             .10142E-02
   210  ST          .11240E-02    .24547E-01   0.              0.            0.             .26376E-03
        RS    7     .81496E-01    .44170E-01   0.              0.            0.             .49564E-03
        CB          .82620E-01    .68717E-01   0.              0.            0.             .75940E-03
   212  ST          .16271E-02    .32043E-01   0.              0.            0.             .25544E-03
        RS    7     .86985E-01    .49561E-01   0.              0.            0.             .73505E-04
        CB          .88612E-01    .81604E-01   0.              0.            0.             .32895E-03
   214  ST          .27554E-02    .39009E-01   0.              0.            0.             .20160E-03
        RS    7     .83690E-01    .44181E-01   0.              0.            0.             .44977E-03
        CB          .86445E-01    .83190E-01   0.              0.            0.             .65136E-03
   216  ST          .20095E-02    .44175E-01   0.              0.            0.             .10854E-03
        RS    7     .76908E-01    .26400E-01   0.              0.            0.             .80390E-03
        CB          .78918E-01    .70575E-01   0.              0.            0.             .91244E-03
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B E A M   E N D   R E S U L T A N T S

NAS MOFFETT FIELD - HANGAR 46 TYPICAL TRANSVERSE ARCH
LOAD COMBINATION DEAD + 1.0 * HORIZ. EQ. + 0.3 * VERT. EQ.

  BEAM  NODE AT  NODE AT  LOAD      END-1       END-1     END-1     END-1     END-1       END-1     END-2       END-2
NUMBER    END-1    END-2  CASE       P(X)        V(Y)      V(Z)      T(X)      M(Y)        M(Z)      M(Y)        M(Z)

     1      100      102  ST   5.4659E+01  3.2751E+00  0.        0.        0.     6.3702E+01  0.        3.6442E+00
                          RS 7 5.8656E+00  8.1592E+00  0.        0.        0.     4.3633E+02  0.        2.9346E+02
                          CB   6.0525E+01  1.1434E+01  0.        0.        0.     5.0003E+02  0.        2.9711E+02
     2      200      202  ST   5.4659E+01  3.2751E+00  0.        0.        0.     6.3702E+01  0.        3.6442E+00
                          RS 7 5.8660E+00  8.1592E+00  0.        0.        0.     4.3633E+02  0.        2.9346E+02
                          CB   6.0525E+01  1.1434E+01  0.        0.        0.     5.0003E+02  0.        2.9711E+02
     3      102      104  ST   4.9178E+01  1.9757E+00  0.        0.        0.     3.6442E+00  0.        4.2652E+01
                          RS 7 5.9769E+00  6.6861E+00  0.        0.        0.     2.9346E+02  0.        1.3947E+02
                          CB   5.5155E+01  8.6617E+00  0.        0.        0.     2.9711E+02  0.        1.8212E+02
     4      202      204  ST   4.9178E+01  1.9757E+00  0.        0.        0.     3.6442E+00  0.        4.2652E+01
                          RS 7 5.9768E+00  6.6861E+00  0.        0.        0.     2.9346E+02  0.        1.3947E+02
                          CB   5.5154E+01  8.6618E+00  0.        0.        0.     2.9711E+02  0.        1.8212E+02
     5      104      106  ST   4.3798E+01  3.1147E-01  0.        0.        0.     4.2652E+01  0.        3.5271E+01
                          RS 7 6.0529E+00  5.4184E+00  0.        0.        0.     1.3947E+02  0.        1.3655E+01
                          CB   4.9851E+01  5.7299E+00  0.        0.        0.     1.8212E+02  0.        4.8926E+01
     6      204      206  ST   4.3798E+01  3.1147E-01  0.        0.        0.     4.2652E+01  0.        3.5271E+01
                          RS 7 6.0526E+00  5.4184E+00  0.        0.        0.     1.3947E+02  0.        1.3655E+01
                          CB   4.9850E+01  5.7299E+00  0.        0.        0.     1.8212E+02  0.        4.8926E+01
     7      106      108  ST   3.8548E+01  6.0277E-01  0.        0.        0.     3.5271E+01  0.        2.1151E+01
                          RS 7 5.8259E+00  4.3715E+00  0.        0.        0.     1.3655E+01  0.        9.2821E+01
                          CB   4.4374E+01  4.9743E+00  0.        0.        0.     4.8926E+01  0.        1.1397E+02
     8      206      208  ST   3.8548E+01  6.0277E-01  0.        0.        0.     3.5271E+01  0.        2.1151E+01
                          RS 7 5.8256E+00  4.3715E+00  0.        0.        0.     1.3655E+01  0.        9.2821E+01
                          CB   4.4374E+01  4.9743E+00  0.        0.        0.     4.8926E+01  0.        1.1397E+02
     9      108      110  ST   3.3554E+01  6.9038E-01  0.        0.        0.     2.1151E+01  0.        5.0946E+00
                          RS 7 5.5296E+00  3.0484E+00  0.        0.        0.     9.2821E+01  0.        1.6287E+02
                          CB   3.9084E+01  3.7388E+00  0.        0.        0.     1.1397E+02  0.        1.6797E+02
    10      208      210  ST   3.3554E+01  6.9038E-01  0.        0.        0.     2.1151E+01  0.        5.0946E+00
                          RS 7 5.5295E+00  3.0484E+00  0.        0.        0.     9.2821E+01  0.        1.6287E+02
                          CB   3.9083E+01  3.7388E+00  0.        0.        0.     1.1397E+02  0.        1.6797E+02
    11      110      112  ST   2.8945E+01  7.2389E-01  0.        0.        0.     5.0946E+00  0.        1.1572E+01
                          RS 7 5.1469E+00  1.2927E+00  0.        0.        0.     1.6287E+02  0.        1.8998E+02
                          CB   3.4092E+01  2.0166E+00  0.        0.        0.     1.6797E+02  0.        2.0156E+02
    12      210      212  ST   2.8945E+01  7.2389E-01  0.        0.        0.     5.0946E+00  0.        1.1572E+01
                          RS 7 5.1469E+00  1.2927E+00  0.        0.        0.     1.6287E+02  0.        1.8998E+02
                          CB   3.4092E+01  2.0166E+00  0.        0.        0.     1.6797E+02  0.        2.0156E+02
    13      112      114  ST   2.4937E+01  7.1628E-01  0.        0.        0.     1.1572E+01  0.        2.7813E+01
                          RS 7 4.5181E+00  1.0980E+00  0.        0.        0.     1.8998E+02  0.        1.6724E+02
                          CB   2.9455E+01  1.8143E+00  0.        0.        0.     2.0156E+02  0.        1.9505E+02
    14      212      214  ST   2.4937E+01  7.1628E-01  0.        0.        0.     1.1572E+01  0.        2.7813E+01
                          RS 7 4.5180E+00  1.0980E+00  0.        0.        0.     1.8998E+02  0.        1.6724E+02
                          CB   2.9455E+01  1.8143E+00  0.        0.        0.     2.0156E+02  0.        1.9505E+02
    15      114      116  ST   2.1863E+01  6.0167E-01  0.        0.        0.     2.7813E+01  0.        4.1257E+01
                          RS 7 3.4067E+00  3.1153E+00  0.        0.        0.     1.6724E+02  0.        9.8213E+01
                          CB   2.5270E+01  3.7169E+00  0.        0.        0.     1.9505E+02  0.        1.3947E+02
    16      214      216  ST   2.1863E+01  6.0167E-01  0.        0.        0.     2.7813E+01  0.        4.1257E+01
                          RS 7 3.4067E+00  3.1153E+00  0.        0.        0.     1.6724E+02  0.        9.8213E+01
                          CB   2.5269E+01  3.7169E+00  0.        0.        0.     1.9505E+02  0.        1.3947E+02
    17      116      118  ST   2.0157E+01  2.4444E-01  0.        0.        0.     4.1257E+01  0.        4.6668E+01
                          RS 7 1.9746E+00  4.4282E+00  0.        0.        0.     9.8213E+01  0.        9.0419E+00
                          CB   2.2131E+01  4.6727E+00  0.        0.        0.     1.3947E+02  0.        5.5710E+01
    18      118      216  ST   2.0157E+01  2.4444E-01  0.        0.        0.     4.6668E+01  0.        4.1257E+01
                          RS 7 1.9745E+00  4.4282E+00  0.        0.        0.     9.0419E+00  0.        9.8213E+01
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B E A M   E N D   R E S U L T A N T S

NAS MOFFETT FIELD - HANGAR 46 TYPICAL TRANSVERSE ARCH
LOAD COMBINATION DEAD + 1.0 * HORIZ. EQ. + 0.3 * VERT. EQ.

 BEAM   NODE AT  NOCE AT  LOAD       END-1       END-1       END-1       END-1       END-1       END-1       END-2       END-2
NUMBER   END-1    END-2   CASE        P(X)        V(Y)        V(Z)        T(X)        M(Y)        M(Z)        M(Y)        M(Z)

  19       10       30  ST      5.0274E+01  1.0025E+00  0.          0.          3.3515E+00  0.          2.3547E+01
                        RS   7  3.2279E+01  5.1802E+00  0.          0.          1.7020E+01  0.          1.2198E+02
                        CB      8.2554E+01  6.1827E+00  0.          0.          2.0371E+01  0.          1.4552E+02
  20       30       40  ST      9.0826E+00  2.4863E+00  0.          0.          2.3547E+01  0.          2.4874E+01
                        RS   7  5.5683E+00  1.2694E+01  0.          0.          1.2198E+02  0.          1.2524E+02
                        CB      1.4651E+01  1.5180E+01  0.          0.          1.4552E+02  0.          1.5011E+02
  21       40       20  ST      3.6365E+01  1.1273E+00  0.          0.          2.4874E+01  0.          3.3989E+00
                        RS   7  2.8131E+01  5.6691E+00  0.          0.          1.2524E+02  0.          1.6943E+01
                        CB      6.4496E+01  6.7964E+00  0.          0.          1.5011E+02  0.          2.0342E+01
  22       10       20  ST      1.1273E+00  2.3268E-01  0.          0.          3.3515E+00  0.          3.3989E+00
                        RS   7  5.6691E+00  1.1706E+00  0.          0.          1.7020E+01  0.          1.6943E+01
                        CB      6.7964E+00  1.4033E+00  0.          0.          2.0371E+01  0.          2.0342E+01
  23       50       70  ST      3.6365E+01  1.1273E+00  0.          0.          3.3989E+00  0.          2.4874E+01
                        RS   7  2.8131E+01  5.6691E+00  0.          0.          1.6943E+01  0.          1.2524E+02
                        CB      6.4495E+01  6.7964E+00  0.          0.          2.0342E+01  0.          1.5011E+02
  24       70       80  ST      9.0826E+00  2.4863E+00  0.          0.          2.4874E+01  0.          2.3547E+01
                        RS   7  5.5683E+00  1.2694E+01  0.          0.          1.2524E+02  0.          1.2198E+02
                        CB      1.4651E+01  1.5180E+01  0.          0.          1.5011E+02  0.          1.4552E+02
  25       60       80  ST      5.0274E+01  1.0025E+00  0.          0.          3.3515E+00  0.          2.3547E+01
                        RS   7  3.2279E+01  5.1802E+00  0.          0.          1.7020E+01  0.          1.2198E+02
                        CB      8.2554E+01  6.1827E+00  0.          0.          2.0371E+01  0.          1.4552E+02
  26       50       60  ST      1.1273E+00  2.3268E-01  0.          0.          3.3989E+00  0.          3.3515E+00
                        RS   7  5.6691E+00  1.1706E+00  0.          0.          1.6943E+01  0.          1.7020E+01
                        CB      6.7964E+00  1.4033E+00  0.          0.          2.0342E+01  0.          2.0371E+01
```

4 12[illegible]

5 92.[illegible]

6 8.[illegible]

CHECK BEAM 1 CHORDS

$P_{MAX} = 59.7^{k}$ - 2-4x14 $L = 10'-9 = 129''$

$F_c = 59.7 / 92.75 = 644$ p.s.i

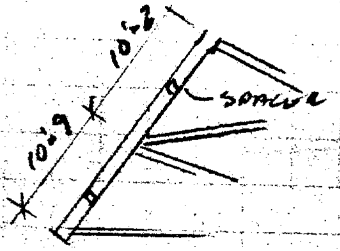
Fc ALL

$L_1/d_1 = 129/3.5 = 36.9 < 80$ o.k

$L_2/d_2 = 129/13.25 = 9.7 < 50$ o.k

$L_3/d_1 = 129/2\times3.5 = 18.4 < 40$

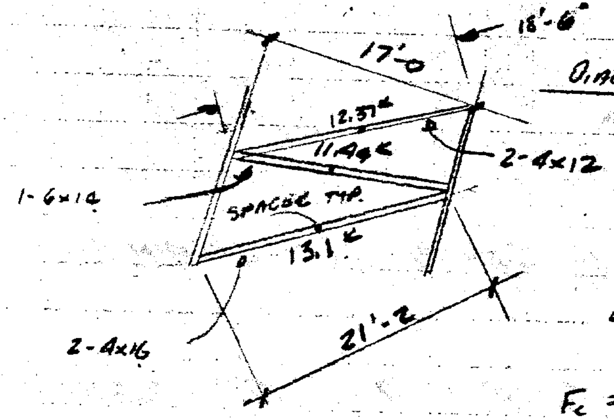
o.k



CHECK L_1/d_1 $F_c = .3\times2.5\times1{,}500{,}000/36.9^2 = 826$ p.s.i ✓

CHECK L_3/d_1 $F_c = .3\times1500{,}000/18.4^2 = 1325$ p.s.i ✓

CHECK WEB - FORCES SHOWN ON SKETCH



DIAG 4x16

$f_c = 13.1/2\times5.5\times15.25 = 123$ p.s.i ✓

$L_1/d_1 = [\overset{254''}{21\times12+2}]/3.5 = 72.6 < 80$ o.k

$L_2/d_2 = 254/15.25 = 16.7 < 50$ o.k

$L_3/d_1 = 254/2\times3.5 = 36.2 < 40$ o.k

o.k.

$F_{c_{ALL}} = .3\times2.5\times1{,}500{,}000/72.6^2 = 213$ p.s.i ✓

or $= .3\times1500{,}000/36.2^2 = 343$ p.s.i

6x14 COL

$f'_c = 11.44/5.5\times13.25 = 157$ p.s.i

o.k

F_c ALL $= .3\times1{,}500{,}000/[204/5.5]^2 = 327$ p.s.i ✓

2 - 4x12

$L_1/d_1 = \overset{222}{18.5\times12}/3.5 = 63.4$

$L_2/d_2 = 222/11.25 = 19.7$

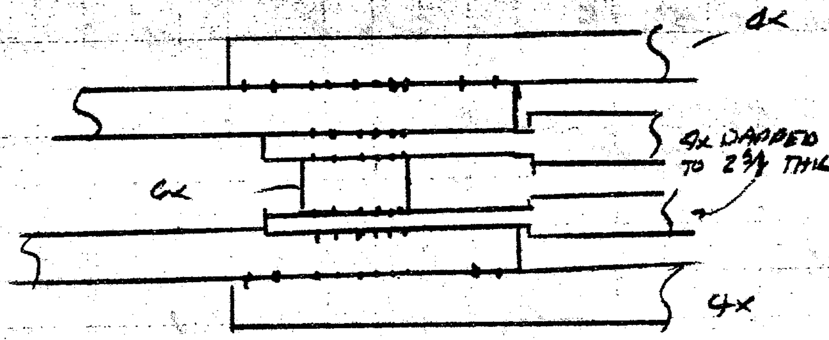
$L_3/d_1 = 222/2\times3.5 = 31.7$

$f_c = 12.37/2\times3.5\times11.25 = 157$ p.s.i

$F_c = .3\times2.5\times1{,}500{,}000/63.4^2 = 280$ p.s.i

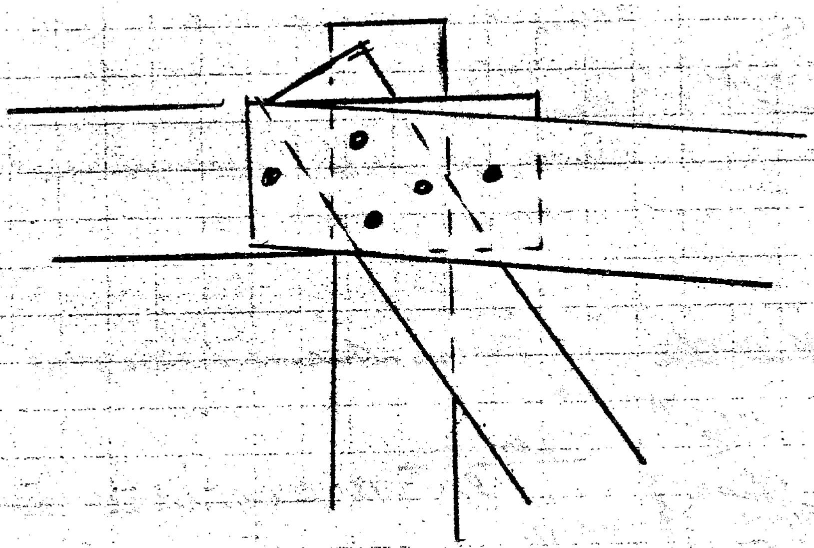
or $E = .3\times1{,}500{,}000/31.7^2 = 448$ p.s.i

TOP CHORD CONN. $P = 59.7^k \leftarrow 59.7/2 = 30^k$



22 4"φ S.R

7-3/4"φ M.B.



SPLIT RINGS @ TOP CHORD, COMPR // TO GRAIN SAY IF 100% EFF.

2 SR - 3 1/2" THICK 1 FACE $P = 5.2^k \times 2 = 10.4^k$
3 SR 3 1/2" THICK 2 FACES $= 3 \times 5.2 = \underline{15.6^k}$
26.0^k

MAX CAP = $26 \times 1.33 = 34.6^k > 30^k$ OK.

WOOD MEMBERS OF ARCH, SUMMARY

MEMBERS AT BASE OF ARCH WERE CHECKED FOR THE CASE 1 EARTHQUAKE OF

DL + 1.0 HORIZ EQ + 0.3 VERT EQ, WHERE VERT = 2/3 HORIZ.

THE HORIZONTAL EARTHQUAKE WAS ½ OF THE CASE 2 EQ, DAMPING WAS 10%. ALL MEMBERS REMAINED ELASTIC, NONE WERE STRESSED HIGHER THAN ALLOWED UNDER CURRENT CODES WITHOUT TAKING A ⅓ INCREASE. BUCKLING CONTROLS THE MEMBER SIZES. THE FACTOR OF SAFETY AGAINST BUCKLING AT DESIGN LEVEL STRESSES IS 2.74. THE LEVEL 2 EQ. IS TWICE THE LEVEL 1, BUT A HIGHER LEVEL OF DAMPING IS PERMITTED, THUS THE MEMBER FORCES RESULTING FROM THE LEVEL 2 EQ ARE LESS THAN 2× THOSE FROM THE LEVEL 1 EQ. ∴ THE FACTOR OF SAFETY AGAINST BUCKLING IN THE LEVEL 2 EQ. IS AT LEAST 2.74/2 = 1.37 AND NO ELEMENTS BUCKLE. SINCE AT LEVEL 2, 2× THE STRESSES AT LEVEL 1 ARE ALLOWED, THE ARCHES ARE ALSO O.K. FOR STRESS AT LEVEL 2

F.S. AGAINST BUCKLING

DESIGN ALLOWABLE STRESS	EULER BUCKLING STRESS
$= \dfrac{.3\,E}{(L/d)^2}$	$= \dfrac{\pi^2 E I}{L^2 A} = \dfrac{\pi^2 E}{\left(\frac{L}{r}\right)^2} \quad r = \dfrac{d}{\sqrt{12}}$

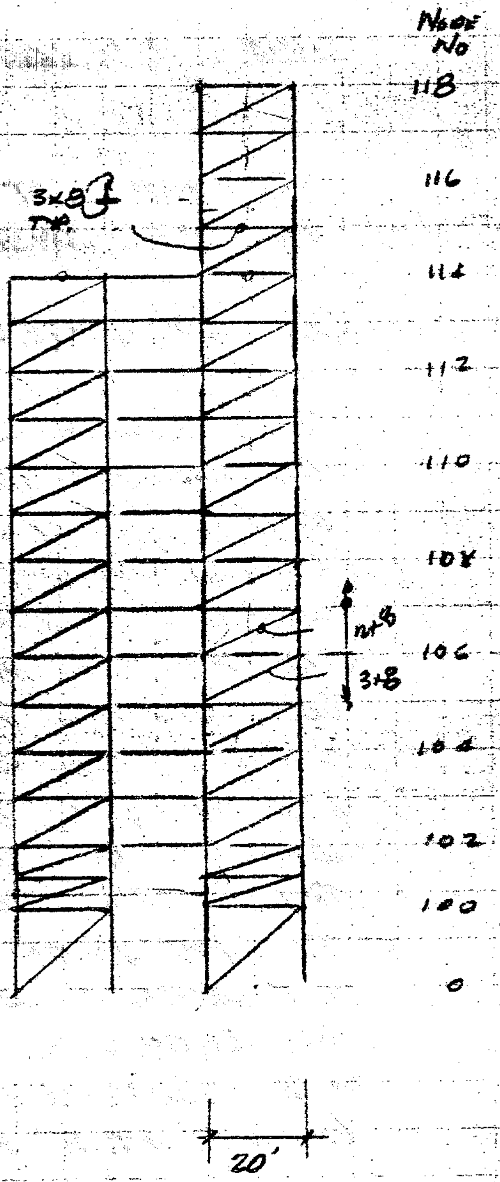
$$F.S. = \frac{.8225}{.3} = \underline{2.74}\ ✓$$

$$\therefore = \frac{\pi^2 E}{\left(\frac{L\sqrt{12}}{d}\right)^2} = \frac{\pi^2\ E}{12\ \left(\frac{L}{d}\right)^2} = .8225\,\frac{E}{(L/d)}$$

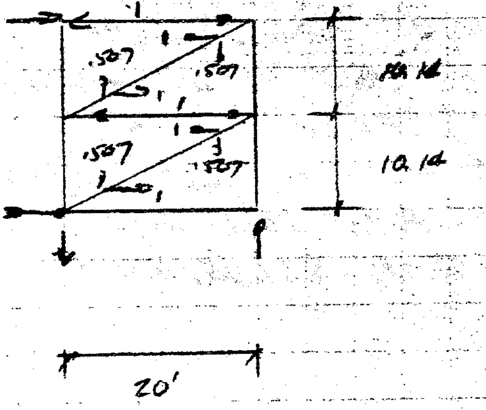
SUBJECT LONGIT. DIRECTION

MODEL X BRACING
AS BEAM
COMPUTE $I = Ad^2 = 2 \times A_{BC} \times 120^2$

SEG	ABC	I	A comp
100-102	92.75	2,670,000	185.5
102-104	92.75	"	"
4-6	66.25	1,910,000	137.5
6-8	66.25	"	
8-10	56.25	1,620,000	112.5
10-12	56.25	"	
12-14	56.25	"	
14-16	56.25	"	
16-18	56.25	"	



SHEAR DEFL. 118-116



$$\Delta = \Sigma \frac{S^2 L}{AE} = \frac{Vh}{A_v \frac{E}{2.4}}$$

	S	L	A	S^2L/A
HORIZ	1	20×12	36.25	6.62
DIAG	1.12	22.42×12	10.88	31.02

$$\Sigma \frac{S^2 L}{A} = 2[31.02 + 6.62] = 75.28$$

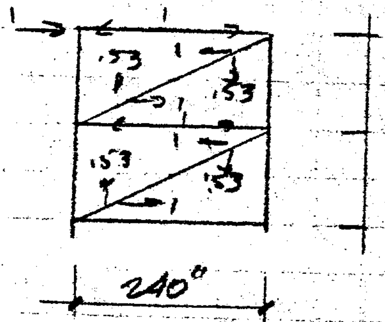
$$\Delta = \frac{75.28}{\cancel{E}} = \frac{1 \times 243.36 \quad 2.4}{A_v \cancel{E}}$$

$A_v = 7.76 \text{ in}^2$

7.8

USE SAME 116-114

SHEAR AREA 114-112



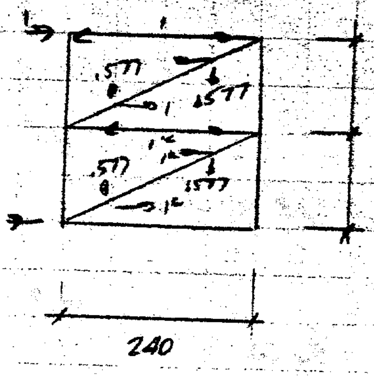
	S	L	A	S^2L/A
HORIZ	1	240	36.25	6.62
DIAG	1.13	272.	10.88	31.92
				38.54

$\Delta = \frac{38.54 \times 2}{E} = \frac{1 \times 256.2 \times 2.5}{A_v E} \Rightarrow A = 7.98$

≈ 8

SAY 112 - 108 $A_v = 8 \text{ in}^2$

106 - 104

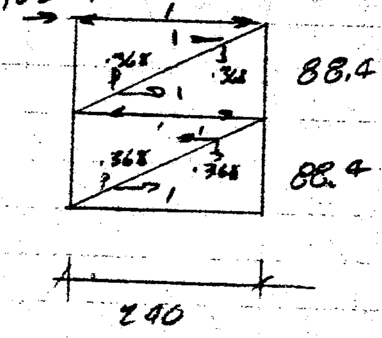


	S	L	A	S^2L/A
HORIZ	1	240	36.25	6.62
DIAG	1.15	277	18.125	20.21
				26.82

$\Delta = \frac{26.82 \times 2}{E} = \frac{277 \times 2.4}{A_v E} \Rightarrow A_v = 12.4 \text{ in}^2$

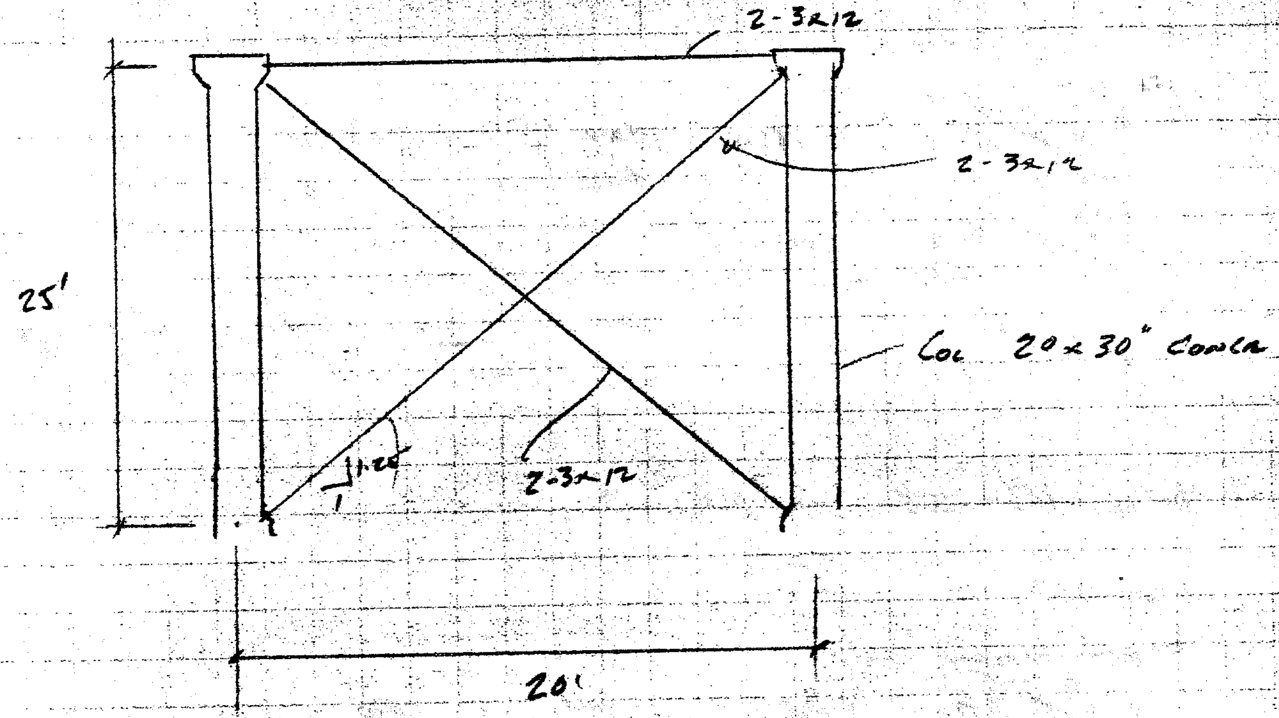
104 - 102 SAME

102 - 100



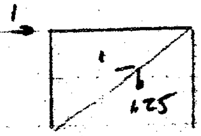
	S	L	A	S^2L/A
HORIZ	1	240	36.25	6.62
DIAG	1.07	255.8	18.125	16.16
				22.78

$\Delta = \frac{22.78 \times 2}{E} = \frac{176.8 \times 2.4}{A_v E} \Rightarrow A_v = 9.3 \text{ in}^2$



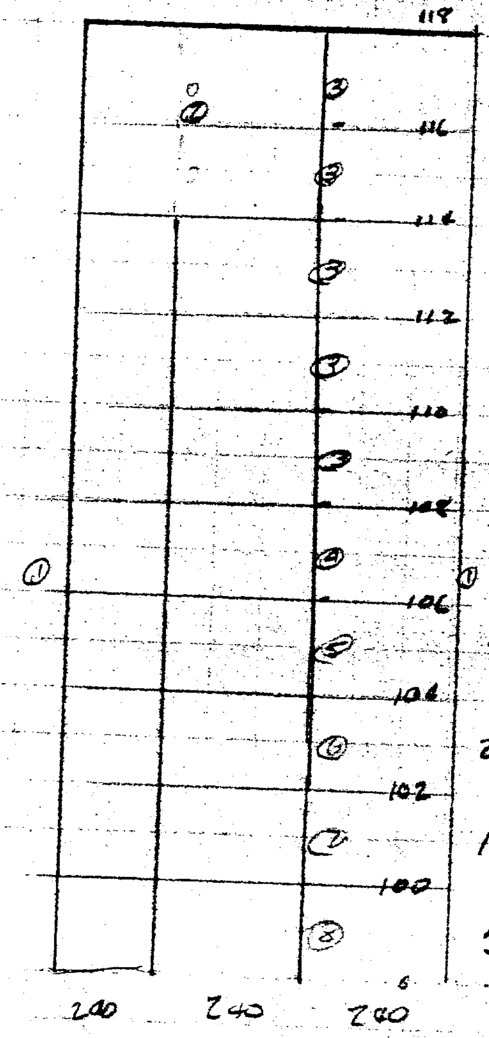
$I = 2Ad^2 = 2\times 20\times 30\times 120^2 = 17,300,000$

$\Delta_v = \Sigma \frac{S^2L}{AE} = \left[1^2\times 240 + 1.6^2[384]\right] / 56.25E = \frac{1\times 300\times 2.4}{A_v E}$



$A_v = 33.3$ in²

COMPUTER MODEL



	COL O.S.			COL I.S.		
δh	A	I	Av	A	I	Av
243.4	100,000	1	,01	112.5	1620000	8.0
248.2						
256.2						
266.5						
270.2						
274.2				137.5	1919,000	8.0
277.0				″	″	12.4
279.2				185.8	2670,000	12.4
176.9				″	″	9.3
300				1200	17,300,000	33.

ALL BEAM $I = 1$
$A = 100,000$

MASS $6^{k}/\text{BAY} \times 4\ \text{BAY} \Big/ 32.2 \frac{f}{\sec^2} \times \frac{12\ \text{in}}{1\ \text{ft}}$ $= .0621 \frac{\text{k sec}^2}{''}$

or $32^{k}/\text{BAY} \times 4 / 32.2 \times 12$ $= .331 \frac{\text{k sec}}{''}$

IN ft UNITS $m = 6 \times 4 / 32.2 = 0.745\ \text{k sec}^2/\text{ft}$

Hangar 46
Longitudinal Earthquake
Level 1 $\zeta = 5\%$

```
>>>>>> M I C R O - T A B S  version 1.3 <<<<<<

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    COMPUTERS AND STRUCTURES INC.
       1930 SHATTUCK AVENUE
       BERKELEY  CA  94704
          415-845-2177



  HANGAR 1 LONGITUDINAL SIES, LEVEL 1
TOTAL NUMBER OF STORIES--   10
NUMBER OF DIFF. FRAMES---    1
TOTAL NUMBER OF FRAMES---    1
NUMBER OF LOAD CONDITIONS    1
TYPE OF ANALYSIS---------    3

 EQ.0-STATIC LOADS ONLY
 EQ.1-MODE SHAPES AND FREQUENCIES ONLY
 EQ.2-STATIC AND MODE SHAPE ANALYSES
 EQ.3-TYPE 2 AND SEISMIC SPECTRUM ANAL
 EQ.4-TYPE 2 AND SEISMIC RESPONSE ANAL

NUMBER OF FREQUENCIES----    8
STORY TRANSLATION CODE---    1

 EQ.0-TRANSLATIONS AND ROTATION
 EQ.1-X TRANSLATION ONLY
 EQ.2-Y TRANSLATION ONLY
```

```
HANGAR 46 LONGITUDINAL                  TBHA1JU .PR1          PAGE   2

LEVEL  ID   HEIGHT   MASS(M)    MR**2     X(M)     Y(M)     K-X      K-Y
 10    1    20.28       .37      0.00    30.00     0.00     0.00     0.00
  9         20.68       .75      0.00    30.00     0.00     0.00     0.00
  8         21.35       .75      0.00    30.00     0.00     0.00     0.00
  7         22.04       .75      0.00    30.00     0.00     0.00     0.00
  6         22.52       .75      0.00    30.00     0.00     0.00     0.00
  5         22.85       .75      0.00    30.00     0.00     0.00     0.00
  4         23.08       .75      0.00    30.00     0.00     0.00     0.00
  3         23.27       .75      0.00    30.00     0.00     0.00     0.00
  2         14.74       .75      0.00    30.00     0.00     0.00     0.00
  1         25.00      3.98      0.00    30.00     0.00     0.00     0.00
                      10.35

STRUCTURE LATERAL LOADS...CASES A AND B

LEVEL            FX-A      FY-A    MOM-A      FX-B      FY-B    MOM-B
                   XA        YA                 XB        YB

 10              0.00      0.00     0.00      0.00      0.00     0.00
                 0.00      0.00               0.00      0.00

  9              0.00      0.00     0.00      0.00      0.00     0.00
                 0.00      0.00               0.00      0.00

  8              0.00      0.00     0.00      0.00      0.00     0.00
                 0.00      0.00               0.00      0.00

  7              0.00      0.00     0.00      0.00      0.00     0.00
                 0.00      0.00               0.00      0.00

  6              0.00      0.00     0.00      0.00      0.00     0.00
                 0.00      0.00               0.00      0.00

  5              0.00      0.00     0.00      0.00      0.00     0.00
                 0.00      0.00               0.00      0.00

  4              0.00      0.00     0.00      0.00      0.00     0.00
                 0.00      0.00               0.00      0.00

  3              0.00      0.00     0.00      0.00      0.00     0.00
                 0.00      0.00               0.00      0.00

  2              0.00      0.00     0.00      0.00      0.00     0.00
                 0.00      0.00               0.00      0.00

  1              0.00      0.00     0.00      0.00      0.00     0.00
                 0.00      0.00               0.00      0.00


FRAME 1
FRAME ID NUMBER----------    1
NUMBER OF COLUMN LINES---    4
NUMBER OF STORY LEVELS---   10
NUMBER OF DIFF. COL. PROP    8
```

```
NUMBER OF PANEL ELEMENTS---- 0

HANGAR 46 LONGITUDINAL                    TBHA1JU .PR1          PAGE   3

 NUMBER OF DIAGONALS------   0

 BAY WIDTHS
    10.000   20.000   10.000

 SILL DEPTHS
     0.000    0.000    0.000

 COLUMN ID           E           A          I         SA         W
         11000000.001000000.00        .01       .01       0.00
         2       10.00         .01        .01       .01       0.00
         3  245000.00          .78      78.13       .06       0.00
         4  245000.00          .95      92.11       .06       0.00
         5  245000.00          .95      92.11       .09       0.00
         6  245000.00         1.29     128.76       .09       0.00
         7  245000.00         1.29     128.76       .06       0.00
         8  446400.00          .83     834.30       .23       0.00

  BEAM ID          E          I          K          C         DB         DA         SA
        1  245000.00         .01       4.00        .50       0.00       0.00       0.00
        21000000.001000000.00          4.00        .50       0.00       0.00       0.00

 BEAM LOCATIONS

   LEV  BAY  BID  GEN  VL1  VL2  VL3
    10    1    2    0    0    0    0
     9    1    1    8    0    0    0
    10    2    2    0    0    0    0
     9    2    1    8    0    0    0
    10    3    2    0    0    0    0
     9    3    1    8    0    0    0


 GENERATED BEAM LOCATIONS

 STORY   1   2   3

   10    2   2   2
    9    1   1   1
    8    1   1   1
    7    1   1   1
    6    1   1   1
    5    1   1   1
    4    1   1   1
    3    1   1   1
    2    1   1   1
    1    1   1   1

 COLUMN LOCATIONS

   LEV  ROW  CID  GEN
    10    1    1    9
    10    2    2    1
     8    2    3    2
```

```
     10    3    3    4
      5    3    4    0
      4    3    5    0
      3    3    6    0
      2    3    7    0
      1    3    8    0
     10    4    1    9


 GENERATED COLUMN LOCATIONS

 STORY   1   2   3   4

   10    1   2   3   1
    9    1   2   3   1
    8    1   3   3   1
    7    1   3   3   1
    6    1   3   3   1
    5    1   4   4   1
    4    1   5   5   1
    3    1   6   6   1
    2    1   7   7   1
    1    1   8   8   1


FRAME POSITION DATA

FRAME  ID  FORCE        X1         Y1        X2         Y2
           CODE
  1     1    0        0.000      0.000    20.000      0.000


ACCELERATION SPECTRUM

 NUMBER OF PERIOD CARDS =       17
 NUMBER OF LOWEST MODES =        6
 ACCEL., UNITS/SEC/SEC  =     32.200 — fc
 ANGEL OF EQ INCIDENCE  =     90.000

  PERIOD      ACCELERATION

    0.000         .170
     .050         .187
     .100         .274
     .150         .351
     .200         .389
     .300         .413
     .400         .375
     .500         .339
     .600         .309
     .700         .284
     .800         .260
     .900         .253
    1.000         .238
```

```
      4.000          .113

HANGAR 46 LONGITUDINAL                  TBHA1JU .PR1         PAGE   5

     5.000           .104


LOAD CONDITION DEFINITION CARDS

LOAD        I        II       III        A         B     SPECTRUM SPECTRUM RESPONSE
                                                             1        2
 1         0.00     0.00     0.00      0.00      0.00      1.00     0.00     0.00


SPECTRUM-1 = ROOT MEAN SQUARE COMBINATION

SPECTRUM-2 = SUM OF ABSOLUTE VALUES
```

```
STRUCTURE DISPLACEMENTS                          LOAD CASES

LEVEL ID   DIRN       I          II         III          A          B

 10     1    X     0.000000   0.000000   0.000000   0.000000   0.000000
  9          X     0.000000   0.000000   0.000000   0.000000   0.000000
  8          X     0.000000   0.000000   0.000000   0.000000   0.000000
  7          X     0.000000   0.000000   0.000000   0.000000   0.000000
  6          X     0.000000   0.000000   0.000000   0.000000   0.000000
  5          X     0.000000   0.000000   0.000000   0.000000   0.000000
  4          X     0.000000   0.000000   0.000000   0.000000   0.000000
  3          X     0.000000   0.000000   0.000000   0.000000   0.000000
  2          X     0.000000   0.000000   0.000000   0.000000   0.000000
  1          X     0.000000   0.000000   0.000000   0.000000   0.000000


LOAD SOLUTION ERRORS                             LOAD CASES

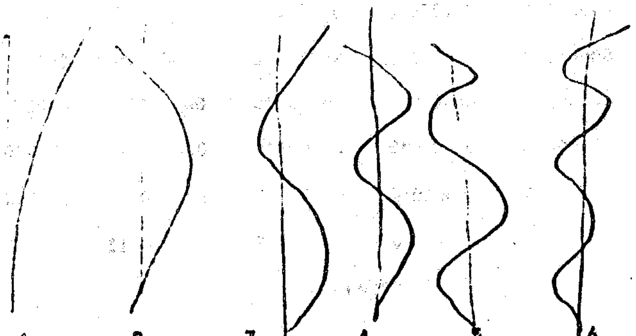
LEVEL ID   DIRN       I          II         III          A          B

 10     1    X     0.000000   0.000000   0.000000   0.000000   0.000000
  9          X     0.000000   0.000000   0.000000   0.000000   0.000000
  8          X     0.000000   0.000000   0.000000   0.000000   0.000000
  7          X     0.000000   0.000000   0.000000   0.000000   0.000000
  6          X     0.000000   0.000000   0.000000   0.000000   0.000000
  5          X     0.000000   0.000000   0.000000   0.000000   0.000000
  4          X     0.000000   0.000000   0.000000   0.000000   0.000000
  3          X     0.000000   0.000000   0.000000   0.000000   0.000000
  2          X     0.000000   0.000000   0.000000   0.000000   0.000000
  1          X     0.000000   0.000000   0.000000   0.000000   0.000000
```

```
HANGAR 46 LONGITUDINAL                    TBHA1JU .PR3          PAGE   7


MODE NUMBER   PERIOD

     1         1.765284
     2          .525000
     3          .321672
     4          .232605
     5          .195800
     6          .166166
     7          .151383
     8          .131987
```



```
MODE SHAPES

LEVEL  ID    DIRN        1          2          3          4          5          6

  10    1     X       .617110   -.587049    .662376   -.493534   -.430541    .916759

   9          X       .599189   -.456310    .326114   -.043518    .104947   -.612976

   8          X       .546225   -.117335   -.350991    .500365    .388411   -.069356

   7          X       .469185    .155079   -.405167    .216642   -.066428    .395830

   6          X       .377982    .392262   -.331432   -.289480   -.420781    .079975

   5          X       .279295    .521679    .028489   -.464055   -.132962   -.403040

   4          X       .180984    .507375    .373069   -.105987    .372793   -.059950

   3          X       .107131    .404734    .464682    .246618    .335515    .278053

   2          X       .047992    .232586    .348171    .408348   -.052058    .212857

   1          X       .009592    .054347    .110615    .266192   -.343603   -.127601


MODE SHAPES

LEVEL  ID    DIRN        7          8

  10    1     X      -.506012   -.105414

   9          X       .490180    .154392

   8          X      -.492331   -.395277

   7          X       .160345    .508474

   6          X       .442509   -.130989
```

```
     4           X    -.301231   .573410

     3           X     .265880  -.036705

     2           X     .368827  -.569567

     1           X    -.123283   .104755
```

```
MODAL PARTICIPATION FACTORS                          m= 10.35

  MODE   P-FACTOR        P-FACTOR
 NUMBER DIRECTION          VALUE
      1          X        2.22254      .4773

      2          X        1.22976      .1461

      3          X         .96478      .0900

      4          X        1.22856      .1158

      5          X       -1.13037       .1235

      6          X        -.30255       .0088

      7          X        -.24209       .0057

      8          X         .15652       .0022
                                      ________
                                       .9996
```

```
MAXIMUM MODAL INERTIA LOADS/TORSIONS GENERATED IN EACH LEVEL (AT CENTER OF MASS

LEVEL  ID    DIRN        1        2        3        4        5        6

  10    1     X       2.81    -2.05     3.08    -2.87     2.24    -1.20

   9          X       5.54    -4.49     3.00     -.51    -1.11     1.63

   8          X       5.05    -1.16    -3.31     5.89    -4.09      .18

   7          X       4.34     1.53    -4.58     2.55      .70    -1.05

   6          X       3.49     3.86    -3.13    -3.41     4.43     -.21

   5          X       2.58     5.14      .27    -5.46     1.40     1.07

   4          X       1.67     5.00     3.52    -1.25    -3.93      .16

   3          X        .99     3.98     4.38     2.90    -3.53     -.74

   2          X        .44     2.29     3.28     4.81      .56     -.57
```

```
HANGAR 46 LONGITUDINAL                    TBHA1JU .PR3       PAGE   9


MAXIMUM MODAL INERTIA LOADS/TORSIONS GENERATED IN EACH LEVEL (AT CENTER OF MASS

LEVEL  ID   DIRN       7        8

 10     1    X        .51     -.06
  9          X      -1.01      .19
  8          X       1.01     -.48
  7          X       -.33      .62
  6          X       -.91     -.16
  5          X        .73     -.49
  4          X        .62      .70
  3          X       -.55     -.04
  2          X       -.76     -.70
  1          X       1.35      .68



MAXIMUM MODAL STORY SHEARS AT EACH LEVEL

LEVEL  ID   DIRN       1         2         3         4         5         6

 10     1    X       2.81     -2.85      3.08     -2.87      2.24     -1.20
  9          X       8.35     -7.34      6.16     -3.38      1.13       .43
  8          X      13.40     -8.50      2.85      2.51     -2.96       .61
  7          X      17.74     -6.96     -1.73      5.06     -2.26      -.44
  6          X      21.23     -3.10     -4.86      1.65      2.17      -.65
  5          X      23.81      2.03     -4.59     -3.81      3.57       .42
  4          X      25.48      7.03     -1.07     -5.06      -.35       .58
  3          X      26.47     11.01      3.32     -2.15     -3.89      -.16
  2          X      26.92     13.30      6.60      2.65      3.33      -.73
                        9         4        14       .27       .87      1.07
```

```
MAXIMUM MODAL STORY SHEARS IN EACH LEVEL

HANGAR 46 LONGITUDINAL                   TBHA1JU .PR3       PAGE  10

LEVEL  ID    DIRN         7          8
  10    1     X          .51       -.06
   9          X        -.50         .13
   8          X          .52       -.36
   7          X          .19         .26
   6          X        -.72         .10
   5          X          .00       -.38
   4          X          .62         .32
   3          X          .08         .27
   2          X        -.68        -.42
   1          X          .66         .25
```

```
HANGAR 46 LONGITUDINAL                        TBHA1JU .PR4         PAGE   1


 ...OUTPUT FOR FRAME NO   1 ...

        FRAME TYPE =   1
        FRAME ID
 ..LATERAL FRAME DISPLACEMENTS..
 MAX...STATIC + DYNAMIC
 MIN...STATIC - DYNAMIC
 LEVEL                1
     10  MAX      .6031902
         MIN     -.6031902
      9  MAX      .5844252
         MIN     -.5844252
      8  MAX      .5316765
         MIN     -.5316765
      7  MAX      .4568990
         MIN     -.4568990
      6  MAX      .3696705
         MIN     -.3696705
      5  MAX      .2760322
         MIN     -.2760322
      4  MAX      .1825796
         MIN     -.1825796
      3  MAX      .1118878
         MIN     -.1118878
      2  MAX      .0533268
         MIN     -.0533268
      1  MAX      .0134182
         MIN     -.0134182


 MEMBER FORCES .....  FRAME ID                           FRAME TYPE  1

                      LEVEL NO   1    ...   LEVEL ID
  COLUMN  LOAD      BOTTOM-MOMENT     TOP-MOMENT    AXIAL FORCE    SHEAR FORCE
     1     1 MAX           .6413         1.6670        26.6332          .0853
           1 MIN          -.6413        -1.6670       -26.6332         -.0853

     2     1 MAX       1755.8636      1360.0470         4.1223        21.1109
           1 MIN      -1755.8636     -1360.0470        -4.1223       -21.1109

     3     1 MAX       1676.4353      1274.1261         2.1847        21.1854
           1 MIN      -1676.4353     -1274.1261        -2.1847       -21.1854

     4     1 MAX           .6404         1.6632        24.7254          .0851
           1 MIN          -.6404        -1.6632       -24.7254         -.0851

    BEAM  LOAD       LEFT-MOMENT   RIGHT-MOMENT BAY-DISTORTION
     1     1 MAX          1.6731          .8714          .0005
           1 MIN         -1.6731         -.8914         -.0005

     2     1 MAX           .0904          .0890          .000
           1 MIN          -.0904         -.0890         -.0
```

V-21.1

```
HANGAR 46 LONGITUDINAL                          TBHA1JU .PR4          PAGE   2


  STORY SHEARS FOR LOAD CASES
                  I               II              III              A               B
               0.0000           0.0000           0.0000          0.0000          0.0000


 MEMBER FORCES .....   FRAME ID                                  FRAME TYPE  1

                             LEVEL NO   2    ...   LEVEL ID
  COLUMN   LOAD          BOTTOM-MOMENT      TOP-MOMENT    AXIAL FORCE     SHEAR FORCE
       1     1 MAX              3.2810          2.2294        26.4428           .3724
             1 MIN             -3.2810         -2.2294       -26.4428          -.3724

       2     1 MAX           1360.9568       1161.8485         3.9130         15.0889
             1 MIN          -1360.9568      -1161.8485        -3.9130        -15.0889

       3     1 MAX           1275.0503       1072.3857         1.9639         15.2207
             1 MIN          -1275.0503      -1072.3857        -1.9639        -15.2207

       4     1 MAX              3.2802          2.2341        24.5343           .3732
             1 MIN             -3.2802         -2.2341       -24.5343          -.3732

    BEAM   LOAD            LEFT-MOMENT    RIGHT-MOMENT BAY-DISTORTION
       1     1 MAX              2.6875          1.8042          .0028
             1 MIN             -2.6875         -1.8042         -.0028

       2     1 MAX               .5225           .5111          .0029
             1 MIN              -.5225          -.5111         -.0029

       3     1 MAX              1.7906          2.6944          .0028
             1 MIN             -1.7906         -2.6944         -.0028
 STORY SHEARS FOR LOAD CASES
                  I               II              III              A               B
               0.0000           0.0000           0.0000          0.0000          0.0000


 MEMBER FORCES .....   FRAME ID                                  FRAME TYPE  1

                             LEVEL NO   3    ...   LEVEL ID
  COLUMN   LOAD          BOTTOM-MOMENT      TOP-MOMENT    AXIAL FORCE     SHEAR FORCE
       1     1 MAX               .7542           .8709        26.0769           .0649
             1 MIN              -.7542          -.8709       -26.0769          -.0649

       2     1 MAX           1164.1044        869.4742         3.5598         14.2193
             1 MIN          -1164.1044       -869.4742        -3.5598        -14.2193

       3     1 MAX           1074.6212        760.7083         1.6028         14.8686
             1 MIN          -1074.6212       -760.7083        -1.6028        -14.8686

       4     1 MAX               .7558           .8712        24.1719           .0650
             1 MIN              -.7558          -.8712       -24.1719          -.0650

    BEAM   LOAD            LEFT-MOMENT    RIGHT-MOMENT BAY-DISTORTION
       1     1 MAX              2.6929          2.3452          .0025
```

```
HANGAR 46 LONGITUDINAL                     TBHA1JU .PR4         PAGE   3

               1 MIN         -1.0664      -1.0370       -.0026

          3    1 MAX          2.2820       2.6875        .0025
               1 MIN         -2.2820      -2.6875       -.0025

 STORY SHEARS FOR LOAD CASES
                 I            II           III           A           B
              0.0000       0.0000       0.0000       0.0000      0.0000


 MEMBER FORCES .....  FRAME ID                          FRAME TYPE  1

                      LEVEL NO    4    ...   LEVEL ID
  COLUMN   LOAD     BOTTOM-MOMENT      TOP-MOMENT    AXIAL FORCE     SHEAR FORCE
     1      1 MAX         1.8640         1.1717        25.6246          .1301
            1 MIN        -1.8640        -1.1717       -25.6246         -.1301

     2      1 MAX       872.8200       618.0775         3.1813        12.5971
            1 MIN      -872.8200      -618.0775        -3.1813       -12.5971

     3      1 MAX       763.9620       471.0024         1.2290        14.1115
            1 MIN      -763.9620      -471.0024        -1.2290       -14.1115

     4      1 MAX         1.8581         1.1612        23.7293          .1293
            1 MIN        -1.8581        -1.1612       -23.7293         -.1293

    BEAM   LOAD        LEFT-MOMENT   RIGHT-MOMENT BAY-DISTORTION
     1      1 MAX         3.8364         3.4435          .0031
            1 MIN        -3.8364        -3.4435         -.0031

     2      1 MAX         1.5998         1.5380          .0032
            1 MIN        -1.5998        -1.5380         -.0032

     3      1 MAX         3.2831         3.8019          .0031
            1 MIN        -3.2831        -3.8019         -.0031

 STORY SHEARS FOR LOAD CASES
                 I            II           III           A           B
              0.0000       0.0000       0.0000       0.0000      0.0000


 MEMBER FORCES .....  FRAME ID                          FRAME TYPE  1

                      LEVEL NO    5    ...   LEVEL ID
  COLUMN   LOAD     BOTTOM-MOMENT      TOP-MOMENT    AXIAL FORCE     SHEAR FORCE
     1      1 MAX         2.7608         2.3467        24.9518          .2226
            1 MIN        -2.7608        -2.3467       -24.9518         -.2226

     2      1 MAX       622.9241       405.4996         2.6301        11.2676
            1 MIN      -622.9241      -405.4996        -2.6301       -11.2676

     3      1 MAX       475.5706       231.5367          .70          13.1979
            1 MIN      -475.5706      -231.5369         -.70         -13.1979
```

```
      1     1 MAX          4.5263       4.1330         .0041
            1 MIN         -4.5263      -4.1330        -.0041

      2     1 MAX          1.9307       1.8258         .0043
            1 MIN         -1.9307      -1.8258        -.0043

      3     1 MAX          3.8311       4.4413         .0042
            1 MIN         -3.8311      -4.4413        -.0042

 STORY SHEARS FOR LOAD CASES
              I             II            III            A             B
            0.0000        0.0000        0.0000        0.0000        0.0000


 MEMBER FORCES .....  FRAME ID                         FRAME TYPE  1

                     LEVEL NO   6    ...  LEVEL ID
  COLUMN   LOAD     BOTTOM-MOMENT    TOP-MOMENT   AXIAL FORCE    SHEAR FORCE
      1     1 MAX          2.3131       2.3946       24.1357          .2072
            1 MIN         -2.3131      -2.3946      -24.1357         -.2072

      2     1 MAX        410.9857     236.3938        1.9682         9.2030
            1 MIN       -410.9857    -236.3938       -1.9682        -9.2030

      3     1 MAX        235.7145     175.2941         .2139        12.5888
            1 MIN       -235.7145    -175.2941        -.2139       -12.5888

      4     1 MAX          2.2582       2.3224       22.3047          .2015
            1 MIN         -2.2582      -2.3224      -22.3047         -.2015

    BEAM   LOAD       LEFT-MOMENT   RIGHT-MOMENT BAY-DISTORTION
      1     1 MAX          4.5571       4.3745         .0042
            1 MIN         -4.5571      -4.3745        -.0042

      2     1 MAX          2.1134       1.9403         .0044
            1 MIN         -2.1134      -1.9403        -.0044

      3     1 MAX          3.8416       4.3084         .0043
            1 MIN         -3.8416      -4.3084        -.0043

 STORY SHEARS FOR LOAD CASES
              I             II            III            A             B
            0.0000        0.0000        0.0000        0.0000        0.0000


 MEMBER FORCES .....  FRAME ID                         FRAME TYPE  1

                     LEVEL NO   7    ...  LEVEL ID
  COLUMN   LOAD     BOTTOM-MOMENT    TOP-MOMENT   AXIAL FORCE    SHEAR FORCE
      1     1 MAX          2.2010       2.4358       23.2008          .2130
            1 MIN         -2.2010      -2.4358      -23.2008         -.2130

      2     1 MAX        241.5342     101.3814        1.2848         7.2024
            1 MIN       -241.5342    -101.3814       -1.2848        -7.2024
```

```
     4    1 MAX          2.1896        2.3382       21.5195          .2044
          1 MIN         -2.1896       -2.3302   •  -21.5195         -.2044

   BEAM  LOAD        LEFT-MOMENT   RIGHT-MOMENT BAY-DISTORTION
     1    1 MAX          4.4087        4.3892         .0040
          1 MIN         -4.4087       -4.3892        -.0040

     2    1 MAX          2.1255        1.8588         .0043
          1 MIN         -2.1255       -1.8588        -.0043

     3    1 MAX          3.5160        4.0877         .0041
          1 MIN         -3.5160       -4.0877        -.0041

 STORY SHEARS FOR LOAD CASES
             I             II             III            A              B
          0.0000         0.0000         0.0000         0.0000         0.0000


 MEMBER FORCES .....   FRAME ID                        FRAME TYPE  1

                       LEVEL NO   8    ...   LEVEL ID
  COLUMN  LOAD       BOTTOM-MOMENT    TOP-MOMENT    AXIAL FORCE     SHEAR FORCE
     1    1 MAX          2.0016        2.7316       22.4325           .2186
          1 MIN         -2.0016       -2.7316      -22.4325          -.2186

     2    1 MAX        105.0532        6.0966         .6112          5.1048
          1 MIN       -105.0532       -6.0966        -.6112         -5.1048

     3    1 MAX        358.1785      581.6981        1.1209         11.8372
          1 MIN       -358.1785     -581.6981       -1.1209        -11.8372

     4    1 MAX          1.7800        2.3903       20.7865           .1914
          1 MIN         -1.7800       -2.3903      -20.7865          -.1914

  _BEAM  LOAD        LEFT-MOMENT   RIGHT-MOMENT BAY-DISTORTION
     1    1 MAX          3.8310        4.0895         .0036
          1 MIN         -3.8310       -4.0895        -.0036

     2    1 MAX          2.0139        1.6171         .0038
          1 MIN         -2.0139       -1.6171        -.0038

     3    1 MAX          2.8421        3.4681         .0037
          1 MIN         -2.8421       -3.4681        -.0037

 STORY SHEARS FOR LOAD CASES
             I             II             III            A              B
          0.0000         0.0000         0.0000         0.0000         0.0000


 MEMBER FORCES .....   FRAME ID                        FRAME TYPE  1

                       LEVEL NO   9    ...   LEVEL ID
  COLUMN  LOAD       BOTTOM-MOMENT    TOP-MOMENT    AXIAL FORCE     SHEAR FORCE
```

```
      3     1 MAX        577.4572      765.1868        1.5358       12.8249
            1 MIN       -577.4572     -765.1868       -1.5358      -12.8249

      4     1 MAX          2.0045        2.5712       20.1590         .2146
            1 MIN         -2.0045       -2.5712      -20.1590        -.2146

    BEAM  LOAD        LEFT-MOMENT   RIGHT-MOMENT BAY-DISTORTION
      1     1 MAX           .9193         .3967         .0023
            1 MIN          -.9193        -.3967        -.0023

      2     1 MAX           .3968         .6557         .0036
            1 MIN          -.3968        -.6557        -.0036

      3     1 MAX          1.7296        2.3169         .0031
            1 MIN         -1.7296       -2.3169        -.0031

  STORY SHEARS FOR LOAD CASES
              I             II             III             A              B
           0.0000         0.0000         0.0000         0.0000         0.0000


  MEMBER FORCES .....  FRAME ID                           FRAME TYPE  1

                       LEVEL NO  10    ...   LEVEL ID    1
   COLUMN  LOAD      BOTTOM-MOMENT    TOP-MOMENT    AXIAL FORCE     SHEAR FORCE
      1     1 MAX          1.1621        1.6309       21.5984          .0748
            1 MIN          1.1621       -1.6309      -21.5984         -.0748

      2     1 MAX           .0000         .0000         .0000          .000*
            1 MIN          -.0000        -.0000        -.0000         -.000*

      3     1 MAX        762.9499      843.0222        1.8429         6.2117
            1 MIN       -762.9499     -843.0222       -1.8429        -6.2117

      4     1 MAX           .6814        1.9608       19.7745          .1066
            1 MIN          -.6814       -1.9608      -19.7745         -.1066

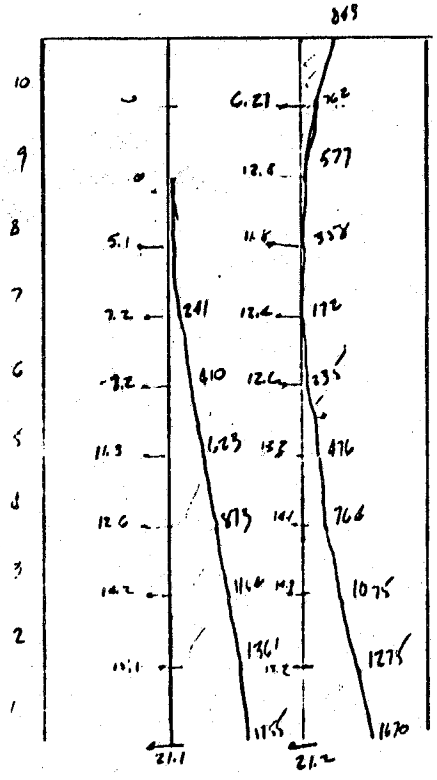
    BEAM  LOAD        LEFT-MOMENT   RIGHT-MOMENT BAY-DISTORTION
      1     1 MAX          1.6308      214.8301         .0013
            1 MIN         -1.6308     -214.8301        -.0013

      2     1 MAX        214.8304      646.7783         .0013
            1 MIN       -214.8304     -646.7783        -.0013

      3     1 MAX        196.2307        1.9606         .0013
            1 MIN       -196.2307       -1.9606        -.0013

  STORY SHEARS FOR LOAD CASES
              I             II             III             A              B
           0.0000         0.0000         0.0000         0.0000         0.0000


  PHASE 6 COMPLETED.
  UNUSED COMMON =   8885
```



Moment Diagram

```
>>>>>>  M I C R O - T A B S  version 1.3 <<<<<<

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       1930 SHATTUCK AVENUE
       BERKELEY  CA  94704
           415-845-2177



  HANGAR 1 LONGITUDINAL SIES, LEVEL 1
TOTAL NUMBER OF STORIES--  10
NUMBER OF DIFF. FRAMES---   1
TOTAL NUMBER OF FRAMES---   1
NUMBER OF LOAD CONDITIONS   1
TYPE OF ANALYSIS---------   3

 EQ.0 STATIC LOADS ONLY
 EQ.1-MODE SHAPES AND FREQUENCIES ONLY
 EQ.2-STATIC AND MODE SHAPE ANALYSES
 EQ.3-TYPE 2 AND SEISMIC SPECTRUM ANAL
 EQ.4-TYPE 2 AND SEISMIC RESPONSE ANAL

NUMBER OF FREQUENCIES- --   8
STORY TRANSLATION CODE---   1

 EQ.0-TRANSLATIONS AND ROTATION
 EQ.1-X TRANSLATION ONLY
 EQ.2-Y TRANSLATION ONLY
```

HANGAR 46
LONGITUDINAL EARTHQUAKE
LEVEL 2 $\zeta = 10\%$

```
HANGAR 46 LONG. LEVEL 2  10% DAMPING       TBHA1JU .PR1         PAGE   2

LEVEL  ID   HEIGHT   MASS(M)      MR**2      X(M)     Y(M)     K-X      K-Y
 10     1    20.28      .37   12  0.00      30.00     0.00     0.00     0.00
  9          20.68      .75   24  0.00      30.00     0.00     0.00     0.00
  8          21.35      .75       0.00      30.00     0.00     0.00     0.00
  7          22.04      .75       0.00      30.00     0.00     0.00     0.00
  6          22.52      .75       0.00      30.00     0.00     0.00     0.00
  5          22.85      .75       0.00      30.00     0.00     0.00     0.00
  4          23.08      .75       0.00      30.00     0.00     0.00     0.00
  3          23.27      .75       0.00      30.00     0.00     0.00     0.00
  2          14.74      .75       0.00      30.00     0.00     0.00     0.00
  1          25.00     3.98  128  0.00      30.00     0.00     0.00     0.00
                             332

STRUCTURE LATERAL LOADS...CASES A AND B

LEVEL          FX-A      FY-A     MOM-A      FX-B      FY-B     MOM-B
                 XA        YA                  XB        YB

 10            0.00      0.00      0.00      0.00      0.00      0.00
               0.00      0.00                0.00      0.00

  9            0.00      0.00      0.00      0.00      0.00      0.00
               0.00      0.00                0.00      0.00

  8            0.00      0.00      0.00      0.00      0.00      0.00
               0.00      0.00                0.00      0.00

  7            0.00      0.00      0.00      0.00      0.00      0.00
               0.00      0.00                0.00      0.00

  6            0.00      0.00      0.00      0.00      0.00      0.00
               0.00      0.00                0.00      0.00

  5            0.00      0.00      0.00      0.00      0.00      0.00
               0.00      0.00                0.00      0.00

  4            0.00      0.00      0.00      0.00      0.00      0.00
               0.00      0.00                0.00      0.00

  3            0.00      0.00      0.00      0.00      0.00      0.00
               0.00      0.00                0.00      0.00

  2            0.00      0.00      0.00      0.00      0.00      0.00
               0.00      0.00                0.00      0.00

  1            0.00      0.00      0.00      0.00      0.00      0.00
               0.00      0.00                0.00      0.00


FRAME 1
FRAME ID NUMBER----------   1
NUMBER OF COLUMN LINES---   4
NUMBER OF STORY LEVELS---  10
NUMBER OF DIFF. COL. PROP   8
NUMBER OF DIFF. BEAM PROP   2
```

```
 NUMBER OF DIAGONALS------    0

 BAY WIDTHS
    10.000    20.000    10.000

 SILL DEPTHS
     0.000     0.000     0.000

 COLUMN ID          E          A          I         SA         W
         11000000.001000000.00        .01        .01      0.00
         2     10.00        .01        .01        .01      0.00
         3 245000.00        .78      78.13        .06      0.00
         4 245000.00        .95      92.11        .06      0.00
         5 245000.00        .95      92.11        .09      0.00
         6 245000.00       1.29     128.76        .09      0.00
         7 245000.00       1.29     128.76        .06      0.00
         8 446400.00        .83     834.30        .23      0.00

  BEAM ID          E          I          K.         C         DB         DA         SA
        1 245000.00        .01       4.00        .50      0.00       0.00       0.00
        21000000.001000000.00       4.00        .50      0.00       0.00       0.00

 BEAM LOCATIONS

   LEV  BAY  BID  GEN  VL1  VL2  VL3
    10    1    2    0    0    0    0
     9    1    1    8    0    0    0
    10    2    2    0    0    0    0
     9    2    1    8    0    0    0
    10    3    2    0    0    0    0
     9    3    1    8    0    0    0


 GENERATED BEAM LOCATIONS

 STORY   1   2   3

   10    2   2   2
    9    1   1   1
    8    1   1   1
    7    1   1   1
    6    1   1   1
    5    1   1   1
    4    1   1   1
    3    1   1   1
    2    1   1   1
    1    1   1   1

 COLUMN LOCATIONS

   LEV  ROW  CID  GEN
    10    1    1    9
    10    2    2    1
     8    2    3    2
     5    2    4    0
          2
```

```
     10     3     3     4
      5     3     4     0
      4     3     5     0
      3     3     6     0
      2     3     7     0
      1     3     8     0
     10     4     1     9


 GENERATED COLUMN LOCATIONS

 STORY   1    2    3    4

   10    1    2    3    1
    9    1    2    3    1
    8    1    3    3    1
    7    1    3    3    1
    6    1    3    3    1
    5    1    4    4    1
    4    1    5    5    1
    3    1    6    6    1
    2    1    7    7    1
    1    1    8    8    1


 FRAME POSITION DATA

 FRAME  ID  FORCE         X1         Y1         X2         Y2
             CODE
   1     1    0          0.000      0.000     20.000      0.000


 ACCELERATION SPECTRUM

  NUMBER OF PERIOD CARDS =        17
  NUMBER OF LOWEST MODES =         6
  ACCEL., UNITS/SEC/SEC  =     32.200
  ANGEL OF EQ INCIDENCE  -     90.000

   PERIOD      ACCELERATION

     0.000             .340
      .050             .366
      .100             .474
      .150             .575
      .200             .620
      .300             .637
      .400             .581
      .500             .528
      .600             .483
      .700             .442
      .800             .401
      .900             .389
     1.000             .371
     2.000             .244
```

```
     5.000          .154


LOAD CONDITION DEFINITION CARDS

LOAD         I        II       III        A         B     SPECTRUM SPECTRUM RESPONSE
                                                              1        2
 1          0.00     0.00     0.00      0.00      0.00     1.00     0.00      0.00


SPECTRUM-1 = ROOT MEAN SQUARE COMBINATION

SPECTRUM-2 = SUM OF ADSOLUTE VALUES
```

```
HANGAR 46 LONGITUDINAL                         TBHA1JU .PR1          PAGE   2

LEVEL  ID    HEIGHT    MASS(M)     MR**2      X(M)      Y(M)       K-X       K-Y
 10     1     20.28       .37       0.00     30.00      0.00      0.00      0.00
  9           20.68       .75       0.00     30.00      0.00      0.00      0.00
  8           21.35       .75       0.00     30.00      0.00      0.00      0.00
  7           22.04       .75       0.00     30.00      0.00      0.00      0.00
  6           22.52       .75       0.00     30.00      0.00      0.00      0.00
  5           22.85       .75       0.00     30.00      0.00      0.00      0.00
  4           23.08       .75       0.00     30.00      0.00      0.00      0.00
  3           23.27       .75       0.00     30.00      0.00      0.00      0.00
  2           14.74       .75       0.00     30.00      0.00      0.00      0.00
  1           25.00      3.98       0.00     30.00      0.00      0.00      0.00
                        10.35

STRUCTURE LATERAL LOADS...CASES A AND B

LEVEL          FX-A      FY-A      MOM-A      FX-B      FY-B      MOM-B
                 XA        YA                   XB        YB

 10            0.00      0.00      0.00       0.00      0.00      0.00
               0.00      0.00                 0.00      0.00

  9            0.00      0.00      0.00       0.00      0.00      0.00
               0.00      0.00                 0.00      0.00

  8            0.00      0.00      0.00       0.00      0.00      0.00
               0.00      0.00                 0.00      0.00

  7            0.00      0.00      0.00       0.00      0.00      0.00
               0.00      0.00                 0.00      0.00

  6            0.00      0.00      0.00       0.00      0.00      0.00
               0.00      0.00                 0.00      0.00

  5            0.00      0.00      0.00       0.00      0.00      0.00
               0.00      0.00                 0.00      0.00

  4            0.00      0.00      0.00       0.00      0.00      0.00
               0.00      0.00                 0.00      0.00

  3            0.00      0.00      0.00       0.00      0.00      0.00
               0.00      0.00                 0.00      0.00

  2            0.00      0.00      0.00       0.00      0.00      0.00
               0.00      0.00                 0.00      0.00

  1            0.00      0.00      0.00       0.00      0.00      0.00
               0.00      0.00                 0.00      0.00


FRAME 1
FRAME ID NUMBER-----------    1
NUMBER OF COLUMN LINES---     4
NUMBER OF STORY LEVELS---    10
NUMBER OF DIFF. COL. PROP     8
NUMBER OF DIFF. BEAM PROP     2
```

```
NUMBER OF PANEL ELEMENTS------ 0

HANGAR 46 LONGITUDINAL                    TBHA1JU .PR1        PAGE   3

 NUMBER OF DIAGONALS------   0

 BAY WIDTHS
    10.000   20.000   10.000

 SILL DEPTHS
     0.000    0.000    0.000

 COLUMN ID        E          A         I         SA         W
         11000000.001000000.00       .01        .01       0.00
         2     10.00        .01       .01        .01       0.00
         3 245000.00        .78     78.13        .06       0.00
         4 245000.00        .95     92.11        .06       0.00
         5 245000.00        .95     92.11        .09       0.00
         6 245000.00       1.29    128.76        .09       0.00
         7 245000.00       1.29    128.76        .06       0.00
         8 446400.00        .83    834.30        .23       0.00

  BEAM ID         E          I         K          C         DB         DA
        1 245000.00        .01      4.00        .50       0.00       0.00      0.
        21000000.001000000.00       4.00        .50       0.00       0.00      0.

 BEAM LOCATIONS

   LEV  BAY  BID  GEN  VL1  VL2  VL3
    10    1    2    0    0    0    0
     9    1    1    8    0    0    0
    10    2    2    0    0    0    0
     9    2    1    8    0    0    0
    10    3    2    0    0    0    0
     9    3    1    8    0    0    0


 GENERATED BEAM LOCATIONS

 STORY   1   2   3

   10    2   2   2
    9    1   1   1
    8    1   1   1
    7    1   1   1
    6    1   1   1
    5    1   1   1
    4    1   1   1
    3    1   1   1
    2    1   1   1
    1    1   1   1

 COLUMN LOCATIONS

   LEV  ROW  CID  GEN
    10    1    1    9
    10    2    2    1
     8    2    3    2
     5    2    4    0
 [illegible]            0
     3    2    4    8
```

```
     10    3    3    4
      5    3    4    0
      4    3    5    0
      3    3    6    0
      2    3    7    0
      1    3    8    0
     10    4    1    9


 GENERATED COLUMN LOCATIONS

 STORY    1    2    3    4

   10     1    2    3    1
    9     1    2    3    1
    8     1    3    3    1
    7     1    3    3    1
    6     1    3    3    1
    5     1    4    4    1
    4     1    5    5    1
    3     1    6    6    1
    2     1    7    7    1
    1     1    8    8    1


 FRAME POSITION DATA

 FRAME  ID  FORCE         X1         Y1         X2          Y2
             CODE
   1     1     0         0.000      0.000     20.000       0.000


 ACCELERATION SPECTRUM

  NUMBER OF PERIOD CARDS =        17
  NUMBER OF LOWEST MODES =         6
  ACCEL., UNITS/SEC/SEC  =      32.200 — fc
  ANGEL OF EQ INCIDENCE  =      90.000

   PERIOD        ACCELERATION

     0.000            .170
      .050            .187
      .100            .274
      .150            .351
      .200            .389
      .300            .413
      .400            .375
      .500            .339
      .600            .309
      .700            .284
      .800            .260
      .900            .253
     1.000            .238
```

```
  4.000          .113
```

```
    5.000          .104


 LOAD CONDITION DEFINITION CARDS

 LOAD      I        II       III        A         B     SPECTRUM SPECTRUM RESPONSE
                                                            1        2
  1       0.00     0.00     0.00      0.00      0.00      1.00     0.00     0.00


 SPECTRUM-1 = ROOT MEAN SQUARE COMBINATION

 SPECTRUM-2 = SUM OF ABSOLUTE VALUES
```

```
STRUCTURE DISPLACEMENTS                          LOAD CASES

LEVEL ID   DIRN        I          II          III          A           B

 10     1    X      0.000000   0.000000   0.000000   0.000000   0.000000

  9          X      0.000000   0.000000   0.000000   0.000000   0.000000

  8          X      0.000000   0.000000   0.000000   0.000000   0.000000

  7          X      0.000000   0.000000   0.000000   0.000000   0.000000

  6          X      0.000000   0.000000   0.000000   0.000000   0.000000

  5          X      0.000000   0.000000   0.000000   0.000000   0.000000

  4          X      0.000000   0.000000   0.000000   0.000000   0.000000

  3          X      0.000000   0.000000   0.000000   0.000000   0.000000

  2          X      0.000000   0.000000   0.000000   0.000000   0.000000

  1          X      0.000000   0.000000   0.000000   0.000000   0.000000


LOAD SOLUTION ERRORS                             LOAD CASES

LEVEL ID   DIRN        I          II          III          A           B

 10     1    X      0.000000   0.000000   0.000000   0.000000   0.000000

  9          X      0.000000   0.000000   0.000000   0.000000   0.000000

  8          X      0.000000   0.000000   0.000000   0.000000   0.000000

  7          X      0.000000   0.000000   0.000000   0.000000   0.000000

  6          X      0.000000   0.000000   0.000000   0.000000   0.000000

  5          X      0.000000   0.000000   0.000000   0.000000   0.000000

  4          X      0.000000   0.000000   0.000000   0.000000   0.000000

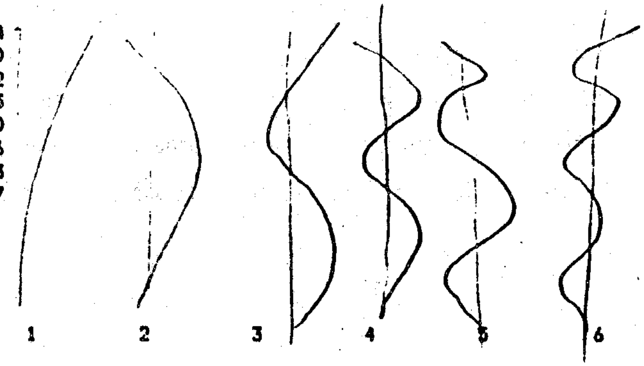
  3          X      0.000000   0.000000   0.000000   0.000000   0.000000

  2          X      0.000000   0.000000   0.000000   0.000000   0.000000

  1          X      0.000000   0.000000   0.000000   0.000000   0.000000
```

```
MODE NUMBER   PERIOD

      1        1.765284
      2         .525000
      3         .321672
      4         .232605
      5         .195800
      6         .166166
      7         .151383
      8         .131987
```



```
MODE SHAPES

LEVEL  ID   DIRN       1         2         3         4         5         6

  10    1    X     .617110  -.587049   .662376  -.493534  -.430541   .916759

   9         X     .599189  -.456310   .326114  -.043518   .104947  -.612976

   8         X     .546225  -.117335  -.350971   .500365   .388411  -.069356

   7         X     .469185   .155079  -.405167   .216642  -.066428   .395830

   6         X     .377982   .392262  -.331432  -.287480  -.420781   .079975

   5         X     .279295   .521679   .028489  -.464055  -.132962  -.403040

   4         X     .180984   .507375   .373069  -.105987   .372793  -.059950

   3         X     .107131   .404734   .464682   .246618   .335515   .278053

   2         X     .047992   .232586   .348171   .408348  -.052858   .212857

   1         X     .009592   .054347   .110615   .266192  -.343603  -.127601


MODE SHAPES

LEVEL  ID   DIRN       7         8

  10    1    X    -.506012  -.105414

   9         X     .490180   .154392

   8         X    -.492331  -.375277

   7         X     .160345   .508494

   6         X     .442509  -.130989
```

```
HANGAR 46 LONGITUDINAL                      TBHA1JU .PR3        PAGE   8

     4          X     -.301231   .573410

     3          X      .265880  -.036705

     2          X      .368827  -.569567

     1          X     -.123283   .104755


 MODAL PARTICIPATION FACTORS                  m= 10.35

   MODE  P-FACTOR         P-FACTOR
 NUMBER DIRECTION          VALUE
      1        X          2.22254      .4773

      2        X          1.22976      .1461

      3        X           .96478      .0900

      4        X          1.22856      .1458

      5        X         -1.13037       .1235

      6        X          -.30255       .0088

      7        X          -.24209       .0057

      8        X           .15652       .0024
                                      ______
                                       .9996



 MAXIMUM MODAL INERTIA LOADS/TORSIONS GENERATED IN EACH LEVEL (AT CENTER OF MASS

 LEVEL  ID   DIRN       1         2         3         4         5         6

   10    1    X       2.81     -2.85      3.08     -2.87      2.24     -1.20

    9         X       5.54     -4.49      3.08      -.51     -1.11      1.63

    8         X       5.05     -1.16     -3.31      5.09     -4.09       .18

    7         X       4.34      1.53     -4.58      2.55       .70     -1.05

    6         X       3.49      3.86     -3.13     -3.41      4.43      -.21

    5         X       2.58      5.14       .27     -5.46      1.40      1.07

    4         X       1.67      5.00      3.52     -1.25     -3.93       .16

    3         X        .99      3.98      4.38      2.90     -3.53      -.74
```

```
HANGAR 46 LONGITUDINAL                    TBHA1JU .PR3        PAGE   9



 MAXIMUM MODAL INERTIA LOADS/TORSIONS GENERATED IN EACH LEVEL (AT CENTER OF MASS

 LEVEL  ID    DIRN        7         8

    10   1     X         .51      -.06

     9         X       -1.01       .19

     8         X        1.01      -.48

     7         X        -.33       .62

     6         X        -.91      -.16

     5         X         .73      -.49

     4         X         .62       .70

     3         X        -.55      -.04

     2         X        -.76      -.70

     1         X        1.35       .68




 MAXIMUM MODAL STORY SHEARS AT EACH LEVEL

 LEVEL  ID    DIRN        1         2         3         4         5         6

    10   1     X        2.81     -2.85      3.08     -2.87      2.24     -1.20

     9         X        8.35     -7.34      6.16     -3.38      1.13       .43

     8         X       13.40     -0.50      2.85      2.51     -2.96       .61

     7         X       17.74     -6.96     -1.73      5.06     -2.26      -.44

     6         X       21.23     -3.10     -4.86      1.65      2.17      -.65

     5         X       23.81      2.03     -4.59     -3.81      3.57       .42

     4         X       25.48      7.03     -1.07     -5.06      -.35       .58

     3         X       26.47     11.01      3.32     -2.15     -3.89      -.16

     2         X       26.92     13.30      6.60      2.65     -3.33      -.73

               X         .39       .14      2.14      7.27     15.8       1.
```

```
HANGAR 46 LONGITUDINAL                  TBHA1JU .PR3        PAGE  10


 LEVEL  ID   DIRN          7         8
   10    1    X          .51      -.06
    9         X         -.50       .13
    8         X          .52      -.36
    7         X          .19       .26
    6         X         -.72       .10
    5         X          .00      -.38
    4         X          .62       .32
    3         X          .08       .27
    2         X         -.68      -.42
    1         X          .66       .25
```

```
...OUTPUT FOR FRAME NO   1 ...

        FRAME TYPE =   1
        FRAME ID
..LATERAL FRAME DISPLACEMENTS..
MAX...STATIC + DYNAMIC
MIN...STATIC - DYNAMIC
LEVEL                 1
    10  MAX      .6031902
        MIN     -.6031902
     9  MAX      .5844252
        MIN     -.5844252
     8  MAX      .5316765
        MIN     -.5316765
     7  MAX      .4568990
        MIN     -.4568990
     6  MAX      .3696705
        MIN     -.3696705
     5  MAX      .2760322
        MIN     -.2760322
     4  MAX      .1825796
        MIN     -.1825796
     3  MAX      .1118878
        MIN     -.1118878
     2  MAX      .0533268
        MIN     -.0533268
     1  MAX      .0134182
        MIN     -.0134182


MEMBER FORCES .....  FRAME ID                        FRAME TYPE  1

                     LEVEL NO   1    ...   LEVEL ID
 COLUMN  LOAD      BOTTOM-MOMENT    TOP-MOMENT    AXIAL FORCE    SHEAR FORCE
     1    1 MAX            .6413        1.6670        26.6332          .0853
          1 MIN           -.6413       -1.6670       -26.6332         -.0853

     2    1 MAX        1755.8636     1360.0470         4.1223        21.1109
          1 MIN       -1755.8636    -1360.0470        -4.1223       -21.1109

     3    1 MAX        1676.4353     1274.1261         2.1847        21.1054
          1 MIN       -1676.4353    -1274.1261        -2.1847       -21.1054

     4    1 MAX            .6404        1.6632        24.7254          .0851
          1 MIN           -.6404       -1.6632       -24.7254         -.0851

   BEAM  LOAD        LEFT-MOMENT  RIGHT-MOMENT BAY-DISTORTION
     1    1 MAX           1.6731         .8714          .0005
          1 MIN          -1.6731        -.8914         -.0005

     2    1 MAX            .0904         .0890          .0
          1 MIN           -.0[illegible]        -.0890         -.0
```

V-21.1

```
 STORY SHEARS FOR LOAD CASES
                I             II            III            A              B
              0.0000        0.0000        0.0000        0.0000         0.0000


 MEMBER FORCES .....  FRAME ID                               FRAME TYPE  1

                    LEVEL NO   2   ...   LEVEL ID
  COLUMN  LOAD     BOTTOM-MOMENT    TOP-MOMENT   AXIAL FORCE    SHEAR FORCE
     1     1 MAX         3.2810        2.2294       26.4428          .3724
           1 MIN        -3.2810       -2.2294      -26.4428         -.3724

     2     1 MAX      1360.9568     1161.8485        3.9130        15.0889
           1 MIN     -1360.9568    -1161.8485       -3.9130       -15.0889

     3     1 MAX      1275.0503     1072.3857        1.9639        15.2207
           1 MIN     -1275.0503    -1072.3857       -1.9639       -15.2207

     4     1 MAX         3.2802        2.2341       24.5343          .3732
           1 MIN        -3.2802       -2.2341      -24.5343         -.3732

    BEAM  LOAD      LEFT-MOMENT   RIGHT-MOMENT BAY-DISTORTION
     1     1 MAX         2.6875        1.8042         .0028
           1 MIN        -2.6875       -1.8042        -.0028

     2     1 MAX          .5225         .5111         .0029
           1 MIN         -.5225        -.5111        -.0029

     3     1 MAX         1.7906        2.6944         .0028
           1 MIN        -1.7906       -2.6944        -.0028
 STORY SHEARS FOR LOAD CASES
                I             II            III            A              B
              0.0000        0.0000        0.0000        0.0000         0.0000


 MEMBER FORCES .....  FRAME ID                               FRAME TYPE  1

                    LEVEL NO   3   ...   LEVEL ID
  COLUMN  LOAD     BOTTOM-MOMENT    TOP-MOMENT   AXIAL FORCE    SHEAR FORCE
     1     1 MAX          .7542         .8709       26.0769          .0649
           1 MIN         -.7542        -.8709      -26.0769         -.0649

     2     1 MAX      1164.1044      869.4742        3.5598        14.2193
           1 MIN     -1164.1044     -869.4742       -3.5598       -14.2193

     3     1 MAX      1074.6212      760.7083        1.6028        14.8686
           1 MIN     -1074.6212     -760.7083       -1.6028       -14.8686

     4     1 MAX          .7558         .8712       24.1719          .0650
           1 MIN         -.7558        -.8712      -24.1719         -.0650

    BEAM  LOAD      LEFT-MOMENT   RIGHT-MOMENT BAY-DISTORTION
     1     1 MAX         2.6929        2.3452         .0025
```

```
HANGAR 46 LONGITUDINAL                      TBHA1JU .PR4         PAGE   3

         1 MIN          -1.0664       -1.0370         -.0026

    3    1 MAX           2.2820        2.6875          .0025
         1 MIN          -2.2820       -2.6875         -.0025

 STORY SHEARS FOR LOAD CASES
           I             II            III             A             B
         0.0000        0.0000        0.0000        0.0000        0.0000


 MEMBER FORCES .....  FRAME ID                        FRAME TYPE  1

                      LEVEL NO   4    ...   LEVEL ID
 COLUMN  LOAD        BOTTOM-MOMENT    TOP-MOMENT    AXIAL FORCE    SHEAR FORCE
    1    1 MAX           1.8640        1.1717        25.6246          .1301
         1 MIN          -1.8640       -1.1717       -25.6246         -.1301

    2    1 MAX         872.8200      618.0775         3.1813        12.5971
         1 MIN        -872.8200     -618.0775        -3.1813       -12.5971

    3    1 MAX         763.9620      471.0024         1.2290        14.1115
         1 MIN        -763.9620     -471.0024        -1.2290       -14.1115

    4    1 MAX           1.8581        1.1612        23.7293          .1293
         1 MIN          -1.8581       -1.1612       -23.7293         -.1293

   BEAM  LOAD         LEFT-MOMENT  RIGHT-MOMENT BAY-DISTORTION
    1    1 MAX           3.8364        3.4435          .0031
         1 MIN          -3.8364       -3.4435         -.0031

    2    1 MAX           1.5998        1.5380          .0032
         1 MIN          -1.5998       -1.5380         -.0032

    3    1 MAX           3.2831        3.8019          .0031
         1 MIN          -3.2831       -3.8019         -.0031

 STORY SHEARS FOR LOAD CASES
           I             II            III             A             B
         0.0000        0.0000        0.0000        0.0000        0.0000


 MEMBER FORCES .....  FRAME ID                        FRAME TYPE  1

                      LEVEL NO   5    ...   LEVEL ID
 COLUMN  LOAD        BOTTOM-MOMENT    TOP-MOMENT    AXIAL FORCE    SHEAR FORCE
    1    1 MAX           2.7608        2.3467        24.9518          .2226
         1 MIN          -2.7608       -2.3467       -24.9518         -.2226

    2    1 MAX         622.9241      405.4996         2.6301        11.2676
         1 MIN        -622.9241     -405.4996        -2.6301       -11.2676

    3    1 MAX         475.5706      231.5369          .704         13.1979
         1 MIN        -475.5706     -231.5369         -.70         -13.1779
```

```
HANGAR 46 LONGITUDINAL                  TBHA1JU .PR4        PAGE   4

      1    1 MAX          4.5263       4.1330        .0041
           1 MIN         -4.5263      -4.1330       -.0041

      2    1 MAX          1.9307       1.8258        .0043
           1 MIN         -1.9307      -1.8258       -.0043

      3    1 MAX          3.8311       4.4413        .0042
           1 MIN         -3.8311      -4.4413       -.0042

 STORY SHEARS FOR LOAD CASES
              I            II           III           A             B
           0.0000       0.0000        0.0000       0.0000        0.0000


 MEMBER FORCES .....  FRAME ID                       FRAME TYPE  1

                     LEVEL NO    6    ...   LEVEL ID
 COLUMN  LOAD      BOTTOM-MOMENT     TOP-MOMENT   AXIAL FORCE    SHEAR FORCE
     1    1 MAX          2.3131       2.3946      24.1357          .2072
          1 MIN         -2.3131      -2.3946     -24.1357         -.2072

     2    1 MAX        410.9857     236.3938       1.9682         9.2030
          1 MIN       -410.9857    -236.3938      -1.9682        -9.2030

     3    1 MAX        235.7145     175.2941        .2139        12.5888
          1 MIN       -235.7145    -175.2941       -.2139       -12.5888

     4    1 MAX          2.2582       2.3224      22.3047          .2015
          1 MIN         -2.2582      -2.3224     -22.3047         -.2015

   BEAM  LOAD        LEFT-MOMENT   RIGHT-MOMENT BAY-DISTORTION
     1    1 MAX          4.5571       4.3745        .0042
          1 MIN         -4.5571      -4.3745       -.0042

     2    1 MAX          2.1134       1.9403        .0044
          1 MIN         -2.1134      -1.9403       -.0044

     3    1 MAX          3.8416       4.3084        .0043
          1 MIN         -3.8416      -4.3084       -.0043

 STORY SHEARS FOR LOAD CASES
              I            II           III           A             B
           0.0000       0.0000        0.0000       0.0000        0.0000


 MEMBER FORCES .....  FRAME ID                       FRAME TYPE  1

                     LEVEL NO    7    ...   LEVEL ID
 COLUMN  LOAD      BOTTOM-MOMENT     TOP-MOMENT   AXIAL FORCE    SHEAR FORCE
     1    1 MAX          2.2010       2.4358      23.2008          .2130
          1 MIN         -2.2010      -2.4358     -23.2008         -.2130

     2    1 MAX        241.5342     101.3814       1.2848         7.2024
          1 MIN       -241.5342    -101.3014      -1.2848        -7.2024
```

```
      4    1 MAX         2.1896       2.3382      21.5195         .2044
           1 MIN        -2.1896      -2.3382     -21.5195        -.2044

    BEAM  LOAD        LEFT-MOMENT   RIGHT-MOMENT BAY-DISTORTION
      1    1 MAX         4.4087       4.3892        .0040
           1 MIN        -4.4087      -4.3892       -.0040

      2    1 MAX         2.1255       1.8588        .0043
           1 MIN        -2.1255      -1.8588       -.0043

      3    1 MAX         3.5160       4.0877        .0041
           1 MIN        -3.5160      -4.0877       -.0041

   STORY SHEARS FOR LOAD CASES
              I             II             III            A              B
            0.0000        0.0000        0.0000        0.0000         0.0000


   MEMBER FORCES .....  FRAME ID                        FRAME TYPE  1

                        LEVEL NO   8    ...  LEVEL ID
    COLUMN  LOAD       BOTTOM-MOMENT    TOP-MOMENT    AXIAL FORCE     SHEAR FORCE
      1    1 MAX         2.0016       2.7316      22.4325         .2186
           1 MIN        -2.0016      -2.7316     -22.4325        -.2186

      2    1 MAX       105.0532       6.0966        .6112        5.1048
           1 MIN      -105.0532      -6.0966       -.6112       -5.1048

      3    1 MAX       358.1785     581.6981       1.1209       11.8372
           1 MIN      -358.1785    -581.6981      -1.1209      -11.8372

      4    1 MAX         1.7800       2.3903      20.7865         .1914
           1 MIN        -1.7800      -2.3903     -20.7865        -.1914

    BEAM  LOAD        LEFT-MOMENT   RIGHT-MOMENT BAY-DISTORTION
      1    1 MAX         3.8310       4.0895        .0036
           1 MIN        -3.8310      -4.0895       -.0036

      2    1 MAX         2.0139       1.6171        .0038
           1 MIN        -2.0139      -1.6171       -.0038

      3    1 MAX         2.8421       3.4681        .0037
           1 MIN        -2.8421      -3.4681       -.0037

   STORY SHEARS FOR LOAD CASES
              I             II             III            A              B
            0.0000        0.0000        0.0000        0.0000         0.0000


   MEMBER FORCES .....  FRAME ID                        FRAME TYPE  1

                        LEVEL NO   9    ...  LEVEL ID
    COLUMN  LOAD       BOTTOM-MOMENT    TOP-MOMENT    AXIAL FORCE     SHEAR FORCE
```

```
HANGAR 46 LONGITUDINAL                    TBHA1JU .PR4          PAGE   6


     3    1 MAX        577.4572      765.1868         1.5358         12.8249
          1 MIN       -577.4572     -765.1868        -1.5358        -12.8249

     4    1 MAX          2.0045        2.5712        20.1590           .2146
          1 MIN         -2.0045       -2.5712       -20.1590          -.2146

   BEAM  LOAD        LEFT-MOMENT   RIGHT-MOMENT BAY-DISTORTION
     1    1 MAX           .9193          .3967          .0023
          1 MIN          -.9193         -.3967         -.0023

     2    1 MAX           .3968          .6557          .0036
          1 MIN          -.3968         -.6557         -.0036

     3    1 MAX          1.7296         2.3169          .0031
          1 MIN         -1.7296        -2.3169         -.0031

 STORY SHEARS FOR LOAD CASES
              I             II            III             A              B
           0.0000        0.0000        0.0000        0.0000         0.0000


 MEMBER FORCES .....  FRAME ID                      FRAME TYPE  1

                     LEVEL NO  10    ...   LEVEL ID    1
  COLUMN  LOAD     BOTTOM-MOMENT    TOP-MOMENT    AXIAL FORCE     SHEAR FORCE
     1    1 MAX          1.1621        1.6309        21.5984           .0748
          1 MIN          1.1621       -1.6309       -21.5984          -.0748

     2    1 MAX           .0000         .0000          .0000           .000*
          1 MIN          -.0000        -.0000         -.0000          -.000*

     3    1 MAX        762.9499      843.0222         1.8429          6.2117
          1 MIN       -762.9499     -843.0222        -1.8429         -6.2117

     4    1 MAX           .6814        1.9608        19.7745           .1066
          1 MIN          -.6814       -1.9608       -19.7745          -.1066

   BEAM  LOAD        LEFT-MOMENT   RIGHT-MOMENT BAY-DISTORTION
     1    1 MAX          1.6308      214.8301          .0013
          1 MIN         -1.6308     -214.8301         -.0013

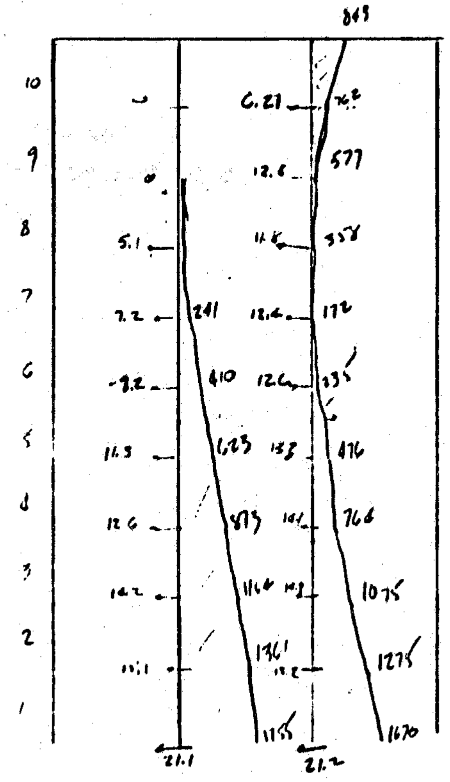
     2    1 MAX        214.8304      646.7783          .0013
          1 MIN       -214.8304     -646.7783         -.0013

     3    1 MAX        196.2307        1.9606          .0013
          1 MIN       -196.2307       -1.9606         -.0013

 STORY SHEARS FOR LOAD CASES
              I             II            III             A              B
           0.0000        0.0000        0.0000        0.0000         0.0000



 PHASE 6 COMPLETED.
 UNUSED COMMON =    8885
```



Moment Diagram

```
>>>>>>  M I C R O - T A B S  version 1.3 <<<<<<

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       1930 SHATTUCK AVENUE
       BERKELEY  CA  94704
           415-845-2177



  HANGAR 1 LONGITUDINAL SIES. LEVEL 1
TOTAL NUMBER OF STORIES--   10
NUMBER OF DIFF. FRAMES---    1
TOTAL NUMBER OF FRAMES---    1
NUMBER OF LOAD CONDITIONS    1
TYPE OF ANALYSIS---------    3

 EQ.0-STATIC LOADS ONLY
 EQ.1-MODE SHAPES AND FREQUENCIES ONLY
 EQ.2-STATIC AND MODE SHAPE ANALYSES
 EQ.3-TYPE 2 AND SEISMIC SPECTRUM ANAL
 EQ.4-TYPE 2 AND SEISMIC RESPONSE ANAL

NUMBER OF FREQUENCIES- --    8
STORY TRANSLATION CODE---    1

 EQ.0-TRANSLATIONS AND ROTATION
 EQ.1-X TRANSLATION ONLY
 EQ.2-Y TRANSLATION ONLY
```

HANGAR 46
LONGITUDINAL EARTHQUAKE
LEVEL 2 $\zeta = 10\%$

```
HANGAR 46 LONG. LEVEL 2  10% DAMPING        TBIIA1JU .PR1         PAGE   2

 LEVEL  ID    HEIGHT   MASS(M)       MR**2      X(M)       Y(M)       K-X        K-Y
  10     1     20.28       .37  12   0.00      30.00       0.00       0.00       0.00
   9           20.68       .75  24   0.00      30.00       0.00       0.00       0.00
   8           21.35       .75       0.00      30.00       0.00       0.00       0.00
   7           22.04       .75       0.00      30.00       0.00       0.00       0.00
   6           22.52       .75       0.00      30.00       0.00       0.00       0.00
   5           22.85       .75       0.00      30.00       0.00       0.00       0.00
   4           23.08       .75       0.00      30.00       0.00       0.00       0.00
   3           23.27       .75       0.00      30.00       0.00       0.00       0.00
   2           14.74       .75       0.00      30.00       0.00       0.00       0.00
   1           25.00      3.98  128  0.00      30.00       0.00       0.00       0.00
                                ----
                                332 <-

 STRUCTURE LATERAL LOADS...CASES A AND B

 LEVEL             FX-A      FY-A      MOM-A      FX-B      FY-B      MOM-B
                     XA        YA                   XB        YB

  10               0.00      0.00      0.00       0.00      0.00      0.00
                   0.00      0.00                 0.00      0.00

   9               0.00      0.00      0.00       0.00      0.00      0.00
                   0.00      0.00                 0.00      0.00

   8               0.00      0.00      0.00       0.00      0.00      0.00
                   0.00      0.00                 0.00      0.00

   7               0.00      0.00      0.00       0.00      0.00      0.00
                   0.00      0.00                 0.00      0.00

   6               0.00      0.00      0.00       0.00      0.00      0.00
                   0.00      0.00                 0.00      0.00

   5               0.00      0.00      0.00       0.00      0.00      0.00
                   0.00      0.00                 0.00      0.00

   4               0.00      0.00      0.00       0.00      0.00      0.00
                   0.00      0.00                 0.00      0.00

   3               0.00      0.00      0.00       0.00      0.00      0.00
                   0.00      0.00                 0.00      0.00

   2               0.00      0.00      0.00       0.00      0.00      0.00
                   0.00      0.00                 0.00      0.00

   1               0.00      0.00      0.00       0.00      0.00      0.00
                   0.00      0.00                 0.00      0.00


FRAME 1
FRAME ID NUMBER-----------   1
NUMBER OF COLUMN LINES---    4
NUMBER OF STORY LEVELS---   10
NUMBER OF DIFF. COL. PROP    8
NUMBER OF DIFF. BEAM PROP    2
```

```
HANGAR 46 LONG. LEVEL 2  10% DAMPING        TBHA1JU .PR1          PAGE   3

 NUMBER OF DIAGONALS------   0

 BAY WIDTHS
    10.000   20.000   10.000

 SILL DEPTHS
     0.000    0.000    0.000

 COLUMN ID          E          A          I         SA         W
        11000000.001000000.00        .01       .01      0.00
        2     10.00        .01        .01       .01      0.00
        3 245000.00        .78      78.13       .06      0.00
        4 245000.00        .95      92.11       .06      0.00
        5 245000.00        .95      92.11       .09      0.00
        6 245000.00       1.29     128.76       .09      0.00
        7 245000.00       1.29     128.76       .06      0.00
        8 446400.00        .83     834.30       .23      0.00

  BEAM ID         E          I          K          C         DB         DA         SA
       1 245000.00        .01       4.00        .50       0.00       0.00       0.00
       21000000.001000000.00        4.00        .50       0.00       0.00       0.00

 BEAM LOCATIONS

   LEV  BAY  BID  GEN  VL1  VL2  VL3
    10    1    2    0    0    0    0
     9    1    1    8    0    0    0
    10    2    2    0    0    0    0
     9    2    1    8    0    0    0
    10    3    2    0    0    0    0
     9    3    1    8    0    0    0


 GENERATED BEAM LOCATIONS

 STORY   1   2   3

   10    2   2   2
    9    1   1   1
    8    1   1   1
    7    1   1   1
    6    1   1   1
    5    1   1   1
    4    1   1   1
    3    1   1   1
    2    1   1   1
    1    1   1   1

 COLUMN LOCATIONS

   LEV  ROW  CID  GEN
    10    1    1    9
    10    2    2    1
     8    2    3    2
     5    2    4    0
          2         0
```

```
STRUCTURE DISPLACEMENTS                          LOAD CASES

LEVEL ID   DIRN       I           II          III          A           B

 10      1   X     0.000000    0.000000    0.000000    0.000000    0.000000
  9          X     0.000000    0.000000    0.000000    0.000000    0.000000
  8          X     0.000000    0.000000    0.000000    0.000000    0.000000
  7          X     0.000000    0.000000    0.000000    0.000000    0.000000
  6          X     0.000000    0.000000    0.000000    0.000000    0.000000
  5          X     0.000000    0.000000    0.000000    0.000000    0.000000
  4          X     0.000000    0.000000    0.000000    0.000000    0.000000
  3          X     0.000000    0.000000    0.000000    0.000000    0.000000
  2          X     0.000000    0.000000    0.000000    0.000000    0.000000
  1          X     0.000000    0.000000    0.000000    0.000000    0.000000


LOAD SOLUTION ERRORS                             LOAD CASES

LEVEL ID   DIRN       I           II          III          A           B

 10      1   X     0.000000    0.000000    0.000000    0.000000    0.000000
  9          X     0.000000    0.000000    0.000000    0.000000    0.000000
  8          X     0.000000    0.000000    0.000000    0.000000    0.000000
  7          X     0.000000    0.000000    0.000000    0.000000    0.000000
  6          X     0.000000    0.000000    0.000000    0.000000    0.000000
  5          X     0.000000    0.000000    0.000000    0.000000    0.000000
  4          X     0.000000    0.000000    0.000000    0.000000    0.000000
  3          X     0.000000    0.000000    0.000000    0.000000    0.000000
  2          X     0.000000    0.000000    0.000000    0.000000    0.000000
  1          X     0.000000    0.000000    0.000000    0.000000    0.000000
```

```
HANGAR 46 LONG. LEVEL 2  10% DAMPING        TDHAIJU .PR3        PAGE   7


MODE NUMBER   PERIOD


      1         1.765284
      2          .525000
      3          .321672
      4          .232605
      5          .195800
      6          .166166
      7          .151383
      8          .131987


MODE SHAPES

LEVEL  ID    DIRN         1          2          3          4          5          6

  10    1     X        .617118   -.587049    .662376   -.493534   -.430541    .916759

   9          X        .599189   -.456310    .326114   -.043518    .104947   -.612976

   8          X        .546225   -.117335   -.350991    .500365    .388411   -.069356

   7          X        .469185    .155879   -.485167    .216642   -.066428    .375830

   6          X        .377982    .392262   -.331432   -.289480   -.420781    .079995

   5          X        .279275    .521679    .028489   -.464055   -.132962   -.403040

   4          X        .180984    .507375    .373069   -.105987    .372793   -.057950

   3          X        .107131    .404734    .464682    .246618    .335515    .278053

   2          X        .047992    .232586    .348171    .408348   -.052858    .212857

   1          X        .009592    .054347    .110615    .266192   -.343603   -.127601


MODE SHAPES

LEVEL  ID    DIRN         7          8

  10    1     X       -.506012   -.105414

   9          X        .490180    .154392

   8          X       -.492331   -.395277

   7          X        .160345    .508494

   6          X        .442507   -.130789
```

```
     4          X   -.301231   .573410

     3          X    .265880  -.036705

     2          X    .368827  -.569567

     1          X   -.123283   .104755


 MODAL PARTICIPATION FACTORS

   MODE  P-FACTOR      P-FACTOR
  NUMBER DIRECTION      VALUE
      1       X         2.22354

      2       X         1.22976

      3       X          .96498

      4       X         1.22856

      5       X        -1.13037

      6       X         -.30255

      7       X         -.24207

      8       X          .15652




MAXIMUM MODAL INERTIA LOADS/TORSIONS GENERATED IN EACH LEVEL (AT CENTER OF MASS

LEVEL  ID    DIRN         1         2         3         4         5         6

  10    1     X         4.47     -4.44      4.76     -4.52      3.57     -1.75

   9          X         8.81     -7.00      4.75      -.81     -1.77      2.64

   8          X         8.03     -1.80     -5.11      7.29     -6.53       .30

   7          X         6.90      2.37     -7.07      4.02      1.12     -1.71

   6          X         5.56      6.02     -4.83     -5.37      7.08      -.34

   5          X         4.10      8.01       .41     -8.61      2.24      1.74

   4          X         2.66      7.79      5.43     -1.97     -6.27       .26

   3          X         1.57      6.21      6.77      4.58     -5.64     -1.20

   2          X          .71      3.57      5.07      7.58       .89      -.92
```

```
HANGAR 46 LONG. LEVEL 2  10% DAMPING        TBHAIJU .PR3        PAGE   9


 MAXIMUM MODAL INERTIA LOADS/TORSIONS GENERATED IN EACH LEVEL (AT CENTER OF MASS

 LEVEL  ID    DIRN          7         8

   10    1     X           .84      -.11

    9          X         -1.65       .31

    8          X          1.66      -.80

    7          X          -.54      1.04

    6          X         -1.49      -.27

    5          X          1.19      -.81

    4          X          1.01      1.17

    3          X          -.90      -.07

    2          X         -1.24     -1.16

    1          X          2.20      1.13



 MAXIMUM MODAL STORY SHEARS AT EACH LEVEL

 LEVEL  ID    DIRN          1         2         3         4         5         6

   10    1     X          4.47     -4.44      4.76     -4.52      3.57     -1.75

    9          X         13.28    -11.45      9.51     -5.33      1.81       .69

    8          X         21.31    -13.23      4.40      3.96     -4.73       .99

    7          X         28.20    -10.86     -2.67      7.78     -3.61      -.71

    6          X         33.76     -4.84     -7.50      2.61      3.47     -1.06

    5          X         37.06      3.17     -7.00     -6.00      5.71       .60

    4          X         40.52     10.96     -1.65     -7.97      -.56       .94

    3          X         42.10     17.17      5.12     -3.39     -6.21      -.26

    2          X         42.80     20.74     10.19      4.18     -5.32     -1.10

    1          X         43.55     25.16     10.74     30.40      5.35      1.74
```

```
HANGAR 46 LONG, LEVEL 2  10% DAMPING         TBHA1JU .FR3         PAGE  10

LEVEL  ID    DIRN         7          8

  10    1     X          .84       -.11
   9          X         -.81        .21
   8          X          .85       -.60
   7          X          .31        .44
   6          X        -1.18        .17
   5          X          .01       -.64
   4          X         1.02        .53
   3          X          .13        .45
   2          X        -1.12       -.71
   1          X         1.09        .42
```

```
...OUTPUT FOR FRAME NO   1 ...

          FRAME TYPE =    1
          FRAME ID
..LATERAL FRAME DISPLACEMENTS..
MAX...STATIC + DYNAMIC
MIN...STATIC - DYNAMIC
LEVEL                  1
    10  MAX      .9590041
        MIN     -.9590041
     9  MAX      .9292492
        MIN     -.9292492
     8  MAX      .8454493
        MIN     -.8454493
     7  MAX      .7265193
        MIN     -.7265193
     6  MAX      .5877247
        MIN     -.5877247
     5  MAX      .4386834
        MIN     -.4386834
     4  MAX      .2899323
        MIN     -.2899323
     3  MAX      .1774431
        MIN     -.1774431
     2  MAX      .0844023
        MIN     -.0844023
     1  MAX      .0212127
        MIN     -.0212127


MEMBER FORCES .....  FRAME ID                        FRAME TYPE   1

                   LEVEL NO   1    ...   LEVEL ID
 COLUMN   LOAD   BOTTOM-MOMENT    TOP MOMENT    AXIAL FORCE    SHEAR FORCE
    1      1 MAX         1.0194        2.6437        42.2771          .1354
           1 MIN        -1.0194       -2.6437        42.2771         -.1354

    2      1 MAX      2788.9707     2162.1843         6.5550        33.3542
           1 MIN     -2788.9707    -2162.1843        -6.5550       -33.3542

    3      1 MAX      2662.3345     2025.4210         3.4740        33.4739
           1 MIN     -2662.3345    -2025.4210        -3.4740       -33.4739

    4      1 MAX         1.0101        2.6376        39.2419          .1351
           1 MIN        -1.0101       -2.6376       -39.2419         -.1351

  BEAM    LOAD     LEFT-MOMENT   RIGHT-MOMENT BAY-DISTORTION
    1      1 MAX         2.6478        1.4111          .0008
           1 MIN        -2.6478       -1.4111         -.0008

    2      1 MAX          .1436         .1414          .0009
           1 MIN         -.1436        -.1414         -.000

           1              .426             3           .00
```

```
HANGAR 46 LONG, LEVEL 2  10% DAMPING        TBHA1JU .PR4          PAGE   2


 STORY SHEARS FOR LOAD CASES
                I              II              III              A              B
              0.0000          0.0000          0.0000          0.0000          0.0000


 MEMBER FORCES .....  FRAME ID                                FRAME TYPE  1

                        LEVEL NO   2    ...   LEVEL ID
  COLUMN   LOAD       BOTTOM-MOMENT     TOP-MOMENT     AXIAL FORCE     SHEAR FORCE
     1      1 MAX         5.1976           3.5234         41.9726           .5893
            1 MIN        -5.1976          -3.5234        -41.9726          -.5893

     2      1 MAX      2163.6296        1847.3846          6.2217         23.8759
            1 MIN     -2163.6296       -1847.3846         -6.2217        -23.8759

     3      1 MAX      2026.8882        1705.0825          3.1229         24.0873
            1 MIN     -2026.8882       -1705.0825         -3.1229        -24.0873

     4      1 MAX         5.2091           3.5309         38.9360           .5906
            1 MIN        -5.2091          -3.5309        -38.9360          -.5906

   BEAM   LOAD         LEFT-MOMENT    RIGHT-MOMENT BAY-DISTORTION
     1      1 MAX         4.2621           2.8639          .0044
            1 MIN        -4.2621          -2.8639         -.0044

     2      1 MAX          .8308            .8126          .0045
            1 MIN         -.8308           -.8126         -.0045

     3      1 MAX         2.8423           4.2731          .0045
            1 MIN        -2.8423          -4.2731         -.0045
 STORY SHEARS FOR LOAD CASES
                I              II              III              A              B
              0.0000          0.0000          0.0000          0.0000          0.0000


 MEMBER FORCES .....  FRAME ID                                FRAME TYPE  1

                        LEVEL NO   3    ...   LEVEL ID
  COLUMN   LOAD       BOTTOM-MOMENT     TOP MOMENT     AXIAL FORCE     SHEAR FORCE
     1      1 MAX         1.1948           1.3815         41.3879           .1032
            1 MIN        -1.1948          -1.3815        -41.3879          -.1032

     2      1 MAX      1850.9705        1382.1414          5.6589         22.5356
            1 MIN     -1850.9705       -1382.1414         -5.6589        -22.5356

     3      1 MAX      1708.6360        1209.2679          2.5483         23.5746
            1 MIN     -1708.6360       -1209.2679         -2.5483        -23.5746

     4      1 MAX         1.1974           1.3820         38.3568           .1033
            1 MIN        -1.1974          -1.3820        -38.3568          -.1033

   BEAM   LOAD         LEFT-MOMENT    RIGHT MOMENT BAY-DISTORTION
     1      1 MAX         4.2797           3.7282          .0040
            1 MIN        -4.2797          -3.7282         -.0040
```

```
             1 MIN          -1.6956        -1.6489        -.0042

        3    1 MAX           3.6277         4.2712         .0040
             1 MIN          -3.6277        -4.2712        -.0040

  STORY SHEARS FOR LOAD CASES
              I            II            III           A            B
           0.0000        0.0000        0.0000       0.0000       0.0000


  MEMBER FORCES .....  FRAME ID                       FRAME TYPE  1

                      LEVEL NO   4    ...   LEVEL ID
   COLUMN  LOAD     BOTTOM-MOMENT     TOP MOMENT    AXIAL FORCE     SHEAR FORCE
       1     1 MAX         2.9631        1.8605        40.6659          .2067
             1 MIN        -2.9631       -1.8605       -40.6659         -.2067

       2     1 MAX      1387.4640      981.3649         5.0563        19.9927
             1 MIN     -1387.4640     -981.3649        -5.0563       -19.9927

       3     1 MAX      1214.4447      747.5466         1.9532        22.4081
             1 MIN     -1214.4447     -747.5466        -1.9532       -22.4081

       4     1 MAX         2.9539        1.8437        37.6501          .2056
             1 MIN        -2.9539       -1.8437       -37.6501         -.2056

     BEAM  LOAD        LEFT-MOMENT   RIGHT-MOMENT BAY-DISTORTION
       1     1 MAX         6.0787        5.4748          .0049
             1 MIN        -6.0787       -5.4748         -.0049

       2     1 MAX         2.5437        2.4453          .0051
             1 MIN        -2.5437        2.4455         -.0051

       3     1 MAX         5.2178        6.0439          .0049
             1 MIN        -5.2198       -6.0439         -.0049

  STORY SHEARS FOR LOAD CASES
              I            II            III           A            B
           0.0000        0.0000        0.0000       0.0000       0.0000


  MEMBER FORCES .....  FRAME ID                       FRAME TYPE  1

                      LEVEL NO   5    ...   LEVEL ID
   COLUMN  LOAD     BOTTOM MOMENT     TOP MOMENT    AXIAL FORCE     SHEAR FORCE
       1     1 MAX         4.3072        3.7209        39.5926          .3538
             1 MIN        -4.3072       -3.7289       -39.5926         -.3538

       2     1 MAX       989.0817      642.2104         4.1790        17.8731
             1 MIN      -989.0819     -642.2104        -4.1790       -17.8731

       3     1 MAX       754.8234      364.7760         1.1181        20.9642
             1 MIN      -754.8234     -364.7760        -1.           -20.9642

                           4.3              835        36.              .350
```

```
      1    1 MAX          7.1946        6.5701         .0065
           1 MIN         -7.1946       -6.5701        -.0065

      2    1 MAX          3.0696        2.9027         .0069
           1 MIN         -3.0696       -2.9027        -.0069

      3    1 MAX          6.0905        7.0596         .0067
           1 MIN         -6.0905       -7.0596        -.0067

 STORY SHEARS FOR LOAD CASES
              I             II            III             A             B
           0.0000        0.0000        0.0000        0.0000        0.0000


 MEMBER FORCES .....  FRAME ID                          FRAME TYPE  1

                      LEVEL NO   6    ...   LEVEL ID
  COLUMN  LOAD      BOTTOM-MOMENT     TOP-MOMENT    AXIAL FORCE    SHEAR FORCE
     1     1 MAX          3.6728        3.8050        38.2920          .3292
           1 MIN         -3.6728       -3.8050       -38.2920         -.3292

     2     1 MAX        650.9551      372.7672         3.1259        14.6060
           1 MIN       -650.9551     -372.7672        -3.1259       -14.6060

     3     1 MAX        371.4654      275.3134          .3338        19.9872
           1 MIN       -371.4654     -275.3134         -.3338       -19.9872

     4     1 MAX          3.5856        3.6903        35.3781          .3201
           1 MIN         -3.5856       -3.6903       -35.3781         -.3201

   BEAM   LOAD         LEFT-MOMENT   RIGHT-MOMENT BAY-DISTORTION
     1     1 MAX          7.2405        6.9519         .0066
           1 MIN         -7.2405       -6.9519        -.0066

     2     1 MAX          3.3593        3.0842         .0071
           1 MIN         -3.3593       -3.0842        -.0071

     3     1 MAX          6.1050        6.9725         .0068
           1 MIN         -6.1050       -6.9725        -.0068

 STORY SHEARS FOR LOAD CASES
              I             II            III             A             B
           0.0000        0.0000        0.0000        0.0000        0.0000


 MEMBER FORCES .....  FRAME ID                          FRAME TYPE  1

                      LEVEL NO   7    ...   LEVEL ID
  COLUMN  LOAD      BOTTOM MOMENT     TOP MOMENT    AXIAL FORCE    SHEAR FORCE
     1     1 MAX          3.6201        3.8690        36.9313          .3303
           1 MIN         -3.6201       -3.8690       -36.9313         -.3303

     2     1 MAX        380.9755      150.6369         2.0397        11.4007
           1 MIN       -380.9755     -150.6369        -2.0397       -11.4007

     3     1 MAX        270.7333      576.4004          .9385        19.6572
```

```
     4    1 MAX           3.4746         3.7139       34.1282          .3246
          1 MIN          -3.4746        -3.7139      -34.1282         -.3246

   BEAM  LOAD         LEFT-MOMENT    RIGHT-MOMENT BAY-DISTORTION
     1    1 MAX           7.0020         6.9734         .0064
          1 MIN          -7.0020        -6.9734        -.0064

     2    1 MAX           3.3779         2.9539         .0068
          1 MIN          -3.3779        -2.9539        -.0068

     3    1 MAX           5.5850         6.4915         .0066
          1 MIN          -5.5850        -6.4915        -.0066

 STORY SHEARS FOR LOAD CASES
            I             II            III             A              B
         0.0000        0.0000         0.0000         0.0000         0.0000


 MEMBER FORCES .....  FRAME ID                          FRAME TYPE  1

                      LEVEL NO   8    ...   LEVEL ID
  COLUMN  LOAD       BOTTOM MOMENT     TOP-MOMENT   AXIAL FORCE    SHEAR FORCE
     1    1 MAX           3.1775         4.3376       35.5823          .3473
          1 MIN          -3.1775        -4.3376      -35.5823         -.3473

     2    1 MAX         164.5132         2.6846         .9694         7.9975
          1 MIN        -164.5132        -2.6846        -.9694        -7.9975

     3    1 MAX         568.4971       924.3985        1.7819        18.7624
          1 MIN        -568.4971      -924.3985       -1.7819       -18.7624

     4    1 MAX           2.8251         3.7945       32.9629          .3041
          1 MIN          -2.8251        -3.7945      -32.9629         -.3041

   BEAM  LOAD         LEFT-MOMENT    RIGHT MOMENT BAY-DISTORTION
     1    1 MAX           6.0741         6.4740         .0056
          1 MIN          -6.0741        -6.4740        -.0056

     2    1 MAX           3.2000         2.5691         .0061
          1 MIN          -3.2000        -2.5691        -.0061

     3    1 MAX           4.5073         5.4930         .0059
          1 MIN          -4.5073        -5.4930        -.0059

 STORY SHEARS FOR LOAD CASES
            I             II            III             A              B
         0.0000        0.0000         0.0000         0.0000         0.0000


 MEMBER FORCES .....  FRAME ID                          FRAME TYPE  1

                      LEVEL NO   9    ...   LEVEL ID
  COLUMN  LOAD       BOTTOM MOMENT     TOP MOMENT   AXIAL FORCE    SHEAR FORCE
     1    1 MAX           2.9756         3.1357       34.337          .2059
          1 M              9756        -              .337              59
```

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HANGAR 46 LONG. LEVEL 2  10% DAMPING        TBHA1JU .PR4          PAGE   6


      3    1 MAX          917.6546      1214.8243          2.4409         20.1317
           1 MIN         -917.6546     -1214.8243         -2.4409        -20.1317

      4    1 MAX            3.1387         4.0563         31.9684          .3373
           1 MIN           -3.1387        -4.0563        -31.9684         -.3373

    BEAM  LOAD         LEFT-MOMENT   RIGHT-MOMENT BAY-DISTORTION
      1    1 MAX            1.4498          .6249          .0036
           1 MIN           -1.4498         -.6249         -.0036

      2    1 MAX             .6250         1.0365          .0057
           1 MIN            -.6250        -1.0365         -.0057

      3    1 MAX            2.7340         3.6530          .0050
           1 MIN           -2.7340        -3.6530         -.0050

  STORY SHEARS FOR LOAD CASES
              I              II             III              A              B
           0.0000          0.0000         0.0000          0.0000         0.0000


  MEMBER FORCES .....  FRAME ID                        FRAME TYPE  1

                     LEVEL NO  10    ...  LEVEL ID    1
   COLUMN  LOAD     BOTTOM-MOMENT    TOP-MOMENT   AXIAL FORCE    SHEAR FORCE
      1     1 MAX          1.8417        2.5771       34.2590          .1195
            1 MIN         -1.8417       -2.5771      -34.2590         -.1195

      2     1 MAX           .0001         .0001         .0001          .0000
            1 MIN          -.0001        -.0001        -.0001         -.0000

      3     1 MAX       1211.2023     1337.1593        2.9273         9.7664
            1 MIN      -1211.2023    -1337.1593       -2.9273        -9.7664

      4     1 MAX          1.0711        3.0961       31.3608          .1693
            1 MIN         -1.0711       -3.0961      -31.3608         -.1693

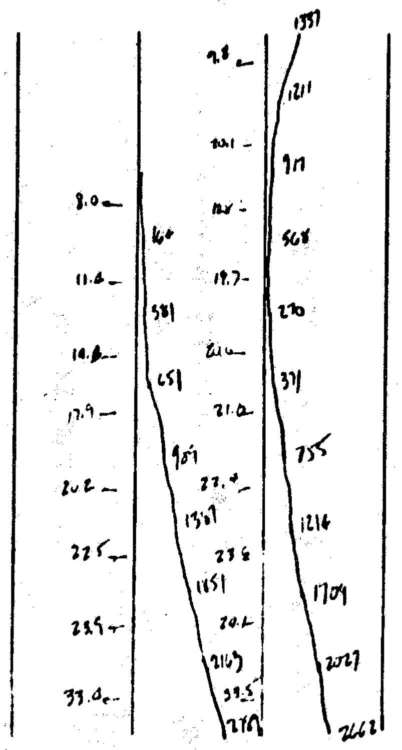
    BEAM  LOAD        LEFT MOMENT   RIGHT MOMENT BAY-DISTORTION
      1     1 MAX          2.5768      340.7704         .0021
            1 MIN         -2.5768     -340.7704        -.0021

      2     1 MAX        340.7708     1025.7497         .0021
            1 MIN       -340.7708    -1025.7497        -.0021

      3     1 MAX        311.2206        3.0963         .0021
            1 MIN       -311.2206       -3.0963        -.0021

  STORY SHEARS FOR LOAD CASES
              I              II             III              A              B
           0.0000          0.0000         0.0000          0.0000         0.0000


  PHASE 6 COMPLETED.
  UNUSED COMMON =   8805
```



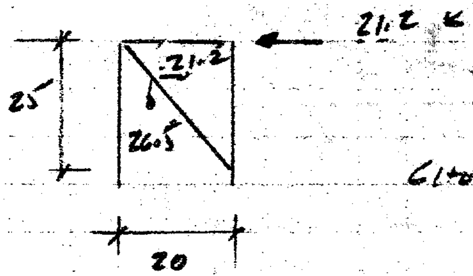
DATE ____________ JOB NO. ____________

BY ________ CHKD. ________ SHEET NO. 46 - 49

SUBJECT Hr. 46 LONGIT. EQ. - MEMBER FORCES

LEVEL 1 EQ $T = 1.77$ SEC
$\xi = 5\%$

CASE $V = 21.2^k$ $M = 2788^{\prime\prime k}$



CHECK MEMBERS & CONN @ YIELD, 2x W.S.

CHECK DIAG - 2-3x12 $A = 2\frac{5}{8} \times 11\frac{1}{2} \times 2 = 60$

$T = (21.2^2 + 26.5^2)^{1/2} = 33.9^k$

$f_T = 33.9 / 60.38 = 0.56$ k.s.i

IF $2 \times f_{all} > .56$
$f_{all} > .28$ ✓ O.K.

END CONN 8 - 4"ϕ SHEAR R, STEEL R 3/8x9

STEEL $A = [9 - 2 \times .75] \times \frac{3}{8} = 2.81 \text{ IN}^2$

$f_s = 33.9 / 2.81 = 12.1$ k.s.i ✓ $< F_y$

SHEAR R, CAPACITY MUST BE $\dfrac{33.9}{2.0 \times 8} = 2.1^{k}$ ea. O.K.

W.S. TO YIELD
O.K. @ LEVEL 2
$V/R = \dfrac{33.9 \times 1.58}{2 \times 8} = 3.3$

BENTS $M/d = 1756 / 20 = 87.8^k$

$f_a = 87{,}800 / 600 = 146$ p.s.i ✓ NEGLIGIBLE

TOP TIE $L = 20 - 1.75 \times 2 = 16.5'$ 2 - 3x12 SPIKED TOGETHER

$f_a = 21.2 / 2 \times 2\frac{5}{8} \times 11.5 = 0.351$ K.S.I

ASSUMED E

$2F_a = 2 \times 0.3 \times 1{,}600{,}000 \Big/ \left(\dfrac{16.5 \times 12}{2 \times 2\frac{5}{8}}\right)^2 = .675$ K.S.I ✓

$\dfrac{f_a}{2.0 F_a} = .351 / .675 = 0.52$

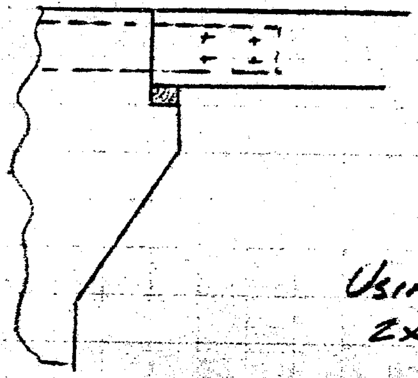
SUBJECT HNGR 46 LONGIT EQ. - MEMBER FORCES

1 ✓

LEVEL 1 EQ

TIE @ TOP OF BENTS

CONN. 4- 3/4" φ BOLTS, PL 3/8×6, P= 21.2 K



$$f_s = \frac{21.2}{(6-1.5)\times.375} = 12.6 \text{ k.s.i} ✓$$

V/BOLT - 21.2 / 4 = 5.3 K/BOLT

USING DOUBLE SHEAR ‖ TO GRAIN @ 2× L SIDE MEMBER = L MAIN MEMBER

2×FV ALL = 2 × 2.86 K = 5.72 K/BOLT

$$\frac{V}{2F_V} = \frac{5.3}{5.72} = .93 ✓$$

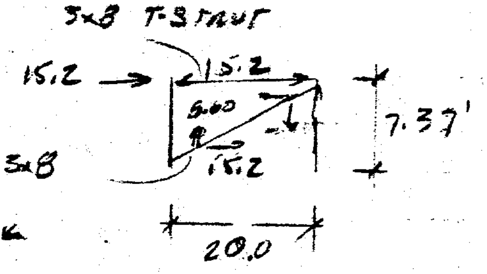
O.K.
O.S. @ LEVEL 2

BRACING @ 1ST LEVEL ABOVE BASE

LEVEL 1 EQ. ✓

V= 15.2K

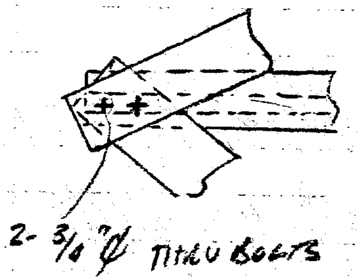
m = 1361 1K



CHECK DIAG T=(15.2² + 5.60)^½ = 16.2K

fT = 16,200 / 2.625 × 7.5 = 822 p.s.i
FTALL > 822/2 = 411 p.s.i O.K.

END CONN.



2- 3/4"φ BOLTS IN SINGLE SHEAR
IN 3× GOOD FOR 1155 # EA

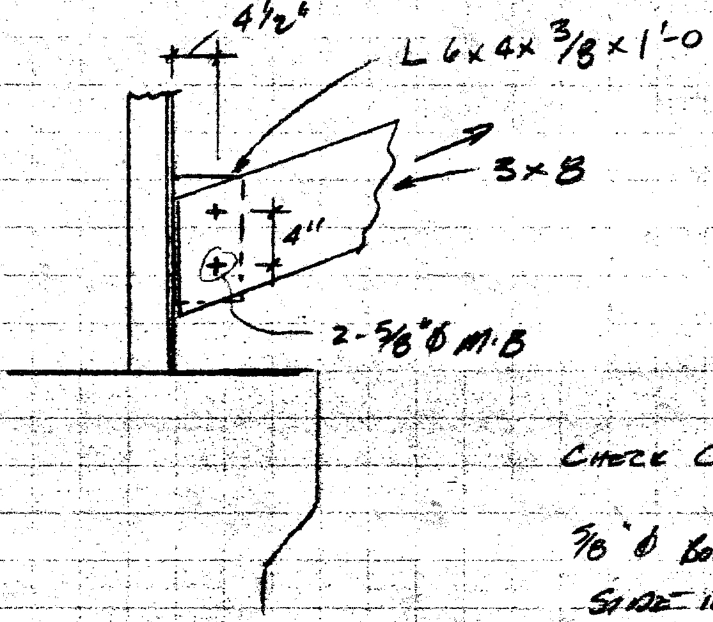
CAP= 2 × 2× 1.155 = 4.62K @ YIELD

$$f_a/F_a = \frac{16.2}{4.62} = 3.51 \text{ N.G.}$$

4.62 = YIELD CAP.

ALL CONN. SUSPECT, LONGIT N.G.

HANGER 2 DIAG CONN @ TOP OF CONCRETE BENTS



$T = \overset{16.2}{\cancel{15.8}}^{k}$ LEVEL 1

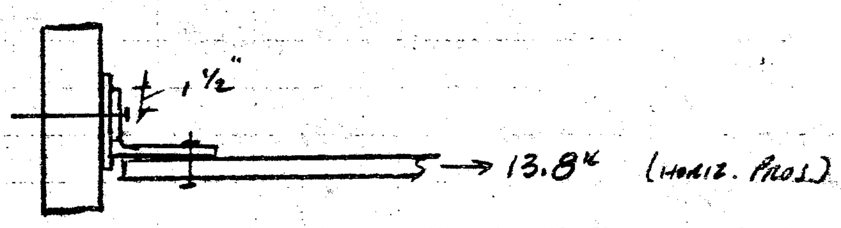
CHECK CONN @ 2x W.S.

5/8"Ø BOLT PARALLEL TO GRAIN w/ METAL SIDE PL

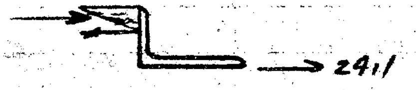
$2\,V_{ALL} = 2 \times 1.25 \times 990 = 2.5^{k}/\text{BOLT}$

$\frac{V}{2V_{ALL}} = \frac{15.8}{2 \times 2.5} = \underline{3.2 \text{ N.G.}}$

CHECK BENDING IN L



CHECK PRYING



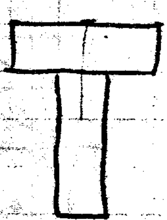
$M = 13.8 \times 2.5 = 34.5$ k.in

$S = 12 \times .375^2/6 = .28$ in²

$f_b = 34.5/.28 = 123$ k.s.i.

N.G. w/16.2, STRESS EVEN WORSE

TYPICAL T STRUT



A	Y	AY
19.7	2.625/2	25.86
19.7	6.375	125.59
39.4		151.45

$\bar{Y} = 3.84$
FROM TOP

$$I_x = \frac{7.5\times2.625^3}{12} + \frac{2.625\times7.5^3}{12} + 19.7[2.53]^2 + 19.7[2.54]^2$$

$$= 11.3 + 92.3 + 126.1 + 127.1 = 356.8$$

$$I_Y = 11.3 + 92.3 = 103.6 \qquad r_Y = \left(\frac{103.6}{39.4}\right)^{1/2} = 1.62$$

$$\therefore Fa = \frac{3.619\,E}{(l/r)^2} = \frac{3.619\times1,600}{(20\times12/1.62)^2} = .264 \text{ k.s.i.}$$

@ LEVEL 1 $P = 15.2$ $fa = \frac{15.2}{39.4} = .386$

$$\frac{fa}{2Fa} = \frac{.386}{2\times.264} = 0.73$$

CHECK FOR LEVEL 2 BUCKLING

@ LEVEL 2 $\xi \sim 10\%$ $P = 24.1^k$ $fa = \frac{20.1}{39.4} = .611$ k.s.i.

$$\frac{fa}{2.74\times Fa} = \frac{.611}{2.74\times.264} = .84 ✓$$

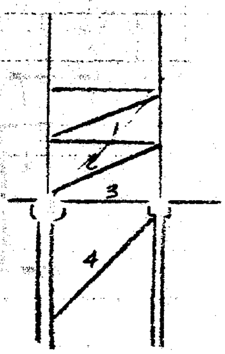
F.S. AGAINST BUCKLING (46-44)

SUBJECT Ha 46 Longit EQ. – Memb Forces

V Level 2 = 33.5 k @ Base
V Level 1 = 21.1 k

$\frac{V_2}{V_1} = 1.58$

Assume T = 650 p.s.i. All.

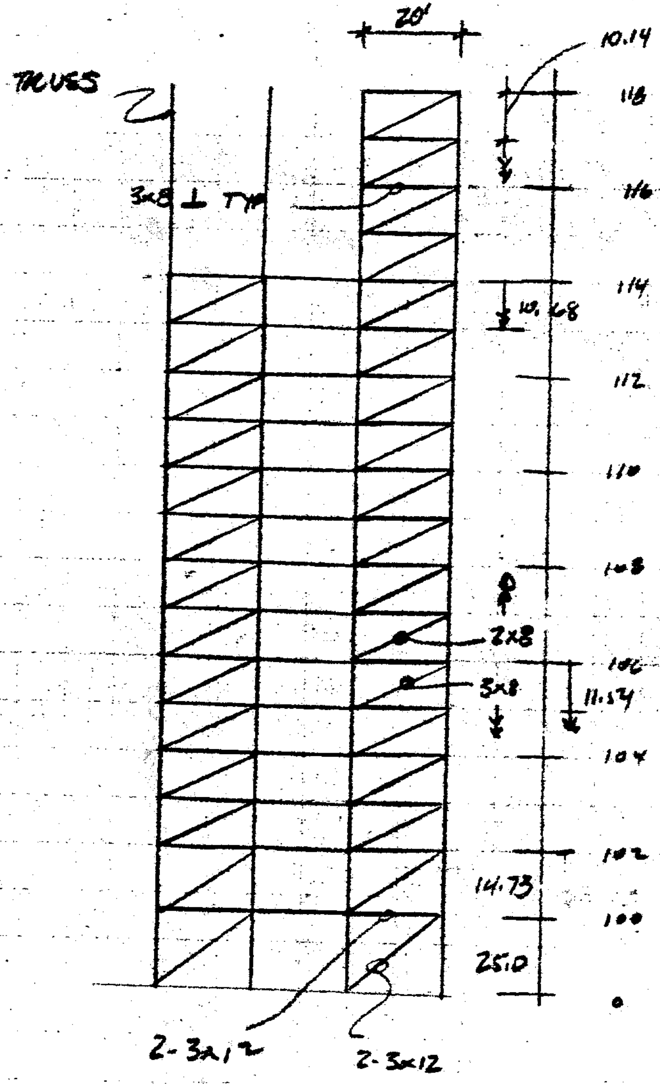


		W.S.	Level 1			Level 2
Memb	A	Fa	P	fa	fa/2×Fa	f/2×Fa × 1.58
1	39.4	.264	16.2	.386	.73	1.15
2	19.7	.65	16.8 16.2 ~~15.8~~	.95 .822 ~~.802~~	~~.63~~ .73	1.00 1.16
3	60.38	.338	21.2	.351	.52	.82
4	60.38	.65	33.9	.561	.43	.68

O.K. F.S. > 2.5 Against Buckling = 2.7

O.S. in T
Revise All.

SUBJECT HANGAR 46 LONGIT SEIS



	F	V	TIN DIAG
118	6.2 =		
		6.2	6.95"
116	6.6		
		12.8	14.4
114	1.0		
		11.8	13.4
112	.6		
		12.4	14.1
110	.2		
		12.6	14.3
108	.6		
		13.2	15.0
106	.9		
		14.1	16.3
104	.8		
		14.9	17.2
102	.3		
		15.2	18.9
100	6.0		
0		21.2"	33.9"

TENS IN DIAG

COMP IN HORIZ

LEVEL 1 EQ
LEVEL 2 = 1.58 LEVEL 1

TENSION DIAG

LEVEL	T	A	f_t P.S.I	$\frac{f_t}{2F_t}$
118				
116	6.95	12.2	570	.32
114	14.4		1,180	.66
112	13.4		1,098	.61
110	14.1		1,156	.64
108	14.3		1,172	.65
106	15.0	12.2	1230	.68
104	16.3	19.7	827	.46
102	17.2	19.7	873	.49
100	18.9	19.7	959	.53
0	33.9	60.4	569	.32

@ LEVEL 1

$1\frac{3}{8}$ or $2\frac{5}{8}$ × $7\frac{1}{2}$

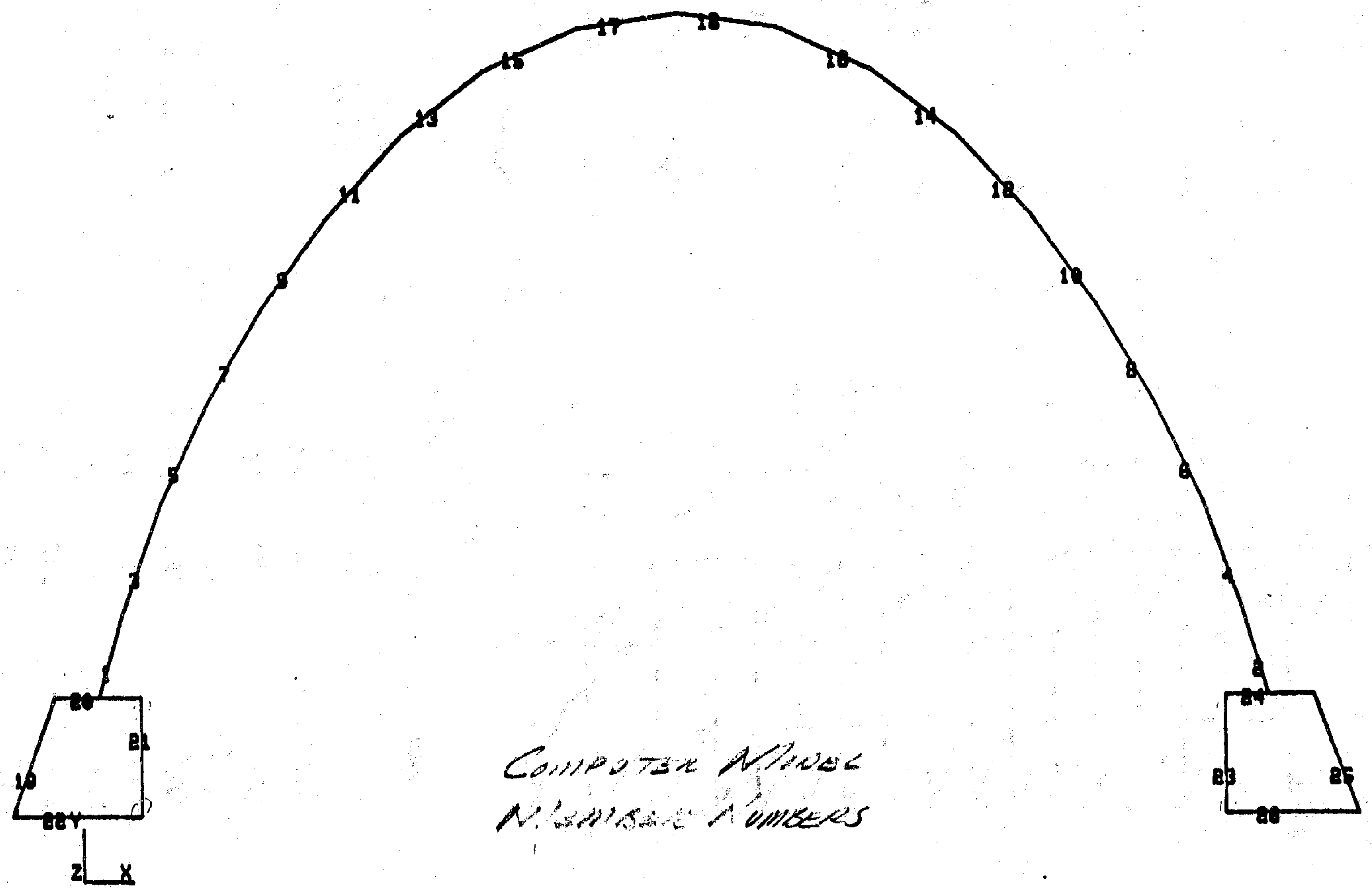
LEVEL 2 - $\frac{1.58 f_t}{2(1.5)F_t} = 1.05\left(\frac{f_t}{2F_T}\right)$

= M.E O.S

NO TENS MEMBERS ARE O.S. ✓

ASSUMING No 1 D.F. FIRE TREATED
$FT = .9 \times 1.0^{K.S.I} = .9 K.S.I$

```
3-D MODE
>lab m
>
```



COMPUTER MODEL
MEMBER NUMBERS

```
THETA Z=   0. THETA Y=   0. THETA X=   0.
```

C DIMENSIONAL PROPERTIES OF AMERICAN STANDARD LUMBER SIZES

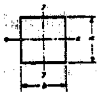


TABLE 12.3

Nominal size	American Standard dressed size (S4S)	Area of section	Moment of inertia		Section modulus	
in. b × h	in. b × h	sq in. $A = bh$	$I_{x-x} = bh^3/12$	$I_{y-y} = b^3h/12$	$S_{x-x} = bh^2/6$	$S_{y-y} = b^2h/6$
1 × 4	25/32 × 3⅝	2.83	3.10	0.14	1.71	0.37
1 × 6	25/32 × 5⅝	4.39	11.59	0.22	4.12	0.57
1 × 8	25/32 × 7½	5.86	27.47	0.30	7.32	0.76
1 × 10	25/32 × 9½	7.42	55.82	0.38	11.75	0.97
1 × 12	25/32 × 11½	8.98	99.02	0.46	17.22	1.17
2 × 2	1⅝ × 1⅝	2.64	0.58	0.58	0.72	0.72
2 × 4	1⅝ × 3⅝	5.89	6.45	1.30	3.56	1.60
2 × 6	1⅝ × 5⅝	9.14	24.10	2.01	8.57	2.48
2 × 8	1⅝ × 7½	12.19	57.13	2.68	15.23	3.30
2 × 10	1⅝ × 9½	15.44	116.10	3.40	24.44	4.18
2 × 12	1⅝ × 11½	18.69	205.95	4.11	35.82	5.06
2 × 14	1⅝ × 13½	21.94	333.18	4.83	49.36	5.94
3 × 4	2⅝ × 3⅝	9.52	10.42	5.46	5.75	4.16
3 × 6	2⅝ × 5⅝	14.77	38.93	8.48	13.84	6.46
3 × 8	2⅝ × 7½	19.69	92.29	11.30	24.61	8.61
3 × 10	2⅝ × 9½	24.94	187.55	14.32	39.48	10.91
3 × 12	2⅝ × 11½	30.19	332.69	17.33	57.86	13.21
3 × 14	2⅝ × 13½	35.44	538.21	20.35	79.73	15.50
3 × 16	2⅝ × 15½	40.69	814.60	23.36	105.11	17.80
4 × 4	3⅝ × 3⅝	13.14	14.39	14.39	7.94	7.94
4 × 6	3⅝ × 5⅝	20.39	53.76	22.33	19.12	12.32
4 × 8	3⅝ × 7½	27.19	127.44	29.77	33.98	16.43
4 × 10	3⅝ × 9½	34.44	259.00	37.71	54.53	20.81
4 × 12	3⅝ × 11½	41.69	459.43	45.65	79.90	25.19
4 × 14	3⅝ × 13½	48.94	743.24	53.59	110.11	29.57
4 × 16	3⅝ × 15½	56.19	1,124.92	61.53	145.15	33.95
6 × 6	5⅝ × 5⅝	30.25	76.26	76.24	27.73	27.73
6 × 8	5⅝ × 7½	41.25	193.36	103.98	51.56	37.81
6 × 10	5⅝ × 9½	52.25	392.96	131.71	82.73	47.00
6 × 12	5⅝ × 11½	63.25	697.07	159.44	121.23	57.98
6 × 14	5⅝ × 13½	74.25	1,127.67	187.17	167.06	68.06
6 × 16	5⅝ × 15½	85.25	1,706.78	214.90	220.23	78.15
6 × 18	5⅝ × 17½	96.25	2,456.38	242.63	280.73	88.23
8 × 8	7½ × 7½	56.25	263.67	263.67	70.31	70.31
8 × 10	7½ × 9½	71.25	535.86	333.98	112.81	89.06
8 × 12	7½ × 11½	86.25	950.55	404.30	165.31	107.81
8 × 14	7½ × 13½	101.25	1,537.73	474.61	227.81	126.56
8 × 16	7½ × 15½	116.25	2,327.42	544.92	300.31	145.31
8 × 18	7½ × 17½	131.25	3,349.61	615.23	382.81	164.06
8 × 20	7½ × 19½	146.25	4,634.30	685.55	475.31	182.81
10 × 10	9½ × 9½	90.25	678.76	678.76	142.90	142.90
10 × 12	9½ × 11½	109.25	1,204.03	821.56	209.40	172.98

C DIMENSION AMERICAN STANDA

TABL

Nominal size	American Standard dressed size (S4S)	Area of section
in. b × h	in. b × h	sq in. $A = bh$
10 × 14	9½ × 13½	128.25
10 × 16	9½ × 15½	147.25
10 × 18	9½ × 17½	166.25
10 × 20	9½ × 19½	185.25
10 × 24	9½ × 23½	223.25
12 × 12	11½ × 11½	132.25
12 × 14	11½ × 13½	155.25
12 × 16	11½ × 15½	178.25
12 × 18	11½ × 17½	201.25
12 × 20	11½ × 19½	224.25
12 × 22	11½ × 21½	247.25
12 × 24	11½ × 23½	270.25
14 × 14	13½ × 13½	182.25
14 × 16	13½ × 15½	209.25
14 × 18	13½ × 17½	236.25
14 × 20	13½ × 19½	263.25
14 × 24	13½ × 23½	317.25

46-56

BUILDING 46- REPAIR

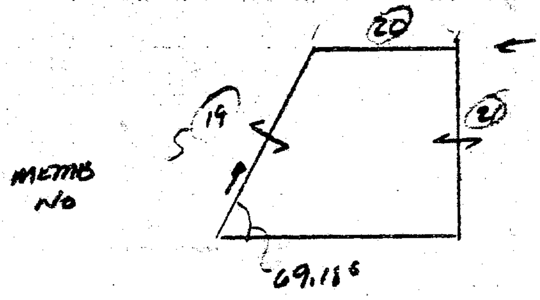
BUILDING 46

TRANSVERSE SEISMIC - EXISTING CONCRETE FRAMES ARE NOT ADEQUATELY REINFORCED TO RESIST SEISMIC FORCES. TRY THE FOLLOWING REPAIR SCHEME:

1. INFILL EVERY 3RD BENT WITH A NEW CONCRETE SHEAR WALL
2. REINFORCE OR REPLACE EXISTING DIAPHRAGM (K-BRACING) AT TOP OF BENTS TO DELIVER LOAD.

FOR SIZING PURPOSES USE SAME BASE SHEAR AS DETERMINED FROM COMPUTER ANALYSIS OF BENTS

RESULTS OF BENT ANALYSIS LEVEL 1 FORCES



$V = V_{21} + P_{19} \cos 69.18 + V_{19} \sin 69.18$

$= 5.67^k + 32.3 \cos 69.18 + 5.18 \sin 69.18$

$= 5.67 + 11.5 + 4.84$

$= 22.01^k$

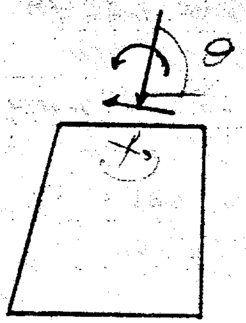
TOTAL WT ON BENT = 83^k

$\therefore Sa_{EFF} = \frac{22.01}{83} = .265g$ AT LEVEL 1

THUS NEW SHEAR WALL MUST RESIST $3 \times 22.01 = 66.03^k$ 66^k

CHECK WHETHER EXISTING PILES CAN RESIST D+E

FORCES AT TOP OF BENT - 1 BENT ONLY, BRACE EVERY 3RD BENT
(LEVEL 1 FORCES)



$V_{ERT} = P \sin\theta - H \cos\theta$

$HORIZ = P \cos\theta + H \sin\theta$

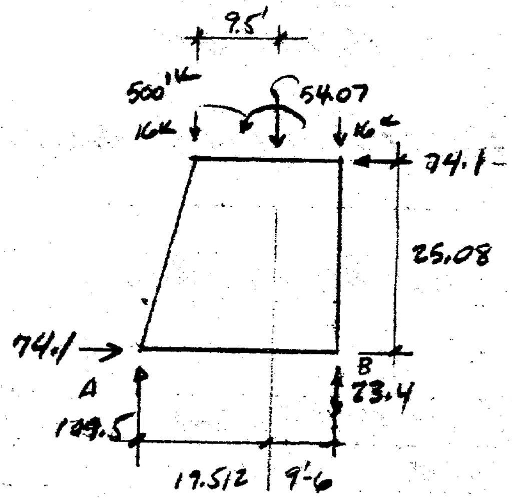
AXIAL DUE TO $M = \frac{M}{d}$ $d = 19.475'$

$\theta = \tan^{-1} 17.448/5.642 = 72.08°$

	P	V	M	VERT	HORIZ	M/d	
D.L	54.7	3.28	63.7	51.0	19.95	3.27	} FORCES/BENT
SEIS	5.87	8.16	436	3.07	9.57	22.38	
			499.1 $500'^{k}$	54.07	29.52	25.65	

∴ AXIAL ON LEFT SIDE $= \frac{54.07}{2} + 25.65 + 16 = 68.7^{k}$ (16: D.L. BENT)

AXIAL ON RIGHT SIDE $= \frac{54.07}{2} - 25.65 + 16 = 17.4^{k}$



SEIS WT BENT

$HORIZ_{TOT} = 19.95 + 3 \times 9.57 + 3 \times .265 \times 32 = 74.1^{k}$

$R_x V_B = \left[500 + 74.1 \times 25.08 - [54.07 + 32]19.52\right] / 29.0$

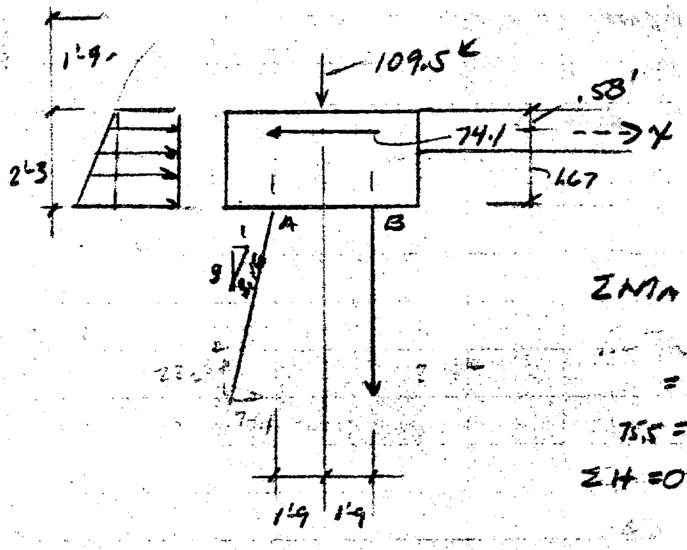
$= [2358 - 1680] / 29.012 = 23.4^{k}$ TENS

$R_x A_V = \left[2358 + 86.07[9.5]\right] / 29.012 = \underline{109.5^{k}}$

86.1^{k} ✓

CHECK WHETHER FOUNDATIONS CAN RESIST APPLIED LOADS

CAP IS 6'-0 WIDE PASSIVE PRESSURE
ON SIDE OF CAP = 200 p.c.f



$\sigma_{TOP} = .2 \times 1.75 \times 6 = 2.1^{k/\prime}$

$\sigma_{BOT} = .2 \times 4 \times 6 = 4.8^{k/\prime}$

$A_{\square} = 2.1 \times 2.25 = 4.73^k$

$A_{\Delta} = 2.7 \times 2.25/2 = \underline{3.04^k}$

7.7k

$\Sigma M_A = (74.1 - X)\,1.67 - 109.5 \times 1.75 - 4.73 \times 2.25/2 - 3.04 \times 2$
$+ R_B \times 3.5$

$= 123.7 - 1.67X - 191.6 - 5.3 - 2.3 + R_B \times 3.5$

$75.5 = 3.5 R_B - 1.67X$

$\Sigma H = 0 = 74.1 - X - 4.73 - 3.04 - [109.5 - R_B]/3$

or $29.8 - X + R_B/3$

$\underline{+49.8} = .56 R_B + 1.67X$

$125.3 = 2.94 R_B \Rightarrow R_B = 42.6^k$

$R_A = [109.5 - 42.6]\,\frac{3.16}{3} = 70.5^k \leftarrow$ 2-60k PILES
O.K.

$X = [3.5 \times 42.6 - 75.5]/1.67 = 44.1^k$

FORCE X IS TAKEN INTO SLABS AND
RESISTED BY FRICTION

ALTERNATELY TAKE FORCE AS SHEAR IN PILES ASSUMING
PINNED HEAD.

$\Sigma M_A = 74.1 \times 1.67 - 109.5 \times 1.75 - 5.3 - 2.3 + 3.5 R_B = 0$

$3.5 R_B = 75.48$

$R_B = 21.6^k$

$R_{VA} = 109.5 - 21.6 = 87.9$

$R_{HA} = 87.9/3 = 29.3$

LOAD IN PILE $= (87.9^2 + 29.3^2)^{1/2}/2$ O.K.

$\Sigma H = 74.1 - 4.73 - 3.04 - 29.3 = \underline{37^k}$

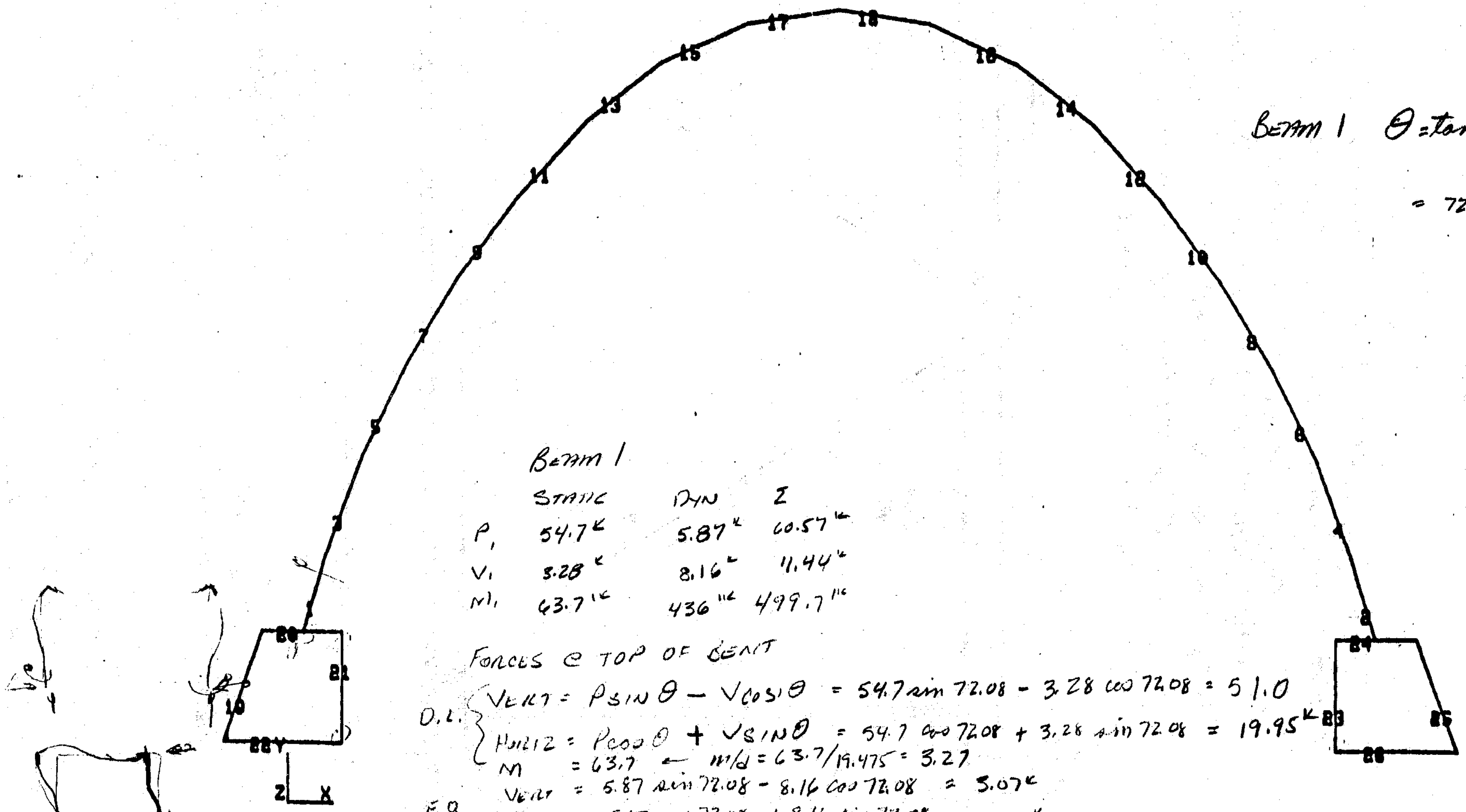
TAKE INTO 7 PILES $= 5.3^k$/PILE @ W.S.

or $\frac{5.3}{2} \times 1.33 = 3.5^k$/PILE @ 1/3 INCREASE
SAY O.K.

```
3-D MODE
>lab m
>
```

Beam 1 $\theta = \tan^{-1}\frac{17.448}{5.642}$

$= 72.08°$



Beam 1

	STATIC	DYN	Σ
P_1	54.7k	5.87k	60.57k
V_1	3.28k	8.16k	11.44k
M_1	63.7'k	436'k	499.7'k

FORCES @ TOP OF BENT

D.L.
VERT = $P \sin\theta - V \cos\theta$ = 54.7 sin 72.08 - 3.28 cos 72.08 = 51.0
HORIZ = $P \cos\theta + V \sin\theta$ = 54.7 cos 72.08 + 3.28 sin 72.08 = 19.95k
M = 63.7 ← M/d = 63.7/19.475 = 3.27

EQ
VERT = 5.87 sin 72.08 - 8.16 cos 72.08 = 3.07k
HORIZ = 5.87 cos 72.08 + 8.16 sin 72.08 = 9.57k
M = 436/19.475 = 22.38k

19.95 + 9.57 = 29.52

```
THETA Z=   0. THETA Y=   0. THETA X=   0.
```

↓ — [51 + 3.07]/2 = 27.03

A — 3.27 + 22.38 = 25.65

↓ 16

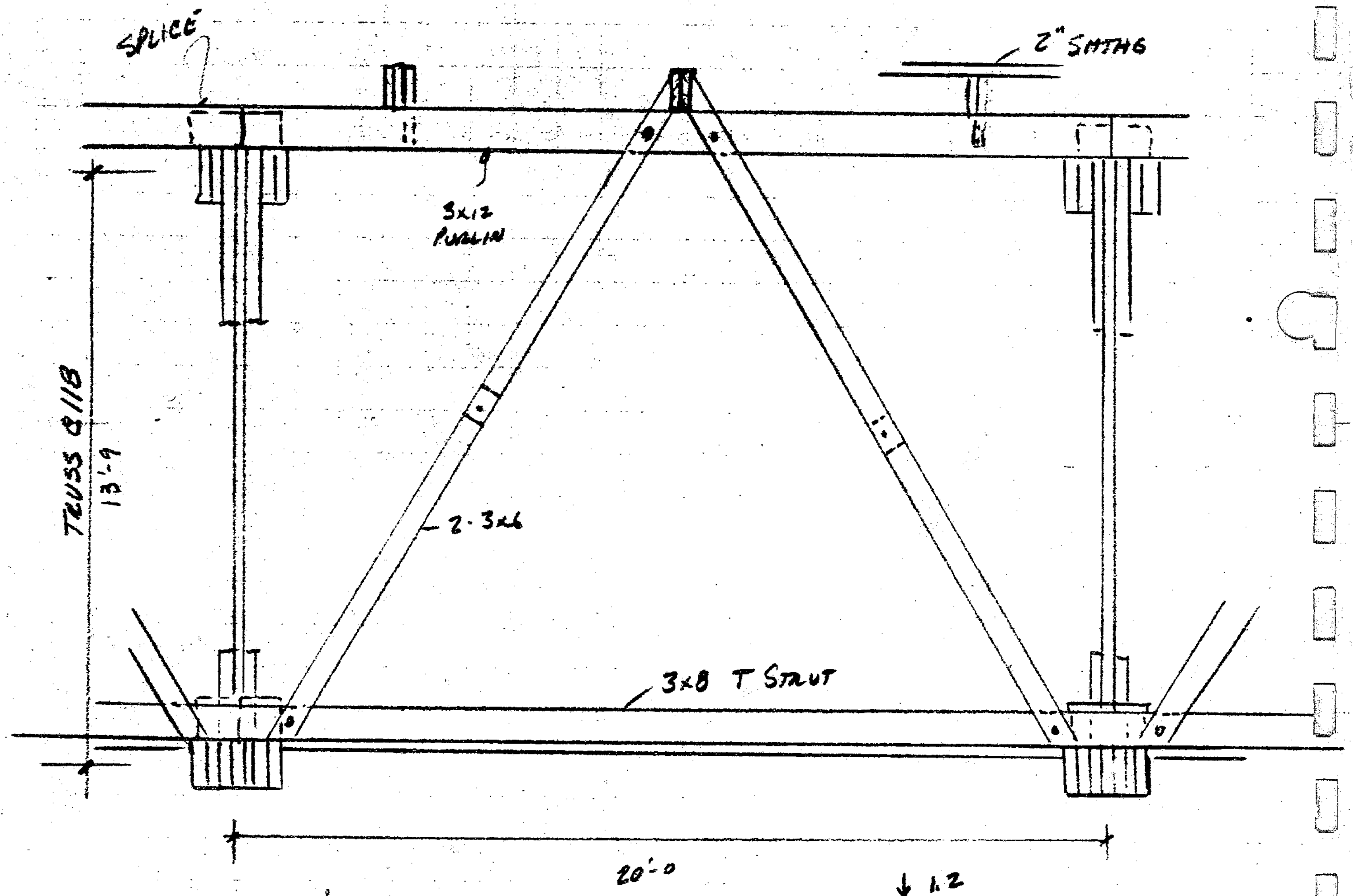
ON COMPR SIDE 27.03 ↓ P/2 ←

25.65 ↓

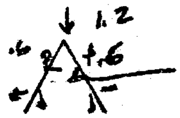
↓ 16

HANGAR 46 LONGIT SEIS.

1. TAKE LOAD FROM ROOF DIAPHRAGM TO BRACING IN PLANE OF LOWER CHORD. FROM DYNAMIC ANALYSIS, THE LARGEST "PANEL POINT" LOAD IS 6.6^k ON 2 PANEL POINTS OR 3.3^k/POINT. THIS LOAD IS COLLECTED OVER 4 BAYS OF TRUSS SPACE (NODE 116)
TAKE LOAD DOWN TYPICAL CROSS BRACING, 1 ONLY, ASSUME 1/2 OF D.L ALSO COMES DOWN BRACE

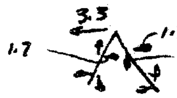


D.L. = 10#/□ × 10' × 12' = 1.2^k ↓
SEIS ← 3.3^k



$.6 \times \frac{10}{13.75} = .44$

$P = (.44^2 + .6^2)^{1/2} = .74$



$1.7 \times \frac{13.75}{10} = 2.34^K$

$P = (1.7^2 + 234^2)^{1/2} = 2.8$

$D+E = 2.89 + .74 = 3.63^k$ $D-E = .74 - 2.89 = -2.15$

$A = 2 \times 14.8 = 29.6 \text{ in}^2$

$f_c = 3630/29.6 = 123$ p.s.i

HANGAR 46 LONGIT SEIS

1. CHECK DIAG FOR COMP. $f_a = 123$ psi

ASSUME $E = .9 \times 1700{,}000 = 1{,}530{,}000$
↳ FIRE TRTD

$L_1/d_1 \leq 80$ $L_1 = [13.75^2 + 10^2]^{1/2} = 17.0'$
$d_1 = 2.63''$

$L_1/d_1 = 17 \times 12 / 2.63$
$= 78$ ✓

$L_2/d_2 \leq 50$ $L_2 = 17'$ $d_2 = 5.5$
$L_2/d_2 = 17 \times 12 / 5.5 = 37$ ✓

$L_3/d_1 \leq 40$ $L_3 = 8.5'$ $d_1 = 2.63''$
$L_3/d_1 = 78/2 = 39$ ✓

$F_c' = 0.3 C_x E / (L_1/d_1)^2$ $C_x = 2.5$ CONS

$= .3 \times 2.5 \times 1530 / 78^2 = \underline{\underline{.189\text{ ksi}}}$ CONTROLS

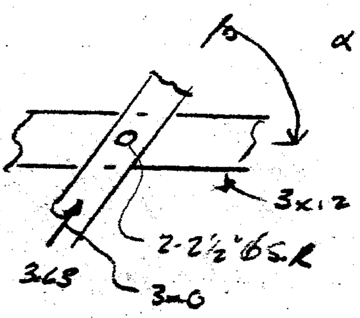
$\sigma = .3E / (L_2/d_2)^2$

$= .3 \times 1530 / (37)^2 = .335$

$\dfrac{f_a}{2F_a'} = \dfrac{.123}{.189 \times 2} = .325$ ✓ MEMBER O.K FOR LEVELS 1 & 2

2. CHECK END CONN $P = 3.63^k$ D+E

$\alpha = \tan^{-1} \dfrac{13.75}{10} = 54°$



CAP IN 3x12 $F_{c\parallel} = 2730$
$F_{c\perp} = 1940$

$F = F_{\parallel} F_{\perp} / F_{\parallel} \sin^2\theta + F_{c\perp} \cos^2\theta$
$= 2.73 \times 1.94 / [2.73 \sin^2 54 + 1.94 \cos^2 54]$
$= 2.16^k$ PER S.R.

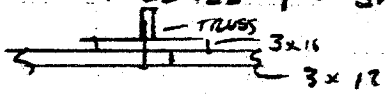
HANGAR 46 LONGIT SEIS.

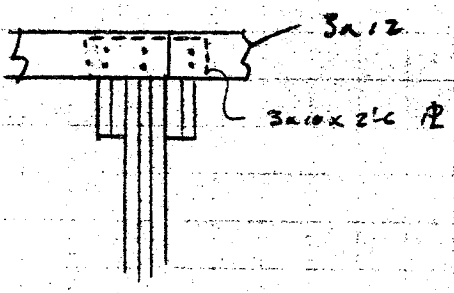
2 END CONN CONT'D

$CAP = \underbrace{2}_{\text{W.S. TO ULT}} \times 2.16 \times \underbrace{2}_{\text{2 RINGS}} = 8.64^{k}$ ✓ CONN O.K FOR LEVELS 1 ; 2

3. COLLECT FORCES TO BRACE

T LEVEL 1 = 3.3^k MAX, CHECK SPLICE





CAP OF 2- 3/4"ϕ BOLTS // TO GRAIN

$P_{ll} = 2 \times 2 \times 1.16 = 4.64^{k}$

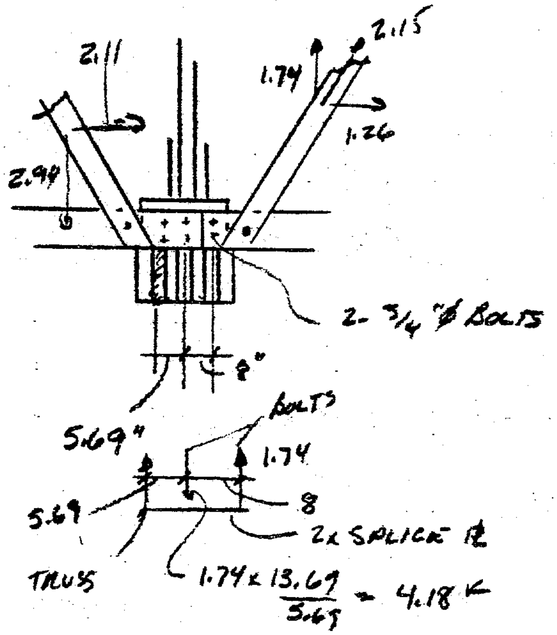
LEVEL 1 EQ = 3.3^k ✓

LEVEL 2 EQ = $1.58 \times 3.3 = 5.21^{k}$

$\frac{Z}{CAP} = \frac{5.21}{4.64} = \underline{1.12}$ SAY O.K

REALIZING 1/2 OF LOAD COMES THROUG SPLICE PL ON EA SIDE OF PL

4. CONN @ BASE OF STRUT



$1.74 \times \frac{13.69}{5.69} = 4.18^{k}$

ON BOLTS THRU VERT IN TRUSS $\overset{\uparrow\ 4.18}{\underset{\rightarrow\ 1.26+2.11=3.37}{+}}$, 2- 3/4"ϕ

BOLTS IN 3x S.S.

$F_{\perp} = 405$ #/BOL

$@ULT = 2 \times 2 \times 405 = 1620 \ll 4.18$

BOLTS N.G.

IF EVERY FRAME TAKES LOAD DOWN, THEN LOAD IN BOLTS IS ~ 1/4 OF ABOVE OR

$\overset{\uparrow 1.05}{+}\!\rightarrow .84$

4
5
3
3

SP1477A

4. CONT'D CONN @ BASE OF STRUT

FOR 3/4" ø BOLT S.S. IN 3x P = 1155#, Q = 450
@ $\theta = \tan^{-1} 1.05/.84 = 51.3°$

$F = 1155 \times 450 \Big/ 1155 \sin^2\theta + 450 \cos^2\theta = 591$#/BOLT @ W.S

$F_{ACT} = (1.05^2 + .84^2)^{1/2} = 1.34^k$ TOTAL

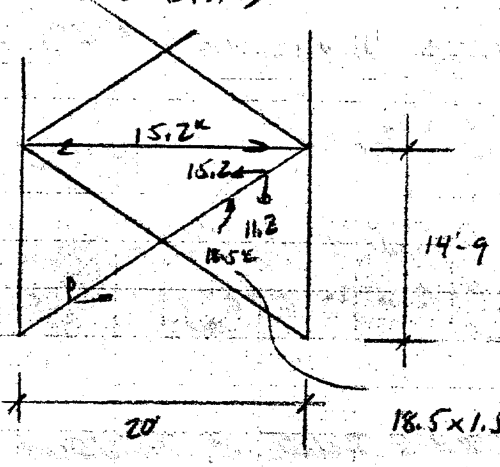
∴ BOLTS OK SINCE 2 @ ULT PROVIDED
CAP = 2x591x2 = 2.36^k ← ALSO O.K @ LEVEL
Z,

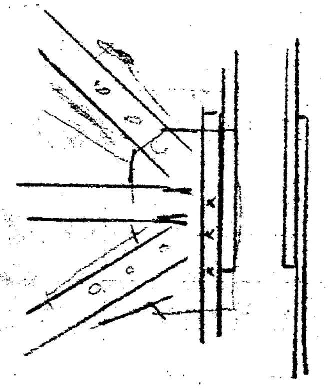
∴ DIAGONAL BRACING TRUSS IS ADEQUATE TO TAKE LOAD FROM ROOF TO LOWER CHORD OF TRUSS

LONGITUDINAL TRUSS CAN BE MOVED TO BOTTOM FACE OF TRUSS AND CONNECTIONS CAN BE MADE CONCENTRIC

HANGAR 46

LONGITUDINAL TRUSS - ALL CONNECTIONS ARE N.G. TO REPAIR, CUT EXIST DIAG, ADD NEW HORIZ & RECONNECT TO MAIN TRUSS - CONN O.S. @ LEVEL 2 = <u>1.0</u> ∴ SIZE CONN FOR LEVEL 2 FORCES AT 2x W.S. ALLOWABLES, ADD NEW DIAG





18.5 × 1.58 = 29.2k @ LEVEL 2

BOLTS REQ'D

3/4"φ IN SINGLE SHEAR IN 3x

V_U = 2x 1155 = 2.31k EA

∴ BOLTS = 29.2/2.31 = 13 BOLTS

OR SHEAR PL V_{ALL} = 2.0x 2.67 = 5.34 k EA

\# = 29.2/5.34 = 5.5 → <u>6</u> - 2 5/8"φ RING

4" SHEAR PL V_{ALL} = 4360x 2.0 = 8.72k

\# = 29.2/8.72 = 3.35 - 4 - 4"φ S.R.

CONN TO TRUSS - USE 2 5/8"φ S.R

\# = 11.2 × 1.58/5.34 = 3.31 - <u>4</u>

HANGAR 46 - LONGIT. SEIS.

ADD NEW HORIZ, USE 3x8 T STRUT OR 5"ϕ PIPE

CONN REQ'D $= 15.2 \times 1.58 / 5.34 = 4.49 - 5$

NEW ⅊, T IN DIAG $= 29.2^{k}$ @ LEVEL 2,

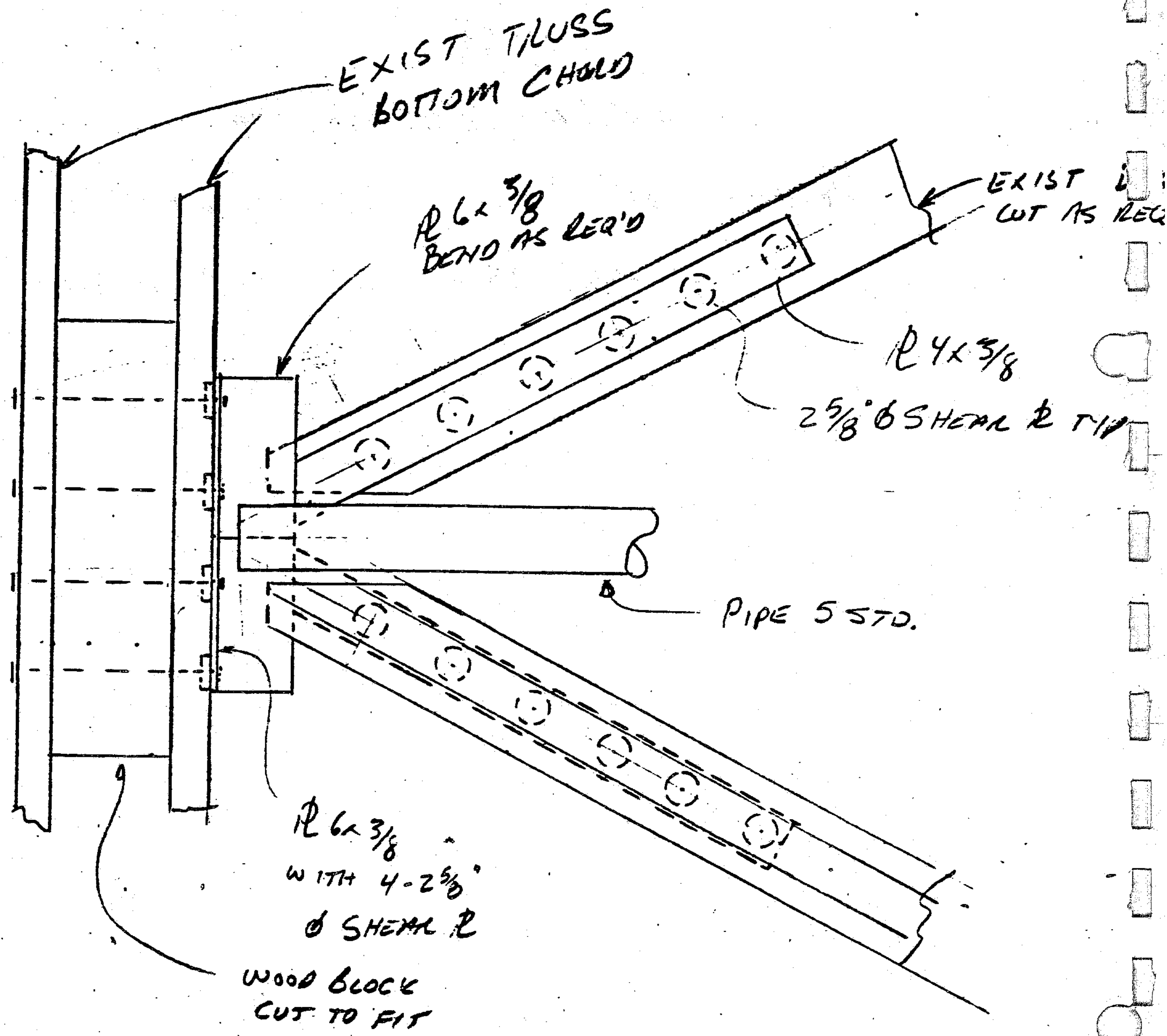
∴ @ YIELD ON 3" WIDE ⅊,

$$t_{PL} = \frac{29.2}{36 \times [3-1]} = .40$$ - USE ⅊ 3 × ½

IF 4" ⅊ IS USED $t = .27$, 3/8

WELD TO PIPE, USING 3/16" FILLET, $C = 15.2 \times 1.58 = 24.0^{k}$

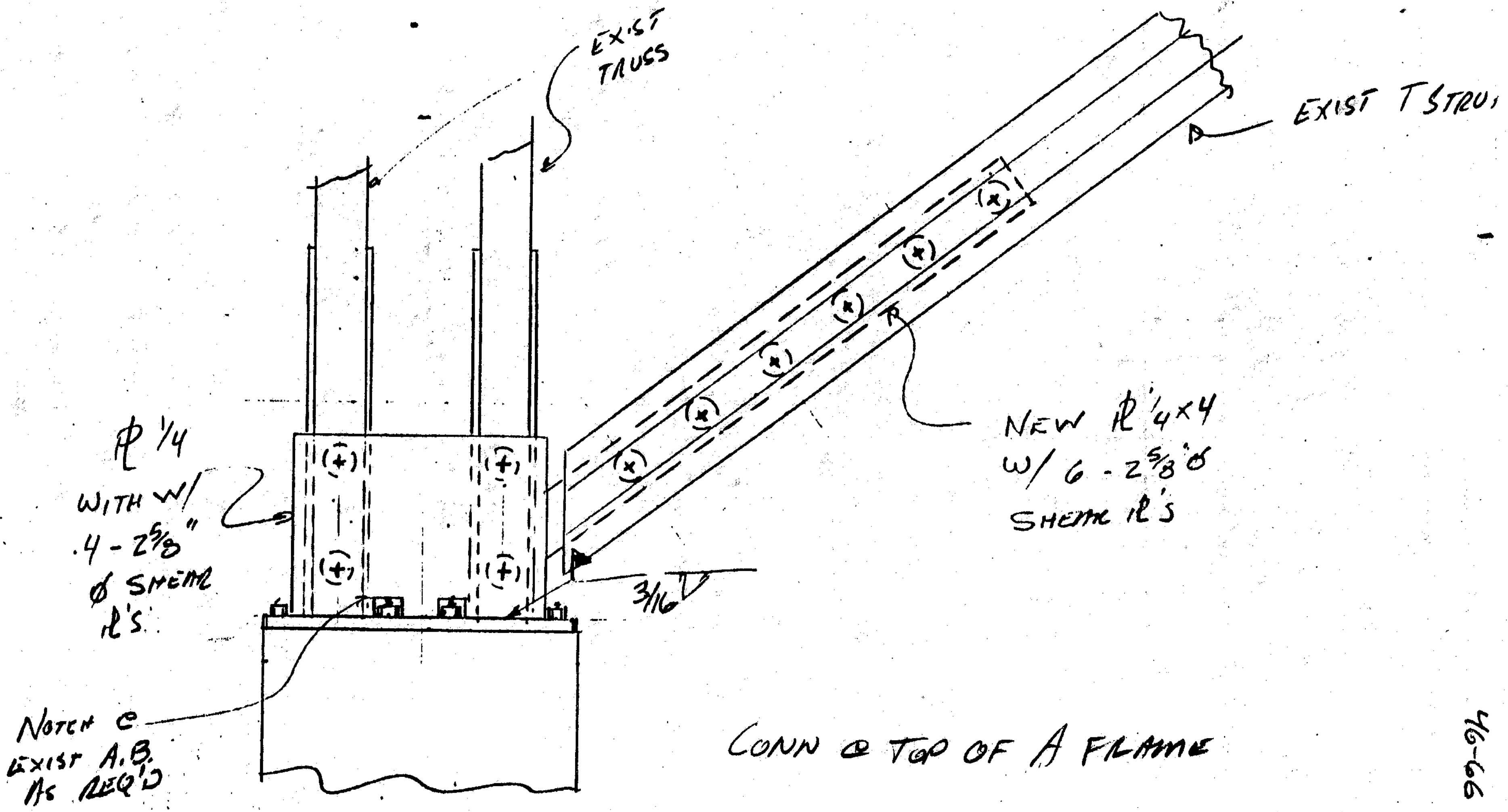
$L = 24.0 / 2.78 \times 2 = 4.3"$; 3" ON 4 FACES


EXIST TRUSS
BOTTOM CHORD
℄ 6x 3/8
BEND AS REQ'D
EXIST
CUT AS REQ
℄ 4x 3/8
2 5/8" ⌀ SHEAR ℄ TYP
PIPE 5 STD.
℄ 6x 3/8
WITH 4-2 5/8"
⌀ SHEAR ℄
WOOD BLOCK
CUT TO FIT

TYP CONN.

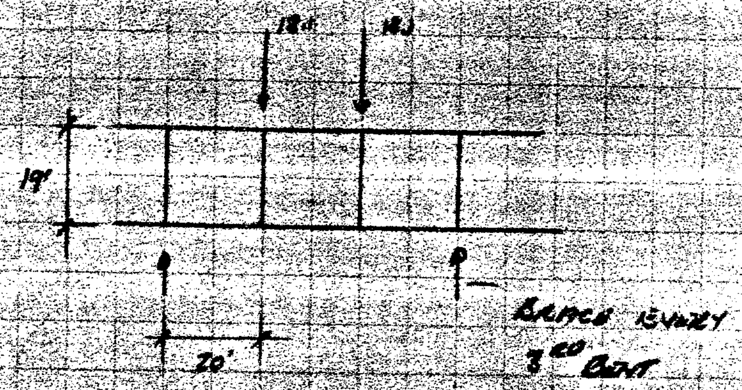
3 3/4

1 1/2 3/16"



CONN @ TOP OF A FRAME

REPLACE DIAPHRAGM @ TOP OF BENT



Bent DL

V/BENT = 9.57 + .265 × 32 = 18.1k

V/L DIAPH = 18.1/19 = .95 k/l

M = 18.1 × 20 = 362'k

M/d = 362/19 = 19k — CHORD

USE 2" QL 99-1B w/ 2½" CONC FILL.
LL CAP = 178#/□ ON A 10' SPAN,
NO SHORING REQ'D, USING 5 PUDDLE WELDS/BUNDLE,
V_{ALL} = 1.62 k/l @ W.S.
DL = 45#/□

SUPPORT BEAMS

CENTER BEAM USING D.L. = 45#/□ LL = 100#/□
A TRIB = 5/8 × 20 × 20 = 250□
D+L = .15 k/l, W = 5/8 × 20 × .15 = 1.88 k/l

$M = 1.88 \times 18.33^2/8 = 79.0'^k$ $V = 1.88 \times \frac{18.33}{2} = 17.2^k$

$\Delta = \frac{5}{384} \times \frac{1.88 \times 18.33^4 \times 1728}{29{,}000 \times I} = \frac{764.7}{I}$

Using $l/360$, $I = \frac{764.7}{\frac{18.33 \times 12}{360}} = 270$ $\underline{W\,14 \times 30}$

EDGE BEAM W = .15 × 5 = .75 k/l
M = 31.5'k V = 6.88k
Δ = 65.7/I l/360 I = 108 $\underline{W\,10 \times 30}$ USE W14x30 THROUGHOUT
P = 19k l = L = 20'

TRY 14x30
A = 8.85
S_y = 24
S_x = 42
r_x = 5.73
r_y = 1.49

l/r_y = 20×12/1.49 = 161 F_a = 5.76 k.s.i. f_b = 31.5 × 12/42 = 9.36
l/r_x = 20×12/5.73 = 42 f_a = 19/8.85 = 2.14 F'_e = 84.7 $F_b = \frac{13000}{\ldots}$ = 9.3

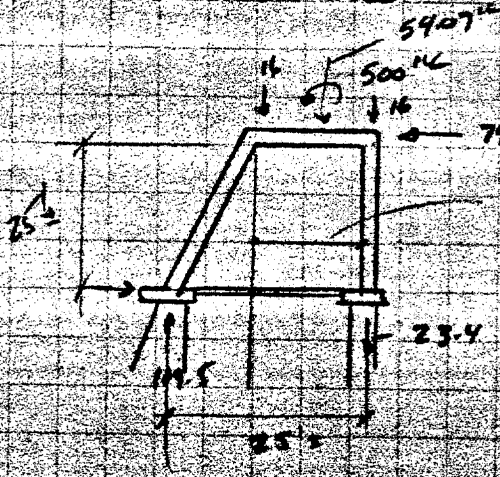
$\frac{2.14}{5.76} + \frac{1 \times 9.1}{(1 - 2.14/84.7)(9.36)}$ = .37 + .99 = 1.36

IF P = 1.5 × 19 = 28.5k, LEVEL 2, $\frac{3.22}{5.76} + \frac{1 \times 9}{(1 - \frac{3.22}{84.7})9.30}$ = .56 + 1.0 = 1.56 ← INCL. L.L. CONS.

CCF OK BOOK

DESIGN NEW SHEAR WALL IN BENT

LEVEL 1 FORCES



19'-2'-6 = 16.5' ∴ $V_u = \frac{74,100}{16.5 \times 12 \times 12} = 51$ psi ✓

← EXIST COL R/F O.K.

MIN. WALL THICKNESS = $^{l}/_{25}$

∴ T = 12" ✓

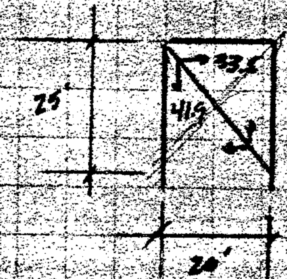
WALL IS O.K. FOR LEVEL 2 FORCES

LEVEL 1 T = .72 ξ=10 Sa = .22g
2 T = .72 ξ=20 Sa = .34g

$^{2}/_{1}$ = 1.54

CONN OF DIAG TO CONC BENT

CHECK CONN FOR LEVEL 2 EQ @ YIELD.

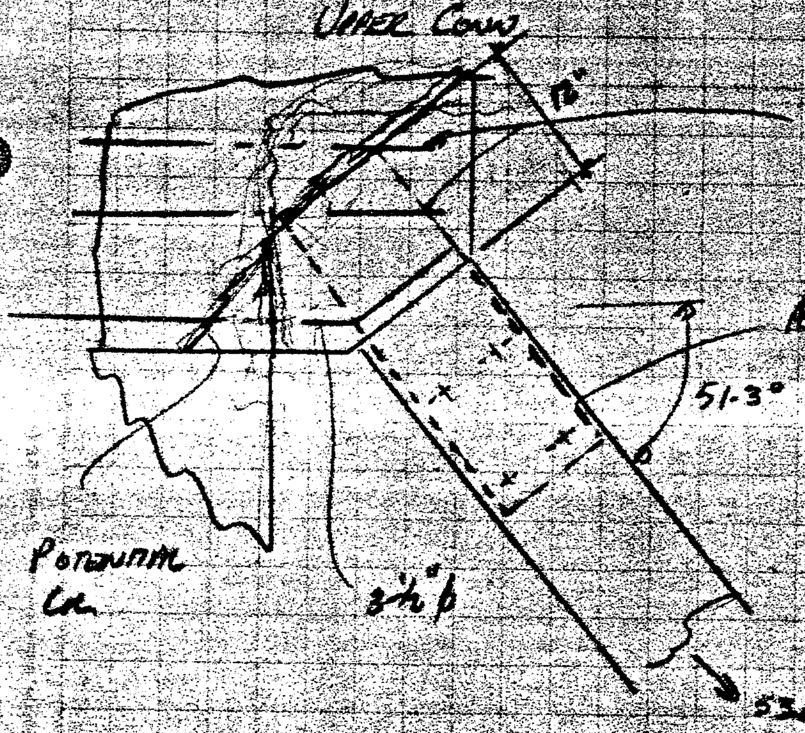


← $21.2 \times 1.58 = 33.5^k$
└ LEVEL 1-2

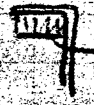
$T = (33.5^2 + 41.5^2)^{1/2} = 53.6^k$

f_c in 2 3x12 = $53100/60.38 = 888$ psi → O.K. YIELD

Working Str = $888/2 = 444$ psi ✓



1. TAKE LOAD IN BENT PORTION



$53.5/9 \times 3.125 = 1.9$ k/in

$M = 1.9 \times 3.125^2/2 = 9.28$ K

$\sigma = \frac{M}{Z}$; $Z = \frac{bh^2}{4} = 1 \times \frac{.375^2}{4} = .035$

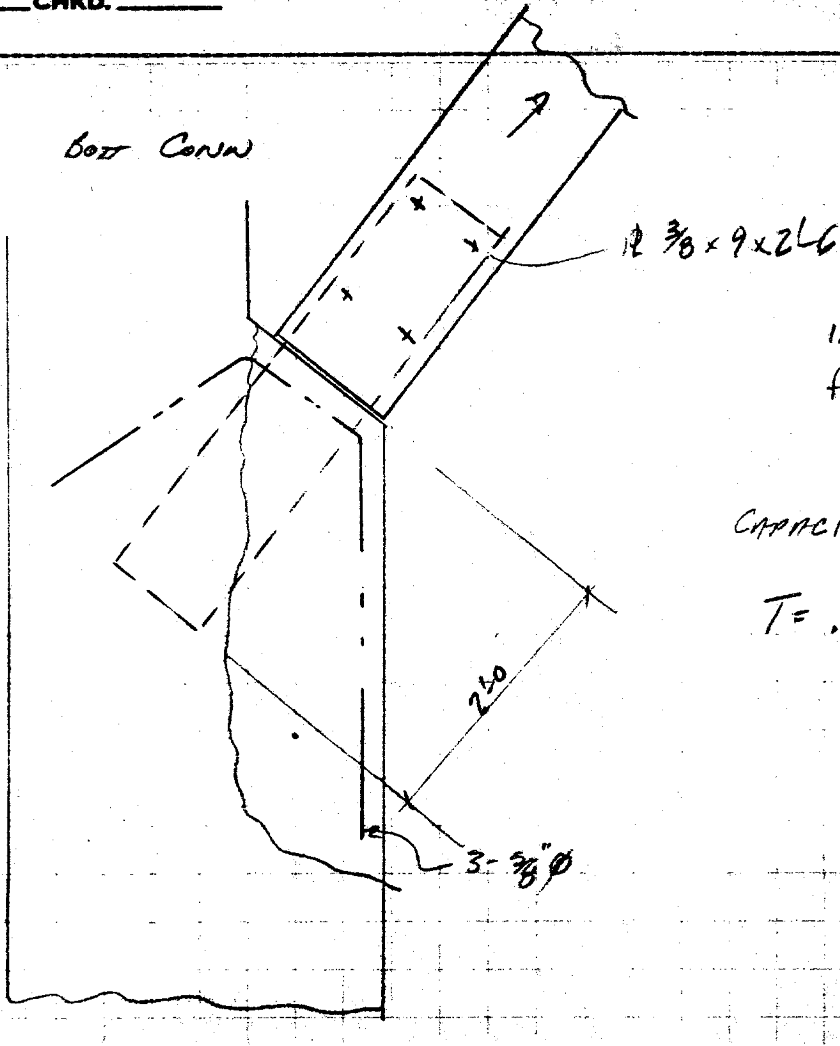
$\frac{M}{Z} = \frac{9.28}{.035} = 269$ p.s.i
N.G.

2. TAKE LOAD IN BOND, $f = \frac{53.6}{2 \times 12 \times 9} = 248$ p.s.i ≅ YIELD BOND STRESS O

3. CHECK SHEAR FRICTION ON CR

$A_{s\,req} = \frac{85.7}{.9 \times 33} = 2.89\ in^2$ $\quad$ As AVAIL = $1.23 + .58 = 1.81\ in^2$ N.G.

BOLT CONN



@ LEVEL 2 T = 53.6

1. BOND ON PL

$f_b = 53{,}600 / 9 \times 24 \times 2 = 124$ p.s.i ✓

CAPACITY OF 3-5/8"ø

$T = .9 \times 33 \times .91 = \underline{27^k} \ll \underline{536^k}$

NO GOOD.

IF BRACES WORK IN COMPRESSION ONLY

$L_{TOTAL} = [20^2 + 25^2]^{1/2} = 32'$

$l/d = 32 \times 12 / (2\tfrac{5}{8} \times 2) = 73$ N.G. ←

IF CENTER IS BRACED BY TENSION DIAG.

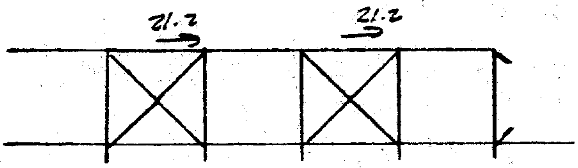
$l/d = 73/2 = 36.6$

$f'_{c\,ALL} = .3 \times 1700 / 36.6^2 = .381$ k.s.i

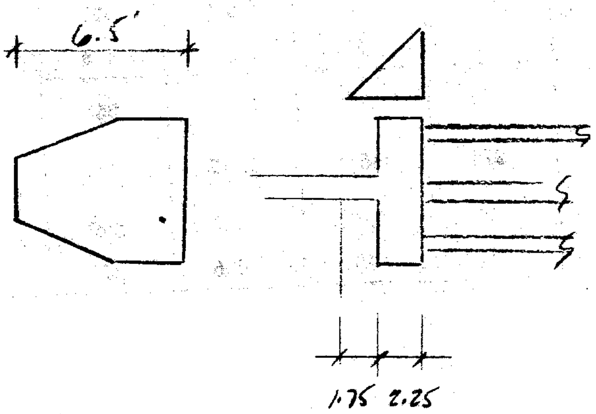
@ BUCKLING $f'_c = .381 \times 2.74 = 1.04$ K.S.I > .888 K.S.I APPLIED

SYSTEM DOES NOT WORK IF TENSION ONLY BRACES ARE ASSUMED
SYSTEM WORKS IF T/C OR C ONLY BRACES ARE USED AND
THE TENSION LEG BRACES THE COMPRESSION LEG AT MIDSPAN

LONGIT SEIS. CHECK PILES



V@ LEVEL 1 = 21.2^k ON 2 CAPS w/ 6 PILES + PASSIVE ON CAP



USING PASSIVE OF 200#/CF @ W.S. =

$200 \times \frac{2}{1.33} = 300\#/_{CF}$ @ YIELD

σ@ TOP = .3×1.75×6.5 = 3.4 k/'

σ@ BOTT = .3×4×6.5 = 7.8

TOTAL FORCE = 1/2 [3.4+7.8]×2.25 = 12.6^k

THUS EA PILE CAP TAKES 12.6^k @ YIELD, AND 2 CAPS TAKE 12.6×2 = 25.2^k > 21.2^k FORCE APPLIED

∴ EXIST FOUNDATION OK FOR SHEAR

TABLE 2 — BOND-SLIP DATA FOR BEAMS EMBEDDED IN CONCRETE BLOCKS

Specimen	Steel beam used	Surface condition of steel	Bond stress corresponding to free end slip of 0.001 in., psi	Maximum bond stress, psi	Free end slip at maximum load, in.	Bond stresses for stage of loading following maximum load, at:			
						Free end slip of 0.05 in., psi	Free end slip of 0.10 in., psi	Free end slip of 0.15 in., psi	Free en slip of 0.20 in., psi
SB-1	14 WF 34	Freshly sandblasted	240	420	0.015	370	325	295	280
SB-2	14 WF 30	Freshly sandblasted	225	474	0.008	400	365	340	320
SB-3	14 WF 34	Freshly sandblasted	275	470	0.006	400	335	305	290
Avg			247	455	0.010	390	340	315	295
R-1	14 WF 30	Sandblasted and allowed to rust	200	508	0.020	420	375	345	—
R-2	14 WF 34	Sandblasted and allowed to rust	255	403	0.018	375	345	325	300
R-3	14 WF 34	Sandblasted and allowed to rust	290	486	0.007	420	370	345	325
Avg			248	466	0.015	405	365	340	315
N-1	14 WF 30	Normal rust and mill scale	265	310	0.003	255	235	225	200
N-2	14 WF 34	Normal rust and mill scale	225	355	0.012	280	245	225	210
N-3	14 WF 30	Normal rust and mill scale	180	287	0.002	270	240	225	210
Avg			223	317	0.006	270	240	225.	205

Specimens N-1, R-1, SB-1, and N-2 were tested at 27 days and the remaining Specimens R-2, SB-2, N-3, R-3, and SB-3 were tested the following day (at 28 days) in the order given.

Slip between the steel beam and the concrete was measured at both the loaded and free ends of the specimen with dial gages which were graduated to 0.001 in. At the loaded end, a gage was attached at the center line of each flange and bore on the concrete at points 1¾ in. from the flanges. A single gage was used to measure the free end slip. This gage was attached to a steel yoke which spanned the specimen and was fixed to the concrete with set screws. The tip of the dial gage made contact at the centroid of the cross section of the steel beam. The displacement of the centroid of the cross section with respect to the concrete was taken as the average slip at the free end.

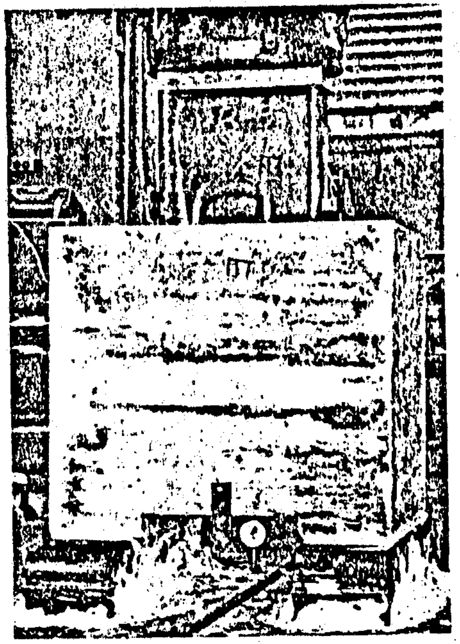


Fig. 2—View of test set up

The specimens were loaded at a rate of 20,000 lb per min and the slips at the loaded and free ends of the specimen were observed at load increments of 20,000 lb without interrupting the application of load. After the maximum load was reached, loading was continued until the free end slip was approximately 0.2 in.

RESULTS

The maximum bond stress and the free end slip at the maximum load for each of the nine specimens are given in Table 2. The bond stress was determined by dividing the applied load by the surface area of the steel which was in contact with the concrete. The three specimens with steel beams freshly sandblasted developed an average maximum bond stress of 455 psi and for specimens with beams sandblasted and allowed to rust the average maximum bond stress was 466 psi. For the three specimens with beams having normal rust and mill scale the average maximum bond stress was 317 psi. The average bond stresses at a free end slip of 0.001 in. were 247, 248, and 223 psi for Specimen Groups SB, R, and N, respectively. Thus, it was observed that the bond stresses at a free end slip of 0.001 in. were nearly the same for beams of all three surface conditions. However, the difference in average maximum bond stresses was considerably greater, with the average value for Group N being about 30 percent less than the combined average for Groups SB and R.

DOOR TOWERS - USE FORCES FROM PRELIMINARY ANALYSIS

FOR MISSION ESSENTIAL STRUCTURES, THE ALLOWABLE OVERSTRESS FACTORS FOR CONCRETE SHEAR WALLS IS 1.5 IN SHEAR AND 2.0 IN BENDING

FOR TRANS, E-W EQ @ LEVEL 1

$T = .78 \quad \xi = 7\% \quad S_a = .24g$

@ LEVEL 2

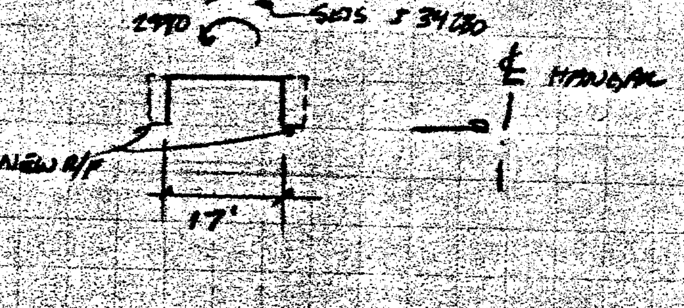
$T = .78 \quad \xi = 15\% \quad S_a = .37g$

$2/1 = \frac{.37}{.24} = 1.54$ ∴ IF LEVEL 1 demand/yield $= \frac{1.5}{1.54} = .97$ OR LESS, THEN THE MEMBER IS OK FOR LEVEL 2 SHEAR. FURTHER ANY MEMBER O.K. FOR LEVEL 1 MOMENT IS O.K. FOR LEVEL 2 MOMENT.

FROM PREVIOUS ANALYSIS, THE DOOR TOWERS WERE O.K. FOR LEVEL 1 SHEAR, BUT N.G. FOR MOMENT. AS THE FIRST SOLUTION, ADD NEW CONCRETE MEMBERS TO THE CORNERS OF THE PYLONS TO TAKE THE MOMENTS

FORCES

BENT BOTTOM - TRANSVERSE FORCES



$M_{max} = 34230 + 2990 = 37220$

$M/BENT = 37220/2 = 18610$

SAY $f_y = 60$ ksi

$d = 18'$

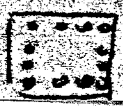
$A_s \cong \frac{18,610}{.9 \times 60 \times 18} = 19 \text{ in}^2$ (12 #11

ALT. EXIST FLANGE CAN CARRY 7380 k

∴ ADDED CAP REQ'D = 18,610 − 7380 = 11,230

$A_s \cong \frac{11,230}{18610} \times 19 = 11.5 \text{ in}^2$ SAY 9 #10

12 #9



TOWER FRAME

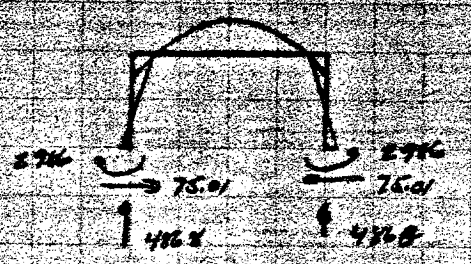
CHECK FDN

D.L. 2826 + 410/2 (PYLON, BOTTOM) = 3031 k

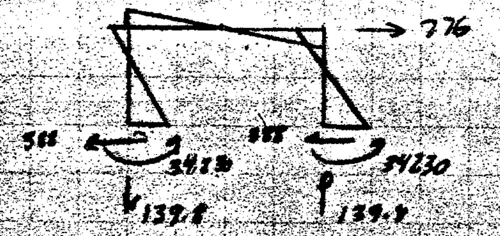
D.L. FDN VOL 29.5 × 59.5 × 4 = 7021 CF
23.5 × 51.5 × 4 = 4841
32 × 3 × 4 = 384
12,246 CF

WT = 12,246 × .15 = 1837 k
ΣW = 3031 + 1837 = 4868 k

∴ UNDER TRANS, E-W SEIS

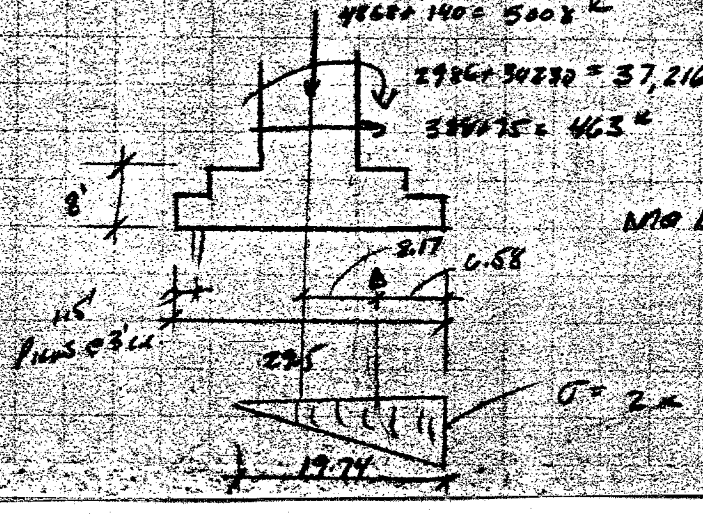


D.L



SEIS

1. CHECK COMPRESSION SIDE



4868 + 140 = 5008 k

2986 + 34230 = 37,216 ik

388 + 75 = 463 k

Mo BASE = 37216 + 463 × 8 = 40,920 = Po

e = 40,920/5008 = 8.17'

σ = 2 × $\frac{5008}{19.74}$ = 507.4 k/l @ 1ST PILES

σ = 5024 × 18.74/19.74 = 46

1 COMP SIDE D+E — CHECK PILES

$P = 469\ ^k/_l \times 3' = 1407^k$

$P/\text{PILE} = 1407/20 = 70\ ^k/\text{PILE}$

ALLOWABLE/PILE = 60^k, ∴ ABOVE O.S. = $\frac{70}{2\times60} = .58$ ✓

W/S TO ULT.

ALTERNATELY ASSUME PILES TAKE TENSION

$\sigma = \frac{P}{A} \pm \frac{M}{S} \Rightarrow$

$A = 29.5 \times 59.5 = 1755^{\#}$

$S = 59.5 \times 29.5^2/6 = 8630\ ft^3$

$I = SC = 8630 \times 29.5/2 = 127{,}300$

@ PILES $\sigma = \frac{5008}{1755} \pm 40{,}990 \times \frac{13.25}{127{,}300} = 2.85 \pm 4.26$

$= 7.11\ ^k/_\# \text{ or } -1.41\ ^k/_\#$

∴ ON PILES $T/\text{PILE} = \frac{1.41 \times 59.5 \times 3}{20} = \underline{12.6\ ^k/\text{PILE}}$ TENS O.K.

$C = \frac{7.11 \times 59.5 \times 3}{20} = \underline{63.5^k}$ ✓

2 CHECK TENSION SIDE

$P = 4868 - 140 = 4728$

$M = 34{,}230 - 2986 = 31{,}244$

$V = 338 - 25 = 313$

$M_{@\text{ BOT OF CAP}} = 31{,}244 + 313 \times 8 = 33{,}750'^k$

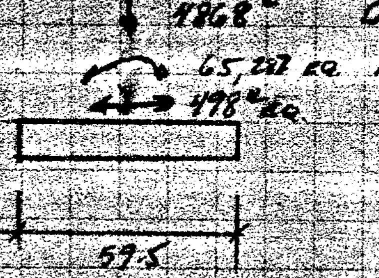
$\sigma = \frac{4728}{1755} \pm \frac{33{,}750 \times 13.25}{127{,}300} = 2.69 \pm 3.51 = \begin{matrix} +6.2 \\ -.82 \end{matrix}$

PILES O.K.

ABOVE

DOOR TOWER

3. CHECK LONGIT (N-S) SOILS



M = 498 x 131.1 = 65,287 ik

A = 29.5 x 59.5 = 1755 ft²

I = bh³/12 = 29.5 x 59.5³/12 = 518,000 ft³

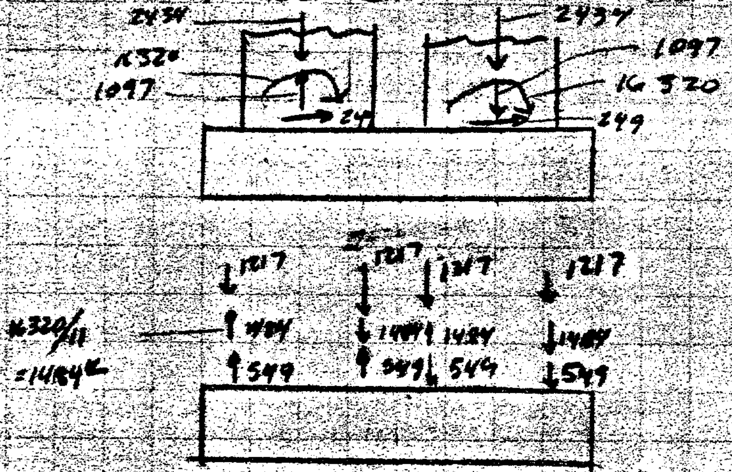
USING C = 28.25

$\sigma = \frac{4868}{1755} \pm 65287 \times 28.25 / 518,000 = 2.77 \pm 3.56 = +6.33$ k/□
$- .79$ k/□

FORCE ON PILES = 6.33 x 28.5 x 3 = 560k

F/PILE = 560/10 = 56k/PILE ✓

4 CHECK CAP



PILE LOCATIONS

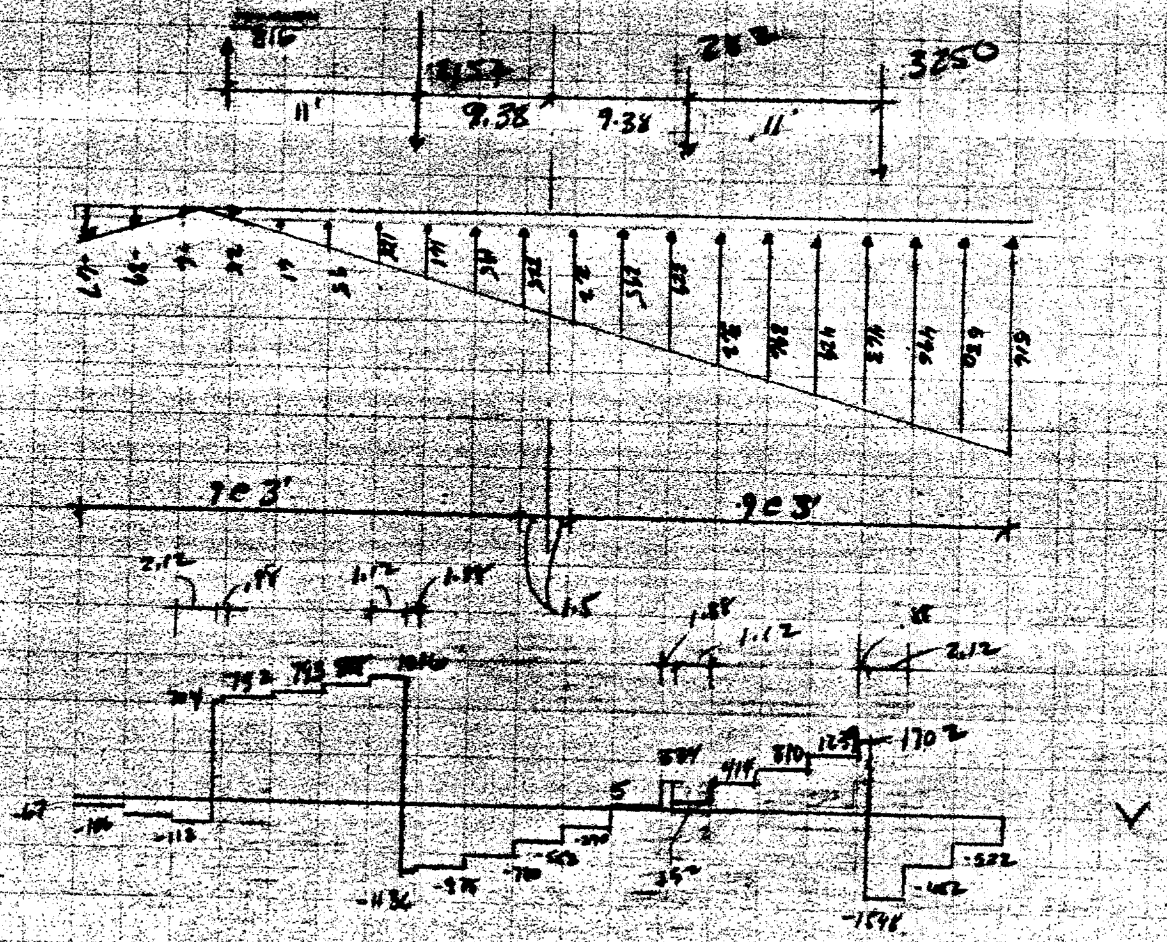
C	Wtrib	P/A+Mc/I	P/A−Mc/I	F σ+×Wtrib×2.85	σ−×W×2.85
1.5	3	+ 2.96	+ 2.58	262	228
4.5	3	+ 3.34	+ 2.20	295	195
7.5	3	+ 3.72	+ 1.82	329	161
10.5	3	+ 4.09	+ 1.45	362	128
13.5	3	+ 4.47	+ 1.07	396	95
16.5	3	+ 4.85	+ .69	429	61
19.5	3	+ 5.23	+ .31	463	28
22.5	3	5.61	− .07	496	− 6
25.5	3	5.98	− .44	530	− 39
28.5	2.75	6.36	− .82	516	− 67
				4078	784

4862 ✓ CLOSE ENOUGH

SUBJECT BLDG 46

DOCK TOWER LONGIT. -N-S SETS

LOAD DIAGRAM FOR PILE CAP



MOMENT = ΣAREA UNDER V

V	k	M	ΣM
-67	3	-201	-201
-106	3	-109	-310
-112	2.12	-237	-547
+704	.88	+620	+73
+732	3	+2196	+2268
+793	3	+2379	4647
+888	3	+2664	7311
+1016	1.12	+1138	8449 ←
-1136	1.88	-2136	6313
-975	3	-2925	3388
-780	3	-2340	1048
-552	3	-1656	-608
-290	3	-870	-1478

V	k	M	ΣM
+5	3	15	-1463
+334	1.88	628	-835
+52	1.12	+58	-777
+414	3	+1242	+465
+810	3	+2430	+2895
+1259	3	+3777	+6672
+1702	.88	+1498	+8170
-1548	2.12	-3282	+4888
-1052	3	-3156	+1732
-522	3	-1566	+166 ✓ CLOSE ENOUGH

$M^- = 1478^k$

$M^+ = 8449$ T ON BOTT

$V_u = 2233$

DOOR TOWER N-S SETS

Pile Cap

$M_u^- = 1478^{k'}$ $b = 29'6 = 354"$
$M_u^+ = 8449^{k'}$ $h = 8' = 96"$
$V_u = 1702^k$ $S = bh^2/6 = 543{,}700 \text{ in}^3$

SINCE SECTION IS UN R/F, CHECK STRESSES BASED ON SOLID SECTION USING A STRENGTH OF MAT'L APPROACH

$$V_{max} = \frac{1.5V}{A} = \frac{1.5 \times 1702{,}000^{\#}}{354 \times 96} = 75 \text{ p.s.i}$$

$$\sigma_{max} = \frac{M}{S} = 8{,}449{,}000 \times 12^{"\#} / 543{,}700 = 186 \text{ p.s.i}$$

ULT SHEAR - ALLOWABLE STRESS = $2\phi\sqrt{f'_c} = 2 \times .85\sqrt{2500} = 85$ p.s.i
ULT BENDING - " " = $5\phi\sqrt{f'_c} = 5 \times .65\sqrt{2500} = 163$ p

FLEXURE IN PLAIN CONCR

∴ O.S. IN BENDING OF 14%

IF R/F TAKES ALL LOAD $M_u^-/1 = 1478/29.5 = 50.1^{k'}$
$M_u^+/1 = 8449/29.5 = 286.4^{k'}$
$b = 12"$ $d = 96"$, $f_y = 60$ k.s.i $f'_c = 2$ k.s.i,

$A_s^- = .11$ $A_{s\,min} = 3.84$
$A_s = .67 \text{ in}^2/1$ $.67 \times 1.3 = .87 \text{ in}^2/1$
$\subset A_s$ @ 18" = 1.30 in² ~ 10's @

DATE

BY CHKD.

SUBJECT

RUTHERFORD & CHEKENE
STRUCTURAL ENGINEERS

JOB NO.

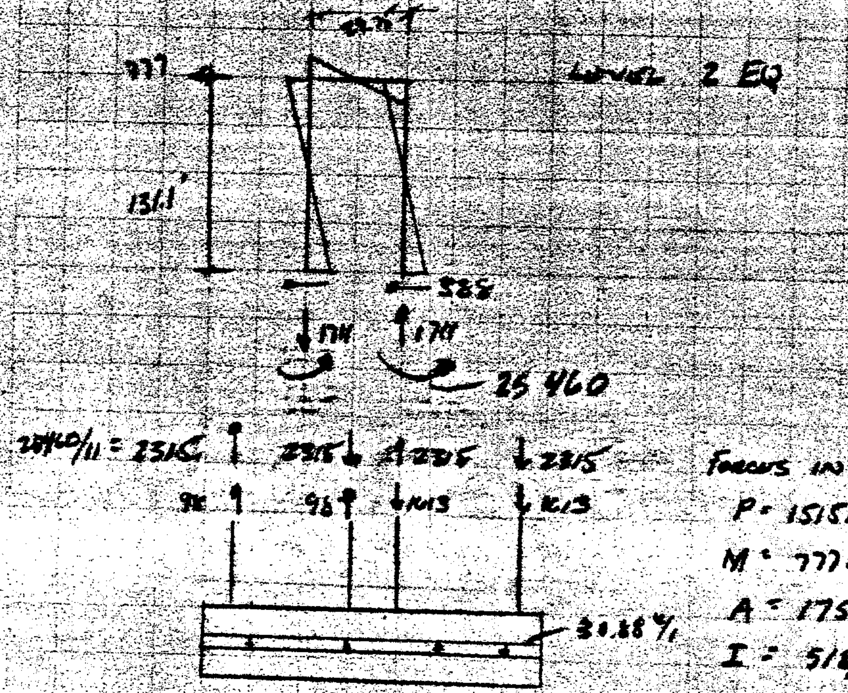
SHEET NO. 46-79

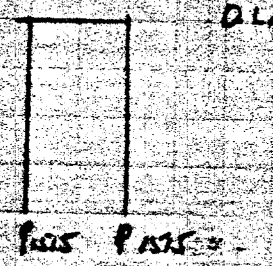
CHECK PILE CAP FOR LEVEL 2 EQ FORCES

LEVEL 1 T = .68 SEC S_a = .289 @ ξ = 5%
LEVEL 2 T = .68 SEC S_a = .450 @ ξ = 10%

LEVEL 2/LEVEL 1 = .45/.289 = 1.56

@ TOP OF PILE CAP





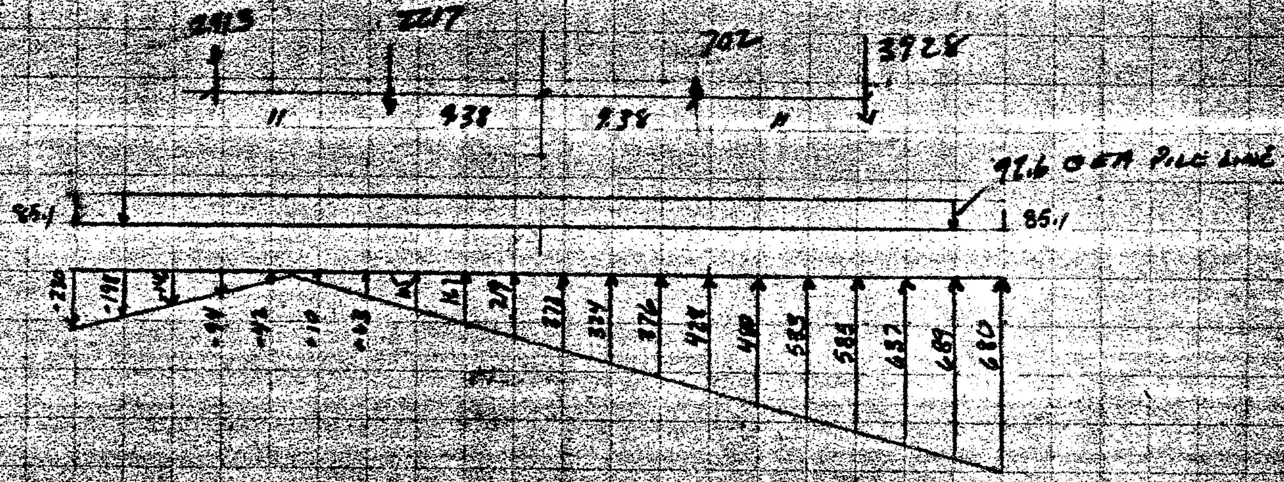
FTG. WT = 1837/59.5 = 30.88 k/'

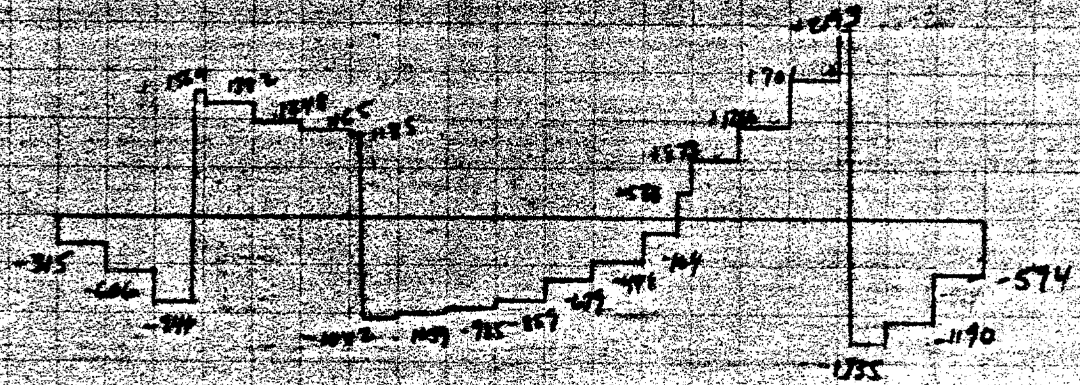
FORCES IN PILE = P/A ± Mc/I
P = 1515×2 + 1837 = 4867 k
M = 777 × 131.1 = 101,900 'k
A = 1755 #
I = 518,000 ft³

P/A = 4867/1755 = 2.773
M/I = 101900/518,000 = .1967

		σ+	σ−		
L	W TRIB	P/A + Mc/I	P/A − Mc/I	σ+·W×29.5	σ−·W×29.5
1.5	3'	3.07	2.48	272	219
4.5	↓	3.66	1.89	324	167
7.5		4.25	1.30	376	115
10.5		4.84	.71	428	63
13.5		5.43	.12	480	10
16.5		6.02	−.47	533	−42
19.5		6.61	−1.06	585	−94
22.5		7.20	−1.65	637	−146
25.5	↓	7.79	−2.24	689	−198
28.5	2.75'	8.38	−2.83	680	−230
				5004	−136 = 4868 ✓

LOAD DIAGRAM FOR PILE CAP LEVEL 2





MOMENT = Σ AREA UNDER V

V	x	Mi	ΣM
-315	3	-945	-945
-606	3	-1818	-2763
-944	1.88	-1789	-4552
+1569	.88	+1381	-3172
+1382	3	+4146	+974
+1248	3	+3744	+4718
+1165	3	+3495	+8213
+1135	1.12	+1271	+9485
-1092	1.88	-2054	+7451
-1059	3	-3177	+4273
-985	3	-2955	+1318
-859	3	-2577	-1259
-679	3	-2037	-3296

V	x	Mi	ΣM
-448	3	-1344	-4640
-164	1.88	-308	-4948
+538	1.12	+603	-4345
+873	3	2619	-1726
+1260	3	3780	+2054
+1701	3	5103	+7157
+2193	.88	1930	+9087
-1735	2.12	-3678	+5408
-1190	3	-3570	+1838
-594	3	-1782	+56 — CLOSE ENOUGH

$V_u = 2193^k$

$M_u^+ = 9485^{1k}$

$M_u^- = 4948^{1k}$

DOCK TOWER PILE CAP

N-S SETS LEVEL 2

$M_u^- = 4948$
$M_u^+ = 9485$
$V_u = 2193$

$v = 1.5\frac{V}{A} = 1.5 \times \frac{2{,}193{,}000}{354 \times 96} = 97.$ p.s.i   85 p.s.i All
∴ 14% O.S.

$\sigma = \frac{M}{S} = \frac{9485{,}000 \times 12}{543{,}700} = 209$ p.s.i > 163 p.s.i 28% O.S

@ LEVEL 2, CAP IS SLIGHTLY OVERSTRESSED IN SHEAR, AND O.K. IN MOMENT

IF @ ULT $M_u^-/1 = 4948/29.5 = 168^{k'}/1$
$M_u^+/1 = 9485/29.5 = 322^{k'}/1$
USING $b = 12$ $d = 96,$ $f'_c = 2$ $f_y = 60$

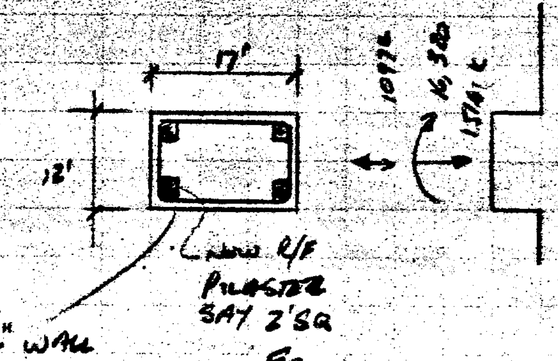
7@12
$A_s = .49 \text{ in}^2/1 \times 1.3 = .63$
$A_s = .75 \text{ in}^2/1$
@18 = 1.13
$\times 1.3 = 1.47 \text{ in}^2/1$
$<< \rho_{min}$

PILON BASE – EACH OF 2 PYLONS/SIDE

FORCES ON EACH PYLON @ TOP OF CAP

	P	M_L	M_T	V_L	V_T
D.L.	1516	0	1495	0	37.5
N-S LONG EQ	1097	16,320	0	249	
E-W TRANS EQ	70^k	0	17,100	0	194^k
			18,595		

1. DESIGN STRENGTHENING SYSTEM FOR LONGITUDINAL FORCES

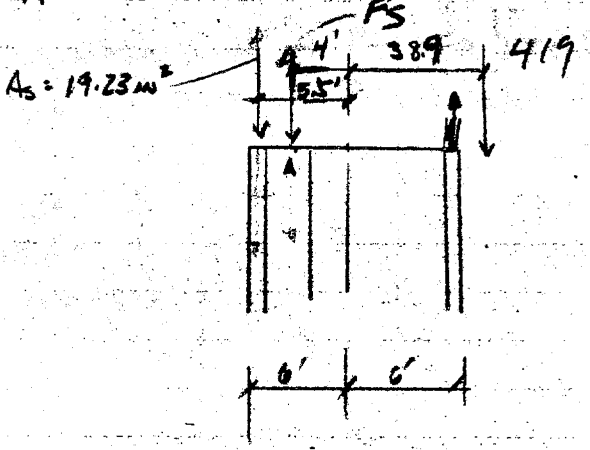


CHECK TENSION SIDE

$M = 16,320^{1k}$

$P = 1516 - 1097 = 419^k$

$e = 16,320/419 = 38.9'$



$\Sigma M_A = 419 \times 42.9 - 19.23 \times 33 \times 1.5$
$- C_c(10 - a/2) = 0$

$a = 5" = .42'$

$\therefore C_c = [419 \times 42.9 - 19.23 \times 33 \times 1.5] / [10 - .4$

$= 17,023/9.79 = 1739^k$

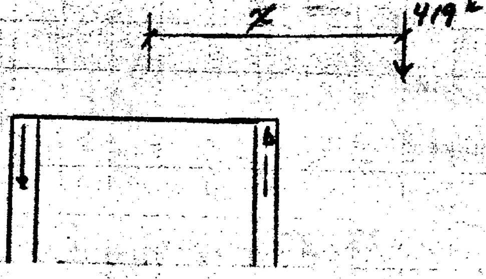
$C_c = .85 f'_c \times b \times a$
$a = C_c / .85 f'_c b =$
$= 1739/.85 \times 2.5 \times 17 \times 12 \doteq 4.01$

TRY $a = 4.0" \Rightarrow C_c = 17,023/9.83 = 1731^k$
$a = 1731/433.5 = 3.99$ ✓

$F_s = 1731 - 419 - 19.23 \times 33 = 677^k$
$A_s = F_s/F_y = 677/60 = 11.3 in^2$, 2 PIERS 8 #'s OR

DOOR TOWER

CAPACITY OF EXIST R/F BASE, TENSION SIDE, LONG FORCES



$F_s = 19.23 \times 33 = 635^k$

$C_c = 635 + 419 = 1054$

$a = \frac{1054}{433.5} = 2.43''$

$419 \times [x + 5.5] = 1054 \, [11.5 - \frac{2.43}{2 \times 12}]$

$419x + 2305 = 12014$

$x = 23.17$

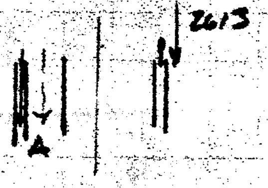
$M = 419 \times 23.17 = 9709'^k$

$\therefore$ R/F CAN END @ $M = 9709 = 16320 - 249h$

$h = 26.5'$

2 LEVELS

2. CHECK COMPR SIDE LONGIT FORCE @ TOWER BASE



M = 16,320

P = 1516 + 1097 = 2613^k

e = 16320/2613 = 6.25'

ΣM_A = 2613 × 10.25 − 19.23 × 33 × 1.5 − C_c [10 − a/2] = 0

TRY a = 6", C_c = 25831/[10 − a/2] = 2649

a = 2649/433.5 = 6.11"

TRY a = 6.11 C_c = 25831/9.745 = 2651 ✓ O.K

F_S = 2651 − 2613 − 19.23 × 33 = −597 ∴

EXIST. STEEL NOT FULLY UTILIZED OR REQ'D,

COMPR SIDE O.K @ BASE

3. CHECK TRANS. FORCES ON TOWER BASE TENSION SIDE

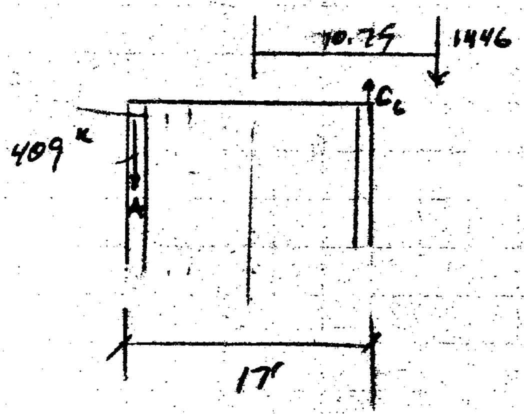
P = 1516 − 70^k = 1446   e = 15,600/1446 = 10.79'

M = −17100 + 1500 = 15,600^{1k}

FLANGE STEEL OUTSIDE FACE, FACE

AS = 20 #6 + 8 #6 = 12.38 in^2

$A_s F_y$ = 12.38 × 33 = 409^k



ΣM_A = 1446 × (10.79 + 8)

− C_c [16.5 − a/2]

C_c = 27,170 / [16.5 − a/2]

C_c = .85 f_c' ba = .85 × 2.5 × 12 × 12 a =

a = C_c/306

TRY a = 6" C_c = 27,170/[16.25] = 1672

a = 1672/306 = 5.46"

TRY a = 5.46, C_c = 27,170/16.27 = 1670^k ✓

Fs_{REQ} = 1670 − 1446 = 224^k — 409 PROVIDED O.K

4. CHECK TRANS FORCES ON TOWER BASE, COMPRESSION SIDE

$P = 1516 + 70 = 1586^k$

$M = 17,115 + 1500 = 18,615$ ✓

$e = 18615/1586 = 11.74'$

$A_S = 15.12\ in^2$

$F_y A_S = 15.12 \times 33 = 499^k$

ΣM ABOUT STEEL $= 1586[11.74 + 8] - C_c[16.5 - a/2]$

$C_c = 31,308/[16.5 - a/2]$

$a = C_c/306$

TRY $a = 6''$, $C_c = 31,308/16.25 = 1927^k$

$a = 1927/306 = 6.29''$

TRY $a = 6.3''$ $C_c = 31,308/16.238 = 1928^k$

$a = 1928/306 = 6.3$ ✓

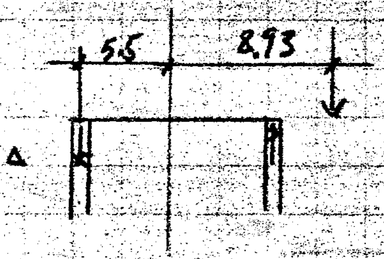
$F_{S\ REQ} = 1928 - 1586 = 342^k$ EXIST STEEL O.K.

TOP OF COLUMN - LONGITUDINAL FORCES (N-S)

$M = 12{,}678^{\text{1k}}$
$P_{EQ} = 1097^{k}$

$P_{DL} = 410/4 = 103^{k}$ - BOX BEAM/PYLON
$+ [27 \times 2 \times 41.75 \times 1 + \frac{18}{12} \times 41.75 \times 12 + 4 \times 27 \times 12 \times 1]\ .15/2 = 323^{k}$/PYLON

1. CHECK COMPRESSION



$M = 12678$
$P = 1097 + 323 = 1420^{k}$
$e = 12678/1420 = 8.93'$

$\Sigma M_{STL} = 1420 \times 14.43 - C_c(11.5 - a/2)$
$C_c = 20{,}490/(11.5 - a/2)$

$C_c = .85 f'_c \times 12 \times 12 \times a$
$= .85 \times 2.5 \times 144\ a = 306a$

TRY $a = 4''$, $C_c = 20490/11.33 = 1808$
$a = 1808/306 = 5.9$
TRY $a = 5.9$ $C_c = 20490/11.25 = 1821$
$a = 1821/306 = 5.95$
$a = 5.95$ $C_c = \qquad = 1821$ ✓

$\therefore F_S = 1821 - 1420 = 401^{k}$
$As_{REQ} = 401/33 = 12.15\ in^2$

As_{PROV}: 20 #8's + CNR BARS $\therefore$ R/F > 15.7 in² ✓

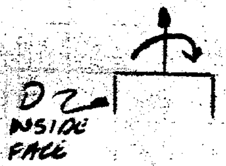
TOP OF COLUMN, LONGITUDINAL N-S. FORCES

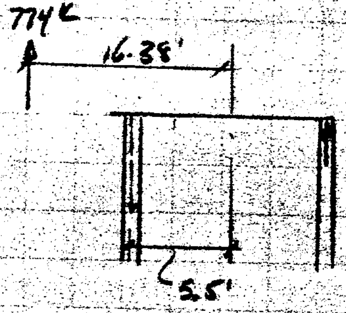
2. CHECK TENSION SIDE

$M = 12{,}678$

$T = 1097 - 323 = 774^k$

$e = 12678/774 = 16.38'$





$\Sigma M_{STEEL} = 774 \times [16.38 - 5.5] = C_c\,[11.5 - a/2]$

$C_c = 8421/[11.5 - a/2]$

$C_c = .85 \times 2.5 \times 12 \times 12\,a$

$a = C_c/306$

TRY $a = 4"$ $C_c = 8421/[11.5 - 4/24] = 743^k$

$a = 743/306 = 2.42"$

TRY $a = 2.40$ $C_c = 8421/[11.40] = 739^k$

$a = 739/306 = 2.41$ ✓

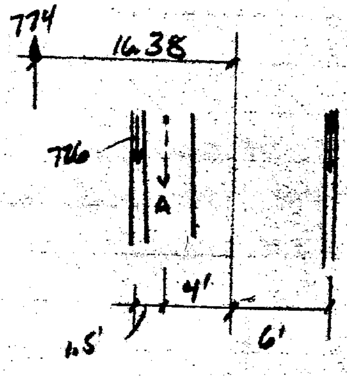
$F_S = 774 + 739 = 1513^k$

$A_{S_{REQ}} = 1513/33 = 45.8\ in^2$

$A_{S\,PROV} = 28\ \#8 = 22\ in^2$ N.G. $(F_S = 33 \times 22 = 726^k)$

∴ ADD R/F

R/F REQ'D ASSUME 2' SQ COL.



$\Sigma M = 774 \times 12.38 - 726 \times 1.5 - C_c\,[10 - a/2]$

$C_c = 8493/[10 - a/2]$

$a = C_c/306$

$a = 3"$ $C_c = 8493/9.825 = 860$

$a = 860/306 = 2.81$

$a = 2.80$ $C_c = 8493/9.883 = 859^k$

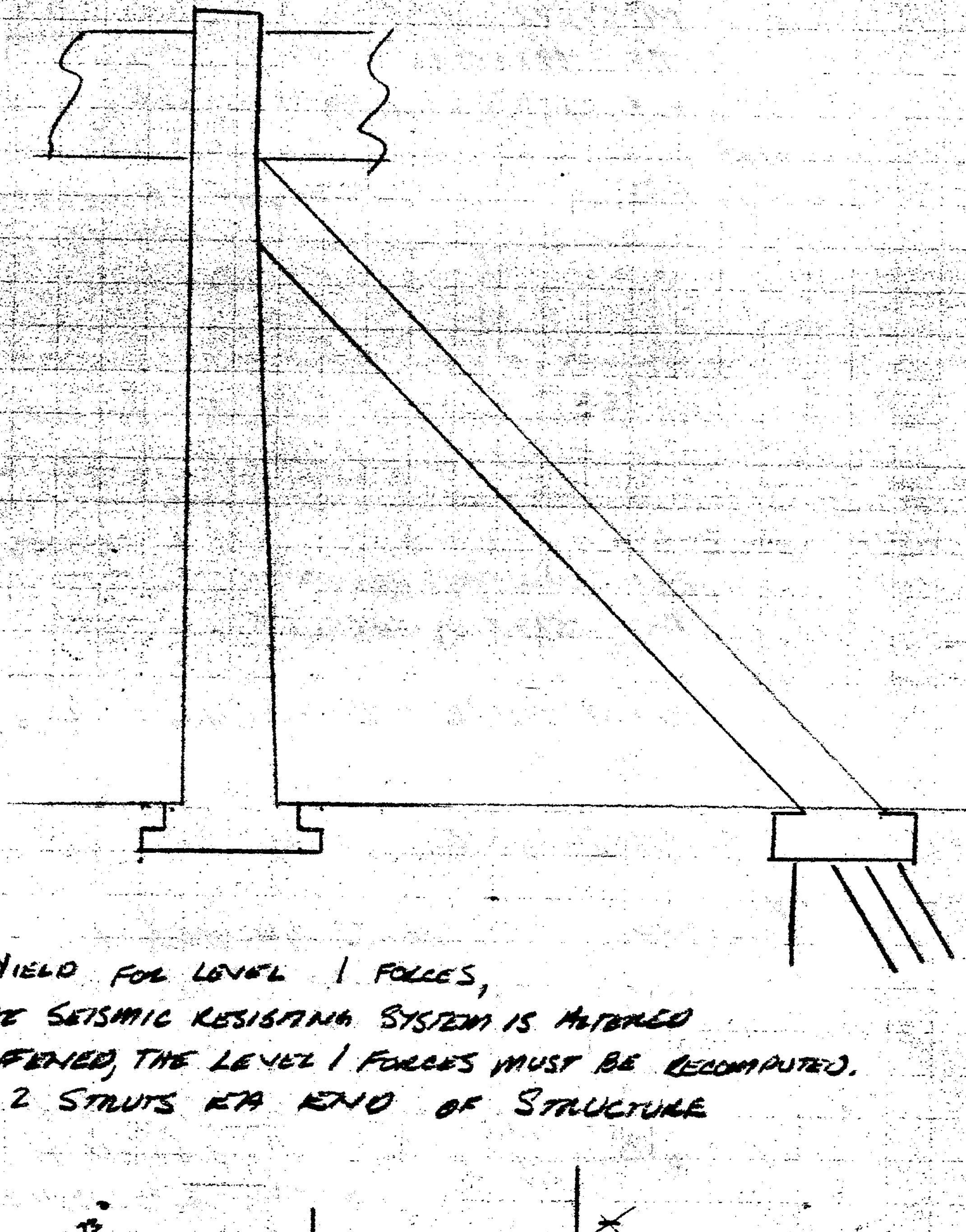
$a = 859/306 = 2.81$ ✓

$F_S = 859 + 774 - 726 = 907^k$

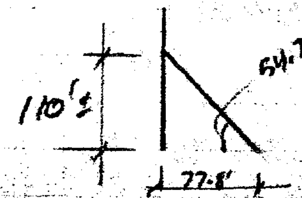
$A_S = 907/60 \times .9 = 16.8\ IN^2$ 11 #11'S

6 #10'S IN 2 PIERS

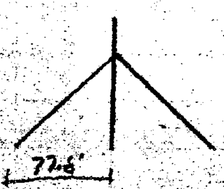
SIZE STRUT TO TAKE LATERAL FROM DOORS



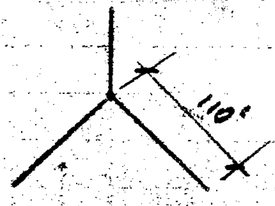
SIZE @ YIELD FOR LEVEL 1 FORCES,
SINCE THE SEISMIC RESISTING SYSTEM IS ALTERED
AND STIFFENED, THE LEVEL 1 FORCES MUST BE RECOMPUTED.
ASSUME 2 STRUTS EA END OF STRUCTURE



END ELEV



SIDE ELEV



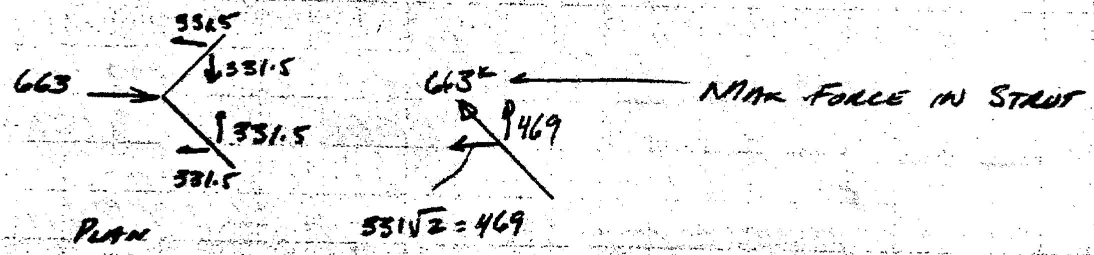
PLAN

1. PRELIMINARY SIZE STRUT

USE $S_a = .41g$ - MAX ACCEL LEVEL 1 $\xi = 5\%$

$V = .41 \times 3236^k = 1327^k$ ON 2 SIDES

$V/\text{SIDE} = 1327/2 = 663^k$



LENGTH OF STRUT $= 110\sqrt{2} \sim 155.6'$

SAY $Kl/r = 34$ $\quad r = 155.6 \times 12/34 = 54.9 = .3d$

$d = 183'' = 15'$

SAY 12x12 WITH 12" WALL

$w/l = 4 \times 11 \times 1 \times .15 = 6.6^k/'$

ADD DIAPHR - 10" @ 20'± ∴ 7 DIAPH, $w = 7 \times 10^2 \times .83 \times .15$
$= 87^k$

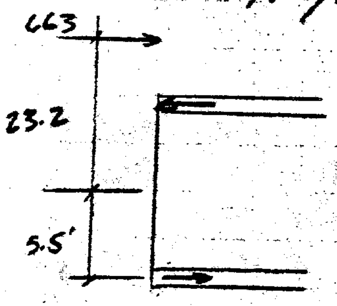
∴ $w_{TOT} = 6.6 + 87/155.6 = 7.2^k/'$

∴ SIZE FOR COMPRESSION + BENDING

$M = 7.2\sqrt{2} \times 110^2/8 = 15,400^{'k}$

$P = 663^k$

$e = 15,400/663 = 23.2'$



Σ M ABOUT TENSION STEEL

$663 \times 28.7 - C_c\,[11.5 - a/2] = 0$

$C_c = 19,028/[11.5 - a/2]$

$C_c = .85 \times 4 \times 144a$

$a = C_c/576$

TRY $a = 6''$ $\quad C_c \sim 1691$ $\quad a = 1691/576 = 2.93$

TRY $a = 2.9$ $\quad C_c \sim 1672$ $\quad a \sim 2.90$ ✓

$F_s = 1672 - 663 = 1009$ $\quad A_s = 1009/60 = 16.8 \approx 1\%$ ✓

BY________ CHKD. ________

JOB NO. ________

SHEET NO. 46 -9

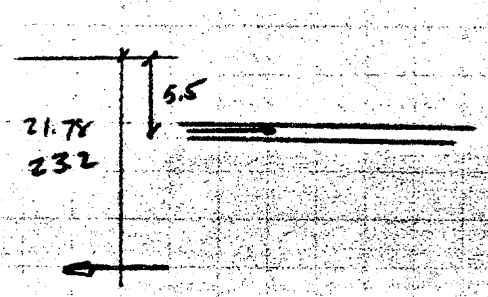
SUBJECT________

1. PRELIMINARY STRUT

CHECK TENSION + BENDING

707 21.78

T = 663 M = 15400'k e = 23.2



707 21.78

ΣM TENS STEEL = 663 [23.2 - 5.5] - Cc [11.5 -

Cc = 11,735 / [11.5 - a/2]

a = Cc / 576

TRY a = 3" Cc = 11,735 / [11.5 - 3/24] = 1032

a = 1032/576 = 1.79

TRY a = 1.75 Cc ~ 1027

a = 1.78

TRY a = 1.78 Cc = 1027 ✓

∴ Fs = 1027 + 663 = 1690 k

As = 1690/60 = 28.2 in² 1.6% ✓

As/1 = 28.2/12 = 2.35 #7 @ 6 EF,

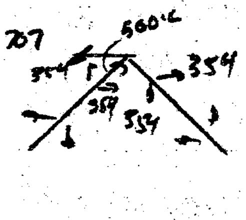
OTHER FACES 1% = 1.44 in²/2

#6 @ 12 EF

SIZE FOR LONGIT FORCES AGAIN USE Sa = .41g

V = .41 × 3452 = 1415 k

V/SIDE = 707 k



AXIAL IN COL = 500√2 = 707 k

SEE ABOVE FOR ALT CALC

Cc = 11 510 / 11.5 - a/2

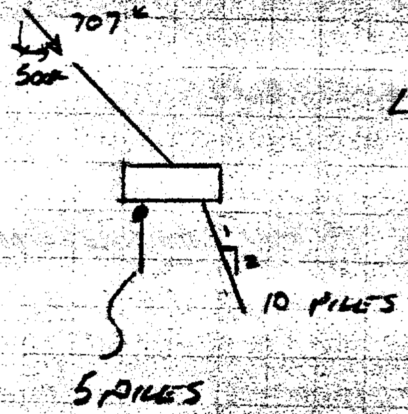
TRY a = 1.75 Cc = 11510 / [11.5 - 1.75/24] = 100

a = 1007/576 = 1.75 ✓

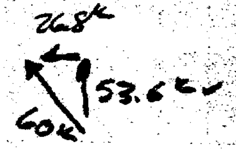
Fs = 707 + 1007 = 1714 k

As = 28.6 in² - 2.38 in²/1 #7 @ 6 OK

PILES AT BASE



LATERAL FORCE PER PILE =

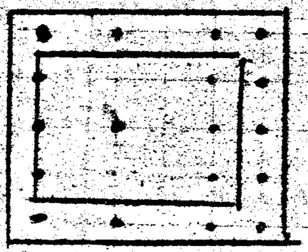


∴ #BATTER PILES REQ. SAY YIELD = 2x ALL.

$P = 500/2x268 = 9.32 - 10$ PILES

THE VERT FORCE = 2x HORIZ ≅ 1000^k

THUS TENS = 1000 - 500 - 72x155/2 =

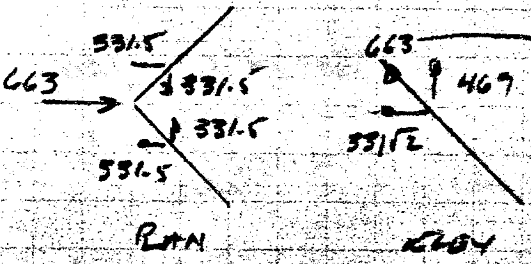


PRELIMINARY STRUT SIZE – REVISE TO APPROPRIATE SIZE
ADD MOMENT MAG.

USE $S_a = .41g$ ← MAX ACCEL @LEVEL 1, $\xi = 5\%$

$V = .41 \times 3236 = 1327^k$ ON 2 SIDES

$V/_{SIDE} = 663^k$

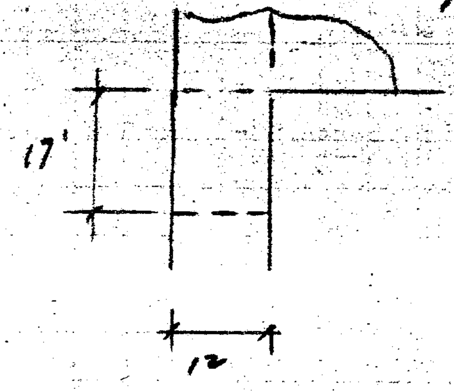


MAX COMPRESSION IN STRUT

PLAN ELEV

LENGTH OF STRUT $= 110\sqrt{2} = 155.6'$

USING X SECTION @ PYLON = TO PROJECTED SECTION OF PYLON FACE, FIRST BAY BELOW BEAM



∴ STRUT HT $= \frac{17}{\sqrt{2}} = 12.02' - 12'$

WIDTH $= 12/\sqrt{2} = 8.49 - 8.5'$

SAY 1' THICK WALLS + DIAPH
@ 20' ± (7-10" DIAPH)

$WEIGHT = 2[11.5+7.5] \times .15 \times 155.6 + 7 \times 11 \times 7.5 \times .83 \times .15 = 959^k$

$M_{DL} = WL \times L/8 = 959 \times 110/8 = 13{,}200$ kft

$M_U = 13{,}200 \times 1.4 = 18{,}500^{1k}$

$P_U = 663^k$

MOMENT MAG

$I_{MAX} = 8.5 \times 12^3/12 - 6.5 \times 10^3/12 = 682$ ft^4

$A = [7.5 + 11] \times 2 \times 1 = 370$

$r_{MAX} = \sqrt{682/37} = 4.29$

$KL/r = 155.6/4.29 = 36.2$

$I_{MIN} = 12 \times 8.5^3/12 - 10 \times 6.5^3/12 = 385$ ft^4

$r_{MIN} = \sqrt{385/37} = 3.23$

$KL/r = 155.6/3.23 = 48.2$

SIZE STRUT USING MAGNIFIED MOMENT

$C_m = 1$

$\beta d = 1$

$EI = E_c I_g / 2.5 / 1+1 = E_c I_g / 5$

$E_c = 57{,}000 \sqrt{3000} = 3100$ K.S.I.

$EI = 3100 \times 144 \times 385/5 = 34{,}400{,}000$ K-ft²

$P_c = \pi^2 EI / (KL)^2 = \pi^2 \times 34{,}400{,}000 / (155.6)^2 = 14{,}000$ K

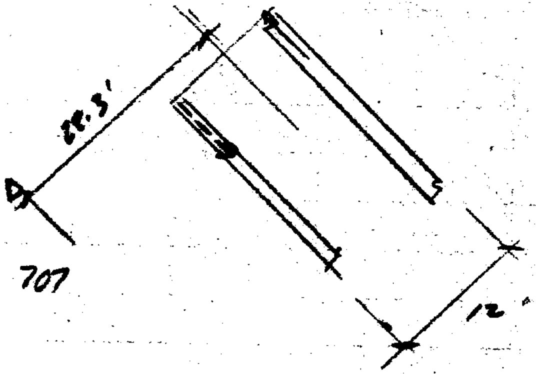
$\delta = C_m / 1 - (P_u / \phi P_c) = 1 / 1 - (707^K / .7 \times 14000) = 1.08$ ← — LONGIT FORCES

∴ $M_u = 1.07 \times 18{,}500 = 20{,}000$ 'K

$P_u = 707$ K

DESIGN FOR TENSION + BENDING

$e = 20{,}000 / 707 = 28.3'$



ΣM ABOUT TENSION STEEL

$M = 707[28.3 - 5.5] - C_c[11.5 - a/2]$

$C_c = 16{,}120 / [11.5 - a/2]$

$C_c = .85 \times 3 \times 8.5 \times 12 \times a = 260a$

$a = C_c / 260$

TRY $a = 3''$ $C_c = 16\,120 / [11.5 - \frac{3}{24}] = 1417$

$a = 1417/260 = 5.45''$

TRY $a = 5.46$ $C_c = 1430$ $a = 5.5$

TRY $a = 5.5$ $C_c = 1430$ ✓

∴ $F_s = 707 + 1430 = 2137$

$A_s = 2137/60 = 35.6$

$A_s/1 = 35.6/8.5 = 4.19$ IN²/1 ≈ 3% STEEL

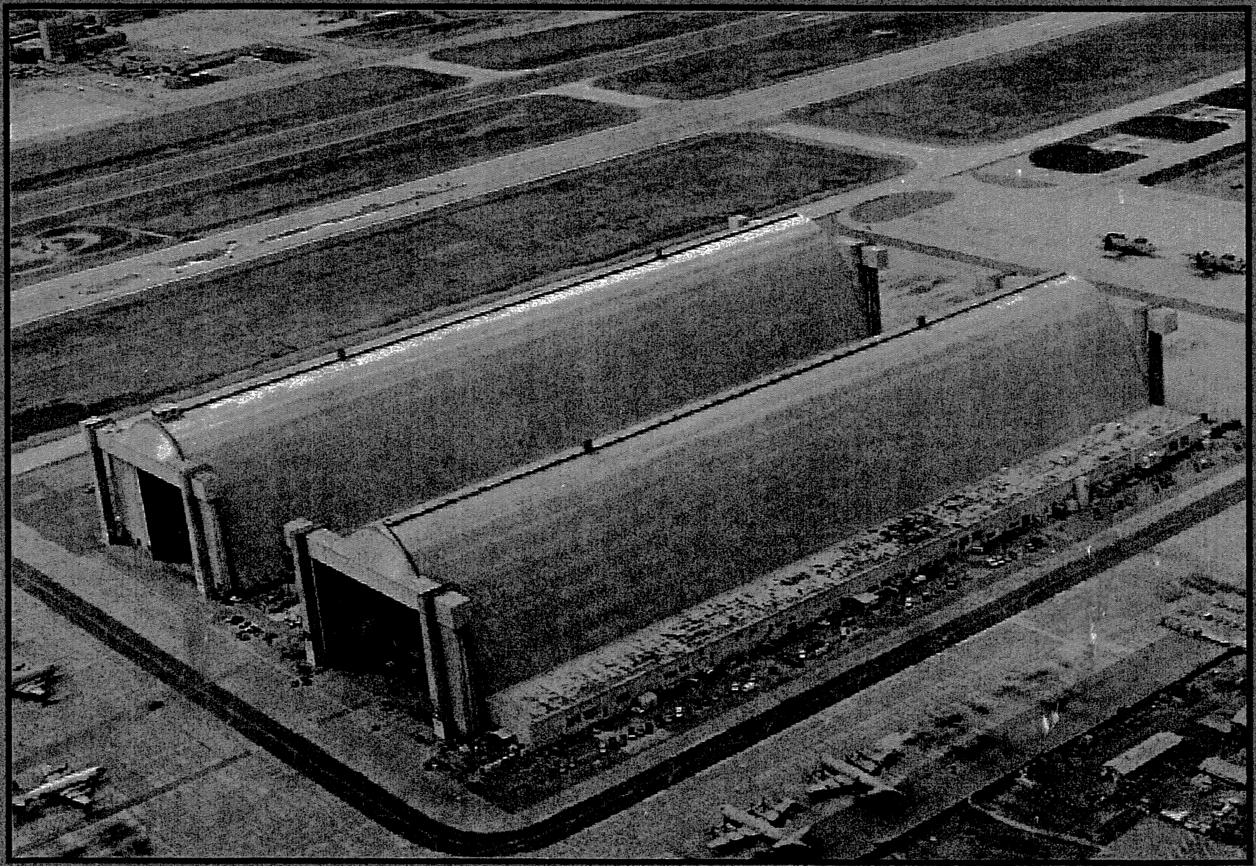
#9 @ 6" E.F.

LEVEL 2 @ $\xi = 10\% = .637g$ $4/1 = .637/.41 = 1.55$

ALLO.S. ≈ 1.5 O.K. ; PERIOD LENGTHENS FORCES DROP.

RETURN TO MIKE MAKINEN
NASA-AMES (650) 604-4740

Ames Research Center



Hangar 3 Exerpts of
Moffet Field Hangar Life Safety Evaluation
Moffett Field Development Project
Plant Engineering Office
February 1994

BAMSI, INC

HANGAR 3

TABLE OF CONTENTS

2.0 OBJECTIVE

The purpose of this report is to acknowledge certain requests by Rose Ashford of the Moffett Field Development Project Office, to accomplish certain functions from the S.O.W. (Appendix D) prepared by Digby Christian also from the M.F.D.P. Office. In short, this consists of informing NASA of the current safety conditions within the Hangars and the capacity/condition of utilities at the locations where the utility infrastructure interfaces with the Hangars. This information is intended to supplement other resources on the Hangars that are available to NASA for planning future facility repairs and improvements; maintenance operations; and contract negotiations with Resident Agencies that are to occupy space within the subject Hangars. Primary among these other resources is the NASA-MOFFETT AIRCRAFT HANGAR FIRE SAFETY PROGRAM (NMAHFSP - Appendix D). It is recommended that they be reviewed in conjunction with this report to best fulfill NASA's planning requirements.

3.0 INTRODUCTION

3.1 Hangar 3 Executive Summary

Hangar 1 was constructed in 1932 to house the USS Macon, a dirigible airship used to scout the coast for Pacific fleet ships. Hangar 1 is designated as a Naval Historical Landmark. Hangars 2 and 3 were constructed in 1942 to facilitate blimps used for coastal patrol during World War II. Due to a nomination from the Organization of Urban Programmers in San Jose, California, Hangers 2 and 3 are both being considered for Naval Historical Landmarks. The decision on this is still pending.

The hangars provide approximately One Million One Hundred and Sixty Six Thousand (1,166,000) square feet of floor space that is designed to accommodate aircraft support group operations. According to The Fire Protection Engineering Survey Report prepared by the NAVY in December 1982, the cost to replace all three hangars and their contents, at that time, would have been approximately One Billion, Five Hundred Million Dollars ($1,500,000,000.00). This monetary figure far exceeds the cost of upgrading the existing structures to meet current safety standards. Consideration should also be given to the fact that it is impossible to calculate a monetary value for the replacement of life, valuable research time, and/or a Historical Landmark.

This study is an overall assessment of the hangar's existing condition and does not include detailed designs/plans to resolve the problems it brings forth herein. However, it does propose brief recommendations and tentative cost estimates for the reader to consider. Each major problem area needs to be thoroughly reviewed and a detailed design/plan to resolve the problem needs to be prepared by the appropriate professionals. The investment of resources into the resolution of these problems will help prevent a negative scenario from occurring and will provide a safer working environment for all of the hangar occupants.

The following pages of this study identify many safety problems that currently exist within the hangars. The major problems consist of code violations/safety hazards that are summarized for each hangar in the following paragraph. The Table preceding the written summary recaptures totals from tentative cost estimates for the resolution of these major safety hazards. These estimates are located in Section 8.0 of this report. The subject estimates do not include fees for contract supervision and are of a Rough Order of Magnitude (R.O.M.) that should be used for planning purposes only. The Recommended Safety Improvements were given a priority ranking of I (Critical - immediate corrective action is needed prior to NASA's/RA's occupation), II (Serious - planning for corrective action should commence immediately and the Recommended Safety Improvements should be completed within four (4) years of the date of occupation), or III (Moderate - Code violation exists that should be remedied as soon as possible but no later than ten (10) years from the date of occupation):

PRIORITY	HANGAR 3	SECTION	TOTAL COST
RANKING	RECOMMENDED SAFETY IMPROVEMENTS	REFERENCE	
I	Inspect/Repair 12 KV elbow terminations at Sub 3	7.3.4.3 HGR 3 ELECTRICAL INFRASTRUCTURE ASSESSMENT	$2,000.00
I	Reroof the eastern mezzanine for support areas	5.3 HANGAR 3 BUILDING CONSTRUCTION	$200,000.00
		TOTAL:	$202,000.00
II	Install additional and upgrade existing Egress Systems	5.3 H [illegible] CONSTRUCTION	$2,649,000.00
II	Install additional and upgrade existing Fire Suppression Systems	6.3 [illegible]	
	OPTION A: Fire protect entire high bay roof area	8. [illegible]	[illegible]
II	Install proper Drainage System for the Fire Suppression Systems	[illegible]	[illegible]
II	Install Fire Rated Mixed Occupancy Separation	[illegible]	[illegible]
II	Repair structural damage in truss areas	[illegible]	[illegible]
II	Install Ground Fault Protection systems for Subs 1,2, & 3	[illegible]	[illegible]
II	Perform study on low voltage distribution systems	[illegible]	[illegible]
II	Install new breakers with higher Instantaneous Current Ratings	[illegible]	[illegible]00
		[illegible]	[illegible]00
	OPTION B: Fire protect up to 100' of the high bay area	[illegible]	[illegible].00)
		[illegible]	[illegible]0.00
III	Test/Calibrate Ground Fault Protection system	7.3 HANGAR 3 ELE[illegible]	[illegible]2,000.00
III	Install oil containment reservoirs around transformers	7.3 HGR 3 ELECTRICAL INFRASTRUCTURE ASSESSMENT	$2,000.00
		TOTAL:	$4,000.00

grow/expeditin (E
and
MF

[illegible] (1

TOTAL FOR ALL IMPROVEMENTS (FPS OPTION A): $19,524,000.00

TOTAL FOR ALL IMPROVEMENTS (FPS OPTION B): $16,373,000.00

Hangar 3

Egress systems, fire suppression systems, and the drainage for fire suppression systems are inadequate throughout the hangar (with the exception of the space occupied by the Air National Guard). The lack of sufficient exiting offers the largest threat to human life in the case of an earthquake or a fire. The fire ratings of many walls, roofs, ceilings, floors, doors, windows and wall penetrations are insufficient. Roof leaks above electrical equipment exist along the eastern portion of Hangar 3. Inadequate short circuit current ratings of breakers in the low voltage distribution systems have been found and need to be upgraded. The study of the low voltage distribution systems was not an objective of this report,

Elec.

Earthquake info

however, the findings herein definitely identify a need for such a study. A series of seismic/structural studies have been performed on Hangar 3: A 1980 report by Neal Engineering Associates; a 1985 report by Rutherford and Chekene; a July, 1992 report by Power Engineering; an August, 1992 report by Rutherford and Chekene; a November, 1992 report by E.Q.E. Engineering; and two (2) reports were prepared by Neal Engineering Associates in January and April of 1993 (Appendix C) detailing major damage to certain chords within the truss assemblies for Hangar 3. These studies by Neal Engineering also specify the necessary repairs and provide supporting plans and cost estimates. The seismic study performed by Rutherford and Chekene in August, 1992 (M.F.D.P. 3.3.3) concluded that Hangar 3 does not meet minimum life safety requirements set forth by NEHRP and recommends certain structural improvements that should be addressed in addition to recommendations set forth in this report. An evaluation of all the above mentioned studies by the NASA/Ames Facilities Engineering Branch in July, 1993 (Appendix D) recommends that "The structural concerns of the hangar be fully disclosed to the resident agency of Hangar 3. The resident agency should perform a thorough structural analysis of the hangar and carry out the additional repairs it deems necessary prior to occupying the facility." The elbow terminations for Sub 3 are overheating and further inspection is needed. Ground fault protection systems need to be installed for Subs 1, 2, & 3.

Structural concerns

This report does not intend/claim to have identified every safety and maintenance problem within the hangar footprints. Separate studies are recommended to be performed by/for each hangar occupant on the electrical distribution systems, HVAC, lighting, and any other items that exclusively pertain to their occupation.

4.0 REPORT DEVELOPMENT

All aspects of this report were created with the objective (provided in section 2.0) in mind. The effort was also to keep the report easy to understand, brief, and to the point while providing sound engineering analysis.

4.1 Overall Process

A team of Engineers, Technicians, and Engineering Aides (between the Moffett Transition office and the Plant Engineering office) was put together. This team then developed analysis methodologies for each topic, collected data, inspected current conditions, performed calculations, and recommended corrective actions.

Some of the information provided in this report was culled from various studies, proposals, and drawings already prepared. Checklists were created from various code books, such as: Uniform Building Codes (UBC); Uniform Mechanical Codes (UMC); Uniform Plumbing Codes (UPC); Uniform Fire Codes (UFC); National Electric Codes (NEC); National Fire Codes (NFC); NASA Safety Manual; NASA Facilities Engineering Handbook; and the Military Handbook 1008A. These checklists were then used for field verification and inspections.

Some of the data collection included thermographic scanning, current readings, and temperature readings.

Data collection and analysis methodology was also greatly enhanced through interviews of Navy Personnel (including Fire Department and Public Works Officials), Consulting Engineers, the MFDP Environmental Group, and various NASA Organizations.

After all available data was collected, it was then manipulated based on the analysis methodologies, to allow comparisons of existing conditions to the required conditions for present and future use. These comparisons were then summarized, and conclusions were drawn to allow recommendations for corrective actions.

4.2 Assumptions

Due to the fact that (a fire destroyed many drawings and references) limited documentation was available, and access to various areas in the Hangars was difficult to acquire, therefore some assumptions were necessary. These assumptions were based on worst-case scenarios, averages, and included safety factors. Some assumptions were also based on prior studies. However, field verifications (where applicable) were conducted to validate the assumptions.

4.3 Report Structure

This report is actually three reports, one for each Hangar, combined into one. For each Hangar, the overall report structure is basically the same. First, the current conditions are described. Then the analysis methodology is explained and carried out. Lastly, conclusions are formed based on analysis results.

5.0 HANGAR BUILDING CONSTRUCTION

5.1 Hangar 3 Building Construction Type

5.1.1 Scope

Hangar 3 is a 433,738-square foot structure that was originally built in 1942 as a blimp hangar and not for its present use as an aircraft maintenance hangar. ✓ The building is 1,000' long by 370' wide at the base and 180' tall. It is framed with long span wood trussed arches supported on 25-foot-tall concrete moment frames. The frames are supported on concrete pile foundations. The roof is covered with green corrugated metal over straight wood sheathing. The structure has wood diagonal bracing between the panel points at the bottom chord of the trusses. Unlike Hangar 2, many of the wood X-braces between the concrete frames have been replaced with steel tubes. The door structure at the ends of the hangar consist of a wood box beam at the top of the doors spanning to two concrete towers at each end of the doors. Office/support spaces, constructed with wood, have been built into the base of the concrete frames on the east and west sides. The two story office/support spaces on the west side are 30' wide by 30' tall, and runs the whole length of the hangar. ✓ On the east side, the two story office/support spaces are 100' wide by 30' tall, and runs the whole length of the hangar too. There is currently approximately 215,300-square feet of these support spaces. These support/service spaces consist principally of offices, classrooms, service shops, and electronic support equipment. The original building and its office/support spaces are almost entirely constructed ✓ with combustible materials.

In 1927, the International Conference of Building Officials enacted the UNIFORM BUILDING CODE (U.B.C.) which is dedicated to the development of better building construction and greater safety to the public by uniformity in building laws. The U.B.C. is recognized in this report as a generic reference which supplements/adopts many life safety standards stipulated in other documentation such as: the National Fire Protection Agency's Life Safety Code, the Uniform Fire Code, the Military Handbook 1008, and the NASA Safety Manual.

The 1986 edition of the Fire Protection Handbook states that the first step of life safety design is to identify the occupant characteristics of the building. It then proceeds to stipulate three alternatives that should be evaluated: (1) evacuation of the occupants (2) defending the occupants in place (3) providing an effective area of refuge. Parts III-IV of the U.B.C. classify different occupancies (based on their characteristics) and define the types of construction. Once the parameters of the occupancy group and construction type have been established, the U.B.C. focuses on the evacuation and/or protection of the occupants within these parameters by implementing certain safety standards. The parameters for Hangar 3 consist of mixed occupancies: Group H-5 within the Hangar Deck area and Group B-2 within the support areas. The construction is of Type IV or Type V for the hangar high bay and Type III-N for the hangar support offices/shops. For what ever reason(s), the overall hangar structure is currently not complying with many of the safety codes applying to these established occupancy and construction parameters.

This section of the Hangar Life Safety evaluation is dedicated to identifying existing/future hazardous situations within the overall structure of Hangar 3. An inspection team, with technical backgrounds in Engineering and General Contracting, performed a series of Safety Inspections on Hangar 3 during the month of October, 1993.

For the following three reasons, the inspections focused primarily on egress systems, fire resistant walls, glazing, stairways, doorways and any obvious safety hazards:

1) deficiencies in these areas would create the largest safety hazard to occupants in the case of a fire or explosion.

2) these items may serve/pertain to more than one Resident Agency and may need to be addressed in contract negotiations.

3) due to locked doors (**INCLUDING SOME DOORS SERVING AS FIRE EXITS**), the access to many areas was limited.

This report does not claim to include all of the code violations/safety hazards that exist within the hangar, only the major items. It is recommended that each Resident Agency perform their own safety inspections on the areas exclusively pertinent to them (i.e. lighting, receptacles, low voltage panels, lead paint, etc.).

5.1.2 Inspection Methodology

The method of field inspection utilized to obtain the necessary data consisted of a field observation of the existing hangar structure. An evaluation of the structure's condition was then performed. The resulting data was recorded on the hangar plans; which includes the documentation of all the areas in non conformance with the applicable codes. This information is introduced in the following pages with a GENERAL LEGEND consisting of generic symbols for specific code violations. Hence, these generic symbols identify the locations of non conformance on the following plans (See Section 5.1.4 "Maps") for each area of the hangar.

5.1.3 Conclusion

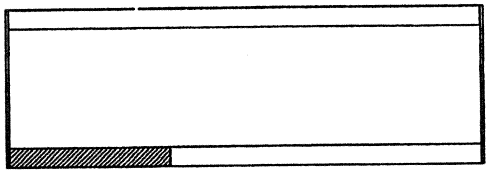
Hangar 3 is a potential Naval Historic Monument and a California Historical Civil Engineering Landmark and should be preserved and protected as required, based on DoD directive 4710.01, 36 CFR 60 and 65 (references (f) and(g)). According to the 1986 edition of the Fire Protection Handbook, from 1977 through 1984 an average of 5,634 deaths occurred each year as a result of structure fires (85% of all fire deaths). The hangar deck is not provided with an automatic sprinkler system, but the first and second floors of the office/support spaces are protected by automatic sprinklers covering approximately 95 percent of the total office/support area (See Section 6.3 Hangar 3 - Fire protection System). A structural fire in Hangar 3 represents the potential for major loss of life and property. Estimated losses for just the structure alone are as high as $100,000,000 in 1988 figures. The potential exist for over 1,000 people to work in Hangar 3, therefore the considerations to both their life safety and to the protection of the building/contents is both complex and serious. The support areas can be occupied by a large number of personnel in spaces that, in general, contain serious life safety deficiencies. Some of the most severe life safety deficiencies include many people required to exit through corridors directly exposed to fueled aircraft or exit onto the hangar deck itself. The high heat release from an aircraft fire would cause untenable conditions for safe egress. Many of the support areas have no exits at all or have non-fire rated exits that exceed the distance requirements set forth by the U.B.C. There are currently code violations in all areas of the hangar, including water supply reliability, the number of fire exits, corridors, fire and sprinkler systems, alarm systems, evacuation systems, and wall penetrations.

It has been proposed in previous reports to construct an approved fire rated corridor extending along the entire length of the deck with exits to the exterior every 75 feet on the first floor and exterior stairways every 150 feet on the second floor. This rather simple construction option along with installing a sprinkler system would solve many of the egress problems in the hangar. ✓

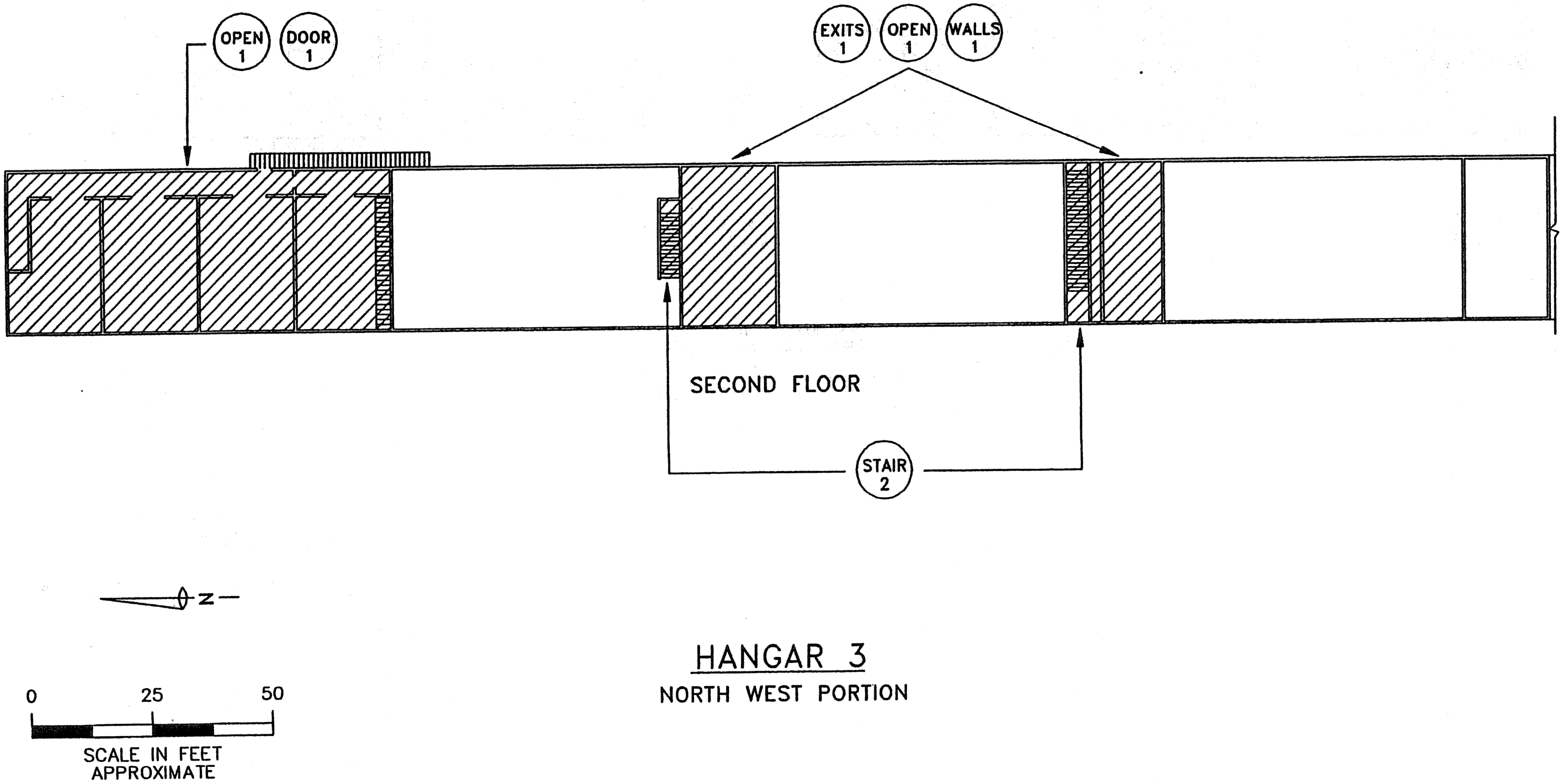
NAS Moffett Field is located in Seismic Zone 4, the US geological rating for an area with the highest incidence of earthquakes. There is no evidence of any earth faults underlying Moffett Field. Nonetheless, Moffett Field is subject to seismic movement caused by the Hayward Fault and the Calaveras Fault located 9 miles and 13 miles respectively to the northeast, and the San Andreas Fault located 9 miles to the southwest. The possibility for ground rupture due to earthquake is remote, but severe ground shaking on tidal lands and sand layers allows for the potential of bay mud consolidation and/or liquefaction. Hangar 3 lacks adequate seismic resistance and a seismic evaluation of Hangar 3 concludes that the structure is in poor condition with severe structural damage with a variety of estimates ranging from $850,000 to $1,654,399. The longer the hangar stands un-repaired, the more likely that further structural damage will occur to the point where the hangar will become un-repairable. Do to seismic damage to major structural members in the roof trusses, occupancy of aircraft and personnel is not recommended at the center portion of Hangar 3 between the catwalks and between frames 10-22 until/unless repairs are completed (See Section 5.1.4 "Maps"). It goes on to conclude that the hangar structure does not meet the criteria for minimum Life Safety performance. A complete detailed seismic evaluation report is available in the MFDP Library upon request. Annual temperature changes, which cause expansion and contraction, have resulted in the loosening of an estimated 25,000 bolts per hangar from the exterior siding since the late 1970's. However, no bolts have been tightened. Between 1981-83 all truss bolt were checked and tightened. Some truss hangars were also replaced. All sag braces were reattached with screws in 1987. It is possible that the hangar suffered structural damage in the 1989 Loma Prieta earthquake, causing truss bolts and exterior siding bolts to loosen.

An asbestos report was also prepared in October 1993. Out of sixty-three areas that were sampled, nineteen were confirmed to contain asbestos and thirty were assumed to contain asbestos. A complete detailed asbestos report on Hangar 3 is available from the MFDP Library upon request.

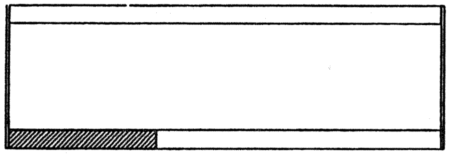
Hangar 3 is one of six original blimp hangars built on the west coast and sixteen built throughout the nation in the 1940's (2 at Moffett Field, California; 2 at Tustin, California; and 2 at Tillamook, Oregon). On August 22, 1992, one of the blimp hangars in Tillamook, Oregon caught on fire from a small stack of straw adjacent to a 7,600-ton stockpile of straw measuring 75' square by 50' tall (A video of the fire/witnesses and a newspaper article are available from the MFDP Library upon request). Reports from fire fighters, taking a stand on the flames from the interior, stated that the hangar structure itself began to collapse approximately 10 minutes after the ceiling rafters, 200' up, ignited with flames. The hangar completely caved in 45 minutes after the fire started. Other reports said that the blaze's intense draft sucked air into the mammoth building causing a ground level wind that approached 60-80 m.p.h. This trapped two people inside the hangar by the force of the wind holding the door to the exterior shut until someone rammed it with a pickup truck. No one was hurt in the fire do to its late night occurrence. The embers floating from the fire set "hundreds" of grass fires that varied in size from 1-square foot to 5,000-square feet. Two very important factors make the hangars at Tillamook different than the ones at Moffett Field (One positive and one negative). We'll state the negative last since it is more important and should be heavily emphasized. First, the current use of the Tillamook hangars was that of storage, in this case a large quantity of flammable straw. The current/future use of the Moffett Field hangars are to facilitate aircraft maintenance and the fuel load is considerably less than that of straw. Second, The hangars in Tillamook are built perpendicular to each other and are separated by approximately 1,000' of open, undeveloped space. The hangars at Moffett Field are built parallel to each other and are spaced a minimal 150' apart. This 150' envelope contains several other support buildings that vary in construction type. This spacing should allow room for radiant heat give off in the case of a large structure fire. In the case of the fire at Tillamook, the spacing served its purpose. But if we take that fire and apply it to the characteristics of the Moffett Field hangars, it would be nearly impossible to save either hangar if the other was completely engulfed in flames. Hangar 3 may not and should not have the same fuel load as that of the hangars in Tillamook, but the point remains that in a densely populated area, such as the south bay, to prevent a fire is much more cost effective than to pay for the aftermath and liabilities associated to it. The following maps are to help identify specific areas of the hangar and cite the code(s) violated. A complete cost summary for construction repairs is included in Section 8.3.



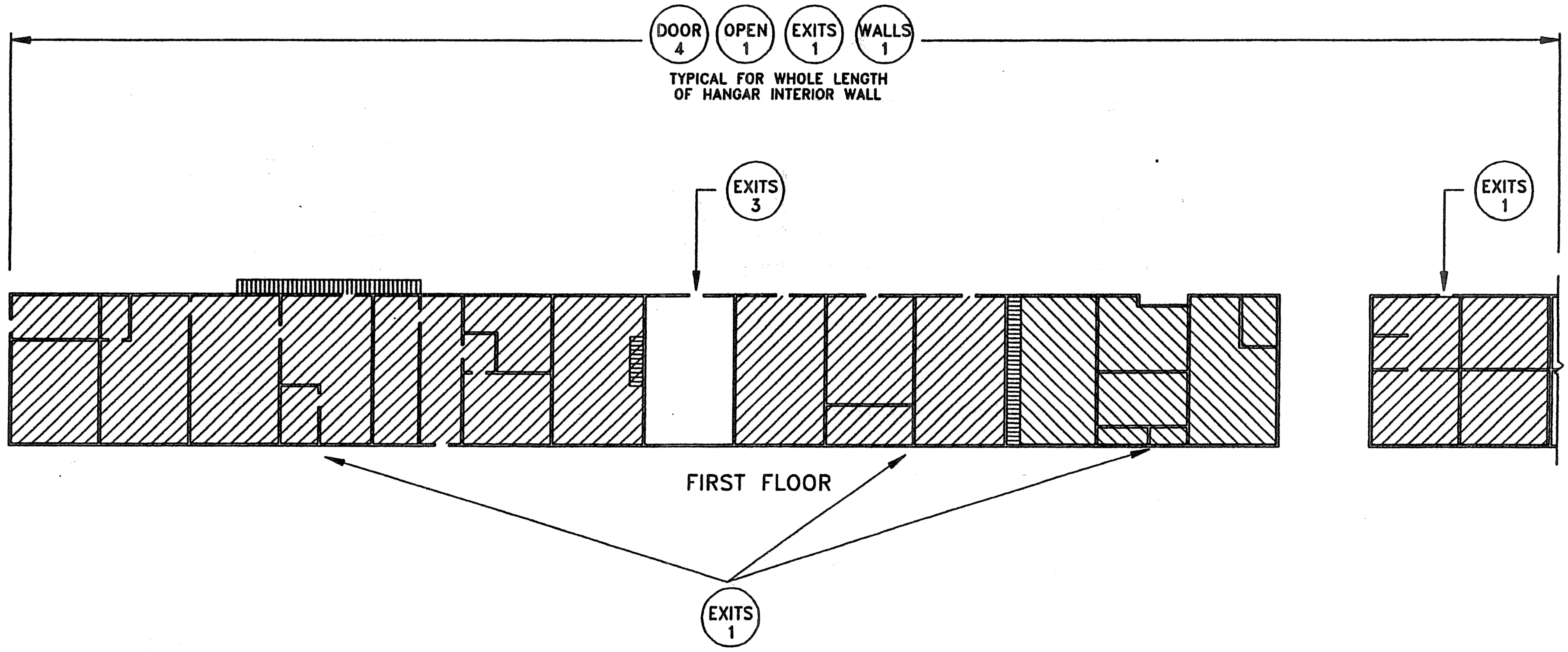
HANGAR 3 PLAN VIEW
SECTION 3

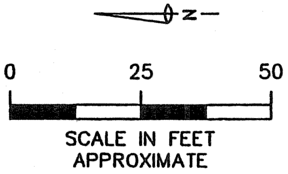


HANGAR 3
NORTH WEST PORTION

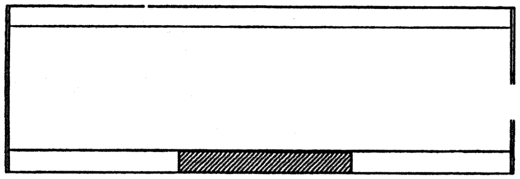


HANGAR 3 PLAN VIEW
SECTION 3

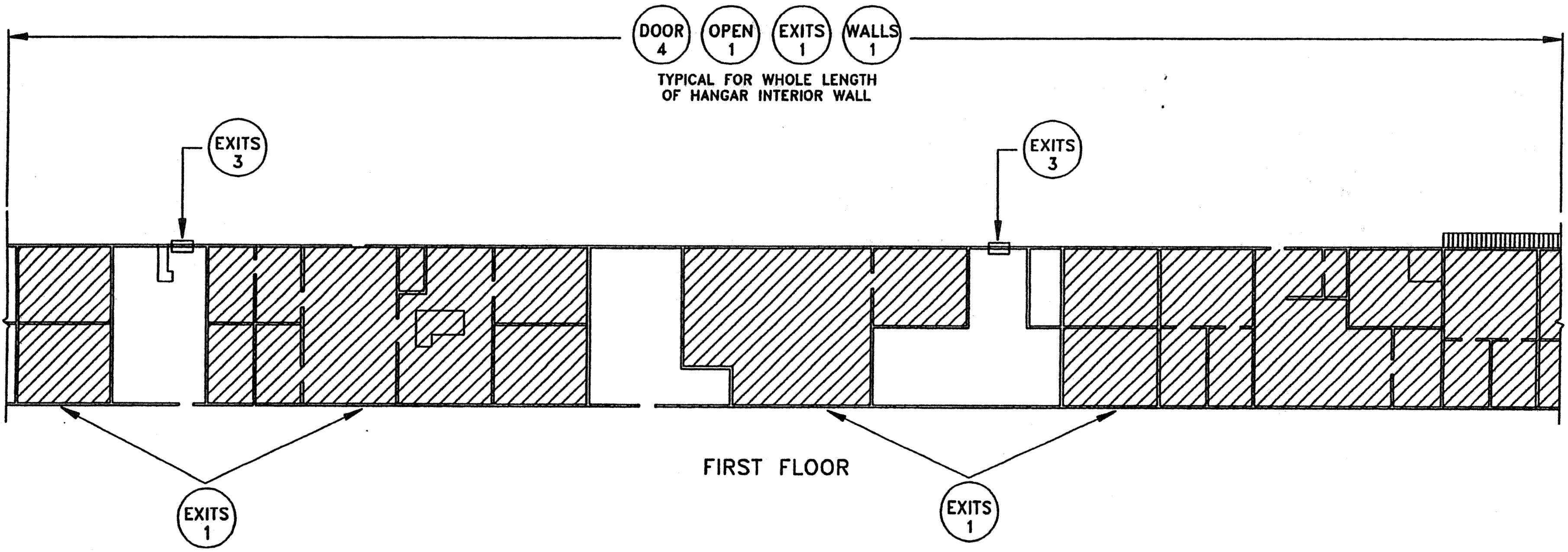




HANGAR 3
NORTH WEST PORTION

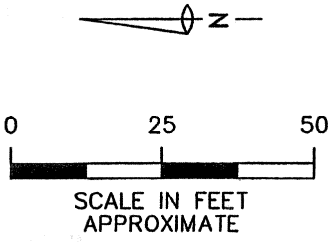


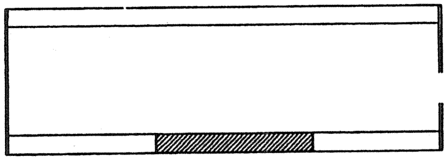
HANGAR 3 PLAN VIEW
SECTION 2



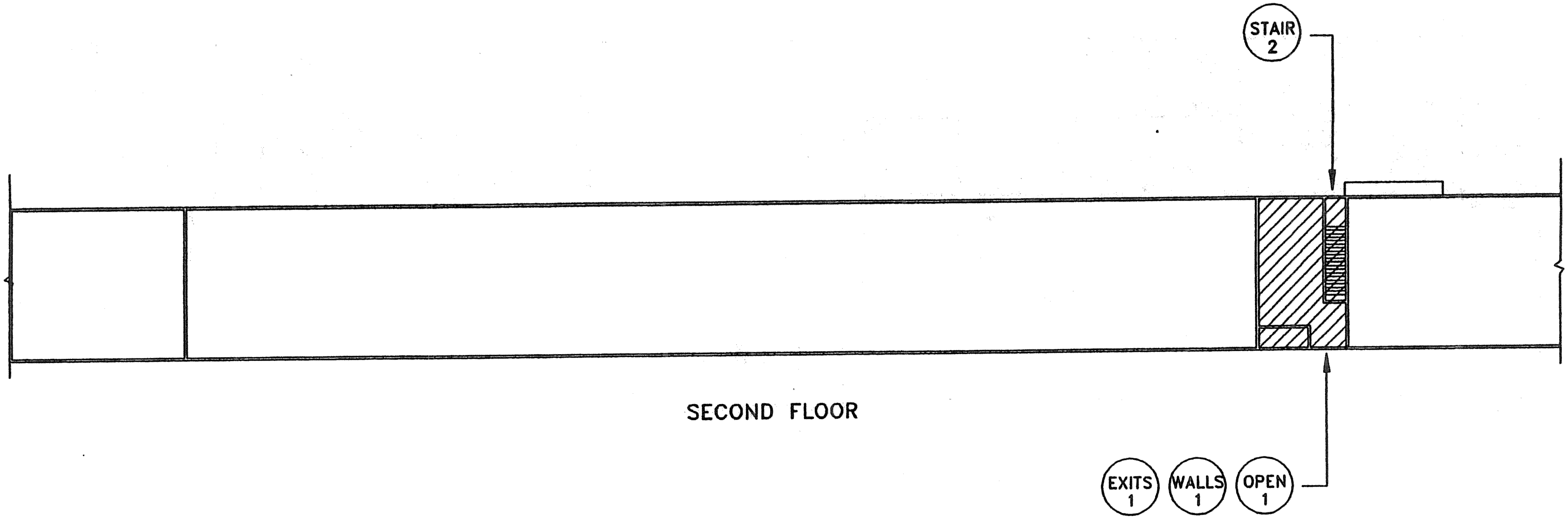
HANGAR 3

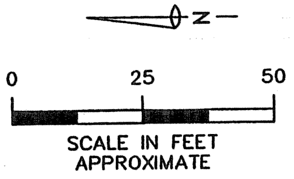
WEST CENTER PORTION



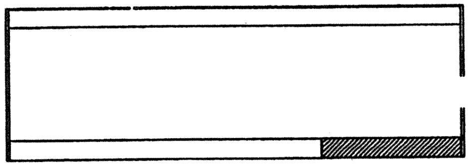


HANGAR 3 PLAN VIEW
SECTION 2

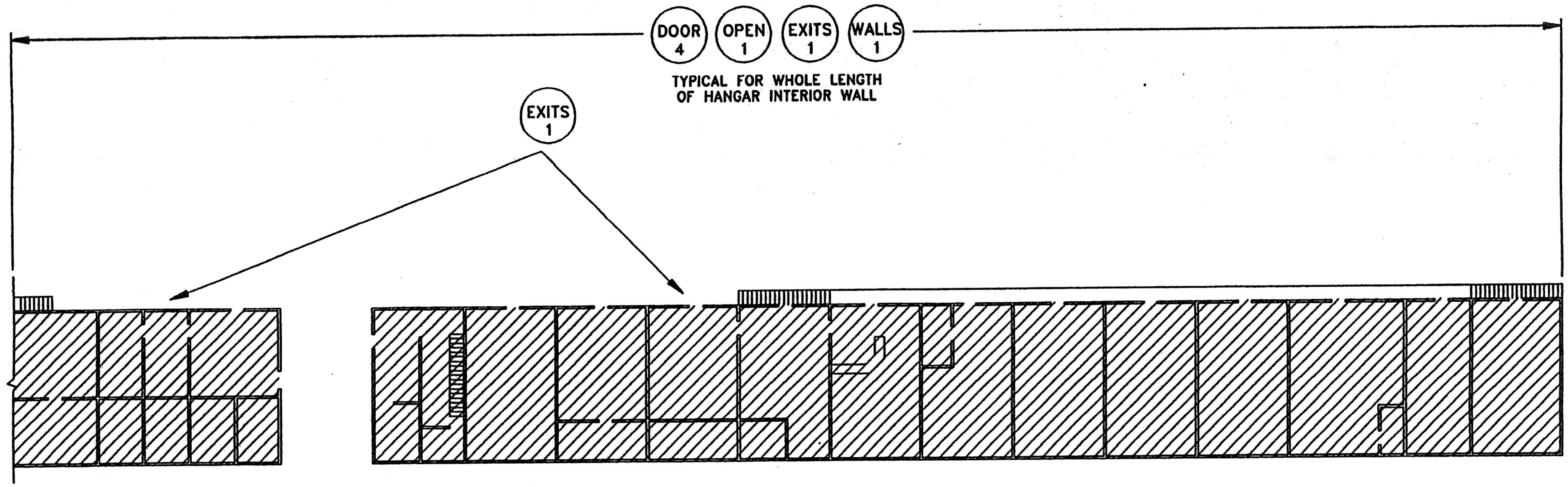




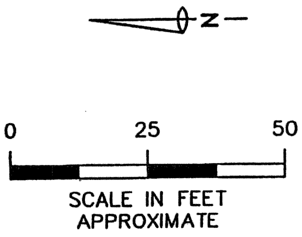
HANGAR 3
WEST CENTER PORTION



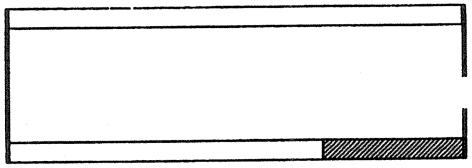
HANGAR 3 PLAN VIEW
SECTION 1



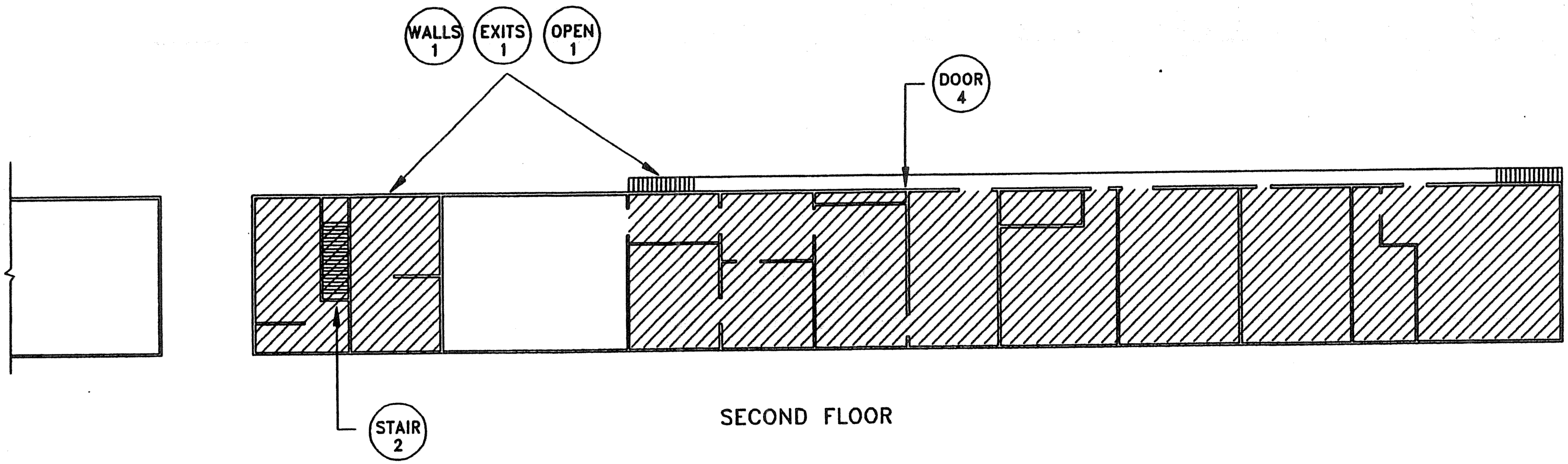
FIRST FLOOR



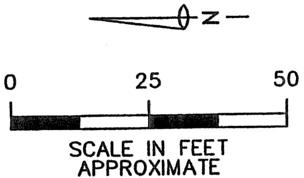
HANGAR 3
SOUTH WEST PORTION



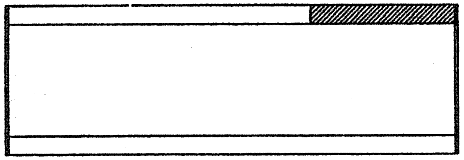
HANGAR 3 PLAN VIEW
SECTION 1



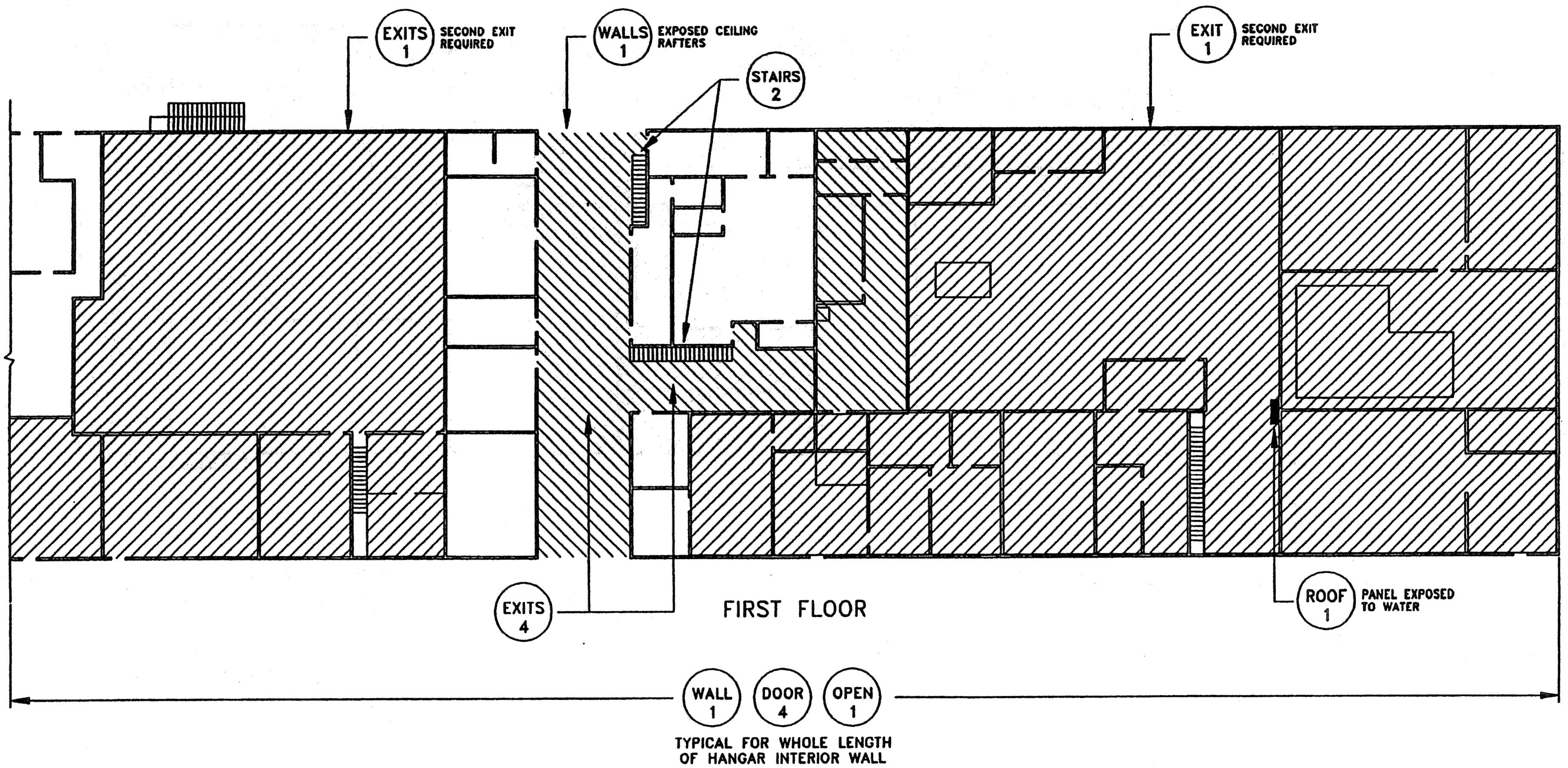
SECOND FLOOR

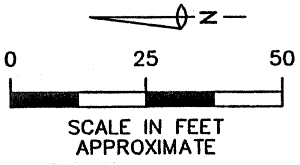


HANGAR 3
SOUTH WEST PORTION

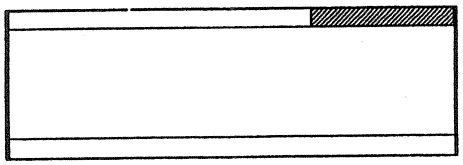


HANGAR 3 PLAN VIEW
SECTION 6

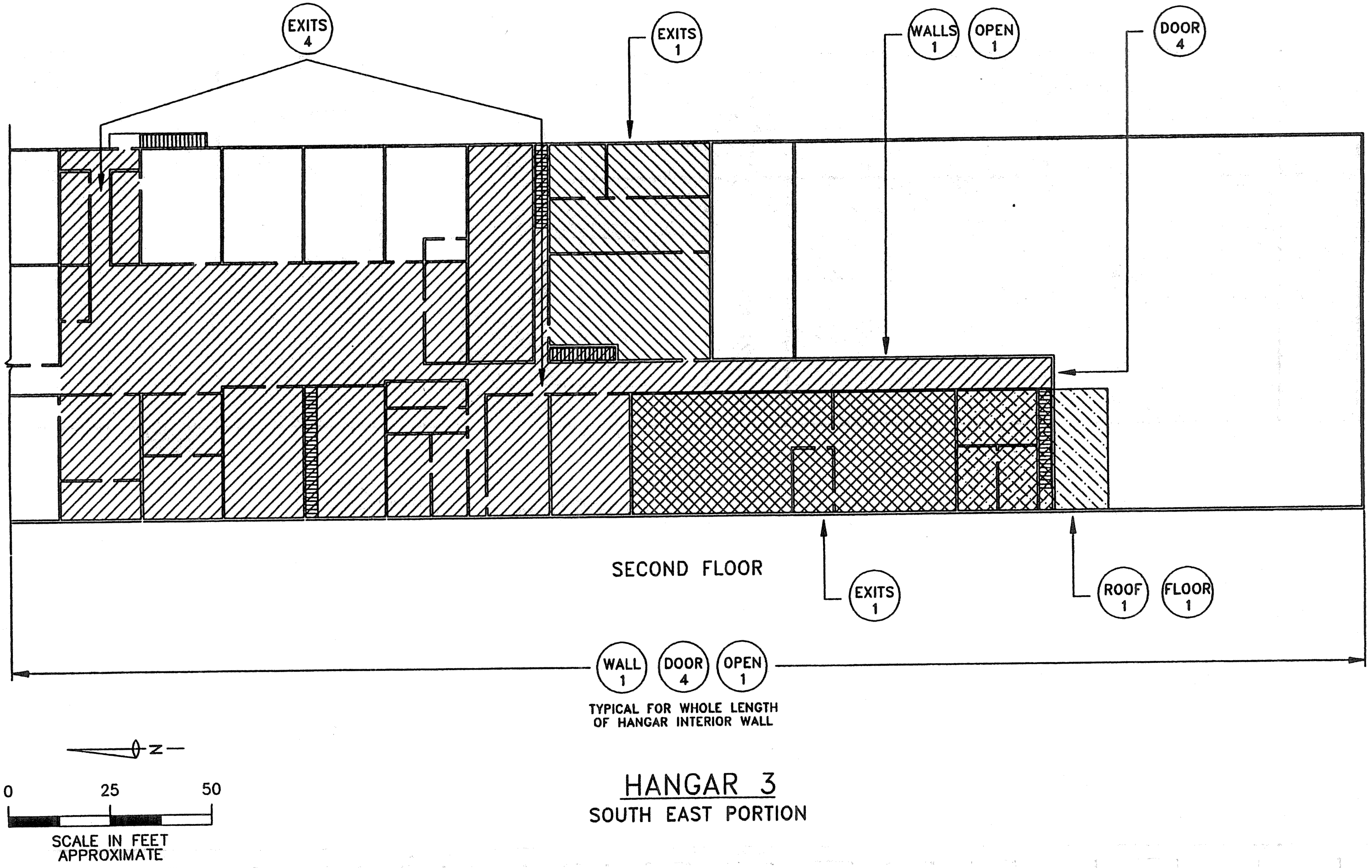




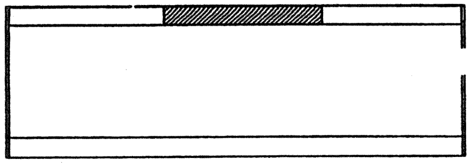
HANGAR 3
SOUTH EAST PORTION



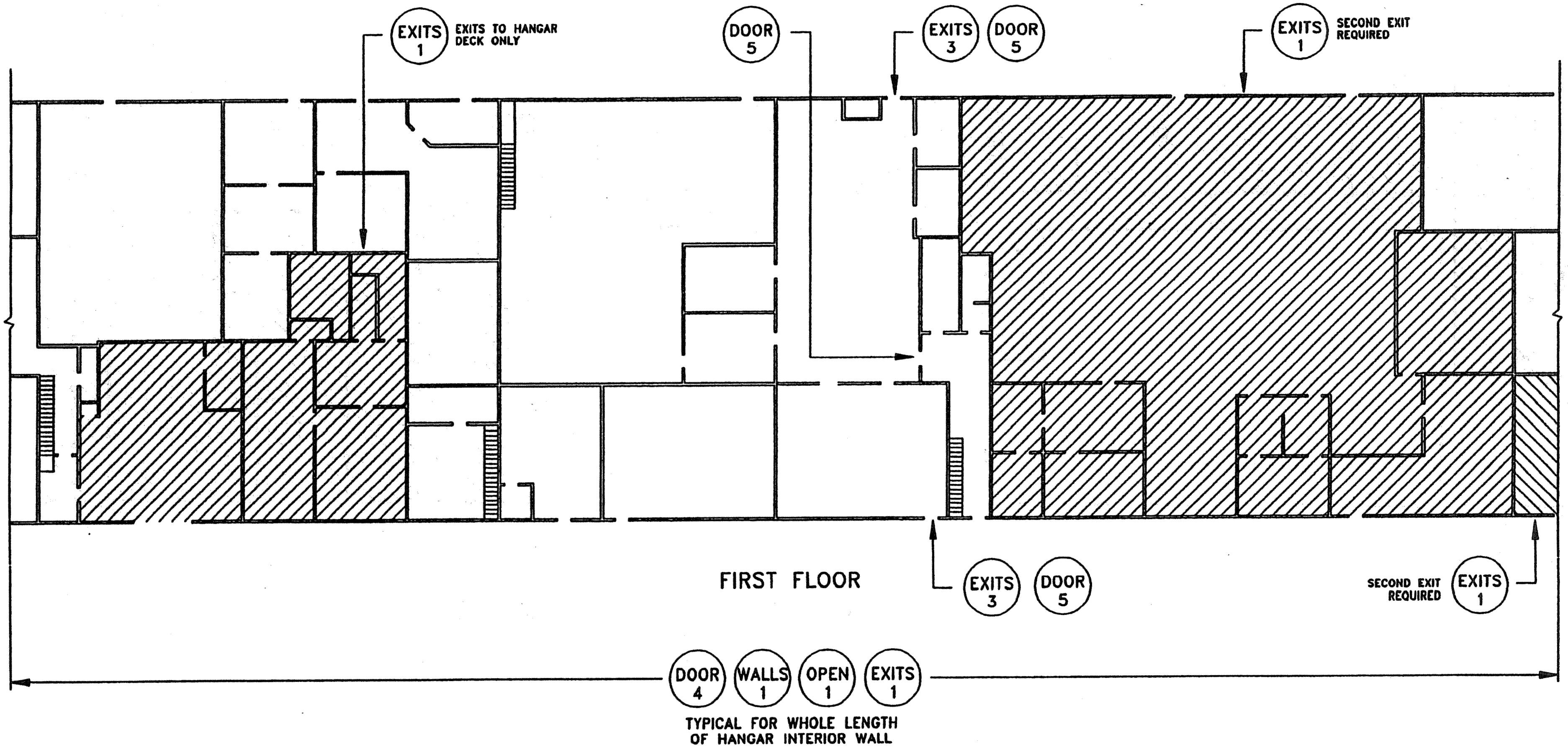
HANGAR 3 PLAN VIEW
SECTION 6

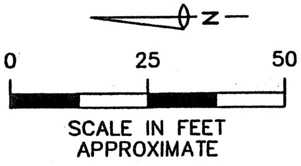


HANGAR 3
SOUTH EAST PORTION

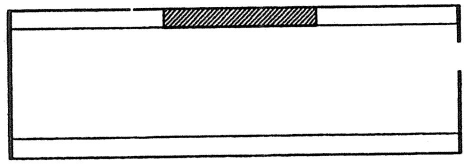


HANGAR 3 PLAN VIEW
SECTION 5

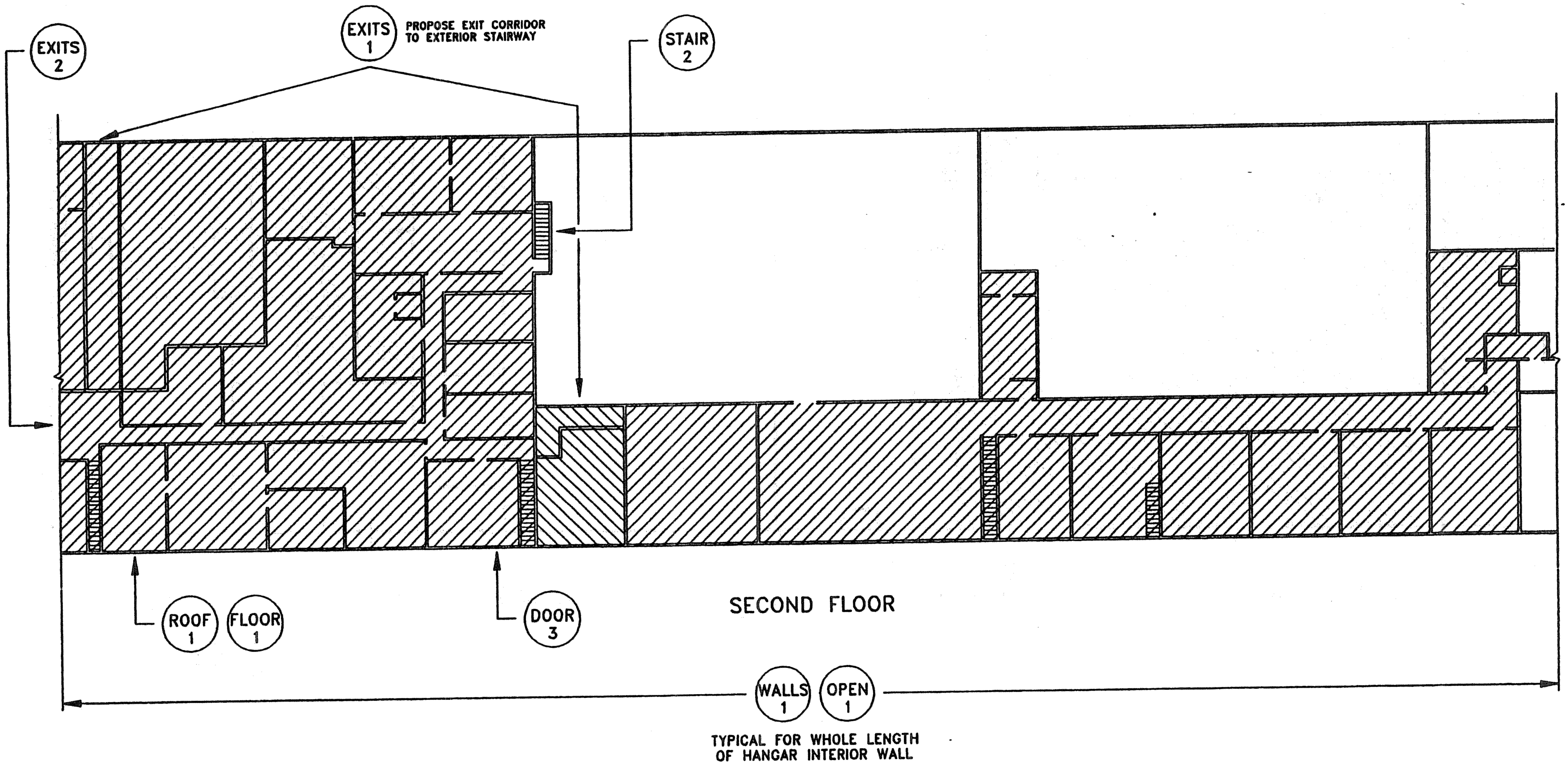


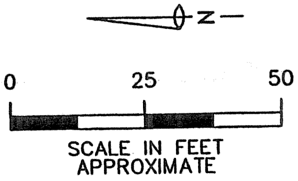


HANGAR 3
EAST CENTER PORTION

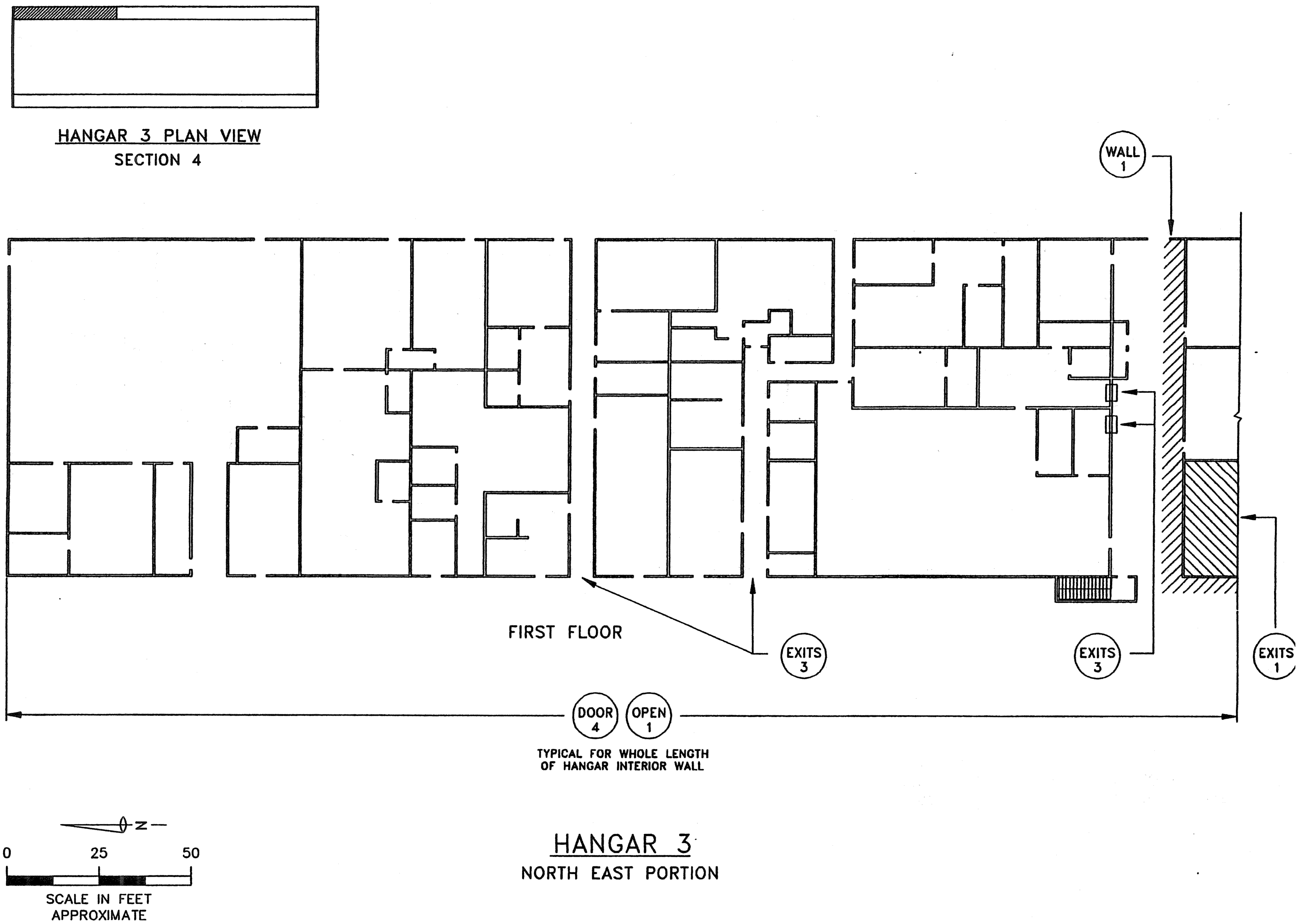


HANGAR 3 PLAN VIEW
SECTION 5

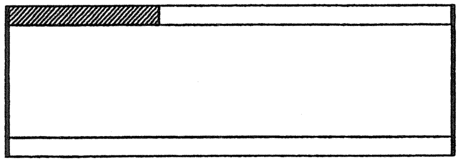




HANGAR 3
EAST CENTER PORTION



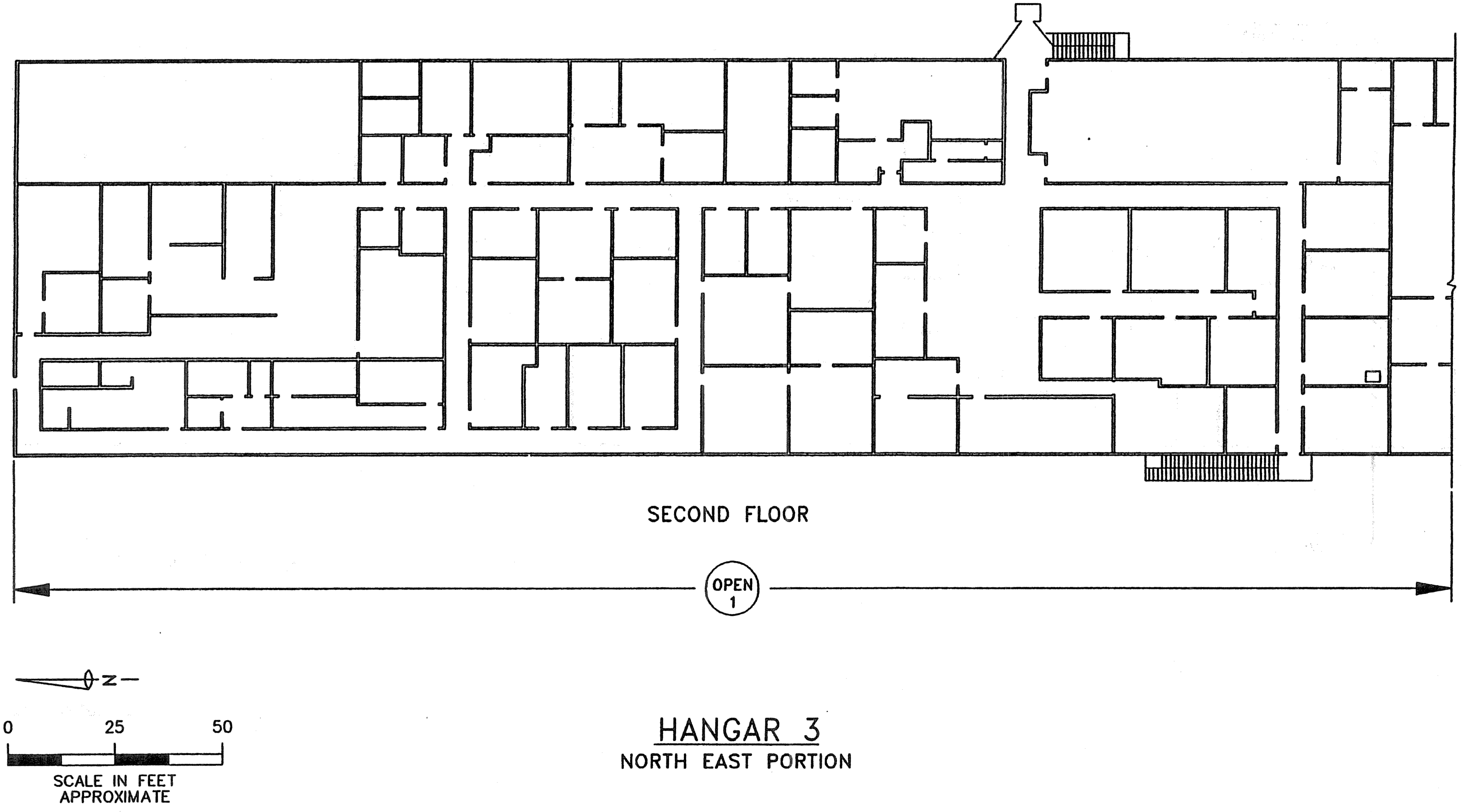
HANGAR 3
NORTH EAST PORTION



HANGAR 3 PLAN VIEW
SECTION 4

NOTE:

THIS SECTION IS AN EXCELLENT EXAMPLE OF HOW FLOOR SPACE SHOULD BE CONSTRUCTED TO COMPLY WITH SAFETY REGULATIONS.



HANGAR 3
NORTH EAST PORTION

5.1.4 Hangar 3 General Legend and Maps

walls 1 The construction of the existing wall/ceiling needs be fire rated as per UBC § 503 for seperation of different occupancies.

walls 2 The Hangar deck is construed to be a Group H-5 occupancy that is assumed to be either Type IV (heavy timber construction) or Type V (Light lumber). The construction of the hangar's wall and roof structure has features that will support postulations for both construction types; refer to UBC § 2106 and 2205. The hangar does not conform with the maximum allowable floor area requirements stipulated in the UBC or the MIL-HDBK-1008 handbook. The installation of area separation walls per UBC § 505 is not practical. However, compliance can be attained by the installation of a sprinkler system for the hangar deck area (refer to Sections 6.1.3, 6.2.3 and 6.3.3 of this report for more details on the Hangar Fire Protection Systems) as per UBC § 506 (b).

walls 3 The Hangar deck is construed to be a Group H-5 occupancy that is assumed to be either Type IV (heavy timber construction) or Type V (Light lumber). The construction of the hangar's wall and roof structure has features that will support postulations for both construction types; refer to UBC § 2106 and 2205. The exterior walls of the hangar must be fire rated as stipulated in Table 9C of the UBC.

haz. 1 Exposed fryable asbestos was observed in this area (An asbestos report prepared in April 1993 by Tetra Tech, Inc. is available from the MFDP Library upon request).

open 1 The openings that must be in a fire rated wall should be protected by glazing (with 3/4 hour fire resistance rating) or fire dampers in accordance with UBC § 4306.

exits 1 Fire exits: the quantity and/or accessability to Fire Exits in this area is insufficiant and in non-compliance with the U.B.C. Article 3303, the N.F.P.A. 101 and the MIL-HDBK-1008. Additional corridor(s) leading directly to the outside of the hangar (not through the deck) and/or exit(s) need to be installed per these safety codes in addition to all of Chapter 33 in the Uniform Building Code.

exits 2 This branch of the corridor exceeds 20 feet in length and does not lead to an exit; in non compliance with UBC § 3305.

exits 3 Door does not swing in the direction of egress. This door is in non compliance with NFPA 101 § 5-2.1.7 & UBC § 3304 .

exits 4 The occupancy load serving this corridor exceeds 30 people (if not sprinkled) or 100 people (if sprinkled) and the corridor width is not more than 30 feet with a seperate exit. This corridor is required to be enclosed by a 1 hour fire rated wall per UBC § 3305 (g), illluminated as per UBC § 3313 and identified per UBC § 3314.

stair 1 The width of this stairway is in non compliance with UBC § 3306 (b). One or more of the following situations exist: The width is less than 36" for stairways serving 49 people or less; The width is less than 44" for a stairway serving 50 or more people; or the width is less than the minimum required for an exit corridor as determined by UBC 3303 (b).

stair 2 This stairway needs to be enclosed with fire rated walls and doors as per UBC § 3309, illuminated as per UBC § 3313 and identified per UBC § 3314.

stair 3 Rise and/or run of this stairway or its landing is in non compliance with UBC § 3306.

door 1 The interior doors opening into a 1 hour rated corridor do not meet all the requirements set forth in UBC § 3305 (i.e. fire ratings, smoke and draft control, ability to self close, etc.).

door 2 Door obstructs the means of egress by more than 50% of the required width of the corridor. Must not project into stairway more than 3.5" and into corridor more than 7" when fully open; This door is in non compliance with UBC § 3305 door 3 Floor on both sides of the door must be of the same elevation and must be of at least the width of the door in all dimensions. This doorway does not comply with UBC §3304 & NFPA 101 § 5-2.1.3.3.

door 4 The door(s) contained within this wall must be fire rated as per UBC § 503 and UBC § 4306 (i.e. fire ratings, smoke and draft control, ability to self close, etc.).

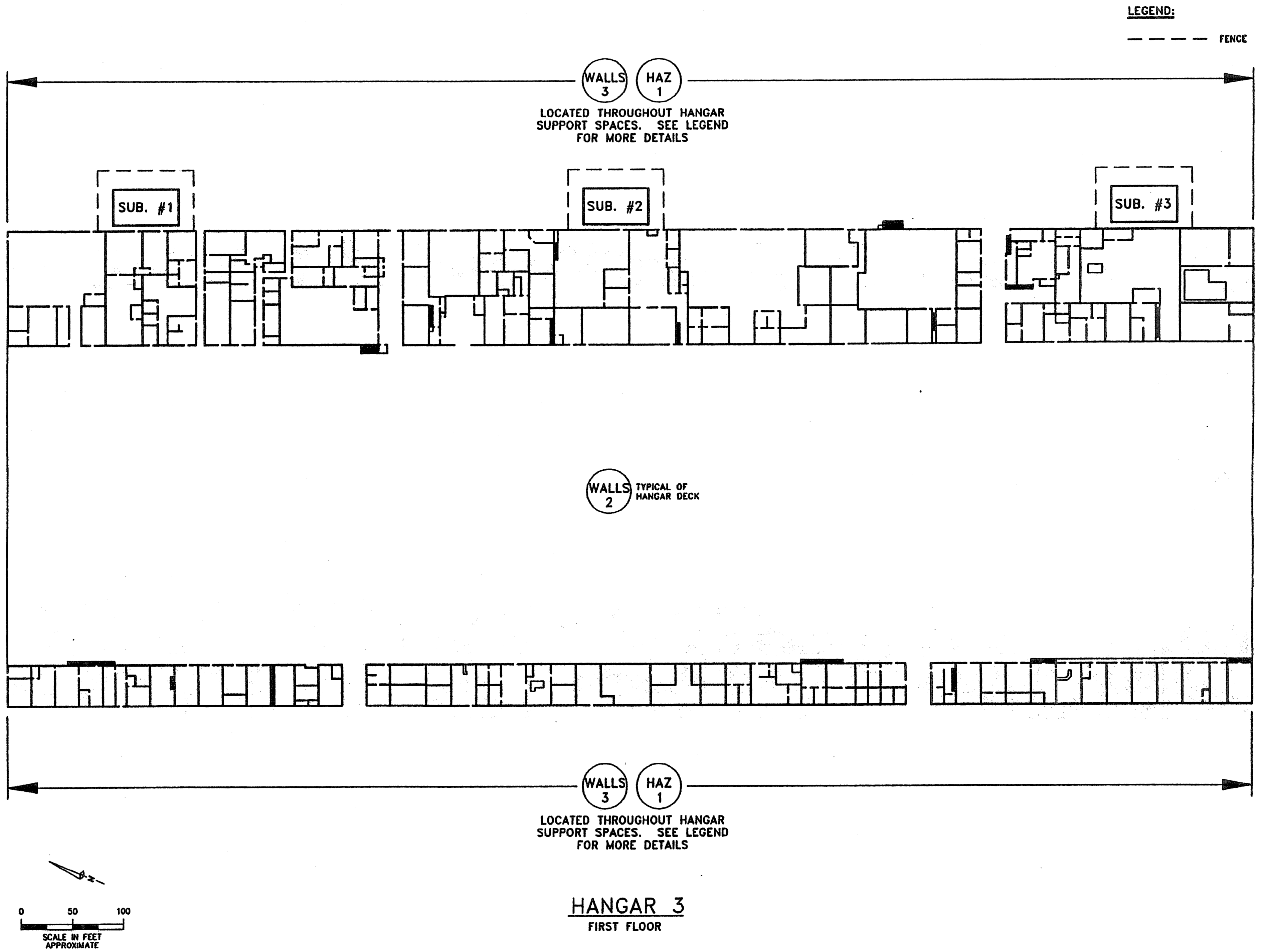
door 5 Door needs a key or special knowledge to open; in non compliance with NFPA 101 § 5-2.1.5.1.

roof 1 Existing roof covering is in non conformance with Chapter 32 of UBC and creating hazardous conditions (i.e. exposing electrical equipment to moisture which is a violation of the NEC § 110-11 and 384-5).

roof 2 The construction of the existing roof , penetrations, and openings between the hangar support area and the hangar deck need be fire rated as per UBC § 503 and 4306 for the separation of different occupancies.

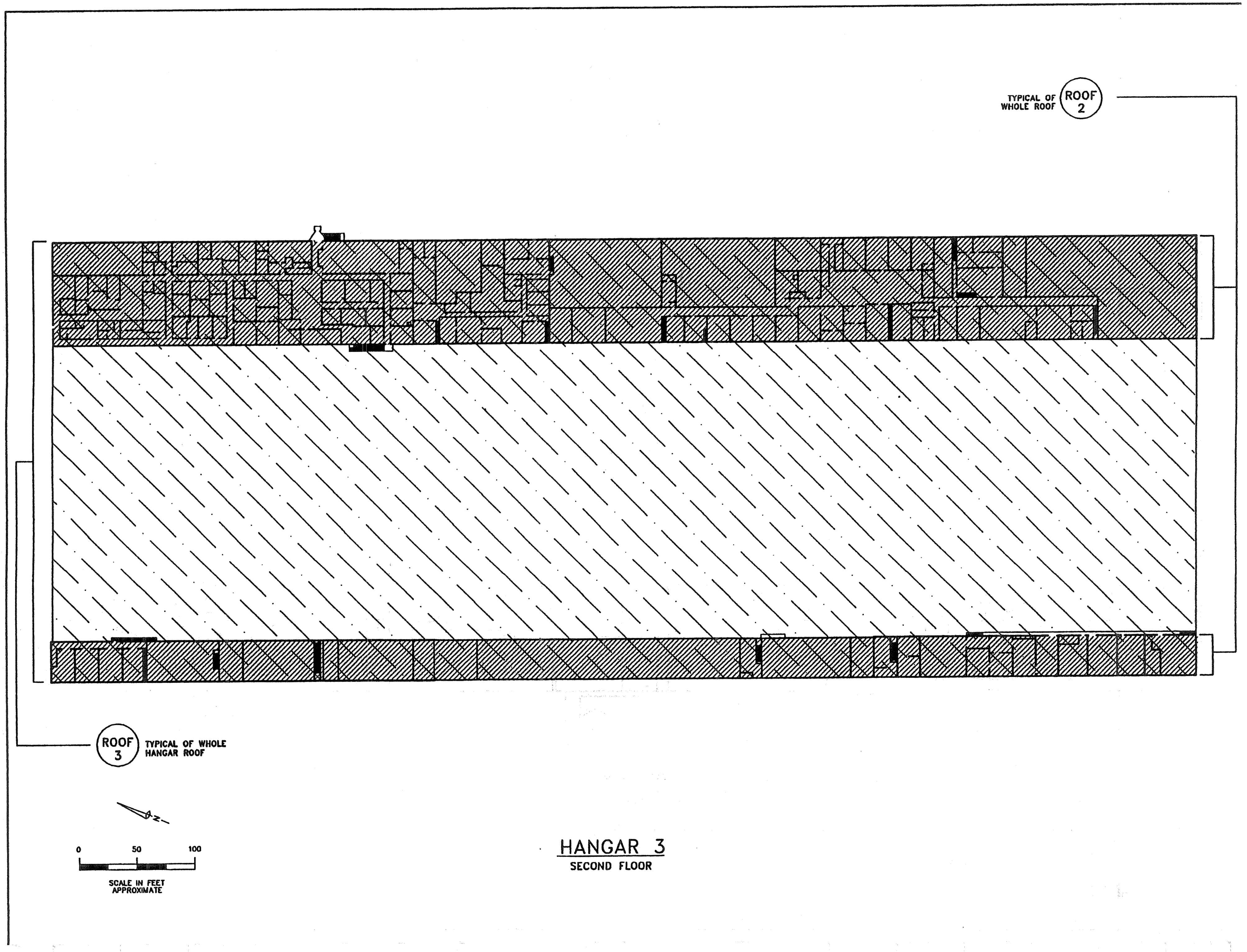
roof 3 The hangar roof needs to be fire rated as per UBC § 2103, 2105 and Chapter 32

flr 1 Water damage has occured to the ceiling/floor in this area. The structural intigrity should be checked.



HANGAR 3

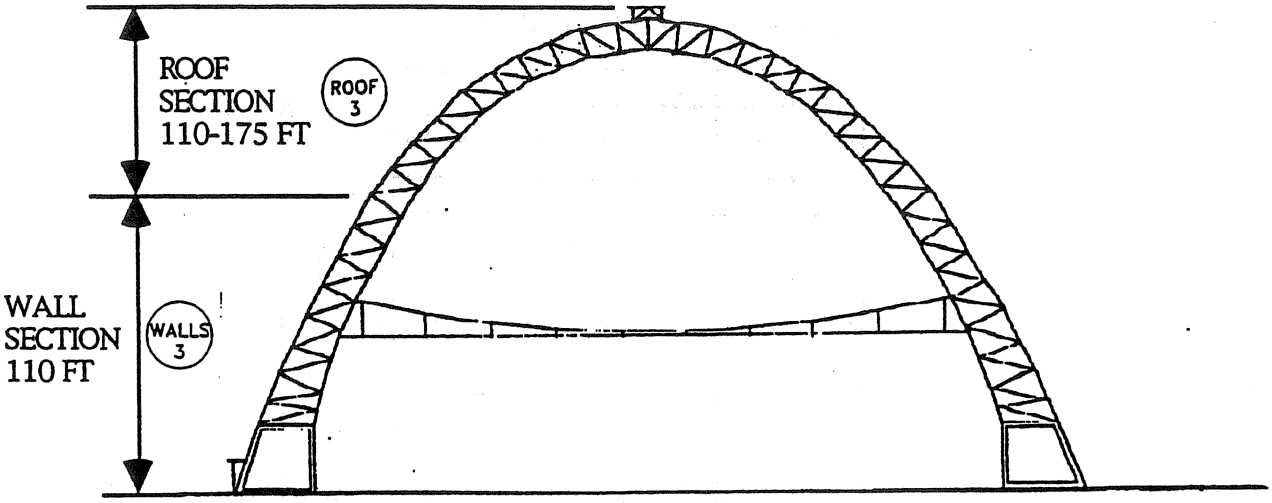
FIRST FLOOR



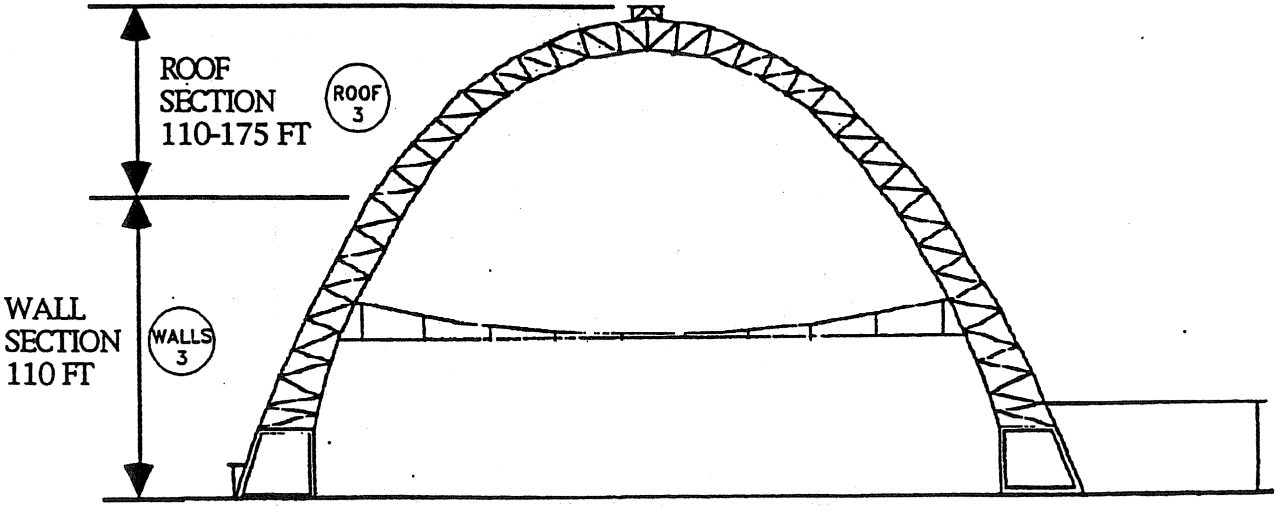
HANGAR 3

SECOND FLOOR

Hangar 2 Elevations

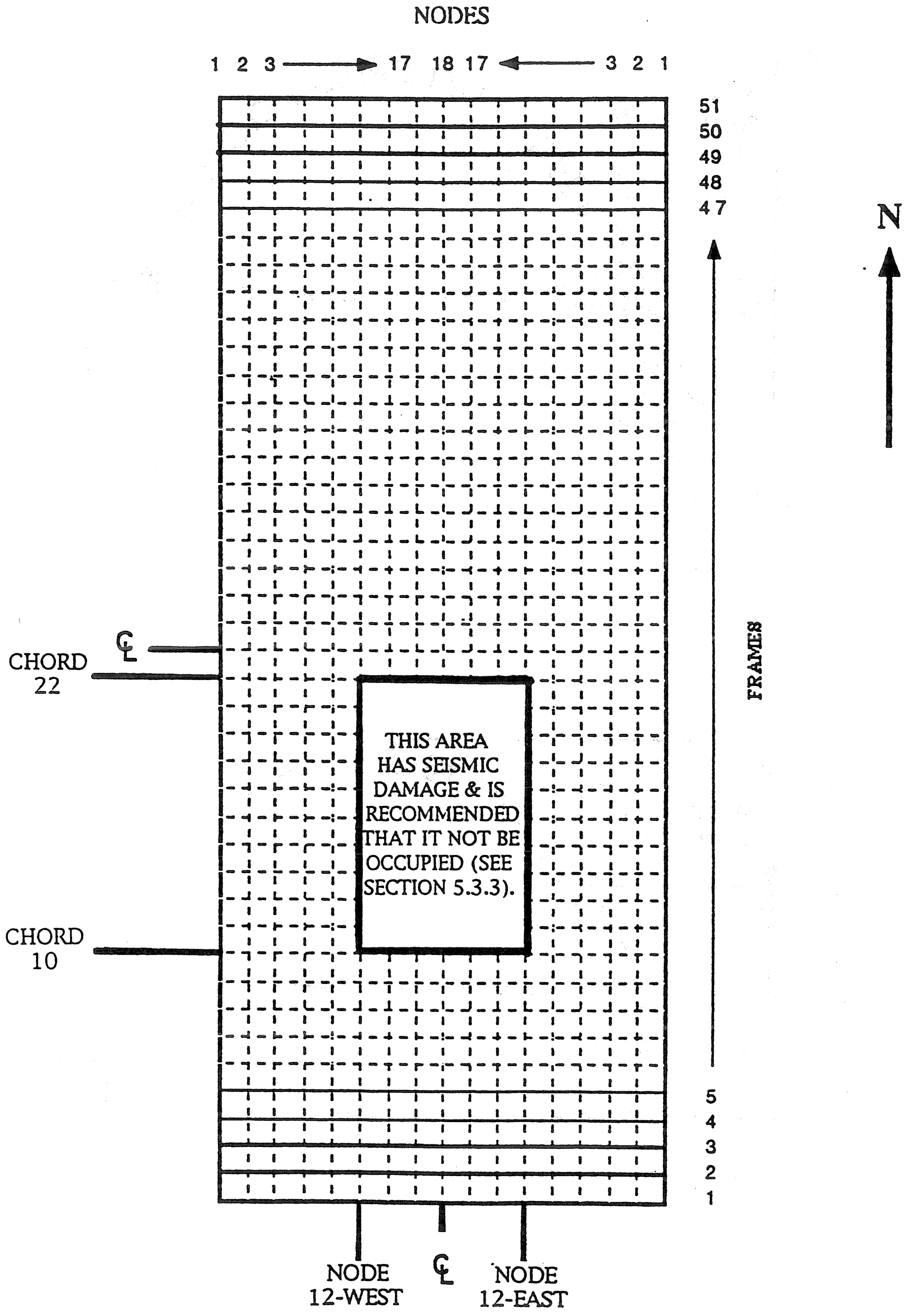


Hangar 3 Elevations



Hangar 3

FRAME AND NODE NUMBERING SYSTEM



6.0 UTILITY CAPACITY

6.1 Hangar 3 - Electrical System

6.1.1 System Description

Hangar 3 draws its power from Switch gear B, one of the five primary switch gear in the NAS. There are 5 substation transformers supplying a total of 2850 KVA electrical power to the hangar, and they are located in 1 electrical room (Rm 4 or Vault 1) in the hangar and 3 substations outside the hangar (see table below and Figure 6.2.1.1). These transformers are fed by Feeders #31, #32, #33 and #34 from Switch gear B. In an event of a failure for Feeder #32 or Feeder #33, the load from either feeder can be shifted to the other feeder by operating the oil switches near the substations.

Feeder	Xfmr #	Vault # or Sub #	Rating (KVA)	*Secondary Voltage
#31	T57.1	Rm 4 (V-1)	300	480/277V
#32	T58	SUB-2	750	480/277V
#33	T59	SUB-1	750	480/277V
	T59.1	SUB-3	750	480/277V
#34	T57.2	Rm 4 (V-1)	300	480/277V
Total			2850	

*Notes:

1. All transformers are rated 12KV, delta connected on the primary, and "Y" connected with a grounded neutral on the secondary.

6.1.2 Analysis Methodology

The electrical utility capacity for this hangar is analyzed using the following method: a sum of KVA rating of all the substation transformers which feed the hangar was obtained from the existing as-built drawings available from the Moffett Field Transition Office (all the information included in the drawings was assumed to be accurate for this analysis). A total KVA for the high bay lights was subtracted from the total KVA of the transformers. The remaining KVA was divided by the square footage of the net office space. The result is then compared to the typical KVA/sq. ft. recommended by the National Electric Code and other established industrial standards.

There are two key elements which are not included in this analysis: the hangar's existing connected load and the typical demand. The existing connected load of Hangar 3 can not be determined unless significant effort is spent taking inventory of all the power consuming equipment in the hangar. This process has not been undertaken due to the limited resources and manpower. However, the lights for the hangar's high bay are counted for load analysis due to the large high bay area which requires special consideration in the analysis. The typical demand can be monitored for a period of time (i.e.: three months or one year) by installing a temporary demand meter on each main feeder for the hangar. However, the typical demand obtained using this method will not reflect the realistic typical demand since the current occupancy in the hangar is very low, and the load drawn is very small. Therefore, the demand factor can not be determined until the hangar is fully occupied again.

6.1.3 System Analysis:

Parameters:

a. Hangar Lights: approx. 323 mercury vapor bulbs at 400W each

b. Gross Square Footage: 433,738

c. Hangar High Bay Square Footage: 223,402

d. Typical Power Demand per Square Foot (Watt/sq. ft.):

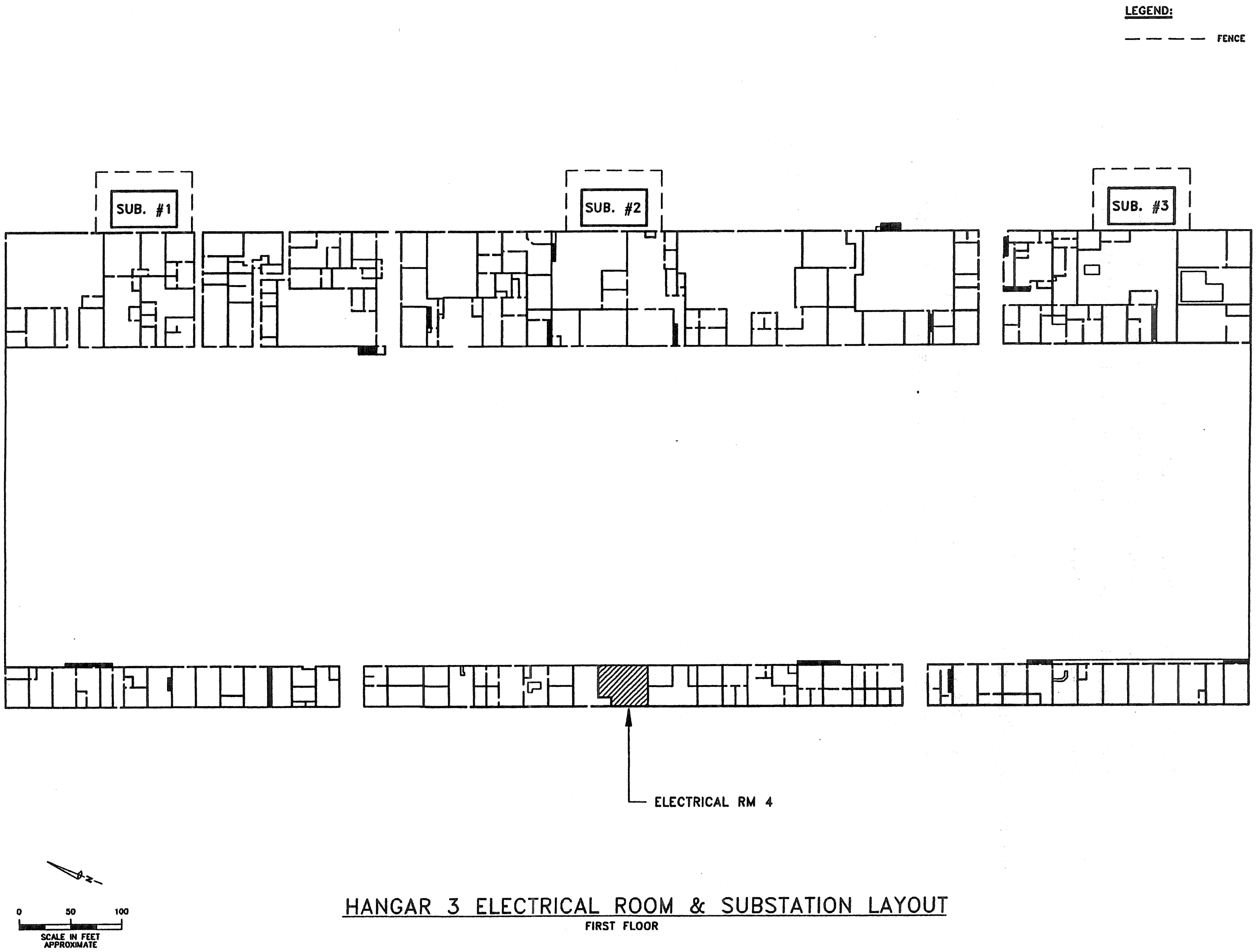
Items	Watts
Lighting	3
Power Outlet	2
Air Conditioning	9
Miscellaneous	1
Typical Demand Total	15

The typical power demand per square foot is 17.6 VA/sq. ft. if a power factor of 0.85 is assumed.

Based on the method of analysis outlined above, the high bay lighting draws 162 KVA assuming the power factor is 0.80 and the demand factor is 1.0. There is 2688 KVA remaining for the rest of the building space, and then, the power available is 12.8 VA per square foot.

6.1.4 Conclusions

The 12.8 VA/sq. ft is approximately 73% of the typical power demand of 17.6 VA/sq. ft. The existing electrical capacity in Hangar 3 may not be sufficient for typical commercial usage if the Hangar 3 office space is fully air conditioned.



HANGAR 3 ELECTRICAL ROOM & SUBSTATION LAYOUT

FIRST FLOOR

6.2 Hangar 3 - Potable Water Distribution

6.2.1 Areas Served

The shaded areas in Figures 10 & 11 show the Potable Water Distribution for Hangar 3. Please note that most of these areas are lavatories, locker rooms, or lounges.

6.2.2 System Description

Since the water pressure is being reduced from 120 psi to 50 psi at the main water meter vault which feeds Moffett Field (References 11.1.1, 11.1.2, & 11.1.3), it will be assumed that approximately 37 psi (P_{SVC}) is being distributed to Hangar 3. This assumption is supported by the flow tests provided in Reference 11.1.4 and the calculations provided in the "FIELD2 Analysis" performed by the University of Kentucky Pipe Network Analysis Program (Reference 11.1.2).

Please note that the flow tests and the Analysis referenced above did not include water supplied to the system through the MILCON P-500 piping project. (The P-500 piping provides approximately 100 psi and is connected to the older system through an 8" pipe and a pressure reducing valve located at the Southwest corner of Hangar 2.) Therefore, a supply pressure greater than 37 psi would result. However, this analysis will not include the additional water supply since extensive calculations would be required to determine the steady-state flow conditions.

The West side of Hangar 3 is currently being supplied potable water through a 6" pipe which is connected (in two places) in parallel to the 8" water main. Two 4" pipes were found supplying the East side. (However, it is believed that there is one more that enters the North end due to the large demand on the East side of the Hangar.) It could not be determined whether these two 4" pipes fed a common header or not (due to limited access and documentation); therefore, it will be assumed that each supplies to 1/2 of the East side. (Documents that show the actual locations of these connections were not found.) See Figure 12 for approximate locations. See Figure 13 for an elevation view of the Potable Water distribution.

6.2.3 Analysis Methodology

The Potable Water Supply to Hangar 3 will be analyzed by comparing the two extreme cases. The first analysis (West side only) assumes that water is only supplied from one connection of each pair and that the piping from the other connection (including its riser) is neglected. This analysis is represented in Figure 12 by the typical pipe segment ABCB. The second analysis (East and West sides) assumes equal flow into Hangar 3 through all 4 connections. This analysis is represented in Figure 12 by the typical pipe segment ABC. Both of these analyses compare the current demand on the system (based on a standard public usage rate for each fixture) to the supply capability of the existing piping. Please note that the actual usage may be more or less.

Both analyses use the same set of calculations as those listed in the Hangar 1 Life Safety Report by Bamsi Inc.(Feb. 1994). The actual calculations, raw data, and other mentioned reports are available upon request at the Moffett Transition Office.

6.2.4 System Analysis

Analysis 1 (West side only)

The West side's Total Demand Load is approximately 125 GPM with an Average Frictional Loss of .78 psi/100 ft. These parameters require a pipe approximately 4.0" in diameter. However, a supply pipe of 6" with the above Average Frictional Loss allows approximately 380 GPM. This means that approximately 67.1% of the system's capability is unused.

Analysis 2 (East and West sides)

The average Total Demand Load on Hangar 3's East side for each branch is approximately 90 GPM with an Average Frictional Loss of 1.81 psi/100 ft. These parameters require a pipe approximately 2.9" in diameter. However, a supply pipe of 4" with the above Average Frictional Loss allows approximately 205 GPM. This means that approximately 56.1% of the system's capability is unused.

The West side's Total Demand Load for one branch to the midpoint of Hangar 3 is approximately 62.5 GPM with an Average Frictional Loss of 1.63 psi/100 ft. These parameters require a pipe approximately 2.5" in diameter. However, a supply pipe of 6" with the above Average Frictional Loss allows approximately 550 GPM. This means that approximately 88.6% of the system's capability is unused.

6.2.5 Conclusions

Both analyses show that the Potable Water Supply piping to Hangar 3 is sized properly. The fact that there are two connections per side (Analysis 2) and the additional water supplied by the P-500 project support the assumption that more demand can be applied to the system.

6.2.6 Problems

Some Navy and Air Force personnel mentioned that several of the drinking fountains were inactivated due to high concentrations of lead in the water. However, there was no documentation to support this. Also, it was noticed that some fixtures supplied rusty colored water.

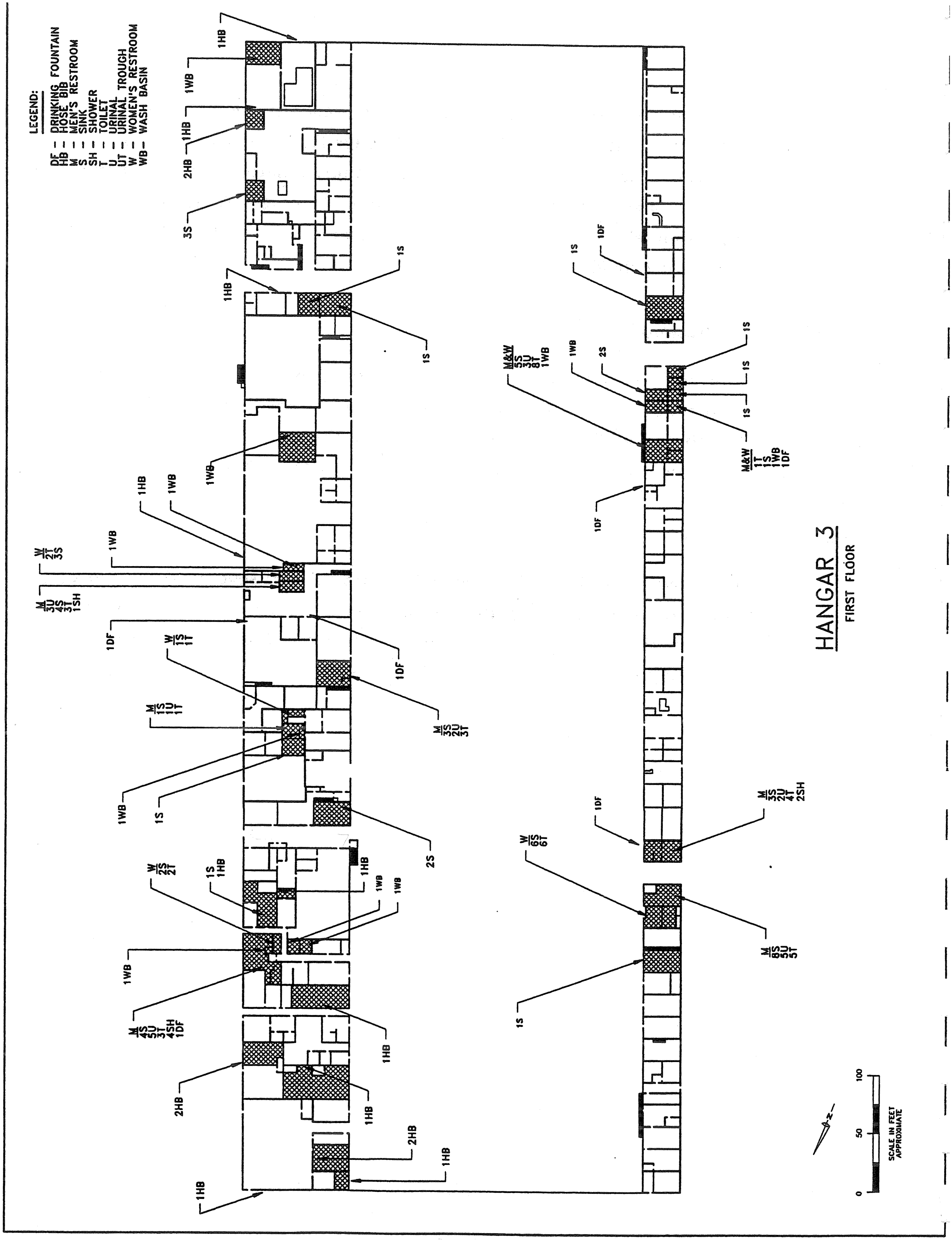
LEGEND:
DF - DRINKING FOUNTAIN
HB - HOSE BIB
M - MEN'S RESTROOM
S - SINK
SH - SHOWER
T - TOILET
U - URINAL
UT - URINAL TROUGH
W - WOMEN'S RESTROOM
WB - WASH BASIN
HANGAR 3
FIRST FLOOR
1HB
1WB
1HB
2HB
3S
1HB
1S
1S
1WB
1HB
1WB
W 2T 3S
1WB
M 3U 4S 3T 1SH
1DF
1DF
W 1S 1T
M 1S 1U 1T
M 3S 2U 3T
1WB
1S
2S
W 2S 2T
1S 1HB
1HB
1WB
1WB
1WB
M 4S 5U 3T 4SH 1DF
1HB
2HB
1HB
2HB
1HB
1HB
1S
1DF
M&W 5S 3U 8T 1WB
1WB
2S
1S
1S
1S
M&W 1T 1S 1WB 1DF
1DF
1DF
M 3S 2U 4T 2SH
W 6S 6T
M 8S 5U 5T
1S
N
0
50
100
SCALE IN FEET APPROXIMATE

FIGURE 10

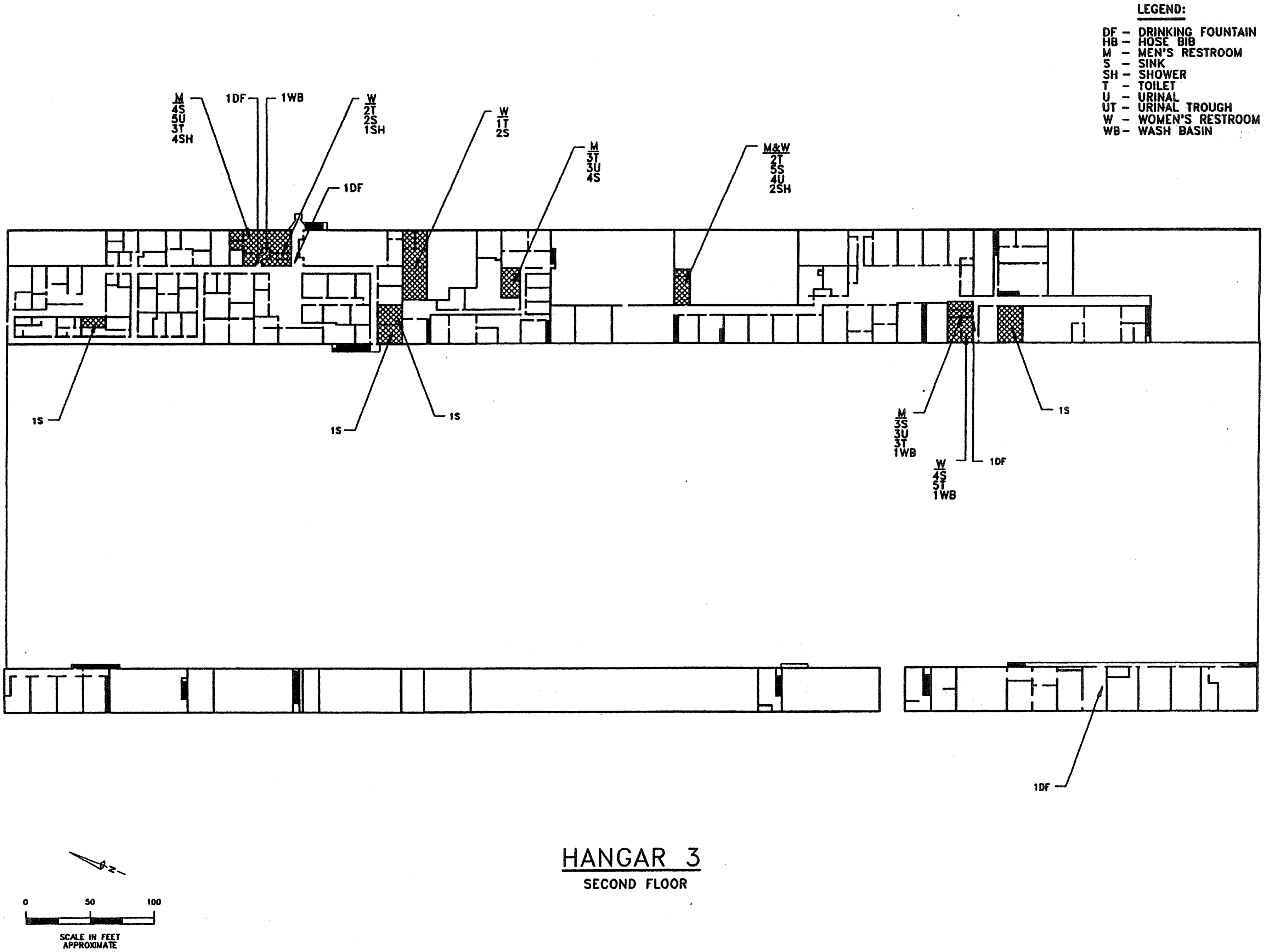
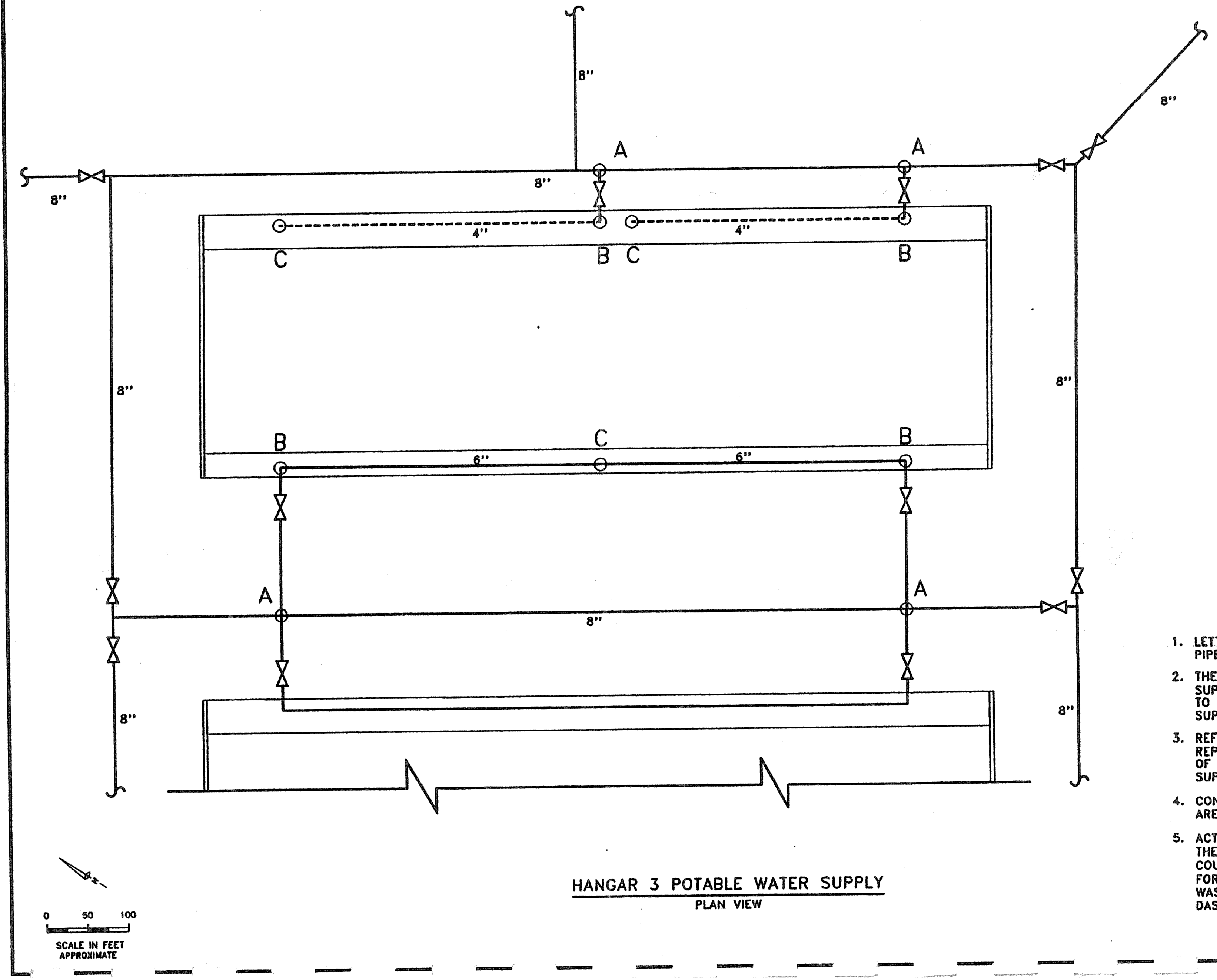

LEGEND:
DF - DRINKING FOUNTAIN
HB - HOSE BIB
M - MEN'S RESTROOM
S - SINK
SH - SHOWER
T - TOILET
U - URINAL
UT - URINAL TROUGH
W - WOMEN'S RESTROOM
WB - WASH BASIN
M 4S 5U 3T 4SH
1DF
1WB
W 2T 2S 1SH
1DF
W 1T 2S
M 3T 3U 4S
M&W 2T 5S 4U 2SH
1S
1S
1S
M 3S 3U 3T 1WB
W 4S 5T 1WB
1DF
1S
1DF
HANGAR 3
SECOND FLOOR
0
50
100
SCALE IN FEET APPROXIMATE
N

FIGURE 11



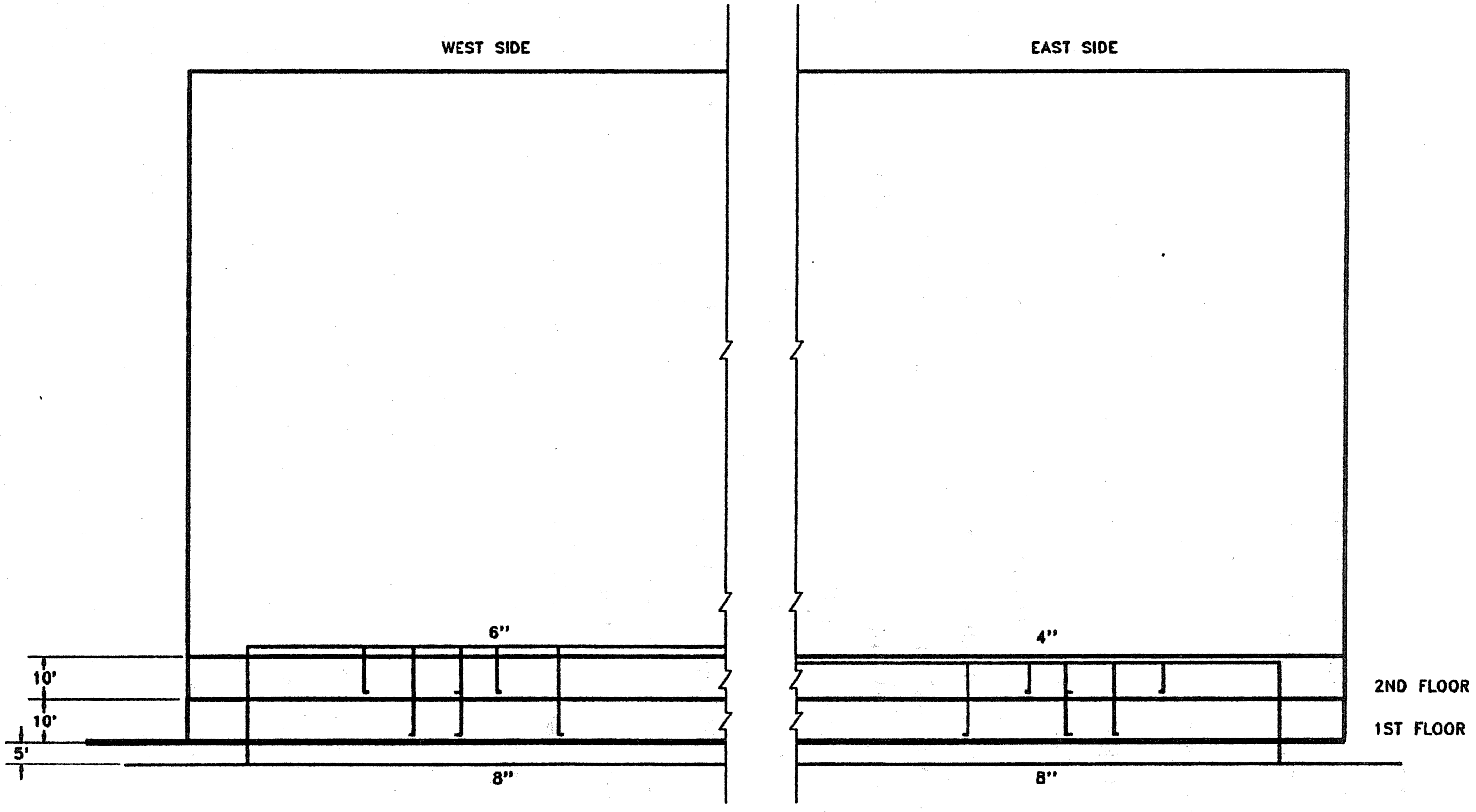
HANGAR 3 POTABLE WATER SUPPLY

PLAN VIEW

NOTES:

1. LETTERS ARE USED TO DEFINE PIPE SEGMENTS FOR ANALYSIS.
2. THE WATER SUPPLY CAN BE SUPPLEMENTED BY THE CONNECTION TO THE HIGH PRESSURE WATER SUPPLY (P-500 PROJECT).
3. REFER TO SECTION 6.4 FOR A REPRESENTATION AND DESCRIPTION OF THE HIGH PRESSURE WATER SUPPLY (P-500 PROJECT).
4. CONNECTIONS FOR FIRE PROTECTION ARE SHOWN IN SECTION 6.4.
5. ACTUAL WATER DISTRIBUTION ON THE EAST SIDE OF HANGAR 3 COULD NOT BE VERIFIED. FOR CALCULATIONS, DISTRIBUTION WAS ASSUMED AS SHOWN WITH DASHED LINES.

FIGURE 12



HANGAR 3 POTABLE WATER SUPPLY

ELEVATION VIEW

FIGURE 13

6.3 Hangar 3 - Fire Protection System

6.3.1 Areas Served

The shaded areas in Figures 8 & 9 show the areas in Hangar 3 that are currently fire protected.

6.3.2 System Description

Hangar 3 can be broken into three types of occupancies: Hangar Support areas, Active Aircraft Servicing areas, and Inactive Aircraft Servicing areas. The Hangar Support areas consist mainly of offices, classrooms, service shops, electric vaults, and other support functions. Fire extinguishers are placed throughout the Support areas. These areas total to approximately 215,300 sq. ft. with virtually all of the floorspace sprinkler protected (Ordinary Hazard, 165° F pendent and upright sprinkler heads (212° F near heating coils), Automatic Wet Pipe w/ Thermal Actuators.)

The East side of Hangar 3 is served by 10 - 6" fire protection risers that are tied into the old low pressure system. The West side is served by 2 - 6" risers. See Figure 10 for a representation of the Fire Protection supply piping. Also, there are 12 - 12" pipes which run from the P-500 high pressure system to points just outside Hangar 3 for future connections.

Due to the fact that fenced-in storage areas have been built in the original Aircraft Servicing area, some of this area is "Inactive" as far as aircraft storage and maintenance is concerned. Approximately 193,990 sq. ft. of the initial 223,400 sq. ft. is still considered "Active." The only type of fire protection available inside either the Active or Inactive areas are manually-operated fire extinguishers. A system of 2-1/2" hose valve stations at the first floor level was originally installed in the Hangar. However, this system has been abandoned (hoses were removed and pipes capped off) by the Fire Department due to age and lack of suitability to fight a fire. There are also 10 low pressure and 9 high pressure fire hydrants located outside of Hangar 3. (See Figure 10 for locations.)

Since the water pressure is being reduced from 120 psi to 50 psi at the main water meter vault which feeds Moffett Field (References 11.2.1, 11.2.2, & 11.2.3), it will be assumed that approximately 37 psi (P_{SVC}) is being distributed to Hangar 3. This assumption is supported by flow tests (Reference 11.2.5) and the calculations provided in the "FIELD2 Analysis" performed by the University of Kentucky Pipe Network Analysis Program (Reference 11.2.2).

Please note that the flow tests and the Analysis referenced above did not include water supplied to the system through the MILCON P-500 piping project. (The P-500 piping provides approximately 100 psi and is connected to the older system through an 8" pipe and a pressure reducing valve located at the Southwest corner of Hangar 2.) Therefore, a supply pressure greater than 37 psi at Hangar 3 could result. However, this analysis will not include the additional water supply since flow tests or extensive calculations would be required to determine the steady-state flow conditions.

6.3.3 Analysis Methodology

*Note:

This analysis is based on findings and proposals in References 11.2.4 and 11.2.5, codes provided in References 11.2.6 through 11.2.8, and concepts/calculations provided in References 11.2.9 and 11.2.10.

Hangar 3 is considered a Group I Aircraft Hangar. The existing conditions will be compared to key Fire Protection Code requirements. These requirements are as follows:

1. An Aqueous Film Forming Foam (AFFF) Deluge System (Code 409, Section 3-1.1 of Reference 11.2.6) with a sustained (10 minute minimum - (Code 409, Section 3-2.3.13 of Reference 11.2.6)) discharge rate of .16 GPM/sq. ft. (Code 409, Section 3-2.3.12 of Reference 11.2.6 & Section 4.4.6(a) of Reference 11.2.7) using a protection area of 35,000 sq. ft. to determine water volume requirements (Section 4.4.6(b)(3) of Reference 11.2.7).

2. A supplementary low-level, fixed AFFF Nozzle System (Code 409, Section 3-1.2 of Reference 11.2.6) with a sustained (10 minute minimum - (Code 409, Section 3-2.3.13 of Reference 11.2.6)) discharge rate of .10 GPM/sq. ft. (Section 4.4.6(c) of Reference 11.2.7) using a protection area of 35,000 sq. ft. (Section 4.4.6(b)(3) of Reference 11.2.7) to determine water volume requirements.

3. Foam concentrate tanks, proportioning equipment, and deluge valves must be separated from the main Hangar areas by construction having a minimum of 1-hour fire resistance rating (Section 4.4.6(d) of Reference 11.2.7).

4. Fire walls rated at 3 hours between adjoining Active Aircraft Servicing Areas (Code 409, Section 2-2.1 of Reference 11.2.6).

5. Separations between the Active Aircraft Service Areas and Hangar Support Areas must have 1-hour rated walls & ceilings, and 45 minute-rated doors (Code 409, Section 2-2.3 of Reference 11.2.6).

6. Automatic Wet-pipe Sprinkler Systems for all other Hangar Support Areas (Code 409, Section 3-1.3 of Reference 11.2.6) with a sustained pressure of 15 psi for a minimum of 60 minutes (Code 13, Table 2-2.1.1(a) of Reference 11.2.6).

Analysis of the first 5 requirements listed above will be based on the analysis (Reference 11.2.4). This study was reviewed with the intent to enhance/update the original design recommended for Hangar 1 while focusing on saving money. The available pressure from the P-500 water supply was calculated based on peak flow requirements. This data was combined with the pressure requirements for the AFFF systems to determine the pumping requirements. Also, since the roof is made of combustible materials, two roof protection systems were compared by calculating the interior surface area, and the flow/pressure requirements for each.

As previously mentioned, most of the Hangar Support Areas are sprinkler protected. It will be assumed that sprinkler protection is not required in the areas that are not currently protected. The areas that *are protected* were analyzed first by comparing the existing conditions to the code requirement (Code 13, Section 4-2.2.1 of Reference 11.2.6) for the maximum floor area on any one floor to be protected by sprinklers supplied by any one sprinkler system riser or combined system riser (52,000 sq. ft. for Light or Ordinary Hazard designs). Since documentation was not available which shows the distribution of the water supply from the risers, equal distribution will be assumed.

Since equal distribution was assumed, the largest room for each side of the Hangar must be chosen to analyze the fire protection system using the Room Design Method (Code 13, Section 2-2.3 of Reference 11.2.6). The following is a summary of that method. (The actual calculations and raw data are available upon request at the Moffett Transition Office).

1. The area (A) of the room that creates the greatest demand on the sprinkler system was found.
2. Using the Density Curves (Code 13, Figure 2-2.1.1(b) of Reference 11.2.6), the required density (p) for the sprinkler system in question was found for the area found in step 1.
3. The total amount of water needed for sprinklers (Q_{sp}) in this area (assuming that all of the heads were actuated) was found by multiplying A & p.
4. Code 409, Section 3-2.4.5 of Reference 11.2.6 requires that 500 GPM of water consumption be included to account for hoses supplied by a fire hydrant (Q_{hose}). However, it will be assumed that one of the high pressure hydrants is used which would not deplete pressure from the low pressure system that the sprinkler risers are tied into. 20% of the total sprinkler consumption is then added to account for hydraulic imbalances (recommendation from Dan Kaiser, Fire Protection Engineer) to find the total amount of water needed (Q_t).
5. The total flow was then compared to data from flow tests provided in Reference 11.2.5 to determine if the supply to the building was sufficient. (Although the flow test data was from 1985, due to water conservation measures, and variables such as increased water demand, and the additional water from the cross-connection between the older system and the P-500 Project have not been included, it will be assumed to be accurate until the data is updated.)

6. The building service pressure (P_{svc}) was then assumed based on findings listed in Section 6.3.3.2.

7. The static pressure loss (P_s) was then calculated.

8. The friction pressure loss (P_f) was then calculated.

9. The minimum P_{svc} necessary to maintain a minimum residual pressure (P_r) of 15 psi for Ordinary Hazard designs (Code 13, Table 2-2.1.1(a) of Reference 11.2.6) was then calculated by adding P_s , P_f , & P_{svc}. This value was then compared to the actual P_{svc}.

10. The Pipe Schedules (Code 13, Chapter 8 of Reference 11.2.6) were then used to determine if system riser is sized properly.

6.3.4 System Analysis

The requirements for a Group I Hangar were analyzed in the Fire Protection Planning Study for Hangar 1 (Reference 11.2.4). Most of the comments and recommendations would also apply to Hangar 3 since its size and configuration is similar. However, since it is constructed with combustible materials, provisions should be made to protect the wooden roof structure.

The exposed interior surface area of the roof amounts to approximately 507,250 sq. ft. To comply with Code 409, Section 3-2.3.3 of Reference 11.2.6 , approximately 3,902 sprinklers (based on Code 13, Section 4-2.2.2.1 of Reference 11.2.6) and 10 risers (based on Code 13, Section 4-2.2.1 of Reference 11.2.6) would be required to protect the roof with an Ordinary Hazard design. If the 12 existing 12" P-500 pipes were used, each would be required to provide 8,716 GPM (including hose connections and a 20% hydraulic imbalance) at a pressure of 106.9 psi. If this fire protection was used without the AFFF system, approximately 108.9 psi would be available which is greater than the required pressure. (Note: The roof fire protection system can be broken up into more zones which would result in less pressure/flow requirements).

The exposed interior surface area of the roof directly above the Hangar Support areas (below the 100 foot level) amounts to approximately 160,500 sq. ft. This coverage would require a total of 1235 sprinklers. If the 12 existing 12" P-500 pipes were used, each would be required to provide 3,168 GPM (including 500 GPM for hose connections and 20% for hydraulic imbalances) at a pressure of 62.2 psi. If this fire protection was used without the AFFF system proposed for Hangar 1, approximately 126.8 psi would be available which is greater than the required pressure. (Note: The roof fire protection system can be broken up into more zones which would result in less pressure/flow requirements.)

If partial roof protection is incorporated with the AFFF system, a peak flow of 14,168 GPM would be required from the P-500 piping. After friction losses, approximately 78.2 psi would be available at Hangar 3. This pressure is greater than the pressure required for the partial roof protection; however, a pumping station would be necessary for the AFFF system. This pumping station would require 4 pumps (3 for peak flow, 1 backup) rated at a minimum of 195 HP, as well as support equipment.

The Active Aircraft Servicing Area in Hangar 3 is one large high bay that can serve up to twelve P-3 Orion planes or numerous planes smaller in size. There are no 3 hour-rated partitions between Service stations. Also, the Hangar Support Areas are not separated from the Active Servicing Area with the required fire rated construction.

Upon analyzing the sprinkler systems, it was found that both the Ordinary Hazard systems were within the maximum coverage limit of 52,000 sq. ft. by any one sprinkler system riser (approximately 16,537 sq. ft. per riser on the East side & 24,960 sq. ft. per riser on the West side.)

The room with the largest demand Hangar 3 on the East side was found to have a projected area of 6,400 sq. ft.. This equates to a peak demand of approximately 749 GPM which is more than the measured rate available provided in Reference 11.2.5. After adding the losses to the minimum residual pressure, the minimum service pressure was found to be 29.9 psi which is less than the available pressure (37 psi). Approximately 127 sprinklers are required to protect each 16,537 sq. ft. area on the East side (based on a pipe schedule design of 130 sq. ft. coverage per sprinkler). Using Code 13, Table 8-2.2 of Reference 11.2.6, it can be seen that a 6" steel pipe can support 275 sprinklers.

6.3.5 Conclusions

Human life and millions of dollars in property are at great risk in Hangar 3 (see Reference 11.2.4). Several Fire Protection projects must be undertaken to prevent a catastrophe.

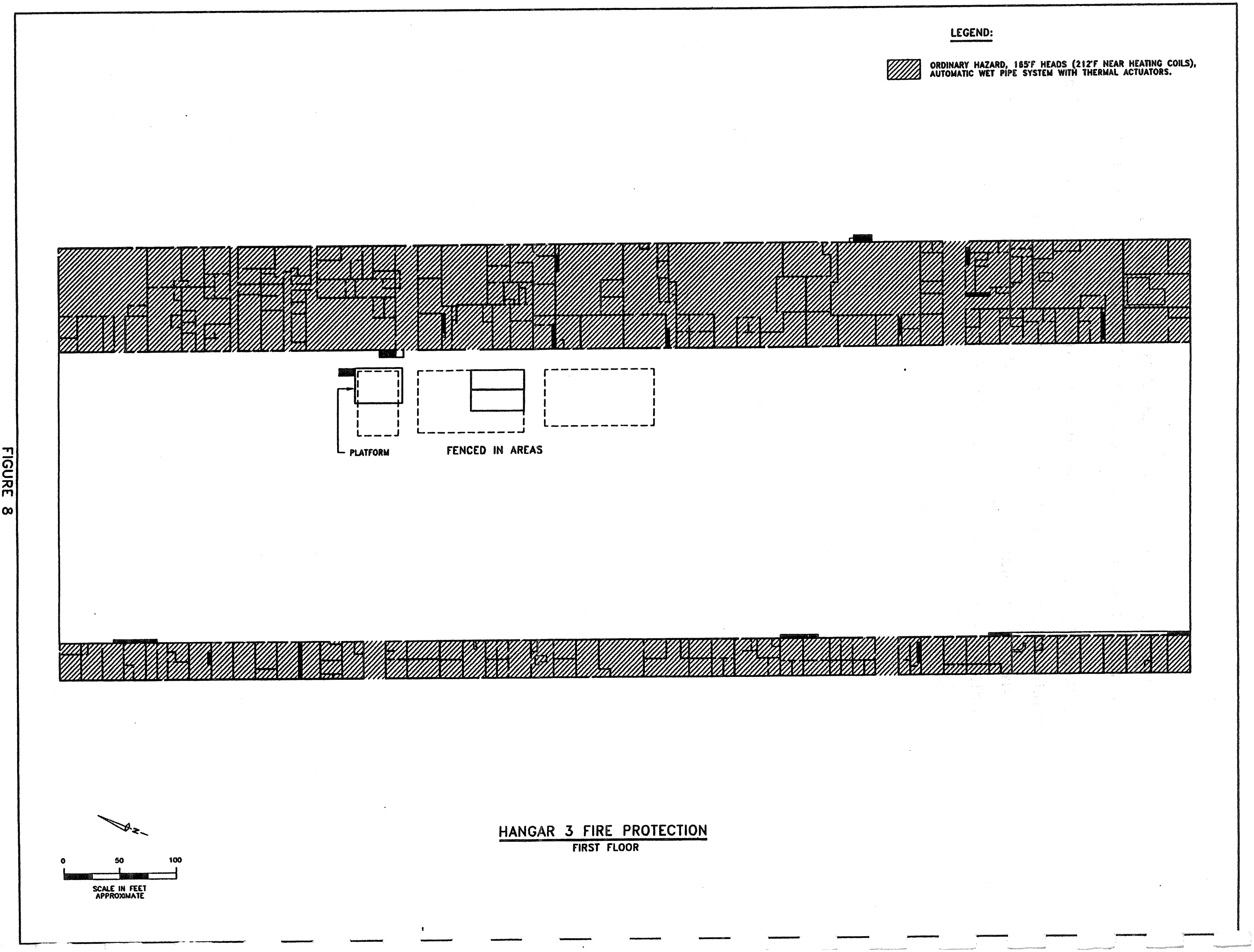
Due to the fact that the roof of Hangar 3 is constructed of combustible material, it should be protected by an AFFF deluge system. However, the P-500 piping does not have the capability to protect the entire roof at the required flow rate of .16 GPM/sq. ft. and maintain a residual pressure of 15 psi at the highest point. Therefore, at least part of it (~80 feet and below) should be protected. If the partial protection of the roof is chosen, the proposed upper & lower AFFF systems (Reference 11.2.4) should also be installed in the Active Aircraft Servicing Areas. Also, the AFFF pumping station and supply equipment can be shared between Hangars 2 & 3 to save money and since the water supply would not be able to handle fires in both Hangars.

In either case the foam concentrate tanks, proportioning equipment, and deluge valves should be installed in the hangar with a 1 hour fire resistance rated separation or outside the Hangar. Either system would also require a drainage project (discussed in Section 6.4.3 of this document.)

The requirement of 3-hour rated fire walls between adjoining Active Aircraft Servicing Areas does not seem feasible due to the configuration and size of the Hangar. This requirement is only necessary if you size the fire protection system to handle a smaller area. The proposed systems mentioned above are sized to eliminate the need for 3-hour fire walls. The requirement for 1-hour rated walls & ceilings, and 45-minute rated doors (or an equivalent separation such as a water curtain) between the Active Aircraft Service Areas and Hangar Support Areas should be adhered to since the aircraft that are brought into the hangar still have approximately 500 gallons of residual fuel (JP-5) in their tanks. Also, this modification should include water damage protection from a deluge system.

Based on the data from the flow tests in 1985, the water supply to the East side is inadequate to protect its largest room. However, the cross-connection between the older system and the P-500 Project may have increased the flow capabilities to this area. The existing 6" risers are sized to handle their current load plus they have the capability of handling more demand on them (provided that the building supply can handle it.)

The West side of the Hangar Support Area that is sprinkler protected was found to be fully supported by existing water supply. The existing 6" risers are sized to handle their current load plus they have the capability of handling more demand on them (provided that the building supply can handle it.)



HANGAR 3 FIRE PROTECTION
FIRST FLOOR

FIGURE 8

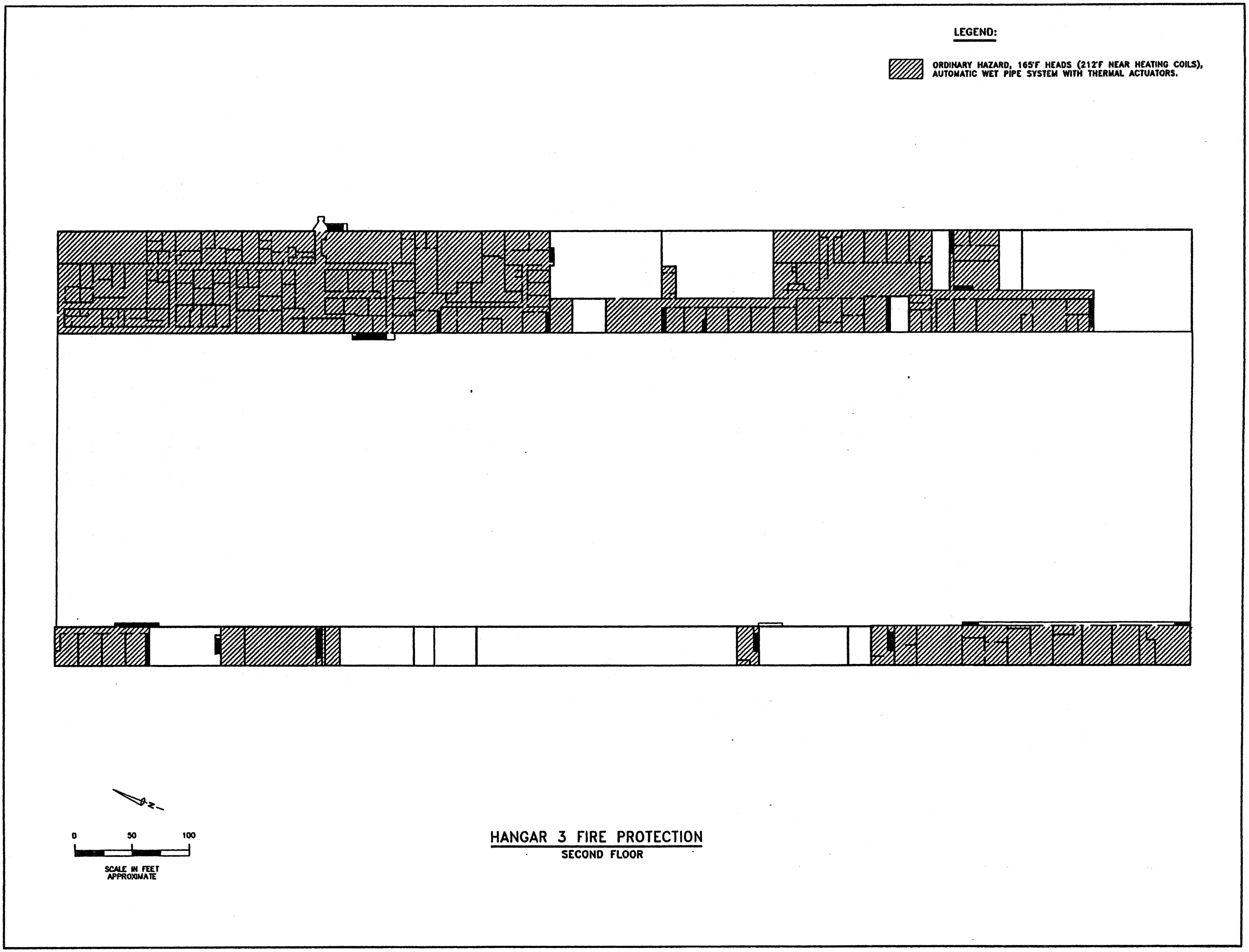
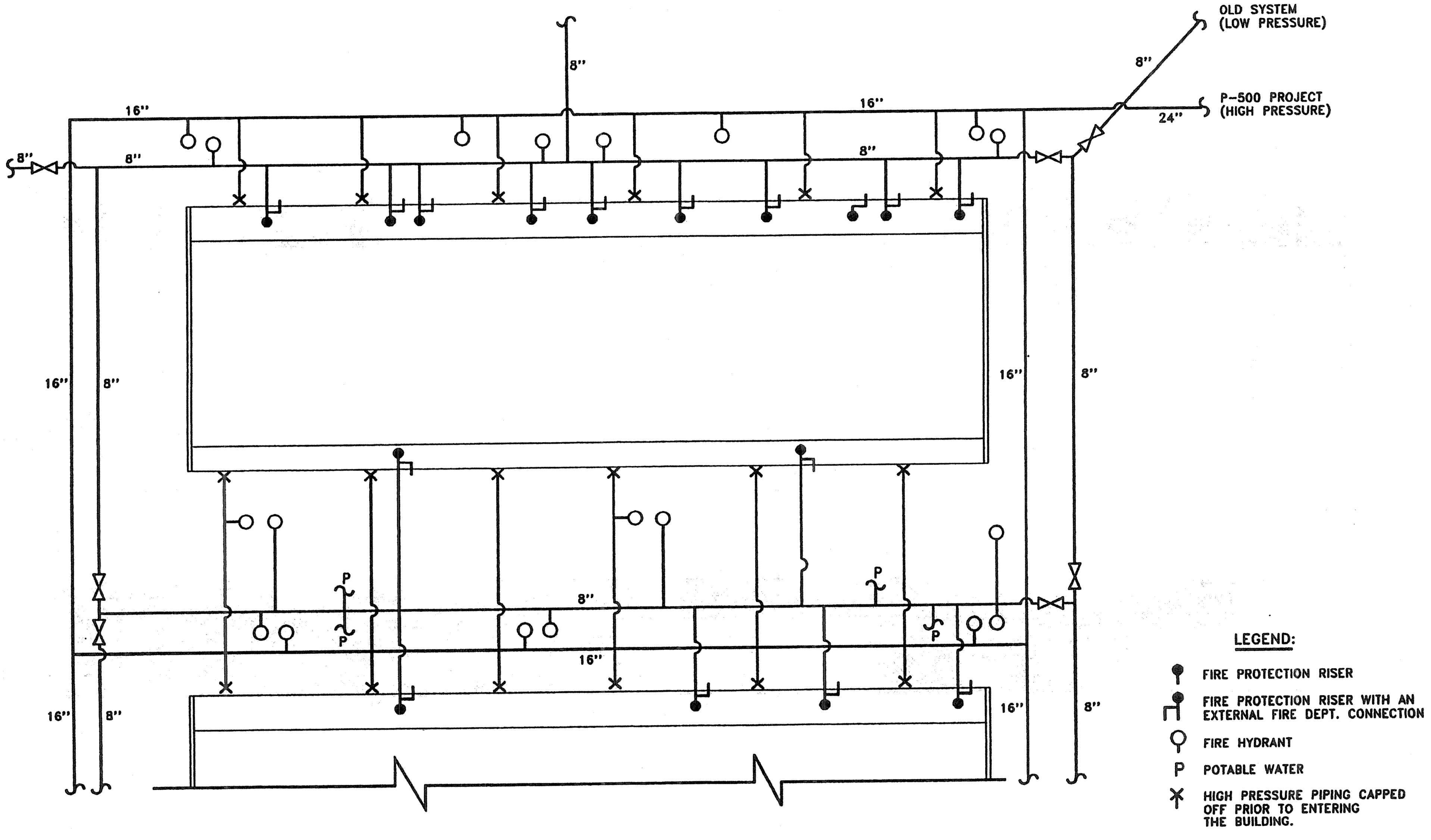

LEGEND:
ORDINARY HAZARD, 165°F HEADS (212°F NEAR HEATING COILS), AUTOMATIC WET PIPE SYSTEM WITH THERMAL ACTUATORS.
HANGAR 3 FIRE PROTECTION
SECOND FLOOR
N
0
50
100
SCALE IN FEET
APPROXIMATE

FIGURE 9



HANGAR 3 FIRE PROTECTION SUPPLY

PLAN VIEW

NOTES:

1. THE WATER SUPPLY CAN BE SUPPLEMENTED BY THE CONNECTION TO THE HIGH PRESSURE WATER SUPPLY (P-500 PROJECT).
2. POTABLE WATER PIPING IS SHOWN IN SECTION 6.3.

FIGURE 10

6.4 Hangar 3 - Sanitary Sewer System

6.4.1 System Description

Two sources which supply liquid waste to the Sanitary drainage system are:

1. Domestic water supply.
2. Fire protection systems.

6.4.2 Domestic Water Drainage.

Hangar 3 drainage system is evaluated according to UPC which takes into account the number of plumbing fixtures and multiplying them by a unit factor unique to each fixture.

This is summarized in Table 3.

Table 3

Plumbing fixture	Amount	Unit factor	Total
Drinking fountain	11	1	11
Sink	88	3	264
Toilet	59	6	354
Urinal	36	3	108
Wash basin	15	2	30
Shower	15	2	30
Hose bibs	30	4	120
		Total:	917

Per Table 4-3 of the Uniform Plumbing Code, one 6" horizontal pipe line (720 units capacity) and one 4" pipe (216 units capacity) are required to remove liquid waste in the amount of 917 fixture units.

There are no as-built or other documentations which can assure, that the drainage system of Hangar 3 is in compliance with the UPC. However, there is one available drawing which shows the Sanitary Sewer system outside of the hangar. It is assumed, that the building drain is connected to this Sanitary Sewer, which consists of one 6" line running on West side and one 10" line running on the East side of the hangar. Therefore, Hangar 3 has more than sufficient Sanitary Sewer capacity for domestic water applications. However, as stated previously, there is no proof that the inside hangar part of the drainage system is sized properly.

Typically the building sewer lines (the lines which run outside of the building) are either equal or slightly bigger than the building drain lines (the lines inside of the building).

Taking this into account, and based on the lack of major complaints during the long maintenance experience, it can be safely assumed that the hangar 3 drainage system is sized properly.

6.4.3 Fire Protection Water Drainage.

NFPA 409 requires that a fire protection system (sprinkler water plus AFFF) shall be matched by a drainage system of equal capacity. There is no special drainage system currently available for fire protection usage in Hangar 3. In order to upgrade the fire protection systems in accordance to the codes, new drainage systems shall be designed and installed. As per code, floor drainage systems are required not only to remove the fire sprinkler water and the AFFF flow, but to restrict the spread of fuel as well in order to reduce the fire and explosion hazards from fuel spillage.

Previous engineering studies have recommended that in case of fire the sprinkler water and the water from deluge systems shall be discharged to the existing Storm Drain System.

The latest instructions from the EPA do not allow to use the Storm Drain for fire protection water removal.

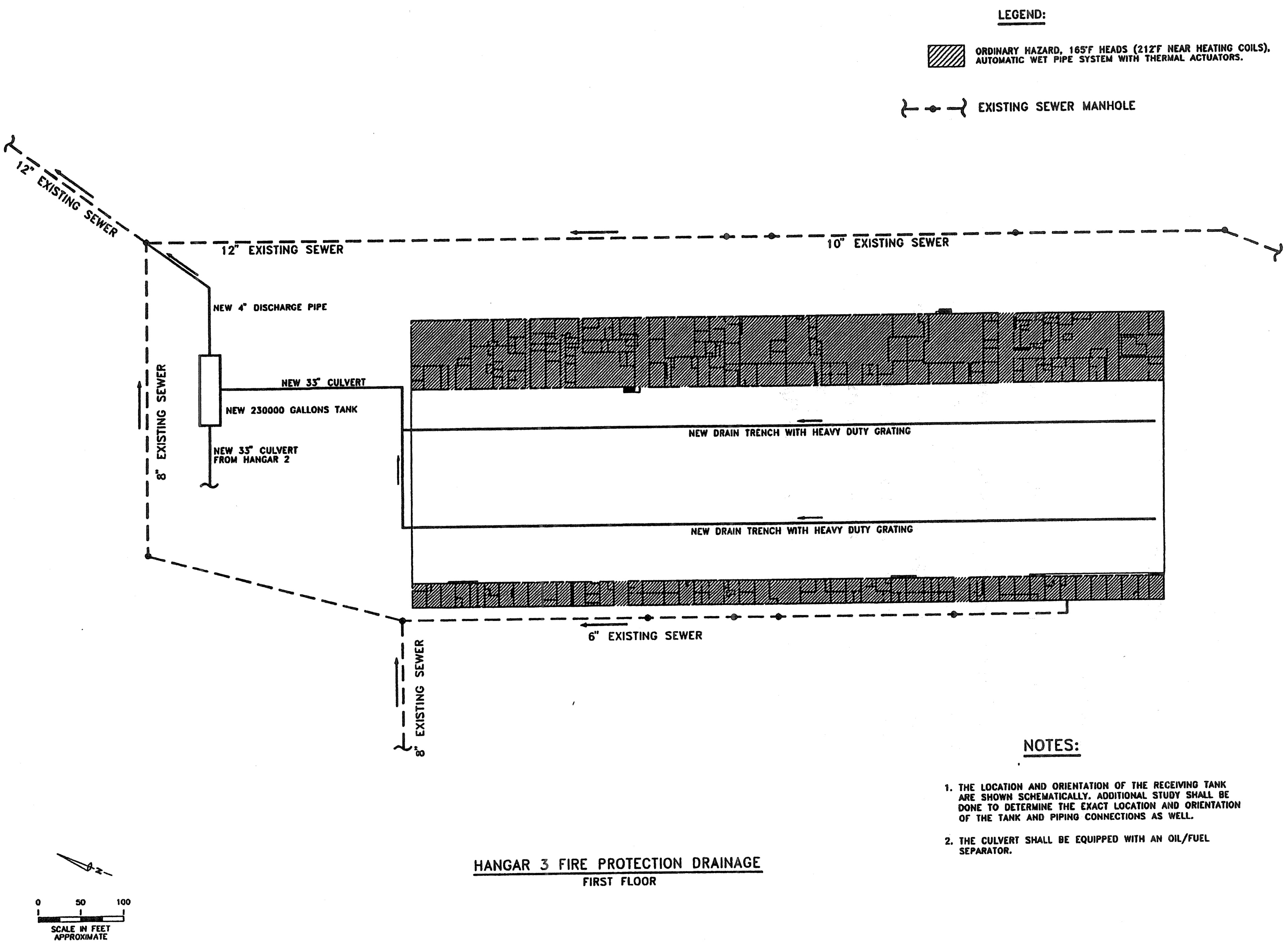
The Sanitary Sewer system can be utilized instead of the Storm Drainage system for fire protection. However, the existing sanitary sewer is not big enough to handle the water flow at the estimated rate of approximately 12,150 GPM.

For the above reasons the fire protection drainage problem shall be resolved in a different way.

6.4.4 Conclusions

These are the recommendations for new Fire protection drainage system:

Based upon the Fire Protection System analyses by Gary Storck for Hangar 3, a maximum of 12,150 GPM of water will be required for both the sprinkler and AFFF systems. Since the existing sanitary sewer cannot handle such an amount of water at the indicated rate, a receiving tank has to be installed. That can be accomplished in such a way that both Hangar 2 and Hangar 3 can be served by the same tank. For trench and culvert runs see Figure 4-2, for tank location see Figure 4-3.



HANGAR 3 FIRE PROTECTION DRAINAGE
FIRST FLOOR

NOTES:

1. THE LOCATION AND ORIENTATION OF THE RECEIVING TANK ARE SHOWN SCHEMATICALLY. ADDITIONAL STUDY SHALL BE DONE TO DETERMINE THE EXACT LOCATION AND ORIENTATION OF THE TANK AND PIPING CONNECTIONS AS WELL.
2. THE CULVERT SHALL BE EQUIPPED WITH AN OIL/FUEL SEPARATOR.

FIGURE 4-3

7.0 ELECTRICAL INFRASTRUCTURE ASSESSMENT

7.1 Background

Approximately 1,100 deaths resulting from electrical shock are reported each year in the United States. Approximately 25% of industrial building fires in the United States are attributed to faults in the electrical systems. According to the 1986 edition of the Fire Protection Handbook, electrical system failure is the leading nonhuman (2nd only to arson) cause of industrial fires. Electrical connections (splices, switch gear, winding taps, etc.) and conductors are all susceptible to heating caused by high resistance or overloading. Normal wear and tear, faulty materials, and problems with the design and workmanship all contribute to this destructive situation. Once a connection begins to heat, its failure, without maintenance, is just a matter of time. Imbalanced circuits or overloaded conductors can indicate serious problems or lead to failures.

This section of the Life Safety Report is dedicated to identifying Existing/Future Failure Conditions and Life Safety Hazards in the hangar's infrastructure electrical system. An inspection team, with technical backgrounds in Engineering, General Contracting, High voltage Electricity and Thermography, thoroughly inspected the hangar electrical infrastructure and reported it's findings herein. However, two limitations existed at the time of the inspections that prevented a complete assessment of the overall electrical system:

1) The electrical systems inspected were limited to the electrical infrastructure interface with the low voltage distribution systems to the hangar (unless specified otherwise, inspections were limited to six (6) individual 12kv medium voltage electric services, the associated utility voltage transformation equipment and over-current protective devices). The low voltage distribution systems were not inspected and are not included in the contents of this report. A separate study of the low voltage distribution system for the hangar space occupied by each Resident Agency is strongly recommended (based on the RA's individual needs).

2) Due to the lack of specialized resources and the requirement for an electrical shutdown of each system, the inability to conduct all the

recommended electrical test procedures (i.e. checking the calibration of the over-current protective devices, checking the resistance of winding insulation, etc.) existed. There is no record of these tests or of any preventive maintenance (almost all the equipment that was inspected had excessive dust accumulation) ever being performed on this equipment. It is recommended that these test procedures and that standard preventative maintenance procedures be performed on this equipment as soon as possible.

7.2 Inspection Methodology

Two methods of field inspection were utilized to obtain the necessary data:

1) Visual Inspections - An inspection sheet (questionnaire-check list; a sample is included in Appendix B) was prepared. A field observation of the existing infrastructure electrical systems, plus an evaluation of their condition was performed. The resulting data was recorded on the inspection sheets; which includes the documentation of all the areas of conformance or non conformance with the 1993 version of the National Electrical Code and the most recent edition of the NASA Facilities Engineering Handbook. Obvious failure conditions were also documented.

2) Thermographic Inspections - Since the mid-1960s infrared thermography has been highly accepted by the utility industry worldwide as a vital inspection and diagnostic tool. This extremely sensitive equipment senses surface temperature differences as small as .15 degrees C; making the location of the "hot spots" easily identifiable. The thermal information was recorded and is presented hereinafter as a black and white photo image, with warmer objects appearing lighter. The inspection team focused on these warmer areas and attained the temperature and electrical current readings associated with the circuits that generated the heat. Using this data, FUTURE SCENARIOS were calculated with the intent to predict the electrical system's possible future failure. The goal, for these predictions, is to prevent SAFETY HAZARDS and property damage before they occur.

*Note:

Copies of the inspection sheets and the video tapes containing the thermographic data are available from the Moffett Transition Office.

7.3 Analysis Methodology

The inspection data was then analyzed and the findings were organized into the following report format, which includes: the date of inspection, the name of the inspector(s), the system location (supported by the attached map of the Hangar 3 first floor), the system description, the visual and thermographic inspection findings, the recommended action to be taken (if applicable), and the potential future scenario (the future failure condition that could occur if the corrective action is not taken). All the findings requiring corrective action were evaluated and prioritized with a system based on the following criteria:

Category I - **Critical.** This category is to be used when components are ready to fail or are in the process of failing. It is also to be used when component failure could cause a fire, explosion, loss of life, personal injury, major component damage, damage to safety - related systems, or release of radiation. Response to this finding should be immediate. The proper management should be alerted and informed of the evaluation and recommendations.

Category II - **Serious.** This category is to be used when indications of probable failure are observed, but not to the magnitude of the critical category. The potential for personal injury is very small. Response to this type of problem should be very prompt to minimize equipment damage.

Category III - **Moderate.** This category is to be used when indications are those where increased surveillance would be prudent. Management should be promptly advised that this may be an early indication of trouble. Repair or replacement should be effected before the indication jumps to the serious category.

Category IV - **Advisory.** Most indications, that are found, fall into this category. These include poor electrical connections, phase imbalances, etc. All of these should be on a reasonable preventive maintenance schedule. Plant management should be advised that increased surveillance may be necessary.

Calculations: The calculations concluding the hypothetical data setforth in Tables 7.1 - 7.3 (used to depict certain FUTURE SCENARIOS) are based on a formula derived from Ohm's Law: $P = I^2 X R$ [1]. This is an accurate estimate of the heat generated by current through a conductor/connection/contacts with a fixed resistance. However, there are additional variables (unavailable at the time of performing the calculations) that can also influence the temperature of the conductor/connection/contacts as the demand load increases on the circuit.

The actual temperature of the conductor was unknown at the time of the inspection; the surface temperature of the insulation surrounding it was the only data available for measurement. The insulation surface temperature can also be influenced by several other variables:

1) Solar insolation (if applicable).
2) Heat dissipation from adjacent heat sources (i.e., surrounding electrical conductors and equipment carrying a load).
3) Ambient temperature. Ambient temperature may vary along the conductor length as well as from time to time.
4) The resistance across the electrical conductor. Assuming that the majority of the measured surface temperature is attributed to the heat generation from the internal conductor, depending on the conductance of the insulation surrounding it, the internal conductor is inclined to be at a much higher temperature than the surface temperature of the insulation. It could be as high as the melting point. Hence, if the conductor melts and cools as the load varies, then the resistance changes; to become another variable.

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[1] P= Power (Watts; which is later converted to heat generation), I = Current flow (Amperes), R = Resistance (Ohms)

[2] Delta T_2 or T(hyp.rise) = Temperature rise of the conductor in the calculated FUTURE SCENARIO.

[3] Delta T = Recorded surface temperature minus ambiant temperature.

The actual formula used to attain the Delta T_2 or T(hyp. rise)[2] values given in Tables 7.0-7.3 is: $(I_2/I_1)^2$ X Delta T_1[3] = Delta T_2[2]. This formula is exclusively considering the change in current across the internal conductor, and is assuming that a fixed value is maintained for the resistance across the area of focus (the problem area). Considering this assumption along with the four variables mentioned above, it is reasonable to further assume that the <u>actual</u> temperatures resulting from full load conditions will deviate from the calculated estimates. However, it is imperative that the problem area receive continual attention and monitoring until the actual cause of the anomalous data, obtained during the inspection, is dissolved.

7.4 Equipment Assessment

Date of Inspection: 8/18/93-9/30/93

Inspector(s): Ron Airing, Robert Ha, Pete Santos, Mark Shirk, Tim Webb, and Shawn O'brien

7.4.1 Substation # 1

This electrical enclosure is located outside hanger #3 on the northeast side.

The electrical equipment consist of a medium voltage disconnect, oil cooled transformer, and a low voltage single breaker switchboard.

Medium Voltage Switchgear

Type: Oil Disconnect Switch

Transformer

Transformer designation - T59 Type: OIL FILLED - Pad Mounted
Manufacturer: RSE Sierra Model: 65E7741Q9
Serial No: 91J888024 KVA Rating: 750
Voltage: Primary-12KV/ Secondary-480/277 Vac
% Impedance: 6.74 Phase: 3 Freq: 60 hz
Deg rise:
Winding Configuration: primary - delta / secondary - wye

Low Voltage Switchgear

Switchboard designation - EP24 Type 3R Enclosure
Manufacturer - Federal Pacific Mains - 700 amps
Phase - 3 Wires - 4 Voltage: 480/277
Main Breaker: Westinghouse Molded Case - 1200 amps

Findings

1) Equipment Access

Electrical equipment is located outdoor in a concrete block walls and cyclone wire fencing enclosure. Access to electrical equipment is controlled with a lock and key. However, Per NEC 110-31 a fence less than 8 feet in height shall not be considered as preventing access. Existing cyclone wire fencing is only 7 feet high.

2) Working Clearance

Work space around electrical equipment complies with the minimum requirements of NEC 110-34. The base of the transformer is covered with a lot of trash.

3) Warning Signs and Markings

Sufficient warning signs and labels are posted on equipment and on the gate.

4) Equipment Enclosures

Transformer installation complies with the requirements per NEC Section 450-27. However, an oil enclosure to confine the oil in case of the transformer tank getting ruptured maybe be required depending on the degree of fire hazard.

5) System Grounding

The electrical service equipment and system is grounded per NEC Article 250. The approximate size of the grounding conductor is 4/0 bare stranded copper which is terminated to a 5/8 in ground electrode.

6) Equipment Mounting and Ventilation

Equipment is located outdoors, heat generated by the transformer is dissipated by the surrounding ambient air.

The equipment enclosure is fastened on the concrete slab.

7) Overcurrent Interrupt Ratings

The approximate short circuit current available at this point is 12,593.82 amps. The main low voltage breaker is rated for 50,000 amps at 480 volts.

8) System Ground Fault Protection

Ground fault Protection per NEC 230-95 is required for grounded wye electrical service of more than 150 volts to ground for each service disconnecting means rated 1000 amperes or more.

9) Electrical Conductors and insulators

Multiple conductor combined ampacity complies with NEC Article 310 for conductor ampacity requirements.

10) Electrical Connections

Conductor and bus terminations are tight with the absence of any signs of overheating.

11) Electric Meters

KW-HR meter functions, seal broken, needs calibration.

Recommended Action (Moderate)

1) Construct an oil containment enclosure around the transformer.
2) Upgrade main low voltage breaker to include ground fault protection of the system per NEC code compliance.
3) The ratings of feeder breakers and branch breakers downstream of the main breaker on the 480 volt system should be verified and replaced with breakers rated at no less than the available short circuit current available. Breakers with lower rating pose an extreme safety hazard to personnel and equipment in case of a fault in the system involving these breakers.
4) Remove accumulated debris at the base of the transformer.
5) Inspect and calibrate electric meters.

7.4.2 Substation No. 2

This electrical enclosure is located outside hanger #3 right about the middle on the east side. The electrical equipment consist of a medium voltage disconnect, oil cooled transformer, and a low voltage single breaker switchboard, low voltage air cooled transformer and a switchboard.

Switchgear

Type: Oil Disconnect Switch

Transformer

Transformer Designation: T58 Type: Oil filled - Pad Mounted
Manufacturer: RSE-Sierra Model: Serial: 91J888031
KVA Rating: 750 Voltage: Primary-12Kv/Secondary - 480/277V
% Impedance: 6.72 Phase: 3 Freq: 60 Hz
Deg Rise:
Winding Configuration: Primary - Delta/Secondary - Wye

Low Voltage Switchgear

Designation: EP24
Manufacturer: RSE Sierra Model: Serial: 7432-1
Supply Rating: 1000 amps Section Rating: 1000 amps
Phase: 3 Wires: 4 Voltage: 480/277
Main Breaker: Westinghouse Molded Case Breaker - 1200 amps
SWITCH BOARD - SIERRA SWITCHBOARD COMPANY
Catalog No: 9573 360 amps @ 480 volts/1200 amps @ 208 volts
Main Breaker: Westinghouse Molded Case - 1200 amps

Findings

1) Equipment Access

Electrical equipment is located outdoor in a concrete and seven (7) feet high cyclone wire fencing. Access to electrical equipment is controlled with a lock and key. However, Per NEC 110-31 a fence less than 8 feet in height shall not be considered as preventing access.

2) Working Clearance

Work space around electrical equipment complies with the minimum requirements of NEC 110-34.

3) Warning Signs and Markings

Sufficient warning signs and labels are clearly posted on equipment and on the fence swing opening.

4) Equipment Enclosures

Transformer installation complies with the requirements per NEC Section 450-27.

5) System Grounding

The electrical service equipment and system is grounded per NEC Article 250. The approximate size of the grounding conductor is 4/0 bare stranded copper which is terminated to a 5/8" ground electrode.

6) Equipment Mounting and Ventilation

Equipment is located outdoors, heat generated by the transformer is dissipated by the surrounding ambient air.

The equipment enclosure is fastened on the concrete slab.

7) Overcurrent Interrupt Ratings

The approximate short circuit current available at this point is 12,593.82 amps. The main low voltage breaker is rated for 50,000 amps at 480 volts.

8) System Ground Fault Protection

Ground fault Protection per NEC 230-95 is required for grounded wye electrical service of more than 150 volts to ground for each service disconnecting means rated 1000 amperes or more.

9) Electrical Conductors and Insulators

Multiple conductor combined ampacity complies with NEC Article 310 for conductor ampacity requirements.

10) Electrical Connections

Conductor and bus terminations are tight with the absence of any signs of overheating.

11) Electric Meters

Functioning KW-HR meter, seal broken, needs calibration.

Recommended Action (Serious)

1) Upgrade main low voltage breaker to include ground fault protection of the system per NEC code compliance requirement.

2) Inspect and calibrate electric meters.

7.4.3 Substation No. 3

Switchgear

Type: Oil Disconnect Switch

Transformer

Transformer Designation: T59-1	Type: Oil Filled - Pad Mounted	
Manufacturer: RSE Sierra	Model:	Serial: 91J888040
KVA Rating: 750	Voltage: Primary - 12Kv/Secondary - 480/277	
% Impedance: 6.72	Phase: 3	Freq: 60 Hz
Deg Rise:		

Winding Configuration: Primary - Delta/Secondary - Wye

Switchboard

Switchboard designation - EP24	Type 3R Enclosure	
Manufacturer - Federal Pacific	Mains - 700 amps	
Phase - 3	Wires - 4	Voltage: 480/277

Main Breaker: Westinghouse Molded Case - 1200 amps

Findings

1) Equipment Access

Electrical equipment is located outdoor in a concrete and seven (7) feet high cyclone wire fencing. Access to electrical equipment is controlled with a lock and key. However, Per NEC 110-31 a fence less than 8 feet in height shall not be considered as preventing access.

2) Working Clearance

Work space around electrical equipment complies with the minimum requirements of NEC 110-34.

3) Warning Signs and Markings

Sufficient warning signs and labels are clearly posted on equipment and on the fence swing opening.

4) Equipment Enclosures

Transformer installation complies with the requirements per NEC Section 450-27. However, an oil enclosure to confine the oil in case of the transformer tank getting ruptured maybe be required depending on the degree of fire hazard.

5) System Grounding

The electrical service equipment and system is grounded per NEC Article 250. The approximate size of the grounding conductor is 4/0 bare stranded copper which is terminated to a 5/8" ground electrode.

6) Equipment Mounting and Ventilation

Equipment is located outdoors, heat generated by the transformer is dissipated by the surrounding ambient air.

The equipment enclosure is fastened on the concrete slab.

7) Overcurrent Interrupt Ratings

The approximate short circuit current available at this point is 12,593.82 amps. The main low voltage breaker is rated for 50,000 amps at 480 volts.

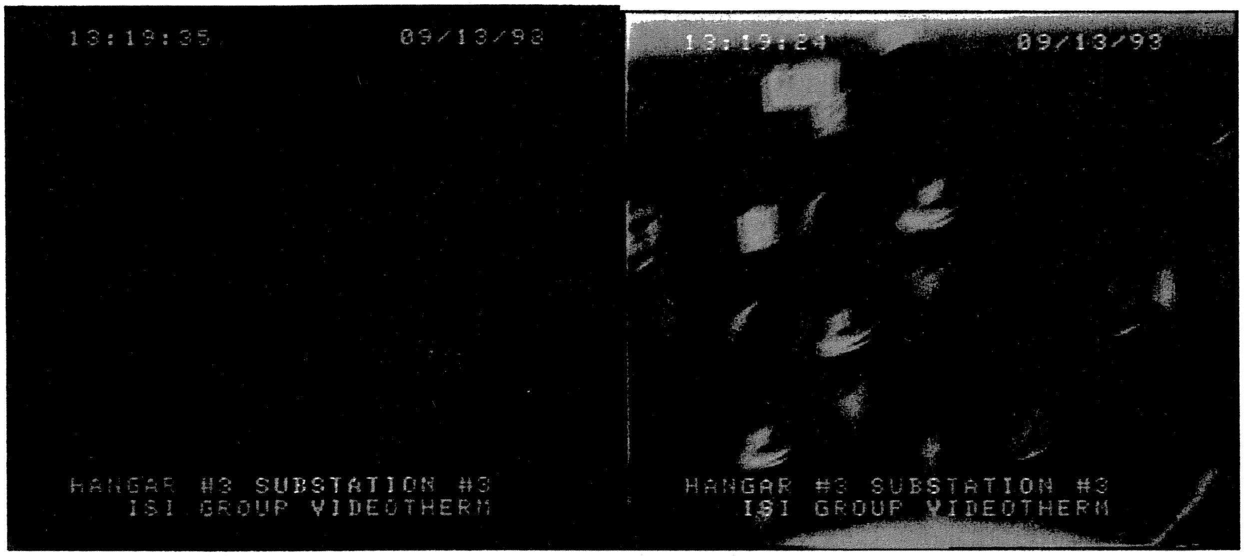
8) System Ground Fault Protection

Ground fault Protection per NEC 230-95 is required for grounded wye electrical service of more than 150 volts to ground for each service disconnecting means rated 1000 amperes or more.

9) Electrical Conductors and Insulators

Multiple conductor combined ampacity complies with NEC Article 310 for conductor ampacity requirements.

10) Electrical Connections: The visual inspection found discoloration of the insulation at all 3 feeder elbow terminations at the bushings; this indicated signs of previous/present overheating at those locations. The thermographic scan indicated thermal anomalies approximately at the same locations as above. Phase C was drawing 4.3 amperes and had an insulation surface temperature of 125 degrees F. at the top of the elbow connection to the oil transformer T-59-1.



11) Electric Meters

None installed.

Recommended Action (CRITICAL)

1) Construct an oil containment enclosure around the transformer.
2) Upgrade main low voltage breaker to include ground fault protection of the system per NEC code compliance.
3) Inspect cable terminations on the primary feeder disconnect for loose connections and/or damage.

4) Request and implement a power outage to perform the following tasks: Check the condition, tightness, continuity, and cleanliness of all splices, connections and elbow terminations; check the integrity of all the insulation pertinent to the Main Feeder (from the 15 K.V. Gas Switch to the elbow terminators at the Main Transformer, T-59-1). Correct any discrepancies that exist. When climate conditions maintain a dry bulb Ambient Temperature of 85 degrees F. or more, and when optimum solar insolation is available, perform another temperature measurement under full load conditions.

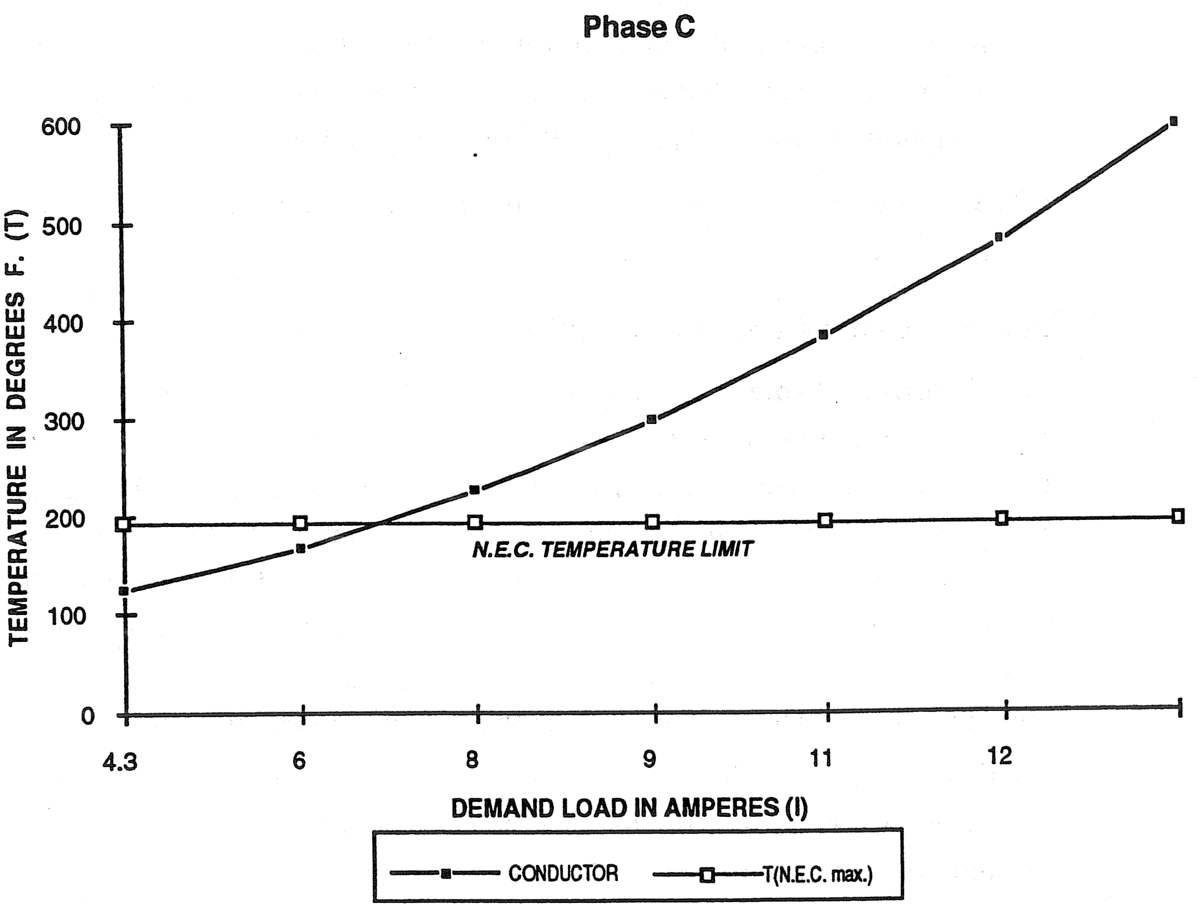
*Note: On 9/13/93 Mr. Pete Santos of P.W.C. was notified of the above problem.

Future Scenario (If Not Corrected)

The following Table 7.2 reflects the calculated resultant conditions that could occur if the subject elbow terminations and the conductors feeding them were exposed to a hypothetical full demand load. Based on the stipulations set forth in Article 450-3 of the National Electrical Code, the calculated full design load on the primary side of transformer T-59-1 cannot exceed 14 amperes ($I_{max.}$). At the time of the most recent data acquisition (specified above), the primary load was approximately 4.3 amperes ($I_{rec.}$). This is only 31% of the maximum design load. Hence, if the existing or future Resident Agency(s) were to utilize the full capacity of this transformer (100% of the maximum design load), the temperature of the elbows and conductors could be greater or equal to 595 degrees F. As depicted in the following graph for Phase C, this temperature exceeds the temperature limit set forth in Article 310 of the N.E.C. by 401 degrees F. and will seriously damage the conductors, the elbow terminations and the insulation surrounding them; making a failure condition imminent. The hypotheses stated above is considering the facts that the strength of copper and aluminum decreases significantly, and that these metals are subject to embrittlement after being exposed to temperatures above the N.E.C. limit. Aluminum melts at 1220^{o} F. and Copper melts at 1980^{o} F.

Table 7.2

SYSTEM	T	T	T	I	I	I	C	T	T	T	T	DEV.
DESC.	(amb)	(rec. rise)	(surface)	(rec.)	(rec)/I(max)	(max.)	(adj.)	(NEC max. rise)	(hyp. rise)	(NEC max.)	(at I max)	
T-59-1 ELB.	DEG. F.	DEG. F.	DEG. F.	AMPS	%	AMPS	RATIO	DEG. F.	DEG. F.	DEG. F.	DEG. F.	DEG. F.
PHASE A	76	12	88	4.9	35%	14	8.16	90	97.96	194	173.96	-20.04
PHASE B	76	39	115	5	36%	14	7.84	90	305.76	194	381.76	187.76
PHASE C	76	49	125	4.3	31%	14	10.60	90	519.42	194	595.42	401.42



$T_{(amb)}$ Ambient Temperature at the time of inspection

$T_{(rec.\ rise)}$ Recorded Surface Temperature minus Ambient Temperature (R.O.A.- Rise Over Ambient)

$T_{(surface)}$ Recorded Surface Temperature of the Elbow Termination at the time of inspection

$I_{(rec.)}$ Recorded System Load of the primary side of transformer at the time of inspection

$I_{(rec.)}/I_{(max.)}$ Recorded System Load divided by the Maximum Design Load

$I_{(max.)}$ Hypothetical Maximum Design Load permitted on the primary side of T-59-1

$C_{(adj.)}$ Adjustment Coefficient determined by the square of $I_{(max.)}$ $/I_{(rec.)}$

$T_{(N.E.C.\ max.\ rise)}$ The maximum rise (R.O.A.) in temperature of a conductor above Ambient Temperature allowed in Article 310 of the N.E.C. (based on an Ambient Temperature of 104 Degrees F.)

$T_{(hyp.\ rise)}$ Hypothetical R.O.A. (when the conductor is exposed to a Full Load condition) determined by multiplying the $C_{(adj.)}$ by the $T_{(rec.\ rise)}$

$T_{(N.E.C.\ max.)}$ The maximum temperature of a conductor allowed in Article 310 of the N.E.C. (based on an Ambient Temperature of 104 Degrees F.)

$T_{(at\ Imax.)}$ Hypothetical Conductor Temperature (when the conductor is exposed to a Full Load condition) determined by adding the $T_{(hyp.\ rise)}$ to the $T_{(amb)}$

7.4.4 Electrical Room No. 4

Switchgear

A. Manufacturer: Sierra Switch Board Co. M/N: D8954
Type: Metal Enclosed - Fusible Max Voltage: 14.5 Kv
Switch Rating: 600 amps Impulse Level: 95 Kv
Sw-Mom Rating: 40,000 amps Frequency: 60 Hz

B. Manufacturer: Sierra Switch Board Co. M/N: D8954
Type: Metal Enclosed - Fusible Max Voltage: 14.5 Kv
Switch Rating: 600 amps Impulse Level: 95 Kv
Sw-Mom Rating: 40,000 amps Frequency: 60 Hz

Transformer

A. Transformer Designation: T57-1 Type: Dry, Pad Mounted-Ventilated
Manufacturer: Sierra Switch Board Co. Model: HTDO
KVA Rating: 300 Voltage: Primary - 12 Kv/Secondary - 480/277
% Impedance: 5.75 Phase: 3 Freq: 60Hz
Deg Rise: 150C
Winding Configuration: Primary - Delta/Secondary - Wye

B. Transformer Designation: T57-2 Type: Dry, Pad Mounted-Ventilated
Manufacturer: Sierra Switch Board Co. Model: HTDO
KVA Rating: 300 Voltage: Primary - 12 Kv/Secondary - 480/277
% Impedance: 5.75 Phase: 3 Freq: 60Hz
Deg Rise: 150C
Winding Configuration: Primary - Delta/Secondary - Wye

Switchboard

A. Manufacturer: Sierra Switch Board Co. Type 1 Enclosure
Supply Rating: 600 amps Section Rating: 600 amps
Phase: 3 Wires: 4 Voltage: 480/277
Main Breaker:
Type: Westinghouse w/ Integral Ground Fault Frame: 800 amps
Plug Rating: 500 amps Gnd Fault Setting: 0.20 amps @ 0.5 sec

B. Manufacturer: Sierra Switch Board Co. Type 1 Enclosure

Supply Rating: 600 amps Section Rating: 600 amps

Phase: 3 Wires: 4 Voltage: 480/277

Main Breaker:

Type: Westinghouse w/ Integral Ground Fault Frame: 800 amps

Plug Rating: 500 amps Gnd Fault Setting: 0.20 amps @ 0.5 sec

Findings

1) Equipment Room Access

   Electrical room access is controlled with a lock and key. Further, electrical equipment are metal enclosed.

2) Working Clearance/Illumination

   Work space around electrical equipment complies with the requirements of NEC 110-34.

3) Warning Signs and Markings

   Sufficient warning signs and labels are clearly posted on equipment and doors leading to the equipment room.

4) Equipment Enclosures

   Compliance to NEC Article 450 covering the requirements for transformer installations, specifically Part C is not required per NEC Section 450-21 Paragraph (b), Exception No. 2.

5) System Grounding

   The electrical service equipment and system is grounded per NEC Article 250. The approximate size of the grounding conductor is 4/0 bare stranded copper which is terminated to a 5/8" ground electrode.

6) Equipment Mounting and Ventilation

   The approximate heat gain into the space from the transformers at full load is 49,104 Btu/Hr, which would correspondingly require an air flow of approximately 3,031 cfm to limit the temperature rise of the leaving air to 15 degrees fahrenheit above ambient. However, the size of the room and type of construction materials used would dissipate part of the heat gain from the transformers through heat transmission and infiltration.

Ventilation air is provided through filtered openings on the doors and windows.

7) Overcurrent Interrupt Ratings

The approximate short circuit current available at this point is 6,098.26 amps. The main low voltage breaker is rated for 30,000 amps at 480 volts.

8) System Ground Fault Protection

Existing service equipment is provided with an integral ground fault protection.

9) Electrical Conductors and insulators

Multiple conductor combined ampacity complies with NEC Article 310 for conductor ampacity requirements.

10) Electrical Connections

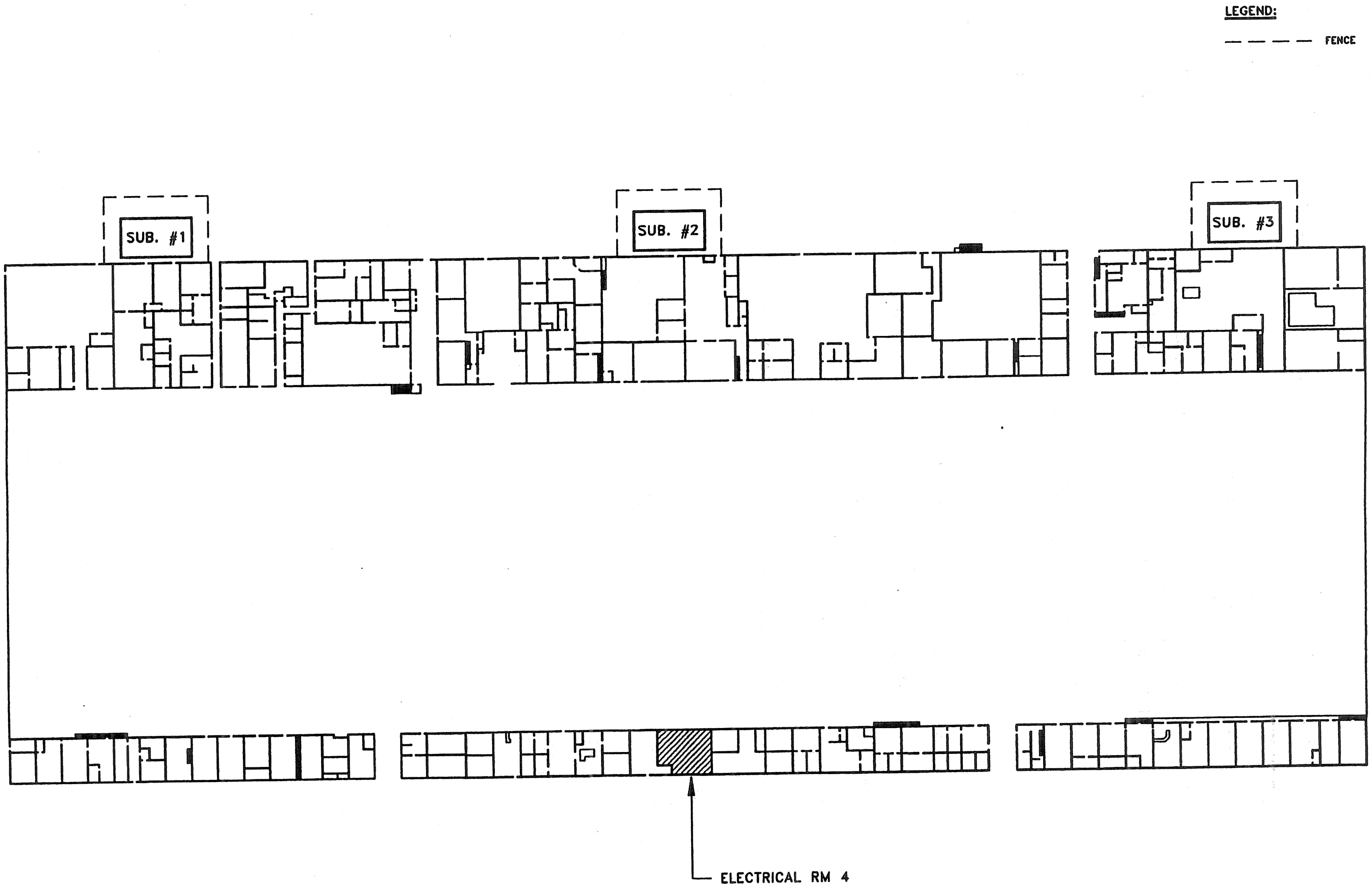
Conductor and bus terminations are tight with the absence of any signs of overheating.

11) Electric Meters

Functioning meters, seal broken, need calibration.

Recommended Action (Advisory)

1) Inspect and calibrate electric meters.



HANGAR 3 ELECTRICAL ROOM & SUBSTATION LAYOUT

FIRST FLOOR

FILE:

8.0 PRELIMINARY COST SUMARY

8.1 Conclusion and Summary Tables

(Refer to Item 3.0 Introduction)

8.2 Estimating Methodology

A combination of methods were utilized for the preparation of the following preliminary cost estimates: the partial take-off method, the parameter cost method, the panel unit cost method and the square foot cost method. Unit cost multipliers were derived and/or obtained from the 1986 Koepf & Lange estimates (Available in the MFDP Library upon request), the Means Repair and Remodeling Cost Data, and the San Francisco Bay Area Blacks Guide for Office Leasing. Values were converted to 1994 Dollars where it was required. All the estimates herein are to be considered of a Rough Order of Magnitude (R.O.M.) and should be used for planning purposes only.

8.3.1

HANGAR 3 SECTION 1 ESTIMATE

DATE: 11-25-93
ITEM 5.0 BUILDING CONSTRUCTION

SUPPORT AREA description: SECTION 1	AREA	% OF SUBTOTAL	$/SQUARE FT	EXTENSION
PLANS/ENGINEERING	19160	14%	$2.00	$38,000.00
ASBESTOS ABATEMENT	19160	26%	$3.82	$73,000.00
DEMOLITION/ALTERATIONS	19160	14%	$2.00	$38,000.00
EXITS/CORRIDORS/STAIRS	19160	15%	$2.15	$41,000.00
ELECTRICAL MODIFICATIONS	19160	20%	$3.00	$57,000.00
DOORS/FRAMES/HARDWARE	19160	12%	$1.69	$32,000.00
SUB-TOTAL		100%	$14.66	$281,000.00
CONTINGENCY		10%	$1.47	$28,000.00
CONTRACTOR		20%	$3.24	$62,000.00
ETT SURCHARGE		6%	$1.16	$22,000.00
TOTAL			$20.52	$393,000.00
FIRE SEPARATION				
MIXED OCCUPANCY OPTION:				
ROOF/CEILING SURFACE AREA	10400	64%	$6.07	$63,000.00
WALL SURFACE AREA	10400	36%	$3.40	$35,000.00
			$6.07	
SUB-TOTAL				$98,000.00
CONTINGENCY		10%	$0.61	$10,000.00
CONTRACTOR		20%	$1.34	$22,000.00
ETT SURCHARGE		6%	$0.48	$8,000.00
TOTAL			$7.20	$138,000.00
FIRE SEPARATION (4 hr.)				
IF CONSTRUED TYPE IV CONST.				
OUTSIDE WALLS	39000		$6.00	$234,000.00
UP TO 120 FEET HIGH				
CONTINGENCY		10%	$0.60	$23,000.00
CONTRACTOR		20%	$1.32	$52,000.00
ETT SURCHARGE		6%	$0.48	$19,000.00
TOTAL			$17.10	$328,000.00
REPAIR ROOF LEAKS				
TOTAL COST FOR SECTION			$44.82	$859,000.00

8.3.2 HANGAR 3 SECTION 2 ESTIMATE

DATE: 11-25-93

ITEM 5.0 BUILDING CONSTRUCTION

SUPPORT AREA

description:	AREA	% OF SUBTOTAL	$/SQUARE FT	EXTENSION
SECTION 2				
PLANS/ENGINEERING	10915	14%	$2.00	$22,000.00
ASBESTOS ABATEMENT	10915	26%	$3.82	$42,000.00
DEMOLITION/ALTERATIONS	10915	14%	$2.00	$22,000.00
EXITS/CORRIDORS/STAIRS	10915	15%	$2.15	$23,000.00
ELECTRICAL MODIFICATIONS	10915	20%	$3.00	$33,000.00
DOORS/FRAMES/HARDWARE	10915	12%	$1.69	$18,000.00
SUB-TOTAL		100%	**$14.66**	**$160,000.00**
CONTINGENCY		10%	$1.47	$16,000.00
CONTRACTOR		20%	$3.24	$35,000.00
ETT SURCHARGE		6%	$1.16	$13,000.00
TOTAL			**$20.52**	**$224,000.00**
FIRE SEPARATION				
MIXED OCCUPANCY OPTION:				
ROOF/CEILING SURFACE AREA	10368	74%	$6.07	$63,000.00
WALL SURFACE AREA	6352	26%	$3.40	$22,000.00
			$6.07	
SUB-TOTAL				**$85,000.00**
CONTINGENCY		10%	$0.61	$8,000.00
CONTRACTOR		20%	$1.34	$19,000.00
ETT SURCHARGE		6%	$0.48	$7,000.00
TOTAL			**$10.84**	**$118,000.00**
FIRE SEPARATION (4 hr.)				
IF CONSTRUED TYPE IV CONST.				
OUTSIDE WALLS	38880		**$6.00**	**$233,000.00**
UP TO 120 FEET HIGH				
CONTINGENCY		10%	$0.60	$23,000.00
CONTRACTOR		20%	$1.32	$51,000.00
ETT SURCHARGE		6%	$0.48	$18,000.00
TOTAL			**$29.92**	**$327,000.00**
REPAIR ROOF LEAKS				
TOTAL COST FOR SECTION			**$61.29**	**$669,000.00**

8.3.3 HANGAR 3 SECTION 3 ESTIMATE

DATE: 11-25-93
ITEM 5.0 BUILDING CONSTRUCTION

SUPPORT AREA

description:	AREA	% OF SUBTOTAL	$/SQUARE FT	EXTENSION
SECTION 3				
PLANS/ENGINEERING	11494	14%	$2.00	$23,000.00
ASBESTOS ABATEMENT	11494	26%	$3.82	$44,000.00
DEMOLITION/ALTERATIONS	11494	14%	$2.00	$23,000.00
EXITS/CORRIDORS/STAIRS	11494	15%	$2.15	$25,000.00
ELECTRICAL MODIFICATIONS	11494	20%	$3.00	$34,000.00
DOORS/FRAMES/HARDWARE	11494	12%	$1.69	$19,000.00
SUB-TOTAL	.	100%	$14.66	$169,000.00
CONTINGENCY		10%	$1.47	$17,000.00
CONTRACTOR		20%	$3.24	$37,000.00
ETT SURCHARGE		6%	$1.16	$13,000.00
TOTAL			$20.52	$236,000.00
FIRE SEPARATION				
MIXED OCCUPANCY OPTION:				
ROOF/CEILING SURFACE AREA	10400	66%	$6.07	$63,000.00
WALL SURFACE AREA	9648	34%	$3.40	$33,000.00
			$6.07	
SUB-TOTAL				$96,000.00
CONTINGENCY		10%	$0.61	$10,000.00
CONTRACTOR		20%	$1.34	$21,000.00
ETT SURCHARGE		6%	$0.48	$8,000.00
TOTAL			$11.68	$134,000.00
FIRE SEPARATION (4 hr.)				
IF CONSTRUED TYPE IV CONST.				
OUTSIDE WALLS	38880		$6.00	$233,000.00
UP TO 120 FEET HIGH				
CONTINGENCY		10%	$0.60	$23,000.00
CONTRACTOR		20%	$1.32	$51,000.00
ETT SURCHARGE		6%	$0.48	$18,000.00
TOTAL			$28.41	$327,000.00
REPAIR ROOF LEAKS				
TOTAL COST FOR SECTION			$60.62	$697,000.00

8.3.4 HANGAR 3 SECTION 4 ESTIMATE

DATE: 11-25-93
ITEM 5.0 BUILDING CONSTRUCTION

SUPPORT AREA

description:	AREA	% OF SUBTOTAL	$/SQUARE FT	EXTENSION
SECTION 4				
PLANS/ENGINEERING	0	0%	$2.00	$0.00
ASBESTOS ABATEMENT	31200	100%	$3.82	$1,000.00
DEMOLITION/ALTERATIONS	0	0%	$2.00	$0.00
EXITS/CORRIDORS/STAIRS	0	0%	$2.15	$0.00
ELECTRICAL MODIFICATIONS	0	0%	$3.00	$0.00
DOORS/FRAMES/HARDWARE	0	0%	$1.69	$0.00
SUB-TOTAL		100%	**$14.66**	**$1,000.00**
CONTINGENCY		10%	$1.47	$100.00
CONTRACTOR		20%	$3.24	$220.75
ETT SURCHARGE		6%	$1.16	$79.25
TOTAL			**$20.52**	**$1,400.00**
FIRE SEPARATION				
MIXED OCCUPANCY OPTION:				
ROOF/CEILING SURFACE AREA	11050	99%	$6.07	$67,000.00
WALL SURFACE AREA	200	1%	$3.40	$1,000.00
SUB-TOTAL			$9.47	**$68,000.00**
CONTINGENCY		10%	$0.95	$7,000.00
CONTRACTOR		20%	$2.09	$15,000.00
ETT SURCHARGE		6%	$0.75	$5,000.00
TOTAL				**$95,000.00**
FIRE SEPARATION (4 hr.)				
IF CONSTRUED TYPE IV CONST.				
OUTSIDE WALLS	39000		**$6.00**	**$234,000.00**
CONTINGENCY		10%	$0.60	$23,000.00
CONTRACTOR		20%	$1.32	$52,000.00
ETT SURCHARGE		6%	$0.48	$19,000.00
TOTAL			**$10.50**	**$328,000.00**
REPAIR ROOF LEAKS	20150		**$2.30**	**$46,000.00**
CONTINGENCY		10%	$0.23	$5,000.00
CONTRACTOR		20%	$0.51	$10,000.00
ETT SURCHARGE		6%	$0.18	$4,000.00
TOTAL			**$2.08**	**$65,000.00**

TOTAL COST FOR SECTION			**$15.66**	**$489,000.00**

8.3.5 HANGAR 3 SECTION 5 ESTIMATE

DATE: 11-25-93
ITEM 5.0 BUILDING CONSTRUCTION

SUPPORT AREA				
description:	**AREA**	**% OF SUBTOTAL**	**$/SQUARE FT**	**EXTENSION**
SECTION 5				
PLANS/ENGINEERING	44232	14%	$2.00	$88,000.00
ASBESTOS ABATEMENT	44232	26%	$3.82	$169,000.00
DEMOLITION/ALTERATIONS	44232	14%	$2.00	$88,000.00
EXITS/CORRIDORS/STAIRS	44232	15%	$2.15	$95,000.00
ELECTRICAL MODIFICATIONS	44232	20%	$3.00	$133,000.00
DOORS/FRAMES/HARDWARE	44232	12%	$1.69	$75,000.00
SUB-TOTAL		**100%**	**$14.66**	**$648,000.00**
CONTINGENCY		10%	$1.47	$65,000.00
CONTRACTOR		20%	$3.24	$143,000.00
ETT SURCHARGE		6%	$1.16	$51,000.00
TOTAL			**$20.52**	**$908,000.00**
FIRE SEPARATION				
MIXED OCCUPANCY OPTION:				
ROOF/CEILING SURFACE AREA	11084	65%	$6.07	$67,000.00
WALL SURFACE AREA	10432	35%	$3.40	$35,000.00
			$6.07	
SUB-TOTAL				**$103,000.00**
CONTINGENCY		10%	$0.61	$10,000.00
CONTRACTOR		20%	$1.34	$23,000.00
ETT SURCHARGE		6%	$0.48	$8,000.00
TOTAL			**$3.25**	**$144,000.00**
FIRE SEPARATION (4 hr.)				
IF CONSTRUED TYPE IV CONST.				
OUTSIDE WALLS	39120		**$6.00**	**$235,000.00**
UP TO 120 FEET HIGH				
CONTINGENCY		10%	$0.60	$23,000.00
CONTRACTOR		20%	$1.32	$52,000.00
ETT SURCHARGE		6%	$0.48	$19,000.00
TOTAL			**$7.43**	**$329,000.00**
REPAIR ROOF LEAKS	20150		**$2.30**	**$46,000.00**
CONTINGENCY		10%	$0.23	$5,000.00
CONTRACTOR		20%	$0.51	$10,000.00
ETT SURCHARGE		6%	$0.18	$4,000.00
TOTAL			**$1.47**	**$65,000.00**
TOTAL COST FOR SECTION			**$32.67**	**$1,445,000.00**

8.3.6 HANGAR 3 SECTION 6 ESTIMATE

DATE: 11-25-93

ITEM 5.0 BUILDING CONSTRUCTION

SUPPORT AREA **description:** SECTION 6	**AREA**	**% OF SUBTOTAL**	**$/SQUARE FT**	**EXTENSION**
PLANS/ENGINEERING	43180	14%	$2.00	$86,000.00
ASBESTOS ABATEMENT	43180	26%	$3.82	$165,000.00
DEMOLITION/ALTERATIONS	43180	14%	$2.00	$86,000.00
EXITS/CORRIDORS/STAIRS	43180	15%	$2.15	$93,000.00
ELECTRICAL MODIFICATIONS	43180	20%	$3.00	$130,000.00
DOORS/FRAMES/HARDWARE	43180	12%	$1.69	$73,000.00
SUB-TOTAL		100%	$14.66	$633,000.00
CONTINGENCY		10%	$1.47	$63,000.00
CONTRACTOR		20%	$3.24	$140,000.00
ETT SURCHARGE		6%	$1.16	$50,000.00
TOTAL			$20.52	$886,000.00
FIRE SEPARATION				
MIXED OCCUPANCY OPTION:				
ROOF/CEILING SURFACE AREA	11050	65%	$6.07	$67,000.00
WALL SURFACE AREA	10432	35%	$3.40	$35,000.00
			$6.07	
SUB-TOTAL				$103,000.00
CONTINGENCY		10%	$0.61	$10,000.00
CONTRACTOR		20%	$1.34	$23,000.00
ETT SURCHARGE		6%	$0.48	$8,000.00
TOTAL			$3.32	$144,000.00
FIRE SEPARATION (4 hr.)				
IF CONSTRUED TYPE IV CONST.				
OUTSIDE WALLS	39120		$6.00	$235,000.00
UP TO 120 FEET HIGH				
CONTINGENCY		10%	$0.60	$23,000.00
CONTRACTOR		20%	$1.32	$52,000.00
ETT SURCHARGE		6%	$0.48	$19,000.00
TOTAL			$7.61	$329,000.00
REPAIR ROOF LEAKS	20150		$2.30	$46,000.00
CONTINGENCY		10%	$0.23	$5,000.00
CONTRACTOR		20%	$0.51	$10,000.00
ETT SURCHARGE		6%	$0.18	$4,000.00
TOTAL			$1.50	$65,000.00
TOTAL COST FOR SECTION			$32.96	$1,423,000.00

8.4 FIRE PROTECTION SYSTEM ESTIMATES

DATE: 1-3-94
ITEM 6.3 UTILITY CAPACITY
FIRE PROTECTION

Hangar 3

The estimate for the AFFF System for Hangar 3 is based on an estimate provided in a "fire Protection Engineering Survey Report" prepared by the Naval Facilities Engineering Command in 1988 for Hangar 2 (Appendix A). Although the existing water supply (p500 Piping) has the capability to protect the entire roof, it is not necessary. The Active Aircraft Service Area can be protected with the AFFF System, and a Water Deluge System can be used to prevent fire from climbing up the wall above the Hangar Support Areas.

It is not necessary to provide a separate pumping system for both Hangars 2 & 3 since it is unlikely that both experience a fire at the same time. Therefore, it is recommended to install a pumping station that serves both hangars. The pressure and flow requirements for Hangars 2 &3 are approximately the same as Hangar 1. (Note: It may be possible to reduce this estimate, since the available pressure is believed to be greater than that calculated at Hangar 1 However, more time is required for further calculations).

LINE ITEM	HANGAR 3 RECOMMENDED IMPROVEMENTS	SECTION REFERENCE	TOTAL COST
1	AFFF System (Active Aircraft Service Area)		
	Engineering		$64,000.00
	Construction (from 1988 NAVY estimate)	Sheet 1 of 1	$6,774,000.00
	Inflation Adjustment		$1,443,000.00
	TOTAL AFFF SYSTEM (ACTIVE AIRCRAFT SERVICE AREA)		$8,281,000.00
2	Sprinkler System (Roof protection Wet Pipe ordinary Hazard)		
	Engineering		$64,000.00
	Construction (estimate 508,500 sf @ $7/sf)		$3,553,000.00
	TOTAL SPRINKLER SYSTEM (ROOF PROTECTION WET PIPE)		$3,617,000.00
3	Roof to 100 ft level (Deluge)		
	Engineering		$64,000.00
	Construction (estimate 80,250 sf @ $5/sf)		$401,000.00
	TOTAL ROOF TO 100 FT (DELUGE)		$465,000.00
4	Shared Pumping Station for AFFF Systems (50 % of total costs)		
	Engineering		$64,000.00
	Construction (from K&L estimate)	Sheet 2 of 33	$2,743,000.00
	Inflation Adjustment		$1,136,000.00
	Downsizing of pump		($872,000.00)
	TOTAL PUMPING STATION COST		$3,071,000.00
	50% of TOTAL PUMPING STATION COST FOR HGR 3		$1,536,000.00

DRAINAGE ESTIMATES

DATE: 12/28/93

ITEM 6.4.3 DRAINAGE FOR FIRE SUPPRESSION SYSTEM

LINE ITEM	HANGAR 3 Description	Unit	Quantity	Total
1	Engineering and design	Hours	450	$21,000.00
2	Demolish floor to trenches	Sq Ft	6.4	$27,000.00
3	Excavation, trench	CY	1300	$18,000.00
4	Base, trench	CY	200	$6,000.00
5	Concrete, trench	CY	540	$344,000.00
6	Trench grating	Sq Ft	5,000	$247,000.00
7	Trench angles	Lb.	72,000	$153,000.00
8	Restore floor to trench	CY	460	$48,000.00
9	Remove pavement, culvert	Sq Ft	600	$1,000.00
10	Excavation, culvert	CY	440	$5,000.00
11	Bedding and base	CY	230	$10,000.00
12	Backfill	CY	210	$2,000.00
13	Pavement replacement	Sq Ft	2,350	$13,000.00
14	33" concrete culvert	Ft	400	$51,000.00
15	Concrete, oil/fuel separator	CY	20	$16,000.00
16	Cut in manhole	Ea.	1	$2,000.00
17	Paving at separator	Sq Ft	200	$3,000.00
18	Separator trim	Lot	1	$3,000.00
19	Separator oil alarm system	Lot	1	$4,000.00
20	Remove pavement, tank	Sq Ft	3,200	$5,000.00
21	Pavement patch	Sq Ft	1,600	$9,000.00
22	Excavation, tank	CY	2,000	$28,000.00
23	Concrete, tank foundation ring	CY	26	$17,000.00
24	Metal frames	Sq Ft	1,900	$11,000.00
25	Receiving tank, steel	Gal	225,000	$200.00
26	Devices, field installed	Lot	1	$14,000.00
27	Test tank	Lot	1	$6,000.00
28	Pump station	Lot	1	$17,000.00
29	Remove pavement, 8" pipe	Sq Ft	520	$1,000.00
30	Excavation, pipe	CY	385	$4,000.00
31	Bedding and base	CY	200	$8,000.00
32	Backfill	CY	180	$2,000.00
33	Pavement replacement	Sq Ft	2,040	$12,000.00
34	8" pipe line to existing sewer	Ft	220	$7,000.00
35	Cut in 8" to sewer and tank	Ea.	1	$3,000.00
	SUB-TOTAL			**$1,117,000.00**
	CONTINGENCY			$112,000.00
	CONTRACTOR			$246,000.00
	ETT SURCHARGE			$88,000.00
	TOTAL			**$1,562,000.00**

8.6 ESTIMATE FOR ELECTRICAL REPAIRS

DATE: 12-23-93

ITEM 7.0 ELECTRICAL INFRASTRUCTURE ASSESSMENT

LINE ITEM	HANGAR NO. 3. RECOMMENDED IMPROVEMENTS	TOTAL COST
	SUBSTATION NO. 1.	
30	CONSTRUCT CONCRETE OIL CONTAINMENT BARRIER	$1,000.00
31	UPGRADE MAIN BREAKER FOR GROUND FAULT PROTECTION	$12,000.00
32	INSPECT DISTRIBUTION PANELS	$4,000.00
33	CALIBRATE PANEL METER	$1,000.00
	SUBSTATION NO. 2.	
34	UPGRADE MAIN BREAKER FOR GROUND FAULT PROTECTION	$12,000.00
35	INSPECT AND CALIBRATE METER	$1,000.00
36	INSPECT DISTRIBUTION PANELS	$4,000.00
	SUBSTATION NO. 3.	
37	SUB 3 ELBOW TERMINATIONS	$2,000.00
38	CONSTRUCT CONCRETE OIL CONTAINMENT BARRIER	$1,000.00
39	UPGRADE MAIN BREAKER FOR GROUND FAULT PROTECTION	$12,000.00
40	INSPECT DISTRIBUTION PANELS	$4,000.00
	WEST ELECTRICAL ROOM	
41	INSPECT DISTRIBUTION PANELS	$4,000.00

TOTAL ESTIMATE FOR HANGAR 3 **$56,000.00**

APPENDIX A

FIRE PROTECTION ENGINEERING SURVEY REPORT

DATE OF REPORT: 15 December 1982

1. **NAVAL SHORE INSTALLATION:** Naval Air Station, Moffett Field, California

   LOCATION: Moffett Field, California

2. **DATES OF SURVEY:** 18 October 1982 thru 29 October 1982 (80 m/h)

   DATE OF LAST REPORT: 7 March 1980

3. **SURVEYED BY:** E. S. Munyak, Fire Protection Engineer

   APPROVED BY: D. P. Eadens, Head, Fire Protection Engineering Branch

4. **SURVEY DISCUSSED WITH:**

CAPT Jampoler	Commanding Officer
CAPT Munch	Executive Officer
LCDR Seagers	Operations Officer
ENS Tayloe	Public Works
Mr. Yacopetti	Fire Chief
Mr. Koelling	Chief Fire Inspector

5. **SUMMARY OF CONDITIONS:** The mission of this large Naval Air Station is to serve as the west coast homeport for ASW squadrons and tenant activities. The ion consist of three Lighter-than-Air (LTA) aircraft hangars and a large er of buildings of construction ranging from combustible to fire resistive. The aircraft servicing areas in the hangars are extremely large (1000 ft. X 250 ft.), single, undivided fire areas with no fixed, automatic protection. The large squadron support areas contain a large number of personnel in areas that in general contain serious life safety deficiencies. The exterior fire alarm system is unreliable due to problems associated with the fire alarm circuits in wet weather. The water supply for the station is antiquated and very deficient in the vicinity of all hangars and the entire east side.

6. **MAJOR CHANGES:** None.

7. **STATUS OF RECOMMENDATIONS APPEARING IN PREVIOUS REPORT BUT NOT IN THIS REPORT:** Previous report recommendation 5 - (80) has been included in the local recommendations.

8. **RECOMMENDATIONS:** (Note: Recommendations are in descending priority. Cost estimates are "order of magnitude" only.)

-- **Recommendation 1 - (82) Rev.:** The water supply system throughout the station should be improved as follows:

a. Provide a second connection to the Hetch-Hetchy aqueduct at the east end of the station. Each hangar should have a water supply availability of 10,000 GPM @ 100 psi at the base of the hangar.

Enclosure (1)

REPRODUCED AT GOVERNMENT EXPENSE

b. Replace all deteriorated underground piping to improve the distribution and reliability of the water supply system.

c. The condition of the 50 year old elevated water storage tank should be investigated to determine its ability to resist seismic forces. If reinforcement is not practical, the elevated water tank should be razed and on-base storage capacity and pumping consisting of two 500,000 gallon water reservoirs and two 2500 GPM @ 100 psi, diesel engine driven fire pumps, should be provided.

-- Justification:

a. Code/Criteria Reference: NAVFAC DM-8, Fire Protection Engineering Design Manual and NFPA 409, Standard for Protection of Aircraft Hangars, require water supplies capable of supplying open head deluge systems and oscillating nozzles.

b. Approximate Current Cost of Accomplishing Recommendation: $3,000,000.

c. Monetary Justification:

(1) Estimated Replacement Value at Risk: Undetermined.

(2) Estimated Probable Loss Without Implementation of Recommendation: $500,000,000. Based on the value of one LTA Hangar, twelve (12) P-3 aircraft and equipment.

(3) Estimated Probable Loss With Implementation of Recommendation: $250,000.

d. Life Safety: Moderate. Loss of life potential exists in LTA Hangars No. 1, No. 2 and No. 3 due to the lack of any automatic fire protection in the hangar space and substandard alarm and exiting provisions.

e. Strategic Importance: This is the largest P-3 base in the world and the hub of ASW operations in the Pacific. An uncontrolled fire in one very large, combustible, unprotected hangar would have a major impact on mission of the activity. Manual fire fighting would probably be ineffective thus increasing the chances of fire exposure damage to other aircraft on the apron and/or other LTA Hangars.

f. Brief Supporting Statement:

(1) The water supply for Moffett Field is 50 years old and unreliable. It was originally designed for a very limited fire flow requirement of LTA aircraft filled with an inert gas. The water system has never been upgraded to the high fire flow requirements of extremely large aircraft hangars holding up to twelve P-3 aircraft each. The present fire flow availability, less than 1000 GPM @ 20 psi, is grossly deficient. National Fire Code No. 419 "Airport Water Supply Systems" recommends a water supply availability of 15,000 GPM @ 125 psi for hangars that exist or may be built at this facility.

(2) Moffett Field is situated between two major earthquake faults on tidal land subject to liquefaction. The Hetch-Hetchy aqueduct is a gravity flow system. In a course of approximately 150 miles it transerses many active

earthquake fault zones. A recent engineering analysis concluded that this water supply, which supplies most of the water to surrounding area is erable to interruption by earthquake.

(3) Many millions of dollars worth of construction are scheduled for the east side of this activity. The deficient water supply in this area will result in more costly designs and delays.

-- Recommendation 2 - (80) Rev.: The deteriorated station fire alarm system should be replaced. (Note: A replacement system is currently under design which will complete this recommendation when funded and constructed.)

-- Justification:

a. Code/Criteria Reference: NAVFAC DM-8, Fire Protection Engineering Design Manual, Chapter 9 requires an operable exterior fire reporting system.

b. Approximate Current Cost of Accomplishing Recommendation: $750,000

c. Monetary Justification: Undetermined.

d. Life Safety: Any delay in notification of a fire would result in greatly increased fire damage and loss of life potential.

e. Strategic Importance: Loss of major unprotected building or aircraft from delayed alarm could have a major impact on the mission of this activity.

f. Brief Supporting Statement: The original fire alarm system is plagued a high water table which has grounded circuits and collapsed duct runs. The uation is critical during the wet season when system reliability is nil.

-- RECOMMENDATION 3 (82): Improve the fire protection for the HANGAR DECK AREAS OF HANGARS NO. 1, No. 2 and No. 3 as follows:

a. Provide a system of low level oscillating turret nozzles that will automatically and manually discharge AFFF foam solution onto the hangar deck at a minimum application rate of 0.10 gpm/sq. ft.

b. Provide grated floor drains in the approximate center of the hangar running the length of the hangar space, able to drain 5,000 gpm. The concrete floor should be sloped at 1% from the lean-to areas toward the center. The floors of the lean-to area should be built up or ramped to prevent flammable liquids from flowing into the lean-to space.

-- Justification:

a. Code/Criteria Reference: NAVFAC DM-8, Fire Protection Engineering Design Manual, Chapter 6, requires open head deluge systems and oscillating foam nozzles with proper floor drain systems. Deluge systems are not practical due to size and roof height. However, nozzle systems will provide a high level of protection.

b. Approximate Current Cost of Accomplishing Recommendation: $5,000,000.

c. Monetary Justification:

(1) Estimated Replacement Value at Risk: $1,500,000,000 for all three ...gars.

(2) Estimated Probable Loss Without Implementation of Recommendation: ;00,000,000 based on the loss of one hangar with twelve (12) P-3 aircraft inside.

(3) Estimated Probable Loss with Implementation of Recommendation: 250,000.

d. Life Safety: Moderate. Many hundreds of people who work in the attached hops, offices and classrooms would be exposed to loss of life potential due ɔ inadequate alarms and exit provisions.

e. Strategic Importance: Loss of a hangar and up to twelve (12) P-3 ircraft would have a sever impact on the mission of the activity.

f. Brief Supporting Statement: There are no automatic fire protection systems or floor drainage in the two combustible and one unprotected noncombustible angars. All three hangar areas are very large (250,000 sq. ft.) and contain fueled P-3 aircraft, small planes fueled with av-gas, flammables and combustibles cattered throughout. Compounding the problem is a high occupant load in djacent areas with major exiting deficiencies and negligible fire fighting water available. Thus a small fire could rapidly spread out of control.

– Recommendation 4 – (74) Rev.: Upgrade fire protection and life safety in LTA . 2 and No.3, shop, office and classroom areas by:
HGARS NO. 1,

a. Installing a wet-pipe automatic sprinkler system throughout the lean-to ıreas. This primarily applies to Hangar No. 1 where only 20% of the lean-to space is protected.

b. Installing a one hour fire rated wall to separate the lean-to areas from the aircraft servicing areas. All necessary openings in this wall should be protected with approved fire door assemblies.

c. Providing additional exits so that every room or space within the lean-to areas has at least one means of egress to the exterior that doesn't pass through the high hazard space. On the second and third deck, a one hour fire rated enclosed corridor extending the full length of the deck should be provided with exterior stairways every 150 feet.

d. Improving, extending and consolidating the existing fire alarm system to provide manual pull stations near all major exits and audible alarm devices throughout.

-- Justification:

a. Code/Criteria Reference: NAVFAC DM-8, Fire Protection Engineering Desing ...nual requires automatic sprinkler protection in lean-to areas and exit provisions in accordance with NFPA No. 101, Life Safety Code.

Approximate Current Cost of Accomplishing Recommendation: $2,000,000.

c. Monetary Justification: Not applicable

d. Life Safety: Moderate. Personnel on the second deck must exit directly into an open corridor exposed by the hangar aircraft. In the event of an aircraft fuel fire, the high heat release would cause an untenable condition in this avenue of escape. Enclosing the corridor in a one hour fire rated enclosure will provide a safe route of evacuation for personnel. The existing original fire alarm systems are inadequate and unreliable. Upgrading and extending the existing system is necessary to provide proper and effective operation throughour for prompt evacuation of personnel and notification of the fire department.

e. Strategic Importance: Not applicable.

f. Brief Supporting Statement: There are approximately 1000 people working in each of the hangar buildings.

-- Recommendation 5 - (82): Fire protection and life safety in the Building 300/301 ASWOC complex should be improved by the following:

a. Provide complete, wet-pipe automatic sprinkler protection throughout the unprotected portion (approximately 8000 sq. ft.).

b. Provide a smoke detection system at the ceiling and under the floor of electronic areas.

-- Justification:

a. Code/Criteria Reference: NAVFAC DM-8, Fire Protection Engineering Design Manual, Chapters 6 and 8 require automatic sprinkler protection in windowless areas and smoke detection systems in electronic equipment areas.

b. Approximate Current Cost of Accomplishing Recommendation: $100,000

c. Monetary Justification:

(1) Estimated Replacement Value at Risk: $30,000,000

(2) Estimated Probable Loss Without Implementation of Recommendation: $10,000,000.

(3) Estimated Probable Loss With Implementation of Recommendation: $10,000.

d. Life Safety: Not applicable.

e. Strategic Importance: Building 300/301 is the informational hub of A.S.W operations throughout the Pacific. The building contains critical equipment and personnel vital to the mission of the activity.

f. Brief Supporting Statement: Building 300/301 is essentially windowless hich complicates exiting and manual fire fighting. Some of the operations must be attended to without interruption of any kind.

Recommendation 6 - (74): Provide a wet-pipe automatic sprinkler system outhout Building No. 3; Officers' Club.

-- Justification:

a. Code/Criteria Reference: NAVFAC DM-8, Fire Protection Engineering Design Manual requires automatic sprinkler protection in clubs in excess of 8,000 sq. ft.

b. Approximate Current Cost of Accomplishing Recommendation: $120,000

c. Monetary Justification: Not applicable

d. Life Safety: Moderate. A major loss of life potential exists in this lar wood frame building with high occupant load.

e. Strategic Importance: Not applicable.

f. Brief Supporting Statement: This building has approximately 30,000 sq. ft. of essentially windowless wood frame and noncombustible construction.

-- Recommendation 7 - (82) Rev.: Provide a wet-pipe automatic sprinkler system in the Weapons Assembly Building No. 484. In addition, a high speed pre-primed deluge system should be installed in areas where high explosives might be worked on or exposed. Water supplies to the AUW area should be upgraded so that at least 1500 GPM @-70 psi is available.

- Justification:

a. Code/Criteria Reference: NAVFAC DM-8, Fire Protection Engineering Design Manual requires automatic protection in buildings used for testing or processing of propellants or explosives.

b. Approximate Current Cost of Accomplishing Recommendation: $100,000.

c. Monetary Justification:

(1) Estimated Replacement Value at Risk: $4,000,000

(2) Estimated Probable Loss Without Implementation of Recommendation: $4,000,000.

(3) Estimated Probable Loss With Implementation of Recommendation: $25,000.

d. Life Safety: Not applicable.

e. Strategic Importance: A loss of this building would have a major impact on the mission of this activity.

f. Brief Supporting Statement: The building has a partial sprinkler system is vulnerable to earthquake damage since it has no sway bracing.

-- Recommendation 8 - (82): An engineering investigation should be initiated to upgrade the fuel barge unloading pier to the standards required by NAVFAC DM-22, Petroleum Fuel Facilities Design Manual. Included should be a source of reliable fire protection water, an extinguishing system for the wood pier and an exterior fire alarm system.

-- Justification:

a. Code/Criteria Reference: NAVFAC DM-22, Petroleum Fuel Facilities Design Manual requires fire water systems, hydrants and fire alarm reporting systems on fuel piers.

b. Approximate Current Cost of Accomplishing Recommendation: $150,000 for the fire protection portion.

c. Monetary Justification: Not applicable.

d. Life Safety: Not applicable.

e. Strategic Importance: The fuel pier is the primary method of resupplying the activity with fuel. Fuel storage is very limited and damage to the fuel pier would have a major impact on the mission of the activity.

f. Brief Supporting Statement: The fuel pier is in poor condition, located remote portion of the base and lacking in any automatic fire protection. al procedure is for the fire department to standby during fuel unloading. A fuel pipeline to the base is planned for the future.

-- Recommendation: 9 - (82) Rev.: Provide a smoke detection system with connection to the station fire alarm system in the following ground control approach electronics areas: Buildings 158, 329, 408, 446 and 454.

-- Justification:

a. Code/Criteria Reference: NAVFAC DM-8, Fire Protection Engineering Design Manual requires automatic smoke detection systems in electronic areas.

b. Approximate Current Cost of Accomplishing Recommendation: $60,000.

c. Monetary Justification:

(1) Estimated Replacement Value at Risk: $2,000,000.

(2) Estimated Probable Loss Without Implementation of Recommendation: $500,000.

(3) Estimated Probable Loss With Implementation of Recommendation: $10,000.

d. Life Safety: Not applicable.

e. Strategic Importance: All buildings contain electronic equipment necessary instrument landings. A loss of key equipment would have an adverse impact e mission of the activity.

f. Brief Supporting Statement: The buildings are normally unattended.

Recommendation 10 - (80): Provide a smoke detection system with connection to the station fire alarm system in the interior corridors and lounges of the ollowing hotel-style buildings: UOPH Building No. 20 and UEPH Building Nos. 148, 49, 150, 151, 153, 154, 155 and 156.

Justification:

a. Code/Criteria Reference: NAVFAC DM-8, Fire Protection Engineering Design Manual requires smoke detections systems for UOPH and UEPH occupancies with interi- orridors.

b. Approximate Current Cost of Accomplishing Recommendation: $250,000.

c. Monetary Justification: Not applicable.

d. Life Safety: Moderate. A fire in one room could spread smoke and heat rapidly hroughout the building which would create a loss of life potential for sleeping ccupants.

e. Strategic Importance: Not applicable.

f. Brief Supporting Statement: These are large multi-story buildings . high occupant loads.

Recommendation 11 - (80): Install a manual fire evacuation alarm system in each of the following buildings: Administration Building No. 17; Gymnasium Building No. 2; Office Building No. 240; Crafts Hobby Shop Building No. 543; Pro Shop/Coffee Shop Building No. 234.

Justification:

a. Code/Criteria Reference: NAVFAC DM-8, Fire Protection Engineering Design Manual and DOD 4270.1M, Construction Criteria Manual, require manual evacuation alarm systems in buildings with more than 50 people.

b. Approximate Current Cost of Accomplishing Recommendation: $150,000.

c. Monetary Justification: Not applicable.

d. Life Safety: Prompt notification and evacuation in an emergency is vital in order to minimize injuries.

e. Strategic Importance: Not applicable.

f. Brief Supporting Statement: None.

9. BRIEF DESCRIPTION OF WATER SUPPLY SYSTEM: Normal water supply is obtained om the Bay Division of the San Francisco Water Department's 72-inch and 90-inch nsmission mains through three 6-inch compound meters. The meters connect to an

10-inch main which feeds into a pit located outside the west entrance to the ion. Extending from the pit is a single 10-inch main which supplies the Air ion, and a 200,000 gallon elevated storage tank which floats on the distribution system. Emergency connections consist of 8 and 10-inch ties to the NASA (Ames Research Laboratory) distribution system, and a 10-inch tie to the Lockheed Company distribution system on the east side of the Station. The majority of water mains on the base are old unlined cast iron mains, tuberculated on the inside and subject to frequent breaks.

10. WATER FLOW TEST DATA:

LOCATION	STATIC (psi)	RESIDUAL (psi)	FLOW (GPM)	AVAILABLE GPM @ psi	REQUIRED GPM @ psi
Between Hangar #2 and #3 N. end. 8" main flowed Hyd. 35 static and res. pressure on riser.	53	22	710	740 @ 20	10,000 @ 100
S. E. end of Hangar #1 wed Hyd. #8 atic res. on Hyd. #7 8" mains	45	37	750	1600 @ 20	10,000 @ 100
Air National Guard bldg. No. 683	35	10	710	500 @ 20	1500 @ 20
A.U.W. Bldg. 484 dead end main	55	22	750	250 @ 50	1500 @ 50
Bldg. 549 Hyd. No. 59 8" main	46	20	650	300 @ 40	1500 @ 40
Bldg. 144 N. end NASA Hyds. F-44-flow F-37-pressure	70	43	1110	1000 @ 50	3000 @ 50
Moffet Homes ange Ave.	41	18	820	800 @ 20	750 @ 20

ION	STATIC (psi)	RESIDUAL (psi)	FLOW (GPM)	AVAILABLE GPM @ psi	REQUIRED GPM @ psi
Berry Court Housing	50	45	920	2200 @ 20	750 @ 20
Bldg. 19 N end	47	33	840	1200 @ 20	1500 @ 20

NAVAL AIR STATION

MOFFETT FIELD CALIFORNIA

LOCAL RECOMMENDATIONS NOT INCLUDED IN THE FIRE PROTECTION ENGINEERING SURVEY REPORT DATED 15 December 1982

1. Fire protection in Building No. 127 (flammable liquids storage) is seriously deficient and should be upgraded as follows:

   a. Existing ordinary-hazard automatic sprinkler piping should be changed to an extra-hazard piping schedule.

   b. All ordinary electrical equipment should be changed to explosion-proof suitable for Class 1, Division 2, Group D locations.

   c. Acids and flammable liquids should never be stored together. Provide a 3-hour fire wall so that each can be stored separately.

   d. Provide a 3-hour fire wall between the flammable liquids storage area and the rest of the building.

   e. Provide a remote exit at the north end of the storage area.

3. Existing automatic sprinkler protection should be extended to include the following:

   a. The hallway of the new classroom area of Hangar No. 3.

   b. The VP-40 Duty Office of Hangar No. 3*.

   c. The office and snackbar on the west side at Bent 14 of Hangar No. 3*.

   d. The tool room on the west side at Bent 6 of Hangar No. 3.

   e. The offices on the east side at Bents 13 to 16, Hangar No. 2. (lights obstruct the existing sprinkler protection.)

   f. The CPO lounge on the east side at Bent 13 of Hangar No. 2*.

   g. The snackbar area of Building No. 49*.

   h. The front entry area of Building No. 29.

   i. The cafeteria and shops of Building No. 476.

   j. The entry area and the south side of the Navy Exchange building, and the employees lounge.

   k. The inside of the paint spray area exhaust plenums in Building No. 45.

   l. The candy storage area of the Commissary Warehouse Building No. 13.

Enclosure (2)

m. The office area, the U. S. Army Vet Inspector Office, the refrigerators e northwest corner (use dry pendent heads), and the butcher's office of the sary Building No. 12.

n. The office areas of Building No. 142.

o. The office area in Section 5 of Building No. 127.

p. The office, the cold storage areas (use dry pendent heads), and the tchen entry area of Building No. 243.

*NOTE: Existing sprinkler protection has been cut off due to installation of a op ceiling in these areas.

4. In Building No. 3, Officers' Club, the dry-chemical fire extinguishing system otecting the cooking appliances should be equipped with an automatic fuel shut-f and a pressure actuated alarm switch so that when the dry chemical system is activated the natural gas will be shut-off, and an alarm will be transmitted to the fire station automatically.

Provide a fire alarm pull station adjacent to the fuel pier.

In Building No. 17, provide a wet-pipe automatic sprinkler system throughout he basement area. In addition, ionization detectors should be provided in the telephone switchgear room with a connection to the base fire alarm system.

In Building No. 23, replace the altered fire door in the basement with a new listed fire door.

In Building No. 144, warehouse, the automatic sprinkler systems in areas above ubber tire storage, rack storage in excess of 12' in height and two tier storage areas should be upgraded to an extra-hazard pipe schedule. In addition, all fire oors should be tested for proper operation by releasing the fusible links.

9. All hydrants should be consistently identified on the barrel of the hydrant and on the water supply plans.

10. Provide a wet-pipe automatic sprinkler system throughout Building No. 88, Navy Exchange dry cleaning and laundry.

11. All sprinkler risers in Hangar Nos. 1, 2 and 3 should be equipped with earthquake bracing. ✓

12. Smoke detectors should be provided in corridors, lounges and recreation areas of the child care centers.

13. Provide a water flow switch with connection to the station fire alarm system on the existing sprinkler system in Building No. 45.

Interior finish materials should have a flame spread rating of 25 or less nd smoke developed rating of 50 or less in paths of exit, and flamespread of 5 or less and smoke developed of 100 or less elsewhere when tested in accordance ith ASTM E-84, Test Method for Surface Burning Characteristics of Building Materials, n accordance with NAVFAC DM-8, Chapter 2, Section 5. Paneling in Building Nos. (hangar), 2 (hangar), 3 (hangar), 3, 14, 16, 19, 20, 23, 25, 146, 148, 149, 50, 151, 153, 154, 155, 156, 134, 140, 146, 256, 301, NEX III, not meeting the bove criteria, should be removed or replaced with material meeting above requirements.

5. Either repair or replace the fire doors in the following: The stairwells of uilding Nos. 12, 17, 19, 20, 23, 25, 148-151, 153-156, and 158; and the Battery Shop of Building No. 146. All fire doors should be either Underwriters Laboratories, Inc. listed or Factory Mutual approved.

1. COMPONENT		2. DATE
NAVY	FY 1985 MILITARY CONSTRUCTION PROJECT DATA	JUN 8, 1983

3. INSTALLATION AND LOCATION	4. PROJECT TITLE
NAVAL AIR STATION MOFFETT FIELD, CALIFORNIA	FIRE PROTECTION WATER SUPPLY

5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER	8. PROJECT COST ($000)
	843-10	P-500	1,800

9. COST ESTIMATES

ITEM	U/M	QUANTITY	UNIT COST	COST ($000)
PRIMARY FACILITY	-	-	-	1278
TRANSMISSION MAIN	LF	7,675	99.30	(762)
HANGAR DISTRIBUTION GRID	LF	6,000	86.00	(516)
SUPPORTING FACILITY	-	-	-	302
JACKING UNDER FREEWAY	LF	275	371.80	(102)
UTILITY CONNECTION AND METERING DEVICES	LS	-	-	(200)
SUBTOTAL	-	-	-	1,580
CONTINGENCY (5%)	-	-	-	79
TOTAL CONTRACT COST	-	-	-	1,659
SUPERVISION, INSPECTION & OVERHEAD (5.5%)	-	-	-	91
TOTAL REQUEST	-	-	-	1,750
TOTAL REQUEST (ROUNDED)	-	-	-	1,800
EQUIPMENT PROVIDED FROM OTHER APPROPRIATIONS		- (NON-ADD)		

10. DESCRIPTION OF PROPOSED CONSTRUCTION

Construct a direct water connection to nearest aqueduct, which includes a utility connection and metering devices at the aqueduct, the installation of a transmission line, a connection to the existing system and a distribution grid around Hangars 2 and 3. The distribution grid will provide the necessary service and connections to the existing systems in the hangar area and will support future sprinkler and foam nozzle systems. The installation of the transmission line will require the jacking of a steel casing under a freeway.

11. REQUIREMENT: 13,675 LF. ADEQUATE: 0 LF. SUBSTANDARD: 0 LF.
PROJECT: Provides fire protection water supply for the two wooden aircraft maintenance hangars located on the east side of the station.
REQUIREMENT: The two wooden aircraft hangars, their equipment and surrounding aircraft require a minimum 10,000 gallons per minute of water, and 100 pounds per square inch in order to cope with any major fire involvement. At the present time, maintenance for the P-3 aircraft is being performed in the two wooden hangars. These hangars also serve as the administrative and operations headquarters for seven Anti-Submarine Patrol (VP) Squadrons and a Naval Air Reserve Training Detachment as well as one Rescue and Recovery Group of the California Air National Guard. Domestic and fire flow requirements for existing facilities and any future growth on the east side of the station would also be improved.

1 COMPONENT
NAVY

FY 19 85 MILITARY CONSTRUCTION PROJECT DATA

2 DATE
JUN 8, 1983

3. INSTALLATION AND LOCATION
NAVAL AIR STATION, MOFFETT FIELD, CALIFORNIA

4. PROJECT TITLE
FIRE PROTECTION WATER SUPPLY

5. PROJECT NUMBER
P-500

11. REQUIREMENT (Continued)

CURRENT SITUATION: The existing water distribution mains in the area of the two wooden aircraft maintenance hangars can provide a maximum of about 1,000 gallons per minute, at 20 pounds per square inch. This is completely inadequate to cope with any major fire involvement in the two hangars which comprise 722,384 SF of space and can hold up to 24 P-3 aircraft. The 1981 estimated replacement cost of the two hangars is in excess of 59 million dollars and for a single P-3 aircraft this cost is in excess of 19 million dollars.

IMPACT IF NOT PROVIDED: The ability to successfully fight a major fire in the wooden aircraft maintenance hangars will continue to be inadequate and the potential for a major catastrophe will continue to be great.

ADDITIONAL: A primary economic analysis cannot be applied to this project because the existing distribution system around the wooden aircraft maintenance hangars cannot be made adequate for its use through "economically justifiable means".

4

1. COMPONENT NAVY	FY 1985 MILITARY CONSTRUCTION PROJECT DATA	2. DATE JUN 8, 1983

3. INSTALLATION AND LOCATION
NAVAL AIR STATION, MOFFETT FIELD, CALIFORNIA

4. PROJECT TITLE FIRE PROTECTION WATER SUPPLY	5. PROJECT NUMBER P-500

1. POLLUTION PREVENTION, ABATEMENT AND CONTROL
   This project will not cause additional air or water pollution.

2. FLOOD PLAIN MANAGEMENT AND PROTECTION OF WETLANDS
   Requirements of Executive Order No. 11988 (Flood Plain Management) and Executive Order No. 11990 (Protection of Wetlands) are not applicable.

3. ENVIRONMENTAL IMPACT
   A preliminary Environmental Impact Assessment has been made and it has been determined that the proposed project will not have a significant impact on the environment nor is it highly controversial.

4. INTERGOVERNMENTAL COORDINATION
   In accordance with OPNAV Instruction 11010.35, this project has been reviewed with respect to OMB circular A-95 requirements. It has been determined that the project will have no impact on community plans and programs that would require intergovernmental coordination. Therefore, submittal of the project to state and area-wide clearinghouses for review is not required.

5. FALLOUT SHELTER CONSTRUCTION
   Fallout shelter excluded - impairment of project purpose.

6. PRESERVATION OF HISTORICAL SITES AND STRUCTURES
   The project does not directly or indirectly affect a district, site, building, structure, object or setting which is listed or eligible for listing in the National Register or otherwise possesses a significant quality of American History, Archeology, Architecture, or Culture.

7. DESIGN FOR ACCESSIBILITY OF PHYSICALLY HANDICAPPED PERSONNEL
   Provisions for physically handicapped personnel are not required in this facility.

DEPARTMENT OF THE NAVY
NAVAL AIR STATION
MOFFETT FIELD, CALIFORNIA 94035

IN REPLY REFER TO

NASMFINST 5100.4L
186
NOV 1 9 1985

NASMF INSTRUCTION 5100.4L

Subj: OPERATION OF HANGAR DOORS ON HANGARS 1, 2 AND 3

Ref: (a) NASMFINST 3140.1H

1. Purpose. To establish responsibility and procedures for operation of hangar doors on Hangars 1, 2 and 3.

2. Cancellation. NASMF Instruction 5100.4K.

3. Background. The effects of wind (both direction and velocity) on the operation of the hangar doors, and positive and negative overpressure effects on the roof and structure of the hangars caused by wind forces during opening and closing of hangar doors are potentially extreme hazards. Specific precautions must be observed any time hangar doors are operated. The responsibilities of the Door Control Officer, outlined within this instruction, cannot be overemphasized. Door tracks must be checked and cleared of obstructions and at least three personnel (one operator and two safety observers) are required to operate the doors and provide traffic control while the doors are moving. The following precautions and procedures will be observed while operating hangar doors.

a. General

(1) Hangar doors will be operated only by personnel who are qualified. This requires special training and certification in the operation of the hangar doors by the NAS Public Works Department.

(2) At the time Hazardous Weather Condition One is set (this condition exists with sustained winds of 20 knots or gusts in excess of 25 knots) all hangar doors are to be closed. The operations of the doors will then be handled only by Public Works Department.

(3) Only in winds below 20 knots may hangar doors be operated by non-Public Works, but qualified, personnel with the approval of the cognizant Door Control Officer. However, in the case of an actual fire, the NAS Fire Chief can direct the operation of the hangar doors.

(4) Only one door will be operated at any one time. As a precaution against an electrical overload and cumulative weather effects, there will be no simultaneous openings or closings of eith adjacent doors or doors at opposite ends of the Hangars. Doors wil be left in the fully open or fully closed position when unattended.

(5) During fire drills, opening and closing of hangar doors shall be simulated.

R) (6) Door lock pins are to be removed prior to the operation of any hangar doors, and replaced when doors are closed.

(7) The Door Control Officer or Public Works personnel shall verify the weather condition set and actual wind conditions prior to operating doors.

b. Specific Precautions and Procedures

(1) Hangar 1 Doors

(a) Door tracks must be checked each time before doors are operated to insure the tracks are completely clear of all refuse, equipment, vehicles, personnel and other obstructions.
R) Past experience has shown that from the operator's position, at least two safety observers - one at each end of the door - are required. During working hours, these safety observers will be provided by the organization requesting the doors be opened. Safety observers will possess a warning whistle and shall keep the door track clear of all refuse, personnel and vehicular traffic while the hangar doors are in motion. The warning whistle will be used to signal the Door Control Operator to cease door movement if conditions require.

(b) In Hazardous Weather Condition One or greater, the windward doors shall not be opened except in true emergencies. In such emergencies, the approval of the NAS Public Works Officer is required.

(2) Hangar 2 and 3 Doors

(a) Door tracks must be checked prior to each time these doors are operated to insure the tracks are completely clear of all refuse, equipment, vehicles, personnel and other obstructions. Two safety observers are required - one positioned inside the hangar and the other outside the hangar - in close proximity to the moving set of doors. Each safety observer will possess a warning whistle or air powered horn and the observers will remain in sight of each other at all times. They shall keep the door tra clear of all pedestrian and vehicular traffic and shall use their warning whistles or air powered horn to signal the door control operator to cease door movement if conditions require.

(b) In Hazardous Weather Condition One or greater, the possibility exists for these doors to jump their tracks. The following procedures _must be_ followed to insure a safe door operation:

_1_. The Public Works Officer must approve all operations.

_2_. Doors at the opposite end of the hangar must be closed before opening the doors. If the doors at both ends of the hangar are already open when the winds develop, the doors at the _windward end_ of the hangar _must be closed first_ (one at a time).

_3_. If the wind is blowing at an angle to the door opening (quartering or diagonal wind) at the windward end of the hangar, the door which moves into the wind must be opened (or closed) first. (R

4. _Responsibilities_

a. _NAS Public Works Officer shall:_

(1) Render a decision regarding opening or closing of hangar doors in any hazardous weather condition.

(2) Provide qualified Public Works personnel to operate the doors when conditions dictate.

(3) Provide repair personnel between the hours of 0700 and 1600 to correct malfunctions to hangar doors as required. Requests for repairs will be reported to Public Works Transportation Department, ext. 5856. After 1600 hours contact PW Trouble Desk at ext. 5698. (R

(4) Establish and maintain a program to train and certify qualified hangar door operators. Door operator candidates are to be provided by the Door Control Officers. A list of certified door operators shall be provided to the Door Control Officers. Personnel designated by the NAS Fire Chief shall also be qualified and certified. (R

b. _Door Control Officers_

(1) A Door Control Officer is appointed for each hangar, as follows:

Hangar 1 - Commanding Officer of VP-31

Hangars 2 & 3 - Commanding Officer of an on-board VP Squadron as designated by COMPATWINGTEN

(2) If a Door Control Officer listed above desires to designate a person to act on his behalf for performing the routine functions of Door Control Officer, the person designated shall be above the rank of LT or shall be the activity Duty Officer. Routine functions do not include hangar door movements conducted during Hazardous Weather conditions.

(3) Door Control Officers shall have the following responsibilities:

(a) Maintain custody of the keys to the operating controls for the hangar doors. Emergency keys shall be located at each Squadron Duty Office in a metal box with a breakable glass front. Emergency keys shall only be used in a true emergency situation. If a situation develops which necessitates the use of the emergency key, a report shall be provided by the cognizant Doo Control Officer stating full justification for use of the key. Operating controls will be kept locked at all times except when closely attended by a qualified operator.

(b) Designate a minimum number of personnel, second class petty officers and above, to be trained and certified by Public Works in the operation of the hangar doors. Maintain an up-to-date listing of trained personnel.

(c) For each authorized operation of hangar doors, issue the key only to a person whose qualification to operate the doors is certified in writing by the Public Works Officer.

R) (d) Insure that operation of hangar doors is carried out in strict adherence to the instructions which are posted inside hangar door control panel and Section 3b of this instruction.

(e) Maintain a log indicating the date, time of
R) issue and return of key, and any problems with door operation.

(f) In Hazardous Weather Condition One or greater, carefully screen all requests to open hangar doors. Make every effort to coordinate requests so hangar doors will be opened a minimum number of times and for short periods only. Obtain approval from the NAS Public Works Officer following the procedure specified in paragraphs 5b and 5c of this instruction before opening any hangar doors. Observe precautions and procedures as outlined in this instruction.

(g) Operations which require doors to be opened during Hazardous Weather Condition One or other more severe destructive weather conditions shall be scheduled during the hour of 0700 to 1600, whenever possible. Door operations which are required after those hours will be delayed so that personnel can be recalled to evaluate the situation and open the doors, if necessary.

(h) The Door Control Officer will be responsible for assessing the affect of door opening on any ongoing or squadron operation within the hangar; i.e., other aircraft on jacks.

5. Procedure for Requesting Operation of Hangar Doors

a. Requests to operate hangar doors will be made to the cognizant Door Control Officer or his designated representative. In the absence of any hazardous weather conditions or any destructive weather conditions as defined in reference (a) the Door Control Officer or his designated representative as specified i paragraph 4b(2), above, may authorize operation of the hangar doors.

b. If it is requested that the hangar doors be moved during Hazardous Weather Condition One or while any destructive weather condition as defined in reference (a) has been set, the requestor will provide the following information to the Door Control Officer or his designated representative:

(1) Requesting activity.

(2) Name of requestor.

(3) Hangar number and door location.

(4) Desired time for operating doors.

(5) Full justification of the need for operating the doors.

c. If the Door Control Officer or his designated representative determines the operational requirements are such that the hangar doors must be opened during Hazardous Weather Condition One or greater, he shall so inform the NAS Public Works Officer during normal working hours or the NASMF OOD at all other times.

d. The NASMF OOD will inform cognizant Public Works personnel according to existing instructions.

6. Procedure for Securing Hangar Doors for Maintenance. Prior to securing any hangar doors for maintenance or repairs, Public Works will inform the cognizant Door Control Officer and, whenever possible, repair work will be coordinated with required plane movements.

H.H. DAVIS, JR.

DISTRIBUTION:
NASMFINST 5216.2F
Lists A & F

APPENDIX B

DO ALL REQUIRED EQUIPMENT SHARE A COMMON GROUND OR NEUTRAL? YES/NO____________

CHECK RESISTANCE OF GROUND:______ CHECK IMPEDENCE OF GROUND:____________

ARE CONDUIT, FITTINGS, AND ENCLOSERS MADE OF ONE METAL TYPE? YES/ NO IF NOT, ARE THERE APPROPRIATE BONDING JUMPERS PRESENT? YES/NO

IS THERE ALUMINUM CONDUIT BURRIED IN CONCRETE? YES/NO ARE THERE MORE THAN 4-90° BENDS IN CONDUIT FROM FITTING TO FITTING(OUTLET)? YES/NO

ARE THE VOLTAGE VALUES CONSISTENT WITH INSULATION LEVELS ON NAMEPLATE? YES/NO____________

WAS XFORMER CORRECTLY INSTALLED AS PER NEC§450? YES/NO____________

ARE ALL HARDWARE/ELECTRICAL CONNENCTIONS TIGHT PER NEC§110? YES/NO____________

HOW IS THE SYSTEM WIRED? DELTA-WYE/ DELTA-DELTA/ WYE-DELTA/ WYE-WYE/ ________ ARE WINDINGS DETERIORATING? YES/NO____________

ARE ALL CONTACTS CLEAN? YES/NO ____________ RELAYS CLEAN? YES/ NO ____________

ARE INSULATORS/ SHUNTS/ __________ FREE OF TRACKS/ CRACKING/ SPLITTING? YES/NO____________

ANY MECHANICAL(SWITCHES/BEARINGS/RECORDERS/CAMS) DEVICES IN NEED OF LUBRICATION? YES/NO____________

ARE ALL LATCHES/ BEARINGS/ SWITCHES/ BUSHINGS/ FUSE CONTACTS FREE OF DIRT/ CORROSION/ HARD GREASE/ CRACKS/ OIL? YES/NO____________

IS CIRCUIT BREAKER CONDUCTOR TERMINAL TIGHT AND FREE OF DIRT/ CORROSION/ OIL?____________

ARE FUSES READILY ACCESSABLE? YES/NO ____________ ARE BUSWAYS READILY VISABLE AND ACCESSABLE? YES/NO____________

XFORMERS CONNENCTED LINE-TO-NEUTRAL MUST HAVE A RATING EQUAL TO THE LINE-TO-LINE POTENCIAL DIFFERENCE(VOLTMETER) DOES IT? YES/NO____

DO TERMINAL BOARD CONNENCTIONS MATCH DIAGRAM ON NAMEPLATE? YES/NO____________

DO ALL LEADS HAVE THE CORRECT CLEARENCES? YES/NO____________

ARE ALL TERMINAL NUTS/ CONNENCTING LINKS/ LOAD-TAP-CHANGER BOARDS TIGHT? YES/NO____________

DOES ANY ACCESSORY/ CONTROL/ ALARM/ __________ EQUIPMENT WIRING HAVE CRACKS OR SPLITS? YES/NO____________

DO BUSHINGS HAVE SUFFICIENT SLACK ON ALL EXTERNAL CONNENCTIONS? YES/NO ANY INDICATOR LAMPS BURNT OUT? YES/NO____________

ARE THE TERMINAL CONNENCTIONS OF AMPLE SIZE TO KEEP THE BUSHING TERMINAL TEMPURATURE BELOW 70°C? YES/NO____________

ARE ALL CONNENCTIONS CLEAN AND TIGHT? YES/NO____________ ANY LEADS DAMAGED? YES/NO____________

ANY LOOSE BOLTS AT BUS BARS? YES/NO____________

IS THE LIGHTING ADEQUATE? YES/NO____________ ARE FEEDER CONNENCTIONS TIGHT? YES/NO____________

DO THE PRESSURE RELIEF DEVICES WORK PROPERLY? YES/NO____________HAS THE PRESSURE RELIEF DEVICE BEEN RESET? YES/NO

ANY CERAMIC INSULATORS BROKEN/ CRACKED? YES/NO____________ HAS PROTECTIVE SYSTEM BEEN TESTED? YES/NO

HAS HI-POT OR ANOTHER TEST BEEN PERFORMED TO TEST FOR VACCUUM LEAKS? YES/NO____________WHEN?________

ON LOAD-VAC TAP CHANGER, ARE THE GEAR TEETH PAINT MARKS PROPERLY ALIGNED? YES/NO____________

DO ALL LEADS HAVE CORRECT CLEARENCES AS PER NEC§450? YES/NO____________ DOES EQUIPMENT HAVE CORRECT INSULATION CLASS? YES/NO

ARE ALL WIRE/ CABLE CONNECTIONS AND TERMINATIONS TAPED WITH VARNISH CAMBRIC TAPE, THEN PLASTIC TAPE? YES/NO____________

IS THERE GENERAL DETERIORATION OF EQUIPMENT? YES/NO____________ ARE THE FUSES OF THE APPROPRIATE RATING? YES/NO____________

ANY LOOSE OR FLEXABLE CORDS THAT ARE NOT WITHIN NEC§400 CODE? YES/NO____________

INSPECTION NOTES:____________

____

____

____

____

____

____

____

DO ALL REQUIRED EQUIPMENT SHARE A COMMON GROUND OR NEUTRAL? YES/NO____

CHECK RESISTANCE OF GROUND:______ CHECK IMPEDENCE OF GROUND:____

ARE CONDUIT, FITTINGS, AND ENCLOSERS MADE OF ONE METAL TYPE? YES/ NO IF NOT, ARE THERE APPROPRIATE BONDING JUMPERS PRESENT? YES/NO

IS THERE ALUMINUM CONDUIT BURRIED IN CONCRETE? YES/NO ARE THERE MORE THAN 4-90° BENDS IN CONDUIT FROM FITTING TO FITTING(OUTLET)? YES/NO

ARE THE VOLTAGE VALUES CONSISTENT WITH INSULATION LEVELS ON NAMEPLATE? YES/NO____

WAS XFORMER CORRECTLY INSTALLED AS PER NEC§450? YES/NO____

ARE ALL HARDWARE/ELECTRICAL CONNENCTIONS TIGHT PER NEC§110? YES/NO____

HOW IS THE SYSTEM WIRED? DELTA-WYE/ DELTA-DELTA/ WYE-DELTA/ WYE-WYE/ ______ ARE WINDINGS DETERIORATING? YES/NO____

ARE ALL CONTACTS CLEAN? YES/NO ____ RELAYS CLEAN? YES/ NO ____

ARE INSULATORS/ SHUNTS/ ______ FREE OF TRACKS/ CRACKING/ SPLITTING? YES/NO____

ANY MECHANICAL(SWITCHES/BEARINGS/RECORDERS/CAMS) DEVICES IN NEED OF LUBRICATION? YES/NO____

ARE ALL LATCHES/ BEARINGS/ SWITCHES/ BUSHINGS/ FUSE CONTACTS FREE OF DIRT/ CORROSION/ HARD GREASE/ CRACKS/ OIL? YES/NO____

IS CIRCUIT BREAKER CONDUCTOR TERMINAL TIGHT AND FREE OF DIRT/ CORROSION/ OIL?____

ARE FUSES READILY ACCESSABLE? YES/NO ____ ARE BUSWAYS READILY VISABLE AND ACCESSABLE? YES/NO____

XFORMERS CONNENCTED LINE-TO-NEUTRAL MUST HAVE A RATING EQUAL TO THE LINE-TO-LINE POTENCIAL DIFFERENCE(VOLTMETER) DOES IT? YES/NO____

DO TERMINAL BOARD CONNENCTIONS MATCH DIAGRAM ON NAMEPLATE? YES/NO____

DO ALL LEADS HAVE THE CORRECT CLEARENCES? YES/NO____

ARE ALL TERMINAL NUTS/ CONNENCTING LINKS/ LOAD-TAP-CHANGER BOARDS TIGHT? YES/NO____

DOES ANY ACCESSORY/ CONTROL/ ALARM/ ______ EQUIPMENT WIRING HAVE CRACKS OR SPLITS? YES/NO____

DO BUSHINGS HAVE SUFFICIENT SLACK ON ALL EXTERNAL CONNENCTIONS? YES/NO ANY INDICATOR LAMPS BURNT OUT? YES/NO____

ARE THE TERMINAL CONNENCTIONS OF AMPLE SIZE TO KEEP THE BUSHING TERMINAL TEMPURATURE BELOW 70°C? YES/NO____

ARE ALL CONNENCTIONS CLEAN AND TIGHT? YES/NO____ ANY LEADS DAMAGED? YES/NO____

ANY LOOSE BOLTS AT BUS BARS? YES/NO____

IS THE LIGHTING ADEQUATE? YES/NO____ ARE FEEDER CONNENCTIONS TIGHT? YES/NO____

DO THE PRESSURE RELIEF DEVICES WORK PROPERLY? YES/NO____HAS THE PRESSURE RELIEF DEVICE BEEN RESET? YES/NO

ANY CERAMIC INSULATORS BROKEN/ CRACKED? YES/NO____ HAS PROTECTIVE SYSTEM BEEN TESTED? YES/NO

HAS HI-POT OR ANOTHER TEST BEEN PERFORMED TO TEST FOR VACCUUM LEAKS? YES/NO____WHEN?____

ON LOAD-VAC TAP CHANGER, ARE THE GEAR TEETH PAINT MARKS PROPERLY ALIGNED? YES/NO____

DO ALL LEADS HAVE CORRECT CLEARENCES AS PER NEC§450? YES/NO____ DOES EQUIPMENT HAVE CORRECT INSULATION CLASS? YES/NO

ARE ALL WIRE/ CABLE CONNECTIONS AND TERMINATIONS TAPED WITH VARNISH CAMBRIC TAPE, THEN PLASTIC TAPE? YES/NO____

IS THERE GENERAL DETERIORATION OF EQUIPMENT? YES/NO____ ARE THE FUSES OF THE APPROPRIATE RATING? YES/NO____

ANY LOOSE OR FLEXABLE CORDS THAT ARE NOT WITHIN NEC§400 CODE? YES/NO____

INSPECTION NOTES:____

APPENDIX C

COST ESTIMATE

The cost estimate presented is approximate. Material quantities from the recent Tustin, California MCAS hangar repair were used for similar repairs. Glulam timber has increased about 80% in cost since summer 1992 and that increase is included. Labor costs were increased over those used at Tustin to reflect the smaller quantity of repairs over which to distribute start up costs, inflation and the fact that most of the repair work is at the high point of the hangar and difficult to reach with a crane.

ACTIVITY
Moffett Field NAS, CA
PROJECT TITLE
Hangar 3 Truss Repair

SPECIFICATION NO.
12 - __-____
ESTIMATED BY
FIRM:
EST. NAME: Don Neal
STATUS OF DESIGN
☐ 35% ☐ 100% ☐ FINAL ☐ PED ☐ ______

A-E FIRM NAME
Neal Enginnering Assoc.
CHECKED BY

SHEET 55 OF
DATE
18 FEB 1993
WESTDIV JOB ORDER NO.

DESCRIPTION	QUANTITY		MATERIAL COST		LABOR COST		ENGINEERING ESTIMATE	
	NUMBER	UNIT	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
2 - Segment Bypass - 14 places								
Glulam Members (768 FBM)	10,752	FBM	2.05	22,042.	11.00	118,272.	13.05	140,314.
Bolts, Washers, Timber Connectors	14	EA	140.00	1,960.	2,200.00	30,800.	2,340.00	32,760.
								173,074.
1 - Segment Bypass - 1 place								
Glulam Members (585 FBM)	585	FBM	2.05	1,200.	11.00	6,435.	13.05	7,635.
Bolts, Washers, Timber Connectors	1	EA	110.00	110.	1,100.	1,100.	1,210.	1,210.
								8,845.
Web Bypass - 8 places								
Glulam Members (297 FBM)	2,376	FBM	2.05	4,870.	11.00	26,136.	13.05	31,006.
Bolts, Washers, Timber connectors	8	EA	110.00	880.	1,100.	8,800.	1,210.	9,680.
								40,686.
Buckling Repair - 3 places								
Glulam Members (816 FBM)	2,448	FBM	2.05	5,018.	11.00	26,928.	13.05	31,946.
Bolts, Washers, H'dwe.	3	EA	100.00	300.	1,100.	3,300.	1,200.	3,600.
								35,546.
Lower Chord T-Strut Repl. - 1 place								
Glulam Members (80 FBM)	80	FBM	2.05	164.	11.00	880.	13.05	1,044.
Bolts, Washers, H'dwe.	1	EA	100.00	100.	1,100.	1,100	1,200.	1,200.
								2,244
Clamps - 51 places								
Angle Clamp & Bolts	51	EA	16.	816.	125.	6,375.	141.	7,191.
Stitch Bolts - 17 places	17	EA	2.50	42.	125.	2,125.	127.50	2,167.
Stitch Bolt, Washers						SUBTOTAL		269,753
Contingencies +25%								67,438.
Contr. Supervision/General Requir. +15%								40,463.
Overhead & Profit +12%								32,370.
Engineering, Inspection, Etc. +12%								32,370
							TOTAL	442,394.

COST ESTIMATE — WEST NAVFAC 11012/3 (REV 6-82)

CONCLUSIONS

1. Hangar 3 structural timber frames were found to be seriously distressed near their peak within the frame 11-21 work area. The most serious and largest quantity of structural distress and frame damage was observed at frames 13-17. Several frames sustained very serious distress in the upper portion between grid lines 16E and 16W. The severest distress observed is such that the chord force path is essentially severed with chord members split or severely separated and some chord splice joints distorted.

2. The structure is presently standing and may remain standing for considerable time in its distressed condition for the following reasons. This should not obscure the fact that Hangar 3 is a distressed structure in need of repair if it is to remain occupied:

   (1) The structure is highly redundant and shifts loading to adjacent frames and to secondary members such as bracing, purlins, roof deck, etc. in many ways that are too complex to analyze.

   (2) Live loading is negligible on the hangars. Critical loading is dead plus wind loading or dead plus seismic loading. Between windstorms or seismic events the structure is carrying only a fraction of its design loading.

   (3) Material ultimate stress required to cause member failure are substantially higher (2 to 2.5) than allowable stresses which are prescribed for use by the building code. The allowable stress is arrived at by dividing the ultimate stress by a safety factor. The number of individual member failures suggests that material stresses have substantially exceeded allowable code prescribed stresses.

   (4) Failure of redundant secondary bracing members which are probably now overstressed, or the next significant windstorm or seismic event could cause further frame disintegration of it occurs prior to structural repairs. The longer the hangar stands un-repaired, the more likely that further structural damage will occur to the point where the hangar will become un-repairable.

   (5) The most likely mode of failure, in the event that should occur, would be failure in stages with progressively increasing frame deformation accompanied by considerable noise and portions of fractured members falling to the floor in the zone between grids 16E and 16W. This is approximately a 50-foot wide strip down the center of the hangar. If/when any progression of the structural distress is observed the hangar should be vacated.

   (6) The condition of trussed frames as measured by length and separation opening is essentially unchanged from the data recorded by Power Engineering Contractors Inc. in their report dated July 1992.

(7) Frame deformation/deflection due to distress cannot be restored. The best that can be done is to repair the member and lock it into its deformed position. Without a detailed measurement and analysis of each deformed frame, the magnitude of induced secondary forces resulting from the frame deformation cannot be determined. The best that can be expected if the recommended repairs are made in a timely fashion is restoration of the frame to its approximate capacity not considering the detrimental effect of secondary stresses due to frame deformation while distressed.

(8) Hangars 2 & 3 were structurally repaired in 1981 based upon a repair design by Neal Engineering Associates. In 1987, Don Neal visited Moffett Field at the request of Commander Skip Simms regarding a problem with falling sag braces. The sag braces were repaired, secured, or replaced about 1987 and no additional distressed members were observed. Inspection in 1992 and 1993 revealed extensive structural distress at Hangar 3. Based upon the above sequence of events, the weight of circumstantial evidence suggests the present frame distress was caused by the Loma Prieta earthquake.

RECOMMENDATIONS

1. Occupancy of aircraft and personnel is not recommended at the center portion of Hangar 3 between the catwalks and between Frames 11-21 until and unless repairs are completed. A recommended restricted zone would be the area between the center of frames 10-22 except for an approximate 50 feet wide passage and fire lane adjacent to the offices at each side.

2. Specific repair recommendations at frames 11-21 are furnished on repair detail sheets in the Inspection/Repair portion of this report.

3. Power Engineering Contractors, Inc. in their report dated July 1992 identified several buckled top chords at the east half of Hangar 3 at the following locations:

Frame	Location	
* 13E	Grid 6-8 Top Chord	
* 14E	" 6-8 " "	
16E	" 4-6 " "	
16E	" 6-8 " "	
20E	" 6-8 " "	
* 21E	" 6-8 " "	
24E	" 6-8 " "	
24E	" 8-10 " "	
37E	" 6-8 " "	(Did not inspect.)

I inspected all of these locations except the frame 37E location and recommended repairs to realign the buckled top chords at the locations as shown by asterisk (*). In my opinion no repair for buckling is required at the other locations.

4. The last detailed structural inspection/evaluation of Hangars 2 and 3 was done in 1981 and repairs were completed based on recommendations from the report of that evaluation. The recent inspection/evaluation was confined to the top portion of frames 11-21 at Hangar 3. When ownership and tenancy questions are settled, Hangar 2 and the portion of Hangar 3 not covered by this report are due for a structural inspection/evaluation.

Respectfully Submitted,

REGISTERED PROFESSIONAL ENGINEER
DONALD W. NEAL
No. 1820
STRUCTURAL
STATE OF CALIFORNIA

Donald W. Neal

EXP 9/30/93

Donald W. Neal, P.E.
NEAL ENGINEERING ASSOCIATES

APPENDIX D

5/4/93

DRAFT
NASA-MOFFETT FIELD
AIRCRAFT HANGAR FIRE SAFETY PROGRAM

Purpose

It is the Federal government's policy to develop and operate facilities which comply with established building, life safety and fire codes. This is also the policy for facilities at NASA-Moffett Field(NMF) including aircraft hangars. All renovation and new construction at NMF will meet the appropriate codes and standards. All modifications to the hangars shall meet codes applicable to rehabilitation of a Historic structure. All new structures constructed or installed inside the hangar shall be meet applicable codes for new construction.

It is not fiscally practical to upgrade all existing NMF facilities to meet these codes and standards before allowing use once Moffett Field is transferred to NASA. The purpose of this document is to provide a fire safety program for the continued use of the existing Moffett Field aircraft hangars while minimizing the risk to personnel and property.

Fire Safety Program

The lack of automatic fire suppression in the 3 hangars underscores the need for each occupying Resident Agency(RA) of a hangar to have an aggressive fire safety program. The is especially true in Hangars #2 and #3 which are wood truss construction. The RA's shall implement as a minimum the following fire safety program:

1) Designate an on-site Fire Safety Representative.

2) Conduct monthly fire safety reviews of their own operations in the hangar and offices utilizing a comprehensive inspection format applicable to their specific operations. Findings and corrective actions are to be conveyed to the cognizant Ames organization responsible for fire prevention.

3) Provide appropriate fire extinguishers for the fire classifications involved; train personnel on use of these fire extinguishers, and provide adequate servicing and maintenance.

4) Participate in quarterly Fire Department Fire Safety inspections, and provide a timely response for the identified deficiencies. NASA will provide to the RA's the results of inspections performed to identify fire code compliance deficiencies as part of the use agreement process.

5) Actively pursue good housekeeping practices and remove discarded items from the hangar at the end of each work day.

Operational Practices Fire Safety Program

Normal maintenance and operations in the hangars must address the higher risk of operations in a hangar without a fire detection or suppression system. A major concern in hangar safety is the accidental spilling of fuel or the misuse of low flash-point liquids. Maintenance and modifications on aircraft require the use of many of these types of flammable liquids. This is compounded by the constant hazard of ignition sources from internal combustion equipment, lighting, electrical equipment and static electricity. To reduce the fire hazard, operational safety constraints must be placed on work performed in the hangars. The following minimum hangar operating constraints will be followed to reduce the fire risk:

1) Fueling and defueling aircraft shall not be done inside the hangar nor within 50 feet of any permanent structure or other aircraft.

2) There shall be no open flame or hot work operations without a NMF Fire Department permit.

3) There shall be no open flame or hot work operations on the hangar structure without a NMF Fire Department permit and NMF supervision.

4) Storage of flammable materials within the hangar and outdoor/nearby storage areas shall comply with the Uniform Fire Code and Santa Clara County Hazardous Materials Storage Ordinance.

5) There shall be no maintenance operations with fire safety impact (such as painting or stripping) without NMF Fire Department approval.

6) Any compartmentalization of the hangar shall not limit existing means of egress.

7) Inside the hangar, all internal combustion equipment shall have a spark arrestor on the exhaust and be located as far as practical (at least 50 feet) from aircraft. The equipment shall be so designed that all electrical systems, sparking contacts, hot surfaces and any possible ignition sources will be at least 18 inches above the hangar floor.

8) Use only non-flammable or high flash-point solvents and use collection pans. Remove electrical power, shutdown the aircraft's electrical systems, and remove all sources of ignition during cleaning.

9) Connect aircraft to an approved grounding rod or connection during servicing and storage.

10) Prior to performing any fuel cell work on an aircraft, perform the following outside the hangar in a designated area: shutdown the aircraft's electrical systems, remove all sources of ignition, and properly drain and purge the fuel cell of fumes.

11) Maintain all designated fire lanes free from equipment, vehicles or materials

Code Compliance Program

The fire safety and operating constraints act only to reduce the fire risk to life and property in the hangars. It is NASA's goal to develop a plan with the RA's for renovating and upgrading the hangars to meet fire safety codes. The plan will have two primary elements: fire detection and alarm, and fire suppression.

The first element will be the installation of a fire detection/alarm system in the hangars which will reduce the risk to life in the event a fire does occur. NASA will, working with the RA's, develop a concept for this system. The RA's will be responsible for system installation cost in that portion of the hangar they occupy. It is NASA's goal to have these systems fully installed within two years of the transfer to NASA.

The second element will be the installation of an automatic fire suppression system. NASA will work with the RA's to develop the concepts and plans for the fire suppression system. The RA's will be responsible for system installation cost in that portion of the hangar they occupy. It is NASA's goal to have these systems fully operational within four years of the transfer to NASA. To achieve this goal NASA and the RA's must also establish a construction program to assure adequate water is available to the hangars. That program is currently under development.

National Aeronautics and
Space Administration

Ames Research Center
Moffett Field, California 94035

NASA

Reply to Attn of: EEF: 213-3

DATE: July 8, 1993
MEMO TO: Michael Falarski, Chief, Moffett Field Development Project
FROM: Cliff Imprescia, Chief, Facilities Engineering Branch
SUBJECT: Moffett Hangar 3

As you requested, the NASA/Ames Facilities Engineering Branch has reviewed the available structural engineering studies that were done for Hangar 3 during the last decade. The purpose of this review was to assess the structural condition of the hangar for its new resident agency. The attached report summarizes the studies that were performed by several engineering firms. and it gives recommendations for actions to be taken by the new resident agency of the hangar. Please do not hesitate to call me if you have any questions about any part of the report.

Cliff Imprescia

National Aeronautics and Space Administration
Ames Research Center
Facilities Engineering Branch
Moffett Field, California

MOFFETT NAVAL AIR STATION
HANGAR NO. 3

BACKGROUND

Moffett N.A.S. Building 47, or Hangar 3, was built in 1942 to serve originally as a blimp hangar. The building is 170 feet tall, 300 feet wide, and 1000 feet long. The main structure consists of wood-trussed parabolic arches spaced at 20 feet on center supported on 25-foot-tall concrete moment frames. The structure has wood diagonal bracing between panel points of the lower chords and k-bracing between the roof purlins and the lower chord panel points. Bracing between the concrete frames consists of steel pipes. The hangar roof is constructed of corrugated metal over straight wood sheathing. The door structures at each end of the hangar consist of a wood box beam supported by two concrete towers and are isolated from the hangar by a seismic joint. All structural components of the hangar and doors are supported on concrete pile foundations.

Attached to the east side and extending the full length of the hangar is a wood-framed one story to structure that is 30 feet tall and 60 feet wide. This structure is self supporting for loads in tical direction but is supported laterally by the hangar.

PREVIOUS EVALUATIONS

Since 1980 the following evaluations and repairs have been performed:

1980
Neal Engineering Associates inspected the structural frames of Hangars 2 and 3 and provided repair recommendations. Damage consisted of buckled members scattered throughout the hangars but mostly in Hangar 3. This repair work was completed in 1981.

1985
Rutherford & Chekene performed a seismic evaluation of Hangar 2. Because Hangar 3 is identical to Hangar 2, except for the lean-to structure, the conclusions were also applied to Hangar 3. A dynamic modal analysis was performed to apply seismic loads in the transverse and longitudinal directions. The door structures were checked by hand calculations. The analysis identified three deficiencies in Hangar 3: (1) the concrete frames supporting the arches were severely overstressed and inadequately reinforced for ductile behavior, (2) all the connections of the longitudinal bracing trusses were overstressed, and (3) the door towers were overstressed at the top and base. Also, in Hangar 2, the wood cross bracing between the concrete frames were found to be overstressed at their connections.

A structural repair scheme was proposed consisting of infilling every other concrete frame with a concrete shear wall, adding a concrete diaphragm at the top of the concrete frames, strengthening all the overstressed bracing connections, and providing new exposed concrete struts to brace the door towers. The estimated cost for this structural repair scheme was $2,620,000 for Hangar 2 only (this included an estimated $220,000 for securing and bracing nonstructural components). The cost for repairs to Hangar 3 would have been similar. The repairs recommended, however, were never done.

July 1992
Power Engineering performed a detailed structural inspection of the wood framing in Hangar 3. This was the first detailed examination of the hangar since the Loma Prieta earthquake of 1989. Major damage was found in the top and bottom chord members at the top of the arches primarily in frames 11 through 21, which are located near the middle of the building.

August 1992
Rutherford & Chekene performed further review of Hangar 3 to determine whether it met life-safety performance criteria as defined by the National Earthquake Hazard Reduction Program (NEHRP). The study concluded that there were major deficiencies in the lateral force resisting systems of the hangar and that the structure did not meet the criteria for minimum life-safety performance. The major areas of concern were the presence of a soft or weak story in the concrete frames due to inadequate reinforcing, and a discontinuity in the load path to the foundation for the wood sheathing.

The report also stated that the conclusions were pertinent only to the undamaged portions of the hangar. During field observations, two adjacent arches were found to have splits in both their top and bottom chords at the top of the arches. The splits at each damaged chord were at least 1 inch wide and extended through the entire member from end to end. At those locations the chords carried no load, thus the load path for both dead load and lateral loads was removed. The report emphasized that the damaged arches presented a life safety hazard and must be repaired.

November 1992
EQE Engineering and Design prepared a conceptual design for the repair of Hangar 3 using the report by Power Engineering with minimal field investigation. The repair scheme involved bolting pairs of channels over damaged truss members, adding steel gusset plates at joints of damaged members, and adding epoxy and stitch bolts to members with cracks smaller than about 1 inch in width. The estimated cost of this procedure to repair damaged members throughout the hangar was $1,650,000.

January 1993
Neal Engineering Associates performed a detailed inspection of the damage in the upper portions of frames 11 through 21. A report of the damage was furnished to NASA and the Navy with recommendations for repairs. The recommended repairs involved adding glulam bypass members to strengthen the damaged portions of the arches. This concept was similar to the one designed by Neal Engineering in 1980 for the same hangar. The estimated cost for these repairs, limited to the damaged locations observed in frames 11 through 21, was $450,000.

The report also noted that extensive separations in both top and bottom chords were present in most of the frames 11 through 21, and that some of the chords were split into separate pieces. This led Neal Engineering to recommend that the center portion of the hangar between the catwalks and between frames 10 and 22 be cleared of aircraft and personnel.

April 1993

Neal Engineering was hired by NASA to inspect all the arches of Hangar 3 in detail and to provide construction bid documents to repair the damaged members in the hangar. The detailed inspection of every wood arch was completed 4/12/93, and construction documents were completed 6/11/93. The estimated cost for these repairs was $810,000.

RECOMMENDATION OF NASA/AMES FACILITIES ENGINEERING BRANCH

The immediate concern of the Facilities Engineering Branch is that the damaged arches pose a life-safety hazard. The floor areas of the hangar below the damaged frames are unsafe to personnel and aircraft and should be kept clear at least until the damaged arches have been repaired.

The long-term safety of Hangar 3 will continue to be a concern even after the damaged arches are repaired. Even though the buckled members that were repaired in 1981 have performed well, similar buckling has occurred in many other locations in addition to the severely split arch members. At present, we do not understand the cause of these failures. Due to the extensive damage, some truss members are very likely stressed beyond their allowable capacity. The unknown redistribution of stress throughout the hangar makes an accurate estimate of the structure's reserve capacity very difficult. It is likely that even after the existing damaged members are repaired, damage will appear in other members due to wind or seismic loads, although an ordinary linear analysis may not predict this to occur.

We recommend that the structural concerns of the hangar should be fully disclosed to the resident agency of Hangar 3. The resident agency should perform a thorough structural analysis of the hangar and carry out the additional repairs it deems necessary prior to occupying the facility. Finally, we recommend the hangar be inspected periodically by a structural engineer for signs of new or progressing damage. The inspection intervals should be semiannual for the first year after a major repair; however, they may be extended if the results are consistently favorable. Any damage found from these inspections should be evaluated for level of urgency and repaired accordingly.

July 8, 1993

DRAFT

- STATEMENT OF WORK -

CURRENT CONDITION ASSESSMENT OF MOFFETT FIELD HANGARS

May 5, 1993

A: PURPOSE

The purpose of this assessment is to enable NASA to inform other agencies seeking to occupy hangar space on Moffett Field, of the condition of that space. Of particular relevance are any existing life safety issues.

B: BACKGROUND

Moffett Field has three large aircraft hangars. The oldest one, Hangar 1 was built in 1933 for the airship, USS Macon. The other two were built in 1943. All three hangars have been modified to some extent over the years. NASA will obtain these hangars between now and June, 1994.

C: LOCATION OF WORK

The facilities to be assessed are Hangar 1 (Building 1), Hangar 2 (Building 46) and Hangar 3 (Building 47). The assessment will be limited to the areas enclosed by the hangar structures, the hangars exterior surfaces, the area around the hangar that lies within 5 feet of its footprint and the associated transformers, where they lay outside this boundary.

D: ACCESS

Permission for Contractor access to the hangars will be arranged by NASA's Moffett Field Development Office.

E: SCOPE OF WORK

The Contractor will obtain and review relevant drawings, fire/safety and maintenance reports, and previous structural studies of these facilities. The Contractor will conduct a physical inspection of the facilities and produce a full written report of the findings.

As a minimum the following items will be inspected:

ELECTRICAL - Building transformers, MCC, panels, wires and alarms. Significant over or under utilization of utility capacity will also be noted.

MECHANICAL - Heating, ventilation, air conditioning (where applicable), plumbing, and sprinkler systems. Significant over or under utilization of utility capacity will also be noted.

STRUCTURAL - Fire exits, fire hazards, hazardous materials etc. (NOTE: assessment of the overall structural integrity of the facility is NOT required.)

For each facility, the report will document, in the following order, these issues:

1) **Life Safety Hazards**
2) **Outstanding major repairs - (greater than $10,000)**
3) **Any repairs needed to prevent significant future failures**
4) **Over/under usage of utility capacity**

In addition, an order of magnitude engineering estimate of how much it would cost to effect the each of the necessary remedies is required.

Any major safety hazards, repairs etc. that are identified by the Contractor will immediately be reported by the Contractor to the Project Manager. If the item is mutually deemed to require significant further assessment then this will NOT be done as part of this study. It will be noted in the report by the Contractor as Future Required Work. An estimate for this future work will be included.

The full and final report is to be submitted by the Contractor to the Project Manager on or before **Febuary 1, 1994**

F: SCHEDULE

Prior to commencement of the work the Contractor shall submit to the Project Manager a Plan of Action outlining how the requirements of the scope will be met, and a Schedule showing when activities are planned to take place with associated labor loadings.

G: SCOPE CHANGES

Unless otherwise directed by the Project Manager, proposed changes and/or additions to the Scope of Work, Plan of Action or Schedule must be submitted by the Contractor to the Project Manager in writing. Such changes are allowable only if the Contractor receives prior written approval by the Project Manager.

H: REPORTING AND DELIVERABLES

The Contractor will keep the Project Manager informed of progress on a daily basis.

The end deliverable of this project is the final inspection report as described in the Scope of Work above.

Progress submittals will be made by the Contractor at the 30%, 60% and 90% stages. These deliverables will take the following form:

30% - oral presentation on progress and planned activities
60% - draft report including findings, estimates and conclusions.
90% - final draft of report including table of contents, full details of findings and associated estimates, conclusions and any appendices and attachments.

The schedule for these submittals is negotiable but nominally will be as follows:

30% - 2 weeks after contract award (a.c.a.)
60% - 3 weeks a.c.a.
90% - 5 weeks a.c.a.
100% - June 18, 1993

B+ 147 19

LOG NUMBER 431663 DEPT 13/N

SERVICE REQUEST

NASA - AMES RESEARCH CENTER

TO Engineering

Code ETT

MAIL STOP 207-1

COMPLETE WORK BY ~~11/1/00~~ 10/1/93

☐ RUSH JOB ROUTINE RATE

☒ ROUTINE JOB STANDARD RATE

WHEN COMPLETED ☒ MAIL ☐ CALL

REQUEST NUMBER	ORG CODE 28-31	TYPE 32	SERIAL 33	34	35	INSERT ORG CODE AND SERIAL NO.
	EC		1	9	9	

REQUESTED BY Rose Ashford

ORGANIZATIONAL CODE EC

TELEPHONE NUMBER 4-0914

DELIVERY POINT/MAIL STOP NAS-19-01

DATE Apr.30, 1993

TRANS 7-9	FY 10-11	FS 12-13	MA 14-15	OBJ. CLASS 16-20	JOB ORDER 21-27	REQ LINE 36-37	FOC 38-39	DOCUMENT PREFIX 40-44	DOCUMENT SERIAL 45-52	DOCUMENT ITEM 53-55	MISC. 56-64	SG 65	VOUCHER NO. 66-71	AMOUNT DOLLARS 72-78	AMOUNT CENTS 79-80
8C3					[illegible] 80 H37KF	01	99	SERV		001			SERVR9		00
8C3					80	02	99	SERV		002			SERVR9		00
8C3					80	03	99	SERV		003			SERVR9		00

SECURITY CLASSIFICATION NONE

INSPECTION REQUIRED YES NO X

SIMULATOR MODIFICATION APPROVAL N/A

DESCRIPTION OF WORK REQUIRED

Life safety inspection of NAS hangars 1, 2 and 3. Refer to attached S.O.W. for details.

JT Weekly report of accrued charges to be sent to Digby Christian at NAS-19-01

Project Manager for this work is Digby Christian (4-0917)

Responsible ETT Sub-Cotr is Don Nickison (4-4056), M/S 207-1

Work Control Center 3120

Cost not to exceed: $25,000

CALL JIM NIX ~~60~~ 40916

ESTIMATED COST - DOLLARS

MATERIALS & SUPPLIES $ ______

LABOR HRS ____ AT ____ $ ______

COMPUTER ACCOUNTING UNITS ____ AT ____ $ ______

OTHER ______ $ ______

TOTAL ESTIMATED COST $ ______

JOBS UNDER $500.00

IF LESS THAN $500, WORK WILL BE DONE WITH NO FURTHER APPROVAL. IF $500 OR MORE, SERVICE REQUEST WILL BE RETURNED TO ORIGINATOR FOR ADDITIONAL APPROVAL(S).

APPROVALS

SPON. ORG.	INITIALS	DATE
BRANCH	EA	5/14/93
DIVISION	MCF	5/14/93
DIRECTORATE		
OTHER		

JOBS $2500 OR OVER

PERFORMING ORGANIZATION COMPLETES

ACCOUNTING REPRESENTATIVE (PCU) VERIFIES FUNDS ARE AVAILABLE

INITIALS ______ DATE ______

ARC F (REV JUL 81) (Developed on EXCEL 2.2a)

10.0 ACKNOWLEDGMENTS

The following persons provided more than the usual expert counsel and deserve special thanks for their help in producing this document. They are as follows: Ron Airing, Rose Ashford of NASA Moffett Field Development Project, Don Nickison of NASA E.T.T.; LCMDR Jim McGranahan and Lt. Gordon Turner of the U.S. Navy; Inspector Robert Sondgrass of Moffett Field's Fire Prevention Office; Shawn O'Brien of I.S.I. VideoTherm; Ramsey Razik of Chemical Waste Management, Inc.; Brad Brewster and David Reel of Bentley Engineering; Chuck Casson and Pete Santos of P.W.C.; Dan Kaisar of Boeing; Digby Christian, John Koss and Jim Nix of BAMSI.

Special thanks to Lorraine Yu of Bently for her computer support.

Exceptional thanks to the following personnel of the Moffett Field Development Project Office for their administrative support Claire Barksey, and Cyndi Martinez.

Gracious appreciation towards Annette Rodrigues Deputy Chief, Moffett Field Development Project for usage of computer hardware.

Project Team consisted of the following personnel from BAMSI's Engineering and Planning Staff, which included Ali Alkan, Adeline Chong, Frank Chu, Audrey dela Cruz, Peter Ferrari, Robert Ha, Moysha Khaylis, Mark Shirk, Gary Storck and Tim Webb.

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Volume 5 - Appendix B - Calculations - Buildings 46, 49, 88, 144, 146
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11.1.1 "Moffett Infrastructure Report", Rev. 1, Moffett Field Development Project Office, February 26, 1993.

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Encompassing Synopsis of the Condition and Feasible Utility of Blimp Hangars 2 & 3

(More simply put: Overview of the practical use of Hangars 2 & 3 based on their present condition)

Prepared by Robert Dolci and Team

Table of Contents

Usability of Hangars 2 & 3

Forward and Executive Management Overview

On January 5, 2000, Code JF was assigned the responsibility to coordinate the necessary actions between the appropriate functional organizations to assess the conditions of Hangars 2 & 3 and to determine the feasibility of their use. The specific issues requiring consideration are as follows:

1. What are the structural and infrastructure issues associated with Hangars 2&3?
2. What are the major safety issues associated with them?
3. What are possible actions that would make them useable for other purposes once they are vacated?
4. What is the feasibility and possible alternative use for the hangars?
5. What are the regulatory implications and probable costs associated with the demolition of either Hangar 2 or 3 or both?
6. What is the current schedule for the Air Guard to vacate Hangar 3? What are the current plans for construction of the new CANG hangar relative to location, schedule and design?

This study clearly points out that both Hangars, in their present condition, are unsuitable for occupancy. The hangars are considered hazardous and pose unacceptable risk to occupants and NASA Ames. The costs to NASA to remediate the hazards in both hangars would likely be prohibitive. Other than short-term use in a controlled condition incorporating significant life safety and fire protection improvements, use of either hangar should be disallowed. The Air National Guard is aware of the hazards associated with Hangar 3. Based on their current occupancy, they appear willing to accept the risks until such time as their new hangar is constructed.

Because the hangars are historically significant structures, it is unlikely that the State Historic Preservation Officer would allow demolition of both structures. It is recommended that when the National Guard vacates Hangar 3, one of the hangars be demolished or made fire safe. The remaining hangar should not be occupied until such time as the hazards are adequately addressed. The cost to demolish Hangar 2 may exceed $8M. In order to avoid the cost of demolition, each hangar can be made reasonably fire safe for as little as $3,000,000 each. This will not meet occupancy requirements. This would involve installation of a partial fire sprinkler system. It will likely prevent the hangars from burning down. Every effort should be made to preserve at least one of the hangars.

Alternate uses for the hangars have been considered. All options investigated resulted in significant additional costs.

Methodology

Code JF pulled together a team of subject matter experts to help compile the required data and to help prepare a comprehensive information paper for consideration by senior management. Each appropriate functional organization was involved in the data gathering effort. Codes FEF, JFP, JP, QE, and QH provided considerable support. The Airfield Management Office, the Special Projects Office, and the Moffett Development Office also contributed to the effort.

Each of the involved organizations performed an independent on-site assessment of the hangars based on its area of expertise and responsibility. There was considerable redundancy in findings among the functional groups relative to health and safety issues. The California Air National Guard also provided valuable information from a feasibility study comparing the costs associated with the retrofit and upgrade requirements for Hangar 3 versus the construction of a new hangar.

Excerpts from and/or whole sections from the documents provided by the contributing organizations are included in this report. The Facilities, Logistics, and Airfield Management Division have on file all the supporting documentation that was used to prepare this report.

Drafts of this document were provided to each of the contributing organizations for their review and comment. All comments that were received prior to the deadline were considered for inclusion in this document.

Overview of Significant Findings

The Navy Bureau of Yards and Docks built hangars No. 2 and No. 3 at Moffett Field in 1943 to house blimps that patrolled the Pacific Coast. These structures are 171 feet high and enclose a ground floor area of approximately 297,000 (1000’x297’) square feet. Hangars No. 2 and No. 3 are identical structures, consisting of arch-shaped wood trusses which clear-span the high bay of the hangars a distance of 234 feet. The trusses are spaced 20 feet on center and are supported at each end by concrete bents. Within the bent’s spaces and running the entire length of the hangars on both sides are 2-story office, lab, shop and other hangar support facilities. Subsequent to the original construction, a 2-story, 60 foot wide by 1,000 foot long lean to structure was added to the east side of hangar No. 3. This addition was designed for primarily office and shop space.

Hangars Pose Unacceptable Risk to Occupants

The comprehensive review clearly points out that in their present condition the hangars pose considerable risk to occupants relative to health, physical safety, and fire safety. For the most part, the hangars are not in compliance with governing health and safety regulations, the Uniform Building Code (UBC), the National Electrical Code (NEC), the Uniform Plumbing Code (UPC), the National Fire Protection Association (NFPA), and OSHA standards.

From a seismic perspective, both hangars have been determined to be highly hazardous. In addition to the hangars' design not meeting seismic code, there is considerable damage to many of the structural elements. Other than short duration use, the risk to occupants should be considered unacceptable.

Fire safety conditions are not significantly better than seismic safety conditions. The timber is old, dry, and untreated (from a fire retardant perspective). Because of the condition of the wood and the way the hangar is constructed, flame spread will be very rapid. A fire starting near the bents could result in total conflagration within 30 minutes. It is highly likely that a significant seismic event will provide sufficient activation energy, coupled with the highly combustible fuel sources in the hangars, to cause a fire in one or both of the hangars. Even without a seismic event, the hangars pose an unacceptable fire threat. A large hangar structure, similar to Hangar 2, was consumed by fire within 20 minutes in 1995 at a facility in North Carolina. A similar hangar in Oregon was consumed by fire in 1992. The fire was so hot and rapid that the structure started to collapse within 10 minutes.

Use by Non-Federal Tenants

Because of the magnitude and accumulative combination of hazards, the risks should be considered unacceptable. While other federal agencies may be willing to accept the risk, they should be made fully aware of the risks. In their present condition, it is unadvisable to allow use of the hangars by anyone including federal organizations. Short-term use may be considered if certain life safety and fire protection improvements are completed. Under no conditions should the hangars be used for large gatherings without the aforementioned improvements.

If NASA Ames Research Center management decides to make either hangar available to a nonfederal organization by lease or other agreement, NASA can handle the liability issues in a variety of ways, all of which we have used or are now using at Moffett Field for other organizations. If the agreement with the nonfederal entity is a truly collaborative one, meaning that NASA will be working along with the nonfederal entity on a project of common interest, each party can agree to waive any and all claims against the other. Since the endeavor is collaborative, NASA will assume its share of the third party risk, and the nonfederal entity will assume its share.
If, however, the agreement is one in which NASA really has no interest in the project (i.e., noncollaborative) but is willing to make the hangars

available for reimbursement of NASA's costs, NASA can require the nonfederal entity to do any or all of the following: (1) unilaterally waive all claims the nonfederal entity may have against the U.S. Government (but keep open the possibility of NASA claims against the entity); (2) indemnify, defend, and hold harmless the U.S. government and its officers and employees (and we can add "resident agencies" and "resident partners") from all third party claims; and/or (3) obtain insurance covering NASA and its officers and employees as "additional insureds." Of course, if NASA management regards the risk as too great in the first place, it should decide not to make the hangars available to non-federal users.

Risk Analysis

Because of anticipated probability of occurrence and because of the combined magnitude of the hazards, an in-depth risk analysis was not performed. The outcome was obvious, the hangars should be vacated until repairs and upgrades are made. Current users should be made aware of the risks.

Historic Preservation Issues

It is highly unlikely that the State Historic Preservation Office (SHPO) will allow both hangars to be demolished. It is even likely that it would consider the demolition of even one hangar to be an adverse action. The Agency may be able to win approval to have one of the hangars demolished. There is very little chance that approval would be granted by the Federal Government to demolish both hangars.

If neglect of the hangars continue, the State Historic Preservation Officer (SHPO) may determine that our lack of due care constitutes an adverse action. If SHPO so rules, they would be compelled to seek recourse. In other words, we may be forced to repair and fire “safe” the hangars. Requesting authorization to demo both hangars may be politically unwise. From the historic preservation perspective, it might be better to request demolition of one with the understanding that the money saved from it will be used to help maintain and repair the other. Even if NASA choose to ignore SHPO’s ruling, the National Historic Preservation Act would be applicable. It is extremely unlikely that NASA will be allowed to circumvent this law.

Maintenance and Repair

Almost all of the mechanical, electrical, plumbing and structural systems need some attention. The structural systems need considerable repair and up-grade. Many sections of both hangars have seen no maintenance in at least 5 years.

Probable Costs

The costs associated with bringing the hangars up to code are prohibitive. Total cost per hangar is likely to exceed $25,000,000. The costs to make each hangar reasonably safe would be in the neighborhood of $10,000,000 to $15,000,000.

If the intent is to protect the hangars from fire, a partial fire suppression system can be installed along the outer walls. The system would only need to be installed in the lower third of the walls. This would only protect the structure. It would not meet any applicable fire code. Therefore this would not meet the requirement for occupancy.

The cost to demolish one hangar is estimated to be between $6,000,000 and $8,000,000 depending on which hangar is demolished and whether or not the wood has salvage value. The final cost may be higher if the main structure has to be treated as low-grade hazardous waste. If the timber is has to be disposed of as hazardous waste, the cost to do so may be as much as $2,500,000

The chart below reflects what it would cost to bring each structure up to applicable code compliance such that they can be used as hangars.

Function	Hangar 2	Hangar 3	Total
Maintenance/Repair M.E.&P.	$1,250,000	$1,350,000	$2,600,000
Structural/Seismic Upgrades	7,500,000	8,000,000	15,500,000
Fire Protection	14,000,000	15,000,000	29,000,000
Roof Repair	3,000,000	3,500,000	6,500,000
Hazard Remediation	350,000	450,000	800,000
Code Compliance (M&E), OSHA (occupational Safety), ADA	5,000,000	5,000,000	10,000,000
Total	$31,100,000	$33,300,000	$64,400,000
Demolition	$8,500,000	$10,500,000	$19,000,000

Estimates show that other use of the hangars such as light manufacturing, may reduce the fire suppression costs by as much as $8,000,000. The cost to make one of the hangars usable for light manufacturing, commercial or other use can run between $100 and $150 per square foot. There would be no financial advantage to constructing a building within a hangar. Of course, any building or rooms constructed within the hangar would have to have fire suppression. Before any new-use upgrade can be made, at least $20,000,000 would have to be spent per hangar to deal with know code violations, structural problems, and fire suppression concerns. The annual maintenance and repair cost for hangars of this type would be very high. The costs to maintain the hangar as well as the facilities it would house would be exorbitant.

Health and Safety Considerations

In general, the preponderance of the findings has some health and/or safety implications. This section is intended to provide an overview of all the significant health and safety issues. The findings are presented as general conditions and are not provided for specific areas or rooms. For the majority of issues presented the same deficiencies are common throughout each hangar. The issues presented assume that the hangars will continue to be used as hangars. Any other use will likely impact the costs of repair and upgrade to an unknown extent based upon use.

The noted deficiencies were based on the evaluation of existing conditions per the requirements of the1998 California Building Code. As Building Code requirements are dependent on occupancy type, for the purpose of this study the office portion of the hangars were treated as a type-B (Business) occupancy. The Hangar spaces were evaluated using the H-5 occupancy criteria. The following conditions were common to both hangars.

1. At many locations throughout the hangar, lead based paint was found pealing off walls and chipping off wood trim and windows. Asbestos pipe lagging was found in many areas, in some cases labeled and encapsulated, and in other areas assumed asbestos and non-encapsulated. Friable material, possibly asbestos, was noticed on ducts. Broken and friable transite was found throughout. Hydraulic machinery fluid and electrical transformer fluid, which is most likely hazardous material, was also noted.

2. The nearly 60 years of dust accumulation and bird droppings can pose a significant health risk if not properly dealt with.

3. Uncapped plumbing drains and sewer lines were found open in some instances.

4. The stairways to the second floor have stair tread which do not meet current building codes for rise and run, non-compliant handrails, and in some instances they do not meet minimum exit width requirements. The guardrails do not meet minimum standards.

5. Exiting requirements are non-compliant generally throughout most of the building. Many of the exit stairways and office room/area doors terminate in the hangar and not at the exterior of the building as required. Exiting through a hazardous area, in this case a hangar is not permitted by the Building Code.

6. Dead bolts were found on many doors throughout the building. Any locking mechanism must be easily visible and operable from the inside of the room.

7. The second floor and mezzanines are non-handicap accessible. Depending on how the building is used will determine what occupancy requirements apply. More than likely this will be an issue.

8. The restrooms throughout the facility are non-handicap compliant and are in poor condition. They will require significant upgrade.

9. The restroom electrical outlets within six feet of the sinks are not GFCI type.

10. In some second floor offices, windows extend to the floor. There are no Safety Glass certifications or markings on the glass.

11. Exit illumination (permanently on) is generally not provided in corridors and stairways. Emergency lighting is not provided in some areas, estimated to be lacking in at least 80% of the required areas.

12. Illuminated exit signs with emergency power back-up lighting is not provided.

13. Evacuation devices (audible visual type), and manual pull stations at the main exit doors, are lacking throughout.

Fire Suppression and Protection

In their present condition, both Hangars 2 and 3 are considered to be a significant fire hazard. Sister hangars, which have been destroyed by fire, have an overhead flame spread of approximately ten minutes. The flame spread was from one end of the hangar to the other end. Because the hangars are within close proximity and because of their tremendous heat load, if one hangar becomes fully involved it is highly likely that the other will follow. If a fire starts within the main structural members it is questionable that even an immediate response by the fire department could prevent catastrophic loss of the hangars.

Do to the size of the structures, without complete fire sprinkler protection, the buildings exceed the allowable floor area. However, under the provisions of CBC Sec. 8-302.4, with sprinkler protection, Historic Buildings may have unlimited floor area. NASA's fire protection standards state that NASA aircraft hangars shall be constructed and protected in accordance with the appropriate provisions of NFPA 409. Even if the hangars do not house NASA aircraft they are still considered NASA hangars and therefore must meet applicable NASA standards.

According to NFPA 409, hangars shall be protected by one of the following methods:

> (1) Overhead, foam-water deluge systems, utilizing Aqueous Film Forming Foam (AFFF) and designed in accordance with NFPA 409
>
> (2) Over-head foam-water wet-pipe sprinkler systems and AFFF monitor nozzles.

Because Hangars 2 and 3 are historical structures, Chapter 34 of the California Building Code requires full compliance with all fire life safety requirements. Specific fire protection issues follow and, for the most part, are common to both hangars.

1. The Hangar floors do not have proper fire suppression as required by NFPA 409, Standard on Aircraft Hangars. A foam water deluge system capable of extinguishing an aircraft/fuel fire is required.

2. In the limited areas that have sprinklers the systems and heads in some cases are approaching 50 years old. NFPA standards require heads be replaced or representative samples be submitted for testing. The tests should be repeated at 10-year intervals.

3. A one-hour fire rated separation is required between the hangar and the offices. Doors are required to be 1-hour fire rated. Windows opening towards the hangar are required to be fire rated glass and frames.

4. At various locations throughout the office portion of the building, exposed plywood wall finish material most likely exceeds the maximum flame spread and smoke development ratings allowed by the building code. CBC Sec. 804.

5. The allowable travel distance to exits for hangars (H-5) is 300 ft for buildings without sprinklers and 400 ft. for buildings with sprinklers. Portions of the hangar exceed the allowable travel distance in either case, however, the deficiencies would be viewed much less significant in a building with sprinklers.

6. The mezzanines are presently used for limited storage. As this is significant accessible storage space, a future tenant may make extensive use of the area. Should this be the case, additional automatic sprinkler protection will be required.

This section assumes use as hangars. Use of these structures for other than what they were designed for is likely to significantly increase the cost of fire suppression.

Structural Considerations

The main buildings measure 1000 feet long, 297 feet wide, and 171 feet tall. The main structures consist of wood-trussed parabolic arches spaced at 20 feet on centers supported on 25-foot tall concrete moment frames. The structures have wood diagonal bracing between panel points of the lower chords and K-bracing between the roof purlins and the lower chord panel points. Many of the original wood X-braces between the concrete frames have been replaced with steel tubes. The roofs are constructed of corrugated metal over straight wood sheathing. The door structures at each end of the hangars consist of a wood box beam at the top, supported by two concrete towers and are isolated from the hangar by a seismic joint. All structural components of the hangars and doors are supported on concrete pile foundations.

Historical Evaluations of Structural Integrity

1946 & 1953

The fabricator of all the superstructure members, Timber Structures, Inc. of Portland, Oregon, conducted inspections in 1946 and 1953 and recommended some bolt tightening and some minor repair requirements. There are no records to show that these repairs were ever made.

1980 & 1981

Neal Engineering Associates conducted inspections of Hangars 2 & 3 in 1980 and 1981 and provided repair recommendations for both the structural frames and roofing. Most of the damaged structural members were found in Hangar 3. Repair work was completed in 1981.

1981-1983

Power Engineering Contractors, Inc. of Palo Alto performed a major project sometime between 1981 and 1983 to check and tighten all truss bolts in both hangars. Some steel trusses in both hangars were also replaced. The cost of this work was believed to be about $1.2 million.

June 1985

In 1985 Rutherford and Chekene performed an evaluation for seismic vulnerability of the main structure of Hangar 2. Because Hangar 2 is identical to Hangar 3, except for the lean-to-structure, the conclusions were also applied to Hangar 3. A dynamic modal analysis was performed to apply seismic loads in the transverse and longitudinal directions. The door structures were checked by hand calculations. The analysis identified three major deficiencies: (1) the concrete frames supporting the arches were severely overstressed and inadequately reinforced for ductile behavior, (2) all the connections of the longitudinal bracing trusses were overstressed, and (3) the concrete door towers were overstressed at the top and base. Also the horizontal members of the longitudinal truss were determined to be inadequate.

A non-structural field survey showed many potential hazards to life safety and to the essential functions in both Hangar 2 and Hangar 3. These hazards include falling objects such as light fixtures, suspended heaters, and wood planks.

A structural repair scheme was proposed consisting of in-filling every third concrete base frame with a concrete shear-wall, constructing a new concrete diaphragm at the top of the concrete frames, strengthening all the overstressed bracing connections, and constructing two new concrete bracing struts at each concrete door tower. The estimated cost for this structural repair scheme was $2,620,000 for Hangar 2 only (this included an estimated $220,000 for securing and bracing nonstructural components). However, the repairs recommended were never performed. Equivalent construction costs today would be in excess of $8,000,000.

1987

In 1987, Power Engineering Contractors, Inc. reattached all the sag braces in both hangars with screws. The sag braces had originally been nailed in and some were failing as the nails corroded. The cost of this work was about $93,000. Apparently, no work has been done to tighten bolts on the exterior siding.

July 1992

In July 1992, Power Engineering Contractors, Inc. performed a detailed structural inspection of the wood framing in Hangar 3. This was the first detailed examination of the hangar since the Loma Prieta earthquake of 1989. Inspectors climbed every third frame. The frame being climbed was inspected in detail, and the visible faces of the adjacent frames were checked with field glasses. Bolt torque readings were taken for every frame at the bottom and catwalk levels, and for every third frame at the crown level.

Major damage, identified as “split cracks” and/or “open cracks” in the beams were found in the top and lower chord members at the top of the wood-trussed parabolic arches mostly in frames 11 through 21. Smaller cracks, splits, and check cracks were also found throughout the hangar.

August 1992

Rutherford & Checkene performed further review and analysis of Hangar 3 to determine whether it met life safety performance criteria as defined by the National Earthquake Hazard Reduction Program (NEHRP) Handbook for Seismic Evaluation of Existing Buildings.

The study concluded that there were major deficiencies in the lateral force resisting systems of the hangar and the structure did not satisfy the criteria for minimum life safety performance as defined by NEHRP. The major areas of concern were the presence of a soft or weak story in the concrete frames due to inadequate reinforcing, inadequacy of the connections of the diagonal bracing, and the complete lack of connection from the diaphragm to the concrete foundation.

The report also stated that during the field inspection of the hangar, two adjacent arches were found to have splits in both their top and lower chords at the top of the arches. The splits at each damaged chord were at least one inch wide and extended through the entire member from end to end. At those locations, the chords cannot take any load, and therefore the load path for any load is completely removed. The report emphasized that the damaged arches are life safety hazards and must be repaired.

The effect of the lean-to-structure, mezzanines, and new steel bracing cannot be defined until a detailed structural analysis is performed on them.

November 1992
EQE Engineering and Design prepared a conceptual design for the repair of Hangar 3 using the structural inspection report of Hangar 3 dated July, 1992 by Power Engineering Contractors, Inc. and structural repair drawings dated 1981 by Donald W. Neal, Structural Engineer. They did not conduct an independent study to determine the extent of the damage. The strengthening recommendations include installing pairs of channels over damaged members, providing new steel gusset plates at joints to connect all new and existing damaged members, applying epoxy injection to repair cracks and splits for crack widths of 1/2 inch or less, and adding stitch bolts for members with cracks and splits with crack widths greater than 1/2 inch. The estimated cost of this procedure to repair damaged members throughout the hangar was $1,650,000.

January 1993
Neal Engineering Associates conducted a detailed inspection of the damaged arches of Hangar 3. They concentrated their inspection in the top portions of frames 11 through 21. Upon completion they submitted a structural evaluation report of the damage with recommendations for repairs. The recommended repairs involved adding glue-laminated bypass members, placed concentrically on the outside of existing damaged members to strengthen the damaged portions of the arches. This concept is similar to the one designed by Neal Engineering in 1980 for the same hangar. The estimated cost for these repairs, limited to the damaged locations observed in frames 11 through 21, was $450,000.

Neal Engineering Associates also advised that because the area bounded by the longitudinal catwalks and frame 11 through frame 21 is in a deteriorated condition, it is not safe for occupancy by aircraft and personnel until repairs were completed.

April 1993
In April 1993, Neal Engineering Associates was retained by NASA to provide detailed structural evaluation of all arches of Hangar 3 and furnish construction bid documents for the repair of the damaged members in the hangar. Neal Engineering Associates submitted the final construction bid documents to NASA in June 1993. The estimated cost for these repairs was $810,000. Three types of repairs were included in the construction bid documents.

Type A repair is recommended at all locations where a primary chord or web member is severed or seriously distressed. It consisted of a glue-laminated bypass repair member that is placed and fastened concentrically to the existing damaged member.

Type B repair is designed to realign chord buckling. It consist of placing and bolting a very stiff strong-back on each side of a buckled chord with solid blocking in between to straighten and realign the buckled chord.

Type C repair consists of clamps and stitch bolts that are used to close small separations.

1994-1995

In October 1994, a contract was awarded to Philo & Sons, Inc. to perform minimal repair work on Hangar 3 using the construction bid documents submitted by Neal Engineering Associates in June 1993. The repair work was performed, completed, and was accepted in September 1995 at a cost of about $398,000.00.

Structural Recommendations

Hangars 2 & 3 are Naval Historic Monuments and are California Historical Civil Engineering Landmarks which are destined to be preserved and protected as required, based on DoD directive 4710.01, 36 CFR 60 and 65 (references f and g). The longer the hangars stand un-repaired, the more likely that further structural damage will occur to the point where the hangars will no longer be repairable.

The structural hazards of Hangars 2 & 3 should be a concern to all hangar occupants/users. Even though the damaged arches of Hangar 3 were repaired, there is no guarantee that the other undamaged arches or even the repaired arches will not suffer any damage during an earthquake, a typhoon, or after the passage of time. While the buckled members that were repaired in 1981 have performed well, similar buckling has occurred in many other locations. The causes of these failures are unknown.

The structures were designed more than fifty-seven years ago for wind loading conditions. These structures have successfully weathered severe windstorms since their construction in 1942. However, the code provisions of Seismic Zone 4 lateral loads were not conceived of during the late 1930's when the hangars were designed by the U.S. Navy. Therefore, it is likely that more frame damage could occur during a major seismic event. Hangars 2 & 3 lack adequate seismic resistance. Furthermore, it is not considered feasible to upgrade the full structure to meet the current code provisions.

It is strongly recommend that the structural concerns of the hangars be fully disclosed to the users of Hangars 2 & 3. If Ames intends to allow continued use of the hangars it should require a review of the structural repair scheme proposed by Rutherford & Chekene in 1985 for Hangar 2 (which can also be applied to Hangar 3). Construction bid documents should be prepared based on that report and the required repairs should be made prior to occupying the facility.

Finally, it is highly recommend that the hangar be inspected periodically by a structural engineer for signs of new or progressing damage. The inspection intervals should be semiannual for the first year after a major repair and may be less often if the results are consistently favorable. Any damage found from these inspections should be evaluated for level of urgency and repaired as necessary.

Condition of Mechanical/Electrical Systems and Infrastructure

An extensive inspection of the mechanical, plumbing, and electrical systems was recently completed by Johnson Controls. While many of the systems are not in compliance with applicable codes, for the most part they appear to be functioning reasonably well. Many of the systems have not been maintained in the last 5 or more years. The site infrastructure is adequate for the present use of the hangars. There is minimal additional capacity for increased utility loads.

In each hangar the heating from the central plant is grossly undersized and cannot adequately heat offices and shop areas.

Using infrared thermography the mechanical and electrical systems should be inspected to determine if the systems are operating at temperatures that exceed design parameters. Because of the structures' susceptibility to fire, it would be prudent to conduct the tests within the near term.

Not including roofs or structural systems, each hangar has about $2,000,000 in required repairs. Most of the existing systems are no longer parts supportable. This will eventually significantly drive up the annual maintenance and repair costs. Currently, the annual maintenance cost for each hangar would be around $200,000. Of all the systems, the electrical systems require the greatest attention.

The large doors for both hangars require extensive repairs to the rail system as well as the drive motors. The motors are no longer parts supportable and will require major overhaul in the near future.

Historic Preservation Issues

The State Historic Preservation Officer (SHPO) will require a compelling argument if Ames elects to remove one or both of the wooden hangars. With a limited number of structures of this type in California it is not likely that the State would concur with the undertaking to remove both hangars. From the standpoint of a state historical asset, the only other examples of wooden hangars in

California are the Marine Corps hangars at Tustin. The SHPO is well aware of the Moffett hangars and has commented on the Tustin blimp hangars in a letter to the Center's Historic Preservation Officer on November 10, 1999. Ames would have to involve the NASA Administrator, the Advisory Council on Historic Preservation and the public if it decided to proceed with the undertaking without SHPO concurrence.

If Ames decided to proceed with the removal of the hangars, it is highly likely that the strongest position with the SHPO would be to request removal of only one of the wooden hangars. The strongest argument would be that the existence of two hangars of almost identical design and location is not required to interpret the historical significance of this type of structure. Also the argument exists that if one caught fire both would be lost due to their close proximity.

One other consideration that needs to be taken into account is the Historic Resources Protection Plan document. The Center is about to submit this to SHPO for review and comment. Nowhere in this document is it discussed that there may be plans to remove one or both of the wooden hangars.

Any proposal to demolish one or both hangars would require an Environmental Assessment and public review. This would entail public meetings, mailings, and response to comments.

If Hangar 2 were removed, reconstruction of a new facility at this location would also be subject to SHPO review since the land still remains within the original National Historic District. New structures, which detract from historic interpretation of Hangar 3, may not be acceptable to the SHPO. If the removal of Hangar 2 were submitted to the SHPO for consideration, disclosure of plans for replacement structures would most likely be required. It is questionable that the SHPO would accept reduction of the Historic District footprint area to eliminate this condition.

Hangar Utility

Hangar 3 is Best Option

Removal of Hangar 2 would probably be the best choice if one had to be selected for removal. At the present time, there is insufficient space between Hangar 2 and the airfield to provide apron space for aircraft. If Hangar 2 were removed, Hangar 3 would have adequate adjacent apron space and would be more efficient for aircraft use. Also, Hangar 3 is the "best" hangar from the standpoint of having shop and service facilities built into the East Side of the structure. It is also in the best condition and it has had more money invested in it for improvements.

Each hangar can house, by category, approximately the following type and number of aircraft (not inclusive):

• 747-400	approx. 5
• 747-SP	approx. 6
• P-3 size	approx. 12-15
• Blimps	approx. 12+
• Corporate Jets	approx. 20-30, depending on size

The existing 10" thick hangar floor does not have adequate strength to support a fully fueled and loaded 747-400 or 747-SP. The concrete floor would require removal and replacement with 14.5-inch thick reinforced concrete slab. Also, portions of the apron areas outside of these hangars would require removal and replacement with new pavement.

Potential Use Other than Aircraft Hangar

When the hangars' condition, maintenance and repair needs, and upgrade requirements are considered it becomes immediately evident that they have very little practical application. To change the building occupancy classification would be extremely cost prohibitive. If the type of occupancy were changed, the hangars would require full code compliance based on their new occupancy classification.

To return a hangar to a condition in which it can be used would cost between $75 and $95 per square foot. Because the hangars have very little utility other for which they were designed (Blimps) it would be exceedingly difficult to get a reasonable return on the investment. It would not be prudent for NASA to invest a lot of money in the hangars. If a hangar were turned over to a developer the amount that it would have to charge per square foot would be prohibitive.

New hangar construction cost is between $150 and $200 per square foot. While this is considerably more per square foot that the $75 to $95 to upgrade the existing hangars, a new hangar would have far greater utility. In addition, the annual recurring maintenance and repair costs are far cheaper for a new hangar. Floor space in a hangar can be leased for as little as $4 per square foot per year to as much as $8 per square foot.

For commercial purposes hangars 2 and 3 each have approximately 200,000 square feet of net usable aircraft storage space. At $6 per square foot per year each hangar's revenue could be as much as $1,200,000 per year. This would not be sufficient to cover NASA's costs. Also, it is unlikely that the present political climate would allow use of the hangars for commercial aviation. It is important to note that the hangars could be used without a Space Act Agreement because of their historical significance.

Other potential uses for one or both of the hangars might include:
1. Light Manufacturing Plant
2. Sound Stage
3. Major Event Facility
4. Storage Facility
5. Blimp Construction, Maintenance/Repair, and Upgrades Facility
6. Transportation Museum
7. Sports Complex
8. Hydroponics Facility
9. An Aviary

Example 1

What would it cost to utilize Hangar 2 as a sound stage? First, it is important to realize that the hangars have very poor acoustics. Therefore, a standalone sound stage would have to be constructed within the hangar. To make the required repairs and upgrades to hangar 2 would cost about $75 per square foot. To construct a sound stage within Hangar 2 could cost as much as $200 per square foot. Total cost could be as much as $275 per square foot. To construct a sound stage not within a hangar could be as much as $225 per square foot. The cost per square foot to construct it within hangar 2 would be $50 more per square foot. The annual maintenance cost would be at least $3 per square foot per year more. Total additional construction cost would be around $15,000,000. Total annual additional maintenance, repair and infrastructure shared costs could be as much as $1,000,000 per year.

This example can also be used to evaluate other potential uses for the hangar. Light manufacturing for example. The minimum cost of construction for a light manufacturing facility is in excess of $160 per square foot. Constructed in the hangar it may be as little as $120 per square foot. With the required repairs to the hangar construction costs would be around $195 per square foot. This is assuming that the floors could handle the manufacturing equipment load.

Example 2

Consider using a hangar as a major event facility. As a minimum NASA would have to spend $20,000,000 on Hangar 2 to reasonably meet code requirements such that it could be safely used for major events with minimal risks to the Agency. Cost to maintain the facility would likely exceed $1,000,000 per year. If Ames was able to charge $50,000 each time it was used it would require 20 uses per year just to cover the cost of annual maintenance and repair. Of course this would not cover the Center's operating costs nor would it cover the $20,000,000 investment cost.

California Air National Guard Hangar Status

The construction of the Guard's 62,000 square foot hangar is scheduled to start in October 2000. It is anticipated that the project will be completed by February 2002. The Guard will vacate Hangar 3 by September 2002. The new hangar will be located in the southeast corner of the airfield. The design is essentially complete and the procurement process is underway.

We the under signed respectfully submit this document to the Director of Center Operations for consideration and further submission to the Deputy Director of Ames Research Center.

Robert J. Dolci, Chief, JF

Joe Gippetti, Fire Marshal, JP

Trish Morrissey, Chief, FEF

Sandy Olliges, Chief, QE

David King, Chief, QH

Hangars 2 & 3
Hazards Notice and Disclosure Report

NASA Ames Research Center
April 4, 2000

Received by: ________________

1.0 Overview

The purpose of this Hangars Two and Three Hazard Notice and Disclosure Report (Disclosure) is to summarize known deficiencies with respect to current building, fire and safety codes. This disclosure includes information from field reports and results of previous studies from the Facilities Engineering Branch; Plant Engineering Branch; Environmental Services Division; Safety, Health, and Medical Services Division; and Protective Services Office.

NASA Ames hereby provides notice and disclosure of certain existing conditions of the Hangars as known to NASA Ames Research Center. NASA Ames makes no warranty or representation that this disclosure provides a listing of all potentially hazardous conditions. The disclosures in this document are made only to further the user's due diligence and shall in no way relieve or diminish the user's obligation to conduct its own due diligence assessment of the Hangar.

2.0 Health and Safety Considerations

This section is intended to provide an overview of previously identified health and safety issues. It is likely that users will need to mitigate hazards found in their areas of use. The findings are presented as general conditions and are not provided for specific areas or rooms. For the majority of issues presented the same deficiencies are common throughout each hangar.

The noted deficiencies were based on the evaluation of existing conditions per OSHA and the requirements of California Department of Health Services and the1998 California Building Code. As Building Code requirements are dependent on occupancy type, for the purpose of this report the office portion of the hangars were treated as a type-B (Business) occupancy. The Hangar spaces were evaluated using the H-5 occupancy criteria. Other uses may have different Building Code requirements. The following conditions were common to both hangars.

1. At many locations throughout the hangar, lead-based paint was found peeling off walls and chipping off wood trim and windows. Asbestos pipe lagging was found in many areas, in some cases labeled and encapsulated, and in other areas assumed asbestos and non-encapsulated. Friable material, possibly asbestos, was noticed on ducts. Broken and friable transite was found throughout. Hydraulic machinery fluid and electrical transformer fluid, which is most likely hazardous material, was also noted.

2. The nearly 60 years of dust accumulation and bird droppings can pose a significant health risk if not properly remediated.

3. Uncapped plumbing drains and sewer lines were found open in some areas.

4. The stairways to the second floor have stair tread which do not meet current building codes for rise and run, non-compliant handrails, and in some instances they do not meet minimum exit width requirements. The guardrails do not meet minimum standards.

5. Exiting requirements are non-compliant generally throughout most of the building. Many of the exit stairways and office room/area doors terminate in the hangar and not at the exterior of the building as required. Exiting through a hazardous area, in this case a hangar is not permitted by the Building Code.

6. Dead bolts were found on many doors throughout the building. Any locking mechanism must be easily visible and operable from the inside of the room.

7. The second floor and mezzanines are non-handicap accessible. Occupancy requirements will be dependent upon the specific use of the hangar space.

8. The restrooms throughout the facility are not handicap-compliant and are in poor condition.

9. The restroom electrical outlets within six feet of the sinks are not GFCI type.

10. In some second floor offices, windows extend to the floor. There are no Safety Glass certifications or markings on the glass.

11. Exit illumination (permanently on) is generally not provided in corridors and stairways. Emergency lighting is not provided in some areas and is estimated to be lacking in at least 80% of the required areas.

12. Illuminated exit signs with emergency power back-up lighting is not provided.

13. Evacuation devices (audible visual type) and manual pull stations at the main exit doors are lacking throughout.

3.0 Fire Suppression and Protection Considerations

In their present condition, both Hangars 2 and 3 are considered to be a significant fire hazard. Blimp hangars of similar construction and vintage, which have been destroyed by fire, had an overhead flame spread of approximately ten minutes. The flame spread was from one end of the hangar to the other end. Because the hangars are within close proximity and because of their tremendous heat load, if one hangar becomes fully involved it is highly likely that the other will follow. If a fire starts within the main structural members it is questionable that even an immediate response by the fire department could prevent catastrophic loss of the hangars.

3.1 Due to the size of the structures, without complete fire sprinkler protection the buildings exceed the allowable floor area. However, under the provisions of CBC Sec. 8-302.4, with sprinkler protection, Historic

Buildings may have unlimited floor area. NASA's fire protection standards state that NASA aircraft hangars shall be constructed and protected in accordance with the appropriate provisions of NFPA 409. According to NFPA 409, hangars shall be protected by one of the following methods:

> (1) Overhead, foam-water deluge systems, utilizing Aqueous Film Forming Foam (AFFF) and designed in accordance with NFPA 409
>
> (2) Over-head foam-water wet-pipe sprinkler systems and AFFF monitor nozzles.

3.2 Because Hangars 2 and 3 are historical structures, Chapter 34 of the California Building Code requires full compliance with all fire life-safety requirements specific fire protection issues follow and, for the most part, are common to both hangars.

3.2.1 The Hangar floors do not have proper fire suppression as required by NFPA 409, Standard on Aircraft Hangars. A foam water deluge system capable of extinguishing an aircraft/fuel fire is required.

3.2.2 In the limited areas that have sprinklers the systems and heads in some cases are approaching 50 years old. NFPA standards require heads be replaced or representative samples be submitted for testing. The tests should be repeated at 10-year intervals.

3.2.3 A one-hour fire rated separation is required between the hangar and the offices. Doors are required to be 1-hour fire rated. Windows opening towards the hangar are required to be fire rated glass and frames.

3.2.4 At various locations throughout the office portion of the building, exposed plywood wall finish material most likely exceeds the maximum flame spread and smoke development ratings allowed by the building code. (CBC Sec. 804)

3.2.5 The allowable travel distance to exits for hangars (H-5) is 300 ft for buildings without sprinklers and 400 ft. for buildings with sprinklers. Portions of the hangar exceed the allowable travel distance in either case, however, the deficiencies would be viewed much less significant in a building with sprinklers.

3.2.6 The mezzanines are presently used for limited storage. As this is significant accessible storage space, a future tenant may choose to make extensive use of the area. Should this be the case, additional automatic sprinkler protection will be required.

4.0 Structural Conditions and Deficiencies

The main buildings measure 1000 feet long, 297 feet wide, and 171 feet tall. The main structures consist of wood-trussed parabolic arches spaced at 20 feet on centers supported on 25-foot tall concrete moment frames. The structures have wood diagonal bracing between panel points of the lower chords and K-bracing between the roof purlins and the lower chord panel points. Many of the original wood X-braces between the concrete frames have been replaced with steel tubes. The roofs are constructed of corrugated metal over straight wood sheathing. The door structures at each end of the hangars consist of a wood box beam at the top, supported by two concrete towers and are isolated from the hangar by a seismic joint. All structural components of the hangars and doors are supported on concrete pile foundations. Specific structural conditions and deficiencies follow.

4.1 In 1985, a dynamic modal analysis was performed to determine the structural stability of Hangars 2 & 3. The analysis identified three major deficiencies: (1) the concrete frames supporting the arches were severely overstressed and inadequately reinforced for ductile behavior, (2) all the connections of the longitudinal bracing trusses were overstressed, and (3) the concrete door towers were overstressed at the top and base. Also the horizontal members of the longitudinal truss were determined to be inadequate.

A non-structural field survey showed many potential hazards to life safety and to the essential functions in both Hangar 2 and Hangar 3. These hazards include falling objects such as light fixtures, suspended heaters, and wood planks.

4.2 In July 1992, a detailed structural inspection of the wood framing in Hangar 3 was performed. This was the first detailed examination of the hangar since the 1989 Loma Prieta Earthquake. Inspectors climbed every third frame. The frame being climbed was inspected in detail, and the visible faces of the adjacent frames were checked with field glasses. Bolt torque readings were taken for every frame at the bottom and catwalk levels, and for every third frame at the crown level.

Major damage, identified as “split cracks” and/or “open cracks” in the beams were found in the upper and lower chord members at the top of the wood-trussed parabolic arches mostly in frames 11 through 21. Smaller cracks, splits, and check cracks were also found throughout the hangar.

4.3 In 1992, further review and analysis of Hangar 3 was performed to determine whether it met life safety performance criteria as defined by the National Earthquake Hazard Reduction Program (NEHRP) Handbook for Seismic Evaluation of Existing Buildings.

The study concluded that there were major deficiencies in the lateral force resisting systems of the hangar and the structure did not satisfy the criteria for minimum life safety performance as defined by NEHRP. The major areas of concern were the presence of a soft or weak story in the concrete frames due to inadequate reinforcing, inadequacy of the connections of the diagonal bracing, and the complete lack of connection from the diaphragm to the concrete foundation.

The study also determined that during the field inspection of the hangar, two adjacent arches were found to have splits in both their upper and lower chords at the top of the arches. The splits at each damaged chord were at least one inch wide and extended through the entire member from end to end. At those locations, the chords could not take any load, and therefore the load path for any load was completely removed. The study emphasized that the damaged arches are life safety hazards and must be repaired.

4.4 The long-term safety of the Hangars will continue to be a concern in spite of the repairs performed on the arches. Even though the buckled members that were repaired in 1981 have performed well, similar buckling has occurred in many other locations in addition to the severely split arch members. The most severe splits were repaired in 1994 in Hangar 3 and other minor repairs have been performed over the years in both hangars. But at present, we do not understand the cause of these failures. Due to the extensive damage, some truss members are very likely stressed beyond their allowed capacity. The unknown redistribution of stress throughout the hangar makes an accurate estimate of the structure's reserve capacity very difficult. It is likely that even after the existing damaged members are repaired, damage will appear in other members due to wind or seismic loads.

5.0 Condition of Mechanical/Electrical Systems and Infrastructure

An extensive inspection of the mechanical, plumbing, and electrical systems show that while many of the systems are not in compliance with applicable codes, for the most part they appear to be functioning reasonably well. In each hangar the heating from the central plant is grossly undersized and cannot adequately heat offices and shop areas.

5.1 Prior to tenancy of a hangar, the potential user may be required to participate in an infrared thermography check of the mechanical and electrical systems to determine if the systems are operating at temperatures that exceed design parameters. The infrared thermography is required because of the structures’ susceptibility to fire.

5.2 The large doors for both hangars require extensive repairs to the rail system as well as the drive motors. The motors are no longer parts-supportable and they are not reliable.

Summary

Based on the information contained in this “Disclosure Report” it is evident that Hangars 2 and 3 potentially pose a wide variety of hazards that must be carefully reviewed by your organization. Some hazards are clear and identifiable, while some pose unknown potential and yet other hazards may still not be known and identified. In addition, some hazards could potentially expose your organization regulatory violations depending on the area and conditions in which you use the hangar space.

NASA strongly recommends that any organization that intends on using space within Hangars 2 and 3 thoroughly reviews and evaluates their use of the hangar(s) with professionals knowledgeable in hazard identification and risk assessment. Risks involving employee safety, cost, schedule, property, regulatory compliance or any other factors important to your organization should be considered before signing occupancy agreements or using hangar space.

u740 Rm 1007

SERVICE TO INDUSTRY PROGRAM REPORT

An Initial Evaluation of DOUGLAS FIR Wood Components in Hangars 2 and 3 at the NASA/Ames Research Center

by

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And

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Report No. 35.04.470

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MARCH 2002

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INTRODUCTION

This report was written to report on the recent evaluation of wood components in two structures at the NASA/Ames Research Center. The Service to Industry Program (SIP) at the University of California Forest Products Laboratory was contacted regarding an analysis of wood structural elements from Hangars 2 & 3. The future use of these buildings was in question and information regarding the presence of preservative or fire-retardant treatment chemicals was desired. This information was requested so that the impact of any chemicals present in the wood could be analyzed and the effect on the reclamation and future re-use of the wood components could be evaluated.

Previous testing for various chemicals and potential wood preservatives was conducted on material from Hangar 3 in August, 1992 by Chemical Waste Management, Inc. The results of this analysis were provided in an October 23, 1992 report submitted to Steven G. Brisbin. This report indicated the presence of amounts of phthalates, chromium, copper, and arsenic in the wood that were at or above the detection limit. The levels of chromium and copper detected during the evaluation raised concerns that the material may be considered a federally regulated hazardous waste and more information was deemed necessary.

The wood components in the two buildings, Hangars 2 and 3, were sampled for this analysis during site visits on March 4 and 19, 2002. The material was then ground and submitted to various laboratories for analysis.

PROCEDURES

During the site visits sheathing and structural members of various sizes were sampled for analysis. For the structural elements, twenty 5/8 inch diameter by approximately one inch length cores, each from a different wood element, were combined to make up each sample. In Hangar 2 the cross sections of the five wood elements sampled in this manner were: 2 ½ x 5 ½, 2 ½ x 7 ½, 3 ½ x 13 ½, 3 ½ x 15 ½, and 5 ½ x 13 ½ inches. In Hangar 3 the cross sections of the five wood components sampled in this manner were: 2 ½ x 5 ½, 2 ½ x 7 ½, 3 ½ x 13, 3 ½ x 15 ½, and 5 ½ x 13 inches. Sheathing materials were also sampled in each hangar. The sheathing samples were obtained by chiseling a section from one edge of ten individual pieces of the material. The material in each sample (each size of wood element from each hangar) were ground to pass through a 20-mesh screen in a Wiley mill.

For each hangar, ground material from each piece of material in each sample (from wood elements of each size) was combined for the analysis of copper, chromium, arsenic, phosphorous, and sulfate content. For each hangar, material from each of the structural elements was combined into a sample and material from each of the sheathing boards was combined into a different sample for the analysis of pentachlorophenol and creosote content.

RESULTS AND DISCUSSION

A. Hangar 2

Grade stamps on the wood indicated that it was milled by Oregon Lumber and that it met the West Coast Lumber Inspection Bureau (WCLB) standards, with some being in the select merchantable grade ***(Photographs 1 and 2)***. According to a representative from the WCLB the current equivalent grade for this material would be select structural. The wood in this hanger was identified as Douglas-fir (*Pseudotsuga menziessii*). The structural elements in this hangar were incised and additional grade stamps indicated the presence of a fire-retardant treatment (FRT, ***Photograph 3)***. Incisions are small openings caused by teeth pressed into the wood to aid penetration of the treatment chemicals and they cause some loss in strength. The treatment stamps indicated the wood had been treated with Minalith, an early FRT formulation. The components of this FRT are noted in ***Attachment 1***. Wood fibers littered the floor in this hangar ***(Photograph 4)*** and were apparently the result of a breakdown of the surface of the structural wood elements in the building ***(Photograph 5)***.

The results of the chemical analysis were summarized in **Tables 1 and 2**. The results of the analysis were also presented in ***Attachments 2 and 3***. Creosote was detected in the sheathing of this structure. A pooled sample, containing material from each of the wood components sampled, indicated the presence of arsenic, chromium, copper, phosphorous, and sulfate.

B. Hangar 3

The material in this building was of a darker color than that in Hangar 2. The structural elements reportedly bore West Coast Lumber Association (WCLA) rule 10 grade stamps. The different color of the wood and a lack of incisions indicated that the FRT used for the construction of this structure was not the same as the material used in the construction of Hangar 2.The species of wood was identified as Douglas-fir (*Pseudotsuga menziesii*).

The results of the chemical analysis were summarized in **Tables 1 and 2**. The results of the analysis were also presented in ***Attachments 2 and 3***. Creosote was detected in the sheathing of this structure. A pooled sample, containing material from each of the wood components sampled, indicated the presence of chromium, phosphorous, and sulfate at levels above the detection limit. Crystals were noted on the surface of many of the structural components in the building, indicating potential treatment with an FRT salt formulation ***(Photograph 6)***. The surface of this material did not exhibit defiberization like that noted on material in Hangar 2 and the levels of phosphorous and sulfur varied, indicating that any FRT formulation used was not the same as in Hangar 2. Two levels of chromium were reported for this hangar, 120 mg/kg and 2.8 mg/L. The first was the Total Threshold Limit Concentration (TTLC) and the second was the Soluble Threshold Limit Concentration (STLC).

C. Considerations in the reuse of wood from these structures

The results of this analysis and the literature (***Attachment 4***) indicate that all of the material in the structures was treated with an FRT. Fire-retardant treatments are hygroscopic and may affect the ability to finish products manufactured from wood containing these chemicals. The chemicals in many FRT formulations can also contribute to corrosion of metals in contact with treated wood and this should be considered when machining this material or choosing fasteners and hardware for products manufactured from it. FRT's are also known to affect the structural integrity of wood components and may reduce the effective cross section of these elements. Pressure treatment with preservatives or FRT's creates an envelope of treated material around an untreated core. The integrity of the material in the treated zone may be compromised by degradation of the wood components caused by the FRT chemicals. The fire-retardant used to treat wood components in Hangar 3 was unknown, but grade stamps on material in Hangar 2 indicate the FRT used was Minalith.

Wood naturally contains small amounts of most of the materials that were tested for during this study. The background levels of a variety of elements found in the dry plant tissues of softwoods (Gymnosperms) and hardwoods (Angiosperms) are given in ***Attachment 5***. The elemental composition of various species of wood is given in ***Attachment 6***. Information specific to Douglas-fir was not available but would be expected to fall within the same general range.

The one-inch thick sheathing on the two structures was nailed in place and removal without damaging the material may be difficult. In addition, results of the chemical analysis indicate the sheathing on each structure was treated with creosote and reuse of this material will be restricted by its presence. The dimensions of the material, coupled with the high number of fasteners and the presence of the preservative indicate that removal and disposal may be required.

SUMMARY AND CONCLUSIONS

The structural wood components used in the construction of the two hangars had several differences. Hangar 2 was constructed with incised structural elements pressure-treated with Minalith FRT. Hangar 3 was constructed using structural elements that were not incised, but high sulfate levels and the literature indicated that the material was likely treated with some sort of FRT. Chemical degradation of wood in the treated zone was likely to cause some loss of integrity, effectively reducing the cross-section of the material, and a corresponding reduction in the strength of this material. The FRT chemicals may also affect the durability of fasteners and the ability to apply a finish to products manufactured from this material. Stainless steel or hot dipped-galvanized fasteners typically perform well in treated material, but electro-plated or other lower cost fasteners may be subject to corrosion of the metal and the surrounding wood and an early failure.

The presence of the other analytes may prohibit certain uses of this material. Chromium III typically becomes fixed within the wood giving it a low toxicity but material containing this element should not be burned or it will convert to the more toxic chromium VI. Arsenic is toxic and respiratory protection is recommended when cutting or otherwise machining material containing either of these elements.

The sheathing used for each Hangar was treated with creosote. The dimensions of the siding material and the presence of this preservative will limit its reuse and it is likely that this material will need to be disposed of. Federal or other restrictions on the presence of the other elements detected during this analysis may further limit the re-use of these wood components.

FUTURE ACTION

Mechanical testing of some of the wood elements will help evaluate the effects of any possible chemical degradation. Testing of small-scale specimens may be effective for a preliminary evaluation of the effects but full scale testing may be warranted for re-use of the material in structural applications. This information will also be necessary to evaluate the structural integrity of the existing buildings.

If the results from the mechanical testing indicate that the wood components in the buildings were not affected by the fire retardant treatment, an evaluation of the buildings can be undertaken. Evidence of minor fungal degradation was noted during sampling for this study and a more thorough evaluation should help to identify any areas where decay, insect attack, or other degradation has occcurred.

With the listed considerations in mind, the structural elements used in the two hangars are good candidates for reclamation and reuse or remanufacture in applications where these limitations can be accommodated. Stephen L. Quarles, Wood Building Durability Advisor with Cooperative Extension, at the UCFPL should be able to assist with recommendations for groups interested in recycling lumber and finding contact information at the various companies. The market for materials recycled from deconstructed buildings is developing and has grown markedly. ***Attachment*** *7* provides an overview of this emerging field.

Table 1. Results of analysis for Creosote and Pentachlorophenol in wood removed from Hangars 2 & 3, NAS Moffet Field*

Sample Number	Hangar	Element	Parameter	Result	Units	Detection Limit	Laboratory
Hangar 2	Hangar 2	Sheathing	Creosote	6600	ug/kg	5.0000	Spectrum
			Pentachlorophenol	0.00	ug/kg	0.0100	Spectrum
II	Hangar 2	Structural Elements*	Creosote	0.00	ug/kg	5.0000	Spectrum
			Pentachlorophenol	0.00	ug/kg	0.0100	Spectrum
H3S	Hangar 3	Sheathing	Creosote	8000	ug/kg	5.0000	Spectrum
			Pentachlorophenol	0	ug/kg	0.0100	Spectrum
III	Hangar 3	Structural Elements*	Creosote	0.00	ug/kg	5.0000	Spectrum
			Pentachlorophenol	0.00	ug/kg	0.0100	Spectrum

* "Sheathing" indicates a sample that included only material from the sheathing on the structure.
"Structural Elements" indicates a sample that included material from structural elements only

Table 2. Results of analysis for Chromium, Copper, Arsenic, Phosphorous, and Sulfate in wood removed from Hangars 2 & 3, NAS Moffet Field*

Sample Number	Hangar	Element	Analyte	Result	Units	Rep. Limit	Dilution Factor	Laboratory
Hangar 2	Hangar 2	All	Arsenic (As)	13	mg/kg	2.0	4.0	CLS
		All	Chromium (Cr)	23	mg/kg	1.0	1.0	CLS
		All	Copper (Cu)	5.2	mg/kg	1.0	1.0	CLS
1A	Hangar 2	All	Phosphorous (P)	2700	mg/kg	1000	200	CLS
		All	Sulfate	78000	mg/kg	2500	250	CLS
Hangar 3	Hangar 3	All	Arsenic (As)	ND	mg/kg	2.0	4.0	CLS
		All	Chromium (Cr)	120	mg/kg	1.0	1.0	CLS
		All	Copper (Cu)	ND	mg/kg	5.0	5.0	CLS
2A	Hangar 3	All	Phosphorous (P)	280	mg/kg	250	50	CLS
		All	Sulfate	53000	mg/kg	2500	250	CLS

* ND = not detected at or above indicated Reporting Limit

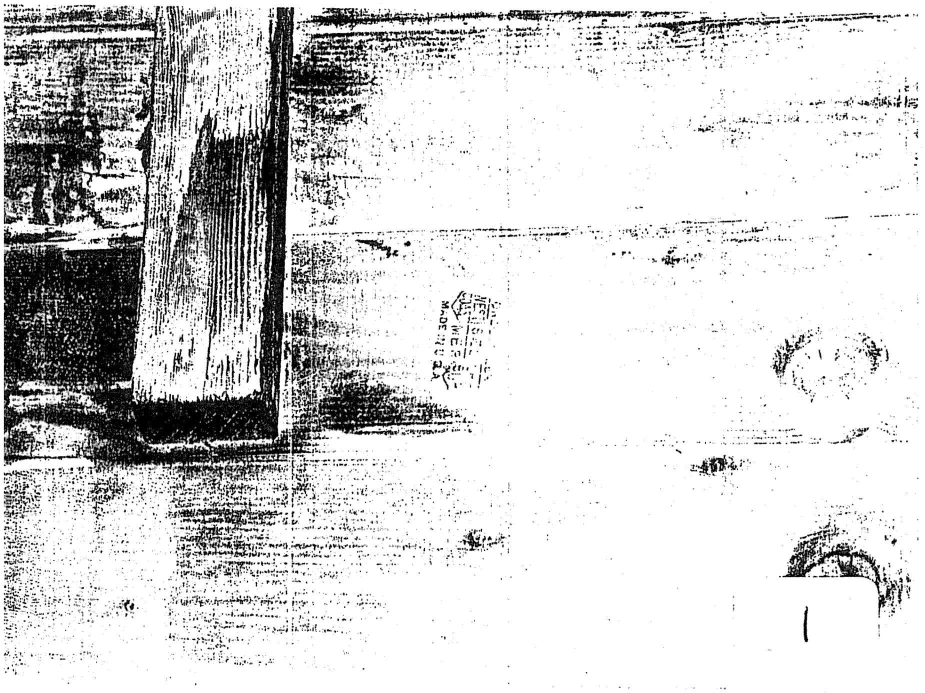
All = composite sample of wood from structural elements and sheathing

PHOTOGRAPH CAPTIONS

1. Hangar 2. West Coast Lumber Inspection Bureau grade stamp indicating the material was milled by Oregon Lumber and was in the select merchantable grade.
2. Hangar 2. Partial grade stamp noted on some wood components. Much of this stamp was illegible.
3. Hangar 2. Grade stamp indicating treatment with the fire-retardant Minalith.
4. Hangar 2. Loose fibers were noted on the floor of the hangar.

PHOTOGRAPH CAPTIONS

5. Hangar 2. Scraping the surface of the structural elements revealed the presence of degradation resulting in loose fibers on the surface of these elements.
6. Hangar 3. A white crystalline deposit was noted on the surface of many of the structural elements in this hangar.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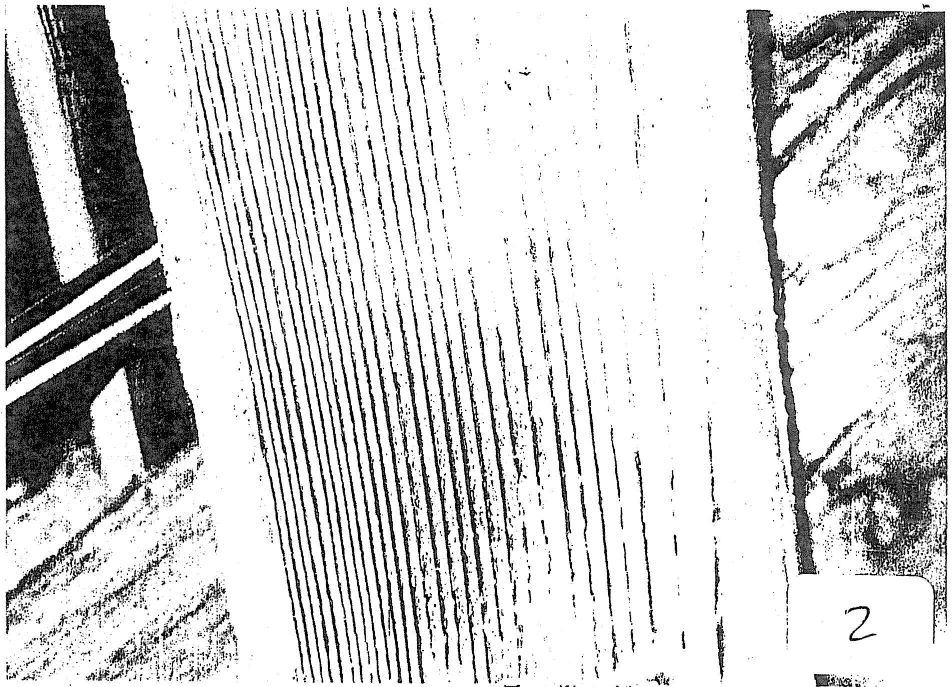
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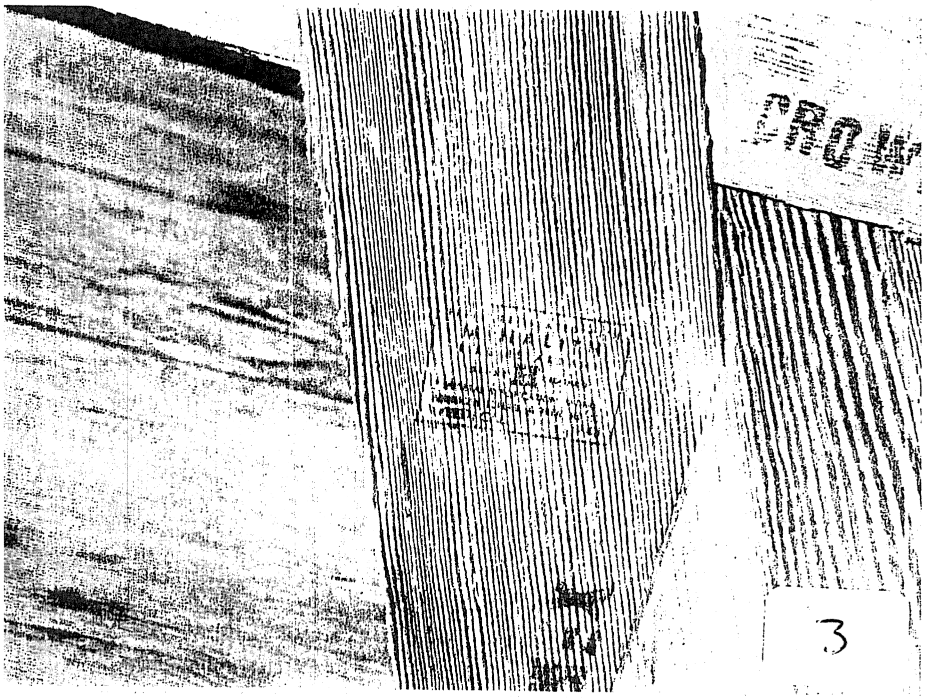
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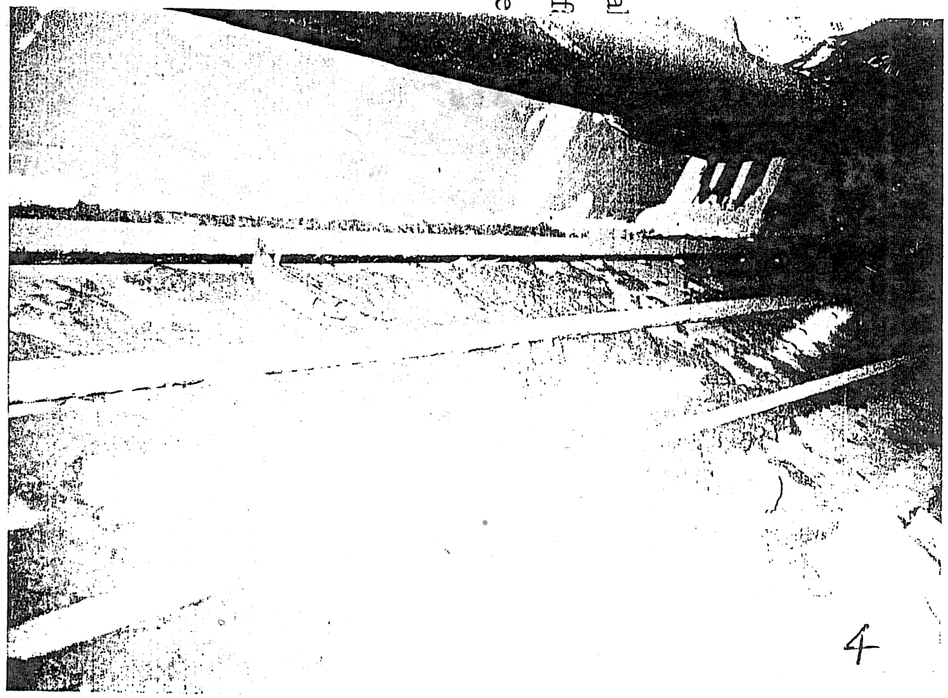
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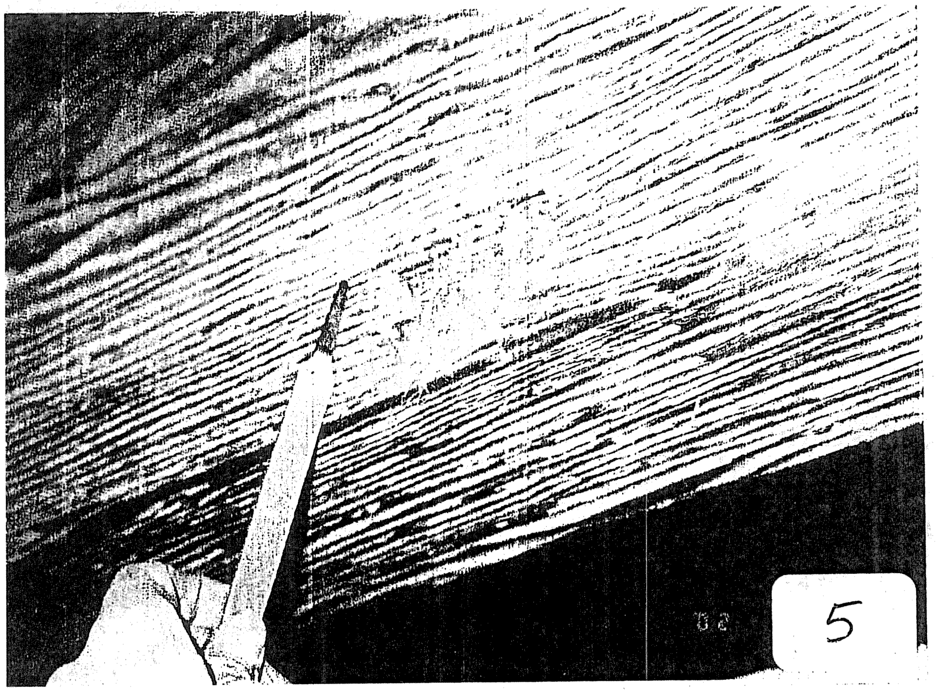

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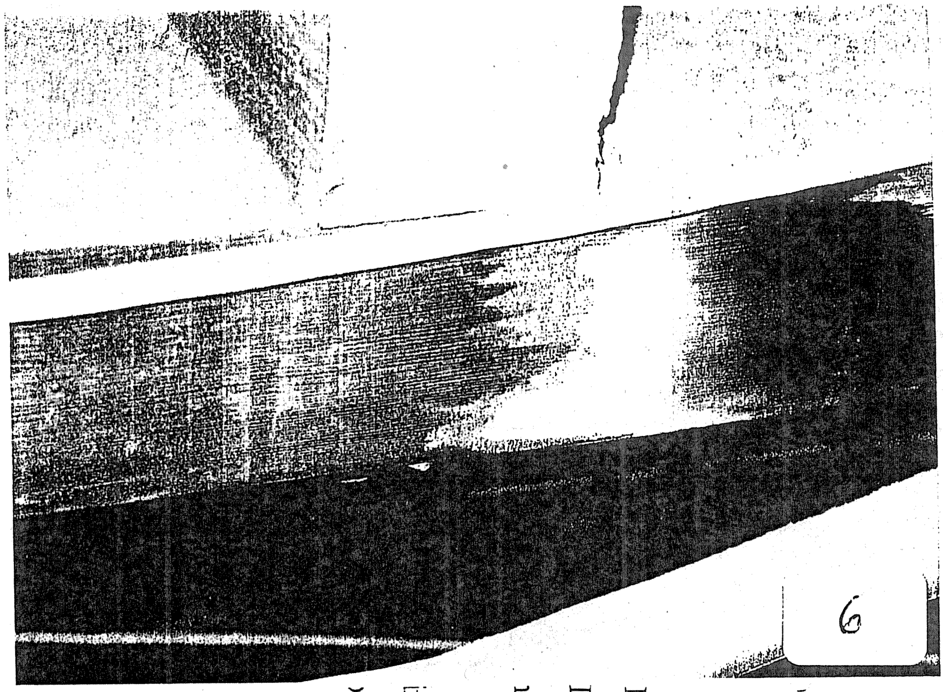

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ATTACHMENT 1

United States
Department of
Agriculture

Forest Service

Forest
Products
Laboratory

Research
Note
FPL-RN-02

Comparison of Wood Preservatives in Stake Tests

1995 Progress Report

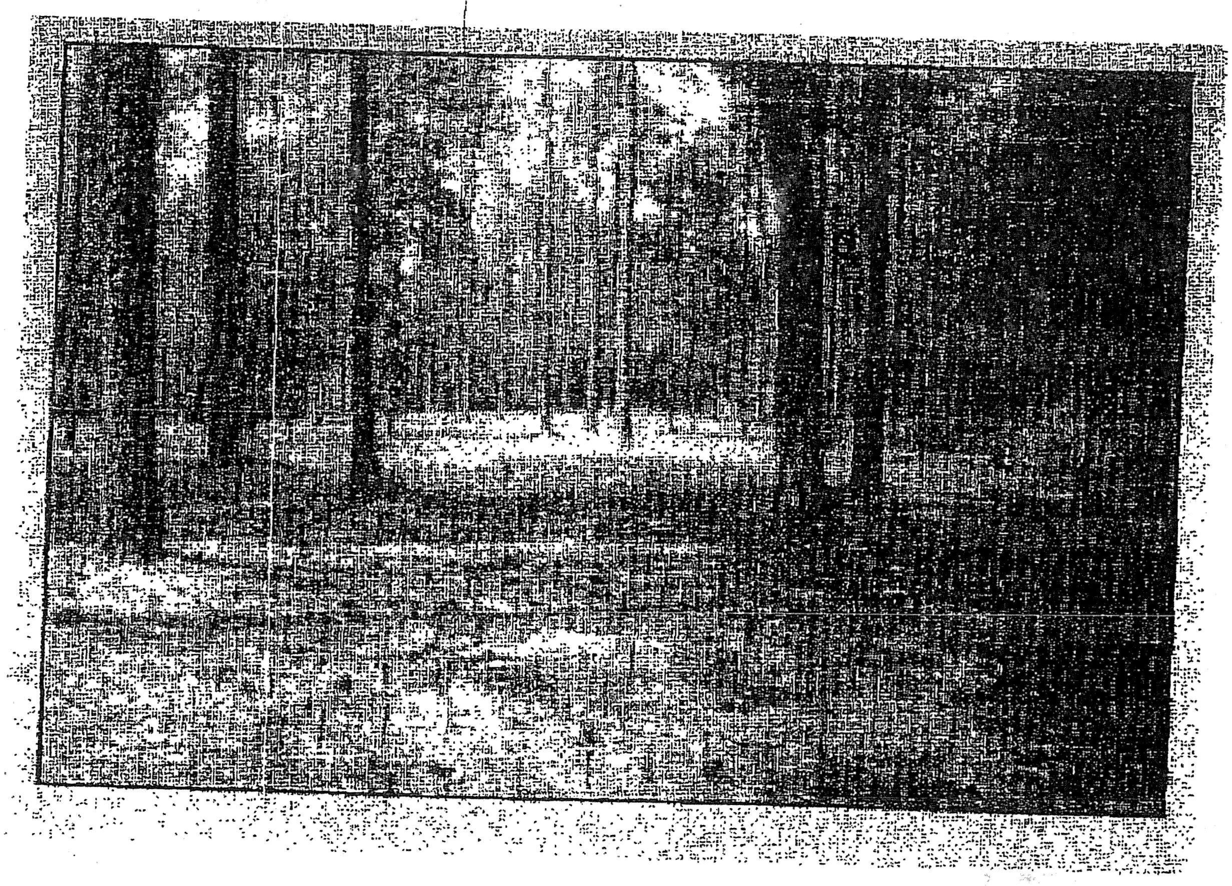

Table 1--Index to materials tested--concluded

Material	Existing specification or AWPA [a] reference	Table number
Chemical--continued		
Heptadecyltrimethyltetra-hydropyrimidine (HTP)	--	44
KP (copper oxide and chlorophenol)	--	35
Lignite-tar extracts	--	39
Mercuric chloride	--	12
Minalith	AWPA P10, Type C	25
Nickel-chromium-arsenic salt	--	15
Nickel-sterate	--	14
Oleo resin	--	27
Paraffin		32
Pentachlorophenol	Fed. Spec. TT-W-570; AWPA P8	5, 8, 12, 16, 17, 22, 23, 27, 29, 31, 32, 33, 41, 42, 43, 45, 47, 49, 54, 58, 60, 61, 63, 64, 65, 68, 69, 71, 76
Petroleum oils (various types)	--	17, 18, 21, 23, 45, 69, 76
Phenyl mercury oleate	--	12
Phenol-formaldehyde		67
Pyresote	AWPA P10, Type D	25
Rosin amine D copper acetate complex	--	27
Rosin amine D pentachlorophenate	--	22, 23
Rosin oil	--	27
Sodium pentachlorophenate	--	2, 5
Sodium tetrachlorophenate	--	2
Tetrachlorophenol	--	65, 69
Toluene	--	6
Tributyltin oxide	--	36, 41, 61
Urea	--	10
Zinc-arsenate-chromium salts	--	20
Zinc chloride	--	2, 4, 20, 26
Zinc naphthenate	--	7, 8
Modified woods, particleboard, plywood, and paper plastic		
Acetylated wood		14
Butylene oxide	U.S. Patent No. 3,985,921	50, 56
Cyanoethylated wood	--	36
Embedded fiberboard	--	40
Epichlorohydrin	--	50
Heat-stabilized wood (staypak)	--	11
Impreg and compreg	--	3
Laminated paper plastic (papreg)	--	11
Mold-infected wood	--	31
Particleboard	--	49
Plywood	--	3, 8, 16, 33, 51
Propylene oxide	U.S. Patent No. 3,985,921	50
Wood with thiamine destroyed		36

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[a] American Wood Preservers' Association.

(Page 2 of 2)

Table 25--*Condition of Southern Pine stakes (2 by 4 in. nominal by 18 in.) treated with four fire-retardant formulations (AWPA P10-51) after about 40 years of service. Stakes placed in test on the Harrison Experimental Forest, Saucier, Miss., March 1952 (Plot 35)*

Preservative	Average retention (lb/ft ^{3})	Number in test	Condition of stakes December 1991 (%)									Average life (Year)
				Serviceable but showing some--			Destroyed by--			Total removed		
			Good	Decay	Termite attack	Decay and termite attack	Decay fungi	Termite attack	Decay fungi and termite attack	Number	%	
Chromated zinc chloride ($ZnCl_2$, 80.4 parts; $Na_2Cr_2O_7 \cdot 2H_2O$, 19.6 parts)	1.50 (0.92)^b 2.91 (1.78) 6.00 (3.67)	10 10 10	-- -- 2	-- -- 10	-- -- 60	-- -- 10	30 60 --	-- 10 --	70 30 --		100 100 --	23.4 32.7 --
Chromated zinc chloride (FR) (Chromated zinc chloride, 80 parts) H_3BO_3, 10 parts; and $(NH_4)_2SO_4$, 10 parts)	1.53 3.00 6.08	10 10 10	-- -- 10	-- -- --	-- -- 30	-- 20 40	30 30 10	20 10 --	50 40 10		100 80 20	16.5 -- --
Minalith ($(NH_4)_2HPO_4$, 10 parts; $(NH_4)_2SO_4$, 60 parts; $Na_2B_4O_7$, 10 parts; and H_3BO, 20 parts)	1.50 3.00 6.13	10 10 10	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	10 10 30	90 90 70		100 100 100	3.6 4.8 5.0
Pyresote ($ZnCl_2$, 35 parts; $(NH_4)SO_4$, $Na_2Cr_2O_7 \cdot 2H_2O$, 5 parts)	1.50 3.01 6.26	10 10 10	-- -- --	-- -- --	-- -- --	-- -- --	-- -- 20	10 20 20	90 80 60		100 100 100	11.2 13.1 18.3
Untreated controls	--	10	--	--	--	--	--	20	80		100	2.6

[a] In cooperation with Bureau of Ships, Department of the Navy.

[b] Retention values in parentheses based on preservative oxides.

This study was initiated by J. Oscar Blew.

ATTACHMENT 2

Page 1 of 1

SPECTRUM

Laboratories, Inc. FORT LAUDERDALE • SAVANNAH

RESULTS OF ANALYSIS

CLIENT: **U OF CA/FOREST PRODUCTS LAB**
SAMPLE NUMBER: 007-031502
LOCATION: **II**
ADDITIONAL DATA: **DOUGLAS-FIR**
SAMPLED BY: CLIENT
SUBMITTED BY: FEDERAL EXPRESS
DATE SAMPLED: 020314
DATE REPORTED: APR. 4 2002
REVISION: 0

FT LAUD: E86006
BABSON PK: E84404
SAVANNAH, GA: E87671, 909
EPA: #FL00095
FDEP CQAP: #870206G
DATE RECEIVED: 020315 0930
SAMPLE MATRIX: SOLID

Parameter	Method	Result	Units	Detection Limit	Analysis Date	Analyst
CREOSOTE	8270B	0.00	ug/kg	5.0000	020320	AC-FTL
PENTACHLOROPHENOL		0.00	ug/kg	0.0100	020321	CJM-FT

LABORATORY MANAGER

HANGAR 2 - STRUCTURAL ELEMENTS

SPECTRUM
Laboratories, Inc. FORT LAUDERDALE • SAVANNAH

RESULTS OF ANALYSIS

CLIENT: **UNIVERISTY OF CA.**
SAMPLE NUMBER: 010-032702
LOCATION: **HANGAR 2**
ADDITIONAL DATA:
SAMPLED BY: CHRISTINE LANGFORD
SUBMITTED BY: FED EX
DATE SAMPLED: 020326 0000
DATE REPORTED: APR. 3 2002
REVISION: 0

FT LAUD: E86006
BABSON PK: E84404
SAVANNAH, GA: E87671, 909
EPA: #FL00095
FDEP CQAP: #870206G
DATE RECEIVED: 020327 0930
SAMPLE MATRIX: SOLID

Parameter	Method	Result	Units	Detection Limit	Analysis Date	Analyst
CREOSOTE	8270B	6600	ug/kg	5.0000	020402	AC-FTL
PENTACHLOROPHENOL		0.00	ug/kg	.0100	020401	AC-FTL
ALSO FOUND		PAH/CRESOL,TURP			020401	AC-FTL

LABORATORY MANAGER

HANGAR 2 - SHEATHING

SPECTRUM
Laboratories, Inc. FORT LAUDERDALE • SAVANNAH

RESULTS OF ANALYSIS

CLIENT: **U OF CA/FOREST PRODUCTS LAB**
SAMPLE NUMBER: 008-031502
LOCATION: **III**
ADDITIONAL DATA: **DOUGLAS-FIR**
SAMPLED BY: CLIENT
SUBMITTED BY: FEDERAL EXPRESS
DATE SAMPLED: 020314
DATE REPORTED: APR. 4 2002
REVISION: 0

FT LAUD: E86006
BABSON PK: E84404
SAVANNAH, GA: E87671, 909
EPA: #FL00095
FDEP CQAP: #870206G
DATE RECEIVED: 020315 0930
SAMPLE MATRIX: SOLID

Parameter	Method	Result	Units	Detection Limit	Analysis Date	Analyst
CREOSOTE	8270B	0.00	ug/kg	5.0000	020320	AC-FTL
PENTACHLOROPHENOL		0.00	ug/kg	0.0100	020321	CJM-FT

LABORATORY MANAGER

HANGAR 3 - STRUCTURAL ELEMENTS

Page 1 of 1

SPECTRUM

Laboratories, Inc. FORT LAUDERDALE • SAVANNAH

RESULTS OF ANALYSIS

CLIENT: **UNIVERISTY OF CA.**
SAMPLE NUMBER: 009-032702
LOCATION: **H3S**
ADDITIONAL DATA:
SAMPLED BY: CHRISTINE LANGFORD
SUBMITTED BY: FED EX
DATE SAMPLED: 020326 0000
DATE REPORTED: APR. 3 2002
REVISION: 0

FT LAUD: E86006
BABSON PK: E84404
SAVANNAH, GA: E87671, 909
EPA: #FL00095
FDEP CQAP: #870206G
DATE RECEIVED: 020327 0930
SAMPLE MATRIX: SOLID

Parameter	Method	Result	Units	Detection Limit	Analysis Date	Analyst
CREOSOTE	8270B	8000	ug/kg	5.0000	020402	AC-FTL
PENTACHLOROPHENOL		0.00	ug/kg	.0100	020401	AC-FTL
ALSO FOUND		PAH,CRESOL,TURP			020401	AC-FTL

LABORATORY MANAGER

HANGAR 3 - SHEATHING

All certified analyses are performed in accordance with Chapter 64E-1 Florida Administrative Code, which has been determined to be equivalent to NELAC standards.

Jeb Bush
Governor

FLORIDA DEPARTMENT OF
HEALTH

John O. Agwunobi, M.D., M.B.A.
Secretary

Laboratory Scope of Certification

THIS LISTING OF CERTIFIED ANALYTES SHOULD BE USED ONLY WHEN ASSOCIATED WITH A VALID CERTIFICATE ISSUED BY THE DEPARTMENT OF HEALTH

State Laboratory ID: E86006 EPA Lab Code: FL00095 954-978-6400

E86006
Spectrum Laboratories, Inc. - FL
1460 West McNab Road
Ft. Lauderdale, FL 33309

Program SDWA

Analyte	Method	Category	Certification Type	Effective Date
1,1,1,2-Tetrachloroethane	EPA 524.2	Group II Unregulated Contaminants	STATE	6/1/01
1,1,1-Trichloroethane	EPA 524.2	Other Regulated Contaminants	STATE	6/1/01
1,1,2,2-Tetrachloroethane	EPA 524.2	Group II Unregulated Contaminants	STATE	6/1/01
1,1,2-Trichloroethane	EPA 524.2	Other Regulated Contaminants	STATE	6/1/01
1,1-Dichloroethane	EPA 524.2	Group II Unregulated Contaminants	STATE	6/1/01
1,1-Dichloroethylene	EPA 524.2	Other Regulated Contaminants	STATE	6/1/01
1,1-Dichloropropene	EPA 524.2	Group II Unregulated Contaminants	STATE	6/1/01
1,2,3-Trichloropropane	EPA 524.2	Group II Unregulated Contaminants	STATE	6/1/01
1,2,4-Trichlorobenzene	EPA 524.2	Other Regulated Contaminants	STATE	6/1/01
1,2-Dibromo-3-chloropropane (DBCP)	EPA 504.1	Synthetic Organic Contaminants	STATE	6/1/01
1,2-Dibromoethane (EDB, Ethylene dibromide)	EPA 504.1	Synthetic Organic Contaminants	STATE	6/1/01
1,2-Dichlorobenzene	EPA 524.2	Other Regulated Contaminants	STATE	6/1/01
1,2-Dichloroethane	EPA 524.2	Other Regulated Contaminants	STATE	6/1/01
1,2-Dichloropropane	EPA 524.2	Other Regulated Contaminants	STATE	6/1/01
1,3-Dichlorobenzene	EPA 524.2	Group II Unregulated Contaminants	STATE	6/1/01
1,3-Dichloropropane	EPA 524.2	Group II Unregulated Contaminants	STATE	6/1/01
1,3-Dichloropropene	EPA 524.2	Group II Unregulated Contaminants	STATE	6/1/01
1,4-Dichlorobenzene	EPA 524.2	Other Regulated Contaminants	STATE	6/1/01
2,2-Dichloropropane	EPA 524.2	Group II Unregulated Contaminants	STATE	6/1/01
2,4,6-Trichlorophenol	EPA 625	Group III Unregulated Contaminants	STATE	6/1/01
2,4-D	EPA 515.1	Synthetic Organic Contaminants	STATE	6/1/01
2,4-Dinitrotoluene (2,4-DNT)	EPA 625	Group III Unregulated Contaminants	STATE	6/1/01
2-Chlorophenol	EPA 625	Group III Unregulated Contaminants	STATE	6/1/01
2-Chlorotoluene	EPA 524.2	Group II Unregulated Contaminants	STATE	6/1/01
2-Methyl-4,6-dinitrophenol	EPA 625	Group III Unregulated Contaminants	STATE	6/1/01
3-Hydroxycarbofuran	EPA 531.1	Group I Unregulated Contaminants	STATE	6/1/01
4-Chlorotoluene	EPA 524.2	Group II Unregulated Contaminants	STATE	6/1/01
Alachlor	EPA 525.2	Synthetic Organic Contaminants	STATE	6/1/01
Aldicarb (Temik)	EPA 531.1	Group I Unregulated Contaminants	STATE	6/1/01
Aldicarb sulfone	EPA 531.1	Group I Unregulated Contaminants	STATE	6/1/01
Aldicarb sulfoxide	EPA 531.1	Group I Unregulated Contaminants	STATE	6/1/01
Aldrin	EPA 508	Group I Unregulated Contaminants	STATE	6/1/01
Aldrin	EPA 525.2	Group I Unregulated Contaminants	STATE	6/1/01
Aluminum	EPA 200.9	Secondary Inorganic	STATE	6/1/01
Antimony	EPA 200.9	Primary Inorganic	STATE	6/1/01

"STATE" indicates certification for the analyte by the method specified. "NELAP" further indicates certification compliant with the NELAC Standards contained in 64E-1, F.A.C.

Laboratory Scope of Certification

THIS LISTING OF CERTIFIED ANALYTES SHOULD BE USED ONLY WHEN ASSOCIATED WITH A VALID CERTIFICATE ISSUED BY THE DEPARTMENT OF HEALTH

State Laboratory ID: E86006 **EPA Lab Code:** FL00095 954-978-6400

E86006
Spectrum Laboratories, Inc. - FL
1460 West McNab Road
Ft. Lauderdale, FL 33309

Program SDWA

Analyte	Method	Category	Certification Type	Effective Date
Arsenic	EPA 200.9	Primary Inorganic	STATE	6/1/01
Atrazine	EPA 525.2	Synthetic Organic Contaminants	STATE	6/1/01
Benzene	EPA 524.2	Other Regulated Contaminants	STATE	6/1/01
Benzo(a)pyrene	EPA 525.2	Synthetic Organic Contaminants	STATE	6/1/01
Beryllium	EPA 200.9	Primary Inorganic	STATE	6/1/01
bis(2-Ethylhexyl) phthalate (DEHP)	EPA 525.2	Synthetic Organic Contaminants	STATE	6/1/01
Bromobenzene	EPA 524.2	Group II Unregulated Contaminants	STATE	6/1/01
Bromodichloromethane	EPA 524.2	Other Regulated Contaminants,Group II Unregulated Contaminants	STATE	6/1/01
Bromoform	EPA 524.2	Other Regulated Contaminants,Group II Unregulated Contaminants	STATE	6/1/01
Butachlor	EPA 525.2	Group I Unregulated Contaminants	STATE	6/1/01
Butyl benzyl phthalate	EPA 625	Group III Unregulated Contaminants	STATE	6/1/01
Cadmium	EPA 200.9	Primary Inorganic	STATE	6/1/01
Carbaryl (Sevin)	EPA 531.1	Group I Unregulated Contaminants	STATE	6/1/01
Carbofuran (Furaden)	EPA 531.1	Synthetic Organic Contaminants	STATE	6/1/01
Carbon tetrachloride	EPA 524.2	Other Regulated Contaminants	STATE	6/1/01
Chlordane (tech.)	EPA 508	Synthetic Organic Contaminants	STATE	6/1/01
Chloride	EPA 300.0	Secondary Inorganic	STATE	6/1/01
Chloride	SM 4500 Cl- D	Secondary Inorganic	STATE	6/1/01
Chlorobenzene	EPA 524.2	Other Regulated Contaminants	STATE	6/1/01
Chloroethane	EPA 524.2	Group II Unregulated Contaminants	STATE	6/1/01
Chloroform	EPA 524.2	Other Regulated Contaminants,Group II Unregulated Contaminants	STATE	6/1/01
Chromium	EPA 200.9	Primary Inorganic	STATE	6/1/01
cis-1,2-Dichloroethylene	EPA 524.2	Other Regulated Contaminants	STATE	6/1/01
Color	SM 2120 B	Secondary Inorganic	STATE	6/1/01
Copper	EPA 200.9	Primary Inorganic,Secondary Inorganic	STATE	6/1/01
Cyanide	SM 4500CN-E	Primary Inorganic	STATE	6/1/01
Dalapon	EPA 515.1	Synthetic Organic Contaminants	STATE	6/1/01
DI(2-ETHYLHEXYL) ADIPATE	EPA 525.2	Synthetic Organic Contaminants	STATE	6/1/01
Dibromochloromethane	EPA 524.2	Other Regulated Contaminants,Group II Unregulated Contaminants	STATE	6/1/01
Dibromomethane	EPA 524.2	Group II Unregulated Contaminants	STATE	6/1/01

"STATE" indicates certification for the analyte by the method specified. "NELAP" further indicates certification compliant with the NELAC Standards contained in 64E-1, F.A.C.

Laboratory Scope of Certification

THIS LISTING OF CERTIFIED ANALYTES SHOULD BE USED ONLY WHEN ASSOCIATED WITH A VALID CERTIFICATE ISSUED BY THE DEPARTMENT OF HEALTH

State Laboratory ID: E86006 EPA Lab Code: FL00095 954-978-6400

E86006
Spectrum Laboratories, Inc. - FL
1460 West McNab Road
Ft. Lauderdale, FL 33309

Program SDWA

Analyte	Method	Category	Certification Type	Effective Date
Dicamba	EPA 515.1	Group I Unregulated Contaminants	STATE	6/1/01
Dichlorodifluoromethane	EPA 524.2	Group II Unregulated Contaminants	STATE	6/1/01
Dichloromethane (DCM, Methylene chloride)	EPA 524.2	Other Regulated Contaminants	STATE	6/1/01
Dieldrin	EPA 508	Group I Unregulated Contaminants	STATE	6/1/01
Dieldrin	EPA 525.2	Group I Unregulated Contaminants	STATE	6/1/01
Diethyl phthalate	EPA 625	Group III Unregulated Contaminants	STATE	6/1/01
Dimethyl phthalate	EPA 625	Group III Unregulated Contaminants	STATE	6/1/01
Di-n-butyl phthalate	EPA 625	Group III Unregulated Contaminants	STATE	6/1/01
Di-n-octyl phthalate	EPA 625	Group III Unregulated Contaminants	STATE	6/1/01
Dinoseb (2-sec-butyl-4,6-dinitrophenol, DNBP)	EPA 515.1	Synthetic Organic Contaminants	STATE	6/1/01
Diquat	EPA 549.2	Synthetic Organic Contaminants	STATE	6/1/01
Endothall	EPA 548.1	Synthetic Organic Contaminants	STATE	6/1/01
Endrin	EPA 508	Synthetic Organic Contaminants	STATE	6/1/01
Ethylbenzene	EPA 524.2	Other Regulated Contaminants	STATE	6/1/01
Fluoride	EPA 300.0	Secondary Inorganic,Primary Inorganic	STATE	6/1/01
Fluoride	EPA 340.2	Secondary Inorganic	STATE	6/1/01
Fluoride	SM 4500 F-C	Primary Inorganic	STATE	6/1/01
gamma-BHC (Lindane, gamma-Hexachlorocyclohexane)	EPA 508	Synthetic Organic Contaminants	STATE	6/1/01
Glyphosate	EPA 547	Synthetic Organic Contaminants	STATE	6/1/01
Heptachlor	EPA 508	Synthetic Organic Contaminants	STATE	6/1/01
Heptachlor epoxide	EPA 508	Synthetic Organic Contaminants	STATE	6/1/01
Hexachlorobenzene	EPA 508	Synthetic Organic Contaminants	STATE	6/1/01
Hexachlorocyclopentadiene	EPA 508	Synthetic Organic Contaminants	STATE	6/1/01
Iron	EPA 200.9	Secondary Inorganic	STATE	6/1/01
Isophorone	EPA 625	Group III Unregulated Contaminants	STATE	6/1/01
Lead	EPA 200.9	Primary Inorganic	STATE	6/1/01
Manganese	EPA 200.9	Secondary Inorganic	STATE	6/1/01
Mercury	EPA 245.1	Primary Inorganic	STATE	6/1/01
Methomyl (Lannate)	EPA 531.1	Group I Unregulated Contaminants	STATE	6/1/01
Methoxychlor	EPA 508	Synthetic Organic Contaminants	STATE	6/1/01
Methyl bromide (Bromomethane)	EPA 524.2	Group II Unregulated Contaminants	STATE	6/1/01
Methyl chloride (Chloromethane)	EPA 524.2	Group II Unregulated Contaminants	STATE	6/1/01
Methyl tert-butyl ether (MTBE)	EPA 524.2	Group II Unregulated Contaminants	STATE	6/1/01
Metolachlor	EPA 525.2	Group I Unregulated Contaminants	STATE	6/1/01

Laboratory Scope of Certification

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State Laboratory ID: E86006 EPA Lab Code: FL00095 954-978-6400

E86006
Spectrum Laboratories, Inc. - FL
1460 West McNab Road
Ft. Lauderdale, FL 33309

Program SDWA

Analyte	Method	Category	Certification Type	Effective Date
Metribuzin	EPA 525.2	Group I Unregulated Contaminants	STATE	6/1/01
Nickel	EPA 200.9	Primary Inorganic	STATE	6/1/01
Nitrate	EPA 300.0	Primary Inorganic	STATE	6/1/01
Nitrate	EPA 353.2	Primary Inorganic	STATE	6/1/01
Nitrite	EPA 300.0	Primary Inorganic	STATE	6/1/01
Nitrite	EPA 353.2	Primary Inorganic	STATE	6/1/01
Odor	SM 2150 B	Secondary Inorganic	STATE	6/1/01
Oxamyl	EPA 531.1	Synthetic Organic Contaminants	STATE	6/1/01
PCBs	EPA 508	Synthetic Organic Contaminants	STATE	6/1/01
Pentachlorophenol	EPA 515.1	Synthetic Organic Contaminants	STATE	6/1/01
pH	EPA 150.1	Secondary Inorganic	STATE	6/1/01
Phenol	EPA 625	Group III Unregulated Contaminants	STATE	6/1/01
Picloram	EPA 515.1	Synthetic Organic Contaminants	STATE	6/1/01
Propachlor (Ramrod)	EPA 508	Group I Unregulated Contaminants	STATE	6/1/01
Propachlor (Ramrod)	EPA 525.2	Group I Unregulated Contaminants	STATE	6/1/01
Selenium	EPA 200.9	Primary Inorganic	STATE	6/1/01
Silver	EPA 200.9	Secondary Inorganic	STATE	6/1/01
Silvex (2,4,5-TP)	EPA 515.1	Synthetic Organic Contaminants	STATE	6/1/01
Simazine	EPA 525.2	Synthetic Organic Contaminants	STATE	6/1/01
Sodium	EPA 200.7	Primary Inorganic	STATE	6/1/01
Styrene	EPA 524.2	Other Regulated Contaminants	STATE	6/1/01
Sulfate	EPA 300.0	Secondary Inorganic	STATE	6/1/01
Sulfate	EPA 375.4	Secondary Inorganic	STATE	6/1/01
Surfactants - MBAS	SM 5540 C	Secondary Inorganic	STATE	6/1/01
Tetrachloroethylene (Perchloroethylene)	EPA 524.2	Other Regulated Contaminants	STATE	6/1/01
Thallium	EPA 200.9	Primary Inorganic	STATE	6/1/01
Toluene	EPA 524.2	Other Regulated Contaminants	STATE	6/1/01
Total Coliform & E. coli	SM 9223 B	Microbiology	STATE	6/1/01
Total dissolved solids	SM 2540 C	Secondary Inorganic	STATE	6/1/01
Total nitrate-nitrite	EPA 300.0	Primary Inorganic	STATE	6/1/01
Total nitrate-nitrite	EPA 353.2	Primary Inorganic	STATE	6/1/01
Total trihalomethanes	EPA 524.2	Other Regulated Contaminants	STATE	6/1/01
Toxaphene (Chlorinated camphene)	EPA 508	Synthetic Organic Contaminants	STATE	6/1/01
trans-1,2-Dichloroethylene	EPA 524.2	Other Regulated Contaminants	STATE	6/1/01
Trichloroethene (Trichloroethylene)	EPA 524.2	Other Regulated Contaminants	STATE	6/1/01

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Laboratory Scope of Certification

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E86006
Spectrum Laboratories, Inc. - FL
1460 West McNab Road
Ft. Lauderdale, FL 33309

Program SDWA

Analyte	Method	Category	Certification Type	Effective Date
Trichlorofluoromethane	EPA 524.2	Group II Unregulated Contaminants	STATE	6/1/01
Vinyl chloride	EPA 524.2	Other Regulated Contaminants	STATE	6/1/01
Xylene (total)	EPA 524.2	Other Regulated Contaminants	STATE	6/1/01
Zinc	EPA 200.9	Secondary Inorganic	STATE	6/1/01

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Spectrum Laboratories, Inc. - FL
1460 West McNab Road
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Program CWA

Analyte	Method	Category	Certification Type	Effective Date
1,2-Dichlorobenzene	EPA 625	Extractable Organics	STATE	6/1/01
1,3-Dichlorobenzene	EPA 625	Extractable Organics	STATE	6/1/01
1,4-Dichlorobenzene	EPA 625	Extractable Organics	STATE	6/1/01
2,4,6-Trichlorophenol	EPA 625	Extractable Organics	STATE	6/1/01
2,4-Dichlorophenol	EPA 625	Extractable Organics	STATE	6/1/01
2,4-Dimethylphenol	EPA 625	Extractable Organics	STATE	6/1/01
2,4-Dinitrophenol	EPA 625	Extractable Organics	STATE	6/1/01
2,4-Dinitrotoluene (2,4-DNT)	EPA 625	Extractable Organics	STATE	6/1/01
2,6-Dinitrotoluene (2,6-DNT)	EPA 625	Extractable Organics	STATE	6/1/01
2-Chloronaphthalene	EPA 625	Extractable Organics	STATE	6/1/01
2-Chlorophenol	EPA 625	Extractable Organics	STATE	6/1/01
2-Methyl-4,6-dinitrophenol	EPA 625	Extractable Organics	STATE	6/1/01
2-Nitrophenol	EPA 625	Extractable Organics	STATE	6/1/01
3,3'-Dichlorobenzidine	EPA 625	Extractable Organics	STATE	6/1/01
4,4'-DDD	EPA 608	Pesticides-herbicides-pcb s	STATE	6/1/01
4,4'-DDE	EPA 608	Pesticides-herbicides-pcb s	STATE	6/1/01
4,4'-DDT	EPA 608	Pesticides-herbicides-pcb s	STATE	6/1/01
4-Bromophenyl phenyl ether	EPA 625	Extractable Organics	STATE	6/1/01
4-Chloro-3-methylphenol	EPA 625	Extractable Organics	STATE	6/1/01
4-Chlorophenyl phenylether	EPA 625	Extractable Organics	STATE	6/1/01
4-Nitrophenol	EPA 625	Extractable Organics	STATE	6/1/01
Acenaphthene	EPA 625	Extractable Organics	STATE	6/1/01
Acenaphthylene	EPA 625	Extractable Organics	STATE	6/1/01
Aldrin	EPA 608	Pesticides-herbicides-pcb s	STATE	6/1/01
Alkalinity as CaCO3	EPA 310.1	General Chemistry	STATE	6/1/01
alpha-BHC (alpha-Hexachlorocyclohexane)	EPA 608	Pesticides-herbicides-pcb s	STATE	6/1/01
Amenable cyanide	EPA 335.1	General Chemistry	STATE	6/1/01
Ammonia as N	EPA 350.3	General Chemistry	STATE	6/1/01
Anthracene	EPA 625	Extractable Organics	STATE	6/1/01
Antimony	EPA 200.7	Metals	STATE	6/1/01
Aroclor-1016 (PCB-1016)	EPA 608	Pesticides-herbicides-pcb s	STATE	6/1/01
Aroclor-1221 (PCB-1221)	EPA 608	Pesticides-herbicides-pcb s	STATE	6/1/01
Aroclor-1232 (PCB-1232)	EPA 608	Pesticides-herbicides-pcb s	STATE	6/1/01
Aroclor-1242 (PCB-1242)	EPA 608	Pesticides-herbicides-pcb s	STATE	6/1/01
oclor-1248 (PCB-1248)	EPA 608	Pesticides-herbicides-pcb s	STATE	6/1/01

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Jeb Bush
Governor

FLORIDA DEPARTMENT OF HEALTH

John O. Agwunobi, M.D., M.B.A.
Secretary

Laboratory Scope of Certification

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E86006
Spectrum Laboratories, Inc. - FL
1460 West McNab Road
Ft. Lauderdale, FL 33309

Program CWA

Analyte	Method	Category	Certification Type	Effective Date
Aroclor-1254 (PCB-1254)	EPA 608	Pesticides-herbicides-pcb s	STATE	6/1/01
Aroclor-1260 (PCB-1260)	EPA 608	Pesticides-herbicides-pcb s	STATE	6/1/01
Arsenic	EPA 200.7	Metals	STATE	6/1/01
Barium	EPA 200.7	Metals	STATE	6/1/01
Barium	EPA 6010	Metals	STATE	6/1/01
Benzidine	EPA 625	Extractable Organics	STATE	6/1/01
Benzo(a)anthracene	EPA 625	Extractable Organics	STATE	6/1/01
Benzo(a)pyrene	EPA 625	Extractable Organics	STATE	6/1/01
Benzo(b)fluoranthene	EPA 625	Extractable Organics	STATE	6/1/01
Benzo(g,h,i)perylene	EPA 625	Extractable Organics	STATE	6/1/01
Benzo(k)fluoranthene	EPA 625	Extractable Organics	STATE	6/1/01
Beryllium	EPA 200.7	Metals	STATE	6/1/01
beta-BHC (beta-Hexachlorocyclohexane)	EPA 608	Pesticides-herbicides-pcb s	STATE	6/1/01
Biochemical oxygen demand	EPA 405.1	General Chemistry	STATE	6/1/01
bis(2-Chloroethoxy)methane	EPA 625	Extractable Organics	STATE	6/1/01
bis(2-Chloroethyl) ether	EPA 625	Extractable Organics	STATE	6/1/01
bis(2-Chloroisopropyl) ether	EPA 625	Extractable Organics	STATE	6/1/01
Boron	EPA 200.7	Metals	STATE	6/1/01
Butyl benzyl phthalate	EPA 625	Extractable Organics	STATE	6/1/01
Cadmium	EPA 200.7	Metals	STATE	6/1/01
Cadmium	EPA 6010	Metals	STATE	6/1/01
Calcium	EPA 200.7	Metals	STATE	6/1/01
Carbonaceous BOD (CBOD)	SM 5210 B	General Chemistry	STATE	6/1/01
Chemical oxygen demand	EPA 410.1	General Chemistry	STATE	6/1/01
hlordane (tech.)	EPA 608	Pesticides-herbicides-pcb s	STATE	6/1/01
hloride	EPA 300.0	General Chemistry	STATE	6/1/01
romium	EPA 200.7	Metals	STATE	6/1/01
rysene	EPA 625	Extractable Organics	STATE	6/1/01
balt	EPA 200.7	Metals	STATE	6/1/01
lor	EPA 110.2	General Chemistry	STATE	6/1/01
ductivity	EPA 120.1	General Chemistry	STATE	6/1/01
per	EPA 200.7	Metals	STATE	6/1/01
per	EPA 6010	Metals	STATE	6/1/01
rosivity (langlier index)	SM 2330 B	General Chemistry	STATE	6/1/01
ide	EPA 335.2	General Chemistry	STATE	6/1/01

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E86006
Spectrum Laboratories, Inc. - FL
1460 West McNab Road
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Program CWA

Analyte	Method	Category	Certification Type	Effective Date
delta-BHC	EPA 608	Pesticides-herbicides-pcb s	STATE	6/1/01
Dibenz(a,h) anthracene	EPA 625	Extractable Organics	STATE	6/1/01
Dieldrin	EPA 608	Pesticides-herbicides-pcb s	STATE	6/1/01
Diethyl phthalate	EPA 625	Extractable Organics	STATE	6/1/01
Dimethyl phthalate	EPA 625	Extractable Organics	STATE	6/1/01
Di-n-butyl phthalate	EPA 625	Extractable Organics	STATE	6/1/01
Di-n-octyl phthalate	EPA 625	Extractable Organics	STATE	6/1/01
Endosulfan I	EPA 608	Pesticides-herbicides-pcb s	STATE	6/1/01
Endosulfan II	EPA 608	Pesticides-herbicides-pcb s	STATE	6/1/01
Endosulfan sulfate	EPA 608	Pesticides-herbicides-pcb s	STATE	6/1/01
Endrin	EPA 608	Pesticides-herbicides-pcb s	STATE	6/1/01
Endrin aldehyde	EPA 608	Pesticides-herbicides-pcb s	STATE	6/1/01
cal coliforms	SM 9222 D	Microbiology	STATE	6/1/01
Fecal streptococci	SM 9230 C	Microbiology	STATE	6/1/01
Fluoranthene	EPA 625	Extractable Organics	STATE	6/1/01
Fluorene	EPA 625	Extractable Organics	STATE	6/1/01
Fluoride	EPA 300.0	General Chemistry	STATE	6/1/01
Fluoride	EPA 340.2	General Chemistry	STATE	6/1/01
gamma-BHC (Lindane, gamma-Hexachlorocyclohexane)	EPA 608	Pesticides-herbicides-pcb s	STATE	6/1/01
Hardness	EPA 130.2	General Chemistry	STATE	6/1/01
Heptachlor	EPA 608	Pesticides-herbicides-pcb s	STATE	6/1/01
Heptachlor epoxide	EPA 608	Pesticides-herbicides-pcb s	STATE	6/1/01
Hexachlorobenzene	EPA 625	Extractable Organics	STATE	6/1/01
Hexachlorocyclopentadiene	EPA 625	Extractable Organics	STATE	6/1/01
Hexachloroethane	EPA 625	Extractable Organics	STATE	6/1/01
Indeno(1,2,3-cd)pyrene	EPA 625	Extractable Organics	STATE	6/1/01
Iron	EPA 200.7	Metals	STATE	6/1/01
Isophorone	EPA 625	Extractable Organics	STATE	6/1/01
Kjeldahl nitrogen - total	EPA 351.2	General Chemistry	STATE	6/1/01
Lead	EPA 200.7	Metals	STATE	6/1/01
Lead	EPA 6010	Metals	STATE	6/1/01
Magnesium	EPA 200.7	Metals	STATE	6/1/01
Manganese	EPA 200.7	Metals	STATE	6/1/01
Mercury	EPA 245.1	Metals	STATE	6/1/01

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Jeb Bush
Governor

FLORIDA DEPARTMENT OF
HEALTH

John O. Agwunobi, M.D., M.B.A.
Secretary

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954-978-6400

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Program CWA

Analyte	Method	Category	Certification Type	Effective Date
Molybdenum	EPA 200.7	Metals	STATE	6/1/01
Molybdenum	EPA 6010	Metals	STATE	6/1/01
Naphthalene	EPA 625	Extractable Organics	STATE	6/1/01
Nickel	EPA 200.7	Metals	STATE	6/1/01
Nickel	EPA 6010	Metals	STATE	6/1/01
Nitrate as N	EPA 300.0	General Chemistry	STATE	6/1/01
Nitrate as N	EPA 353.1	General Chemistry	STATE	6/1/01
Nitrate as N	EPA 353.2	General Chemistry	STATE	6/1/01
Nitrate-nitrite	EPA 300.0	General Chemistry	STATE	6/1/01
Nitrate-nitrite	EPA 353.1	General Chemistry	STATE	6/1/01
Nitrate-nitrite	EPA 353.2	General Chemistry	STATE	6/1/01
Nitrite as N	EPA 300.0	General Chemistry	STATE	6/1/01
Nitrite as N	EPA 354.1	General Chemistry	STATE	6/1/01
Nitrobenzene	EPA 625	Extractable Organics	STATE	6/1/01
n-Nitrosodi-n-propylamine	EPA 625	Extractable Organics	STATE	6/1/01
n-Nitrosodiphenylamine	EPA 625	Extractable Organics	STATE	6/1/01
Oil & Grease	EPA 413.1	General Chemistry	STATE	6/1/01
Organic nitrogen	EPA 351.2	General Chemistry	STATE	6/1/01
rganic nitrogen	SM 4500-NH3 F	General Chemistry	STATE	6/1/01
rthophosphate as P	EPA 365.1	General Chemistry	STATE	6/1/01
rthophosphate as P	EPA 365.2	General Chemistry	STATE	6/1/01
xygen, dissolved	EPA 360.1	General Chemistry	STATE	6/1/01
entachlorophenol	EPA 625	Extractable Organics	STATE	6/1/01
H	EPA 150.1	General Chemistry	STATE	6/1/01
enanthrene	EPA 625	Extractable Organics	STATE	6/1/01
enol	EPA 625	Extractable Organics	STATE	6/1/01
osphorus, total	EPA 365.4	General Chemistry	STATE	6/1/01
tassium	EPA 200.7	Metals	STATE	6/1/01
assium	EPA 6010	Metals	STATE	6/1/01
ene	EPA 625	Extractable Organics	STATE	6/1/01
idual free chlorine	EPA 330.4	General Chemistry	STATE	6/1/01
idue-filterable (TDS)	EPA 160.1	General Chemistry	STATE	6/1/01
due-nonfilterable (TSS)	EPA 160.2	General Chemistry	STATE	6/1/01
due-settleable	EPA 160.5	General Chemistry	STATE	6/1/01
due-total	EPA 160.3	General Chemistry	STATE	6/1/01

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Residue-volatile	EPA 160.4	General Chemistry	STATE	6/1/01
Salinity	SM 2520 B	General Chemistry	STATE	6/1/01
Selenium	EPA 200.7	Metals	STATE	6/1/01
Selenium	EPA 6010	Metals	STATE	6/1/01
Silica-dissolved	EPA 370.1	General Chemistry	STATE	6/1/01
Silicon	EPA 200.7	Metals	STATE	6/1/01
Silver	EPA 200.7	Metals	STATE	6/1/01
Sodium	EPA 200.7	Metals	STATE	6/1/01
Sulfate	EPA 300.0	General Chemistry	STATE	6/1/01
Sulfate	EPA 375.4	General Chemistry	STATE	6/1/01
Sulfide	EPA 376.1	General Chemistry	STATE	6/1/01
Surfactants - MBAS	EPA 425.1	General Chemistry	STATE	6/1/01
mperature, deg. C	EPA 170.1	General Chemistry	STATE	6/1/01
Thallium	EPA 200.7	Metals	STATE	6/1/01
Tin	EPA 200.7	Metals	STATE	6/1/01
Total coliforms	SM 9222 B	Microbiology	STATE	6/1/01
Total organic carbon	SM 5310C	General Chemistry	STATE	6/1/01
Total phenolics	EPA 420.1	General Chemistry	STATE	6/1/01
Toxaphene (Chlorinated camphene)	EPA 608	Pesticides-herbicides-pcb s	STATE	6/1/01
Turbidity	EPA 180.1	General Chemistry	STATE	6/1/01
UN-IONIZED AMMONIA	DEP SOP 10-03-83	General Chemistry	STATE	6/1/01
Vanadium	EPA 200.7	Metals	STATE	6/1/01
Zinc	EPA 200.7	Metals	STATE	6/1/01
Zinc	EPA 6010	Metals	STATE	6/1/01

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EPA Lab Code: FL00095

954-978-6400

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Ft. Lauderdale, FL 33309

Program RCRA/CERCLA

Analyte	Method	Category	Certification Type	Effective Date
1,1,1,2-Tetrachloroethane	EPA 8260	Volatile Organics	STATE	6/1/01
1,1,1-Trichloroethane	EPA 8260	Volatile Organics	STATE	6/1/01
1,1,2,2-Tetrachloroethane	EPA 8260	Volatile Organics	STATE	6/1/01
1,1,2-Trichloroethane	EPA 8260	Volatile Organics	STATE	6/1/01
1,1-Dichloroethane	EPA 8260	Volatile Organics	STATE	6/1/01
1,1-Dichloroethylene	EPA 8260	Volatile Organics	STATE	6/1/01
1,1-Dichloropropene	EPA 8260	Volatile Organics	STATE	6/1/01
1,2,3-Trichlorobenzene	EPA 8260	Volatile Organics	STATE	6/1/01
1,2,3-Trichloropropane	EPA 8260	Volatile Organics	STATE	6/1/01
1,2,4-Trichlorobenzene	EPA 8260	Volatile Organics	STATE	6/1/01
1,2,4-Trimethylbenzene	EPA 8260	Volatile Organics	STATE	6/1/01
1,2-Dibromo-3-chloropropane (DBCP)	EPA 8260	Volatile Organics	STATE	6/1/01
1,2-Dibromoethane (EDB, Ethylene dibromide)	EPA 8260	Volatile Organics	STATE	6/1/01
1,2-Dichlorobenzene	EPA 8260	Volatile Organics	STATE	6/1/01
1,2-Dichlorobenzene	EPA 8270	Extractable Organics	STATE	6/1/01
1,2-Dichloroethane	EPA 8260	Volatile Organics	STATE	6/1/01
1,2-Dichloropropane	EPA 8260	Volatile Organics	STATE	6/1/01
1,2-Diphenylhydrazine	EPA 8270	Extractable Organics	STATE	6/1/01
1,3,5-Trimethylbenzene	EPA 8260	Volatile Organics	STATE	6/1/01
1,3-Dichlorobenzene	EPA 8260	Volatile Organics	STATE	6/1/01
1,3-Dichlorobenzene	EPA 8270	Extractable Organics	STATE	6/1/01
1,3-Dichloropropane	EPA 8260	Volatile Organics	STATE	6/1/01
1,4-Dichlorobenzene	EPA 8260	Volatile Organics	STATE	6/1/01
,4-Dichlorobenzene	EPA 8270	Extractable Organics	STATE	6/1/01
,2-Dichloropropane	EPA 8260	Volatile Organics	STATE	6/1/01
,4,5-T	EPA 8151	Pesticides-herbicides-pcb s	STATE	6/1/01
,4,5-Trichlorophenol	EPA 8270	Extractable Organics	STATE	6/1/01
4,6-Trichlorophenol	EPA 8270	Extractable Organics	STATE	6/1/01
4-D	EPA 8151	Pesticides-herbicides-pcb s	STATE	6/1/01
4-DB	EPA 8151	Pesticides-herbicides-pcb s	STATE	6/1/01
4-Dichlorophenol	EPA 8270	Extractable Organics	STATE	6/1/01
-Dimethylphenol	EPA 8270	Extractable Organics	STATE	6/1/01
-Dinitrophenol	EPA 8270	Extractable Organics	STATE	6/1/01
-Dinitrotoluene (2,4-DNT)	EPA 8270	Extractable Organics	STATE	6/1/01
-Dinitrotoluene (2,6-DNT)	EPA 8270	Extractable Organics	STATE	6/1/01

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E86006
Spectrum Laboratories, Inc. - FL
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Program RCRA/CERCLA

Analyte	Method	Category	Certification Type	Effective Date
2-Butanone (Methyl ethyl ketone, MEK)	EPA 8260	Volatile Organics	STATE	6/1/01
2-Chloroethyl vinyl ether	EPA 8260	Volatile Organics	STATE	6/1/01
2-Chloronaphthalene	EPA 8270	Extractable Organics	STATE	6/1/01
2-Chlorophenol	EPA 8270	Extractable Organics	STATE	6/1/01
2-Chlorotoluene	EPA 8260	Volatile Organics	STATE	6/1/01
2-Hexanone	EPA 8260	Volatile Organics	STATE	6/1/01
2-Methylnaphthalene	EPA 8270	Extractable Organics	STATE	6/1/01
2-Nitrophenol	EPA 8270	Extractable Organics	STATE	6/1/01
3,3'-Dichlorobenzidine	EPA 8270	Extractable Organics	STATE	6/1/01
4,4'-DDD	EPA 8081	Pesticides-herbicides-pcb s	STATE	6/1/01
4,4'-DDE	EPA 8081	Pesticides-herbicides-pcb s	STATE	6/1/01
4,4'-DDT	EPA 8081	Pesticides-herbicides-pcb s	STATE	6/1/01
Bromophenyl phenyl ether	EPA 8270	Extractable Organics	STATE	6/1/01
4-Chloro-3-methylphenol	EPA 8270	Extractable Organics	STATE	6/1/01
4-Chlorophenyl phenylether	EPA 8270	Extractable Organics	STATE	6/1/01
4-Chlorotoluene	EPA 8260	Volatile Organics	STATE	6/1/01
4-Methyl-2-pentanone (MIBK)	EPA 8260	Volatile Organics	STATE	6/1/01
4-Nitrophenol	EPA 8270	Extractable Organics	STATE	6/1/01
Acenaphthene	EPA 8270	Extractable Organics	STATE	6/1/01
Acenaphthylene	EPA 8270	Extractable Organics	STATE	6/1/01
Acetone	EPA 8260	Volatile Organics	STATE	6/1/01
Acetonitrile	EPA 8260	Volatile Organics	STATE	6/1/01
Acrolein (Propenal)	EPA 8260	Volatile Organics	STATE	6/1/01
Acrylonitrile	EPA 8260	Volatile Organics	STATE	6/1/01
Aldrin	EPA 8081	Pesticides-herbicides-pcb s	STATE	6/1/01
alpha-BHC (alpha-Hexachlorocyclohexane)	EPA 8081	Pesticides-herbicides-pcb s	STATE	6/1/01
Anthracene	EPA 8270	Extractable Organics	STATE	6/1/01
Antimony	EPA 6010	Metals	STATE	6/1/01
Aroclor-1016 (PCB-1016)	EPA 8081	Pesticides-herbicides-pcb s	STATE	6/1/01
Aroclor-1221 (PCB-1221)	EPA 8081	Pesticides-herbicides-pcb s	STATE	6/1/01
Aroclor-1232 (PCB-1232)	EPA 8081	Pesticides-herbicides-pcb s	STATE	6/1/01
Aroclor-1242 (PCB-1242)	EPA 8081	Pesticides-herbicides-pcb s	STATE	6/1/01
Aroclor-1248 (PCB-1248)	EPA 8081	Pesticides-herbicides-pcb s	STATE	6/1/01
Aroclor-1254 (PCB-1254)	EPA 8081	Pesticides-herbicides-pcb s	STATE	6/1/01
Aroclor-1260 (PCB-1260)	EPA 8081	Pesticides-herbicides-pcb s	STATE	6/1/01

Laboratory Scope of Certification

THIS LISTING OF CERTIFIED ANALYTES SHOULD BE USED ONLY WHEN ASSOCIATED WITH A VALID CERTIFICATE ISSUED BY THE DEPARTMENT OF HEALTH

State Laboratory ID: E86006 EPA Lab Code: FL00095 954-978-6400

E86006
Spectrum Laboratories, Inc. - FL
1460 West McNab Road
Ft. Lauderdale, FL 33309

Program RCRA/CERCLA

Analyte	Method	Category	Certification Type	Effective Date
Arsenic	EPA 6010	Metals	STATE	6/1/01
Barium	EPA 6010	Metals	STATE	6/1/01
Benzene	EPA 8260	Volatile Organics	STATE	6/1/01
Benzidine	EPA 8270	Extractable Organics	STATE	6/1/01
Benzo(a)anthracene	EPA 8270	Extractable Organics	STATE	6/1/01
Benzo(a)pyrene	EPA 8270	Extractable Organics	STATE	6/1/01
Benzo(b)fluoranthene	EPA 8270	Extractable Organics	STATE	6/1/01
Benzo(g,h,i)perylene	EPA 8270	Extractable Organics	STATE	6/1/01
Benzo(k)fluoranthene	EPA 8270	Extractable Organics	STATE	6/1/01
Benzoic acid	EPA 8270	Extractable Organics	STATE	6/1/01
Benzyl chloride	EPA 8260	Volatile Organics	STATE	6/1/01
Beryllium	EPA 6010	Metals	STATE	6/1/01
beta-BHC (beta-Hexachlorocyclohexane)	EPA 8081	Pesticides-herbicides-pcb s	STATE	6/1/01
beta-Naphthylamine	EPA 8270	Extractable Organics	STATE	6/1/01
bis(2-Chloroethoxy)methane	EPA 8270	Extractable Organics	STATE	6/1/01
bis(2-Chloroethyl) ether	EPA 8270	Extractable Organics	STATE	6/1/01
bis(2-Chloroisopropyl) ether	EPA 8270	Extractable Organics	STATE	6/1/01
bis(2-Ethylhexyl) phthalate (DEHP)	EPA 8270	Extractable Organics	STATE	6/1/01
Bromochloromethane	EPA 8260	Volatile Organics	STATE	6/1/01
Bromodichloromethane	EPA 8260	Volatile Organics	STATE	6/1/01
Bromoform	EPA 8260	Volatile Organics	STATE	6/1/01
Butyl benzyl phthalate	EPA 8270	Extractable Organics	STATE	6/1/01
Cadmium	EPA 6010	Metals	STATE	6/1/01
Calcium	EPA 6010	Metals	STATE	6/1/01
Carbon tetrachloride	EPA 8260	Volatile Organics	STATE	6/1/01
Chlordane (tech.)	EPA 8081	Pesticides-herbicides-pcb s	STATE	6/1/01
Chlorobenzene	EPA 8260	Volatile Organics	STATE	6/1/01
Chloroethane	EPA 8260	Volatile Organics	STATE	6/1/01
Chloroform	EPA 8260	Volatile Organics	STATE	6/1/01
Chromium	EPA 6010	Metals	STATE	6/1/01
Chrysene	EPA 8270	Extractable Organics	STATE	6/1/01
cis-1,2-Dichloroethylene	EPA 8260	Volatile Organics	STATE	6/1/01
cis-1,3-Dichloropropene	EPA 8260	Volatile Organics	STATE	6/1/01
Cobalt	EPA 6010	Metals	STATE	6/1/01
Copper	EPA 6010	Metals	STATE	6/1/01

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Laboratory Scope of Certification

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State Laboratory ID: E86006 EPA Lab Code: FL00095 954-978-6400

E86006
Spectrum Laboratories, Inc. - FL
1460 West McNab Road
Ft. Lauderdale, FL 33309

Program RCRA/CERCLA

Analyte	Method	Category	Certification Type	Effective Date
Corrosivity (pH)	EPA 1110	General Chemistry	STATE	6/1/01
Dalapon	EPA 8151	Pesticides-herbicides-pcb s	STATE	6/1/01
delta-BHC	EPA 8081	Pesticides-herbicides-pcb s	STATE	6/1/01
Dibenz(a,h) anthracene	EPA 8270	Extractable Organics	STATE	6/1/01
Dibromochloromethane	EPA 8260	Volatile Organics	STATE	6/1/01
Dibromomethane	EPA 8260	Volatile Organics	STATE	6/1/01
Dicamba	EPA 8151	Pesticides-herbicides-pcb s	STATE	6/1/01
Dichloroprop (Dichlorprop)	EPA 8151	Pesticides-herbicides-pcb s	STATE	6/1/01
Dieldrin	EPA 8081	Pesticides-herbicides-pcb s	STATE	6/1/01
Diethyl ether	EPA 8260	Volatile Organics	STATE	6/1/01
Diethyl phthalate	EPA 8270	Extractable Organics	STATE	6/1/01
Dimethyl phthalate	EPA 8270	Extractable Organics	STATE	6/1/01
i-n-butyl phthalate	EPA 8270	Extractable Organics	STATE	6/1/01
Di-n-octyl phthalate	EPA 8270	Extractable Organics	STATE	6/1/01
Dinoseb (2-sec-butyl-4,6-dinitrophenol, DNBP)	EPA 8151	Pesticides-herbicides-pcb s	STATE	6/1/01
Endosulfan I	EPA 8081	Pesticides-herbicides-pcb s	STATE	6/1/01
Endosulfan II	EPA 8081	Pesticides-herbicides-pcb s	STATE	6/1/01
Endosulfan sulfate	EPA 8081	Pesticides-herbicides-pcb s	STATE	6/1/01
Endrin	EPA 8081	Pesticides-herbicides-pcb s	STATE	6/1/01
Endrin aldehyde	EPA 8081	Pesticides-herbicides-pcb s	STATE	6/1/01
Epichlorohydrin (1-Chloro-2,3-epoxypropane)	EPA 8260	Volatile Organics	STATE	6/1/01
Ethylbenzene	EPA 8260	Volatile Organics	STATE	6/1/01
Fluoranthene	EPA 8270	Extractable Organics	STATE	6/1/01
Fluorene	EPA 8270	Extractable Organics	STATE	6/1/01
gamma-BHC (Lindane, gamma-Hexachlorocyclohexane)	EPA 8081	Pesticides-herbicides-pcb s	STATE	6/1/01
Heptachlor	EPA 8081	Pesticides-herbicides-pcb s	STATE	6/1/01
Heptachlor epoxide	EPA 8081	Pesticides-herbicides-pcb s	STATE	6/1/01
Hexachlorobenzene	EPA 8270	Extractable Organics	STATE	6/1/01
Hexachlorobutadiene	EPA 8270	Extractable Organics	STATE	6/1/01
Hexachlorocyclopentadiene	EPA 8270	Extractable Organics	STATE	6/1/01
Hexachloroethane	EPA 8270	Extractable Organics	STATE	6/1/01
Ignitability	EPA 1010	General Chemistry	STATE	6/1/01
Indeno(1,2,3-cd)pyrene	EPA 8270	Extractable Organics	STATE	6/1/01
Iodomethane (Methyl iodide)	EPA 8260	Volatile Organics	STATE	6/1/01

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Laboratory Scope of Certification

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State Laboratory ID: E86006 EPA Lab Code: FL00095 954-978-6400

E86006
Spectrum Laboratories, Inc. - FL
1460 West McNab Road
Ft. Lauderdale, FL 33309

Program RCRA/CERCLA

Analyte	Method	Category	Certification Type	Effective Date
Iron	EPA 6010	Metals	STATE	6/1/01
Isobutyl alcohol (2-Methyl-1-propanol)	EPA 8260	Volatile Organics	STATE	6/1/01
Isophorone	EPA 8270	Extractable Organics	STATE	6/1/01
Lead	EPA 6010	Metals	STATE	6/1/01
Magnesium	EPA 6010	Metals	STATE	6/1/01
Manganese	EPA 6010	Metals	STATE	6/1/01
MCPA	EPA 8151	Pesticides-herbicides-pcb s	STATE	6/1/01
MCPP	EPA 8151	Pesticides-herbicides-pcb s	STATE	6/1/01
Methacrylonitrile	EPA 8260	Volatile Organics	STATE	6/1/01
Methyl bromide (Bromomethane)	EPA 8260	Volatile Organics	STATE	6/1/01
Methyl chloride (Chloromethane)	EPA 8260	Volatile Organics	STATE	6/1/01
Methyl methacrylate	EPA 8260	Volatile Organics	STATE	6/1/01
Methylene chloride	EPA 8260	Volatile Organics	STATE	6/1/01
Molybdenum	EPA 6010	Metals	STATE	6/1/01
Naphthalene	EPA 8260	Volatile Organics	STATE	6/1/01
Naphthalene	EPA 8270	Extractable Organics	STATE	6/1/01
Nickel	EPA 6010	Metals	STATE	6/1/01
Nitrobenzene	EPA 8270	Extractable Organics	STATE	6/1/01
n-Nitrosodimethylamine	EPA 8270	Extractable Organics	STATE	6/1/01
n-Nitrosodi-n-propylamine	EPA 8270	Extractable Organics	STATE	6/1/01
n-Nitrosodiphenylamine	EPA 8270	Extractable Organics	STATE	6/1/01
n-Propylbenzene	EPA 8260	Volatile Organics	STATE	6/1/01
p-Dioxane	EPA 8260	Volatile Organics	STATE	6/1/01
Pentachlorophenol	EPA 8270	Extractable Organics	STATE	6/1/01
Phenanthrene	EPA 8270	Extractable Organics	STATE	6/1/01
Phenol	EPA 8270	Extractable Organics	STATE	6/1/01
Potassium	EPA 6010	Metals	STATE	6/1/01
Propionitrile (Ethyl cyanide)	EPA 8260	Volatile Organics	STATE	6/1/01
yrene	EPA 8270	Extractable Organics	STATE	6/1/01
eactive Cyanide	s.7.3 SW-846	General Chemistry	STATE	6/1/01
eactive sulfide	s.7.3 SW-846	General Chemistry	STATE	6/1/01
elenium	EPA 6010	Metals	STATE	6/1/01
licon	EPA 6010	Metals	STATE	6/1/01
lver	EPA 6010	Metals	STATE	6/1/01
vex (2,4,5-TP)	EPA 8151	Pesticides-herbicides-pcb s	STATE	6/1/01

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Laboratory Scope of Certification

THIS LISTING OF CERTIFIED ANALYTES SHOULD BE USED ONLY WHEN ASSOCIATED WITH A VALID CERTIFICATE ISSUED BY THE DEPARTMENT OF HEALTH

State Laboratory ID: E86006 EPA Lab Code: FL00095 954-978-6400

E86006
Spectrum Laboratories, Inc. - FL
1460 West McNab Road
Ft. Lauderdale, FL 33309

Program RCRA/CERCLA

Analyte	Method	Category	Certification Type	Effective Date
Sodium	EPA 6010	Metals	STATE	6/1/01
STRONTIUM	EPA 6010	Metals	STATE	6/1/01
Styrene	EPA 8260	Volatile Organics	STATE	6/1/01
Tetrachloroethylene (Perchloroethylene)	EPA 8260	Volatile Organics	STATE	6/1/01
Toluene	EPA 8260	Volatile Organics	STATE	6/1/01
TOXICITY CHARACTERISTIC LEACHING PROCEDURE	EPA 1311	General Chemistry	STATE	6/1/01
trans-1,2-Dichloroethylene	EPA 8260	Volatile Organics	STATE	6/1/01
trans-1,3-Dichloropropylene	EPA 8260	Volatile Organics	STATE	6/1/01
Trichloroethene (Trichloroethylene)	EPA 8260	Volatile Organics	STATE	6/1/01
Trichlorofluoromethane	EPA 8260	Volatile Organics	STATE	6/1/01
Vanadium	EPA 6010	Metals	STATE	6/1/01
yl acetate	EPA 8260	Volatile Organics	STATE	6/1/01
yl chloride	EPA 8260	Volatile Organics	STATE	6/1/01
Xylene (total)	EPA 8260	Volatile Organics	STATE	6/1/01
Zinc	EPA 6010	Metals	STATE	6/1/01

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CALIFORNIA LABORATORY SERVICES

Environmental Chemistry

ATTACHMENT 3

Unv Of Cali Forest Product Lab
1301 So. 46th Street
Richamond, CA 94804

04/23/2002

Attention: Kevin Flynn

Reference: Analytical Results

Project Name: Nasa/Ames Hangers 2 & 3
Project No.: 02-010
Date Received: 04/04/2002
Chain Of Custody: 30838

CLS ID No.: T6886
CLS Job No.: 846886

The following analyses were performed on the above referenced project:

No. of Samples	*Turnaround Time*	*Analysis Description*
2	10 Days	Total Phosphorus, Standard Method 4500-P
2	10 Days	Cr,Cu,As TTLC, EPA Methods 6010/7000
2	10 Days	Sulfate Analysis

These samples were received by CLS Labs in a chilled, intact state and accompanied by a valid chain of custody document.

Calibrations for analytical testing have been performed in accordance to and pass the EPA's criteria for acceptability.

Analytical results are attached to this letter. Please call if we can provide additional assistance.

Sincerely,

James Liang, Ph.D.
Laboratory Director

Analysis Report: Total Phosphorus as P, EPA Method 365.2

Client:	Unv Of Cali Forest Product Lab 1301 So. 46th Street Richamond, CA 94804	*Project No.:*	02-010
		Contact:	Kevin Flynn
		Phone:	(510)215-4242
Project:	Nasa/Ames Hangers 2 & 3	*Lab Contact:*	James Liang
		Lab ID No.:	T6886
Date Sampled:	04/03/2002	*Job No.:*	846886
Date Received:	04/04/2002	*COC Log No.:*	30838
Date Extracted:	04/05/2002	*Batch No.:*	W020404C
Date Prepared:	04/05/2002	*Instrument ID:*	UV002
Date Reported:	04/15/2002	*Analyst ID:*	SCOTTF
		Matrix:	SOLID

ANALYTICAL RESULTS

Lab / Client ID Analyte	CAS No.	Results (mg/kg)	Rep. Limit (mg/kg)	Dilution (factor)
1A / Hangar 2				
Total Phosphorus as P	N/A	2700	1000	200
2A / Hangar 3				
Total Phosphorus as P	N/A	280	250	50

ND = Not detected at or above indicated Reporting Limit

HANGARS 2 & 3 - ALL COMPONENTS

CALIFORNIA LABORATORY SERVICES

Environmental
Chemistry

Analysis Report: Sulfate as SO4, EPA Method 300.0

Client: Unv Of Cali Forest Product Lab
1301 So. 46th Street
Richamond, CA 94804

Project No.: 02-010
Contact: Kevin Flynn
Phone: (510)215-4242

Project: Nasa/Ames Hangers 2 & 3

Date Sampled: 04/03/2002
Date Received: 04/04/2002
Date Extracted: 04/10/2002
Date Analyzed: 04/12/2002
Date Reported: 04/17/2002

Lab Contact: James Liang
Lab ID No.: T6886
Job No.: 846886
COC Log No.: 30838
Batch No.: IC2020412
Instrument ID: IC002
Analyst ID: SCOTTF
Matrix: SOLID

ANALYTICAL RESULTS

Lab / Client ID Analyte	CAS No.	Results (mg/kg)	Rep. Limit (mg/kg)	Dilution (factor)
1A / **Hangar 2**				
Sulfate	N/A	78000	2500	250
2A / **Hangar 3**				
Sulfate	N/A	53000	2500	250

ND = Not detected at or above indicated Reporting Limit

HANGARS 2 & 3 - ALL COMPONENTS

CALIFORNIA LABORATORY SERVICES

Environmental
Chemistry

Unv Of Cali Forest Product Lab
1301 So. 46th Street
Richamond, CA 94804

05/24/2002

Attention: Kevin Flynn

Reference: Analytical Results

Project Name: Nasa/Ames Hangers 2 & 3
Project No.: 02-010
Date Received: 04/04/2002
Chain Of Custody: 30838

CLS ID No.: T6886A
CLS Job No.: 846886

The following analyses were performed on the above referenced project:

No. of Samples	*Turnaround Time*	*Analysis Description*
1	10 Days	Cr, STLC, EPA Method 6010/7000

These samples were received by CLS Labs in a chilled, intact state and accompanied by a valid chain of custody document.

Calibrations for analytical testing have been performed in accordance to and pass the EPA's criteria for acceptability.

Analytical results are attached to this letter. Please call if we can provide additional assistance.

Sincerely,

James Liang, Ph.D.
Laboratory Director

CALIFORNIA LABORATORY SERVICES

Environmental
Chemistry

Analysis Report: Chromium, EPA Method 6010
CA Waste Extraction Test (WET)

Client: Unv Of Cali Forest Product Lab
1301 So. 46th Street
Richamond, CA 94804

Project: Nasa/Ames Hangers 2 & 3

Date Sampled: 04/03/2002
Date Received: 04/04/2002
Date Extracted: 05/13/2002
Date Analyzed: 05/22/2002
Date Reported: 05/24/2002
Client ID No.: Hangar 3

Project No.: 02-010
Contact: Kevin Flynn
Phone: (510)215-4242

Lab Contact: James Liang
Lab ID No.: T6886A-2A
Job No.: 846886
COC Log No.: 30838
Batch No.: M020513A
Instrument ID: IP004
Analyst ID: JAMESL
Matrix: SOLID

HANGAR 3

Analyte	CAS No.	Results (mg/L)	Rep. Limit (mg/L)	Method	Dilution (factor)
Cr (Chromium)	7440473	2.8	0.50	6010	1.0

ND = Not detected at or above indicated Reporting Limit

HANGAR 3 - ALL COMPONENTS

STATE OF CALIFORNIA
DEPARTMENT OF HEALTH SERVICES

ENVIRONMENTAL LABORATORY CERTIFICATION

is hereby granted to

CLS LABS

3249 FITZGERALD ROAD
RANCHO CORDOVA, CALIFORNIA

to conduct analyses of environmental samples as specified in the "List of Approved Fields of Testing and Analytes" which accompanies this Certificate.

This Certificate is granted in accordance with provisions of Section 1010, et seq. (New Section 100825) of the Health and Safety Code.

Certificate No.: 1233

Expiration Date: 06/30/2002

Issued on: 06/01/2000
at Berkeley, California,
subject to forfeiture or revocation.

George C.

George C. Kulasingam, Ph.D.
Manager
Environmental Laboratory Accreditation Program

Divided as follows:

Corporate	660	
Associate	127	
Junior	4	
Honorary	6	
Life	13	810

Respectfully submitted,

HORACE L. DAWSON,
Secretary–Treasurer.

(Note: These reports of the Secretary–Treasurer and the books of account of the Association were audited on April 25, 1944, by three members of the Executive committee appointed as auditing committee by President Colley, and were certified to be correct.)

PRESIDENT COLLEY: Will the secretary read the names of the men who have been appointed to the Resolutions committee and also the names of the election tellers.

SECRETARY DAWSON: The following appointments have been made.

Election Tellers: M. S. Hudson, chairman; V. C. Otley, E. H. Rieman, W. W. Ward, and H. E. Weeks.

Resolutions Committee: H. R. Condon, chairman; C. S. Burt, Carl G. Crawford, and E. T. Howson.

PRESIDENT COLLEY: At this time we will make a change in the order of papers in the printed program. The next item will be a paper on fireproofed wood for airship hangars by Captain William H. Smith of the U. S. Navy.

Captain Smith found it impossible to be with us today. The paper will be presented by Lt. Comdr. Neil W. French. I am glad to announce also that following the presentation of Captain Smith's paper, Commander French will show us a motion picture, complete with sound and color, titled Construction of an LTA Hangar.

LIEUTENANT COMMANDER FRENCH: Gentlemen, I am sure Captain Smith regrets exceedingly that he cannot be here today on account of pressure of business in Washington.

However, since it is an ill wind that blows nobody good, I must express my own appreciation of the opportunity to listen to your discussions.

FIREPROOFED WOOD FOR AIRSHIP HANGARS

By Captain William H. Smith (CEC) USN
Director, Planning and Design Dept., Bureau of Yards and Docks, Navy Dept.

(The opinions or assertions contained herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Navy Department or the Naval service at large.)

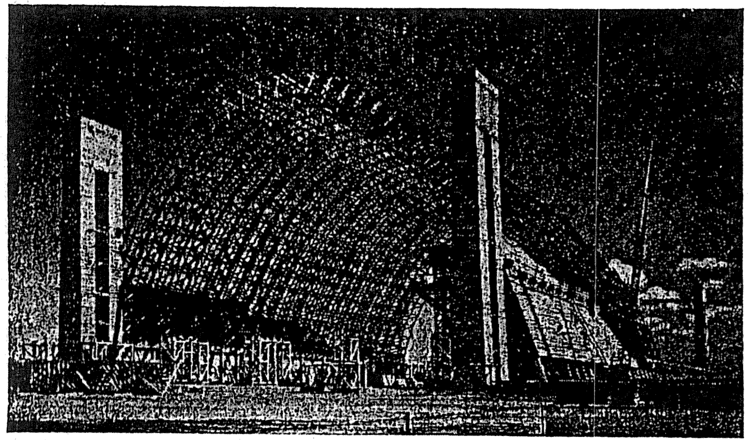
The serious inroads made on allied transatlantic shipping in 1941 and early 1942 by the German submarine campaign necessitated the most aggressive development and application of every practicable form of anti-submarine warfare. The use of non-rigid dirigible airships, familiarly known as blimps, for anti-submarine patrol and counter-attack was among the defensive measures adopted.

Blimps were used to some extent during the first World War for similar purposes and the Bureau of Yards and Docks of the Navy department built a number of dirigible airship bases in this country and in Western France. These hangars were of temporary construction, relatively small, the largest having a length of about 600 ft., a clear height of about 80 ft. and a clear width of about 70 ft.

Shortly after the World War, the United States Navy pioneered the development of rigid airships, culminating in the acquisition of the famous dirigibles Los Angeles and Shenandoah. These airships were based at the Naval air station, Lakehurst, N. J. The first large airship hangar in this country was erected there in 1919. This hangar was 807 ft. long, 316 ft. wide and 200 ft. high, and was of steel-frame construction. The Navy's operating experience with the Los Angeles was so favorable that in 1930 orders were placed for two rigid airships of 3,000,000 cu. ft. volume and plans were initiated for the subsequent development of rigid airships of 6,000,000 cu. ft. capacity. The two 3,000,000 cu. ft. ships, the Akron and Macon, were delivered in 1931 and were based at Lakehurst and Sunnyvale, respectively. At the Sunnyvale air station a complete lighter-than-air base was developed including a hangar of steel construction 1,124 ft. long, 308 ft. wide and 194 ft. high, with orange-peel doors somewhat similar in design to those on the Goodyear dock, which had been built at Akron for the manufacture of these airships.

{ NO:
6,500,000 ft^3
each for
Akron & Macon

The first hangars built during the present war, to accommodate the non-rigid blimps for the anti-submarine patrol, were of smaller dimensions and of welded steel-arch construction. When the increasing menace of the submarine campaign forced a large expansion of the airship program, it was necessary to provide a considerable number of additional airship hangars in strategic locations in the shortest possible time. Consideration was given to constructing these hangars of structural steel, duplicating those which had been provided earlier. By this time, however, structural steel had become one of the critical items of the procurement program. The Navy was faced with the problem of executing the greatest combatship expansion program in history. Simultaneously the Maritime Commission was engaged in a vast merchant-ship construction program which was scheduled to be stepped up to the greatest production rate ever accomplished by any country. When it came to a choice between steel for ships and steel for buildings, the Navy department lost no time in reaching a decision. The use of steel for the additional hangars was vetoed, not by the War Production Board but by the Navy itself.



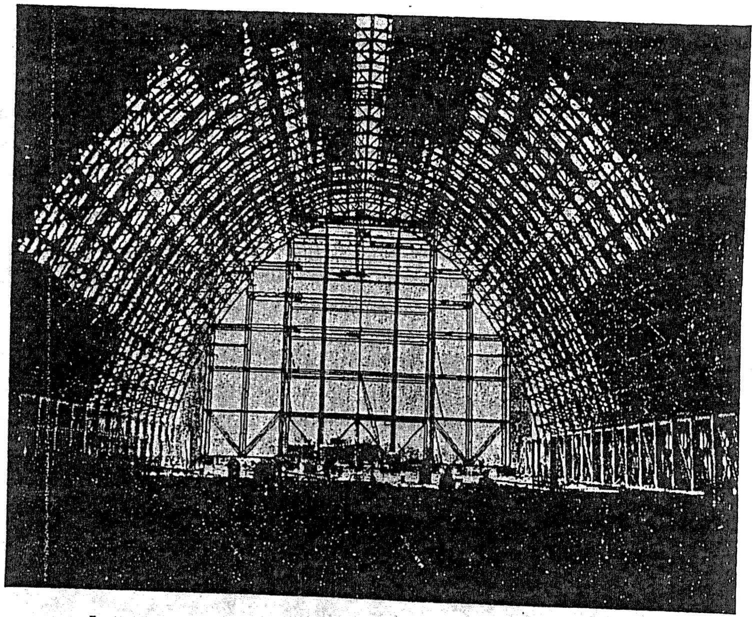
Exterior View of Airship Hangar Under Construction.

The Bureau of Yards and Docks was faced with the problem of pioneering an original design for airship hangars that, so far as practicable, eliminated the use of structural steel. There were two obvious alternatives—concrete and wood. Both types of construction were considered seriously. Timber construction was finally selected for reasons that need not be elaborated here.

The development of a successful and practical design in timber for these great hangars constituted one of the major pioneer engineering achievements of this war. I can say this in all modesty because the supervision of the design for this project was in the hands of my predecessor, Capt. Carl Trexel, CEC, USN, and the major credit for the achievement belongs to our design manager, Comdr. E. H. Praeger, CEC, USNR, his assistant, Comdr. G. A. Hunt, CEC, USNR, and the Bureau's principal engineer, Arsham Amirikian and his assistant designing engineers.

These timber hangars are approximately 1,058 ft. long, 297 ft. wide and 174 ft. high with a clear span of 234 ft. and a span on the center line of the arches of 258 ft. Three different designs were used, based on earthquake, hurricane and snow conditions, respectively, depending on the geographical location. The amount of timber in each hangar varies from 3,100,000 to 3,500,000 ft. b. m., depending on the design characteristics and the type of door used.

The adoption of timber for these hangars imposed many special problems on the designers. The question of safety from fire was of great concern. The fire hazard from the blimps themselves is relatively small, thanks to the fact that American airships are filled with helium, which is completely inert, instead of with hydrogen, which is highly inflammable and explosive, and which all other countries must use because of their lack of helium resources. The principal fire hazard comes from the shop, storage, and office spaces which are located in lean-tos at ground level along both sides of the hangars. Adequate fire protection by sprinkler systems can readily be provided for these areas and the use of concrete construction for the support of the timber arches also contributed to the degree of fire protection afforded these relatively hazardous areas. The timber in the structure itself thus constituted the major



Interior View of Airship Hangar Under Construction.

fire hazard with lightning as one of the principal possible sources of fire.

Consideration was given in the early stages of the development of the design to the provision of deluge sprinklers, hose reels on the roofs and similar fire fighting equipment as a measure of protection of the structure against fire. The difficulties encountered in providing reliable protection by these methods, the hazard of having men on the arch roof nearly 200 feet in the air fighting a fire underneath them, the problem of supplying sufficient water to combat a serious fire in a structure of this size and the consumption of critical materials for any adequate system of fire fighting, all dictated a different approach to the problem of fire protection of these hangars.

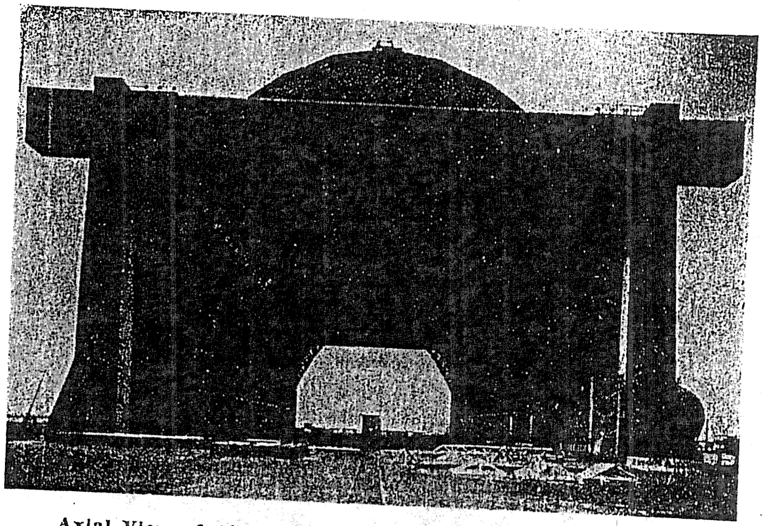
Before the war, the Bureau had become interested in the use of ireproofed wood in connection with several peacetime projects. Fireproofing of wood was adopted, first, for part of the roof heathing on one of the steel frame airship hangars in the initial var program for such structures. When the difficulties of provid-ng adequate fire fighting equipment for the timber hangars became ıpparent, it was decided that the fireproofing of all principal tructural timber for the wooden hangars was the only practicable lternative and this requirement was adopted.

Considerable thought was given to the specification requirements or the fireproofing, in co-operation with firms specializing in this vork. After intensive discussions the decision was reached to speify the fireproofing on a performance basis rather than on a tated retention of fireproofing salts per cubic foot. This decision vas reached, partly because of the variation in absorption of mber of different sizes, partly because of the lack of specific and uthentic data available to the consumer on the relation between bsorption and fire resistance for the various treatments available ommercially, and primarily because the fire resistance which was e sole objective of the treatment could be evaluated with reasonble assurance by direct performance tests. In this respect the eproofing of wood differs radically from most other branches of e wood-preserving industry since, as you all know, a new treatent for resistance against marine borers, for example, cannot be oven authoritatively until after actual service tests have been nducted extending over long periods of years.

The specification requirements in brief were that all material except llwork and except timber wholly within areas provided with rinklers should be treated in general accordance with specifican 38b of the American Wood-Preservers' Association which is, course, a pressure and vacuum impregnation process. It was ecified that the timber should not be degraded by the impregnan process, that the strength of structural material should not be paired materially by the chemicals or process, that the treatment

should be permanent under normal exposure conditions and that the chemicals should not corrode material, affect paint or glue, cause hygroscopicity, create hazards to health during working or emit injurious fumes under direct fire attacks. Where cutting or drilling after treatment could not be avoided, it was specified that the cut surfaces should be brushed with at least three applications of the chemical solution.

Performance tests on treated timber were required on samples selected, one from each lot of 5,000 bd. ft. These tests were in accordance with the tentative method of test for fire retardant properties of wood, ASTM Serial C160–41T, more familiarly known as the crib test.

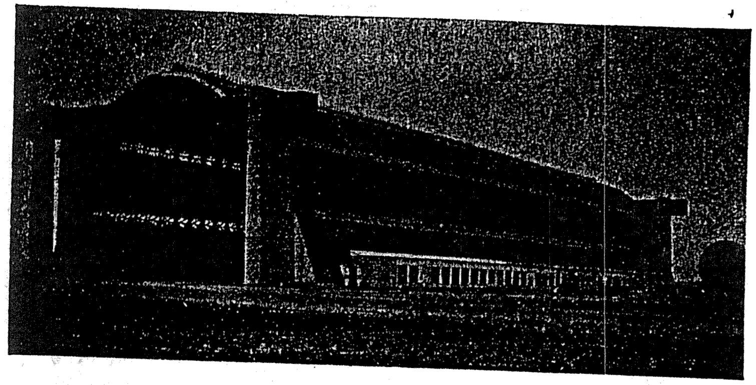


Axial View of Airship Hangar Complete Except for Doors.

It was specified originally that when subjected to this test the final loss in weight after a 3-min. exposure to the flame should not be more than 25 per cent, that the duration of flaming after removal of the burner flame should not be more than 20 sec. and that visible glowing should persist for not more than 20 sec. after flaming had ceased.

Experience with the grades of timber being supplied under war conditions indicated that many otherwise satisfactory samples failed to meet these requirements because pitch pockets continued to burn after the rest of the sample was extinguished. By addendum to the standard specification the requirements were modified to permit flaming more than 20 sec. after the removal of the burner flame, if such flaming was from pitch pockets only and providing also that total period of flaming should not be more than 40 sec. in more than 6 pieces of a specimen, and not longer than 90 sec. in not more than 2 pieces of such specimen, a specimen consisting of 24 pieces.

By another addendum, the restrictive requirement that treatment be in accordance with AWPA Specification 38b, which is applicable only to Douglas fir, was modified to require that the treatment be by the pressure process in accordance with the Manual of the American Wood-Preservers' Association, to provide the proper treatment for other woods.



Exterior View of Completed Airship Hangar.

The main trusses for these hangars were 13 ft. 6 in. deep between working lines at the crown and 19 ft. between working lines at the haunches. The trusses were of Pratt form with top and bottom chords consisting of two timbers up to 4 in. by 14 in. in size, lapped at splices without dapping, and separated by two diagonals, up to 4 in. by 14 in. in size, by a vertical up to 6 in. by 8 in. in size and by fillers at intermediate joints. The width of the chords thus reached a maximum of 30 in.

The question of shrinkage naturally assumed major proportions. It is well known that the fire-retardant treatment tends to increase the moisture content of the wood over that of the untreated material and it was generally found that treated timbers were slightly larger in finished size than the untreated stock. This is attributed partly to the amount of moisture forced into the wood during the treatment and partly to the deliquescent action of the salts. It can be stated that shrinkage troubles on these treated structures are, if anything, less than the troubles encountered on other timber structures which were not given a fire-retardant treatment. Possibly this may be explained by the fact that the treated timber

tends to vary less in moisture content over considerable periods of time and thus has less overall volume change.

It will be noted that the specification requires that the strength of the material shall not be impaired materially by the treatment. Research on the subject of the effect of treatment on strength revealed that this problem had not been thoroughly explored and that little authentic information was available in published form, except in very general terms. Time did not permit detailed experimentation or investigation of the relation between treatment and strength prior to placing contracts for the work. Test programs were initiated at several universities with a view to securing comprehensive information on this subject. A considerable amount of valuable data have been accumulated from these tests and these data are now being reviewed and correlated by the Bureau of Yards and Docks. It is rather difficult at this time to present a clear picture of the results of these tests, since all tests are not complete, the methods adopted by the various investigators differed somewhat and the conclusions are based on varying premises, particularly with respect to the correction for moisture content.

These tests included static-bending tests, flexural-shear tests, compression tests parallel to the grain, compression tests on split ring connector joints with the connected timbers subjected to load both parallel and perpendicular to the grain, tension tests on split ring connector joints with the load applied parallel to the grain, shear tests on notched-block specimens, hardness tests and moisture, specific gravity and ring-count determinations on all tested samples. Tests were conducted on both treated and untreated specimens matched in pairs so far as practicable, selected at the treating plant from materials furnished for the project. Test results were in general adjusted to 12 per cent moisture by the methods recommended by the Forest Products Laboratory.

The Bureau is not in a position to publish data, findings and conclusions on these tests pending their completion and correlation. It is hoped that a comprehensive report on these investigations can be published when the pressure of work permits. I can say, however, that whereas many structural properties of the treated timber appear to be actually better than the corresponding properties of the untreated timber when adjusted by formula to equal moisture content, there is serious doubt in my mind as to the propriety of comparison on this basis. If the treated timber, as it exists in the structure after a reasonable exposure, always tends to have a higher moisture content than untreated timber in the same structure and under the same exposure, it follows that in comparing the structural properties of the treated and untreated wood, this normal excess of moisture in the treated specimens must be taken into consideration. The comparative strength of treated and untreated timber on this basis, will, of course, be less favorable to the treated material than is indicated by laboratory results adjusted to standard moisture conditions.

This conclusion emphasizes the need for further research on the matter of deliquesence of the salts. The specification demands that the chemicals used shall not cause hygroscopicity. This is an indefinite term and implies perfection which cannot be attained in practice. In fact there is probably no salt suitable for the purpose which is not hygroscopic to the extent that it tends to increase the permanently retained moisture content of the wood and thus indirectly reduces the strength of the treated wood. I would like to suggest the desirability of quantitative research on this characteristic.

Fortunately I am unable to report any results on fire resistance in actual use, because we have had no hangar fires to date. We do believe, however, that the adoption of this fireproofing treatment was completely justified under the circumstances and know that it permitted us to adopt an available material in place of a critically scarce material with much more confidence than if the fireproofing treatment had not been available.

This airship hangar program is but one of many instances in which the war effort has been aided materially by the use of materials treated by member firms of the American Wood-Preservers' Association and by processes developed under its auspices. The nembers of this association may well feel proud of their contribuion toward the winning of the war.

LIEUTENANT COMMANDER FRENCH: Now we will have the film, vhich shows the actual construction of one of these hangars.

A moving picture, Construction of an LTA Hangar, was then xhibited by Lieutenant Commander French.

PRESIDENT COLLEY: I think that is one of the most remarkable ictures, regarding one of the most remarkable achievements that as ever been demonstrated before this group. I know that many f you who were involved in actually doing the work are grateful Commander French for presenting this picture.

It would be a shame if some of you who have had your fingers this job do not rise and say something about it. Aren't you tisfied with the results? Mr. Hartman, are you?

F. A. HARTMAN: Yes, I am. However, the picture speaks for self.

PRESIDENT COLLEY: Mr. Gottschalk, are you?

F. W. GOTTSCHALK: Very much so. The pictures reminded me a tle of the problem the fabricators and the treaters had before em, namely, that of having the right piece for the contractor ien he wanted that piece to go into the structure. There was a of scurrying around and keeping track of pre-fabricated mateal. Again, there is a reminder in these pictures of the fact that the fire-retardant treated wood is more or less a chemically seasoned material, that is, it has anti-check properties.

PRESIDENT COLLEY: There will be an opportunity later on, when we have some other papers on fire-retardant treatment, for a more extended discussion of the whole subject.

We will now proceed with the report of Committee 4, but before we start, I want to make clear the way we are going to try to conduct the meeting today. We have a long program. I have asked each committee chairman and each member or guest who is going to present a paper, to make a brief oral presentation, summing up the main facts and calling your attention to some new developments or adaptations which have occurred since the paper was written, leaving the time for discussion, which probably can be stimulated by the presentation of the various committee reports and papers.

As you note, there is no row of chairs on the side for the committee members to sit in. The chairmen of the committees only will come to the front. You know most of them. They will present their reports briefly and be ready for your questions and discussion.

Mr. Baechler, chairman, will present the report of Committee 4—Preservatives.

REPORT OF COMMITTEE 4—PRESERVATIVES

R. H. BAECHLER, *Chairman*
R. M. ALPEN
W. W. BARGER
R. H. BESCHER
S. J. BUCKMAN
H. B. CARPENTER
E. B. FULKS
W. H. FULWEILER
F. W. GOTTSCHALK
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A. L. KAMMERER
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P. B. MAYFIELD
W. MCMAHON
C. S. REEVE
E. O. RHODES
A. P. RICHARDS
HENRY SCHMITZ
L. B. SHIPLEY
R. R. THURSTON
J. A. VAUGHAN
J. M. WINGERT
GALEN WOOD

Committee.

To the Members of the American Wood-Preservers' Association:

The instructions to the committee were as follows:

1. Give special study to and report on current and possible future applications of committee work to war emergency problems.
2. Revision of Manual.
3. Review analytical and service data on creosote used in the United States and Canada with special reference to possible revision of the standard specification for creosote.
4. Review current use of solutions of creosote and petroleum for wood preservation and submit a specification for such solutions for adoption by the Association.

1427 EYE STREET, N. W.
WASHINGTON 5, D. C.

DEMOCRAT PRINTING COMPANY
MADISON, WISCONSIN

PROCEEDINGS

OF THE

Fortieth Annual Meeting

OF THE

American Wood-Preservers' Association

HELD AT THE
Palmer House, Chicago, Ill.
April 26, 1944

VOLUME 40

Table 5.4

ppm elements in dry plant tissues*

Element	Plankton[1]	Brown algae[2]	Bryophytes	Ferns[3]	Gymno-sperms	Angio-sperms[4]	Bacteria[5]	Fungi[6]
Ag	0·25 Va	0·28 Bl	0·1 La, Se	0·23 H, La	0·07 La	0·06 C, La		0·15 La
Al	1000 Va	62 V	1400 Se		65 By	550 C	210 P	29 By
As		30 V, Y				0·2 Bu, Sm		
Au		0·012 F				< 0·00045 C		
B		120 Bl, V	20 La	77 La	63 L	50 C, La	5·5 P	5 La
Ba	15 Va	31 Bl, Bo	150 Se	8 Bd		14 Bd		
Be			< 0·2 Se			< 0·1 C		< 0·1 Le
Bi			< 1 Se			0·06 Sh		
Br		740 V				15 N		20 N
C	225000	345000	450000	450000	450000	454000	538000	494000
Ca	8000 V	11500 V	3000 Se	3700 H+	6500 L	18000 L	5100 P	1700 P
Cd	0·4 Va	0·4 V	0·1 La	0·5 La	0·24 La	0·64 Bu, La		4 La
Ce			⩽ 14 Se			⩽ 34 Se		
Cl		4700 V	670 Se	6000 H+		2000 Sp	2300 P	10000 Mc
Co	5 Va	0·7 Bl, V, Y	0·33 La, Se	0·8 La	0·2 C, La	0·48 C, La		0·5 La
Cr	3·5 Va	1·3 Bl	2 La, Se	0·8 La	0·16 C, La	0·23 C, La		1·5 La
Cs		0·067 S				0·2 Ya		
Cu	200 Va	11 Bl, V, Y	7 La, Se	15 La	15 L	14 C, La	42 P	15 La
Eu						0·021 Si		
F		4·5 Y				0·5 Mo		
Fe	3500 Va	690 Bl	1200 M	300 M	130 L	140 L, M	250 P	130 M, P
Ga	1·5 Va	0·5 B	0·1 La, Se	0·23 La	< 0·07 La	0·05 Bu		1·5 La
H	46000	41000	55000	55000	55000	55000	74000	55000
Hg		0·03 V				0·015 Bu, Mo		
I	300 V	1500 V, Y	5 Se			0·4 J		
K		52000 V, Y	2400 Ba, Se	18000 H+	6300 L	14000 L	115000 P	22300 L
La		10 B	3 Se			0·085 Bu, Si		
Li		5·4 Bl				0·1 Mi		
Mg	3200 V	5200 V	800 Ba, Se	1800 H+	1300 L	3200 L	7000 P	1500 P
Mn	75 Va	53 Bl, V, Y	290 M	250 M, H+	330 L	630 L, M	30 P	25 M
Mo	1 Va	0·45 Bl, V, Y	0·7 La, Se	0·8 H, La	0·13 C, La	0·9 C, La		1·5 La

ATTACHMENT 5

N	38000	15000	25000	20500	32000	30000	96000	51000
Na	6000 Va	33000 V, Y	1100 Ba	1400 H +	340 L	1200 L	4600 P	1500 P
Nb			0·3 Ty		0·3 Ty	0·3 Ty		
Nd			≤ 6·5 Se			≤ 24 Se		
Ni	36 Va	3, Bl, V, Y	2·5 La, Se	1·5 H, La	1·8 C, La	2·7 C, La		1·5 La
O	440000	470000	450000	430000	440000	410000	230000	340000
P	4250 Va	2800 V	400 Ba, Se	2000 H +	2900 L	2300 L	30000 P	14000 P
Pb	5 Va	8·4 Bl	3·3 La, Se	2·3 La	1·8 C, La	2·7 C, La		50 La
Ra	4×10^{-7} K	9×10^{-8} V				10^{-9} Tb		
Rb		7·4 S				20 Bu		
Re		0·014 F						
Ru						0·005 Bu		
S	6000 V	12000 V	1100 Ba	1000 Th	1100 Th	3400 Th	5300 P, Sp	4000 P
Sb						0·06 Bu		
Sc			≤ 0·3 Se			0·008 Bu		
Se		0·84 Ch				0·2 Bn		2 Sf
Si	200000 V	1500 V	2000 Se	5500 H +		200 Sp	180 P	
Sm						0·0055 Si		
Sn	35 Va	1·1 Bl	1 La, Se	2.3 La	< 0·24 La	< 0·3 C		5 La
Sr	260 Va	1400 Bl, Bo	15 Se	13 Bd, H		26 Bd		320 Le
Tb						< 0·0015 Si		
Ti	80 Va	12 Bl, V	65 Se	5·3 H		1 Mi		
Tm						0·0015 Si		
U			< 0·35 Mk		≤ 0·35 Mk	0·038 C		0·25 Le
V	5 Va	2 Bl	2·3 Se	0·13 H	0·69 Ca	1·6 Ca		0·67 Be
W		0·035 F				0·07 Bw		
Y			0·33 La, Se	0·77 La	< 0·24 La	< 0·6 La		0·5 La
Yb			0·2 Se			< 0·0015 Si		
Zn	2600 Va	150 Bl, V, Y	50 La, Se	77 H, La	26 C, La	160 C, La		150 La
Zr	20 Va		0·33 La, Se	2·3 La	0·24 La	0·64 La		5 La

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[1] Mainly diatoms.
[2] Figures for Au, Re and W are for red/green algae.
[3] Does not include horsetails or clubmosses.
[4] Figures are for woody species where there are plenty of data.
[5] Figures are for vegetative cells.
[6] Lichens included.

*See page 78 for references.

7

Trace Elements in Biochemistry

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Department of Chemistry, The University, Reading, England

1966
ACADEMIC PRESS
London and New York

ood Science"; Iowa
.: New York,

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Components", Vol.
. 38; SPCI: Stock-

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ATTACHMENT 6

2

The Chemical Composition of Wood

ROGER C. PETTERSEN

U.S. Department of Agriculture, Forest Service, Forest Products Laboratory,
Madison, WI 53705

This chapter includes overall chemical composition of wood, methods of analysis, structure of hemicellulose components and degree of polymerization of carbohydrates. Tables of data are compiled for woods of several countries. Components include: cellulose (Cross and Bevan, holo-, and alpha-), lignin, pentosans, and ash. Solubilities in 1% sodium hydroxide, hot water, ethanol/benzene, and ether are reported. The data were collected at Forest Products Laboratory (Madison, Wisconsin) from 1927–68 and were previously unpublished. These data include both United States and foreign woods. Previously published data include compositions of woods from Borneo, Brazil, Cambodia, Chile, Colombia, Costa Rica, Ghana, Japan, Mexico, Mozambique, Papua New Guinea, the Philippines, Puerto Rico, Taiwan, and the USSR. Data from more detailed analyses are presented for common temperate-zone woods and include the individual sugar composition (as glucan, xylan, galactan, arabinan, and mannan), uronic anhydride, acetyl, lignin, and ash.

THE CHEMICAL COMPOSITION of wood cannot be defined precisely for a given tree species or even for a given tree. Chemical composition varies with tree part (root, stem, or branch), type of wood (i.e., normal, tension, or compression) geographic location, climate, and soil conditions. Analytical data accumulated from many years of work and from many different laboratories have helped to define average expected values for the chemical composition of wood. Ordinary chemical analysis can distinguish between hardwoods (angiosperms) and softwoods (gymnosperms). Unfortunately, such techniques cannot be used to identify individual tree species because of the variation within each species and the similarities among many species. Further identification is possible with detailed chemical anal-

Published 1984, American Chemical Society

2.

ysis of extractives (chemotaxonomy). Chemotaxonomy is discussed fully elsewhere in the literature (*1*, *2*).

There are two major chemical components in wood: lignin (18–35%) and carbohydrate (65–75%). Both are complex, polymeric materials. Minor amounts of extraneous materials, mostly in the form of organic extractives and inorganic minerals (ash), are also present in wood (usually 4–10%). Overall, wood has an elemental composition of about 50% carbon, 6% hydrogen, 44% oxygen, and trace amounts of several metal ions.

A complete chemical analysis accounts for all the components of the original wood sample. Thus, if wood is defined as part lignin, part carbohydrate, and part extraneous material, analyses for each of these components should sum to 100%. The procedure becomes more complex as the component parts are defined with greater detail. Summative data are frequently adjusted to 100% by introducing correction factors in the analytical calculations. Wise and coworkers (*3*) presented an interesting study on the summative analysis of wood and analyses of the carbohydrate fractions. The complete analytical report also includes details of the sample, such as species, age, and location of the tree, how the sample was obtained from the tree, and from what part of the tree. The type of wood analyzed is also important; i.e., compression, tension, or normal wood.

Vast amounts of data are available on the chemical composition of wood. Fengel and Grosser (*4*) made a compilation for temperate-zone woods. This chapter is a compilation of data for many different species from all parts of the world, and includes much of the data in Reference 4. The tables at the end of this chapter summarize these data.

Chemical Components

Carbohydrates. The carbohydrate portion of wood comprises cellulose and the hemicelluloses. Cellulose content ranges from 40 to 50% of the dry wood weight, and hemicelluloses range from 25 to 35%.

CELLULOSE. Cellulose is a glucan polymer consisting of linear chains of 1,4-β-bonded anhydroglucose units. (The notation 1,4-β describes the bond linkage and the configuration of the oxygen atom between adjacent glucose units.) Figure 1 shows a structural diagram of a portion of a glucan chain. The number of sugar units in one molecular chain is referred to as the degree of polymerization (DP). Even the most uniform sample has molecular chains with slightly different DP values. The average DP for the molecular chains in a given sample is designated by $\overline{\mathrm{DP}}$.

Table XV. Elemental Composition of Some Woods

Wood	Parts Per Thousand					Parts Per Million					Reference
	Ca	*K*	*Mg*	*P*	*Mn*	*Fe*	*Cu*	*Zn*	*Na*	*Cl*	
					Temperate Woods						
Abies balsamea (L.) Mill/Balsam fir[a]	0.8	0.8	0.27	—	0.13	13	17	11	—	—	93
	0.9	0.5	—	—	0.09	—	—	—	18	—	93
Acer rubrum L./Red maple[a]	0.8	0.7	0.12	0.03	0.07	11	5	29	—	—	93
	0.7	0.5	—	—	0.07	—	—	—	5	18	93
Betula papyrifera Marsh./White birch[a]	0.7	0.3	0.18	0.15	0.03	10	4	28	—	—	93
	0.9	0.2	—	—	0.03	—	—	—	9	10	93
raxinus americana L./White ash[b]	0.3	2.6	1.8	0.01	—	—	—	—	31	—	94
iquidambar styraciflua L./ Sweetgum[c]											
Bottomland	0.65	0.4	0.37	0.26	0.06	—	—	22	88	—	95
Upland	0.55	0.3	0.34	0.15	0.08	—	—	19	81	—	95
icea rubens Sarg./Red spruce[a]	0.8	0.2	0.07	0.05	0.14	14	4	8	—	—	93
	0.7	0.1	—	—	0.11	—	—	—	8	0.3	93
inus strobus L./Eastern white pine[a]	0.2	0.3	0.07	—	0.03	10	5	11	—	—	93
	0.3	0.1	—	—	0.02	—	—	—	9	19	93

Continued on next page

Table XV. Continued

ulus deltoides Bartr./Eastern ottonwood[a,d]	0.9	2.3	0.29	—	0.02	1 × 10²	—	30	9.4 × 10²	—	94
	1.2	2.5	[e]	—	<0.01	—	—	—	1.1 × 10²	30	94
ulus tremuloides Michx./Quaking spen[a]	1.1	1.2	0.27	0.10	0.03	12	7	17	—	—	93
	0.8	0.9	—	—	0.04	—	—	—	5	—	93
rcus alba L./White oak[b]	0.5	1.2	0.31	—	<0.01	—	—	—	21	15	94
rcus falcata Michx./Southern d oak[c]	0.3	0.6	0.03	0.02	0.01	30	73	38	44	—	76
americana L./Basswood[b]	0.1	2.8	0.35	—	—	—	—	—	63	38	94
ga canadensis (L.) Carr./Eastern emlock[a]	0.8	0.4	0.11	0.12	0.15	6	5	2	—	—	93
	1.1	0.3	—	—	0.12	—	—	—	6	—	93
				Tropical Woods[b]							
theca sp.	0.1	8.7	4.0	—	<0.01	—	—	—	1.5 × 10²	2.5 × 10²	93
gyne prophyrocardia Griseb.	0.2	9.8	8.6	—	0.06	—	—	—	48	97	93
phnodendron polystachum (Miq.) einh.	0.5	26.1	1.0	—	0.01	—	—	—	6.8 × 10²	1.1 × 10³	93

NOTE: Values of parts per thousand or parts per million are for oven-dry wood.

[a] Values in the first row obtained by atomic spectrometric methods. Values in second row for same tree species obtained by neutron activation iod.

[b] Values obtained by neutron activation method.

[c] Values obtained by atomic spectrometric methods.

[d] Sawdust.

[e] Ob[illegible]ed, but not measured.

ADVANCES IN CHEMISTRY SERIES **207**

The Chemistry of Solid Wood

Roger Rowell, Editor
U.S. Department of Agriculture

Based on a short course and symposium
sponsored by the Division
of Cellulose, Paper, and Textile Chemistry
at the 185th Meeting
of the American Chemical Society,
Seattle, Washington,
March 20–25, 1983

American Chemical Society, Washington, D.C. 1984

SECRETARY OF INTERIOR STANDARDS FOR THE TREATMENT OF HISTORIC PROPERTIES, STANDARDS FOR PRESERVATION

1. A property will be used as it was historically, or be given a new use that maximizes the retention of distinctive materials, features, spaces, and spatial relationships. Where a treatment and use have not been identified, a property will be protected and, if necessary, stabilized until additional work may be undertaken.

2. The historic character of a property will be retained and preserved. The replacement of intact or repairable historic materials or alteration of features, spaces, and spatial relationships that characterize a property will be avoided.

3. Each property will be recognized as a physical record of its time, place, and use. Work needed to stabilize, consolidate, and conserve existing historic materials and features will be physically and visually compatible, identifiable upon close inspection, and properly documented for future research.

4. Changes to a property that have acquired historic significance in their own right will be retained and preserved.

5. Distinctive materials, features, finishes, and construction techniques or examples of craftsmanship that characterize a property will be preserved.

6. The existing condition of historic features will be evaluated to determine the appropriate level of intervention needed. Where the severity of deterioration requires repair or limited replacement of a distinctive feature, the new material will match the old in composition, design, color, and texture.

7. Chemical or physical treatments, if appropriate, will be undertaken using the gentlest means possible. Treatments that cause damage to historic materials will not be used.

8. Archeological resources will be protected and preserved in place. If such resources must be disturbed, mitigation measures will be undertaken.

This information has been taken from the taken from Code of Federal Regulations, Title 36, *Parks, Forests, and Public Property*, Chapter I, ("National Park Service, Department of the Interior"), Parts 1 to 99, Revised as of July 1, 1998, p. 329, it states: PART 68--The Secretary of the Interior's Standards for the Treatment of Historic Properties.

SECRETARY OF INTERIOR STANDARDS FOR THE TREATMENT OF HISTORIC PROPERTIES: STANDARDS FOR REHABILITATION

1. A property will be used as it was historically or be given a new use that requires minimal change to its distinctive materials, features, spaces, and spatial relationships.

2. The historic character of a property will be retained and preserved. The removal of distinctive materials or alteration of features, spaces, and spatial relationships that characterize a property will be avoided.

3. Each property will be recognized as a physical record of its time, place, and use. Changes that create a false sense of historical development, such as adding conjectural features or elements from other historic properties, will not be undertaken.

4. Changes to a property that have acquired historic significance in their own right will be retained and preserved.

5. Distinctive materials, features, finishes, and construction techniques or examples of craftsmanship that characterize a property will be preserved.

6. Deteriorated historic features will be repaired rather than replaced. Where the severity of deterioration requires replacement of a distinctive feature, the new feature will match the old in design, color, texture, and, where possible, materials. Replacement of missing features will be substantiated by documentary and physical evidence.

7. Chemical or physical treatments, if appropriate, will be undertaken using the gentlest means possible. Treatments that cause damage to historic materials will not be used.

8. Archeological resources will be protected and preserved in place. If such resources must be disturbed, mitigation measures will be undertaken.

9. New additions, exterior alterations, or related new construction will not destroy historic materials, features, and spatial relationships that characterize the property. The new work shall be differentiated from the old and will be compatible with the historic materials, features, size, scale and proportion, and massing to protect the integrity of the property and its environment.

10. New additions and adjacent or related new construction will be undertaken in such a manner that, if removed in the future, the essential form and integrity of the historic property and its environment would be unimpaired.

This information has been taken from the taken from Code of Federal Regulations, Title 36, *Parks, Forests, and Public Property*, Chapter I, ("National Park Service, Department of the Interior"), Parts 1 to 99, Revised as of July 1, 1998, p. 329, it states: PART 68--The Secretary of the Interior's Standards for the Treatment of Historic Properties.

SECRETARY OF INTERIOR STANDARDS FOR THE TREATMENT OF HISTORIC PROPERTIES: STANDARDS FOR RESTORATION

1. A property will be used as it was historically or be given a new use which reflects the property's restoration period.

2. Materials and features from the restoration period will be retained and preserved. The removal of materials or alteration of features, spaces, and spatial relationships that characterize the period will not be undertaken.

3. Each property will be recognized as a physical record of its time, place, and use. Work needed to stabilize, consolidate and conserve materials and features from the restoration period will be physically and visually compatible, identifiable upon close inspection, and properly documented for future research.

4. Materials, features, spaces, and finishes that characterize other historical periods will be documented prior to their alteration or removal.

5. Distinctive materials, features, finishes, and construction techniques or examples of craftsmanship that characterize the restoration period will be preserved.

6. Deteriorated features from the restoration period will be repaired rather than replaced. Where the severity of deterioration requires replacement of a distinctive feature, the new feature will match the old in design, color, texture, and, where possible, materials.

7. Replacement of missing features from the restoration period will be substantiated by documentary and physical evidence. A false sense of history will not be created by adding conjectural features, features from other properties, or by combining features that never existed together historically.

8. Chemical or physical treatments, if appropriate, will be undertaken using the gentlest means possible. Treatments that cause damage to historic materials will not be used.

9. Archeological resources affected by a project will be protected and preserved in place. If such resources must be disturbed, mitigation measures will be undertaken.

10. Designs that were never executed historically will not be constructed.

This information has been taken from the taken from Code of Federal Regulations, Title 36, *Parks, Forests, and Public Property*, Chapter I, ("National Park Service, Department of the Interior"), Parts 1 to 99, Revised as of July 1, 1998, p. 329, it states: PART 68--The Secretary of the Interior's Standards for the Treatment of Historic Properties.

SECRETARY OF INTERIOR STANDARDS FOR THE TREATMENT OF HISTORIC PROPERTIES: STANDARDS FOR RECONSTRUCTION

1. Reconstruction will be used to depict vanished or non-surviving portions of a property when documentary and physical evidence is available to permit accurate reconstruction with minimal conjecture, and such reconstruction is essential to the public understanding of the property.

2. Reconstruction of a landscape, building, structure, or object in its historic location will be preceded by a thorough archeological investigation to identify and evaluate those features and artifacts, which are essential to an accurate reconstruction. If such resources must be disturbed, mitigation measures will be undertaken.

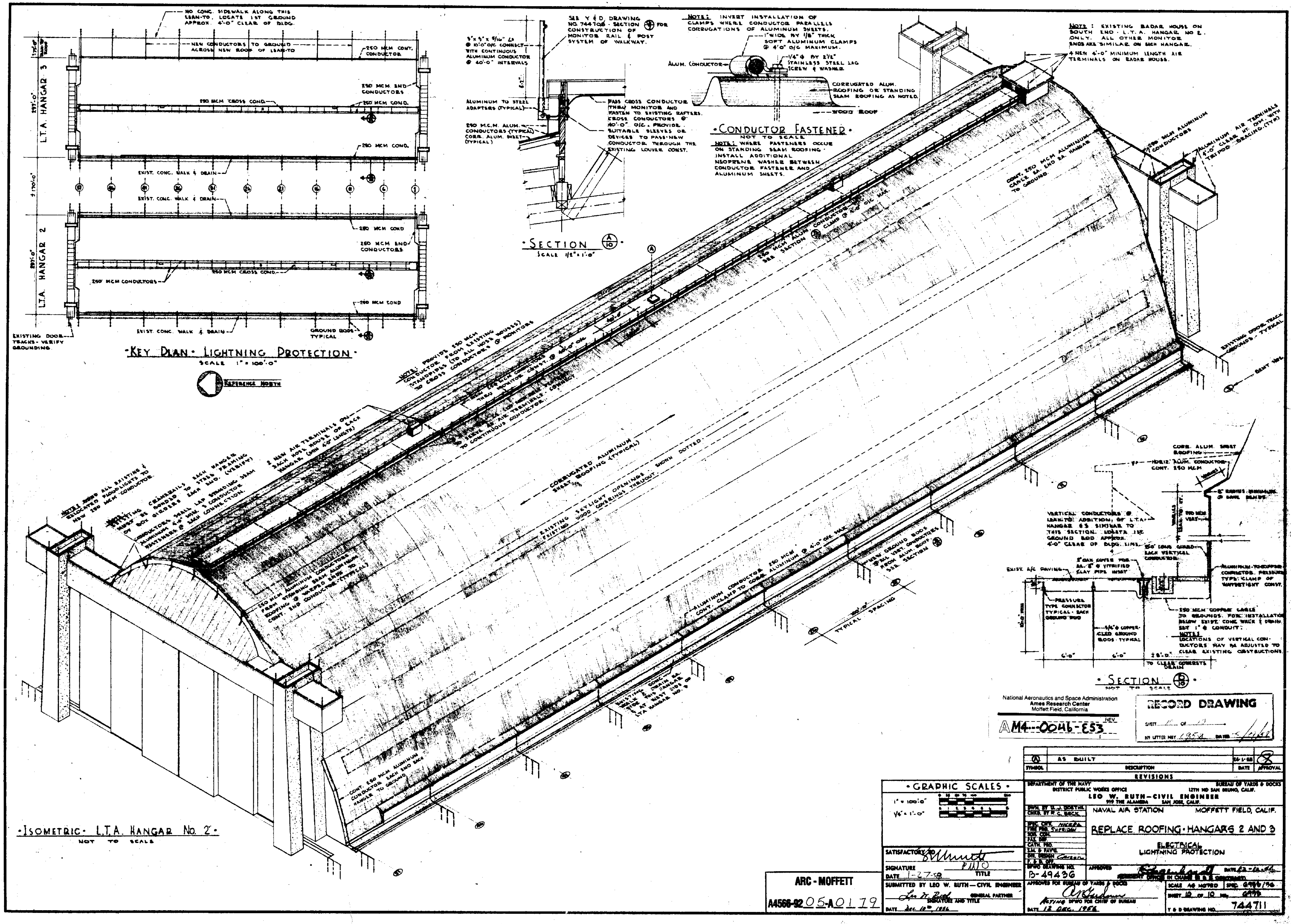
3. Reconstruction will include measures to preserve any remaining historic materials, features, and spatial relationships.

4. Reconstruction will be based on the accurate duplication of historic features and elements substantiated by documentary or physical evidence rather than on conjectural designs or the availability of different features from other historic properties. A reconstructed property will re-create the appearance of the non-surviving historic property in materials, design, color, and texture.

5. A reconstruction will be clearly identified as a contemporary re-creation.

6. Designs that were never executed historically will not be constructed.

This information has been taken from the taken from Code of Federal Regulations, Title 36, *Parks, Forests, and Public Property*, Chapter I, ("National Park Service, Department of the Interior"), Parts 1 to 99, Revised as of July 1, 1998, p. 329, it states: PART 68--The Secretary of the Interior's Standards for the Treatment of Historic Properties.



KEY PLAN - LIGHTNING PROTECTION
SCALE 1" = 100'-0"

SECTION A/10
SCALE 1/2" = 1'-0"

CONDUCTOR FASTENER
NOT TO SCALE

ISOMETRIC - L.T.A. HANGAR No. 2
NOT TO SCALE

SECTION B/10
NOT TO SCALE

National Aeronautics and Space Administration
Ames Research Center
Moffett Field, California

AM4--0046-E53
REV

RECORD DRAWING
SHEET 10 OF 10
BY LETTER MAY 1958 DATED 5/26/58

SYMBOL	DESCRIPTION	DATE	APPROVAL
A	AS BUILT	24-1-58	8

REVISIONS

DEPARTMENT OF THE NAVY
DISTRICT PUBLIC WORKS OFFICE
BUREAU OF YARDS & DOCKS
12TH ND SAN BRUNO, CALIF.
LEO W. RUTH - CIVIL ENGINEER
919 THE ALAMEDA SAN JOSE, CALIF.

DWN. BY W. J. GOETHE
CHKD. BY R. C. BECK
SPEC. CHK. NICERA
FIRE PRO. SHERIDAN
SOIL CON.
FAC. DEF.
CATH. PRO.
S.M. & PAVG.
DIR. DESIGN Carson
P. & D. OFF.
DPWO DRAWING NO. B-49436

NAVAL AIR STATION MOFFETT FIELD, CALIF.

REPLACE ROOFING - HANGARS 2 AND 3

ELECTRICAL
LIGHTNING PROTECTION

APPROVED
RESIDENT OFFICER IN CHARGE (B & D CONTRACT)
DATE 12-10-56

APPROVED FOR BUREAU OF YARDS & DOCKS
ACTING DPWO FOR CHIEF OF BUREAU
DATE 12 DEC. 1956

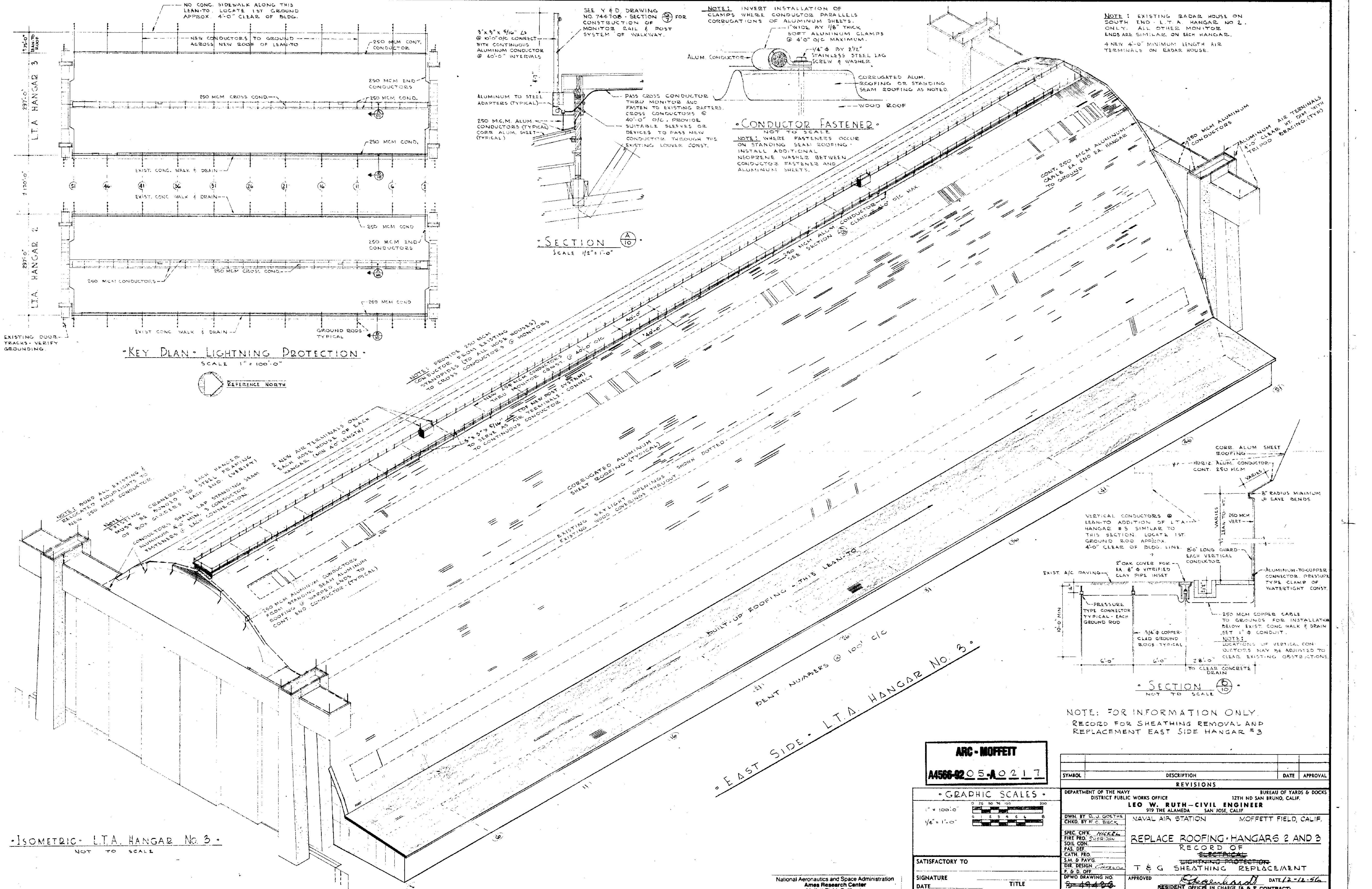
SCALE AS NOTED
SPEC. 6996/56
SHEET 10 OF 10 NO. 6999
Y & D DRAWING NO. 744711

GRAPHIC SCALES
1" = 100'-0"
1/4" = 1'-0"

SATISFACTORY TO
SIGNATURE PWO
TITLE
DATE 1-27-58

SUBMITTED BY LEO W. RUTH - CIVIL ENGINEER
Leo W. Ruth GENERAL PARTNER
SIGNATURE AND TITLE
DATE Dec. 10th, 1956

ARC - MOFFETT
A4566-92 05-A0179



·KEY PLAN· LIGHTNING PROTECTION·

SCALE 1" = 100'-0"

·SECTION A/10·

SCALE 1/2" = 1'-0"

·CONDUCTOR FASTENER·

NOT TO SCALE

·ISOMETRIC· L.T.A. HANGAR NO. 3·

NOT TO SCALE

·EAST SIDE· L.T.A. HANGAR NO. 3·

·SECTION B/10·

NOT TO SCALE

NOTE: FOR INFORMATION ONLY.
RECORD FOR SHEATHING REMOVAL AND
REPLACEMENT EAST SIDE HANGAR #3

·GRAPHIC SCALES·
1" = 100'-0" 0 25 50 75 100 200
1/4" = 1'-0" 0 1 2 3 4 5 6 8

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

DEPARTMENT OF THE NAVY
DISTRICT PUBLIC WORKS OFFICE
BUREAU OF YARDS & DOCKS
12TH ND SAN BRUNO, CALIF.
LEO W. RUTH—CIVIL ENGINEER
919 THE ALAMEDA SAN JOSE, CALIF.

DWN. BY R. J. GOETHE
CHKD. BY R. C. BECK
SPEC. CH'K. NICKEL
FIRE PRO. SHERIDAN
SOIL CON.
PAS. DEF.
CATH. PRO.
S.M. & PAV'G.
DIR. DESIGN Greener
P. & D. OFF.

NAVAL AIR STATION MOFFETT FIELD, CALIF.

REPLACE ROOFING · HANGARS 2 AND 3
RECORD OF
~~ELECTRICAL~~
~~LIGHTNING PROTECTION~~
T & G SHEATHING REPLACEMENT

DPWO DRAWING NO. ~~B-49486~~
APPROVED Eggenhardt RESIDENT OFFICER IN CHARGE (A & E CONTRACT) DATE 12-12-56

SATISFACTORY TO
SIGNATURE
DATE
TITLE

SUBMITTED BY LEO W. RUTH — CIVIL ENGINEER
Leo W. Ruth GENERAL PARTNER
SIGNATURE AND TITLE
DATE Dec. 10th, 1956

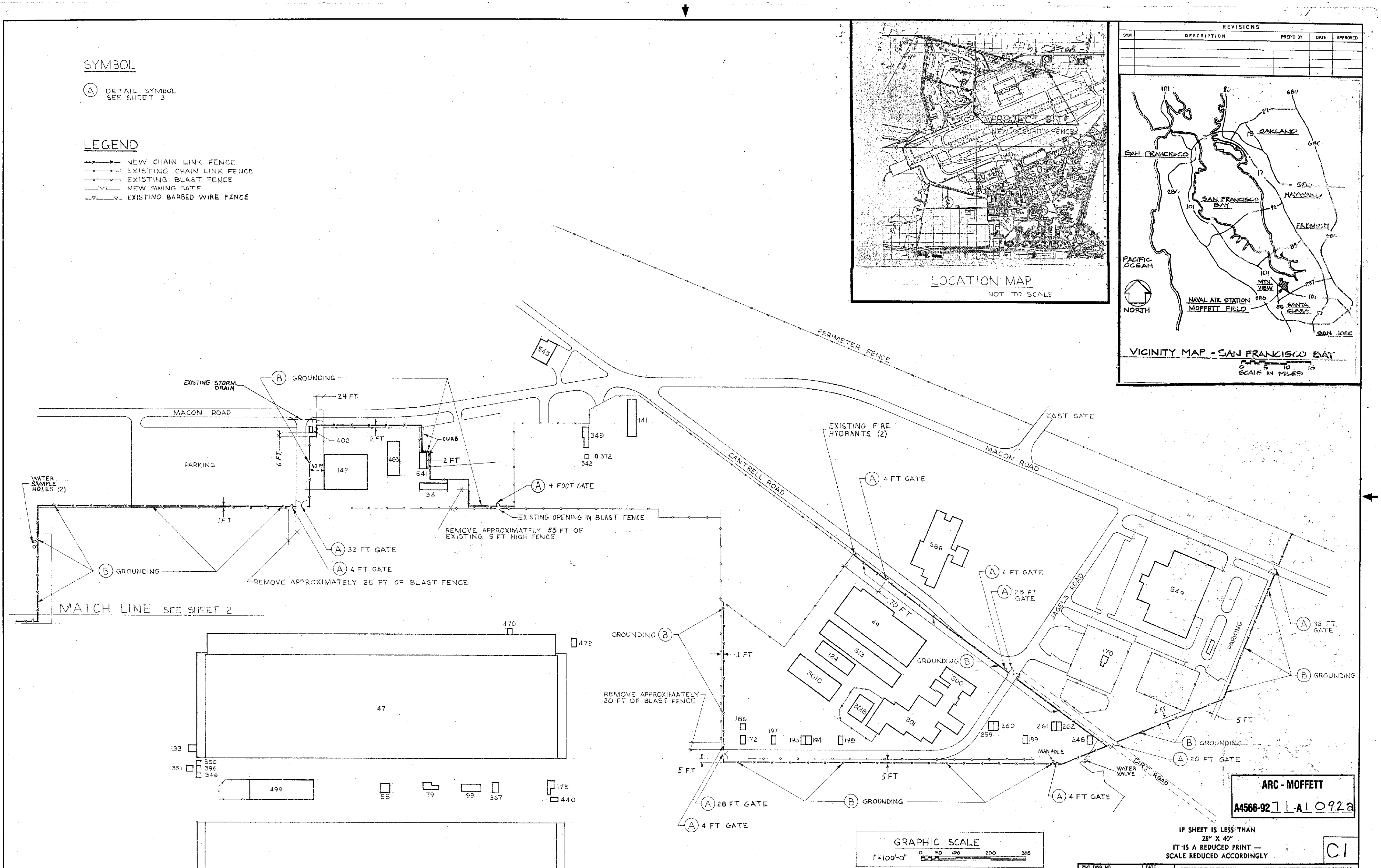
APPROVED FOR BUREAU OF YARDS & DOCKS
Acting DPWO FOR CHIEF OF BUREAU
DATE 12 DEC. 1956

SCALE AS NOTED
SPEC. 6953/56
SHEET ~~10~~ 3 OF ~~10~~ 4 NBy 6953
Y & D DRAWING NO. ~~744711~~

B-49441

6 FEB. 1957 - OMIT PL. SKYLIGHTS.

10721



SITE PLAN - CHAIN LINK SECURITY FENCE

REVISIONS				
SYM	DESCRIPTION	PREP'D BY	DATE	APPROVED

ARC - MOFFETT

A4566-92 7 1 -A 1 0 9 2 a

IF SHEET IS LESS THAN
28" X 40"
IT IS A REDUCED PRINT —
SCALE REDUCED ACCORDINGLY

C1

National Aeronautics and Space Administration
Ames Research Center
Moffett Field, California

AM4---0046-C27

REV

PWO. DWG. NO.		DATE
DSGN. JRA	DR. LWC	DATE 4-23-87
CHECKED JCA	DAY	DATE 7-9-87
APPROVED BY DIRECTOR ENGINEERING DIV.		9 JUL 87
APPROVED BY 10 JUL 87 PUBLIC WORKS OFFICER CDR, CEC, USN		
SATISFACTORY TO		
SATISFACTORY TO		

DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND
NAVAL AIR STATION — MOFFETT FIELD, CA.

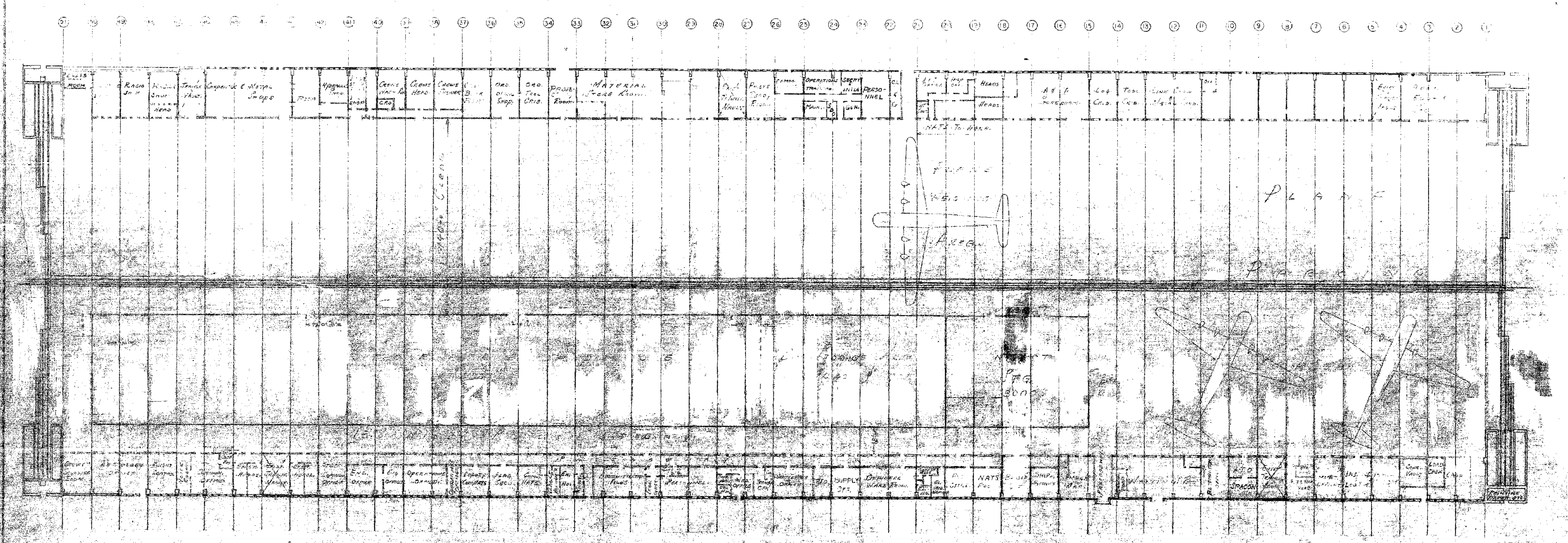
SPECIAL PROJECT C7-85
NEW CHAIN LINK SECURITY FENCE
AIRFIELD EAST SIDE END - HANGER 2 & 3

SITE PLAN

SIZE	CODE IDENT. NO.	NAVFAC. DRAWING NO.
F	80091	6201027
		CONST. CONTR. NO. N62474-87-B-D089
SCALE 1"=100'	SPEC. 12-87-D089	SHEET 1 OF 3

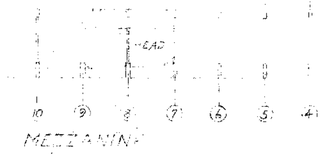
BRUNING 40-107

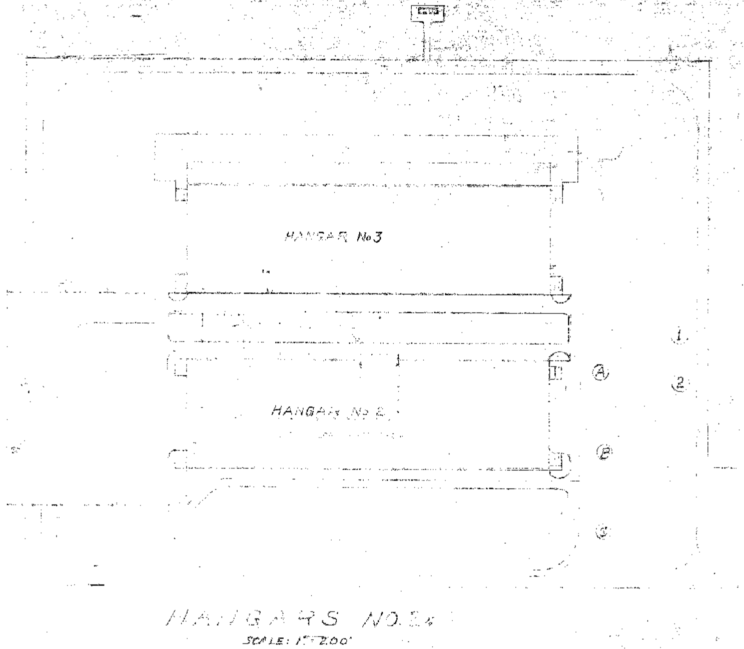
☆GPO 790-897-197



FLOOR PLAN

SCALE - 1/16" = 1'-0"





HANGARS NO.2 & 3

SCALE: 1" = 200'

Superseded By
316-36-6

G	5-15-49	[illegible] Spare		
F	12-3-46	Relocation Gates in Stg. Area	G.M.	
E	10-15-46	[illegible] WEST LEAN TO		
D	10-7-46	[illegible]	G.M.B.	
C	9-17-46	[illegible]		
B		[illegible]		
A	8-4-46	[illegible]		
Revision	Date			

Drawn by T.E.B.
Traced by
Checked by
Chief Dftsm.
Design Supt. W.H.L.

Sheet 1 of 1

U.S. NAVAL AIR STATION
MOFFETT FIELD, CALIF.

HANGAR No. 2

GENERAL PLAN OF OFFICES,
SHOPS, STG. & N.A.T.S.
TERMINAL FACILITIES

Approved June 21, 1946.

Public Works Officer

Approved by:

W.R. No.

Scale: 1/32" = 1'-0"

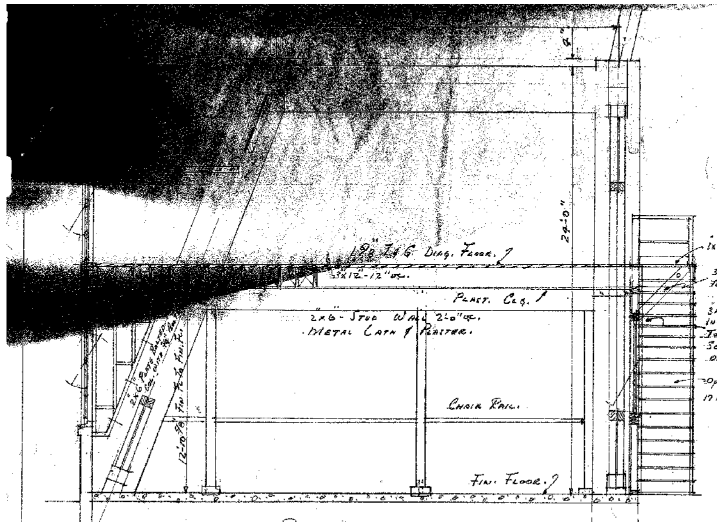
P.W. Drawing No.
316-36-30

National Aeronautics and Space Administration
Ames Research Center
Moffett Field, California

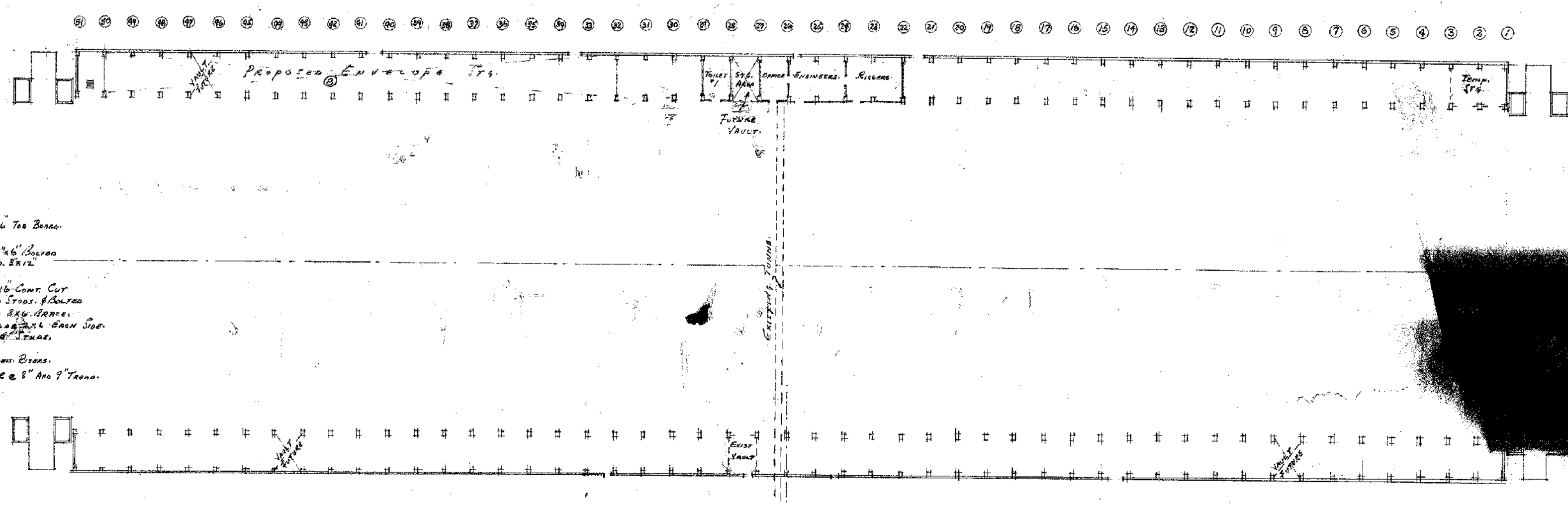
AM4---0046-A66 REV

ARC - MOFFETT

A4566-9205-A0122



SECTION
Scale 1/4"=1'-0"

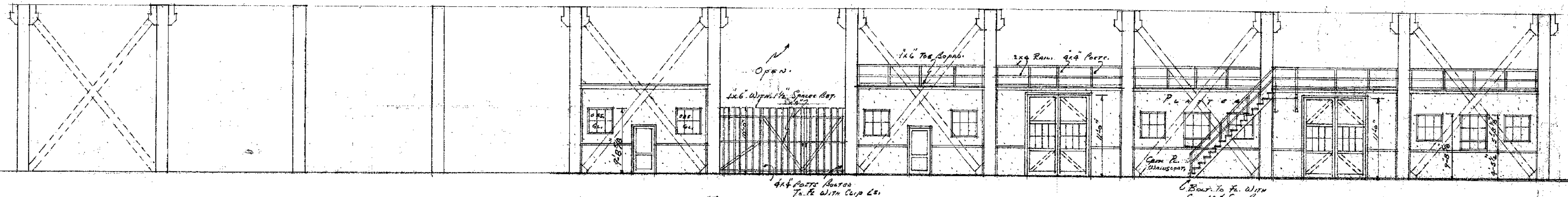


KEY PLAN
Scale 1"=50'-0"

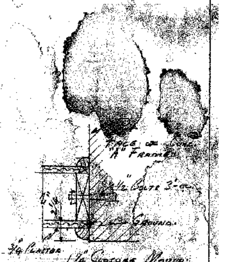
N

Door Schedule

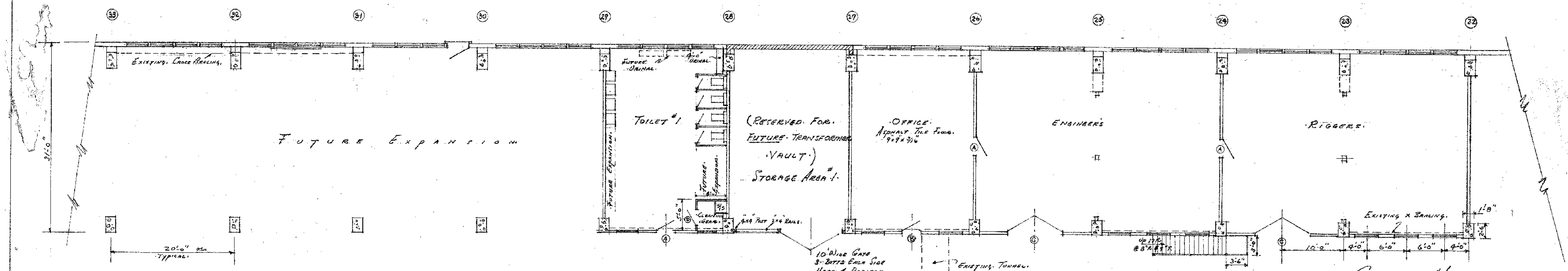
- (A) 3'-0"x7'-0"x1 3/4" 2 Panel Top Gl. Obs. Gl.
- (B) 3'-0"x7'-0"x1 3/4" 2 Panel " " Cl. "
- (C) 9'-0"x11'-0"x2 5/8" Solid Panel B Lts.
- (D) 2'-6"x9'-0"x1 3/8" 2 Panel (Wood).



ELEVATION
Scale 1/8"=1'-0"



Relation of Wall At Conc. "A" Frames.
Scale 1 1/2"=1'-0"

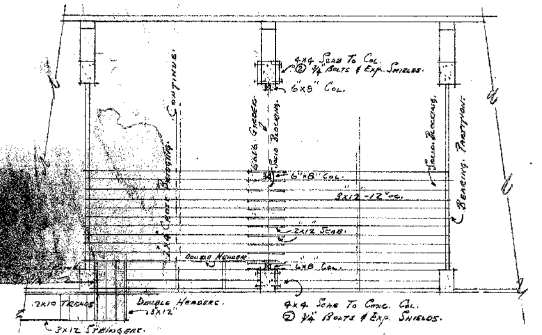


PLAN
Scale 1/8"=1'-0"

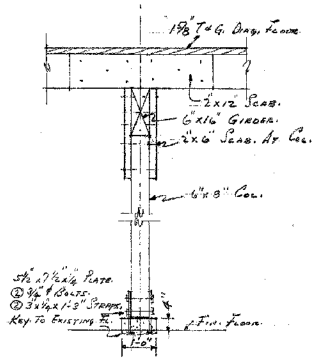
General Notes.

Doors, Windows, Joists, Bolts, & Metal Lath Available From Surplus Materials At Hangar Site. Asphalt Tile Floor In Office Space Only Similar To Kentile No. 130 & 105 Group "C". Other Floors To Remain As Is. Painting Similar To Hangar #2.

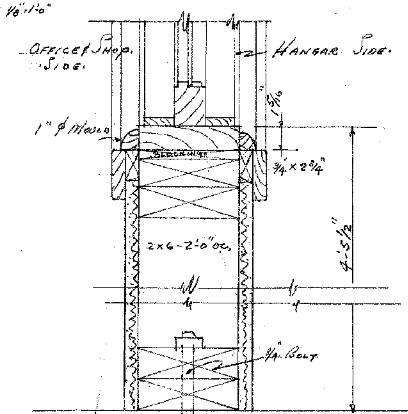
ARC - MOFFETT
A4566-9297-A 1406



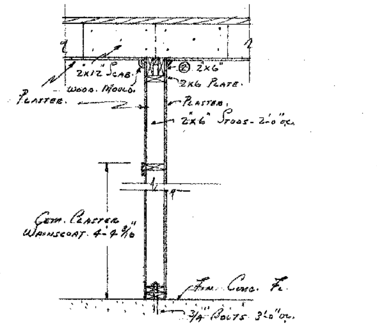
Typical Framing
Scale 1/8"=1'-0"



Framing At Columns.
Scale 1/2"=1'-0"



3" Scale Detail of Typical Sect. Thru. Interior. Window.



Framing At Bearing Partition.
Scale 1/2"=1'-0"

Scale: As Indicated.

(B)	7-6-44	Location of Trans. Vaults & Outside Doors.	R.
(A)	1-4-44	Proposed Envelope Stg.	B.
Revision	Date	Brief	By

Designed by
Drawn by T.E.B.
Checked by
Chief Drftmn. E.L.W.
Design Mgr.
Y. & D. Drawing No.
P.W. Drawing No.
321-10-1

U. S. NAVAL AIR STATION
MOFFETT FIELD CALIFORNIA

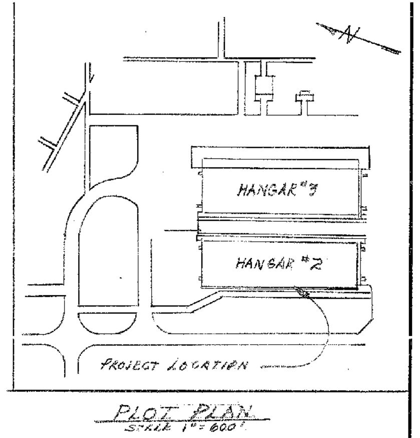
HANGAR NO 3
PLAN OF OFFICES AND SHOPS (ARCHITECTURAL) FOR OPERATIONS DEPT.

Approved Nov. 11, 1943.

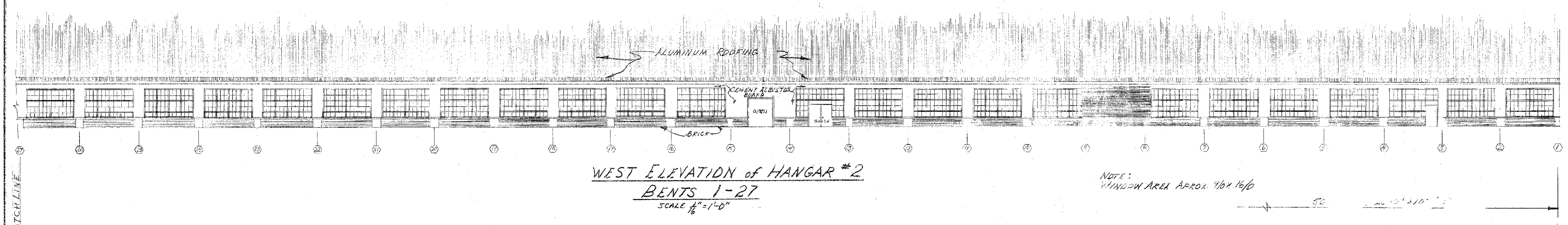
R L Mann
Public Works Officer.

National Aeronautics and Space Administration
Ames Research Center
Moffett Field, California

A M4---0047-A45
REV

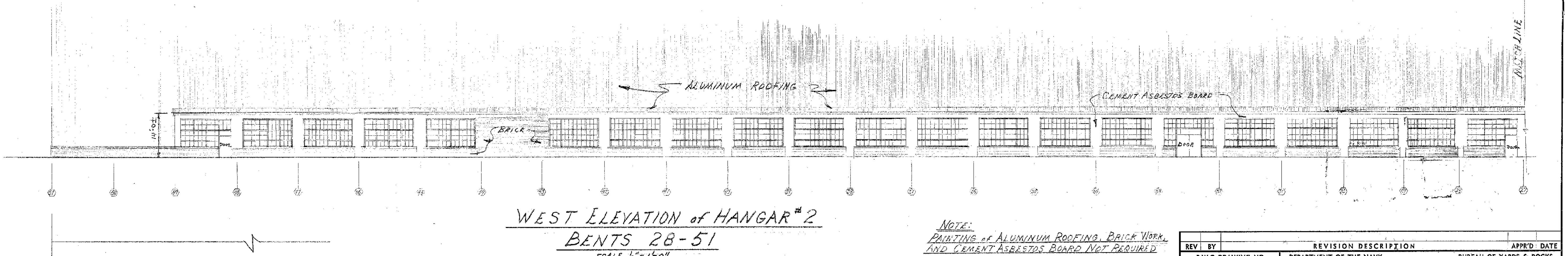


PLOT PLAN
SCALE 1" = 600'



WEST ELEVATION of HANGAR #2
BENTS 1-27
SCALE 1/16" = 1'-0"

NOTE:
WINDOW AREA APROX. 9/0 x 16/0

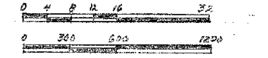


WEST ELEVATION of HANGAR #2
BENTS 28-51
SCALE 1/16" = 1'-0"

NOTE:
PAINTING of ALUMINUM ROOFING, BRICK WORK, AND CEMENT ASBESTOS BOARD NOT REQUIRED

1/16" = 1'-0"
1" = 600'

GRAPHIC SCALES



AMH---0046-C31 REV

ARC - MOFFETT
ARC-88-9296-A1386

REV	BY	REVISION DESCRIPTION	APPR'D	DATE

P W O DRAWING NO 316-81
SHEET 1 OF 1
W R NO
DES BY
DRWN FIELD 5/25/62.
PLAN'G BR
ARCH BR T M OLSON 5/25/62
ELECT BR
CIVIL BR
MECH BR
DIR DES 5/28
A P W O

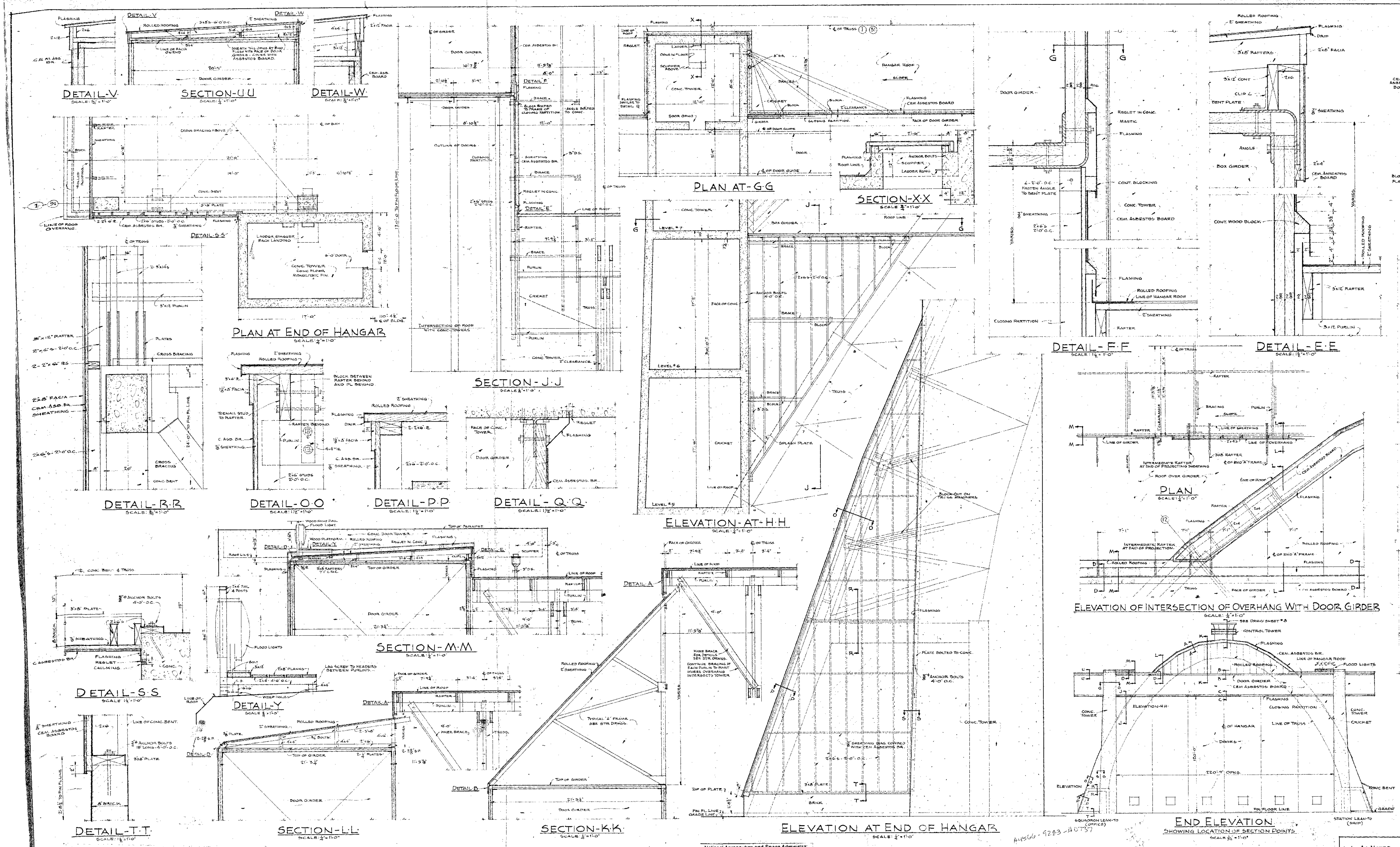
DEPARTMENT OF THE NAVY
BUREAU OF YARDS & DOCKS
NAVAL AIR STATION
MOFFETT FIELD, CALIF.

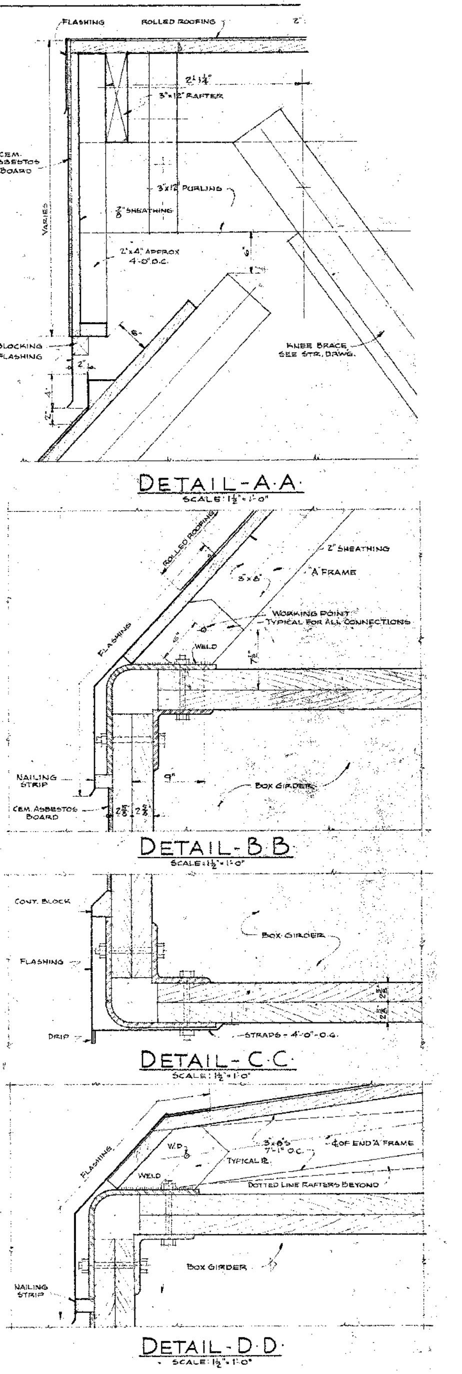
HANGAR 2
PAINT WEST LEAN-TO
ELEVATION & LOCATION PLAN

APPROVED
PUBLIC WORKS OFFICER
DATE 5/28/62

SATISFACTORY TO
DATE

SCALE AS NOTED
SPEC 36071/62
SHEET 1 OF 1 NBy 36071
Y & D DRAWING NO. 894915





Revision	Date	Brief	By

APPROVED BY BUREAU OF AERONAUTICS

Date: ....

Prepared by GILDER
Traced by GILDER
Checked by G. BASSETT
Supervisor G. BASSETT
Group Chief
Chief Dftmn.
Des. Engr.
Proj Mgrs.
Design Mgr.

SHEET No.

Scale: As Noted

NAVY DEPARTMENT BUREAU OF YARDS & DOCKS

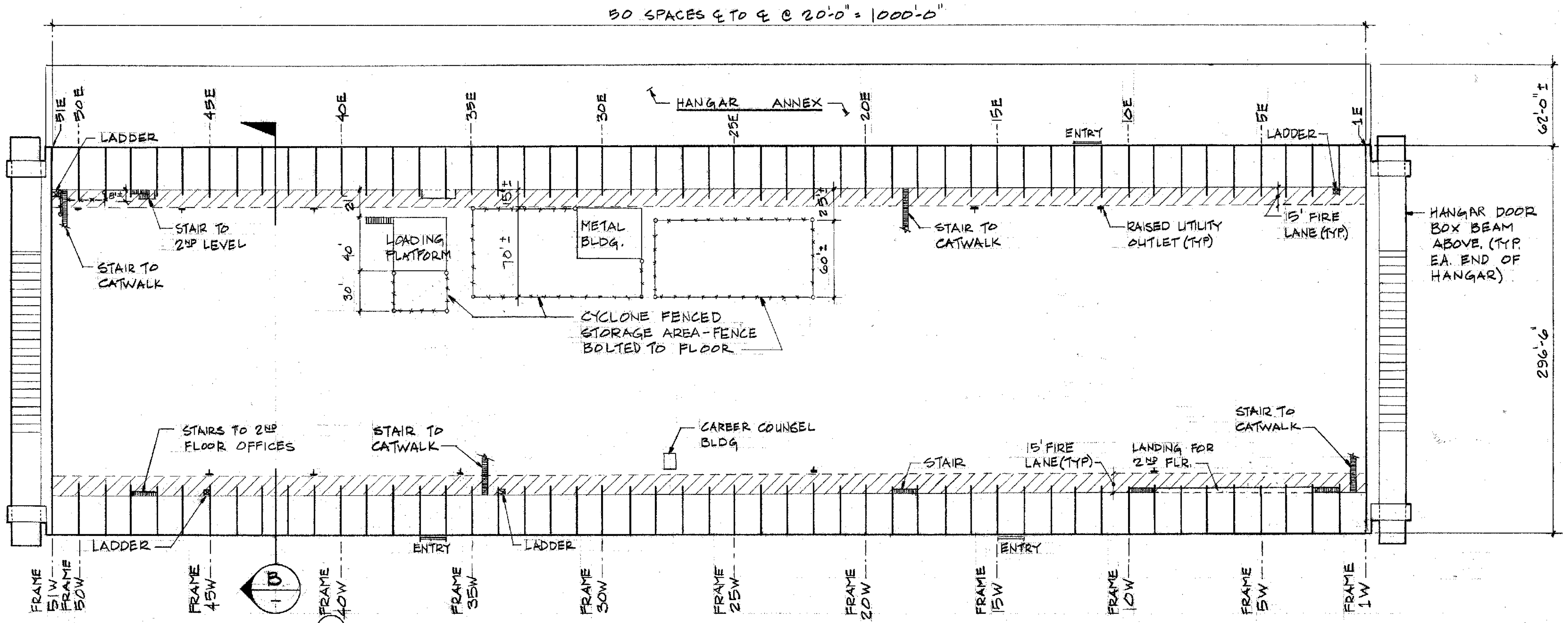
STANDARD
LIGHTER THAN AIR HANGAR
DETAILS AT DOOR
GIRDER & TOWERS
220'-9 COMPOSITE DOOR
OR 5'-0" THICK STEEL DOOR

Approved Nov. 17, 1942 Y. & D. Drawing No.
236673
For Chief of Bureau

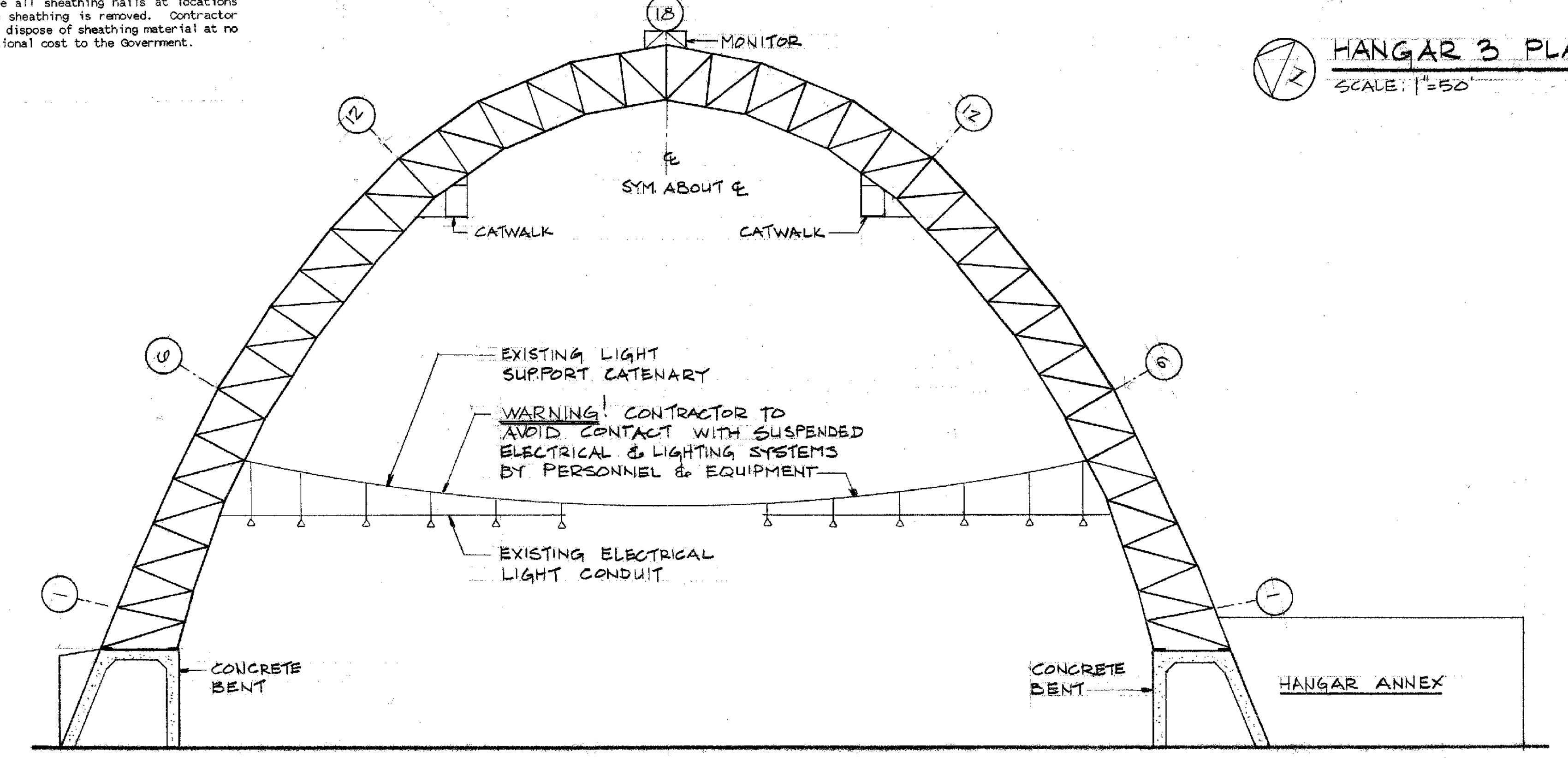
HOUMA, LOUISIANA. SHEET OF ACCOMPANYING CONTRACT Noy 5745	BRUNSWICK GA. SHEET OF ACCOMPANYING CONTRACT Noy 5743	PORT ARTHUR, TEXAS SHEET OF ACCOMPANYING CONTRACT	MOFFETT FIELD, CALIF. SHEET OF ACCOMPANYING CONTRACT	S.WEYMOUTH, MASS. SHEET OF ACCOMPANYING CONTRACT	ELIZABETH CITY, N.C. SHEET OF ACCOMPANYING CONTRACT	LAKEHURST, N.J. SHEET OF	RICHMOND, FLA. SHEET OF	SANTA ANA, CALIF.	TILLAMOOK, ORE.

NOTES:

1. The contractor shall verify all dimensions and check actual site conditions.
2. The contractor shall protect the existing structure, including roofing and all structural members from damage or distress due to construction repair work.
3. The Hangar 3 floor plan shows existing conditions at hangar floor as of April 1993. The drawing is furnished to assist the contractor in planning the repair work, but does not forego the need for a site visit. Location of obstruction items on the floor is approximate. Some fenced areas and mini-buildings are semi-portable and may be moved from time to time to meet Government mission requirements.
4. At the contractors option, the cyclone fencing enclosing storage areas may be removed during the repair work and reinstalled to original condition as soon as possible following completion and approval of repairs to that area.
5. 120 volt electric power outlets are located at various locations near floor level. Electric power is available for use without cost to the contractor when not in conflict with Government mission activity.
6. The known location of asbestos materials is indicated on drawing sheet S2 above the roof over office areas.
7. All struts, wood or steel x-bracing, monitor framing, catwalk framing, blocking etc. whether specifically indicated on repair drawing or not, shall be removed and relocated in comparable condition when it interferes with any of the repair members. Use same diameter and quantity of bolts and in similar fashion to original connection.
8. At many locations the double webs and chords are covered with timber board sheathing nailed in place. Remove the sheathing in the vicinity of clamp or stitch bolt for type "C" repairs and for the full extent of the glulam repair member for type "A" and "B" repairs. Remove all sheathing nails at locations where sheathing is removed. Contractor shall dispose of sheathing material at no additional cost to the Government.



HANGAR 3 PLAN (A)
SCALE: 1"=50'



TYPICAL SECTION (B)
SCALE: 1"=20'

National Aeronautics and Space Administration
Ames Research Center
Moffett Field, California

A M4---0047-A 00 REV

ARC - MOFFETT
A4566-9284-A0752

EXP 9/30/93
DONALD W. NEAL
No. 1820

Donald W. Neal

ZONE	LETTER	DESCRIPTION	DRAWN	DATE	APPROVAL
		REVISIONS			

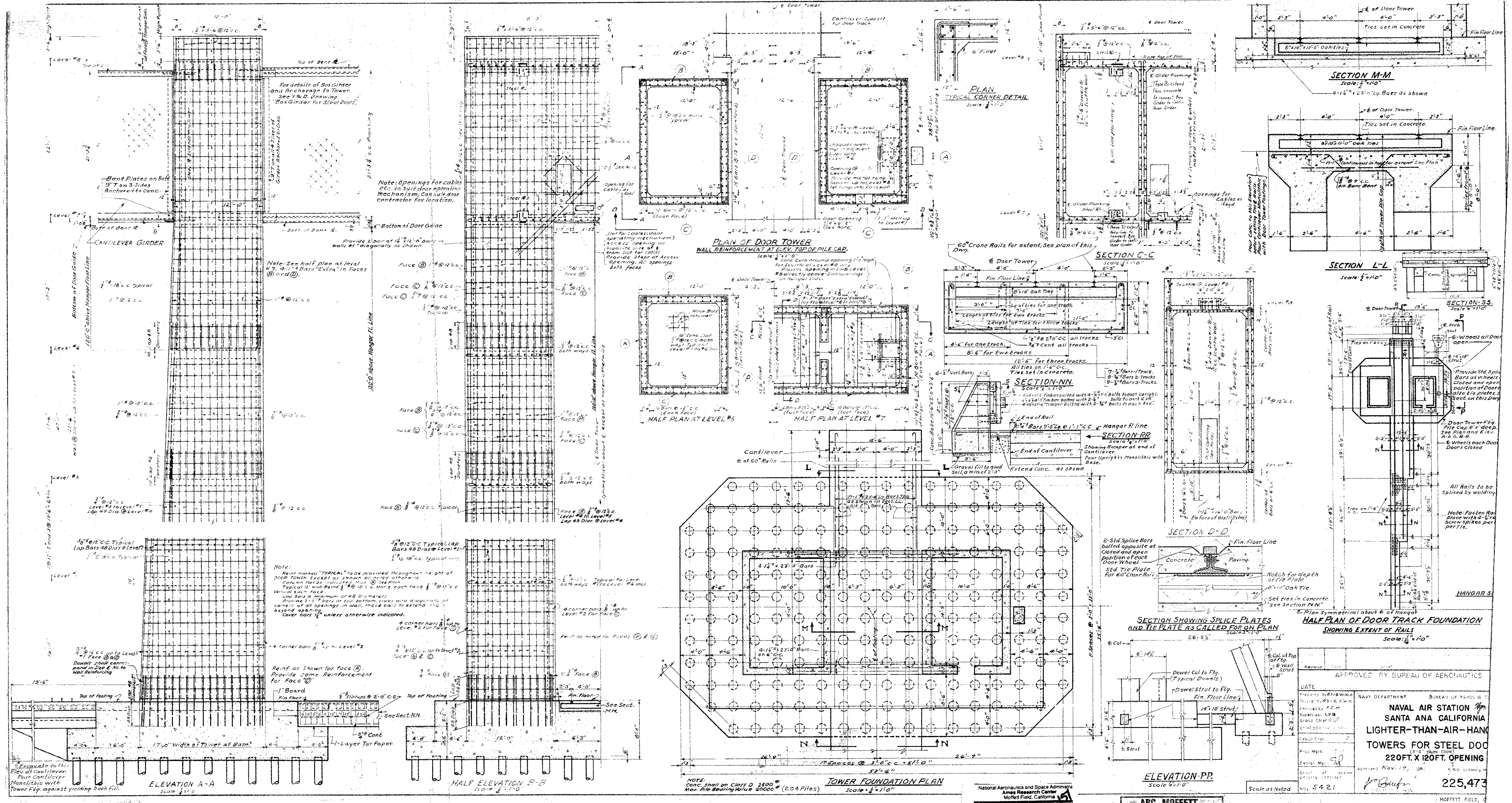
DRAWN W.E.B DATE 5/20/93
DESIGNED DWN DATE 5/20/93
CHECKED Donald W. Neal DATE 5/20/93
PROJ MGR M. Italia DATE 6/23/93
REQUESTER DATE
R&QA DATE
SAFETY DATE
SUPVISOR DATE 6/25/93
DATE

NASA Ames Research Center
Moffett Field, California 94035

REPAIR OF HANGAR No. 3
PLAN AND SECTION

SIZE D
CAGE CODE 25307
A 2A47-9301-S1 REV
SCALE AS SHOWN
INDEX DATE 03-27-95
SHEET OF
FILE NAME:

2A47-9301 · S1
PLAN-SECTION
EASI FILE CORP. IRVINE, CA
EFH 24



Note:

Reinf. marked "TYPICAL" to be provided throughout height of DOOR TOWER Except as shown or noted otherwise.

Column faces indicated thus Ⓐ See Plan

Typical 12" Wall Reinf. ½"ϕ @ 18" c.c. Horiz. each face ⅝"ϕ @ 12" c.c. Vertical each face.

Lap Bars a minimum of 48 Diameters

Provide 2-¾"ϕ bars at top, bottom, sides and diagonally at corners of all openings in wall, these bars to extend 1'-6" beyond opening.

Cover bars 1½" unless otherwise indicated.

NOTE:
Conc. shall be Class D 2500#
Max. Pile Bearing Value 60000# (204 Piles)

Revision	Date	

APPROVED BY BUREAU OF AERONAUTICS

DATE

Prepared by R.Y.I. & W.W.A.
Traced by R.Y.I. & F.W.K.
Checked by F.E.M.
Supervisor L.F.B.
Group Chief
Chief Designer
Design Engr.
Proj. Mgrs.
Design Mgr.
Sheet of accompanying contract
No. 5421

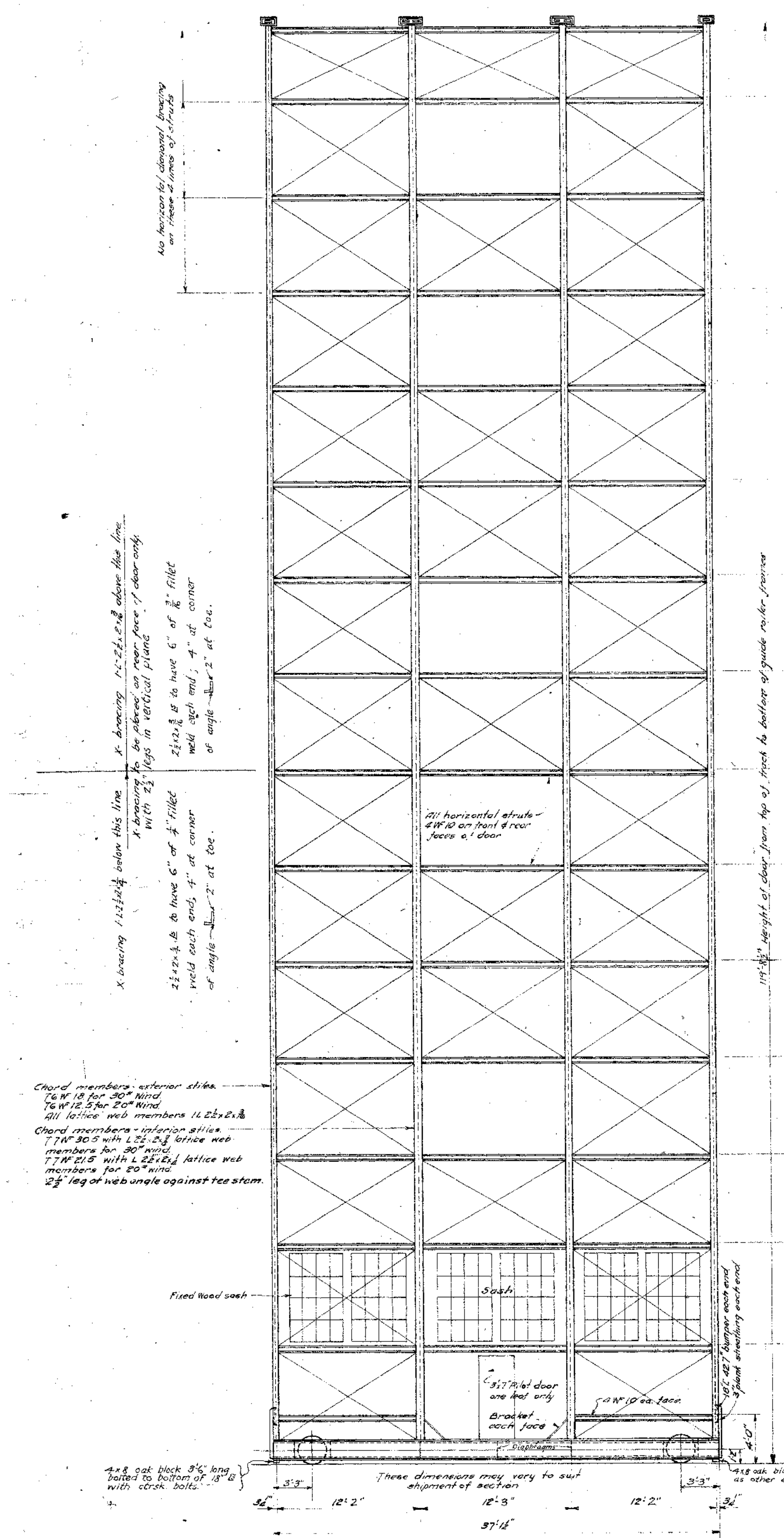
NAVY DEPARTMENT BUREAU OF YARDS & D

NAVAL AIR STATION
SANTA ANA CALIFORNIA
LIGHTER-THAN-AIR-HANG
TOWERS FOR STEEL DOO
(3'-6" THICK DOOR)
220FT. X 120FT. OPENING

Approved Nov. 17, 194
Y. & D. Drawing N
225,473

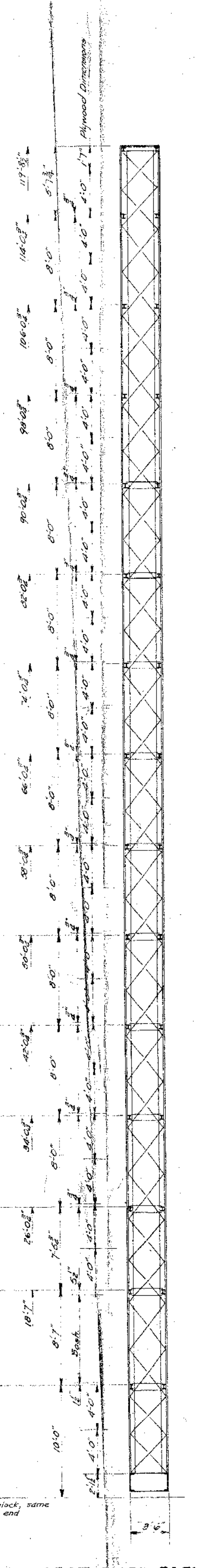
MOFFETT FIELD, C
Sheet of
accompanying contr
No. 5604

Scale as Noted



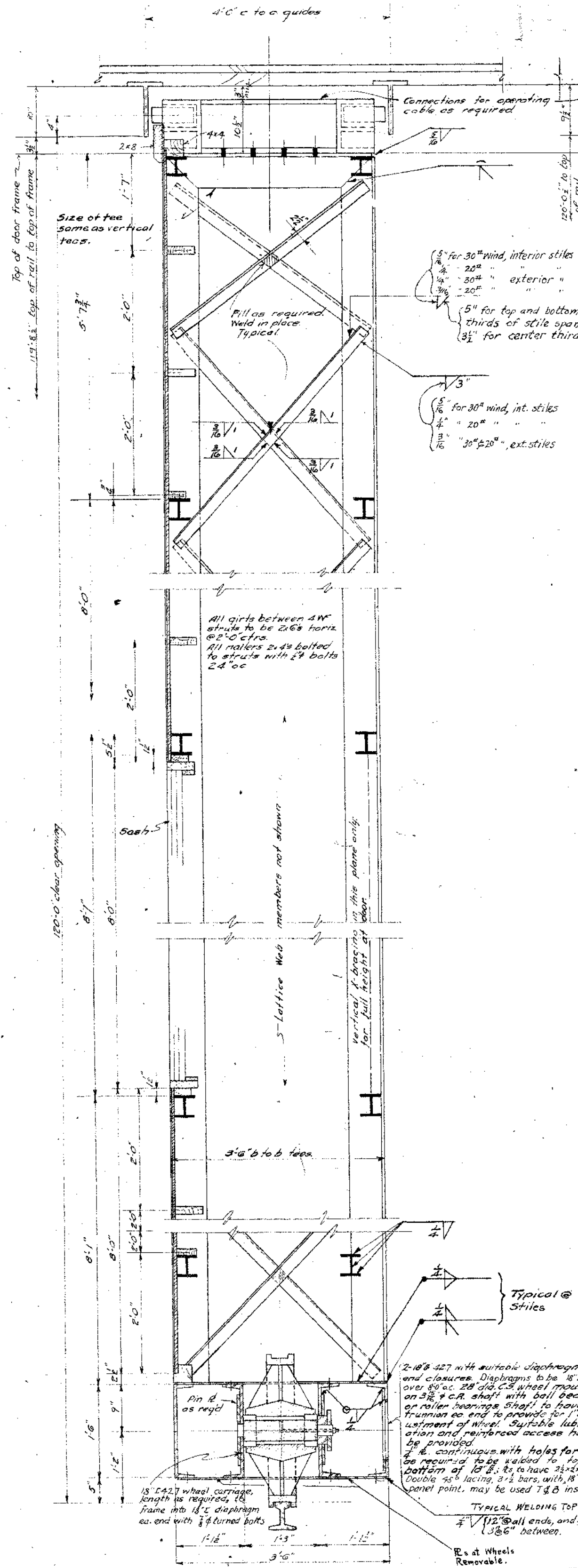
FRONT ELEVATION

Scale ⅛"=1'-0"



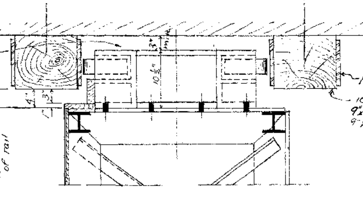
SECTIONAL ELEVATION

Scale ⅛"=1'-0"



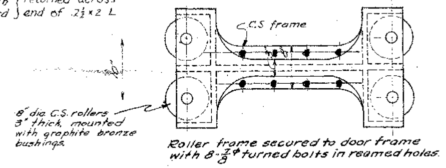
SECTIONAL ELEVATION AT WHEEL

Scale 1"=1'-0"



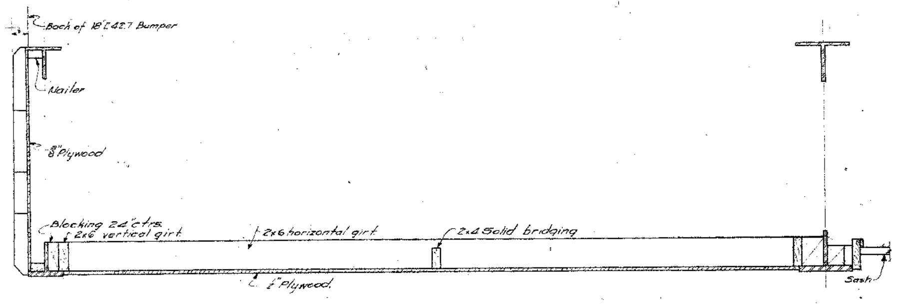
ALTERNATE DOOR GUIDE DETAIL

Scale 1"=1'-0"



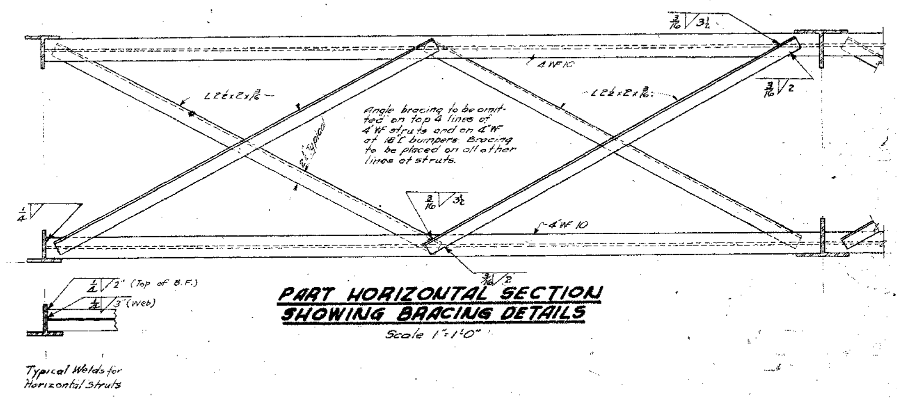
PLAN OF TOP INTERIOR GUIDE ROLLERS
EXTERIOR ROLLERS SIMILAR

Scale 1"=1'-0"



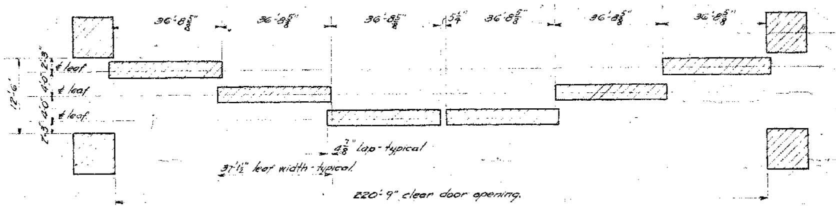
PART HORIZONTAL SECTION
SHOWING FINISH DETAILS

Scale 1"=1'-0"



PART HORIZONTAL SECTION
SHOWING BRACING DETAILS

Scale 1"=1'-0"



PLAN OF DOOR LEAF ARRANGEMENT

Not to Scale

Notes:

Door leaf designed for 20#/□' and 30#/□' wind pressure as noted. All steel framework welded. All major connections to develop the strength of the members. All secondary welded connections and details to develop required strength for wind and for all operating stresses.
Design stress = 20,000# base.

Weathering between and at bottoms of doors to consist of any flexible material capable of insuring reasonable weathertightness during the expected life of the hangar.

Door to have suitable overhead operating mechanism, door stops each end of run, and all accessories required to provide a first-class smoothly operating job.

Contractor may submit for approval alternate schemes for any construction detail shown on this drawing.

Computation books No. 2875 & 3106
Calculated bending stress = 24000#/□"
Calculated deflection = 8½"t

Estimated weight of one door leaf

	20# wind	30# wind
Structural steel	53000#	62000#
Wood covering	20000#	20000#
Total	73000#	82000#

(3)

REVISION	DATE	BRIEF	BY

APPROVED BY BUREAU OF AERONAUTICS

DATE 1942

PREPARED BY C.C. L.B.
TRACED BY J.F.R.
CHECKED BY A.B.
SUPERVISOR A.S.
GROUP CHIEF
CHIEF DFMN.
DES. ENGR.
PROJ. MGRS.
DESIGN MGR.
SHEET ... OF ... ACCOMPANYING SPECIFICATION
NO. ......

NAVY DEPARTMENT — BUREAU OF YARDS & DOCKS

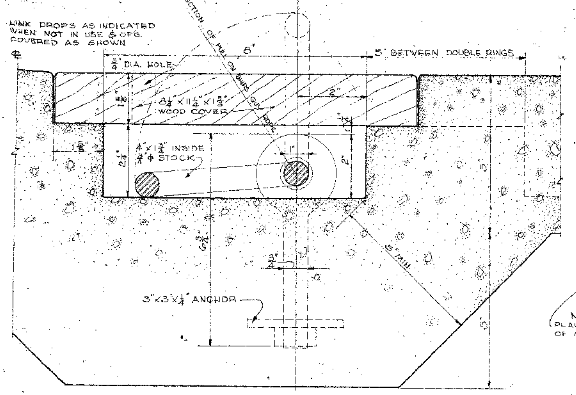
STANDARD
LIGHTER THAN AIR HANGAR
WOOD CONSTRUCTION
3'-6" STEEL ROLLING DOOR
220FT. X 120FT. OPENING

APPROVED 1942
FOR CHIEF OF BUREAU

Y. & D. DRAWING NO. 220068

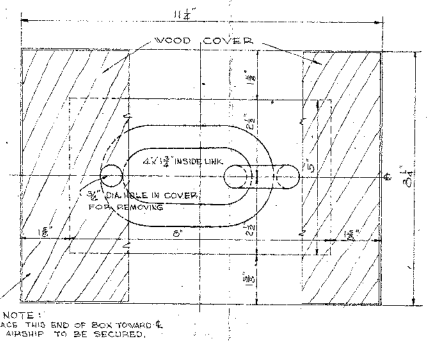
SCALE AS NOTED

~~HOUMA, LA.~~	BRUNSWICK, GA.	~~PORT ARTHUR, TEXAS~~	MOFFETT FIELD, CALIF.	~~SO. WEYMOUTH, MASS.~~	~~ELIZABETH CITY, N.C.~~	LAKEHURST, N.J.	RICHMOND, FLA.	SANTA ANA, CALIF.	TILLAMOOK, ORE.
~~Sheet ... of ... accompanying contract~~	Sheet ... of ... accompanying contract	~~Sheet ... of ... accompanying contract~~	Sheet ... of ... accompanying contract	~~Sheet ... of ... accompanying contract~~	~~Sheet ... of ... accompanying contract~~	Sheet ... of ... accompanying contract	Sheet ... of ... accompanying contract	Sheet ... of ... accompanying contract	Sheet ... of ... accompanying contract



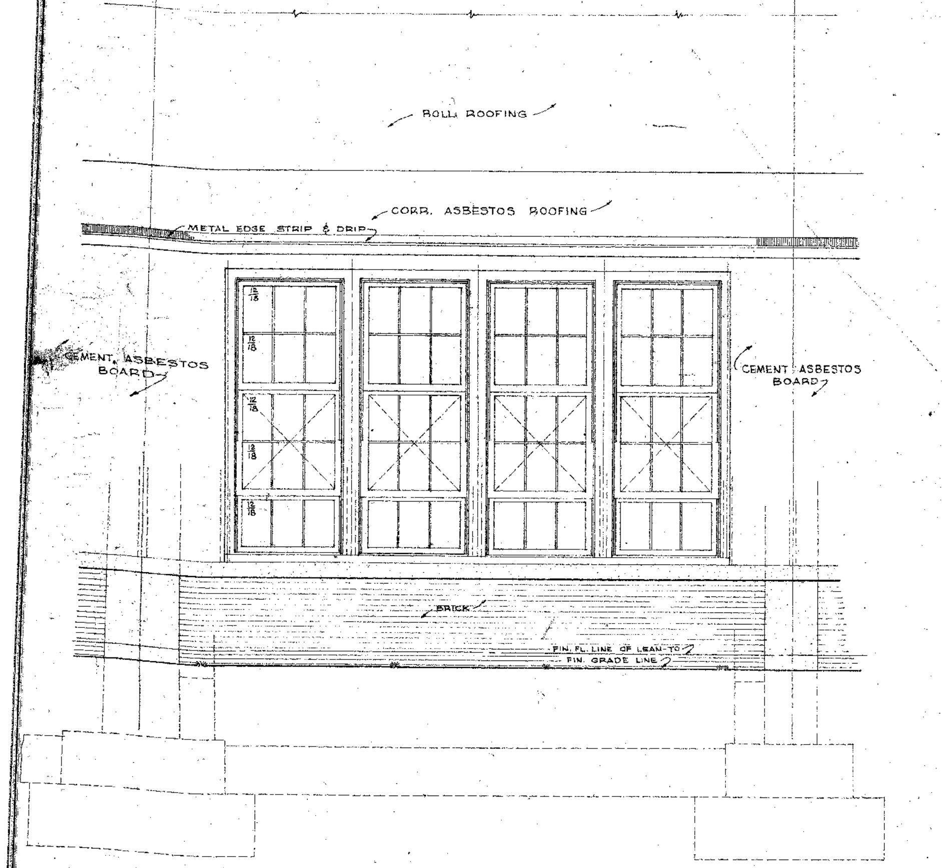
SECTION

½ FULL SIZE DETAILS OF HOLD DOWN RINGS IN HANGAR FLOOR



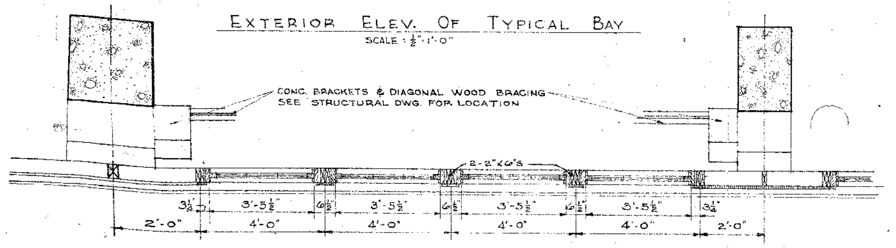
NOTE: PLACE THIS END OF BOX TOWARD ℄ OF AIRSHIP TO BE SECURED.

PLAN



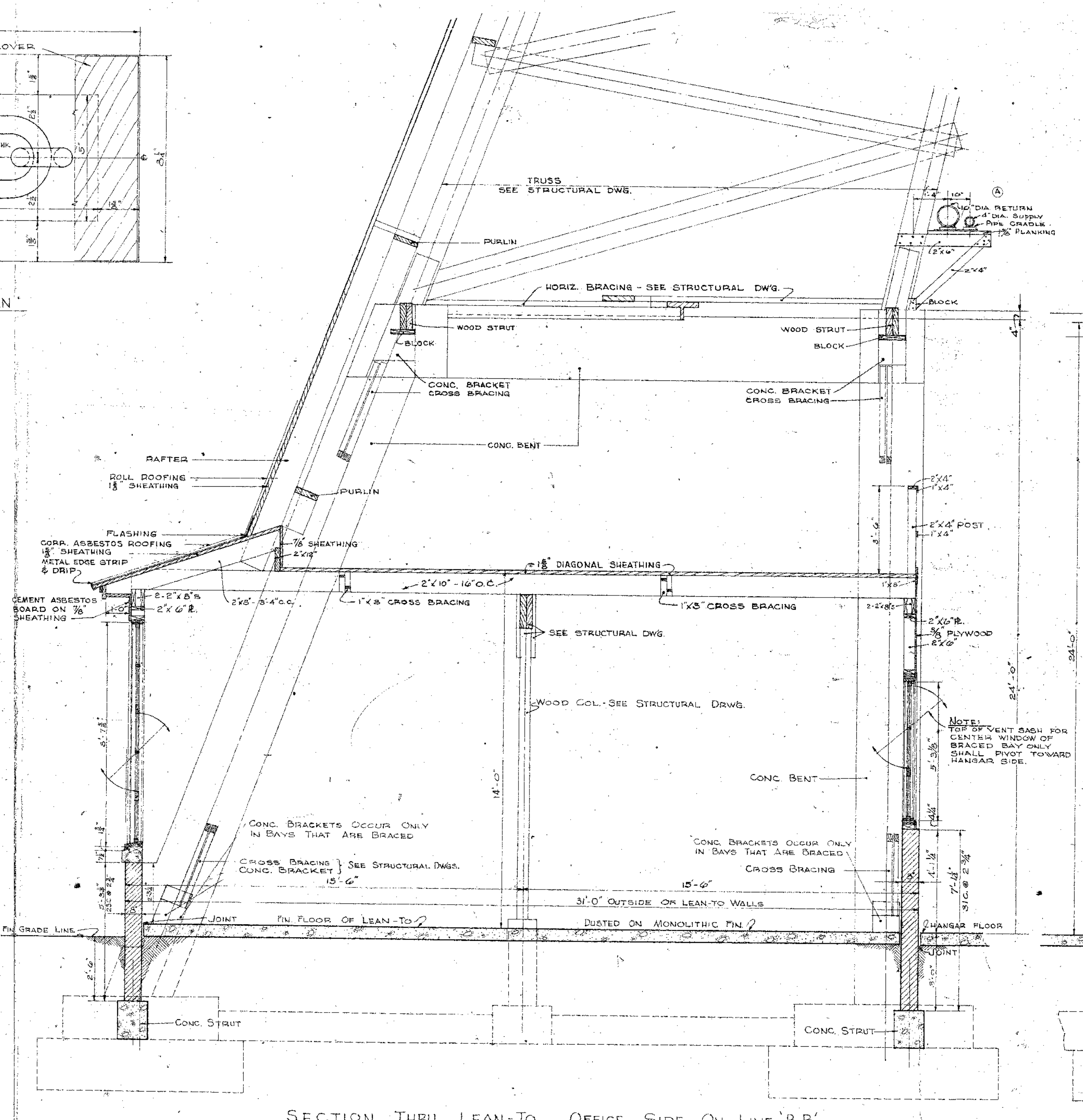
EXTERIOR ELEV. OF TYPICAL BAY

SCALE: ½"=1'-0"



PLAN OF TYPICAL BAY

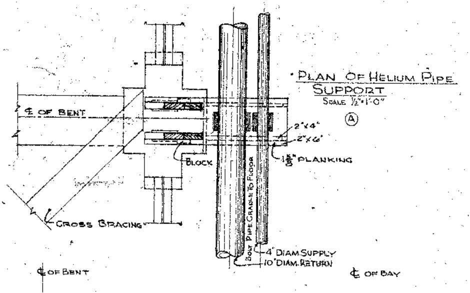
SCALE: ¼"=1'-0" ½"



SECTION THRU. LEAN-TO OFFICE SIDE ON LINE 'B-B'

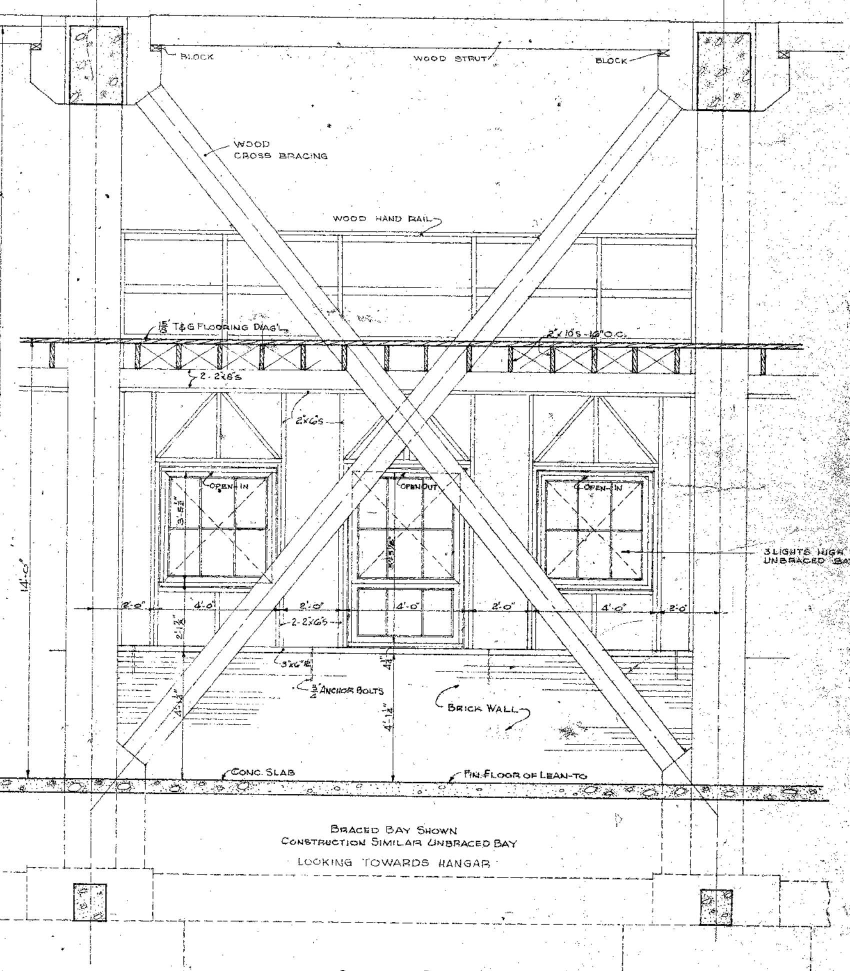
(SEE SHEET NO. 2 FOR LOCATION)

SCALE: ½"=1'-0"



PLAN OF HELIUM PIPE SUPPORT

SCALE ½"=1'-0"



BRACED BAY SHOWN
CONSTRUCTION SIMILAR UNBRACED BAY

LOOKING TOWARDS HANGAR

OFFICE SIDE

INTERIOR ELEVATION OF LEAN-TO

SCALE: ½"=1'-0"

Revision	Date	Brief	By
A	10-29-42	RELOCATED HELIUM PIPE SUPPORT	D.O.H.

APPROVED BY BUREAU OF AERONAUTICS

Date:

Prepared by D.O. HAFNER J.E. GILDER
Traced by D.O. HAFNER
Checked by W. BROWN
Supervisor BASSETT
Group Chief
Chief Dftsmn.
Des. Engr.
Proj. Mgrs. EBH.
Design Mgr.

NAVY DEPARTMENT BUREAU OF YARDS & DOCKS

STANDARD
LIGHTER-THAN-AIR-HANGAR
WOOD CONSTRUCTION
DETAILS OF OFFICE LEAN-TO

Scale: As noted.

SHEET No.
4

Approved July 21 1942

For Chief of Bureau

Y. & D. Drawing No. 212,806

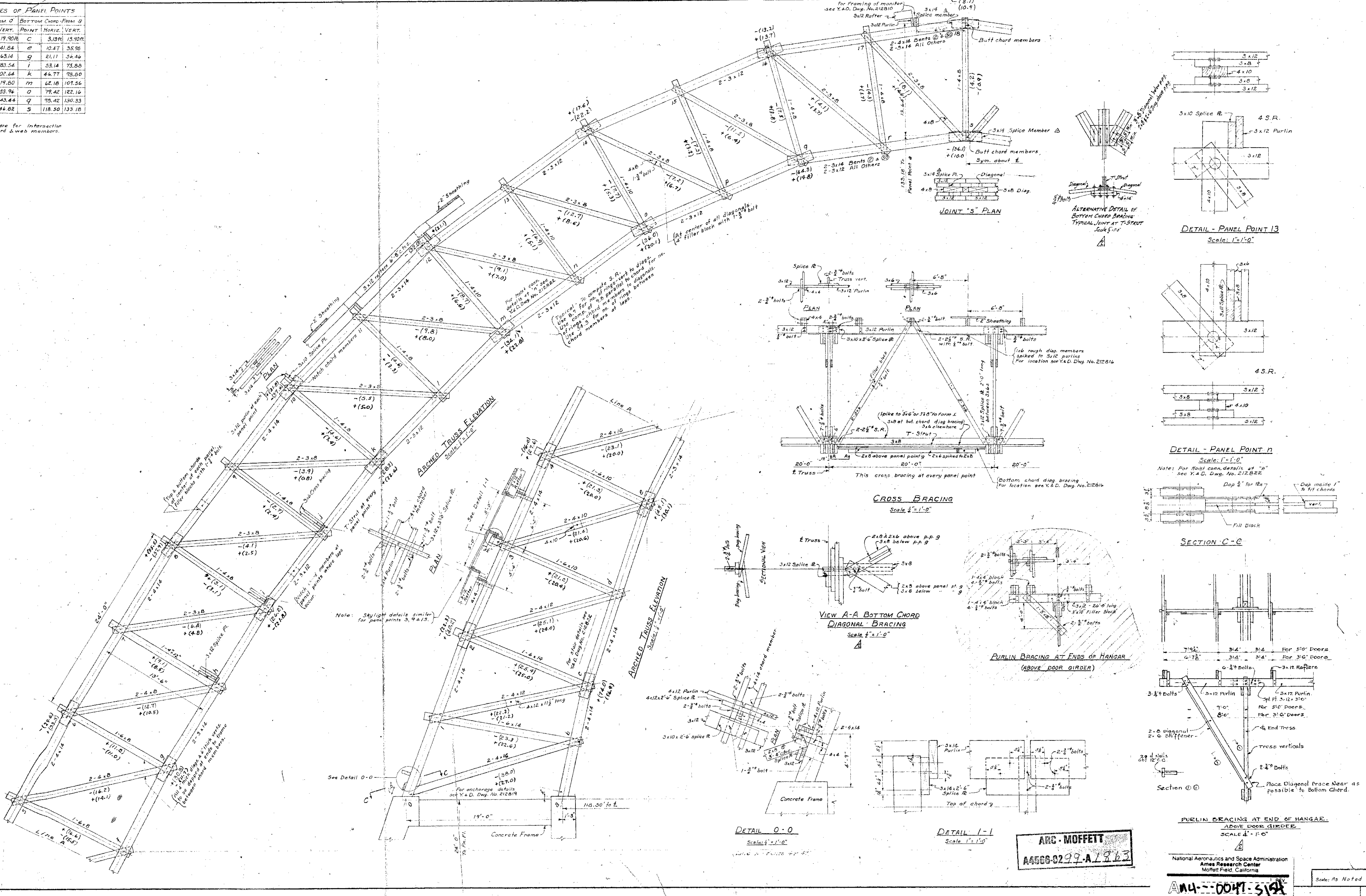
HOUMA, LA.	BRUNSWICK, GA.	PORT ARTHUR, TEXAS	MOFFET FIELD, CALIF.	S. WEYMOUTH, MASS.	ELIZABETH CITY N.C.	LAKEHURST N.J.	RICHMOND, FLA.	SANTA ANA, CALIF.	TILLAMOOK, ORE.
SHEET 4 OF	SHEET 4 OF	SHEET 4 OF	SHEET 4 OF	SHEET 4 OF	SHEET 4 OF	SHEET 4 OF	SHEET 4 OF	SHEET 4 OF	SHEET 4 OF
ACCOMPANYING CONTRACT	ACCOMPANYING CONTRACT	ACCOMPANYING CONTRACT	ACCOMPANYING CONTRACT	ACCOMPANYING CONTRACT	ACCOMPANYING CONTRACT	ACCOMPANYING CONTRACT	ACCOMPANYING CONTRACT	ACCOMPANYING CONTRACT	ACCOMPANYING CONTRACT
Noy 5745	Noy 5743	Noy 5739	Noy 5604	Noy 4962	Noy 4956	Noy 4833	Noy 5460	Noy 5421	Noy 5424

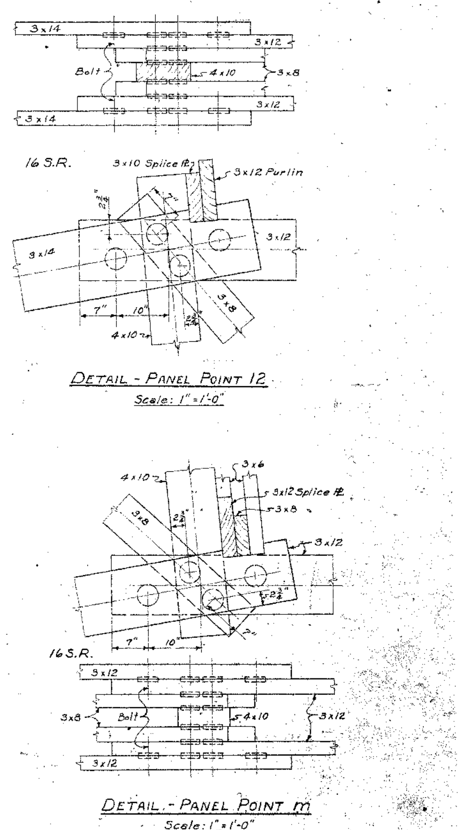
1-45-58

COORDINATES OF PANEL POINTS

TOP CHORD - FROM 0			BOTTOM CHORD - FROM 8		
POINT	HORIZ.	VERT.	POINT	HORIZ.	VERT.
2	7.57ft.	19.90ft.	c	3.13ft.	13.90ft.
4	17.30	41.84	e	10.47	35.98
6	28.36	63.14	g	21.11	56.46
8	41.00	83.54	i	33.14	75.88
10	55.53	102.64	k	46.77	93.80
12	72.31	119.80	m	62.18	109.56
14	91.69	133.96	o	79.42	122.16
16	113.74	143.44	q	98.42	130.33
18	137.50	146.82	s	118.50	133.18

Note:
Coordinates are for intersection of ℄s of chord & web members.





Notes:

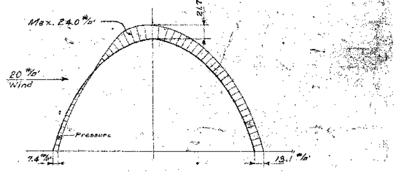
Design loads - Snow 0.0#/□' • Wind - 10#/□' normal, either as a suction, or pressure, plus 20#/□' horizontal distributed as per diagram. Hoist 5000# at panel point "n". Earthquake - 10% of dead load

Stresses are shown (34.3 etc.) in thousands of lbs; and are to be used in detailing joints, + Compression - Tension

Arched truss members are to be connected with split rings (S.R). Unless shown otherwise, 4"φ S.R. with ¾"φ bolts, and 4"φ shear plates (S.P.) with ¾"φ bolts are to be used.

Timber to be 1400#f - 1100#c grade for arched truss members, and 1200#f - 1000#c elsewhere.

Max. stresses determined by the following combinations of D.L., D.L.+ Wind, D.L.+ Hoist + ½ Wind, or D.L.+ Earthquake.



DISTRIBUTED WIND LOAD

Revision	Date	Brief	By
2	12/30/42	Bottom chord bracing changed and alternative added. Detail of purlin bracing at ends of hangar added.	G.C.R.
1	8-22-42	Splice Member Changed - 3x12 to 3x14	P.S.N.

APPROVED BY BUREAU OF AERONAUTICS

DATE

Prepared by F.M.-I.B.A.
Traced by H.H.
Checked by BGA
Supervisor LFB
Group Chief
Chief Dftmn.
Des. Engr.
Proj. Mgrs.
Design Mgr.
Sheet ... of ... accompanying contract
Noy. 5421

NAVY DEPARTMENT
BUREAU OF YARDS & DOCKS

NAVAL AIR STATION
SANTA ANA, CALIF.
LIGHTER-THAN-AIR HANGAR
ROOF TRUSS DETAILS
1400#f-DESIGN

Approved August 5 1942
Y. & D. Drawing No. 212817
For Chief of Bureau

Scale: As Noted

Sheet ... of ... accompanying contract
NOy ...

Sheet ... of ... accompanying contract
NOy ...

MOFFETT FIELD, CALIF.
Sheet ... of ... accompanying contract
NOy

A NEW **PERSPECTIVE** IN PRESERVATION

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